

Engineering Log - Cored Borehole

client: **ACT Government - Commerce and Works**

principal:

project: **Parkes Way Geotechnical Profiling**

location: **Refer to Figure 1**

Borehole ID: **BH05**

sheet: 3 of 3

project no. **GEOTFYSH09693AA**

date started: **05 Dec 2013**

date completed: **05 Dec 2013**

logged by: **SB**

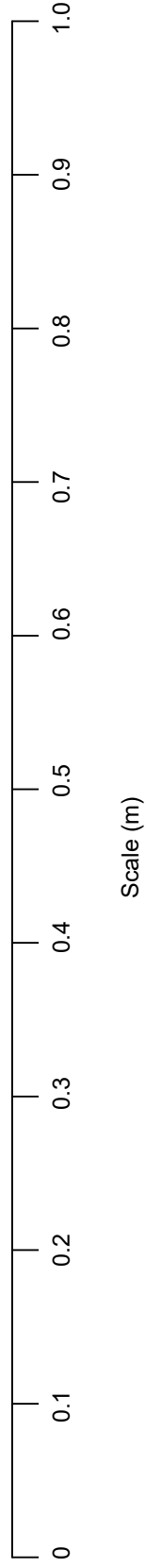
checked by: **DB**


position: E: 693451; N: 6093177 (WGS84 Zone 55) surface elevation : 559.80m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

drilling information		material substance			rock mass defects				
method & support	water	depth (m)	material description ROCK TYPE: grain characteristics, colour, structure, minor components	weathering & alteration	estimated strength & Is(50) O - axial diameter X - radial diameter	samples, field tests & Is(50) (MPa) a - axial d - diametral	defect spacing (mm)	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other)	
		graphic log						particular	
		9.0	SILTSTONE: As described previously. (continued)	MW	X O	a=0.34 d=0.93	RQD=73%	CS, Clay JT, 80°, UN, RO, Mg SN PT, 60°, PL, RO, Mg SN	
		10.0			X O	a=0.42 d=0.60	RQD=60%	JT, 80°, UN, RO, Mg SN PT, 60°, PL, RO, Mg SN JT, 80°, UN, RO, Mg SN	
		11.0			X O	a=0.50 d=0.50	RQD=33%	PT, 60°, UN, RO, Mg SN JT, 80°, UN, RO, Mg SN	
		12.0	NO CORE: 0.48 m			a=0.54 d=0.19	RQD=33%	JT, 80°, UN, RO, Mg SN	
		13.0	SILTSTONE: As described previously.	MW	O X	a=0.60 d=0.37	RQD=27%	PT, 70 - 80°, UN, RO, Mg SN JT, 80 - 90°, UN, RO, Mg SN JT, 90°, UN, RO, VN, Clay	
		14.0	Borehole BH05 terminated at 13.50 m						


CDF_0_9_04AW.GLB Log_COF_BOREHOLE_CORED_GF9693AA_V2.GPJ <-DrawingFile>> 18/12/2013 17:22

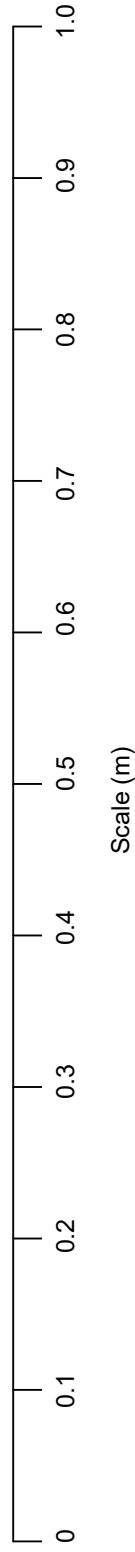
method & support DT diatube AS auger screwing AD auger drilling RR roller/fricone CB claw or blade bit W washbore NMLC NMLC core (51.9 mm) NQ wireline core (47.6mm) HQ wireline core (63.5mm) PQ wireline core (85.0mm) SPT standard penetration test	water 10/10/12, water level on date shown water inflow complete drilling fluid loss partial drilling fluid loss water pressure test result (lugeons) for depth interval shown 25ul	graphic log / core recovery core recovered (graphic symbols indicate material) no core recovered core run details barrel withdrawn TCR = Total Core Recovery (%) SCR = Solid Core Recovery (%) RQD = Rock Quality Designation (%)	weathering & alteration* RS residual soil XW extremely weathered HW highly weathered DW distinctly weathered MW moderately weathered SW slightly weathered FR fresh *W replaced with A for alteration strength VL very low L low M medium H high VH very high EH extremely high	defect type PT parting JT joint SZ shear zone SS shear surface CS crushed seam SM seam DB drilling break roughness SL slickensided POL polished SO smooth RO rough VR very rough	planarity PL planar CU curved UN undulating ST stepped IR irregular coating CN clean SN stain VN veneer CO coating
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drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013		title:	CORE PHOTO BH05: 2.0 - 6.0m
scale	NTS		project no:	GEOTFYSH09693AA
original size	A4			Photo no: 1 of 3



drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013		title:	CORE PHOTO BH05: 6.0 - 11.0m
scale	NTS		project no:	GEOTFYSH09693AA
original size	A4			Photo no: 2 of 3



drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013	scale	title:	CORE PHOTO BH05: 11.0 - 13.58m
original size	NTS	project no: GEOTFYSH09693AA	Photo no: 3 of 3	
	A4			

Engineering Log - Borehole

client: **ACT Government - Commerce and Works**

principal:

project: **Parkes Way Geotechnical Profiling**

location: **Refer to Figure 1**

Borehole ID: **BH06**

sheet: 1 of 3

project no. **GEOTFYSH09693AA**

date started: **05 Dec 2013**

date completed: **05 Dec 2013**

logged by: **SB**

checked by: **DB**

position: E: 693583; N: 6093156 (WGS84 Zone 55) surface elevation : 560.00m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

drilling information				material substance			
method & support	penetration	samples & field tests	depth (m)	graphic log	classification symbol	material description	structure and additional observations
method & support: ADW HW casing	penetration: 1 2 3	samples & field tests: SPT 1, 1, 2 N=3 SPT 3, 11, 17 N=28 SPT 17 HB N=R	560			FILL: Silty CLAY low plasticity, dark grey.	TOPSOIL
			559			FILL: Silty CLAY medium plasticity, yellowish-brown with some medium grained sand and fine grained angular gravel.	FILL
			558			FILL: Gravely CLAY medium plasticity, yellowish-brown, fine to medium grained sub-rounded to sub-angular gravel.	
			557			FILL: SAND grey, fine to medium. SILTSTONE: pale-brown, extremely weathered, very low strength.	BEDROCK
			556			Borehole BH06 continued as cored hole	
			555				
			554				
			553				

CDF_0_9_04AW.GLB Log_COE_BOREHOLE_NON_CORED_GF9693AA_V2.GPJ <<DrawingFile>> 18/12/2013 17:21

method AD auger drilling* AS auger screwing* RR roller/tricone W washbore CT cable tool HA hand auger DT diatube B blank bit V V bit T TC bit * bit shown by suffix e.g. AD/T	support M mud N nil C casing penetration 10-Oct-12 water level on date shown water inflow water outflow	samples & field tests U## undisturbed sample ##mm diameter D disturbed sample B bulk disturbed sample E environmental sample HP hand penetrometer (kPa) N standard penetration test (SPT) N* SPT - sample recovered Nc SPT with solid cone VS vane sheapeak/remoulded (uncorrected kPa) R refusal	classification symbol & soil description based on Unified Classification System moisture D dry M moist W wet	consistency / relative density VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense
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Engineering Log - Cored Borehole

Borehole ID: **BH06**
 sheet: 2 of 3
 project no: **GEOTFYSH09693AA**
 date started: **05 Dec 2013**
 date completed: **05 Dec 2013**
 logged by: **SB**
 checked by: **DB**

client: **ACT Government - Commerce and Works**
 principal:
 project: **Parkes Way Geotechnical Profiling**
 location: **Refer to Figure 1**

position: E: 693583; N: 6093156 (WGS84 Zone 55) surface elevation : 560.00m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

drilling information			material substance				rock mass defects			
method & support	water	depth (m)	material description ROCK TYPE: grain characteristics, colour, structure, minor components	weathering & alteration	estimated strength & Is(50) X - axial O - diametral a - axial d - diametral	samples, field tests & Is(50) (MPa)	core run details	defect spacing (mm)	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other)	
		559								
		558								
		557								
		556	start coring at 4.00m							
		555	SILTSTONE: pale-brown, distinctly bedded at 60° to 70°.	XW			RQD= 0%			
		554	NO CORE: 0.18 m							
		553	SILTSTONE: As described previously.	XW			RQD= 0%			

method & support DT diatube AS auger screwing AD auger drilling RR roller/fricone CB claw or blade bit W washbore NMLC NMLC core (51.9 mm) NQ wireline core (47.6mm) HQ wireline core (63.5mm) PQ wireline core (85.0mm) SPT standard penetration test	water 10/10/12, water level on date shown water inflow complete drilling fluid loss partial drilling fluid loss water pressure test result (lugeons) for depth interval shown	graphic log / core recovery core recovered (graphic symbols indicate material) no core recovered core run details barrel withdrawn TCR = Total Core Recovery (%) SCR = Solid Core Recovery (%) RQD = Rock Quality Designation (%)	weathering & alteration* RS residual soil XW extremely weathered HW highly weathered DW distinctly weathered MW moderately weathered SW slightly weathered FR fresh *W replaced with A for alteration strength VL very low L low M medium H high VH very high EH extremely high	defect type PT parting JT joint SZ shear zone SS shear surface CS crushed seam SM seam DB drilling break roughness SL slickensided POL polished SO smooth RO rough VR very rough	planarity PL planar CU curved UN undulating ST stepped IR irregular coating CN clean SN stain VN veneer CO coating
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CDF_0_9_04AW.GLB Log_COF_BOREHOLE_CORED_GF9693AA_V2.GPJ <-DrawingFile>> 18/12/2013 17:22

Engineering Log - Cored Borehole

Borehole ID: **BH06**
 sheet: 3 of 3
 project no: **GEOTFYSH09693AA**
 date started: **05 Dec 2013**
 date completed: **05 Dec 2013**
 logged by: **SB**
 checked by: **DB**

client: **ACT Government - Commerce and Works**
 principal:
 project: **Parkes Way Geotechnical Profiling**
 location: **Refer to Figure 1**


position: E: 693583; N: 6093156 (WGS84 Zone 55) surface elevation : 560.00m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

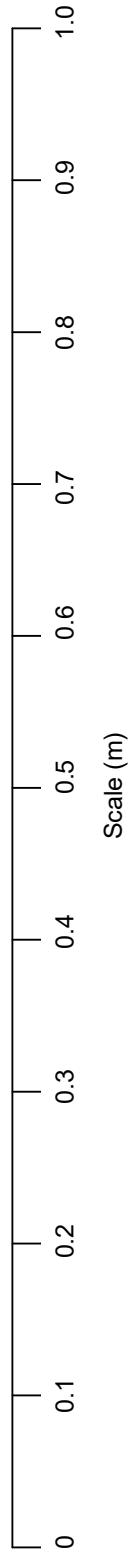
drilling information		material substance				rock mass defects			
method & support	water	depth (m)	material description ROCK TYPE: grain characteristics, colour, structure, minor components	weathering & alteration	estimated strength & Is(50) X - axial O - radial a - axial d - diametral	samples, field tests & Is(50) (MPa)	core run details	defect spacing (mm)	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other)
		8.0	SILTSTONE: As described previously. (continued)	XW			RQD= 0%		
		9.0	NO CORE: 0.20 m			a=0.06 d=0.05			
		10.0	SILTSTONE: As described previously.	XW			RQD= 0%		
		11.0	NO CORE: 0.43 m			a=0.07 d=0.07 a=0.09 d=0.05			
		12.0	SILTSTONE: As described previously.	XW			RQD= 0%		
		13.0	NO CORE: 0.71 m			a=0.06 d=0.05			
		14.0	SILTSTONE: As described previously.	XW			RQD= 0%		
		15.0	Borehole BH06 terminated at 15.00 m				RQD= 0%		


CDF_0_9_04AW/CLB Log_COF_BOREHOLE_CORED_GF9693AA_V2.GPJ <-DrawingFile>> 18/12/2013 17:22

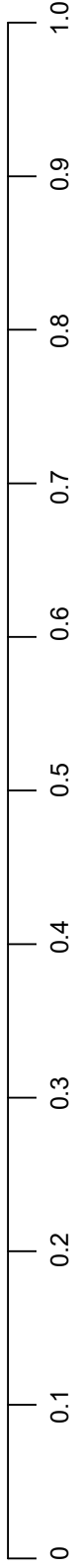
method & support DT diatube AS auger screwing AD auger drilling RR roller/fricone CB claw or blade bit W washbore NMLC NMLC core (51.9 mm) NQ wireline core (47.6mm) HQ wireline core (63.5mm) PQ wireline core (85.0mm) SPT standard penetration test	water 10/10/12, water level on date shown water inflow complete drilling fluid loss partial drilling fluid loss water pressure test result (lugcons) for depth interval shown 25ul	graphic log / core recovery core recovered (graphic symbols indicate material) no core recovered core run details barrel withdrawn TCR = Total Core Recovery (%) SCR = Solid Core Recovery (%) RQD = Rock Quality Designation (%)	weathering & alteration* RS residual soil XW extremely weathered HW highly weathered DW distinctly weathered MW moderately weathered SW slightly weathered FR fresh *W replaced with A for alteration strength VL very low L low M medium H high VH very high EH extremely high	defect type PT parting JT joint SZ shear zone SS shear surface CS crushed seam SM seam DB drilling break roughness SL slickensided POL polished SO smooth RO rough VR very rough	planarity PL planar CU curved UN undulating ST stepped IR irregular coating CN clean SN stain VN veneer CO coating
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drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013		title:	CORE PHOTO BH06: 4.0 - 8.0m
scale	NTS		project no:	GEOTFYSH09693AA
original size	A4			Photo no: 1 of 3



drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013		title:	CORE PHOTO BH06: 8.0 - 13.0m
scale	NTS		project no:	GEOTFYSH09693AA
original size	A4			Photo no: 2 of 3



Scale (m)

drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013	scale	title:	CORE PHOTO BH06: 13.0 - 15.0m
original size	NTS	project no:	GEOTFYSH09693AA	Photo no: 3 of 3
	A4			

Engineering Log - Borehole

client: **ACT Government - Commerce and Works**
 principal:
 project: **Parkes Way Geotechnical Profiling**
 location: **Refer to Figure 1**

Borehole ID: **BH07**
 sheet: 1 of 3
 project no: **GEOTFYSH09693AA**
 date started: **03 Dec 2013**
 date completed: **03 Dec 2013**
 logged by: **SB**
 checked by: **DB**

position: E: 693705; N: 6093131 (WGS84 Zone 55) surface elevation : 559.20m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

drilling information				material substance								
method & support	penetration	samples & field tests	water	RL (m)	depth (m)	graphic log	classification symbol	material description SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa)	structure and additional observations
ADV HW casing	1			-559			CH	FILL: Sandy SILT low plasticity, dark grey.	<Wl			TOPSOIL
	2							CLAY: medium to high plasticity, yellowish-brown, with some fine sand.	<Wp	St		RESIDUAL SOIL
	3			-558	1.0			SILTSTONE: pale-brown, extremely weathered, low strength.				BEDROCK
					2.0			Borehole BH07 continued as cored hole				
					3.0							
					4.0							
					5.0							
					6.0							
					7.0							

CDF_0_9_04AW.GLB Log_COF_BOREHOLE_NON_CORED_GF9693AA_V2.GPJ <<DrawingFile>> 18/12/2013 17:21

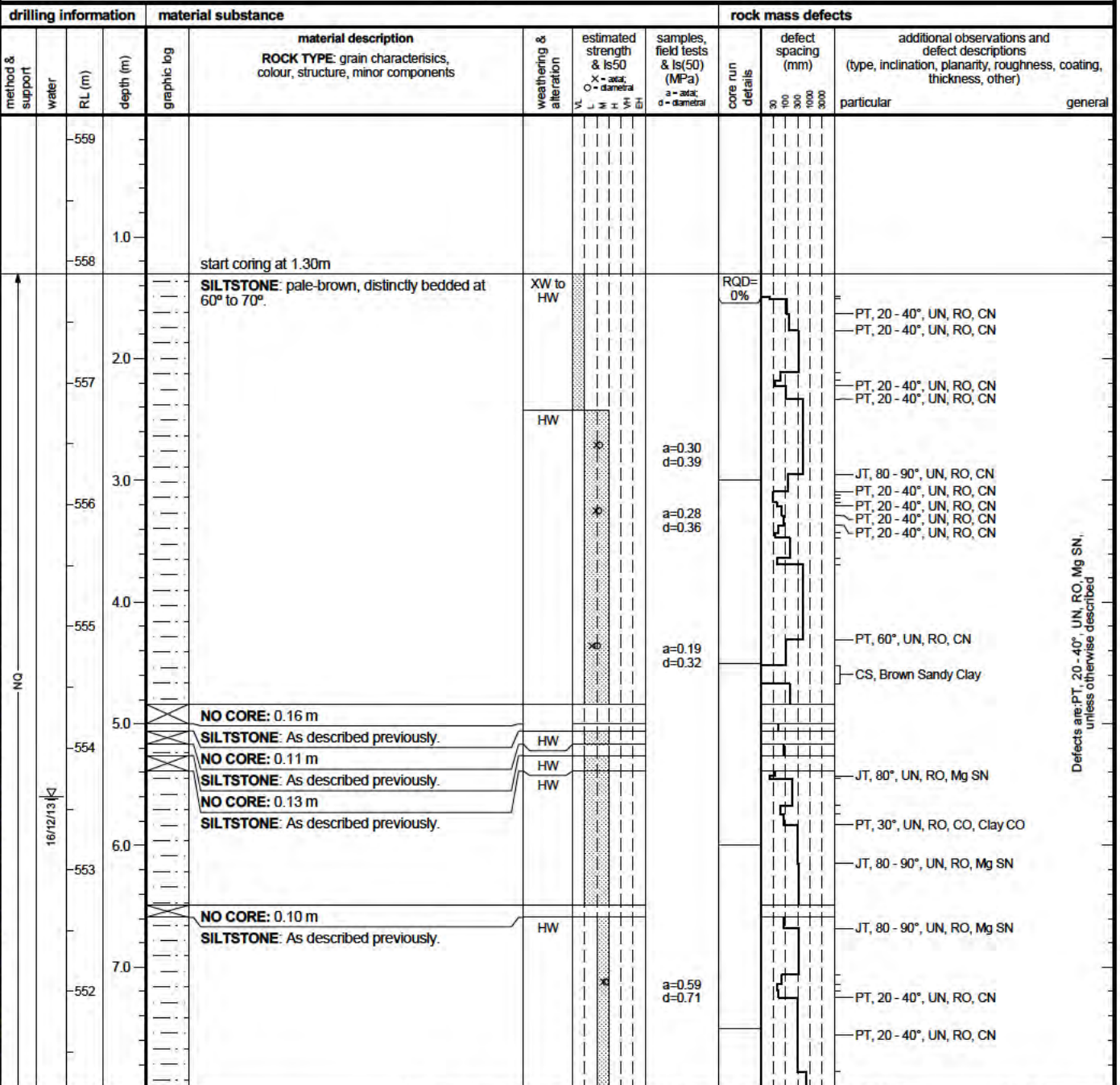
method AD auger drilling* AS auger screwing* RR roller/tricone W washbore CT cable tool HA hand auger DT diatube B blank bit V V bit T TC bit * bit shown by suffix e.g. AD/T	support M mud N nil C casing penetration no resistance ranging to refusal water 10-Oct-12 water level on date shown water inflow water outflow	samples & field tests U## undisturbed sample ##mm diameter D disturbed sample B bulk disturbed sample E environmental sample HP hand penetrometer (kPa) N standard penetration test (SPT) N* SPT - sample recovered Nc SPT with solid cone VS vane shearpeak/remoulded (uncorrected kPa) R refusal	classification symbol & soil description based on Unified Classification System moisture D dry M moist W wet	consistency / relative density VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense
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Engineering Log - Cored Borehole

Borehole ID: **BH07**
 sheet: 2 of 3
 project no: **GEOTFYSH09693AA**
 date started: **03 Dec 2013**
 date completed: **03 Dec 2013**
 logged by: **SB**
 checked by: **DB**

client: **ACT Government - Commerce and Works**
 principal:
 project: **Parkes Way Geotechnical Profiling**
 location: **Refer to Figure 1**

position: E: 693705; N: 6093131 (WGS84 Zone 55) surface elevation : 559.20m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW



method & support DT diatube AS auger screwing AD auger drilling RR roller/tricone CB claw or blade bit W washbore NMLC NMLC core (51.9 mm) NQ wireline core (47.6mm) HQ wireline core (63.5mm) PQ wireline core (85.0mm) SPT standard penetration test	water 10/10/12, water level on date shown water inflow complete drilling fluid loss partial drilling fluid loss water pressure test result (lugesons) for depth interval shown 25µl	graphic log / core recovery core recovered (graphic symbols indicate material) no core recovered core run details barrel withdrawn TCR = Total Core Recovery (%) SCR = Solid Core Recovery (%) RQD = Rock Quality Designation (%)	weathering & alteration* RS residual soil XW extremely weathered HW highly weathered DW distinctly weathered MW moderately weathered SW slightly weathered FR fresh *W replaced with A for alteration strength VL very low L low M medium H high VH very high EH extremely high	defect type PT parting JT joint SZ shear zone SS shear surface CS crushed seam SM seam DB drilling break roughness SL slickensided POL polished SO smooth RO rough VR very rough	planarity PL planar CU curved UN undulating ST stepped IR irregular coating CN clean SN stain VN veneer CO coating
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CDF_0_9_04AW.GLB Log_COF_BOREHOLE_CORED_GF9693AA_V2.GPJ <<DrawingFile>> 18/12/2013 17:23

Defects are: PT, 20 - 40°, UN, RO, Mg SN, unless otherwise described

Engineering Log - Cored Borehole

client: **ACT Government - Commerce and Works**

principal:

project: **Parkes Way Geotechnical Profiling**

location: **Refer to Figure 1**

Borehole ID: **BH07**

sheet: 3 of 3

project no. **GEOTFYSH09693AA**

date started: **03 Dec 2013**

date completed: **03 Dec 2013**

logged by: **SB**

checked by: **DB**


position: E: 693705; N: 6093131 (WGS84 Zone 55) surface elevation : 559.20m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

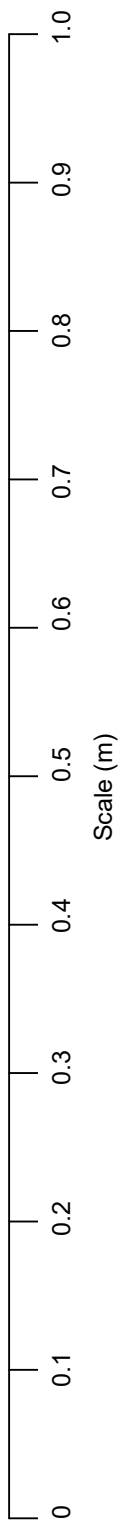
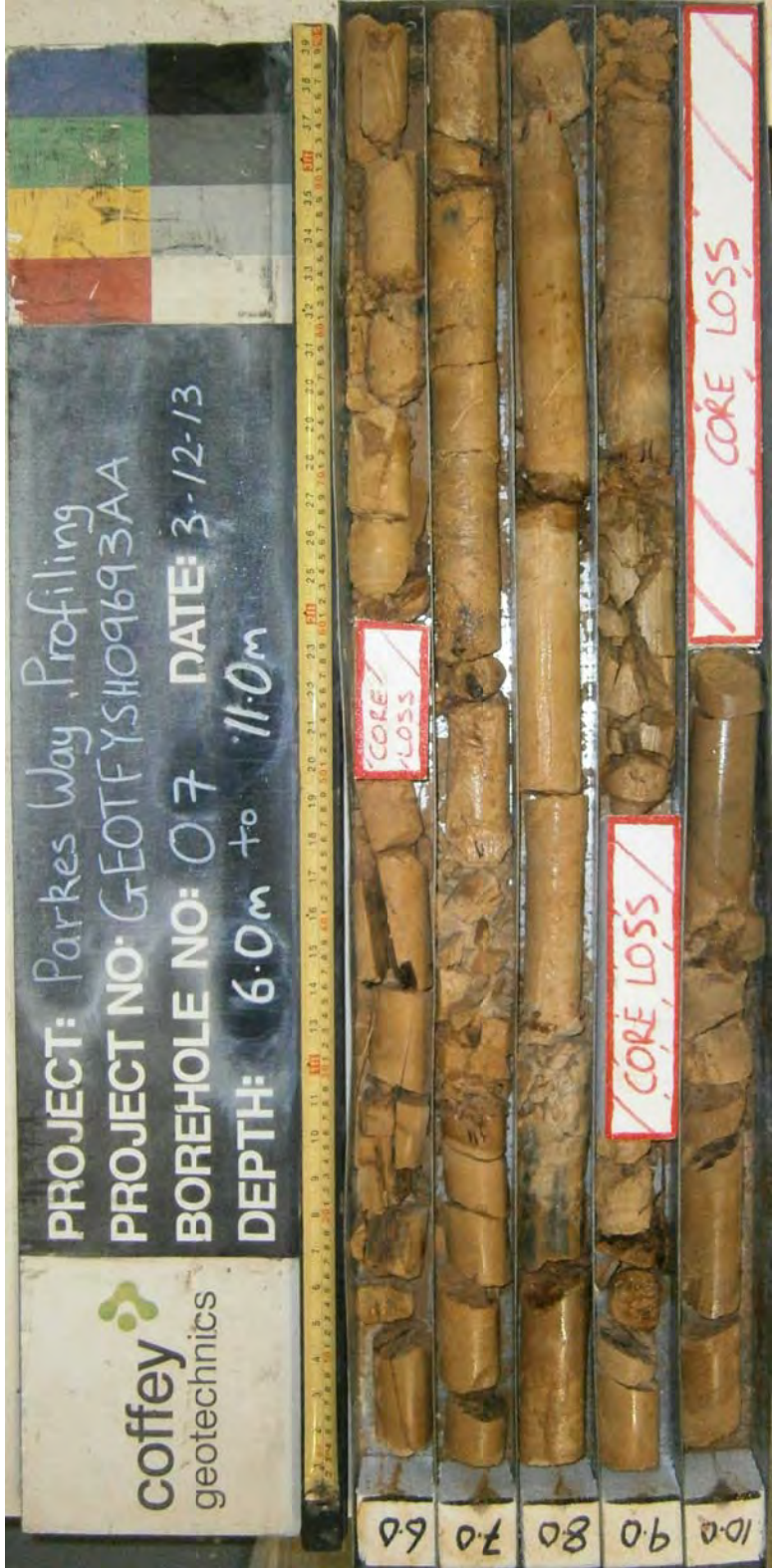
drilling information		material substance				rock mass defects			
method & support	water	depth (m)	material description ROCK TYPE: grain characteristics, colour, structure, minor components	weathering & alteration	estimated strength & Is(50) X - axial O - diametral a - axial d - diametral	samples, field tests & Is(50) (MPa)	defect spacing (mm)	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other)	
		551	SILTSTONE: As described previously. (continued)	HW					
		9.0		XW		a=0.48 d=0.43			
		550	NO CORE: 0.20 m						
		10.0	SILTSTONE: As described previously.	MW		a=0.59 d=0.76		PT, 20 - 40°, UN, RO, CN	
		549						PT, 20 - 40°, UN, RO, CN	
		11.0	NO CORE: 0.93 m			a=0.18 d=0.96			
		548							
		12.0	SILTSTONE: As described previously.	MW		a=0.53 d=0.71		JT, 90°, PL, RO, Mg SN	
		547							
		13.0				a=0.23 d=0.36		JT, 70°, PL, RO, Mg SN	
		546						JT, 80°, UN, RO, Mg SN	
		14.0	Borehole BH07 terminated at 13.50 m						
		545							
		15.0							
		544							


CDF_0_9_04AW.GLB Log_COF_BOREHOLE_CORED_GF9693AA_V2.GPJ <-DrawingFile>> 18/12/2013 17:23

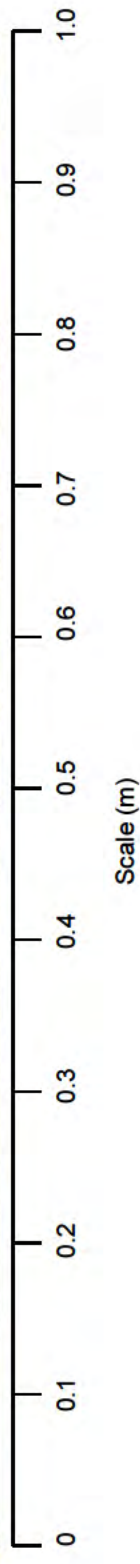
method & support DT diatube AS auger screwing AD auger drilling RR roller/fricone CB claw or blade bit W washbore NMLC NMLC core (51.9 mm) NQ wireline core (47.6mm) HQ wireline core (63.5mm) PQ wireline core (85.0mm) SPT standard penetration test	water 10/10/12, water level on date shown water inflow complete drilling fluid loss partial drilling fluid loss water pressure test result (lugcons) for depth interval shown 25ul	graphic log / core recovery core recovered (graphic symbols indicate material) no core recovered core run details barrel withdrawn TCR = Total Core Recovery (%) SCR = Solid Core Recovery (%) RQR = Rock Quality Designation (%)	weathering & alteration* RS residual soil XW extremely weathered HW highly weathered DW distinctly weathered MW moderately weathered SW slightly weathered FR fresh *W replaced with A for alteration strength VL very low L low M medium H high VH very high EH extremely high	defect type PT parting JT joint SZ shear zone SS shear surface CS crushed seam SM seam DB drilling break roughness SL slickensided POL polished SO smooth RO rough VR very rough	planarity PL planar CU curved UN undulating ST stepped IR irregular coating CN clean SN stain VN veneer CO coating
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drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013	CORE PHOTO BH07: 1.3 - 6.0m	title:	
scale	NTS		project no: GEOTFYSH09693AA	photo no: 1 of 3
original size	A4			



drawn	SB	 coffey	client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013	scale	title:	CORE PHOTO BH07: 6.0 - 11.0m
original size	NTS	project no:	GEOTFYSH09693AA	Photo no: 2 of 3
	A4			



drawn	SB		client	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013		title:	CORE PHOTO BH07: 11.0 - 13.5m
scale	NTS		project no:	GEOTFYSH09693AA
original size	A4			Photo no: 3 of 3

Engineering Log - Borehole

Borehole ID: **BH08**
 sheet: 1 of 3
 project no: **GEOTFYSH09693AA**
 date started: **03 Dec 2013**
 date completed: **03 Dec 2013**
 logged by: **SB**
 checked by: **DB**

client: **ACT Government - Commerce and Works**
 principal:
 project: **Parkes Way Geotechnical Profiling**
 location: **Refer to Figure 1**

position: E: 693779; N: 6093112 (WGS84 Zone 55) surface elevation : 558.80m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

drilling information				material substance								
method & support	penetration	samples & field tests	water	RL (m)	depth (m)	graphic log	classification symbol	material description SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa)	structure and additional observations
ADV ADW casing	1 2 3							FILL: Sandy CLAY medium plasticity, dark brown, mottled orange, fine to coarse grained sand, with some fine to coarse angular to subangular gravel.	<Wp		100 200 300 400	FILL
				-558	1.0			SILTSTONE: pale-brown, extremely weathered, very low to low strength.				BEDROCK
				-557	2.0			Borehole BH08 continued as cored hole				
				-556	3.0							
				-555	4.0							
				-554	5.0							
				-553	6.0							
				-552	7.0							
				-551								

CDF_0_g_04AW.GLB Log_COF_BOREHOLE_NON_CORED_GF9693AA_V2.GPJ <<DrawingFile>> 18/12/2013 17:21

method AD auger drilling* AS auger screwing* RR roller/tricone W washbore CT cable tool HA hand auger DT diatube B blank bit V V bit T TC bit * bit shown by suffix e.g. AD/T	support M mud N nil C casing penetration water 	samples & field tests U## undisturbed sample ##mm diameter D disturbed sample B bulk disturbed sample E environmental sample HP hand penetrometer (kPa) N standard penetration test (SPT) N* SPT - sample recovered Nc SPT with solid cone VS vane shearpeak/remoulded (uncorrected kPa) R refusal	classification symbol & soil description based on Unified Classification System moisture D dry M moist W wet	consistency / relative density VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense
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Engineering Log - Cored Borehole

client: **ACT Government - Commerce and Works**

principal:

project: **Parkes Way Geotechnical Profiling**

location: **Refer to Figure 1**

Borehole ID: **BH08**

sheet: 2 of 3

project no. **GEOTFYSH09693AA**

date started: **03 Dec 2013**

date completed: **03 Dec 2013**

logged by: **SB**

checked by: **DB**

position: E: 693779; N: 6093112 (WGS84 Zone 55) surface elevation: 558.80m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer casing diameter: HW

drilling information			material substance				rock mass defects			
method & support	water	depth (m)	material description	weathering & alteration	estimated strength & Is(50)	samples, field tests & Is(50) (MPa)	defect spacing (mm)	additional observations and defect descriptions		
water	RL (m)	graphic log	ROCK TYPE: grain characteristics, colour, structure, minor components	VL, W, L, H, VH, EH	VL, W, L, H, VH, EH	a = axial diameter d = diametral	30, 100, 300, 1000, 3000	particular	general	
		1.0								
		2.0	start coring at 1.50m SILTSTONE : pale to dark-grey, distinctly bedded at 60° to 70°.	XW MW to SW			RQD= 57%	JT, 40°, IR, RO, CN Highly Fractured Zone		
		3.0				a=1.57 d=2.36	RQD= 51%	JT, 70°, UN, RO, Mg SN		
		4.0		SW to FR		a=1.80 d=5.79	RQD= 66%	CS, Clayey Sand		
		5.0				a=2.45 d=1.28	RQD= 20%	JT, 80 - 90°, UN, RO, Mg SN		
		6.0				a=2.96 d=3.87	RQD= 72%	JT, 80 - 90°, UN, RO, Mg SN		
		7.0				a=2.75 d=4.24	RQD= 69%	CS, Grey Sandy Silt		
						a=2.37 d=1.87	RQD= 71%	PT, 80°, UN, RO, Mg SN		
								CS, IR, ML Silt, 10 mm Highly Fractured Zone		
								PT, 70°, PL, RO, Mg SN		
								JT, 20°, IR, RO, Mg SN		
								PT, 70°, UN, RO, Mg SN		

Defects are: PT, 20 - 40°, UN, RO, Mg SN, unless otherwise described

method & support DT diatube AS auger screwing AD auger drilling RR roller/fricone CB claw or blade bit W washbore NMLC NMLC core (51.9 mm) NQ wireline core (47.6mm) HQ wireline core (63.5mm) PQ wireline core (85.0mm) SPT standard penetration test	water 10/10/12, water level on date shown water inflow complete drilling fluid loss partial drilling fluid loss water pressure test result (lugeons) for depth interval shown 25ul	graphic log / core recovery core recovered (graphic symbols indicate material) no core recovered core run details barrel withdrawn TCR = Total Core Recovery (%) SCR = Solid Core Recovery (%) RQD = Rock Quality Designation (%)	weathering & alteration* RS residual soil XW extremely weathered HW highly weathered DW distinctly weathered MW moderately weathered SW slightly weathered FR fresh *W replaced with A for alteration strength VL very low L low M medium H high VH very high EH extremely high	defect type PT parting JT joint SZ shear zone SS shear surface CS crushed seam SM seam DB drilling break roughness SL slickensided POL polished SO smooth RO rough VR very rough	planarity PL planar CU curved UN undulating ST stepped IR irregular coating CN clean SN stain VN veneer CO coating
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Engineering Log - Cored Borehole

Borehole ID: **BH08**
 sheet: 3 of 3
 project no: **GEOTFYSH09693AA**
 date started: **03 Dec 2013**
 date completed: **03 Dec 2013**
 logged by: **SB**
 checked by: **DB**

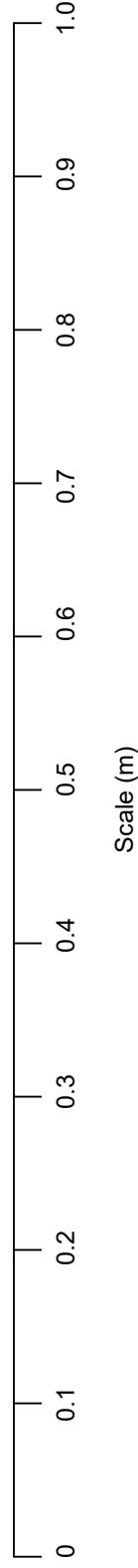
client: **ACT Government - Commerce and Works**
 principal:
 project: **Parkes Way Geotechnical Profiling**
 location: **Refer to Figure 1**


position: E: 693779; N: 6093112 (WGS84 Zone 55) surface elevation : 558.80m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

drilling information		material substance			rock mass defects			
method & support	water	depth (m)	material description	weathering & alteration	estimated strength & Is(50)	samples, field tests & Is(50) (MPa)	defect spacing (mm)	additional observations and defect descriptions
RL (m)	graphic log	ROCK TYPE: grain characteristics, colour, structure, minor components	VL	VL	a - axial	core run details	particular	general
		9.0	SILTSTONE: pale to dark-grey, distinctly bedded at 60° to 70°. (continued)	SW		a=1.38 d=0.83	RQD=71%	PT, 20°, IR, RO, CO, Grey Silt CO
		10.0				a=0.85 d=1.01	RQD=93%	JT, 20°, IR, RO, Mg SN
		11.0		FR		a=1.56 d=2.27	RQD=93%	CS, Brown Clayey Sand
		12.0	Borehole BH08 terminated at 12.00 m			a=2.27 d=1.85		

CDF_0_9_04AW.GLB Log_COF_BOREHOLE_CORED_GF9693AA_V2.GPJ <-DrawingFile> 18/12/2013 17:23


method & support DT diatube AS auger screwing AD auger drilling RR roller/fricone CB claw or blade bit W washbore NMLC NMLC core (51.9 mm) NQ wireline core (47.6mm) HQ wireline core (63.5mm) PQ wireline core (85.0mm) SPT standard penetration test	water 10/10/12, water level on date shown water inflow complete drilling fluid loss partial drilling fluid loss water pressure test result (lugeons) for depth interval shown 25ul	graphic log / core recovery core recovered (graphic symbols indicate material) no core recovered core run details barrel withdrawn TCR = Total Core Recovery (%) SCR = Solid Core Recovery (%) RQD = Rock Quality Designation (%)	weathering & alteration* RS residual soil XW extremely weathered HW highly weathered DW distinctly weathered MW moderately weathered SW slightly weathered FR fresh *W replaced with A for alteration strength VL very low L low M medium H high VH very high EH extremely high	defect type PT parting JT joint SZ shear zone SS shear surface CS crushed seam SM seam DB drilling break roughness SL slickensided POL polished SO smooth RO rough VR very rough	planarity PL planar CU curved UN undulating ST stepped IR irregular coating CN clean SN stain VN veneer CO coating
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drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013		title:	CORE PHOTO BH08: 1.5 - 6.0m
scale	NTS		project no:	GEOTFYSH09693AA
original size	A4			Photo no: 1 of 2



Scale (m)

drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013	scale	title:	CORE PHOTO BH08: 6.0 - 12.0m
original size	NTS	original size	project no:	GEOTFYSH09693AA
	A4			Photo no: 2 of 2

Engineering Log - Borehole

client: **ACT Government - Commerce and Works**

principal:

project: **Parkes Way Geotechnical Profiling**

location: **Refer to Figure 1**

Borehole ID: **BH09**

sheet: 1 of 2

project no. **GEOTFYSH09693AA**

date started: **02 Dec 2013**

date completed: **02 Dec 2013**

logged by: **SB**

checked by: **DB**

position: E: 693841; N: 6093093 (WGS84 Zone 55) surface elevation : 558.30m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

drilling information				material substance			
method & support	penetration	samples & field tests	water	RL (m)	depth (m)	material description	structure and additional observations
1	2	3				SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components	
						moisture condition	consistency / relative density
							hand penetrometer (kPa)
							100 200 300 400
				558		FILL: Sandy CLAY medium plasticity, brown, fine to coarse grained sand.	TOPSOIL
						FILL: CLAY medium plasticity, brownish-orange.	FILL
				557	1.0	CH CLAY : medium plasticity, yellowish-brown, with some fine sand.	RESIDUAL SOIL
						SILTSTONE : pale-brown, highly weathered, very low to low to medium strength.	BEDROCK
					2.0	Borehole BH09 continued as cored hole	
				556			
					3.0		
				555			
					4.0		
				554			
					5.0		
				553			
					6.0		
				552			
					7.0		
				551			

method AD auger drilling* AS auger screwing* RR roller/tricone W washbore CT cable tool HA hand auger DT diatube B blank bit V V bit T TC bit * bit shown by suffix e.g. AD/T	support M mud N nil C casing penetration water 	samples & field tests U## undisturbed sample ##mm diameter D disturbed sample B bulk disturbed sample E environmental sample HP hand penetrometer (kPa) N standard penetration test (SPT) N* SPT - sample recovered Nc SPT with solid cone VS vane shearpeak/remoulded (uncorrected kPa) R refusal	classification symbol & soil description based on Unified Classification System moisture D dry M moist W wet	consistency / relative density VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense
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Engineering Log - Cored Borehole

Borehole ID: **BH09**
 sheet: 2 of 2
 project no: **GEOTFYSH09693AA**
 date started: **02 Dec 2013**
 date completed: **02 Dec 2013**
 logged by: **SB**
 checked by: **DB**

client: **ACT Government - Commerce and Works**
 principal:
 project: **Parkes Way Geotechnical Profiling**
 location: **Refer to Figure 1**


position: E: 693841; N: 6093093 (WGS84 Zone 55) surface elevation : 558.30m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

drilling information			material substance				rock mass defects			
method & support	water	depth (m)	material description	weathering & alteration	estimated strength & Is(50)	samples, field tests & Is(50) (MPa)	defect spacing (mm)	additional observations and defect descriptions		
RL (m)	graphic log	ROCK TYPE: grain characteristics, colour, structure, minor components	VL	X	a	d	particular	general		
-558										
-557			start coring at 1.50m							
-556		2.0	SILTSTONE: pale-brown, distinctly bedded at 60° to 70°.	HW				Highly Fractured Zone		
-555		3.0	Becoming pale to dark-grey	FR		d=3.48	RQD= 67%	PT, 40°, UN, RO, Mg SN		
-554		4.0				a=4.34 d=5.04	RQD= 100%	PT, 20 - 40°, UN, RO, Mg SN		
-553		5.0				a=4.03 d=5.83		PT, 20 - 40°, UN, RO, Mg SN		
-552		6.0				a=2.65 d=8.36	RQD= 76%	PT, 20 - 40°, UN, RO, Mg SN		
-551		7.0				a=6.61 d=8.40	RQD= 100%	PT, 20 - 40°, UN, RO, Mg SN		
			Borehole BH09 terminated at 7.50 m			a=7.19 d=7.28				

CDF_0_9_04AW.GLB Log_COF_BOREHOLE_CORED_GF9693AA_V2.GPJ <-DrawingFile>> 18/12/2013 17:23

method & support DT diatube AS auger screwing AD auger drilling RR roller/fricone CB claw or blade bit W washbore NMLC NMLC core (51.9 mm) NQ wireline core (47.6mm) HQ wireline core (63.5mm) PQ wireline core (85.0mm) SPT standard penetration test	water 10/10/12, water level on date shown water inflow complete drilling fluid loss partial drilling fluid loss water pressure test result (lugcons) for depth interval shown 25uL	graphic log / core recovery core recovered (graphic symbols indicate material) no core recovered core run details barrel withdrawn TCR = Total Core Recovery (%) SCR = Solid Core Recovery (%) RQD = Rock Quality Designation (%)	weathering & alteration* RS residual soil XW extremely weathered HW highly weathered DW distinctly weathered MW moderately weathered SW slightly weathered FR fresh *W replaced with A for alteration strength VL very low L low M medium H high VH very high EH extremely high	defect type PT parting JT joint SZ shear zone DW distinctly weathered CS crushed seam SM seam DB drilling break roughness SL slickensided POL polished SO smooth RO rough VR very rough	planarity PL planar CU curved UN undulating ST stepped IR irregular coating CN clean SN stain VN veneer CO coating
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drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013		title:	CORE PHOTO BH09: 1.5 - 7.5m
scale	NTS		project no:	GEOTFYSH09693AA
original size	A4			Photo no: 1 of 1

Engineering Log - Borehole

client: **ACT Government - Commerce and Works**
 principal:
 project: **Parkes Way Geotechnical Profiling**
 location: **Refer to Figure 1**

Borehole ID: **BH10**
 sheet: 1 of 3
 project no: **GEOTFYSH09693AA**
 date started: **02 Dec 2013**
 date completed: **02 Dec 2013**
 logged by: **SB**
 checked by: **DB**

position: E: 693940; N: 6093059 (WGS84 Zone 55) surface elevation : 557.30m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

drilling information				material substance								
method & support	penetration	samples & field tests	water	RL (m)	depth (m)	graphic log	classification symbol	material description SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa)	structure and additional observations
ADV HW casing	1			557	0.0			FILL: Sandy CLAY low plasticity, dark grey, fine sand.	<Wl			TOPSOIL
	2			556	1.0			FILL: Silty CLAY low to medium plasticity, dark brownish-grey, with some fine sand, organic odour noted.	<Wp			FILL
	3	SPT 2, 2, 2 N=4		555	2.0				>Wp			
			SPT 5, 7, 8 N=15		554	3.0		CH	CLAY: medium to high plasticity, yellowish-red, some fine sand and fine angular to sub-angular gravel.	<Wp	St	
				553	4.0			SILTSTONE: pale-brown, highly weathered, very low to low strength.				BEDROCK
				553	4.0			Borehole BH10 continued as cored hole				
				552	5.0							
				551	6.0							
				550	7.0							

CDF_0_9_04AW.GLB Log_COF_BOREHOLE_NON_CORED_GF9693AA_V2.GPJ <<DrawingFile>> 18/12/2013 17:21

method AD auger drilling* AS auger screwing* RR roller/tricone W washbore CT cable tool HA hand auger DT diatube B blank bit V V bit T TC bit * bit shown by suffix e.g. AD/T	support M mud N nil C casing penetration no resistance ranging to refusal water 10-Oct-12 water level on date shown water inflow water outflow	samples & field tests U## undisturbed sample ##mm diameter D disturbed sample B bulk disturbed sample E environmental sample HP hand penetrometer (kPa) N standard penetration test (SPT) N* SPT - sample recovered Nc SPT with solid cone VS vane shearpeak/remoulded (uncorrected kPa) R refusal	classification symbol & soil description based on Unified Classification System moisture D dry M moist W wet	consistency / relative density VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense
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Engineering Log - Cored Borehole

Borehole ID: **BH10**
 sheet: 2 of 3
 project no: **GEOTFYSH09693AA**
 date started: **02 Dec 2013**
 date completed: **02 Dec 2013**
 logged by: **SB**
 checked by: **DB**

client: **ACT Government - Commerce and Works**
 principal:
 project: **Parkes Way Geotechnical Profiling**
 location: **Refer to Figure 1**

position: E: 693940; N: 6093059 (WGS84 Zone 55) surface elevation : 557.30m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

drilling information		material substance				rock mass defects		
method & support	water	depth (m)	material description ROCK TYPE: grain characteristics, colour, structure, minor components	weathering & alteration	estimated strength & Is(50) x - axial o - diametral a = axial d = diametral	samples, field tests & Is(50) (MPa)	defect spacing (mm)	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other)
		557						
		1.0						
		556						
		2.0						
		555						
		3.0						
		554						
		4.0						
		553	start coring at 4.30m					
		5.0	SILTSTONE: pale-brown, distinctly bedded at 60° to 70°	HW			RQD= 0%	Highly Fractured Zone
		552	Becoming grey	SW		a=1.36 d=1.19	RQD= 29%	PT, 60°, UN, RO, CO, Brown Clay CO CS, CH Clay, 40 mm PT, 50°, UN, RO, CO JT, 0°, PL, RO, Mg SN
		6.0	Becoming grey, yellow and brown	MW		a=1.89 d=1.87	RQD= 23%	PT, 50°, UN, RO, Mg SN CS, CH Clay, 10 mm JT, 80°, UN, RO, Mg SN
		7.0	NO CORE: 0.14 m					
		550	SILTSTONE: As described previously.	MW		a=0.28 d=0.05	RQD= 0%	Highly Fractured Zone

Defects are: PT, 20 - 40°, UN, RO, CN, unless otherwise described

CDF_0_9_04AW.GLB Log_COF_BOREHOLE_CORED_GF9693AA_V2.GPJ <-DrawingFile>> 18/12/2013 17:23

method & support DT diatube AS auger screwing AD auger drilling RR roller/fricone CB claw or blade bit W washbore NMLC NMLC core (51.9 mm) NQ wireline core (47.6mm) HQ wireline core (63.5mm) PQ wireline core (85.0mm) SPT standard penetration test	water 10/10/12, water level on date shown water inflow complete drilling fluid loss partial drilling fluid loss water pressure test result (lugcons) for depth interval shown	graphic log / core recovery core recovered (graphic symbols indicate material) no core recovered core run details barrel withdrawn TCR = Total Core Recovery (%) SCR = Solid Core Recovery (%) RQD = Rock Quality Designation (%)	weathering & alteration* RS residual soil XW extremely weathered HW highly weathered DW distinctly weathered MW moderately weathered SW slightly weathered FR fresh *W replaced with A for alteration strength VL very low L low M medium H high VH very high EH extremely high	defect type PT parting JT joint SZ shear zone SS shear surface CS crushed seam SM seam DB drilling break roughness SL slickensided POL polished SO smooth RO rough VR very rough	planarity PL planar CU curved UN undulating ST stepped IR irregular coating CN clean SN stain VN veneer CO coating
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Engineering Log - Cored Borehole

Borehole ID: **BH10**
 sheet: 3 of 3
 project no: **GEOTFYSH09693AA**
 date started: **02 Dec 2013**
 date completed: **02 Dec 2013**
 logged by: **SB**
 checked by: **DB**

client: **ACT Government - Commerce and Works**
 principal:
 project: **Parkes Way Geotechnical Profiling**
 location: **Refer to Figure 1**


position: E: 693940; N: 6093059 (WGS84 Zone 55) surface elevation : 557.30m (AHD) angle from horizontal: 90°
 drill model: Multidrill mounting: Trailer Casing Diameter : HW

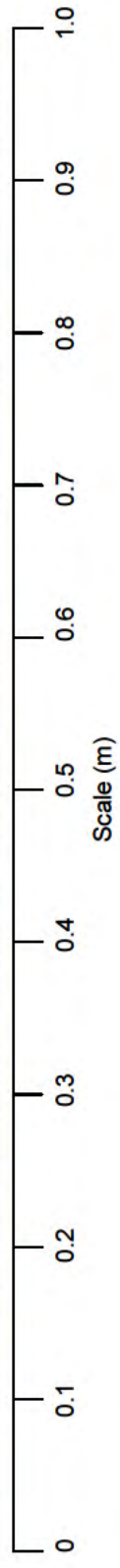
drilling information		material substance			rock mass defects			
method & support	water	depth (m)	material description ROCK TYPE: grain characteristics, colour, structure, minor components	weathering & alteration	estimated strength & Is(50) X - axial diameter O - axial diameter a - axial d - diameter	samples, field tests & Is(50) (MPa)	defect spacing (mm)	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other)
		graphic log					particular	general
		549	SILTSTONE: As described previously. (continued) NO CORE: 0.47 m	MW			RQD= 0%	PT, 30°, IR, RO, Mg SN PT, 60°, UN, RO, Mg SN
		9.0	SILTSTONE: As described previously.	MW				JT, 80°, UN, RO, Mg SN
		10.0	Becoming dark grey	SW to FR			RQD= 14%	JT, 80°, UN, RO, Mg SN PT, 50°, PL, RO, Mg SN JT, 70°, PL, RO, Mg SN
		11.0				a=3.68 d=2.08		JT, 70°, PL, RO, Mg SN PT, 50°, ST, RO, CN
		12.0				a=4.79 d=6.00	RQD= 100%	PT, 50°, IR, RO, CN
		13.0				a=2.87 d=4.03	RQD= 86%	PT, 60°, PL, RO, CN PT, 60°, IR, RO, CN PT, 50°, UN, RO, Fe Clay SN PT, 70°, PL, RO, Fe Clay SN
		14.0				a=2.44 d=4.86	RQD= 100%	PT, 50°, IR, RO, CN PT, 50°, IR, RO, Fe Clay SN
		15.0	Borehole BH10 terminated at 15.00 m			a=4.05 d=4.48	RQD= 100%	PT, 50°, PL, RO, CN


CDF_0_9_04AW/CLB Log_COF BOREHOLE CORED GF9693AA V2.GPJ <-DrawingFile>> 18/12/2013 17:23

method & support DT diatube AS auger screwing AD auger drilling RR roller/fricone CB claw or blade bit W washbore NMLC NMLC core (51.9 mm) NQ wireline core (47.6mm) HQ wireline core (63.5mm) PQ wireline core (85.0mm) SPT standard penetration test	water 10/10/12, water level on date shown water inflow complete drilling fluid loss partial drilling fluid loss water pressure test result (lugoons) for depth interval shown 25µl	graphic log / core recovery core recovered (graphic symbols indicate material) no core recovered core run details barrel withdrawn TCR = Total Core Recovery (%) SCR = Solid Core Recovery (%) RQD = Rock Quality Designation (%)	weathering & alteration* RS residual soil XW extremely weathered HW highly weathered DW distinctly weathered MW moderately weathered SW slightly weathered FR fresh *W replaced with A for alteration strength VL very low L low M medium H high VH very high EH extremely high	defect type PT parting JT joint SZ shear zone SS shear surface CS crushed seam SM seam DB drilling break roughness SL slickensided POL polished SO smooth RO rough VR very rough	planarity PL planar CU curved UN undulating ST stepped IR irregular coating CN clean SN stain VN veneer CO coating
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drawn	SB		client:	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013		title:	CORE PHOTO BH10: 4.3 - 9.0m
scale	NTS		project no:	GEOTFYSH09693AA
original size	A4			Photo no: 1 of 2



drawn	SB		client	ACT Government – Commerce and Works
approved	DB		project:	Parkes Way Geotechnical Profiling
date	17/12/2013		title:	CORE PHOTO BH10: 9.0 - 15.0m
scale	NTS		project no:	GEOTFYSH09693AA
original size	A4			Photo no: 2 of 2



LEGEND

- BOREHOLE LOCATION
- RAPID SEISMIC REFRACTION (RSR) TRACK PLOT
- RAPID SEISMIC SHEAR-WAVE TESTING (RSST) LINE

AERIAL IMAGE SOURCE: GOOGLE EARTH PRO 6.0.2
 AERIAL IMAGE ©: WHEREIS © SENSIS PTY LTD 2013, DIGITALGLOBE 2013

no.	description	drawn	approved	date

client:	ACT GOVERNMENT SHARED SERVICES
project:	PARKES WAY GEOTECHNICAL PROFILING PARKES WAY, PARKES, ACT
title:	GEOPHYSICAL INVESTIGATION LOCATION PLAN
project no:	GEOTFYSH09693AA
figure no:	FIGURE 1
rev:	A

drawn	PH / LH
approved	DB
date	19 / 12 / 13
scale	1:3000
original size	A3

 Scale (metres) 1:3000	
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APPENDIX D HYDROGEOLOGY ASSESSMENT



Parkes Way Upgrade

Groundwater Investigation Report

Prepared for: ACT Government - Commerce and
Works for The Economic Development Directorate
Date: 1 April 2014



DOCUMENT CONTROL

Title	Parkes Way Groundwater Investigation Report			
Prepared for	Client			
Project Ref	30012385			
	Name	Position	Signed/Approved	Date
Originator	Sch 2.2(a)(ii)	Hydrogeologist		
Review	Sch 2.2(a)(ii)	Senior Hydrogeologist		
Approval	Sch 2.2(a)(ii)	Project Manager		

Details of Revisions

Rev	Date	Description	Approved
0	31/03/2014	Parkes Way Groundwater Investigation Report	01/04/2014

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1.2 Objectives	5
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APPENDICES

APPENDIX A: SLUG TEST REPORTS

APPENDIX B: COC AND LABORATORY REPORT

DISCLAIMER

The information within this document is and shall remain the property of SMEC Australia Pty Ltd. This report has been prepared for ACT Government - Commerce and Works for The Economic Development Directorate in accordance with the terms and conditions of appointment for Hydrogeological Services. SMEC Australia Pty Ltd and its servants, employees and officers otherwise expressly disclaim responsibility to any person other than ACT Government - Commerce and Works for The Economic Development Directorate arising from or in connection with this Report. To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by SMEC and the Report are excluded unless they are expressly stated to apply in this Report.

1. INTRODUCTION

1.1 Background

SMEC Australia Pty Ltd (SMEC) is undertaking a design review for the upgrade of Parkes Way, ACT. The proposed design is to lower the current road level by up to 8m between Coranderrk St and Edinburgh Ave in order to extend the parklands from Civic to Lake Burley Griffin. Groundwater levels provided in the Coffey Geotechnics Report Dated 13th January 2014 (GEOTFYSH09693AA-AE) in ten monitoring bores have been recorded at between 3.1m and 7.2m below ground level. These groundwater levels are several meters lower than the water level recorded for Lake Burley Griffin and vary significantly along the alignment. SMEC consider these groundwater levels to be unusual given the close proximity to the Lake but may be explained by dewatering activities from deep building basements in Civic near the alignment and possible disconnect between the lake and the groundwater table. Therefore SMEC undertook a groundwater investigation program.

1.2 Objectives

The objective of the groundwater investigation program was to assess the condition of the monitoring bores, monitor groundwater levels, undertake hydraulic testing, collect groundwater samples and undertake analytical groundwater modelling.

The purpose of this investigation is to assess;

- the permeability of the formation,
- inflows to the excavation; and
- long term impacts of the alignment design on groundwater system.

1.3 Scope of Works

This report covers the following Scope of Works (SoW):

- measurement of the standing water level in all bores;
- cleaning / development of monitoring bores;
- hydraulic permeability testing;
- collection of water quality samples and laboratory analysis;
- download of data loggers;
- analytical groundwater modelling; and
- reporting.

1.4 Limitations

This report was prepared taking due care and with the usual thoroughness of the consulting profession. All information provided in this report was considered valid and up to date at the time of reporting. This report presents the groundwater level monitoring and rainfall data collected between 26th February 2014 and 14th March 2014 3rd. The assessment is based on the data collected from the installed monitoring bores only and rainfall records provided by the Bureau of Meteorology.

2. FIELD INVESTIGATION

Fieldwork along the Parkes Way alignment was undertaken by SMEC personnel on the following dates:

- 25th to 26th February 2014;
- 5th to 6th March 2014;
- 10th to 11th March 2014; and
- 14th March 2014.

During each site visit the groundwater level was measured using an electronic dip meter and recorded to the top of the PVC casing.

2.1 Site Visit 1 - 25th to 26th February 2014

The groundwater level and monitoring bore total depth (Table 2.1) was recorded for each monitoring bore prior to development and installation of electronic pressure transducer data loggers. The monitoring bore total depth was found to be shallower than the total depth recorded in the Coffey Report for most bores.

TABLE 2-2-1 - MEASURED GROUNDWATER LEVEL AND BOREHOLE DETAILS

Bore ID	SWL (mTOC)	Total Depth (TOCm)	Total Depth from Coffey Report (m)	Total Depth After Development (mTOC)	Screened Lithology (from Coffey Report)
BH01	6.73	8.62	13.5	13.26	Siltstone
BH02	3.71	9.57	13	12.88	Siltstone
BH03	3.09	10.48	11.7	11.55	Fill/Siltstone
BH04	5.81	10.87	13.5	13.29	Siltstone
BH05	7.51	9.72	13.5	13.31	Siltstone
BH06	7.85	12.43	15	14.99	Siltstone
BH07	5.95	10.6	13.5	13.29	Siltstone
BH08	5.31	11.25	12	11.8	Siltstone
BH09	5.11	6.57	7.5	-	Fill/Siltstone
BH10	4.65	14.77	15	14.8	Siltstone

SWL – Standing Water Level, mTOC – meters to top of casing

The development method involved an air compressor and tremeline which was placed down the monitoring bore to the base of the hole. Air was used to blow out the water and drilling mud from the borehole and filter pack. When the air compressor was first turned on SMEC personnel were able to push the tremeline line further down the borehole through hard blockages. This resulted in thick mud and drill cuttings being brought to the

surface. Potable water was added to the borehole to assist in the cleaning when formation water ran out.

Due to the un-anticipated large volumes of thick mud and drill cuttings and low water make of the bores, lots of water was required to continue with the cleaning. The following observations were made during development:

- BH1: red orange thick mud, water added. Borehole not fully clean;
- BH2: silty yellow thick mud with drill cuttings. Borehole not fully clean;
- BH3: dark green rock chips/ drill cuttings coming to surface, lots of water added but not much surface return of water. Borehole not fully clean;
- BH4: yellow silty thick mud, water added and after 10mins appears to be less thick. Borehole not fully clean;
- BH5: yellow mud, water added. Noted air bubbling up the inside annulus, borehole not fully clean;
- BH6: orange brown silty thick mud with some drill cuttings, water added several times. Borehole not fully clean;
- BH7: yellow silty thick mud, water added. Noted air bubbles coming up the inside annulus. Borehole not fully clean;
- BH8: silty grey green mud, water added. After 10mins became slightly lighter and less cloudy;
- BH9: grey silty mud, low yielding bore. Second cleaning attempt added water, borehole not fully clean; and
- BH10: brown silty water for first 10mins then became orange brown and less cloudy. Moderate yield, no water added, starting to become clean.

For each borehole the recovery of the water level was recorded using an electronic dip meter for up to 10 minutes before the data loggers were installed. The loggers were set to record at 10 minute intervals. All monitoring bores, with the exception of BH10, were blown dry for the recovery test.

During this site visit it was not practical to sufficiently clean all the monitoring boreholes.

2.2 Site Visit 2 - 5th to 6th March 2014

SMEC personnel attended site to measure the groundwater level and download the data loggers to assess the length of recovery time required for sampling. In addition further cleaning, using a wattera foot valve and tubing was undertaken on BH1, BH2, BH3, BH4, BH5 and BH6. In these boreholes the foot valve was used to purge the bore dry and remove more drilling mud. Additional water was added in some cases. The measured groundwater levels and observations are presented in Table 2-2.

TABLE 2-2-2 - MEASURED GROUNDWATER LEVEL AND OBSERVATION

Bore ID	SWL (mTOC)	Observations
BH01	6.73	Cloudy water, fast recovery of water level
BH02	3.48	Cloudy water, fast recovery of water level
BH03	3.10	Still very muddy, fast recovery of water level
BH04	6.29	Still muddy, logger showed one week recovery of water level from previous development
BH05	7.52	Logger showed 3 days recovery of water level from previous development
BH06	7.86	Still very muddy
BH07	6.02	Fast recovery of water level
BH08	5.42	Fast recovery of water level
BH09	6.37	Groudwater level appears not to have recovered to fully cover the data logger
BH10	4.71	Fast recovery of water level

2.3 Site Visit 3 - 10th to 11th March 2014

SMEC personnel attended site to undertake further development and cleaning of the monitoring boreholes, recovery testing and download of data loggers. An air compressor and tremeline, with the addition of water, was used. The boreholes were air lifted until the water became less cloudy or clean and then, if possible, blown dry and the data loggers installed. Data loggers were set to record at 1 minute intervals. The following observations were made during development:

- BH01: groundwater was cloudy, water added. Air lifted until clearer then blown dry;
- BH02: groundwater was cloudy, water added. Air lifted until clearer then blown dry with water observed at 12.73mTOC one minute later;
- BH03: no recovery test or further cleaning was undertaken as this monitoring bore is screened across the fill/rock interface and not suitable for assessment. The data logger was removed and downloaded;
- BH04: thick mud at the start of development with air observed bubbling up the annulus. Water added and cleaning for over 1 hour before becoming cloudy;
- BH05: cloudy muddy water at the start of development, water added. Air bubbles notes inside the annulus. Became less cloudy after 1 hour, blown dry;
- BH06: thick tan coloured mud, water added repeatedly. After 2 hours, still producing mud, borehole not fully clean;
- BH07: cloudy water with air bubbles noted in the annulus. Groundwater recharge observed, no water added. Became clear to slightly cloudy and difficult to blow dry.

Air lift for 20 minutes with flow rate approximately 500mL in 11 seconds to 15 seconds;

- BH08: cloudy tan coloured water with occasional clear flows at start. Became less cloudy after 5 minutes and clear after 15 minutes. Groundwater recharge observed, no water added. Air lifted for 20 minutes with flow rate approximately 500mL in 11 seconds;
- BH09: no recovery test or further cleaning was undertaken as this monitoring bore is screened across the fill/rock interface and not suitable for assessment. The data logger was removed and downloaded; and
- BH10: cloudy tan coloured water at start, becoming clear after 10 minutes. Groundwater recharge observed, no water added. Air lifted for 20 minutes with flow rate approximately 500mL in 8 seconds.

2.4 Site Visit 4 - 14th March 2014

SMEC personnel attended site to measure groundwater levels, collect groundwater quality samples and removed data loggers. The measured groundwater levels are shown in Table 2-3.

Groundwater samples were collected from the following boreholes; BH01, BH02, BH05, BH06, BH08 and BH10. A duplicate sample (QC1) was collected from BH10. The samples were sent to ALS Canberra, a Nata accredited laboratory under Chain of Custody (COC) procedures and analysed for the following analytes:

- Physical: pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS);
- Major Anions and Cations: Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate, Ammonia, Bicarbonate;
- Dissolved Metals: Arsenic, Chromium, Cadmium, Nickel, Copper, Lead, Zinc, Mercury, Iron, Manganese;
- Total Metals: Iron, Manganese;
- Total Petroleum Hydrocarbons (TPH); and
- Nutrients: Total Phosphorous, Total Nitrogen, Nitrate and Nitrite.

TABLE 2-3 - MEASURED GROUNDWATER LEVEL

Bore ID	SWL (mTOC)
BH01	6.74
BH02	3.49
BH03	3.09
BH04	9.05
BH05	7.70
BH06	7.90
BH07	6.02
BH08	5.46
BH09	6.13
BH10	4.76

2.5 Borehole Survey

LANDdata Surveys undertook a survey of the monitoring borehole locations and elevations on the 24th March 2014. The results are presented in Table 2-4. SMEC assumes the Top of Bore represents the top of the PVC pipe.

TABLE 2-4 - LANDDATA SURVEY RESULTS

Bore ID	Easting (ACT MGA)	Northing (ACT MGA)	Top of Bore (mAHD)	Ground Surface (mAHD)
BH01	210269.50	603383.80	558.33	558.42
BH02	210327.79	603379.13	558.61	558.72
BH03	210419.25	603372.05	558.97	559.06
BH04	210525.08	603361.94	559.30	559.40
BH05	210617.84	603352.84	559.76	559.84
BH06	210729.03	603338.98	559.93	560.02
BH07	210878.01	603309.60	559.09	559.19
BH08	210942.94	603294.62	558.87	558.93
BH09	211008.50	603274.34	558.35	558.44
BH10	211104.22	603247.48	557.27	557.36

3. MONITORING AND SAMPLING RESULTS

3.1 Water Levels

The groundwater level was measured using an electronic dip meter to the top of the PVC casing (designated the measuring point). The results for the manual measurements and survey data are summarised in Table 3-1.

TABLE 3-1 - MANUAL MEASUREMENTS FOR 2014

DATE	BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09	BH10
PVC mAHD	558.33	558.61	558.97	559.30	559.76	559.93	559.09	558.87	558.35	557.27
mTOC										
25/02/14	6.73	3.71	3.09	5.81	7.51	7.85	5.95	5.31	5.11	4.65
6/03/14	6.73	3.48	3.10	6.29	7.52	7.86	6.02	5.42	6.37	4.71
10/03/14	6.73	3.48		7.65						
11/03/14			3.10		7.52	7.85	6.06	5.47	6.40	4.74
14/03/14	6.74	3.49	3.09	9.05	7.70	7.90	6.02	5.46	6.13	4.76
mAHD										
25/02/14	551.6	554.90	555.88	553.49	552.25	552.08	553.14	553.56	553.24	552.62
6/03/14	551.6	555.13	555.87	553.01	552.24	552.07	553.07	553.45	551.98	552.56
10/03/14	551.6	555.13		551.65						
11/03/14			555.87		552.24	552.08	553.03	553.40	551.95	553.53
14/03/14	551.58	555.12	555.88	550.25	552.05	552.02	553.07	553.41	552.22	552.51

Groundwater hydrographs for the monitoring bores with data loggers are shown on Figure 1. The groundwater levels in general have remained relatively stable over the period of the investigation, with the exception of BH04.

The variations in groundwater level, slow recovery, as indicated on the hydrograph (Figure 5), and presence of mud during each development suggest the filter pack around the screen may still be partially blocked. Minor rainfall events do not appear to correspond with any significant changes in groundwater level. All groundwater levels are below the level of Lake Burley Griffin (555.93mAHD), with the exception of BH03, BH02. As BH03 is screened across the fill/rock interface this groundwater level is not considered to be representative of the regional bedrock aquifer and may impact the result for BH02. In addition BH09 is also screened across the fill / residual material interface.

The groundwater flow direction appears to be towards the north, i.e. Civic. Numerous multi-story car park basements surrounding the alignment may be having an influence on the gradient, however the depth of most of these basements, excluding Canberra Casino and Palace Complex on Phillip Law St, are above the groundwater levels of the monitoring bores.

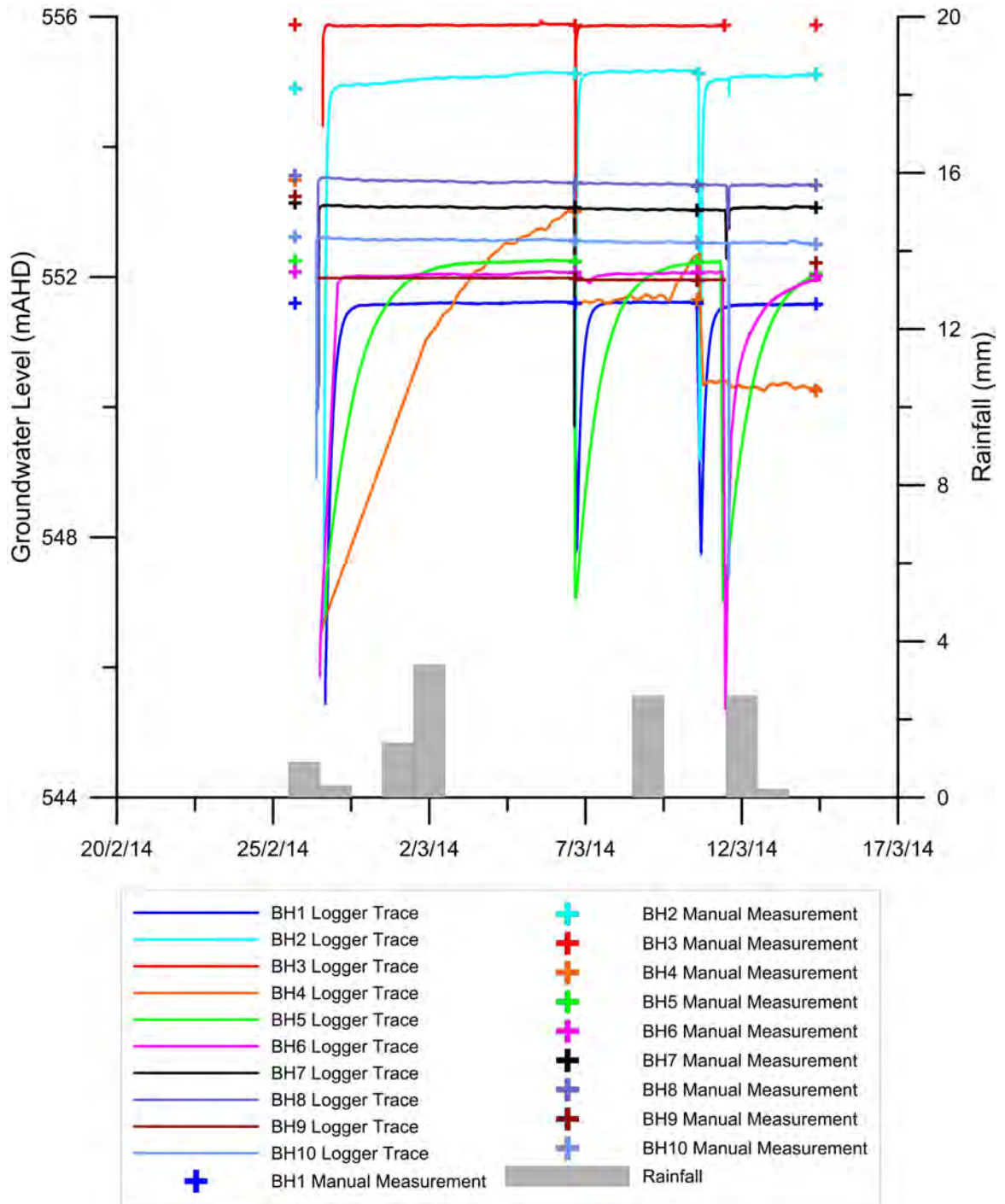


Figure 1: Groundwater Hydrographs

3.2 Hydraulic Permeability

Recovery tests were performed on nine of the ten monitoring bores using the air compressor and wattera foot valve to remove the groundwater (i.e. blow dry) where possible and then the groundwater level recovery was measured. The measured recovery, via electronic dip meter and data logger, was input into AQTESLOV Pro and assessed as a slug test. In essence the removal of groundwater was considered to be instantaneous and thus a rising head test could be performed. The aquifer model is considered to be unconfined and the solution applied was Hvorslev. Well data was determined from the construction details supplied in the Coffey Geotechnics Report and measured manual water levels. Table 3-2 shows the range of permeability (K) for each borehole. Refer to Appendix A for AQTESLOV slug test output files.

TABLE 3-2 - HYDRAULIC PERMEABILITY SLUG TEST RESULTS

Bore ID	Permeability Test 1 (m/day)	Permeability Test 2 (m/day)	Permeability Test 3 (m/day)
BH01	0.0008	0.001	0.001
BH02	0.002	0.003	0.003
BH03	0.004	0.003	-
BH04	0.00006	-	-
BH05	0.0001	0.0002	0.0002
BH06	0.001	0.0003	-
BH07	0.089	0.089	-
BH08	0.060	0.089	-
BH09	-	-	-
BH10	0.089	0.089	-

The results of the hydraulic permeability show values with several orders of magnitude difference. Boreholes which were very muddy and continued to produce mud, such as BH04, BH05 and BH06, have the lowest permeability. This may reflect the extremely weathered nature of the rock in which they are screened, leading to very fine drill cuttings clogging the filter pack.

Boreholes BH07, BH08 and BH10 have the highest permeability, as well as groundwater recharge which allowed for air lifting and considerable cleaning of the bores. These boreholes likely represent the permeability of the less weathered siltstone.

BH01, BH02 and BH03 have permeability results on the same order of magnitude, excluding Test 1 of BH01, and likely represent the permeability of the more weathered siltstone

For the assessment of groundwater inflows into the excavation the permeability may be considered as low and ranges from 0.1 to 0.0001m/day with an average of 0.003m/day.

3.3 Groundwater Chemistry

3.3.1 Laboratory Analysis Results

The groundwater samples were sent to ALS in Canberra a NATA accredited laboratory under Chain of Custody (COC) conditions in chilled eskies and within the required analyte holding times. The laboratory reports and COC forms are provided in Appendix D. A duplicate sample was collected from BH10. The results of the duplicate sample are within the required relative percentage difference of less than 30% to 50% and comply with SMEC Quality Assurance Quality Control procedures. The quality results of selected analytes are summarised in Table 3-3. Refer to Appendix B for COC and laboratory reports.

TABLE 3-3 - LABORATORY RESULTS OF SELECTED ANALYTES FOR MARCH 2014

Analyte	Units	BH01	BH02	BH05	BH07	BH08	BH10
pH	pH unit	7.62	7.74	7.77	7.75	7.89	7.76
EC	µS/cm	2470	1070	1230	875	966	861
TDS	mg/L	1500	629	740	543	585	517
Chloride	mg/L	456	101	224	75.9	97.1	57.9
Sulphate	mg/L	170	41.3	87	62.6	69.6	21.7
Fluoride	mg/L	1	1.3	1.6	0.4	0.7	0.4
Dissolved Heavy Metals							
Cadmium	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.003	<0.002	0.003	0.002	<0.002	<0.002
Lead	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.058	0.012	0.08	0.045	0.014	0.077
Total Metals							
Iron	mg/L	4.05	2.1	12.1	6.66	6.95	8.66
Manganese	mg/L	1.30	0.248	1.43	0.192	0.186	0.526
Nutrients							
Total Nitrogen	mg/L	2.53	3.37	0.88	2.27	1.56	0.34
Total Phosphorus	mg/L	0.08	0.11	0.62	0.18	0.13	0.14
Total Petroleum Hydrocarbons							
C6-C9	µg/L	<20	<20	<20	<20	<20	<20
C10-C14	µg/L	<50	<50	<50	<50	<50	<50
C15-C28	µg/L	<100	<100	<100	<100	<100	<100
C29-C36	µg/L	<50	<50	<50	<50	<50	<50
C10-C36 Sum	µg/L	<50	<50	<50	<50	<50	<50

3.3.2 Groundwater Quality Assessment

This section discusses any high level results which could suggest un-natural contamination. No odour or hydrocarbon sheen was observed during the development or sampling of the monitoring boreholes. TPH was not detected and the levels of heavy metals reflect the geology and are considered natural.

The following criteria may be considered as guidelines for EPA requirements for the upper limit of water quality for discharge to Lake Burley Griffin for key analytes. These are levels obtained from the current lake water quality (as outlined in Lake Burley Griffin Water Quality Management Plan 2011

http://www.nationalcapital.gov.au/index.php?option=com_content&view=article&id=2187&Itemid=852&limitstart=7) and SMEC's previous project experience where groundwater from dewatering activities was discharged under EPA permit to the lake.

- Total Suspended Solids: 40mg/L in East Basin, 20mg/L in West Lake
- Total Phosphorus of 0.06mg/L
- Total Nitrogen of 1.4mg/L in East Basin and 1.0mg/L in West Lake
- pH range of 6.5 to 8.5
- TPH: 300ug/L

Note these levels are indicative only; an EPA discharge licence may have higher or lower limits and could include other parameters not listed above. These are provided as an indication of the current groundwater quality compared to the lake.

The groundwater quality results show the monitoring bores exceed the Lake Burley Griffin guidelines for Total Phosphorus and Total Nitrogen (excluding BH05 and BH10 for Total Nitrogen). No hydrocarbon contamination was observed during sampling or in the laboratory results. Should dewatering require discharge to the lake some treatment of the water may be required unless EPA licence conditions have different levels.

4. GROUNDWATER ANALYTICAL MODELLING

Anaqsim (Analytic Aquifer Simulator) is an analytical element modelling tool that allows a fast assessment of the groundwater regime and the potential impacts of definable activities on water table.

A simple one-layer Anaqsim model was developed based on the available information to:

- simulate the existing local groundwater conditions;
- assess the potential groundwater inflow during excavation activities; and
- simulate the draw-down in a post-construction scenario.

4.1 Model Design and Assumptions

In the absence of a comprehensive conceptual hydrogeological model, several assumptions were made during the design process. These assumptions have been made based on the data and information available, which present many gaps and inconsistencies.

The information collected from the site, including the bore water levels, an estimation of basement levels and their positions relative to the groundwater table, as well as Lake Burley Griffin's stage, do not offer a consistent picture of the local groundwater flow patterns.

While Lake Burley Griffin sits at approximately 556.0 mAHD, all bores read the water table lower than that level (with the exception of BH03, which is screened across the fill/rock interface and hence this groundwater level is not considered a representative measurement). This suggests a flow direction towards the bores (north) from the lake. However, the basements -further north relative to the location of the bores- circumstantially point to groundwater levels higher than those measured in bores (indicating a gradient toward the lake).

A possible disconnect between the lake and the aquifer by an impermeable formation might explain this contradiction. Unreliable data recorded from the bores is another possibility that could be attributed to bore construction defects. In the absence of any other credible groundwater table data, away from the road line -where all the bores are located-, it is exceedingly difficult to determine the nature of the hydrogeological regime in this locale. Therefore, the existing hydrogeological conditions have been simulated to fit the available data. All the available information point to a slight gradient from west to east and from both the lake (south) and the basements (north) to the bores (in the mid-section of the model domain).

This model assumes a single layer for the model with an approximate thickness of 12 meters. This layer is isotropic, and the vertical hydraulic conductivity (K_v) is one tenth of the horizontal hydraulic conductivity (K_h).

All permeability values are based on recent field measurements that can be seen in Table 3-2. After eliminating the seemingly unreliable bore data, an average value of 0.003 m/d was used for parameterization of this model.

Two types of boundaries have been used in this model. The southernmost boundary represents the lake and has been set as a head-specific boundary with the value of 555.93 mAHD. The northern boundary is an arbitrary boundary with a calibrated flux to simulate the lateral groundwater flow in order to simulate the available data on the groundwater table.

4.2 Existing Groundwater Conditions

The analytical element model was manually calibrated to simulate the heads observed at each bore location. In this model, the head values at the bore locations have been set to the values of the field-recorded data through setting a series of head-specific bores. The existing water table is shown on Figure 2.



Figure 2: Existing groundwater table contours

These contours will be used as initial values for the future draw-down estimations, in the post-construction scenario.

While the lack of information and data makes it difficult to verify the water levels across the model domain, simulated groundwater levels match the observed data at bore locations. It is, therefore, assumed that the local impact of proposed construction may be estimated with an acceptable level of accuracy in terms of inflows and local draw-downs. It is important to note that any additional data point might impact the gradient assumed for this scenario and hence the inflows will be affected subsequently.

It is strongly recommended that more data be collected in a spatial context before any decision is made.

4.3 Post-Construction Groundwater Conditions

Based on the long-section and cross-section drawings provided for the ramp/tunnel design, new head-specific values were imposed on the bores in the model.

The immediate impact observed is a local draw-down around each bore (Figure 3). Note that the depression cones seen around each bore is an artefact of model design and will be less localised during construction.

The extraction of groundwater at the bores has resulted in a steeper gradient in the western side of the domain. This predicts a higher lateral flow of groundwater during dewatering and/or construction.



Figure 3: Post-construction groundwater table contours

Local draw-down is limited to 1.3 meters. This is an expected result, provided that all the previously mentioned assumptions hold. Groundwater table is highest at BH01 where the excavation is minimal for the construction of the entrance ramp. BH03 to BH08 were expected, and do indeed show the more severe draw-downs as the average depth of the proposed excavation intersect the water table. The deepest intersection of the water table is approximately 3.4 meters (at BH03) followed by 3.1 meters (at BH04). The rest of the bore locations experience minimal or no intersection. The spatial extension of draw-down effect is also very limited.

4.4 Inflow Assessment

To maintain the water table at the desirable level (8m below ground) a continuous flow is estimated to be extracted from each bore. Note that the water table will not be intersected at BH01 and BH10. Table 4-1 lists discharge values estimated for each bore as well as a total daily discharge rate. The estimated inflow is steady state long term as would be expected after the excavation had been open for several weeks. Initial inflows during excavation may be an order of magnitude higher. Should the groundwater system be connected to Lake Burley Griffin then higher inflows may also be expected.

TABLE 4-1 - MODELLED DISCHARGE RATES AT EACH BORE

Bore ID	Discharges of head-specific wells (m ³ /d)
BH01:	0.0
BH02:	0.02
BH03:	0.05
BH04:	0.05
BH05:	0.04
BH06:	0.04
BH07:	0.04
BH08:	0.04
BH09:	0.03
BH10:	0.0
Total inflow	-0.4

A polyline has been super-imposed on the model domain that closely follows the line of the bore locations (Figure 4) called the "discharge line". This line is approximately 1 km long and starts from BH01. Discharge along this line is graphed on Figure 5. Where discharge is positive, no pumping is required; where discharge is negative pumping is required.



Figure 4: Discharge Line Location

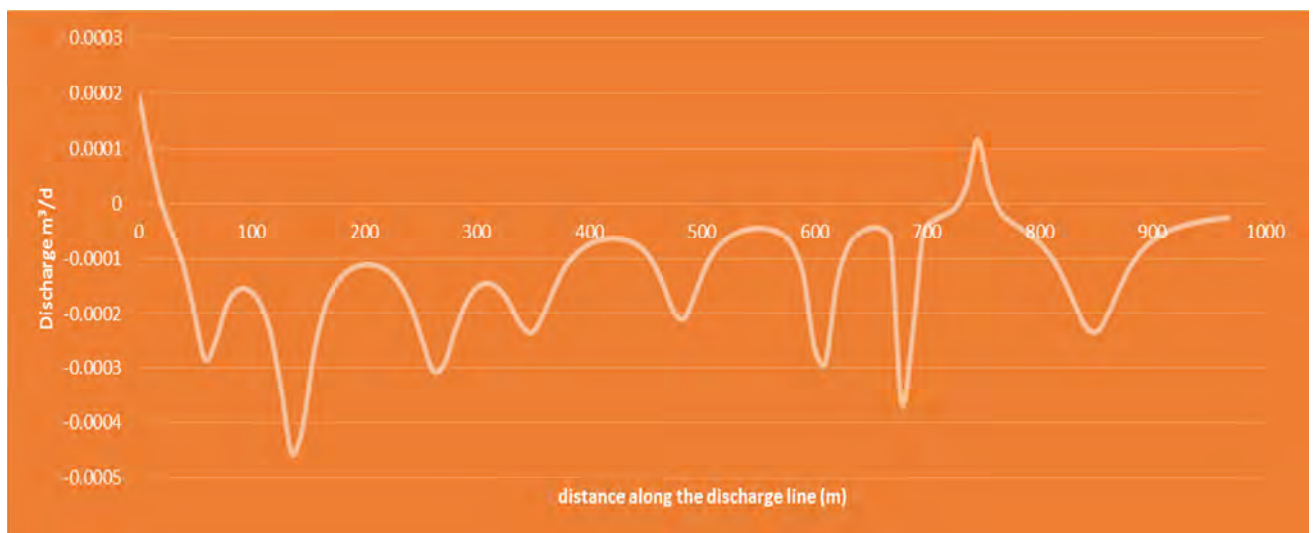


Figure 5: Discharge graph along the discharge line

5. DISCUSSION

The groundwater conceptual model carries high levels of uncertainty as there is very limited information on groundwater levels surrounding the alignment. The monitoring bores installed along the alignment were exceptionally muddy and several rounds of cleaning were required before hydraulic conductivity testing could be undertaken with any certainty.

The permeability of the bedrock is low, ranging from 0.0001m/day to 0.1m/day and inflows are expected to be low in the order of 1 m³/day are anticipated into the excavation.

Whilst there are numerous car park basements north of the alignment it is not known whether these are currently dewatering and whether or not they are below the groundwater table. Evidence of water seepage was observed in several of the deeper basements indicating they may be close to the groundwater table. Impacts from the excavation may reach the basements closest to BH01 to BH03.

Based on the modelling there may be a 0.5m increase in average groundwater level in this area, assuming the basements are not actively dewatering.

Groundwater sample analysis shows no evidence of hydrocarbon contamination and the quality of the water in general may be suitable for discharge to Lake Burley Griffin (under an approved EPA licence). Treatment of water before discharge would be dependent on license conditions, however total phosphorous and nitrogen exceed the Lake Burley Griffin guideline value. Additional sampling and a broader analysis suite may be required by the EPA as part of any licence conditions.

Dewatering Requirements:

Under the provided set of assumption, inflows to the excavation will be small (< 1m³/day or 0.001 L/sec).

Inflows to the excavation may be controlled by either:

- conventional dewatering systems consisting of dewatering bores down each side of the excavation; or
- a series of sumps in the excavation.

A network with pumping bores could result in rapid drawdown of enough magnitude to minimise/stop the inflows into the excavation during construction. However this method would require installation of at least 20 dewatering bores to a depth of around 12m around the perimeter of the excavation.

The use of sump and pump methods for control of groundwater inflows may not allow sufficient dewatering of the base of the excavation and subsequent traffic ability issues.

Note should the excavation be deeper than modelled or structures intercepted of high permeability the inflow to the excavation may be higher.

6. CONCLUSION AND RECOMMENDATIONS

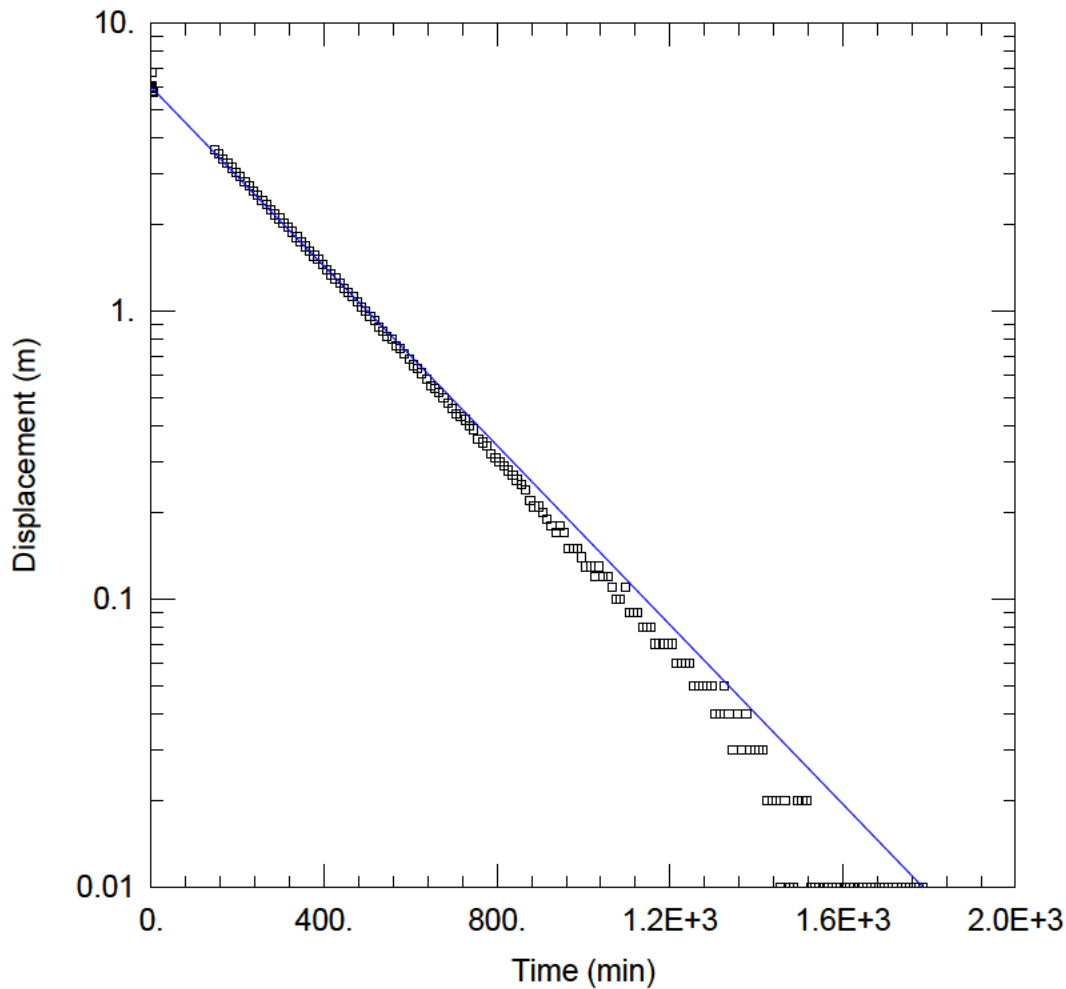
The following conclusions are drawn from the assessment:

- The estimated inflows heavily reflect the assumed gradient of the groundwater in the model domain and will be significantly impacted by any change to the assumed regime;
- groundwater quality is suitable for discharge to Lake Burley Griffin with the exception of Total Phosphorous and Nitrogen;
- The drawdown will be conveniently localised and no permanent adverse impact is expected as a result of the drawdown; and
- Groundwater inflows are anticipated to be around 1m³/day and may be controlled by sump and pump or a conventional dewatering network.

Recommendations:

- information on the water table elevation surrounding the site should be gathered to assess the assumed groundwater gradient and elevation;
- should additional data indicate conditions which are different from that assumed in this report then the modelling should be reassessed; and
- if dewatering via a conventional system be adopted additional modelling to design the system should be undertaken to optimise any installed system.

APPENDIX A: HYDRAULIC CONDUCTIVITY ANALYSIS RESULTS



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\BH1 test 1.aqt
 Date: 03/14/14 Time: 11:06:34

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH01
 Test Date: 26/02/2014

AQUIFER DATA

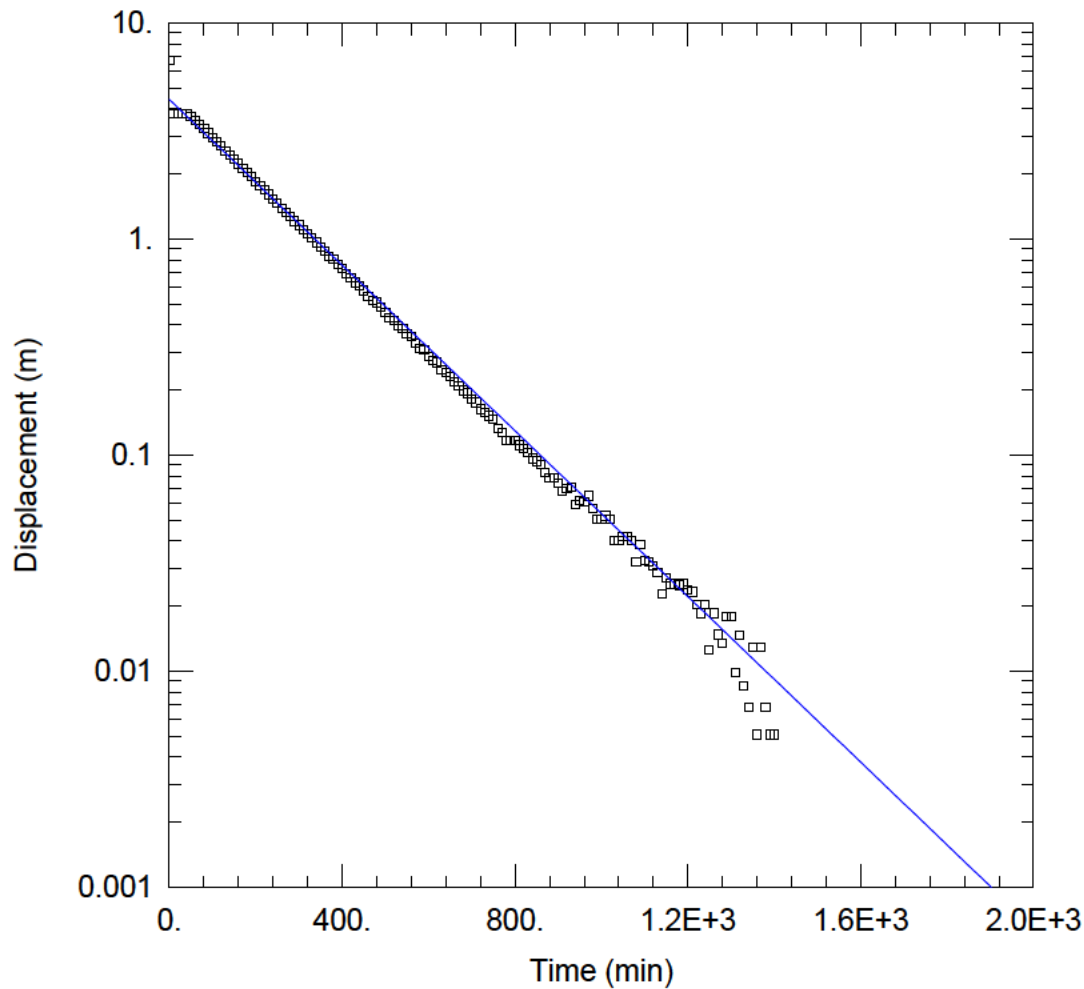
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH1)

Initial Displacement: 6.76 m Static Water Column Height: 6.75 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.0008536 m/day y0 = 5.991 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH1 test 2.aqt
 Date: 03/17/14 Time: 15:42:15

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH01
 Test Date: 6/03/2014

AQUIFER DATA

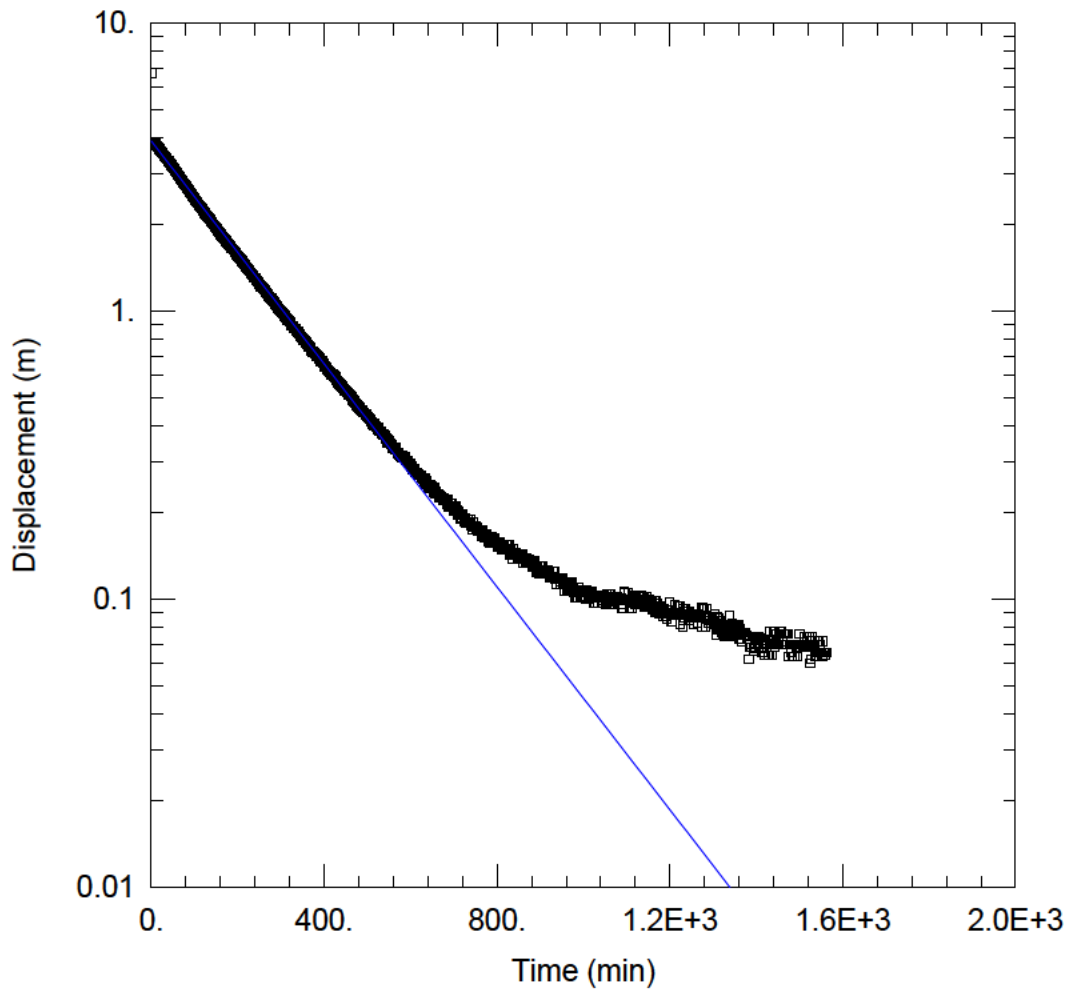
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH1)

Initial Displacement: 6.73 m Static Water Column Height: 6.75 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.001052 m/day y0 = 4.43 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH1 test 3.aqt
 Date: 03/17/14 Time: 15:45:10

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH01
 Test Date: 11/03/2014

AQUIFER DATA

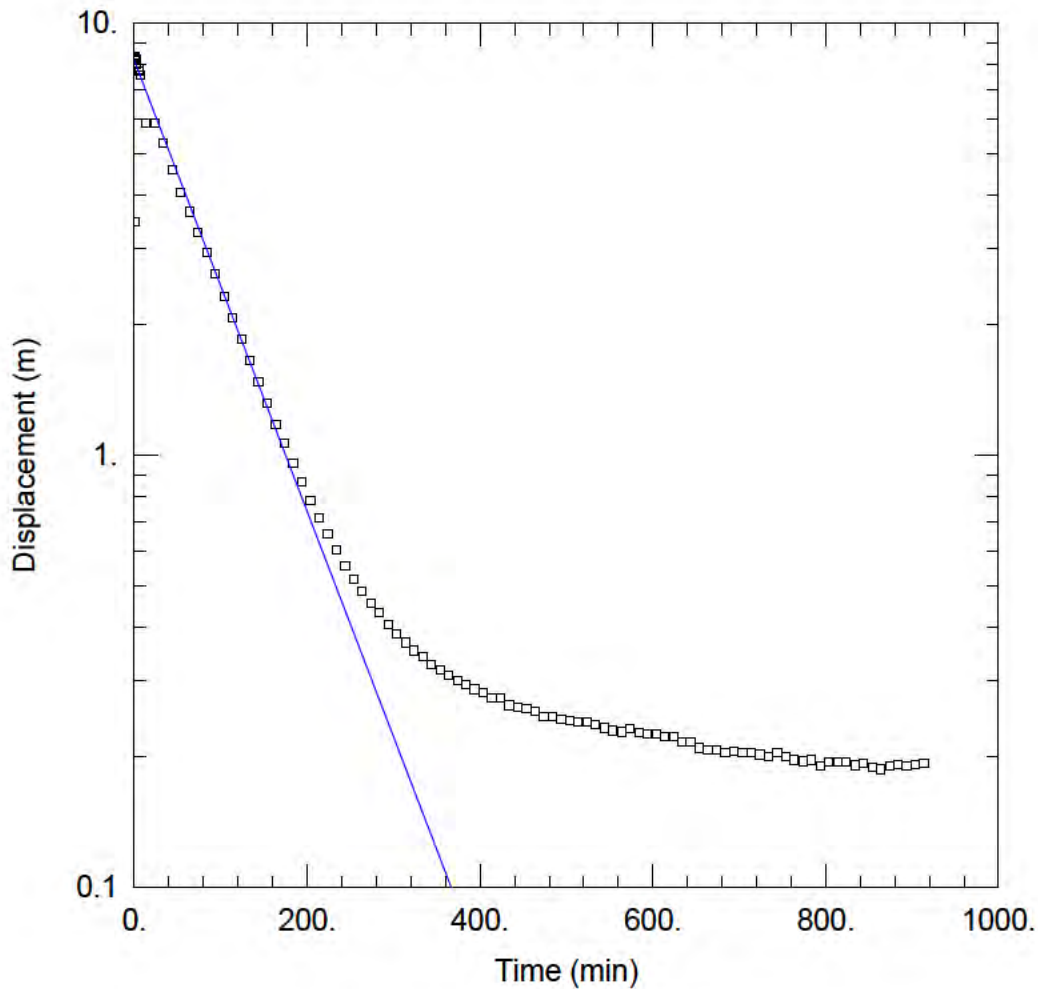
Saturated Thickness: 10. m Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH1)

Initial Displacement: 6.7 m Static Water Column Height: 6.75 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 $K = 0.001062$ m/day $y_0 = 3.896$ m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH2 test 1.aqt
 Date: 03/18/14 Time: 14:38:34

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH02
 Test Date: 26/02/2014

AQUIFER DATA

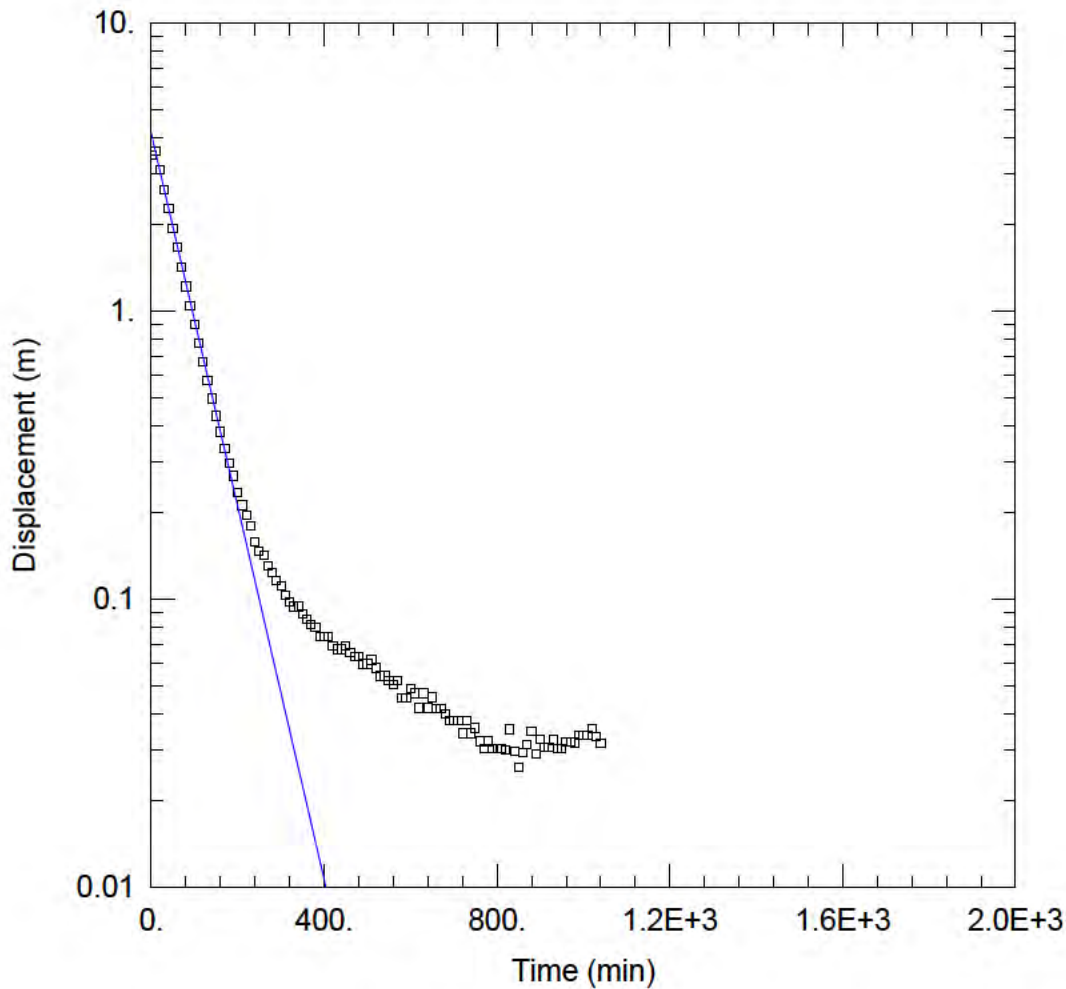
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH2)

Initial Displacement: 3.47 m Static Water Column Height: 9.3 m
 Total Well Penetration Depth: 13. m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.002864 m/day y0 = 8.189 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH2 test 2.aqt
 Date: 03/18/14 Time: 14:40:06

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH02
 Test Date: 6/03/2014

AQUIFER DATA

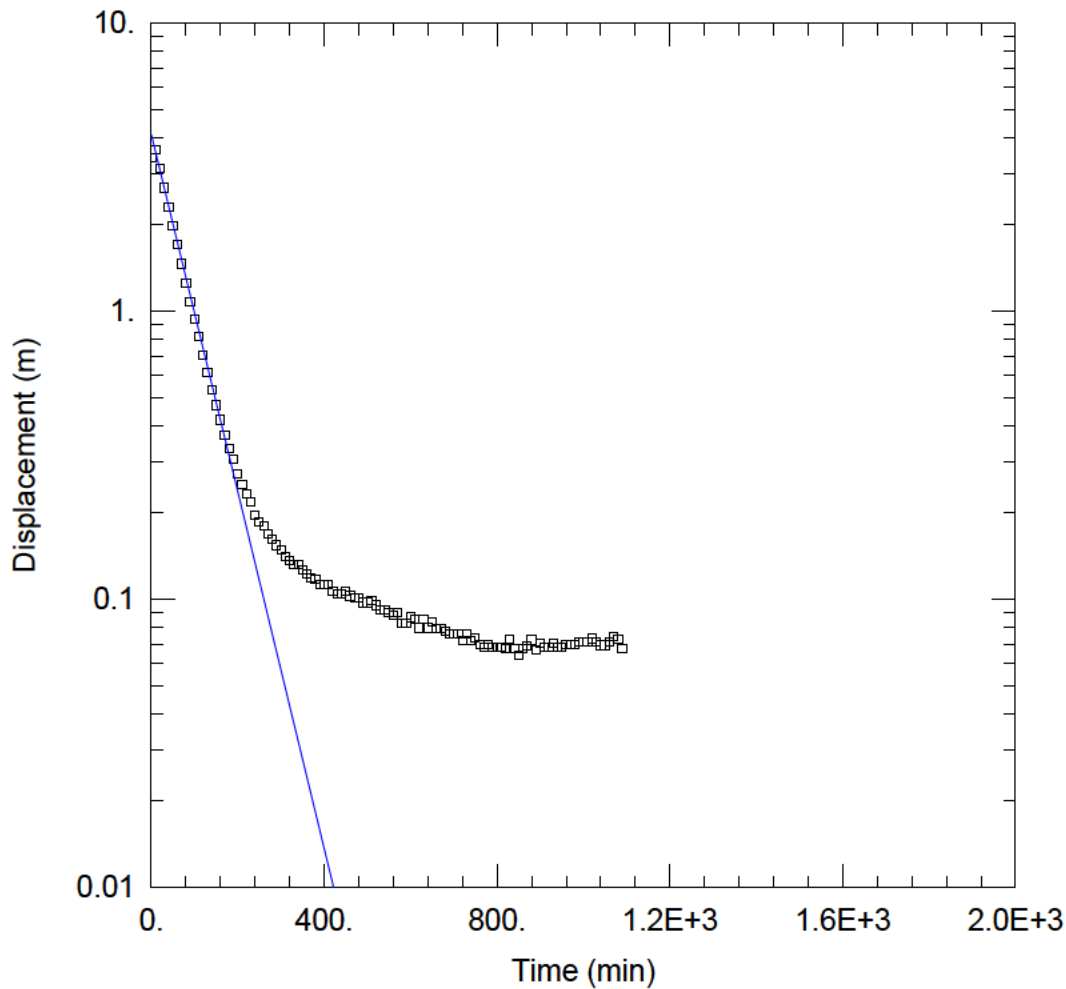
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH2)

Initial Displacement: 3.47 m Static Water Column Height: 9.3 m
 Total Well Penetration Depth: 13. m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.003551 m/day y0 = 4.126 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH2 test 3.aqt
 Date: 03/18/14 Time: 14:40:51

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH02
 Test Date: 11/03/2014

AQUIFER DATA

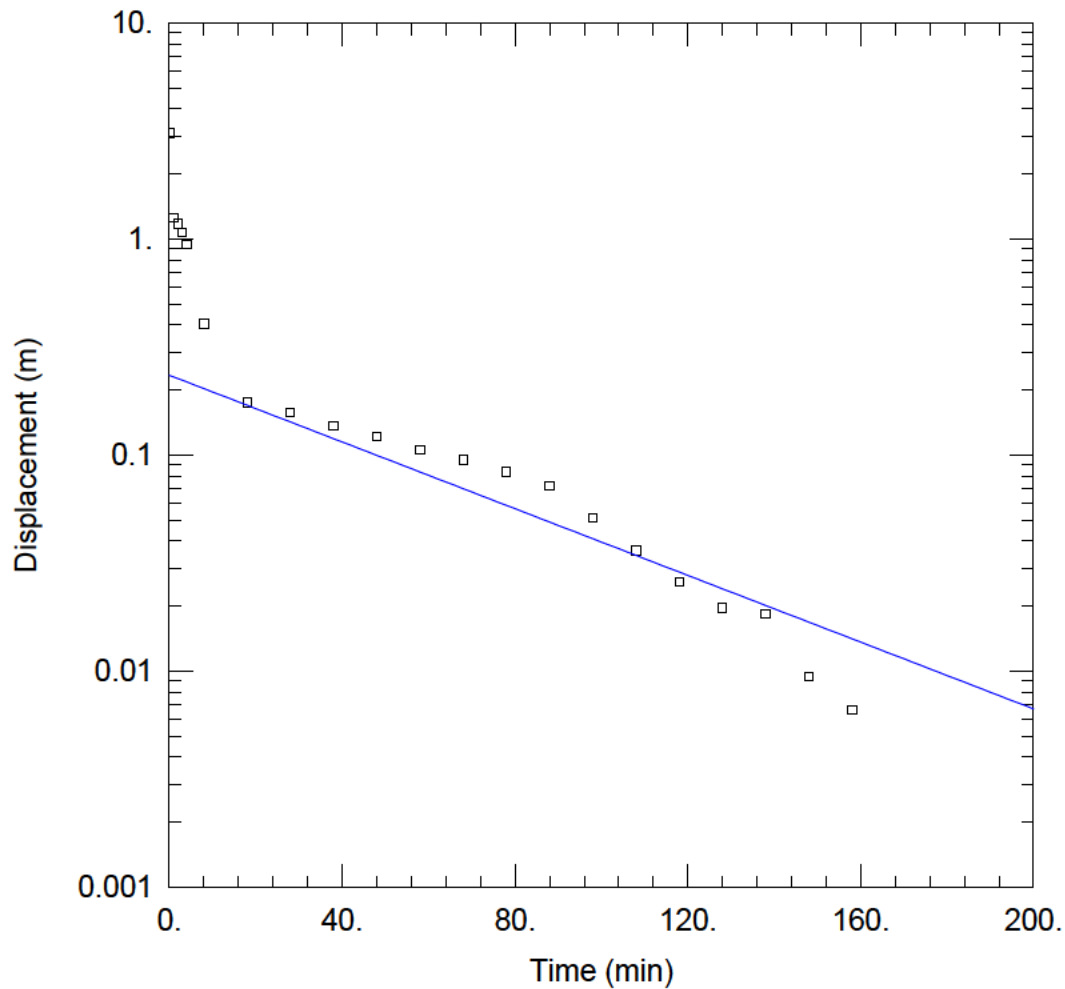
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH2)

Initial Displacement: 3.4 m Static Water Column Height: 9.3 m
 Total Well Penetration Depth: 13. m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.003401 m/day y0 = 4.105 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH3 test 1.aqt
 Date: 03/18/14 Time: 09:50:00

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH03
 Test Date: 26/02/2014

AQUIFER DATA

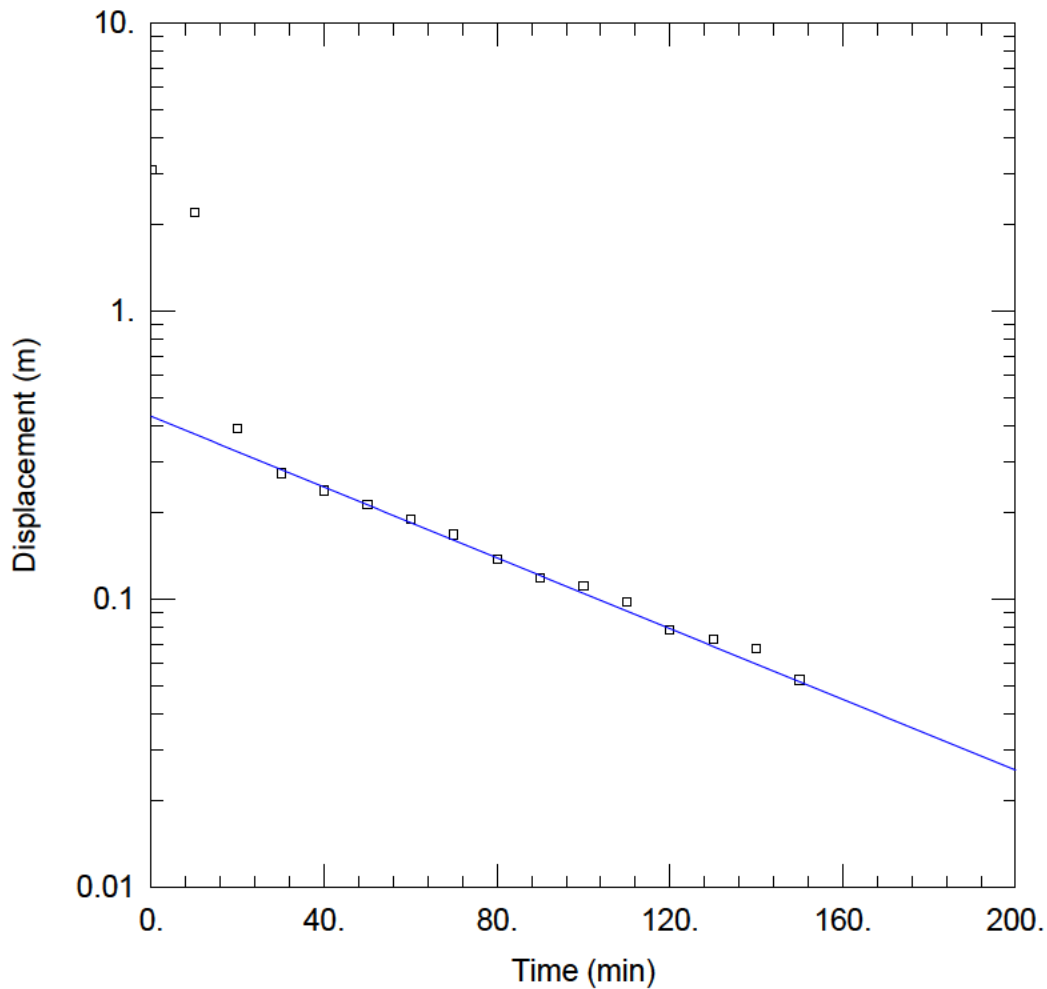
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH3)

Initial Displacement: 3.1 m Static Water Column Height: 8.9 m
 Total Well Penetration Depth: 12. m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.004239 m/day y0 = 0.2346 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH3 test 2.aqt
 Date: 03/18/14 Time: 09:49:09

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH03
 Test Date: 6/03/2014

AQUIFER DATA

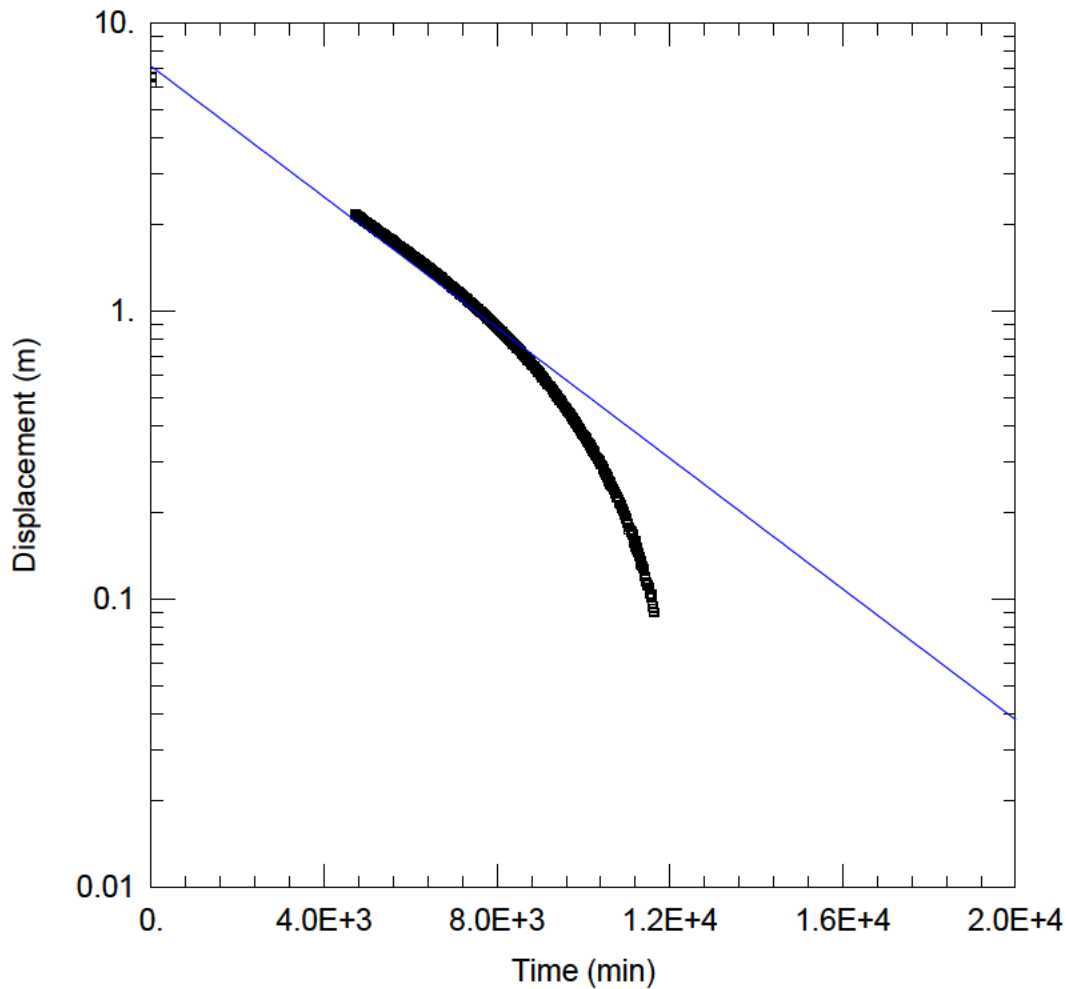
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH3)

Initial Displacement: 3.1 m Static Water Column Height: 8.9 m
 Total Well Penetration Depth: 12. m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.003371 m/day y0 = 0.4314 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH4 test 1.aqt
 Date: 03/14/14 Time: 15:26:08

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH04
 Test Date: 26/02/2014

AQUIFER DATA

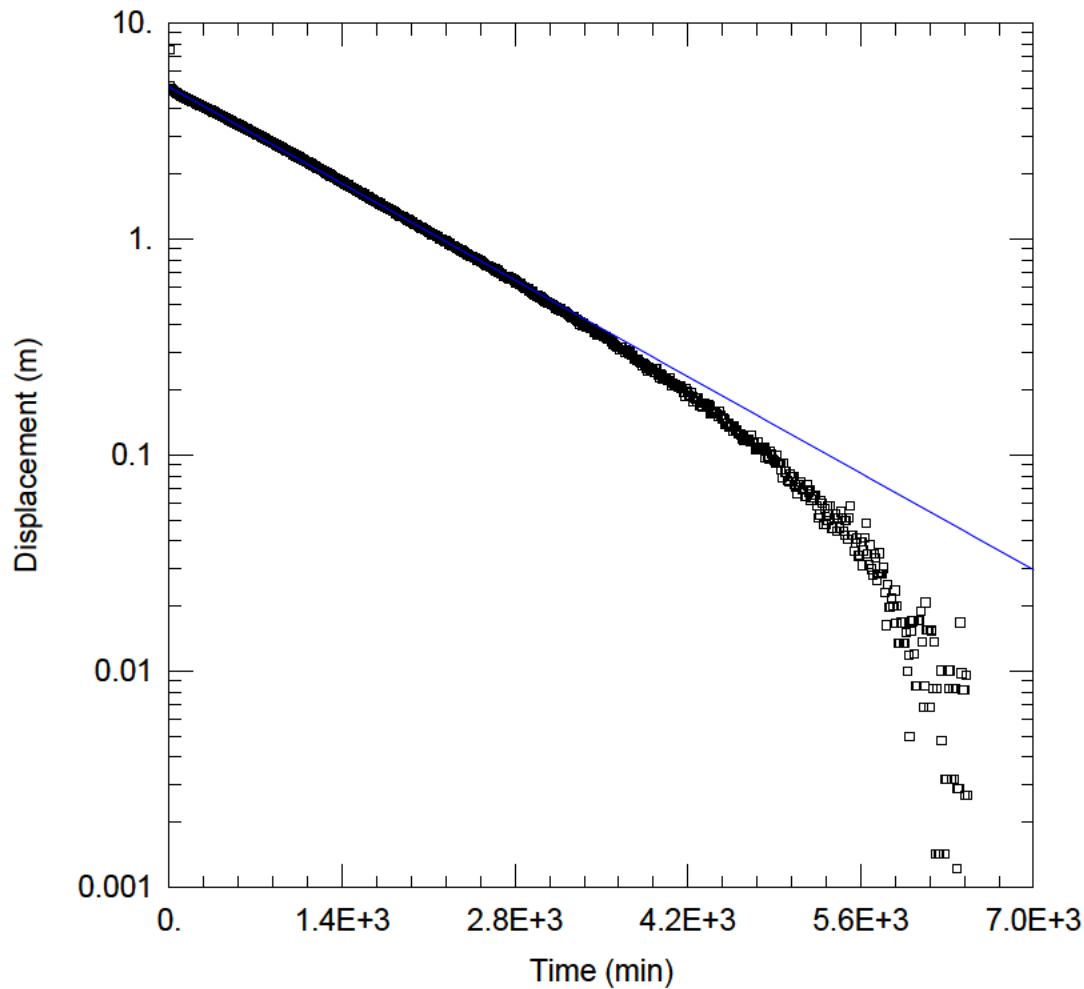
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH4)

Initial Displacement: 6.2 m Static Water Column Height: 7.3 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 6.224E-5 m/day y0 = 7.077 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\BH5 test 1.aqt
 Date: 03/14/14 Time: 11:06:08

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH05
 Test Date: 26/02/2014

AQUIFER DATA

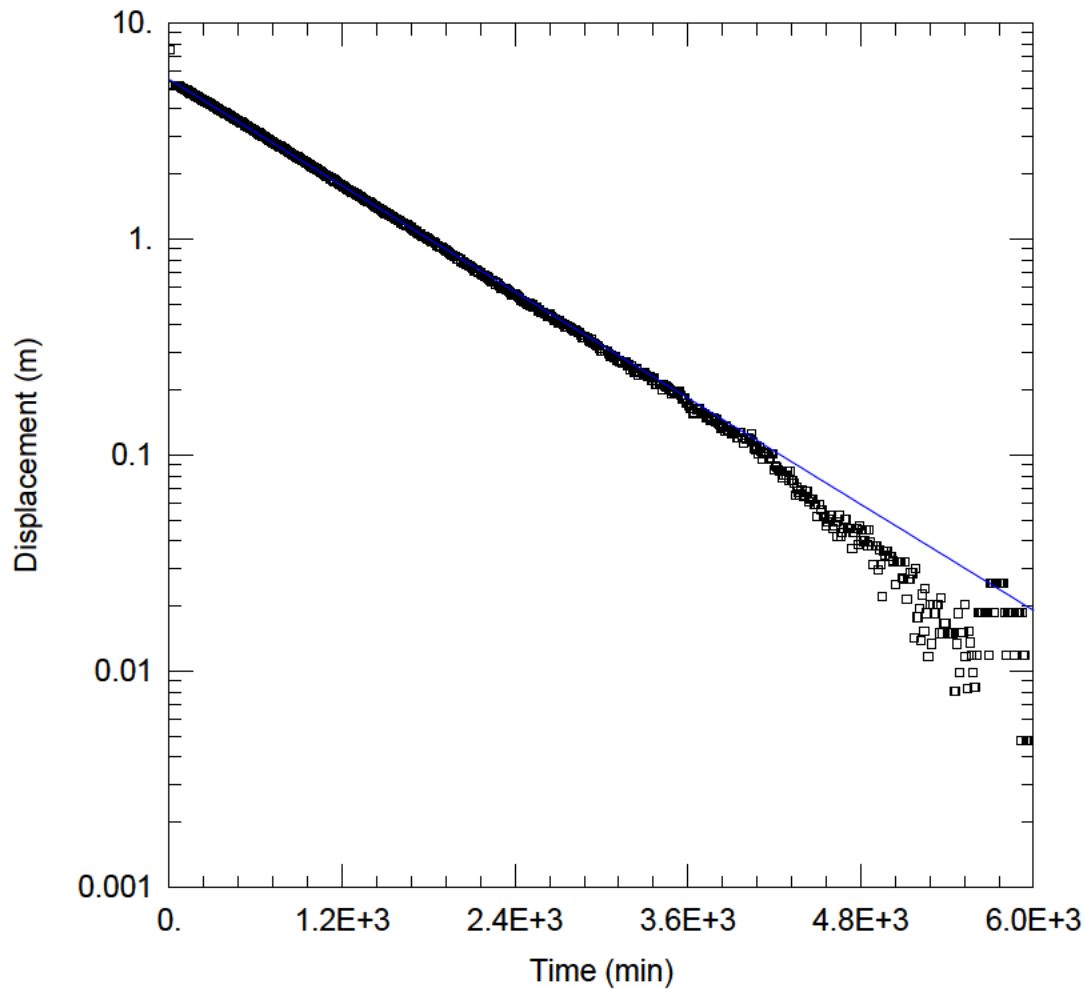
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH5)

Initial Displacement: 7.55 m Static Water Column Height: 5.95 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.0001752 m/day y0 = 5.065 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\BH5 test 2.aqt
 Date: 03/14/14 Time: 11:10:02

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH05
 Test Date: 6/03/2014

AQUIFER DATA

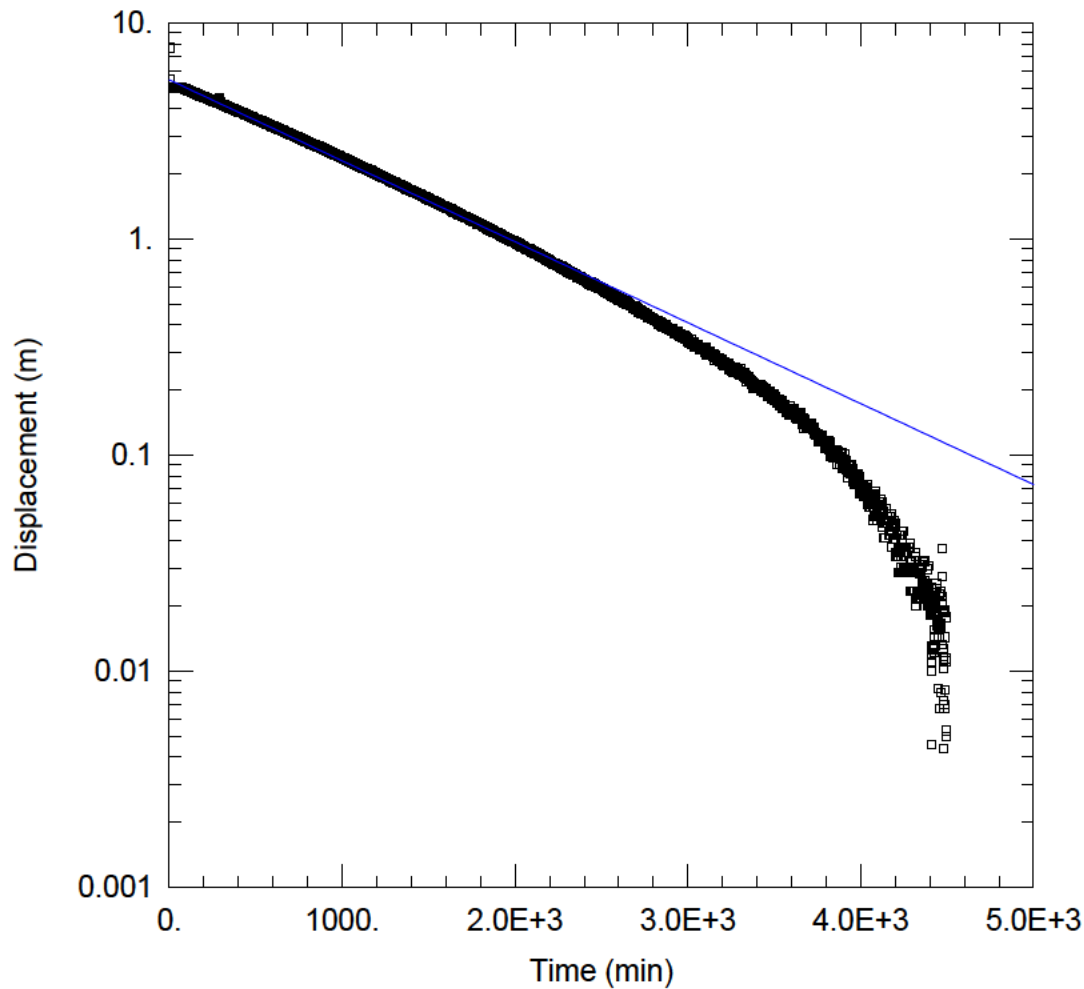
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH5)

Initial Displacement: 7.55 m Static Water Column Height: 5.95 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.0002248 m/day y0 = 5.484 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH5 test 3.aqt
 Date: 03/17/14 Time: 15:47:20

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH05
 Test Date: 11/03/2014

AQUIFER DATA

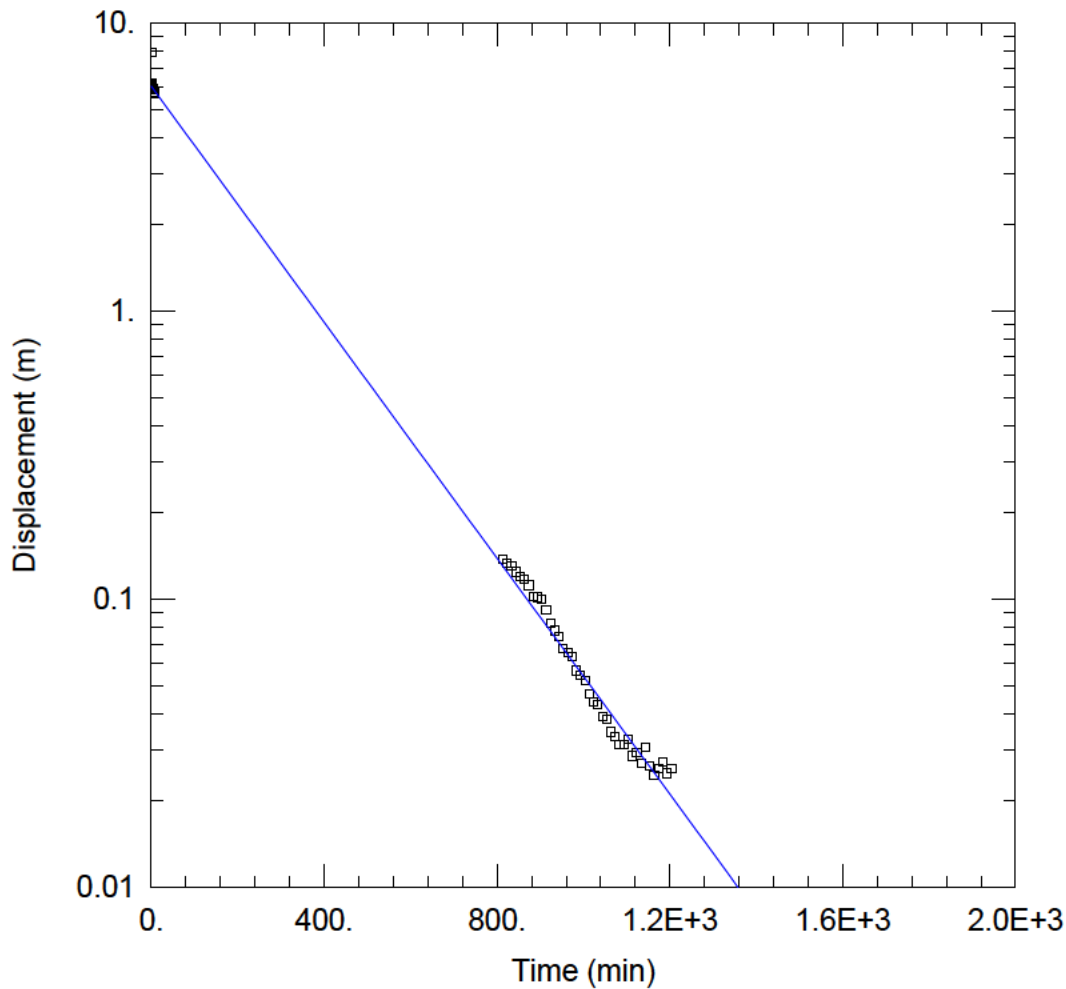
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH5)

Initial Displacement: 7.7 m Static Water Column Height: 5.8 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.0002056 m/day y0 = 5.462 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH6 test 1.aqt
 Date: 03/14/14 Time: 15:23:36

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH06
 Test Date: 26/02/2014

AQUIFER DATA

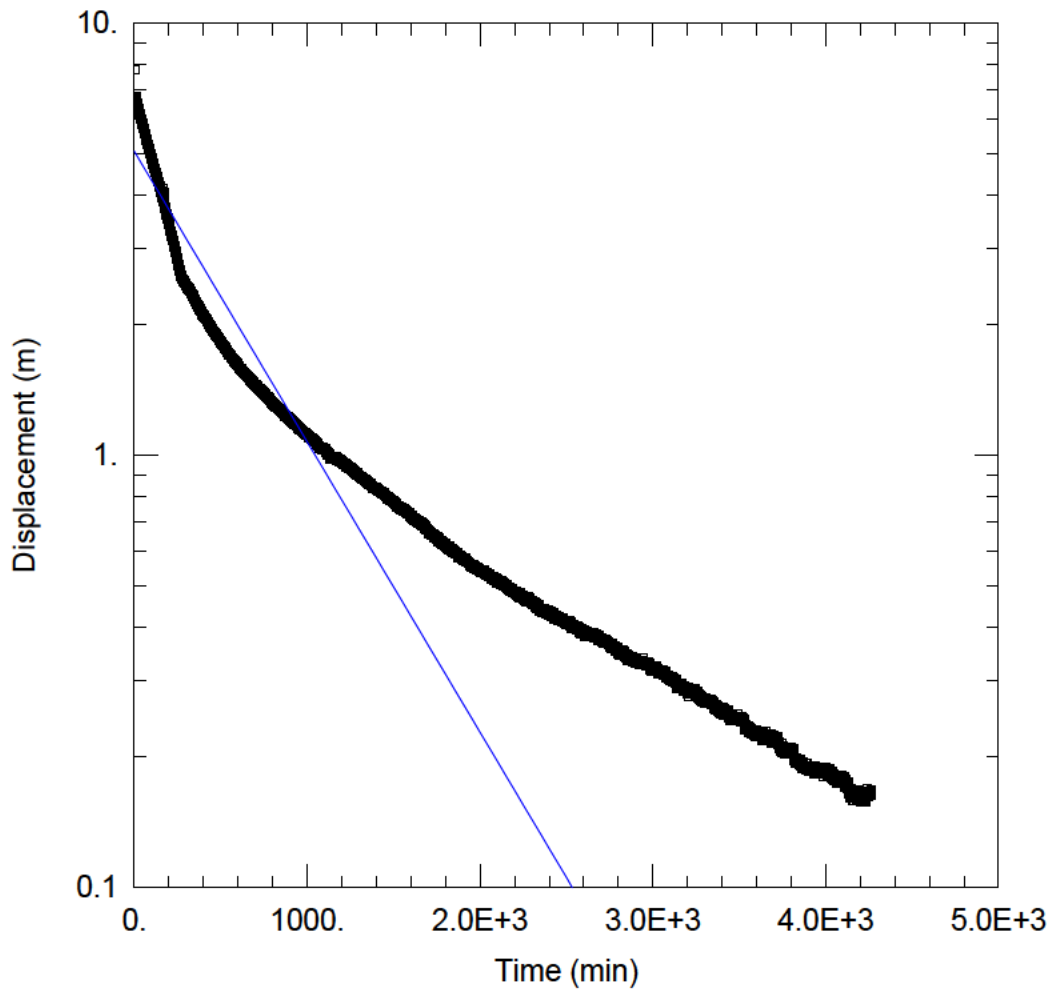
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH6)

Initial Displacement: 7.9 m Static Water Column Height: 7.1 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.001124 m/day y0 = 6.03 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH6 test 2.aqt
 Date: 03/18/14 Time: 14:43:51

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH06
 Test Date: 11/03/2014

AQUIFER DATA

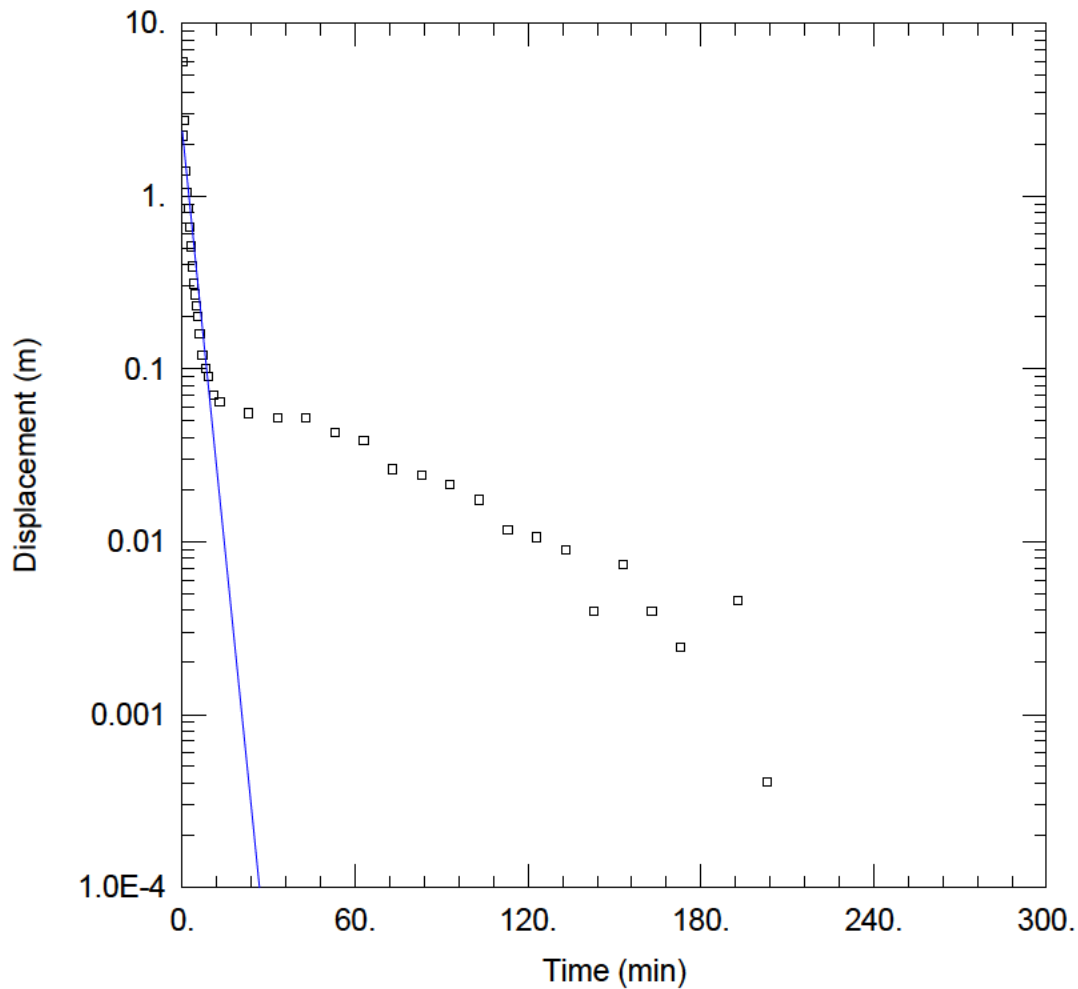
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH6)

Initial Displacement: 7.8 m Static Water Column Height: 7.2 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.0003689 m/day y0 = 5.047 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH7 test 1.aqt
 Date: 03/18/14 Time: 14:44:55

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH07
 Test Date: 26/02/2014

AQUIFER DATA

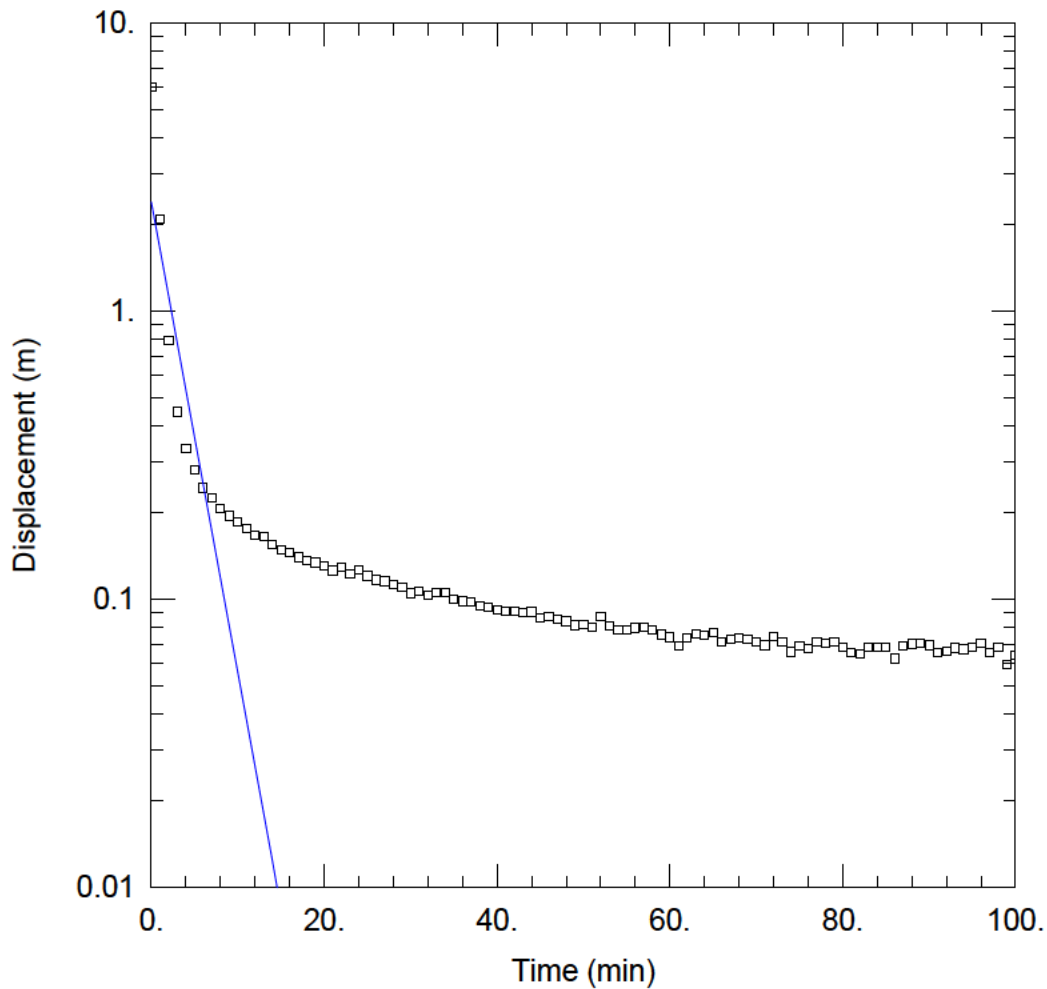
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH7)

Initial Displacement: 6. m Static Water Column Height: 7.5 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.0896 m/day y0 = 2.359 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH7 test 2.aqt
 Date: 03/18/14 Time: 14:46:04

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH07
 Test Date: 11/03/2014

AQUIFER DATA

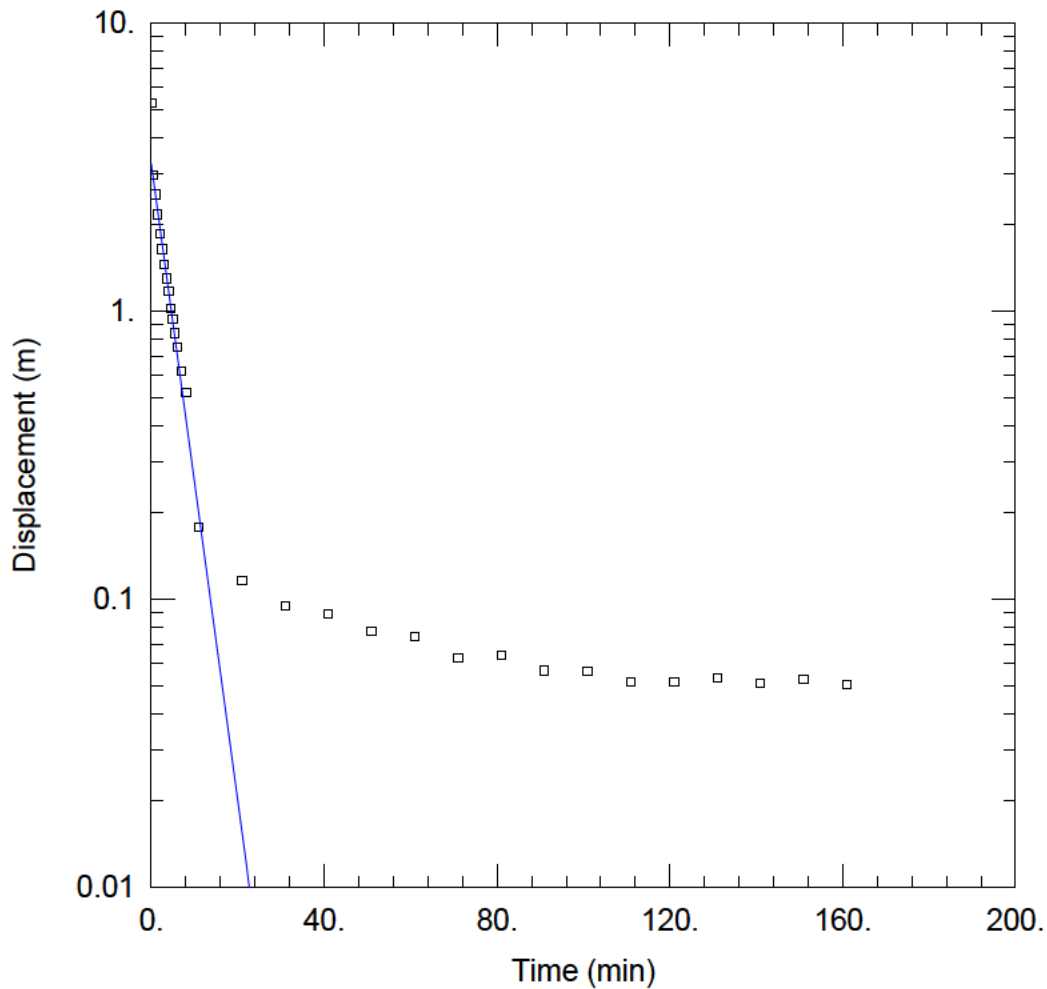
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH7)

Initial Displacement: 6.02 m Static Water Column Height: 7.5 m
 Total Well Penetration Depth: 13.5 m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.0896 m/day y0 = 2.392 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH8 test 1.aqt
 Date: 03/18/14 Time: 09:55:05

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH08
 Test Date: 26/02/2014

AQUIFER DATA

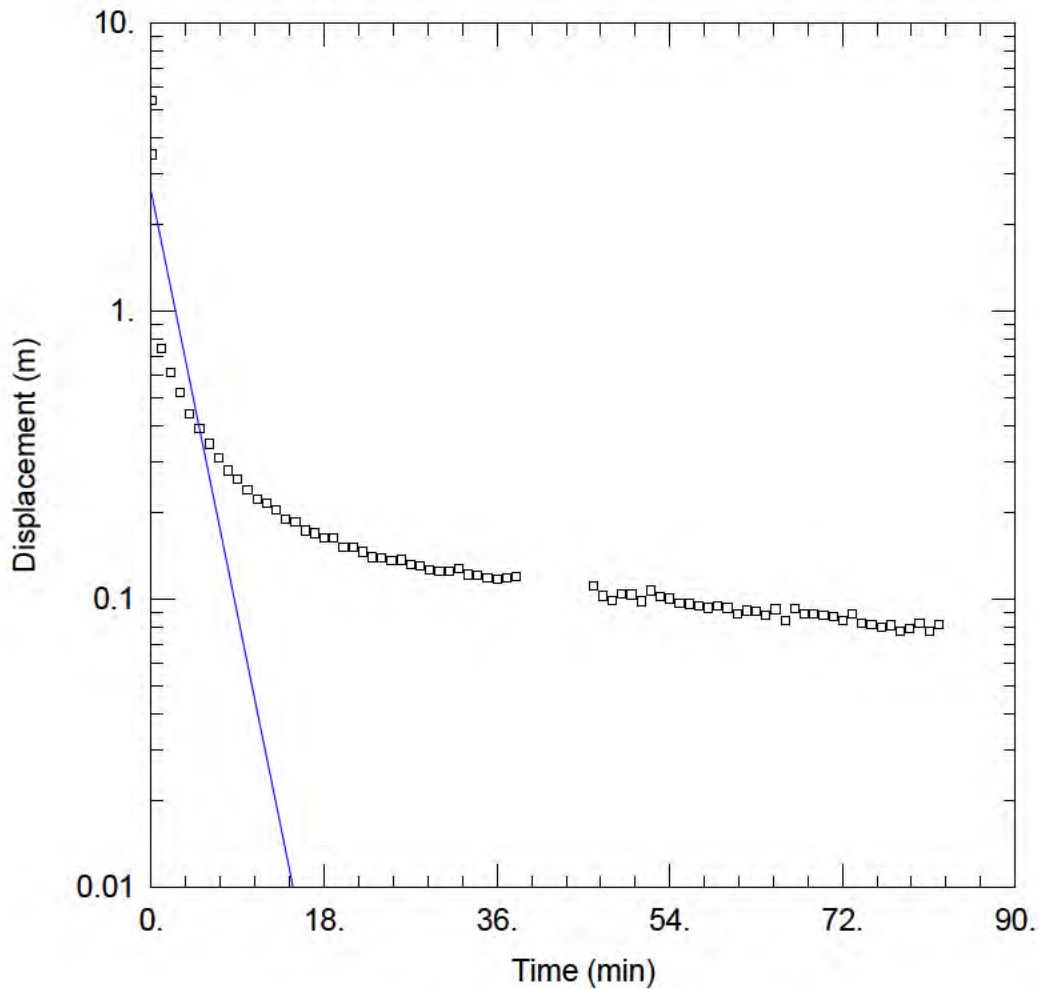
Saturated Thickness: 10. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH8)

Initial Displacement: 5.3 m Static Water Column Height: 6.7 m
 Total Well Penetration Depth: 12. m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.06064 m/day y0 = 3.241 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH8 test 2.aqt
 Date: 03/18/14 Time: 10:07:02

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH08
 Test Date: 11/03/2014

AQUIFER DATA

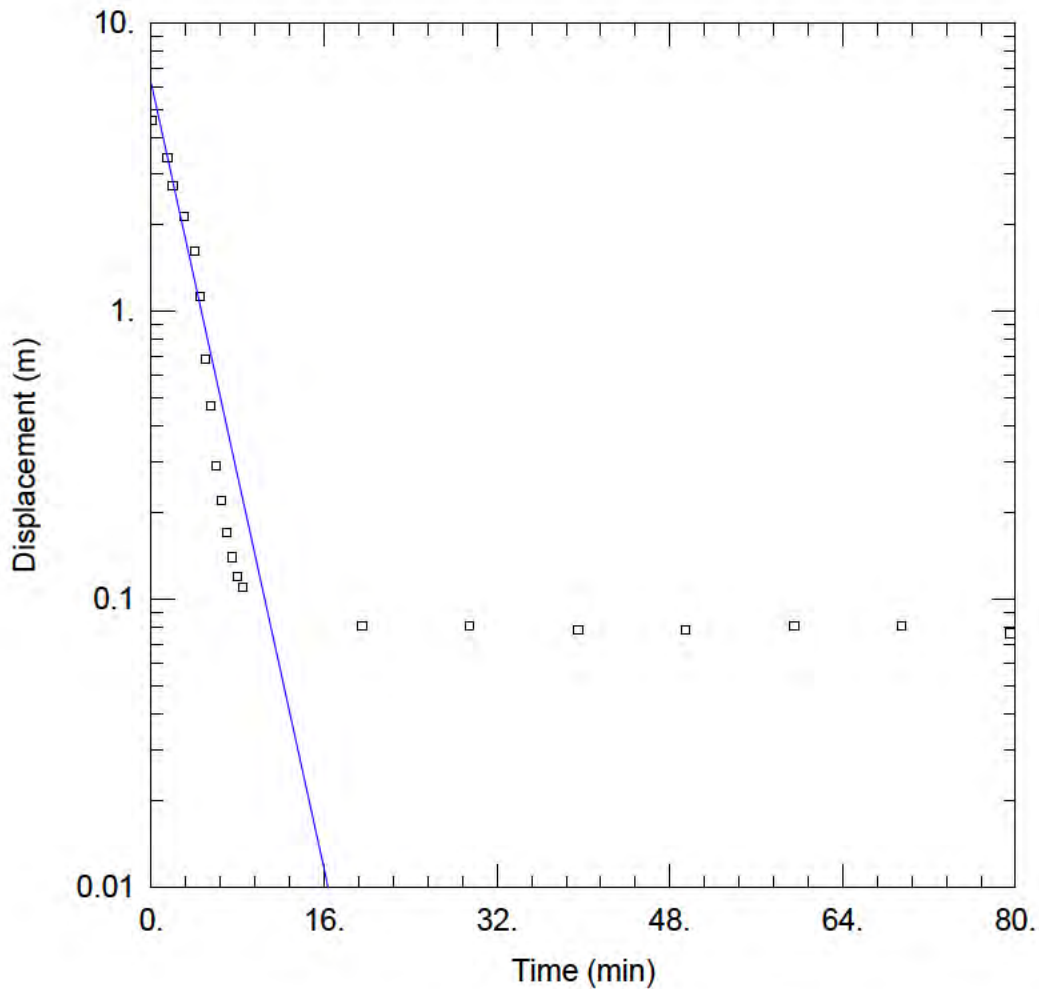
Saturated Thickness: 10. m Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH8)

Initial Displacement: 5.4 m Static Water Column Height: 6.6 m
 Total Well Penetration Depth: 12. m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 $K = 0.0896$ m/day $y_0 = 2.578$ m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH10 test 1.aqt
 Date: 03/18/14 Time: 10:10:25

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH10
 Test Date: 26/02/2014

AQUIFER DATA

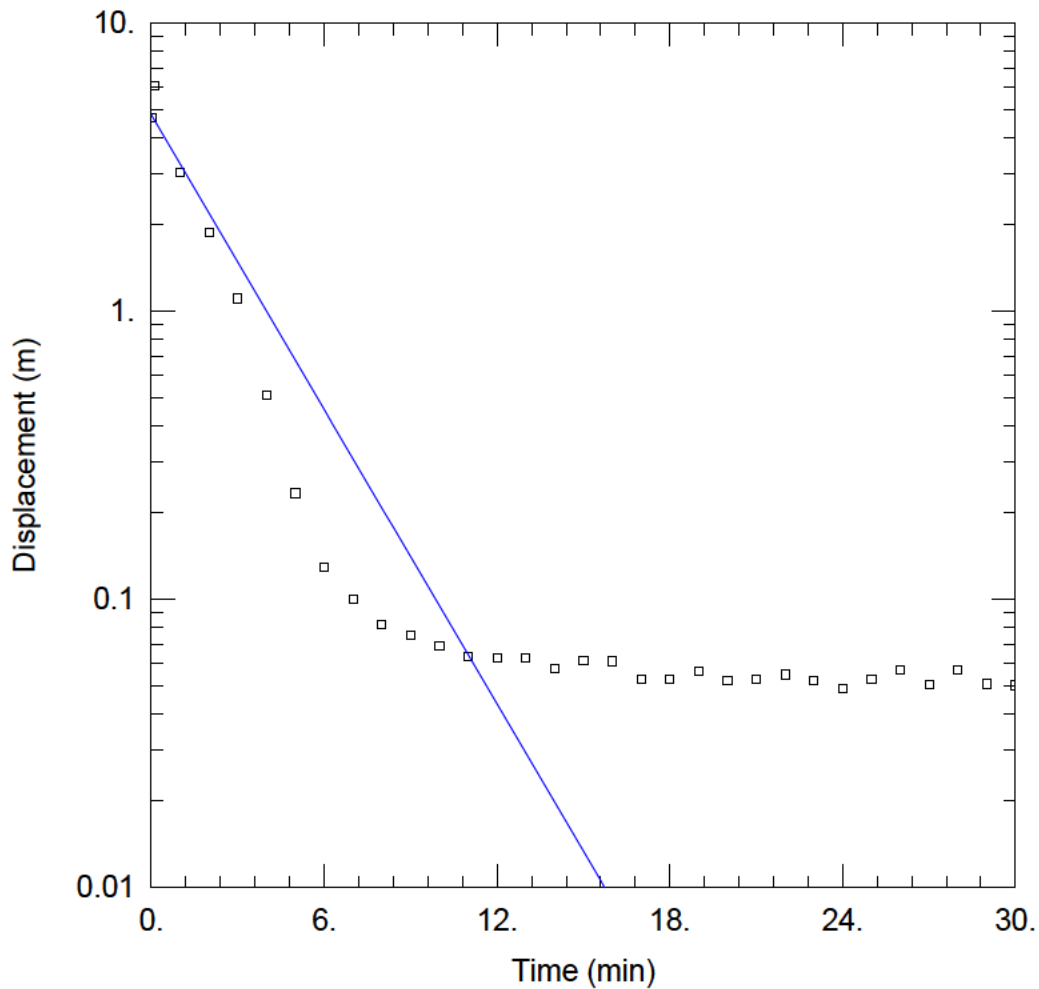
Saturated Thickness: 12. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH10)

Initial Displacement: 4.6 m Static Water Column Height: 10.4 m
 Total Well Penetration Depth: 12. m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.0896 m/day y0 = 6.158 m



WELL TEST ANALYSIS

Data Set: C:\Users\CJ11860\Desktop\Parks Way Canberra\Slug Tests\Aqtesolv Files\BH10 test 2.aqt
 Date: 03/18/14 Time: 10:16:57

PROJECT INFORMATION

Company: SMEC Australia
 Project: 30012385
 Location: Parks Way, ACT
 Test Well: BH10
 Test Date: 11/03/2014

AQUIFER DATA

Saturated Thickness: 12. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH10)

Initial Displacement: 4.7 m Static Water Column Height: 10.4 m
 Total Well Penetration Depth: 12. m Screen Length: 10. m
 Casing Radius: 0.025 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
 K = 0.0896 m/day y0 = 4.81 m

APPENDIX B: COC AND LABORATORY REPORT

CERTIFICATE OF ANALYSIS

Work Order	: CA1400835	Page	: 1 of 5
Client	: SMEC Australia Pty Ltd	Laboratory	: ALS Water Resources Group
Contact	: Ms Cara Jaques	Contact	: Client Services
Address	: Suite 2 Level 1, 243 Northbourne Ave Canberra ACT 2602	Address	: 16B Lithgow Street Fyshwick ACT Australia 2609
E-mail	: cara.jacques@smec.com	E-mail	: ecowisecustomerservice@alsglobal.com
Telephone	: 6234 1926	Telephone	: +61 2 6202 5404
Facsimile	: ----	Facsimile	: ----
Project	: 3002385 Parkes Way	QC Level	: ----
Order number	: 3002385	Date Samples Received	: 14-Mar-2014 16:00
C-O-C number	: ----	Issue Date	: 26-Mar-2014 13:44
Sampler	: ----	No. of samples received	: 7
Site	: ----	No. of samples analysed	: 7
Quote number	: ----		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



**WORLD RECOGNISED
ACCREDITATION**

NATA Accredited Laboratory 992

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Geetha Ramasundara	Teamleader Wet Chem	Inorganics
Shane Reynolds	Lab Manager	Administration
Shane Reynolds	Lab Manager	Inorganics
Terry OBrien	Teamleader Nutrients	Inorganics
Titus Vimalasiri	Teamleader Metals	Inorganics



Analytical Results

Compound	CAS Number	LOR	Unit	Client sample ID		Depth in Meters	Client sampling date / time	BH10		BH8		BH7		BH5		BH2	
				Result	MU			Result	MU	Result	MU	Result	MU	Result	MU	Result	MU
Depth Type								[14-Mar-2014]		[14-Mar-2014]		[14-Mar-2014]		[14-Mar-2014]		[14-Mar-2014]	
Depth in Meters								CA1400835-001		CA1400835-002		CA1400835-003		CA1400835-004		CA1400835-005	
EA005: pH																	
pH	----	0.01	pH Unit	7.76		7.89		7.75		7.77		7.74					
EA010: Conductivity																	
Electrical Conductivity @ 25°C	----	2	µS/cm	861		966		875		1230		1070					
EA015: Total Dissolved Solids																	
^ Total Dissolved Solids	----	10	mg/L	517		585		543		740		629					
ED009: Anions																	
Chloride	16887-00-6	0.1	mg/L	57.9		97.1		75.9		224		101					
Sulfate	14808-79-8	0.4	mg/L	21.7		69.6		62.6		87.0		41.3					
Fluoride	16984-48-8	0.1	mg/L	0.4		0.7		0.4		1.6		1.3					
ED037: Alkalinity																	
Hydroxide Alkalinity as CaCO3	DMO-210-001	0.1	mg/L	<0.1		<0.1		<0.1		<0.1		<0.1					
Carbonate Alkalinity as CaCO3	3812-32-6	0.1	mg/L	<0.1		<0.1		<0.1		<0.1		<0.1					
Bicarbonate Alkalinity as CaCO3	71-52-3	0.1	mg/L	376		283		279		217		380					
Total Alkalinity as CaCO3	----	1	mg/L	376		283		279		217		380					
EG005F: Dissolved Metals by ICP-OES																	
Calcium	7440-70-2	0.05	mg/L	65.6		44.6		54.6		50.7		60.6					
Chromium	7440-47-3	0.001	mg/L	<0.001		<0.001		<0.001		<0.001		0.001					
Copper	7440-50-8	0.002	mg/L	<0.002		<0.002		0.002		0.003		<0.002					
Iron	7439-89-6	0.01	mg/L	<0.01		<0.01		<0.01		<0.01		<0.01					
Magnesium	7439-95-4	0.05	mg/L	24.8		22.5		28.4		34.6		53.6					
Manganese	7439-96-5	0.001	mg/L	0.096		0.011		0.044		0.092		0.065					
Nickel	7440-02-0	0.005	mg/L	<0.005		<0.005		<0.005		<0.005		<0.005					
Potassium	7440-09-7	0.1	mg/L	0.8		1.2		1.2		3.3		0.8					
Sodium	7440-23-5	0.1	mg/L	77.8		120		80.8		136		75.8					
Zinc	7440-66-6	0.005	mg/L	0.077		0.014		0.045		0.080		0.012					
EG005T: Total Metals by ICP-OES																	
Iron	7439-89-6	0.01	mg/L	8.66		6.95		6.66		12.1		2.10					
Manganese	7439-96-5	0.001	mg/L	0.526		0.186		0.192		1.43		0.248					
EG020F: Dissolved Metals by ICP-MS																	
Arsenic	7440-38-2	1	µg/L	<1		1		<1		1		<1					
Cadmium	7440-43-9	0.05	µg/L	<0.05		<0.05		<0.05		<0.05		<0.05					
Lead	7439-92-1	0.2	µg/L	<0.2		<0.2		<0.2		<0.2		<0.2					



Analytical Results

Sub-Matrix: WATER

Compound	CAS Number	LOR	Unit	BH10		BH8		BH7		BH5		BH2	
				Result	MU	Result	MU	Result	MU	Result	MU	Result	MU
Client sample ID				[14-Mar-2014]		[14-Mar-2014]		[14-Mar-2014]		[14-Mar-2014]		[14-Mar-2014]	
Client sampling date / time				Depth Type		Depth in Meters							
Depth in Meters													
EG020F: Dissolved Metals by ICP-MS - Continued													
Mercury	7439-97-6	0.1	µg/L	0.2		0.1		0.2		<0.1		<0.1	
EK057: Nitrite as N													
Nitrite as N	----	0.01	mg/L	<0.01		0.02		0.11		<0.01		<0.01	
EK058: Nitrate as N													
^ Nitrate as N	14797-55-8	0.05	mg/L	0.22		1.31		1.84		0.41		3.17	
EK059: Nitrite plus Nitrate as N (NOx)													
Nitrite + Nitrate as N	----	0.05	mg/L	0.22		1.33		1.95		0.41		3.17	
EK062: Total Nitrogen as N (TKN + NOx)													
Total Nitrogen as N	----	0.05	mg/L	0.34		1.56		2.27		0.88		3.37	
EK067: Total Phosphorus as P													
Total Phosphorus as P	----	0.01	mg/L	0.14		0.13		0.18		0.62		0.11	
EK071F: Dissolved Reactive Phosphorus as P													
Reactive Phosphorus as P	14265-44-2	0.02	mg/L	<0.02		<0.02		0.04		0.02		0.04	
EP080/071: Total Petroleum Hydrocarbons													
C6 - C9 Fraction													
C6 - C9 Fraction	----	20	µg/L	<20		<20		<20		<20		<20	
C10 - C14 Fraction													
C10 - C14 Fraction	----	50	µg/L	<50		<50		<50		<50		<50	
C15 - C28 Fraction													
C15 - C28 Fraction	----	100	µg/L	<100		<100		<100		<100		<100	
C29 - C36 Fraction													
C29 - C36 Fraction	----	50	µg/L	<50		<50		<50		<50		<50	
C10 - C36 Fraction (sum)													
C10 - C36 Fraction (sum)	----	50	µg/L	<50		<50		<50		<50		<50	



Analytical Results

Compound	CAS Number	LOR	Unit	Client sample ID		MU	Result	MU	Result	MU	Result	MU
				BH1	QC1							
				Client sampling date / time								
				Depth Type								
				Depth in Meters								
EA005: pH												
pH		0.01	pH Unit				7.62				7.79	
EA010: Conductivity												
Electrical Conductivity @ 25°C		2	µS/cm				2470				862	
EA015: Total Dissolved Solids												
^ Total Dissolved Solids		10	mg/L				1500				542	
ED009: Anions												
Chloride	16887-00-6	0.1	mg/L				456				58.8	
Sulfate	14808-79-8	0.4	mg/L				170				21.4	
Fluoride	16984-48-8	0.1	mg/L				1.0				0.3	
ED037: Alkalinity												
Hydroxide Alkalinity as CaCO3	DMO-210-001	0.1	mg/L				<0.1				<0.1	
Carbonate Alkalinity as CaCO3	3812-32-6	0.1	mg/L				<0.1				<0.1	
Bicarbonate Alkalinity as CaCO3	71-52-3	0.1	mg/L				518				373	
Total Alkalinity as CaCO3		1	mg/L				518				373	
EG005F: Dissolved Metals by ICP-OES												
Calcium	7440-70-2	0.05	mg/L				72.2				65.3	
Chromium	7440-47-3	0.001	mg/L				<0.001				<0.001	
Copper	7440-50-8	0.002	mg/L				0.003				0.002	
Iron	7439-89-6	0.01	mg/L				<0.01				<0.01	
Magnesium	7439-95-4	0.05	mg/L				68.4				24.4	
Manganese	7439-96-5	0.001	mg/L				0.797				0.106	
Nickel	7440-02-0	0.005	mg/L				<0.005				<0.005	
Potassium	7440-09-7	0.1	mg/L				2.1				0.7	
Sodium	7440-23-5	0.1	mg/L				332				75.3	
Zinc	7440-66-6	0.005	mg/L				0.058				0.016	
EG005T: Total Metals by ICP-OES												
Iron	7439-89-6	0.01	mg/L				4.05				9.02	
Manganese	7439-96-5	0.001	mg/L				1.30				0.450	
EG020F: Dissolved Metals by ICP-MS												
Arsenic	7440-38-2	1	µg/L				3				<1	
Cadmium	7440-43-9	0.05	µg/L				<0.05				<0.05	
Lead	7439-92-1	0.2	µg/L				<0.2				<0.2	



Analytical Results

Sub-Matrix: WATER

Compound	CAS Number	LOR	Unit	Client sample ID		Result	MU	Result	MU	Result	MU
				BH1	QC1						
		Client sampling date / time		[14-Mar-2014]		[14-Mar-2014]					
		Depth Type									
		Depth in Meters									
Compound	CAS Number	LOR	Unit	Result	MU	Result	MU	Result	MU	Result	MU
EG020F: Dissolved Metals by ICP-MS - Continued											
Mercury	7439-97-6	0.1	µg/L	<0.1		0.2					
EK057: Nitrite as N											
Nitrite as N		0.01	mg/L	0.10		<0.01					
EK058: Nitrate as N											
^ Nitrate as N	14797-55-8	0.05	mg/L	1.90		0.21					
EK059: Nitrite plus Nitrate as N (NOx)											
Nitrite + Nitrate as N		0.05	mg/L	2.00		0.21					
EK062: Total Nitrogen as N (TKN + NOx)											
Total Nitrogen as N		0.05	mg/L	2.53		0.36					
EK067: Total Phosphorus as P											
Total Phosphorus as P		0.01	mg/L	0.08		0.14					
EK071F: Dissolved Reactive Phosphorus as P											
Reactive Phosphorus as P	14265-44-2	0.02	mg/L	<0.02		<0.02					
EP080/071: Total Petroleum Hydrocarbons											
C6 - C9 Fraction		20	µg/L	<20		<20					
C10 - C14 Fraction		50	µg/L	<50		<50					
C15 - C28 Fraction		100	µg/L	<100		<100					
C29 - C36 Fraction		50	µg/L	<50		<50					
C10 - C36 Fraction (sum)		50	µg/L	<50		<50					

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

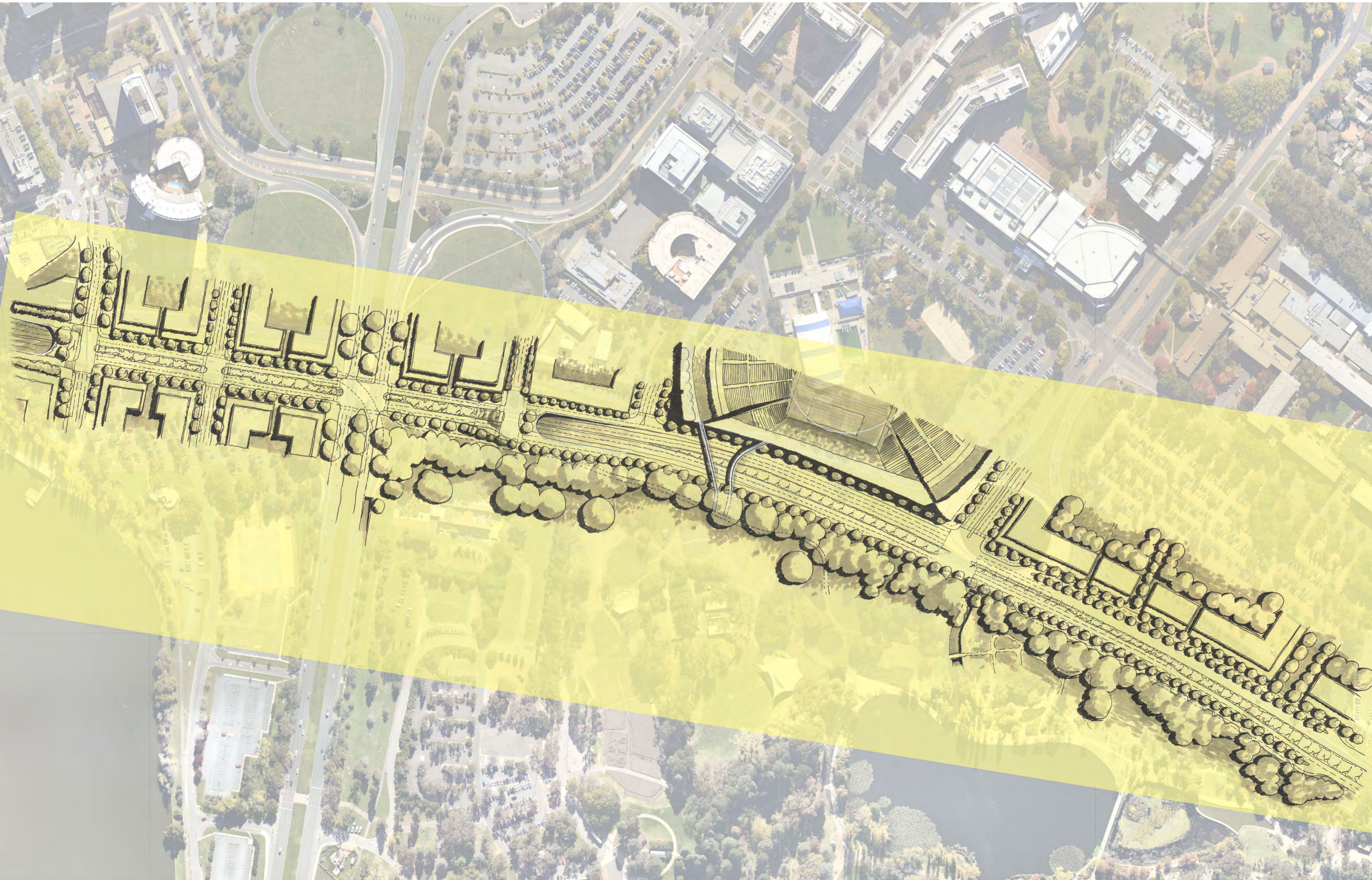
When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.



CONCEPT PLAN



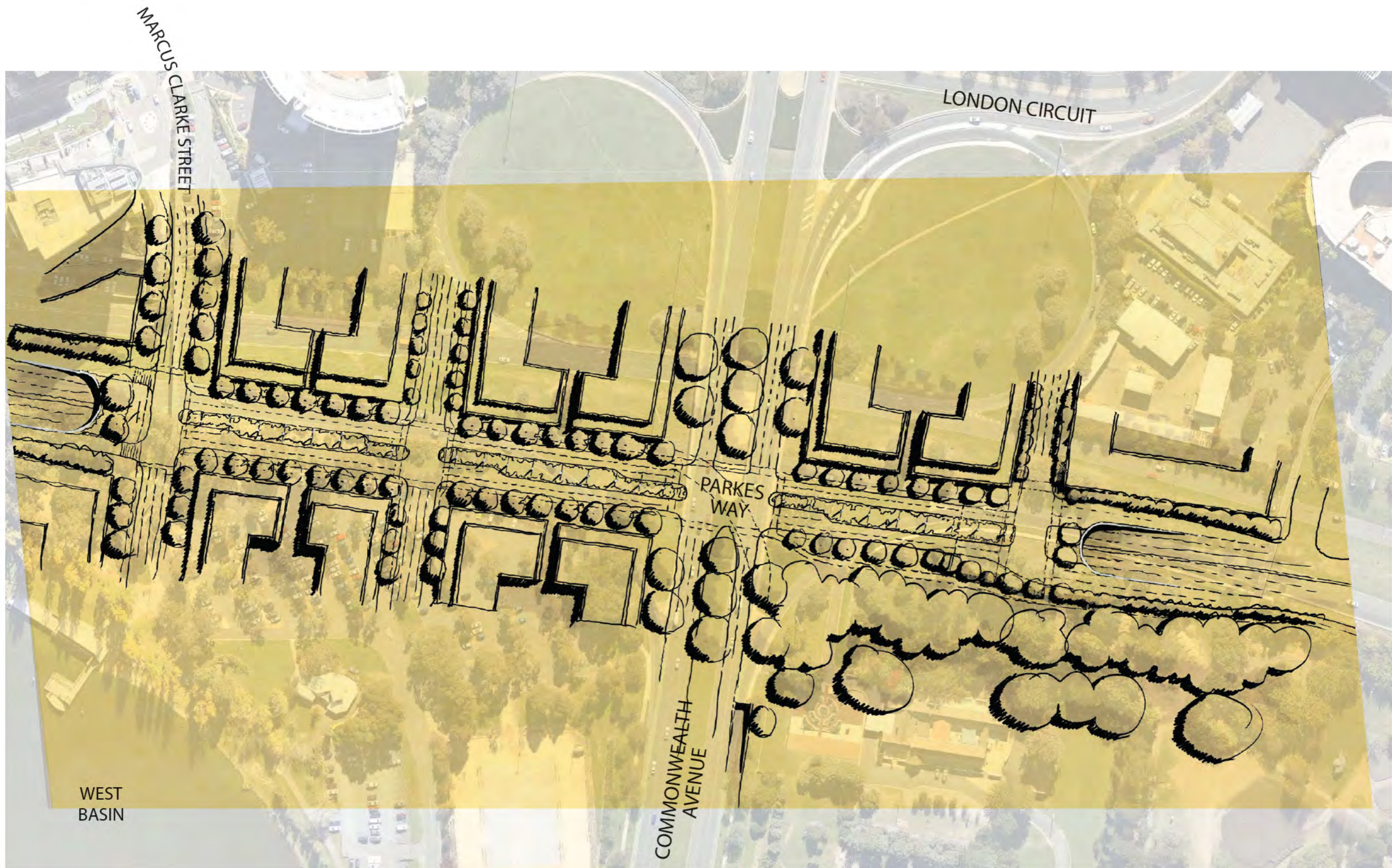
CONCEPT PLAN



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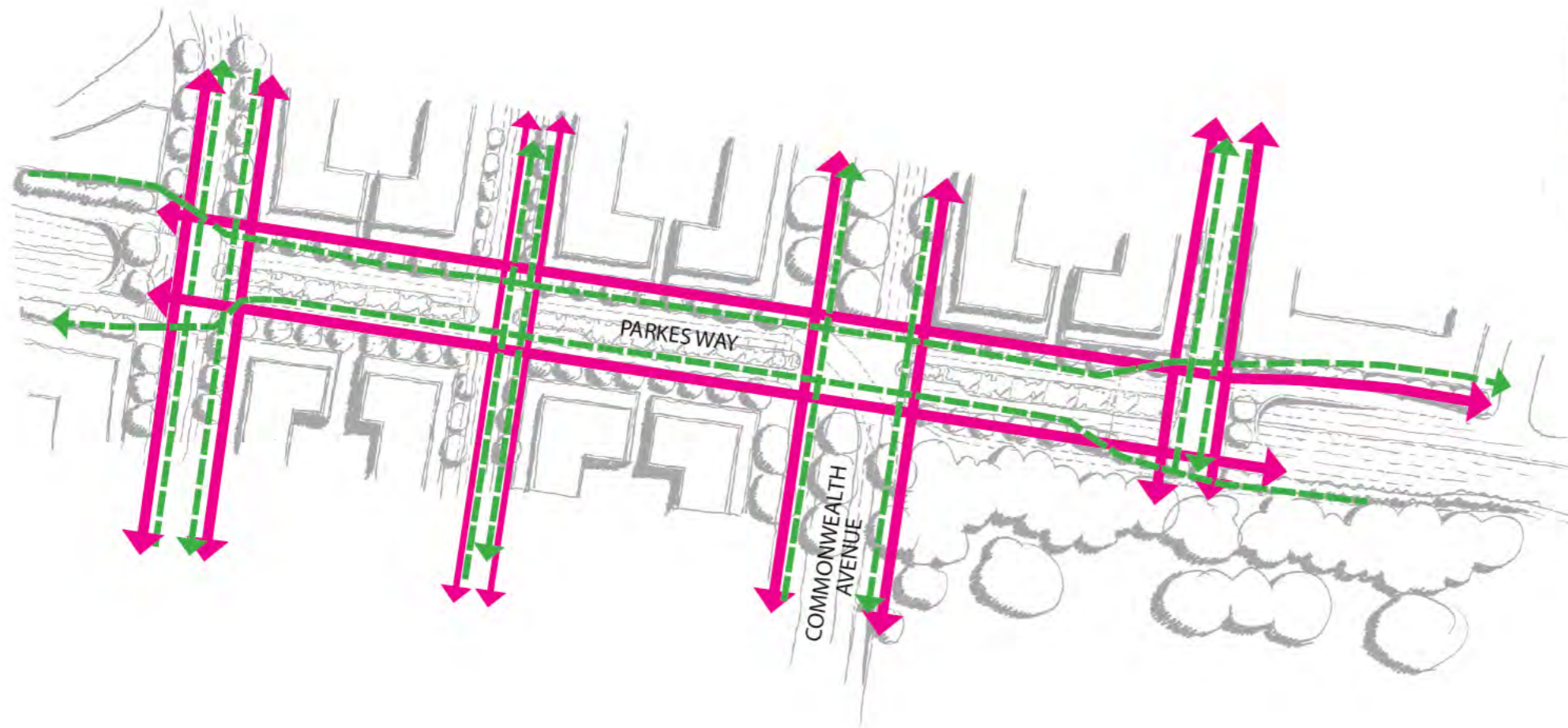


CONCEPT PLAN





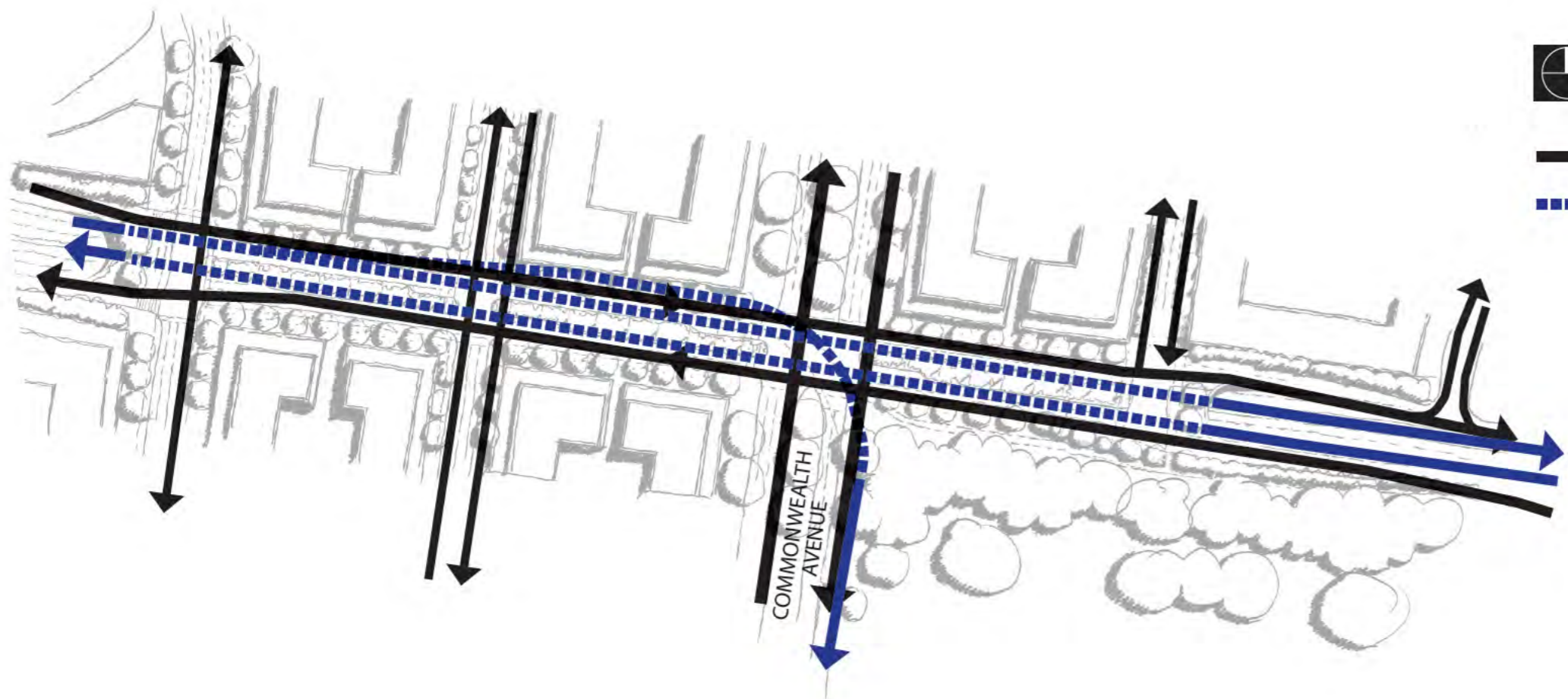
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⊥ PEDESTRIAN AND CYCLING ACCESS

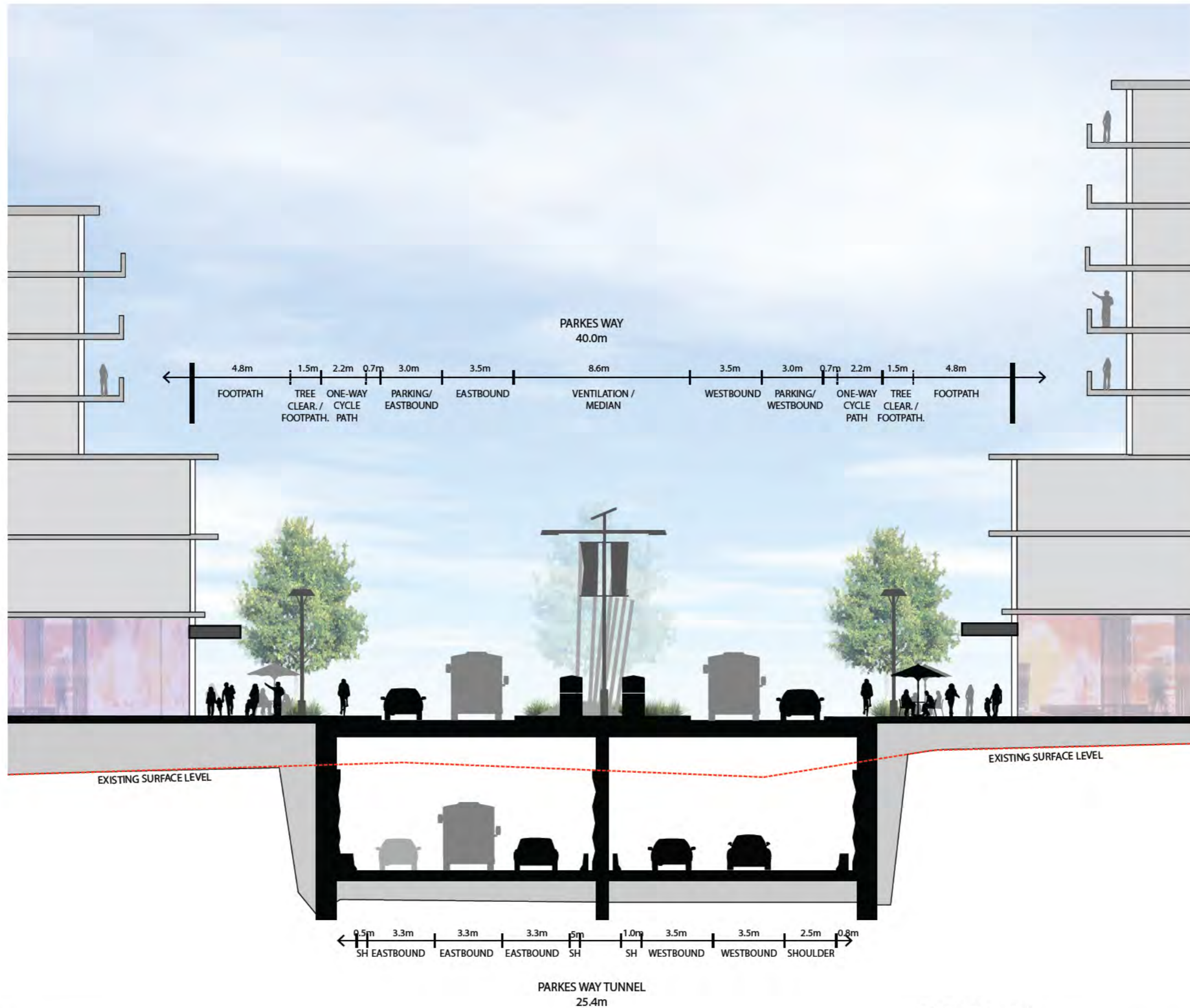
-  PEDESTRIAN ACCESS
-  CYCLE ACCESS



⊥ TRAFFIC FUNCTION

-  GROUND LEVEL STREETS
-  PARKES WAY TUNNEL

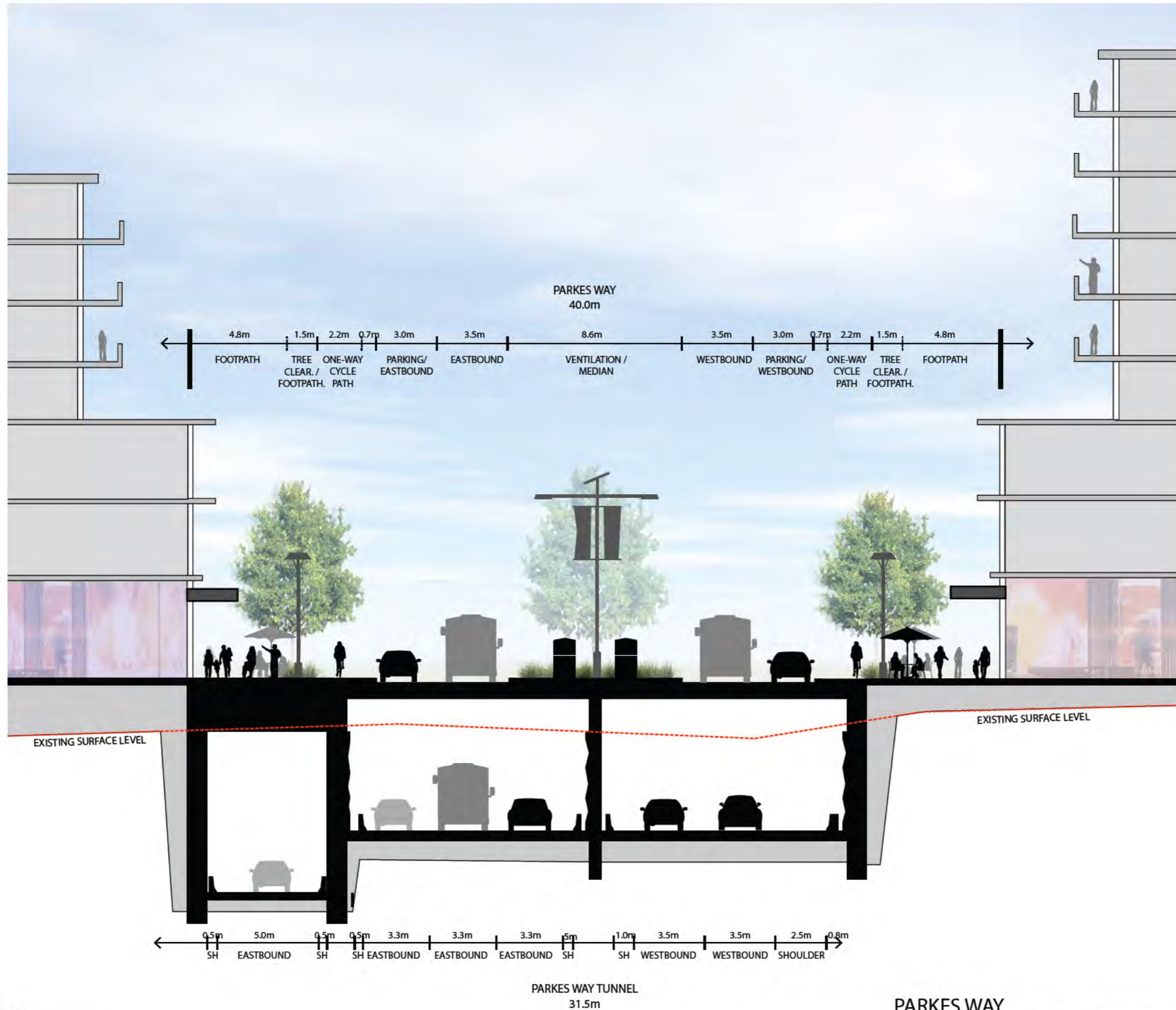
CROSS SECTION



A1
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PARKES WAY
CROSS SECTION BETWEEN MARCUS CLARKE STREET AND NEW WEST ROAD

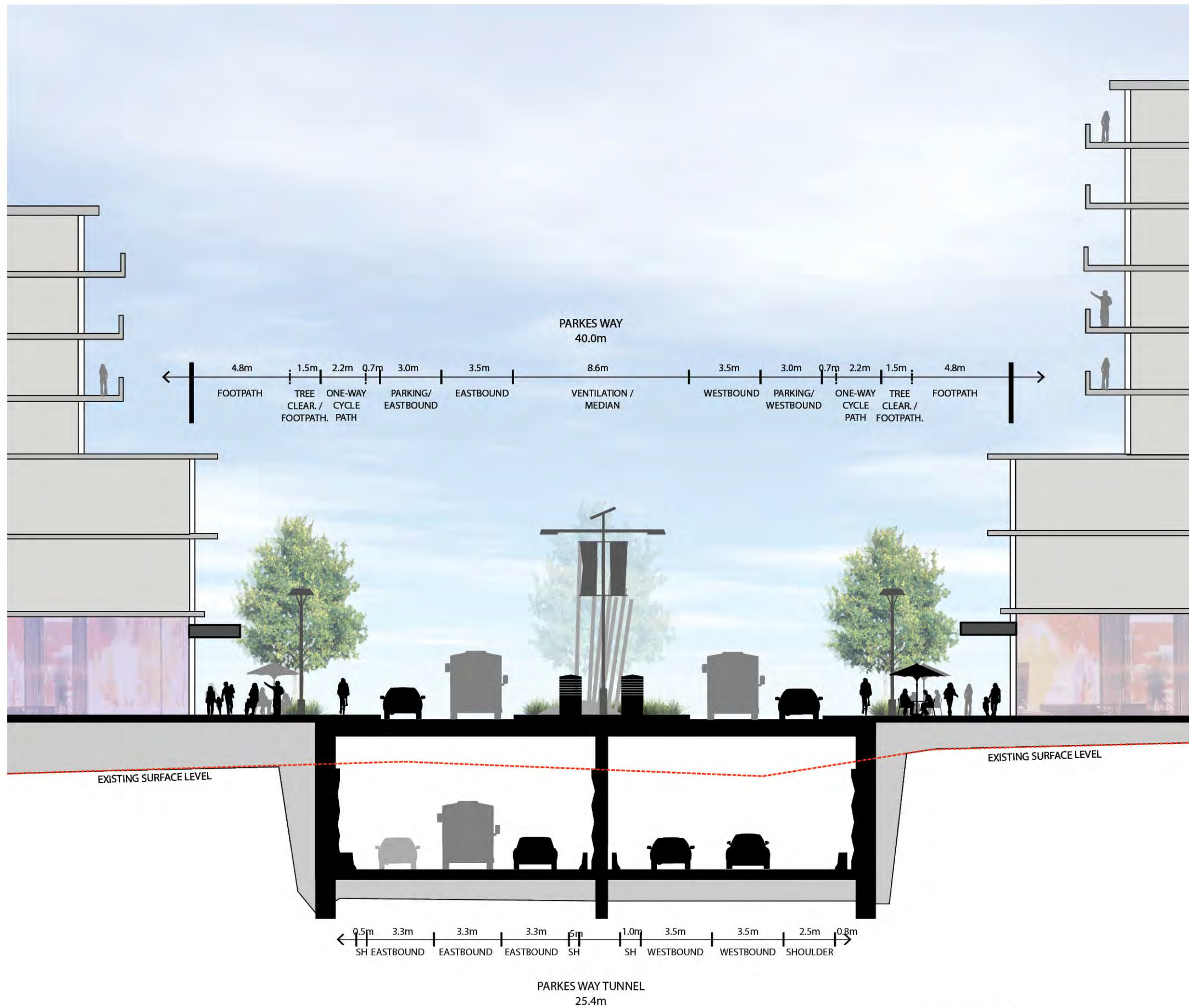
CROSS SECTION



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PARKES WAY
CROSS SECTION BETWEEN NEW WEST ROAD AND COMMONWEALTH AVENUE

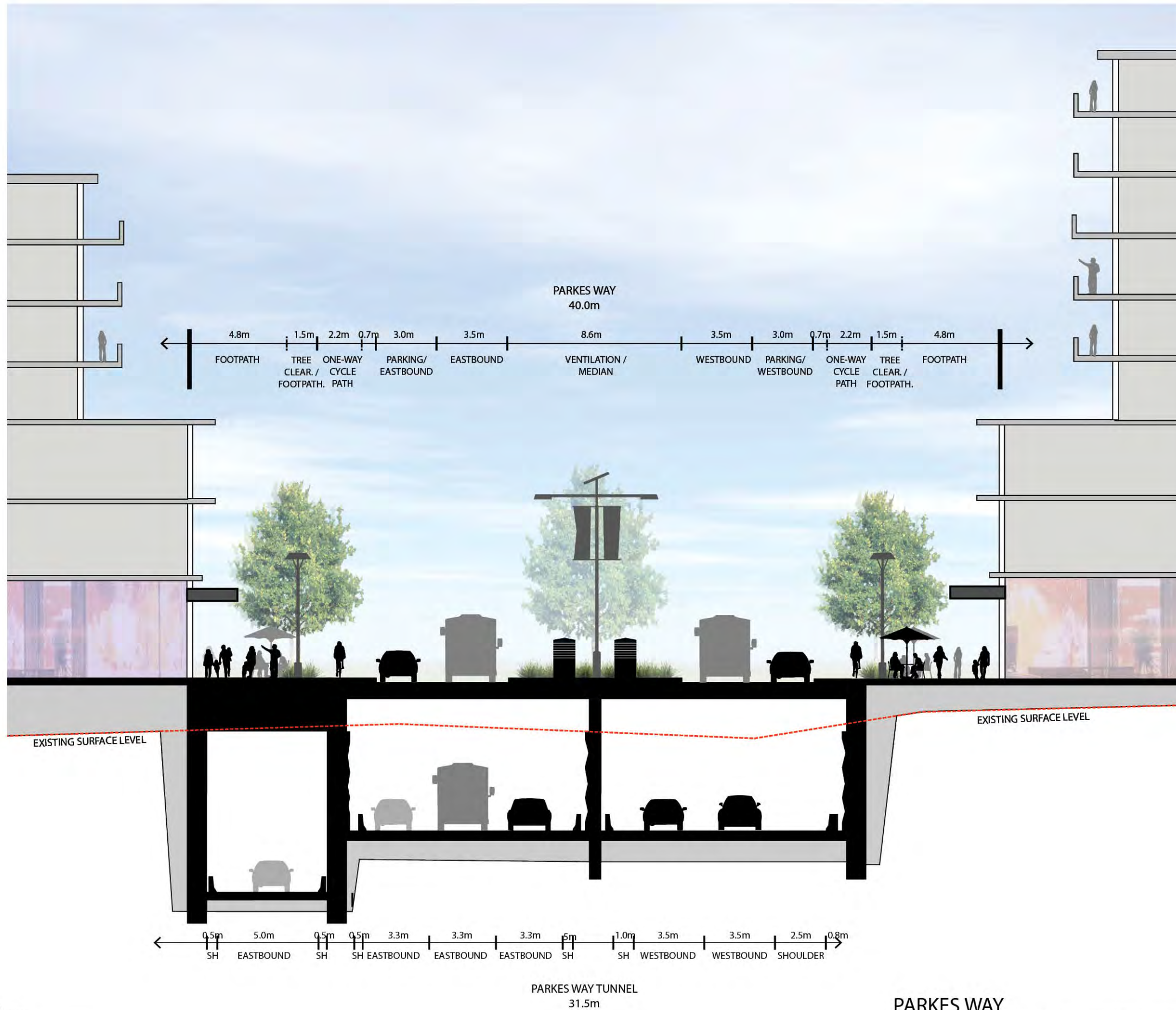
CROSS SECTION



A1
SCALE 1:100
0 1 2 5

PARKES WAY
CROSS SECTION BETWEEN MARCUS CLARKE STREET AND NEW WEST ROAD

CROSS SECTION



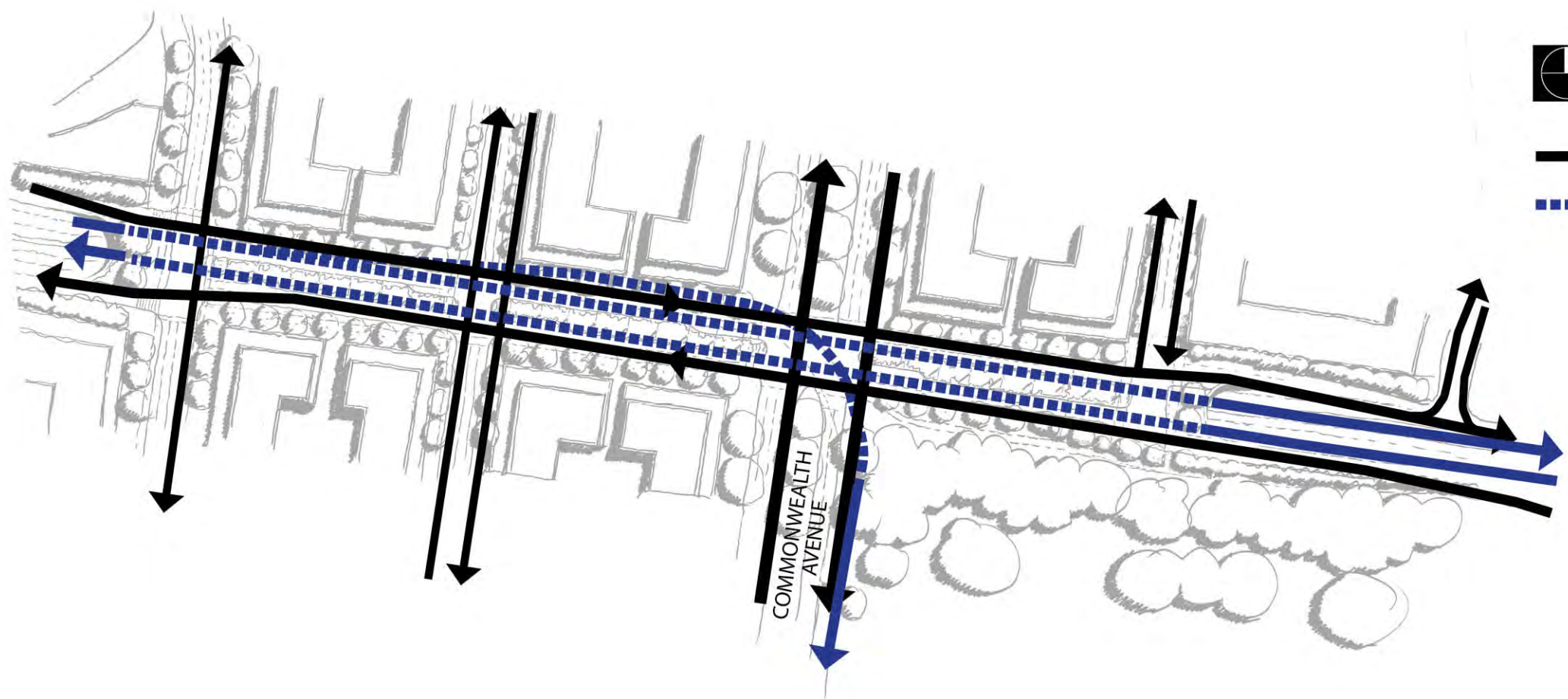
A1
SCALE 1:100
0 1 2 5

PARKES WAY
CROSS SECTION BETWEEN NEW WEST ROAD AND COMMONWEALTH AVENUE





Ⓛ PEDESTRIAN AND CYCLING ACCESS

-  PEDESTRIAN ACCESS
-  CYCLE ACCESS



Ⓛ TRAFFIC FUNCTION

-  GROUND LEVEL STREETS
-  PARKES WAY TUNNEL

Re-engineering Parkes Way and Civic's Southern Road Network

Volume 2 – Constructability Assessment

Project Number: 3002385

Contract Number: 2014.23470.110

Prepared for the ACT Economic Development Directorate

10 December 2014



DOCUMENT CONTROL

Title	Volume 2 – Constructability Assessment			
Prepared for	Economic Development Directorate			
Project No.	3002385			
	Name	Position	Signed/Approved	Date
Originator	Sch 2.2(a)(ii)	Construction Engineer		10 December 2014
Review	Sch 2.2(a)(ii)	Construction Engineer		10 December 2014
Approval	Sch 2.2(a)(ii)	Design Manager		10 December 2014

Details of Revisions

Rev	Date	Description	WVR No.	Approved
01	28 August 2014	Draft – Issued for Client review		
02	10 Dec 2014	Final	003	

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APPENDIX A EDINBROUGH AVENUE INTERSECTION PERFORMANCE ANALYSIS

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1. INTRODUCTION

In 2013 the ACT Government procured an Urban Design Study for the Linking City Centre to the Lake strategy. This study developed a master plan that consisted of numerous design elements including the requirement to undertake significant civil infrastructure works to re-form the street and arterial road grid from City Hill to the West Basin foreshore.

As a major design and cost element of the urban strategy, the Economic Development Directorate (EDD) identified the need to investigate and identify key project risks concerning the major civil infrastructure works associated with the lowering of Parkes Way and adjustment to other major roads within Civic.

This study aims to develop a strategy to mitigate these risks by developing a feasibility design, undertaking constructability and cost assessment, considering the procurement options in the context of the current construction market, and investigating the implications of the project on the local transport network.

This report forms Volume 2 of 6 of the Feasibility Study for the Re-engineering Parkes Way and Civic's Southern Road Network:

- Volume 1 – Feasibility Design
- **Volume 2 – Constructability Assessment**
- Volume 3 – Transport Assessment
- Volume 4 – Procurement Strategies
- Volume 5 – Project Risk
- Volume 6 – Project Cost Estimate

The Constructability Assessment has been undertaken primarily by Tier 1 contractor John Holland. The findings of the assessment are based on experience gleaned on numerous similar major civil construction projects throughout the country, and proposes proven construction techniques and approaches. The assessment provides insight into construction staging, methodology, traffic management and other key construction considerations in the context of the site, its urban setting and the interplay with the City's key east-west and north-south arterial roads.

2. CONSTRUCTION STAGING

2.1 Design Options Considered

Initially a constructability assessment was undertaken on the Feasibility Design presented in Volume 1 of this Feasibility Study. However, following on from the provision of initial cost estimates of the original Feasibility Design, the need to investigate a reduced scale version of the project was identified.

The ambition of the new variant was to reduce the scale and cost of the project, whilst limiting compromises to road network performance and urban design outcomes. To this end, the project team in conjunction with EDD utilised value management principles to undertake an investigations into a number of variants of the original Feasibility Design. This limited optioneering process identified a preferred alternative, Variant 2c, which has subsequently been developed to a pre-concept design level and included in this Feasibility Study.

The commentary presented in the Constructability Assessment concentrates on Variant 2c due to the identified 46% reduction in anticipated cost versus the Feasibility Design Option.

2.2 Construction Staging

A critical element of the constructability assessment is to identify the necessary key stages associated with the construction of the works. Understanding the construction staging of the proposed design provides an appreciation of the project timeframes and likely disruption to the community. It also contributes to the cost estimate for the works and can feed back into the design in order to provide a more constructible and therefore efficient design.

As part of the constructability assessment we have identified five high level construction stages for Variant 2c that will be required to complete the works. The constructability of the Feasibility Design was also assessed, and included a sixth construction stage due to the requirement to build an additional excavated ramp.

Construction Stage	Description of Activities
Stage I	Main works relate to the demolition of existing and construction of new bridges on Commonwealth Avenue, construction of temporary pavement, switching of traffic, relocation of services, and constructing some of the contiguous piles where there is sufficient clearance to traffic. Earthworks carried out at south eastern sector adjacent to Archbishop's residence for widening of corridor.
Stage II	Main excavation of the new alignment takes place between Edinburgh Avenue in the west and Allara Street in the east, westbound traffic on Parkes Way continues to use a temporary side track constructed along the median and then passes under Edinburgh Avenue Bridge on the northern side of the pavement. Eastbound traffic on Parkes Way passes over the Edinburgh ramps and proceeds on the existing Parkes Way alignment before passing under Commonwealth Avenue and continuing on the current pavement to the future Coranderrk Street Intersection. Installation of contiguous piles started in Stage 1 is continued in Stage 2. Those required for the two main carriageways are completed in Stage 2.
Stage III	In this stage the structure over the centre carriageways is built and the service road

	support structure and pavements on each side are built. Traffic is as per Stage 2. Pavements are reconstructed at the extremities of the project
Stage IV	Eastbound and westbound through - traffic on Parkes Way is placed in the newly constructed structure along the new permanent alignment. The northbound ramp on Commonwealth Avenue for the left turn westbound onto Parkes Way is constructed.
Stage V	In this stage the southbound ramp on Commonwealth Avenue for traffic travelling eastbound on Parkes Way and turning right onto Commonwealth is constructed. Temporary bridges on Commonwealth Avenue are removed and fill is placed. Traffic is diverted onto permanent pavement and service roads.

Table 1 - Description of Construction Stages for Variant 2c

Construction Staging drawings have been developed for both the Feasibility Design and Variant 2c. These drawings are contained in the drawing package set that forms Appendix A of the Volume 1 of the Feasibility Design report.

3. CONSTRUCTION ISSUES

3.1 Construction Timeframes

Listed below are the construction durations for Variant 2c.

Construction Stage	Timing	Likely Critical Path Activities
Stage I	15 months	Demolition of existing and construction of new temporary bridges
Stage II	8 months	Installation of contiguous pile walls or excavation
Stage III	9 months	Structure over main carriageways
Stage IV	6 months	Right turn ramp from Parkes to Commonwealth
Stage V	3 months	Removal of temporary bridges and fill construction
Overall Project Duration	41 months	

Table 2 – Construction Time frames for Variant 2C

The Feasibility Design contained an additional ramp and a greater extent of excavation and concrete construction, and it is estimated that it would have required a total of 48 months to construct.

3.2 Construction Approach

Key drivers are to minimise cost and time while maintaining a safe worksite which causes the least disruption to the Canberra public. The site has an extremely high profile which will require construction activities to be carried out in an exemplary fashion.

The construction of Variant 2c has been divided into five stages as defined in Table 1.

Every effort will need to be made in the construction planning and execution to ensure the works activities can proceed without disruption to or interaction with normal traffic flows. Therefore, the excavation and construction of structures between Edinburgh Avenue and Allara Street needs to proceed in an uninterrupted corridor.

Therefore the traffic arrangements are prioritised by demolishing and reconstructing the Commonwealth Avenue Bridges in Stage 1. At the same time, services are relocated and contiguous piles constructed where possible. Traffic diversions will be established and in particular east bound traffic on Parkes way will be diverted over the ramps on Edinburgh Intersection ramps and remain on the existing Parkes Way pavement while west bound will travel along temporary pavements constructed in the existing median and will then travel under Edinburgh Avenue bridge.

This arrangement will enable excavation along the alignment of new carriageways on Parkes Way to be carried out over the full width of the trench and unhindered by cross traffic. Excavated material can be carried along the cut in an easterly direction and emerge near Allara Street where it can then join the normal traffic flows through to Coranderrk Street roundabout without any need to cross major arterial roads. At the same time a low rise fill will

be constructed over a distance of some 400metres at the eastern end of the main alignment terminating at the Coranderrk intersection. Excavated material can also be hauled in a westerly direction and then cross to the south where the material could potentially be used to reclaim the lake foreshore depending on the timeframes for the adjacent developments.

Following excavation of the main cutting in Stage 2 the main structures are constructed on Stage 3. Throughout Stages 1 to 3 it is envisaged that traffic will continue to have the same functional connections between Parkes Way and Commonwealth Avenue that are currently in place.

Stage 4 of the construction is significant in that the through traffic on Parkes Way is placed into the newly constructed cutting and the service roads are also commissioned. This takes place after 32 months into the project. During stage 4 the ramp connecting Parkes Way to Commonwealth Avenue is also completed.

Stage 5 will see the temporary bridges on Commonwealth Avenue either demolished or incorporated into the works. The voids under these bridges may provide a suitable connection between the two commercial zones on either side of Commonwealth Avenue.

3.3 Earthworks & Excavation

3.3.1 Geotechnical conditions

The geotechnical report prepared by Coffey Geotechnics dated 13th January 2014 has been relied upon for the assessment of construction operations. Boreholes BH1 to BH 7 are the most relevant and show the works being excavated variously through fills, residual soils and then down into siltstone.

The deepest excavation on the main carriageway is about 6.5 metres deep at Marcus Clark Street between BH 3 and 4 and terminating at approximately RL 551.8 after allowing for some pavement thickness. At this depth the P wave velocities are about 2200 to 2400m/s. While this parameter alone would indicate marginal rippability the boreholes show the rock to be:

- Low strength (Is50 0.11 to 0.22) with joints at 100mm centres in BH3
- Medium strength (Is50 0.42 to 0.74) with joints at 300mm or less in BH4

The deeper excavation required for the exit ramp from Parkes to Commonwealth is best indicated by BH5 and BH6 however there is no data available on Commonwealth Avenue itself. The excavation descends to RL 549 however Coffey note that this excavation extends into a possible sheared or fault zone. The seismic values at depth are around 2000m/s in this zone however very significant differences were found in the boreholes at RL 549:

- Medium strength (Is50 0.5 to 0.6) with joints at 300mm or less in BH5
- Very low strength (Is50 0.07) with core loss in BH6

Clearly more drilling is required to define the conditions for the exit ramp and design a suitable structure.

3.3.2 Excavation method

For the purposes of this study it has been assessed that the rock is rippable using D9 sized dozers and 30 tonne excavators with rippers. It is assumed the deeper exit ramp will be

located in a zone that is geologically stable or that a suitable structure is designed to address the potential for sheared and faulted siltstone.

The ramp excavation itself is very narrow and is not suited to ripping by dozer. It is likely this material will be excavated using a combination of excavators with rippers and hammers or quite likely surface miners would be used to remove the siltstone.

Surface miners would also be suitable machines to reduce the main carriageways to their final design levels.

Material destined for haulage over public roads would be loaded into trucks and dogs. Material used for closer placing in fills or stockpiles that did not have to be hauled along operating roads could be hauled in articulated all-wheel drive haul trucks.

3.3.3 Comments on rippability as characterised by boreholes down to RL 549

The assessment of rippability is described in Table 3 below and is based on the borehole data and descriptions provided in the Coffey report. It does not incorporate outcomes of the seismic assessment also undertaken by Coffey.

Hole	Condition	Hardness	Jointing	Comment
BH 01	2.5m OTR then HW siltstone	Is50 0.07 – 0.2	100-300	Easily excavated and ripped
BH 02	2.5m OTR then XW to HW siltstone	Is50 0.05 – 0.43	100-300	Easily excavated and ripped
BH 03	5.45m OTR then HW siltstone	Is50 0.04 – 0.22	100-300	Easily excavated and ripped
BH 04	2.0m OTR then MW siltstone	Is50 (av 0.6) 0.02 – 1.24	100-300	Readily ripped, more competent rock
BH 05	2.0m OTR then HW to MW siltstone	Is50 (av 0.51) 0.3 – 0.93,	100-300	Readily ripped, more competent rock
BH 06	4.0m OTR then XW siltstone	Is50 0.04 – 0.1	NR	Very weak material only marginally competent
BH 07	1.3m OTR then XW-HW-MW siltstone	Is50 0.3 – 0.76	100-900	Weak material trending to competent. Easy to moderate ripping
BH 08	1.5m OTR then MW-SW-FR siltstone, grey colour	Is50 (av 2.3) 0.83 – 5.79	100-900	Not rippable, especially in confined excavation (outside scope of excavation)
BH 09	1.5m OTR then FR siltstone, grey colour	Is50 3.48 – 8.4	100-2000	Not rippable anywhere (outside scope of excavation)
BH 10	4.3m OTR then MW-SW siltstone, grey colour	Is50 (av 1.1) 0.05 – 1.9	50-300	Rippable.(outside scope of excavation)

Table 3 – Comments on rippability down to RL 549

3.3.4 Stockpiling, material re-use or disposal

Given the level of detail developed as part of the Feasibility Study for both the Feasibility Design and Variant 2c options, it is not considered appropriate at this stage to undertake a detailed analysis of cut-fill balance for the construction of the works. Notwithstanding this, it is clear that the Parkes Way lowering works will generate a surplus of material. The material derived from the cut will be suitable for general fill though it is unlikely to yield sound material for use in select subgrade or rockfill.

To minimise costs and construction impacts it is most desirable to maximise the use of cut material on site. This eliminates the need to pay to haul off site and then haul new material back onto the sites for redevelopment. This strategy also significantly reduces the impact on public road users and damage to these roads.

Likely locations for the disposal of cut material include:

- Fill at eastern end of main carriageway through to Coranderrk St.
- Lake foreshore reclamation at south west corner of project.
- Filling to London Circuit.
- Filling to the Parkes Boulevard service roads.
- Filling to future block developments and associated road network.

3.4 Groundwater

3.4.1 Groundwater assessment

The assumptions regarding the impact of groundwater on the excavation and structures are drawn from the SMEC Groundwater Investigation Report dated 1st April 2014. Should Variant 2c be the preferred option for design development, groundwater results from BH08, 09 and 10 are not relevant as no excavation will take place near these boreholes.

In essence the following comment from Section 5 of the groundwater report strongly influenced the construction assumptions:

The permeability of the bedrock is low, ranging from 0.0001m/day to 0.1m/day and inflows are expected to be low in the order of 1 m³/day are anticipated into the excavation.

In paragraph 4.4 it is stated that initial construction inflows may be an order of magnitude higher – say 10m³/day.

3.4.2 Management of groundwater during construction

The inflows assessed in the groundwater assessment are very low and do not present an issue of significance in construction. If this initial groundwater assessment is confirmed to be correct by future more detailed investigations then pumping during construction would be limited to a few localised sump pumps.

The suggestion made in the groundwater report that conventional dewatering systems consisting of dewatering bores on each side of the excavation may be conservative and there could be potential savings if future investigations confirm that this level of dewatering is not required.

3.4.3 Groundwater disposal

If the small volumes anticipated in the preliminary groundwater assessment report are borne out in reality then the groundwater could potentially evaporate before it could be extracted. Any water that was gathered in sumps would be directed to water carts for use in dust suppression.

3.4.4 SMEC report limitations

The SMEC Groundwater Investigation Report refers to limitations in the amount of data gathered:

While the lack of information and data makes it difficult to verify the water levels across the model domain, simulated groundwater levels match the observed data at bore locations. It is, therefore, assumed that the local impact of proposed construction may be estimated with an acceptable level of accuracy in terms of inflows and local draw-downs. It is important to note that any additional data point might impact the gradient assumed for this scenario and hence the inflows will be affected subsequently. It is strongly recommended that more data be collected in a spatial context before any decision is made.

The report does not eliminate the possibility of a more permeable direct connection between the lake and the future excavation but the initial results look quite promising. The cost assessment has included for measures to exclude water below RL 556 however should such very low permeability results continue to be realised this inclusion may be significantly reduced.

3.5 Urban Environment

3.5.1 Blasting and difficult excavation

With the feasibility moving towards Variant 2c, the avoidance of hard rock excavation as characterised by BH08 to BH10 would seem to be eliminated.

It's important for the design to eliminate the need to excavate this hard rock. Its excavation could only be carried by slow and noisy hammering or using very small blasts using blasting mats. Properties are located only 50 to 100 metres away. It could be anticipated that excavation rates increase to more than \$120/m³ in this hard rock area.

For the remaining borehole sites blasting would not be required. This is based on the measured rock hardness and jointing in BH01 to BH07 taken together with the seismic values shown in Figure 2 of the Geotechnical Assessment Report.

3.5.2 Curfews

Normal work hours for this project would be 7am to 5pm Monday to Friday with Saturdays 7am to 3pm.

3.6 Traffic Management Variant 2c

The need to maintain essentially uninterrupted traffic flows in the context of cost minimisation and timely and safe construction dominates this construction planning process.

As previously stated, Variant 2c contains five construction stages.

3.6.1 Stage 1

Consists of the demolition of existing and construction of new bridges on Commonwealth Avenue, construction of temporary pavement, switching of traffic, relocation of services, and constructing some of the contiguous piles where there is sufficient clearance to traffic. Earthworks carried out at south eastern sector adjacent to Archbishop's residence for widening of corridor.

Traffic flows will undergo the following changes in this stage:

1. North and Southbound traffic on Commonwealth Avenue where it crosses Parkes Way will be diverted onto shared carriageways while the bridges are demolished and reconstructed. This will mean the north and southbound flows will temporarily share the same carriageway with concrete barrier dividers providing protection. The traffic will switch over the median on new temporary pavements.
2. Parkes Way eastbound traffic will be diverted off the main carriageway west of the Edinburgh Avenue Bridge and will use the existing ramps at Edinburgh Intersection before re-joining the existing Parkes Way pavement and flowing through to Coranderrk Intersection.
3. Parkes Way westbound traffic will enter a new temporary pavement constructed on the Parkes Way median. This will commence at the Coranderrk roundabout and continue under the Commonwealth Avenue Bridges before then being diverted onto the existing northern pavement of Parkes Way under the Edinburgh Avenue bridge. West of this bridge the west bound traffic will be diverted back onto the southern side of Parkes Way.
4. The left turn from Parkes Way into Commonwealth Avenue will have traffic protection installed while excavation proceeds to the south for a new carriageway.
5. The left turn from Commonwealth Avenue into Parkes Way will similarly have traffic protection installed while earthworks for a new pavement takes place to the south. This traffic will be diverted onto a new alignment under the Edinburgh Avenue Bridge.
6. The existing two traffic loops on each side of Commonwealth Avenue and north of Parkes Way will remain in use.

3.6.2 Stage 2 and Stage 3

1. The left turn from Parkes Way into Commonwealth Avenue will now be directed onto the new carriageway to the south to enable excavation of the main carriageways to proceed.
2. The left turn from Commonwealth into Parkes Way will similarly be directed onto its new temporary pavement to the south to enable main carriageway excavation to proceed.
3. Traffic to and from the National Museum uses Liversidge Street through the southern portion of the ANU campus.

3.6.3 Stage 4

1. Parkes Way through traffic is now placed on the new carriageways.

2. Left turn from Commonwealth Avenue to Parkes Way is now placed on the new surface service road.
3. Commonwealth Avenue southbound traffic will be directed onto the northbound carriageway in a shared arrangement to enable construction of the right turn ramp from Parkes way to be completed.
4. Staged traffic controls will be required on the eastern end of the project to enable pavement adjustments at Coranderrk Street intersection through to Anzac Parade.
5. Capacity for left turn from Parkes Way to Commonwealth Avenue is temporarily reduced while new service road pavement is constructed.

3.6.4 Stage 5

1. If the temporary bridges located on Commonwealth Avenue are to be removed, traffic diversions to enable shared use of the carriageways by northbound and southbound traffic will be required in the same manner as their initial construction.
2. Service roads and traffic integration are completed.
3. Traffic diversion using Liversidge to the National museum is restored.
4. Right turn from Parkes to Commonwealth Avenue is commissioned.

3.6.5 London Circuit works

The construction for London Circuit will require fill to enable an at grade intersection to be constructed at the London Circuit bridges. From a cost perspective it would be desirable to use the excavated material from Parkes Way to carry out this filling.

A staging arrangement for the construction of London Circuit has been developed that involves the construction of temporary ramps and realignment of the existing loop ramps, in order to divert London Circuit to an offline alignment, allowing the regrading of London Circuit. Alternatively, London Circuit could be temporarily blocked in this section to be filled each side of Commonwealth Avenue with traffic being diverted to alternative routes.

3.6.6 Implications of the Feasibility Design on traffic management

The Feasibility Design will introduce additional and far more complex traffic staging in Commonwealth Avenue due to the need to construct two ramps descending down through the median. This would have required additional temporary pavements and traffic switches for both the north and southbound carriageways.

3.6.7 Impacts on Edinburgh St Interchange

As noted above, the construction staging has identified the need to divert eastbound Parkes Way Traffic through the Edinburgh Avenue interchange. In order to understand the level of intersection performance throughout the period of this diversion, intersection modelling has been undertaken on the interchange.

The intersection modelling has extracted traffic volumes from the 2021 CSTM as the basis for the SIDRA analysis. The results of the intersection modelling is summarised in Table 4 and

has indicated that the following performance can be anticipated during the construction of the Parkes Way lowering:

Peak Period	Average Intersection Delay	Intersection Level of Service
2021 AM Peak	62.7	E
2021 PM Peak	79.8	E

Table 4 – Intersection Performance of the Edinburgh St Interchange

Detailed output of the SIDRA analysis is contained in Appendix A of this report. Further discussion on the traffic modelling approach and methodology is contained in Volume 3 of the Feasibility Study.

APPENDIX A

EDINBROUGH AVENUE INTERSECTION PERFORMANCE ANALYSIS

1.1 Parkes Way – Edinburgh Avenue Intersection Analysis

The purpose of conducting the SIDRA intersection of Parkes Way – Edinburgh Avenue is to investigate the closure of Parkes Way at the Edinburgh Avenue interchange, due to construction works requiring the closure of this section of Parkes Way.

The turn volumes were extracted from the EMME Canberra Strategic Transport Model (CSTM) for the Business as Usual scenario in the 2021 AM and PM peak periods. The interchange is comprised of two intersections, as shown below:

1. Figure 1: shows Parkes Way eastbound – Edinburgh Avenue northern intersection in Parkes Way Open scenario,
2. Figure 2: shows Parkes Way westbound – Lawson Crescent southern intersection in Parkes Way open scenario,
3. Figure 3: shows Parkes Way eastbound – Edinburgh Avenue northern intersection in Parkes Way closure scenario, and
4. Figure 4: shows Parkes Way westbound – Lawson Crescent southern intersection in Parkes Way closure scenario.

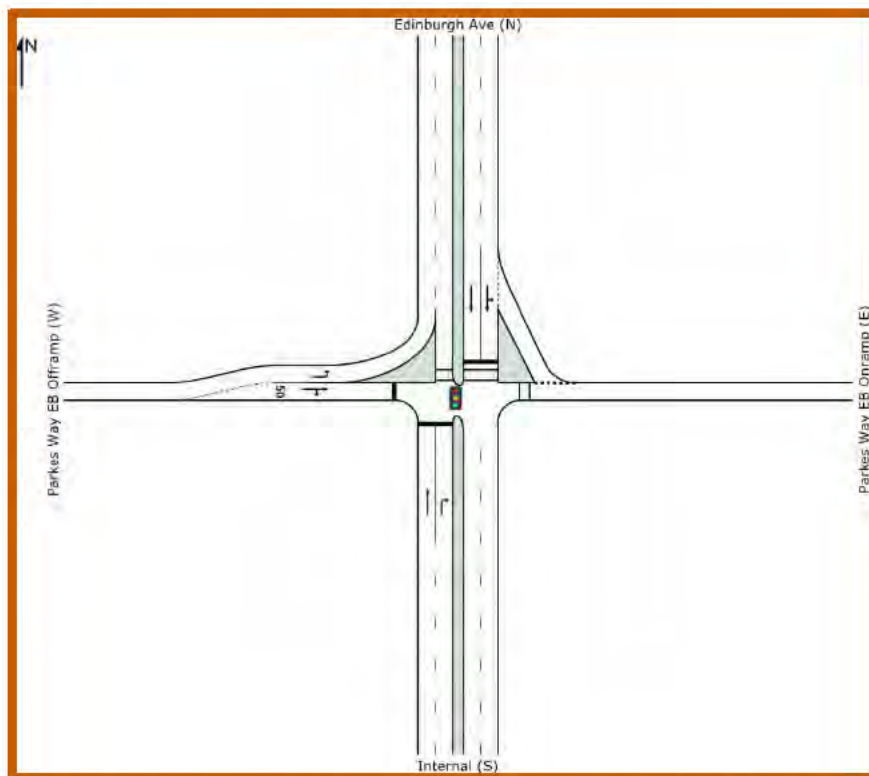


Figure 1: 2021 Parkes Way EB – Edinburgh Avenue (Northern) (Parkes Way Open Scenario)

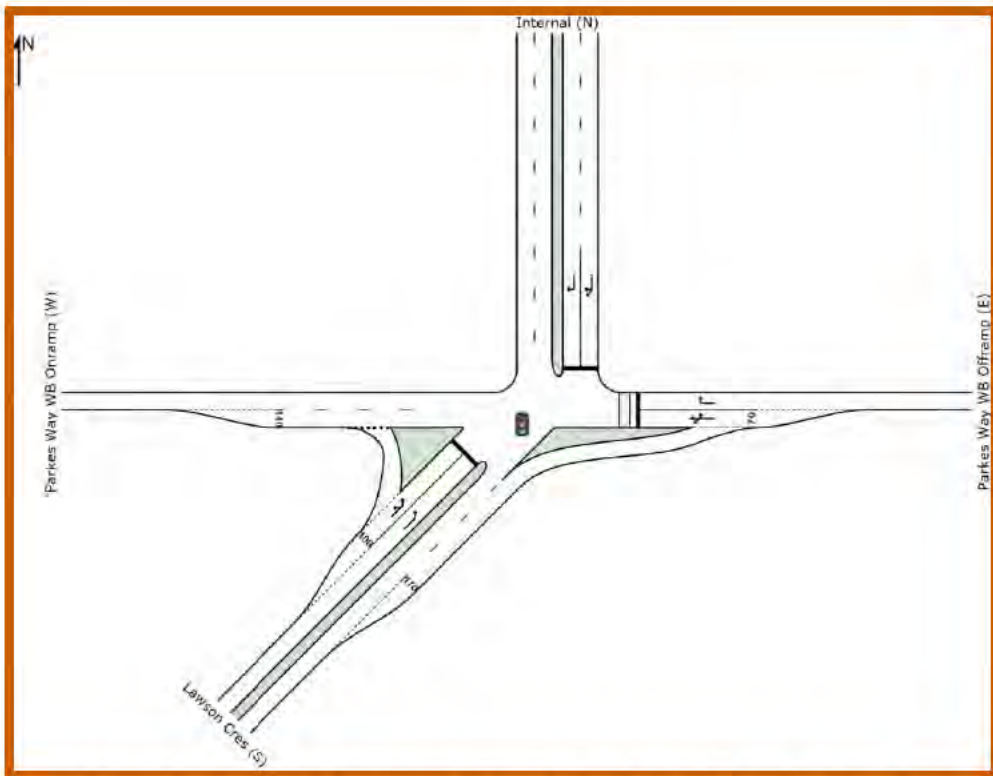


Figure 2: 2021 Parkes Way WB – Lawson Crescent (Southern) (Parkes Way Open Scenario)

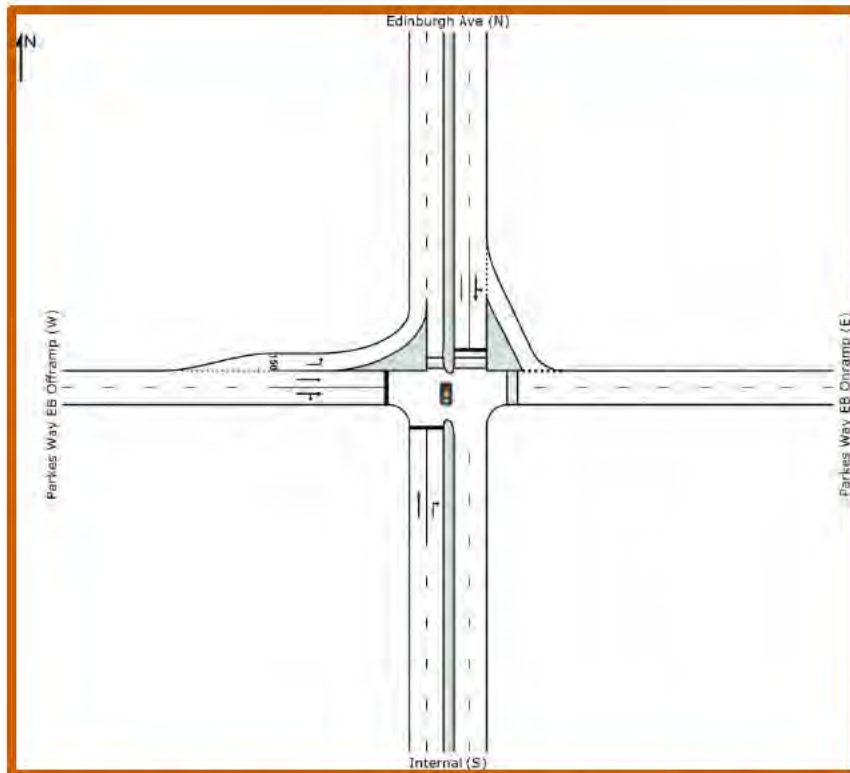


Figure 3: 2021 Parkes Way EB – Edinburgh Avenue (Northern) (Parkes Way Closure Scenario)

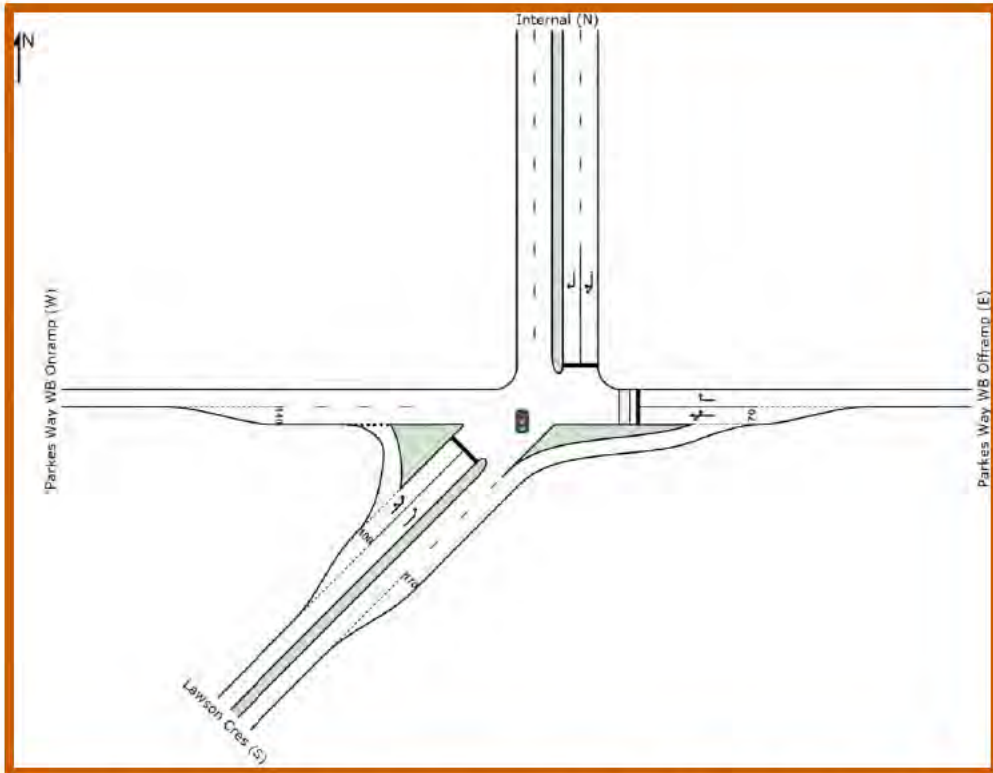


Figure 4: 2021 Parkes Way WB – Lawson Crescent (Southern) (Parkes Way Closure Scenario)

1.2 Parkes Way – Edinburgh Avenue Turns Counts

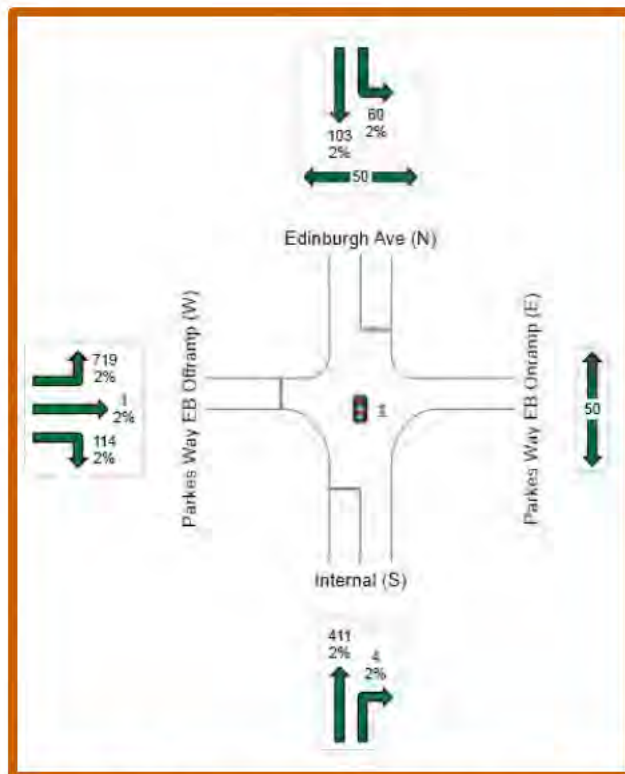


Figure 5: 2021 AM Parkes Way EB – Edinburgh Avenue Counts (Northern) (Parkes Way Open Scenario)

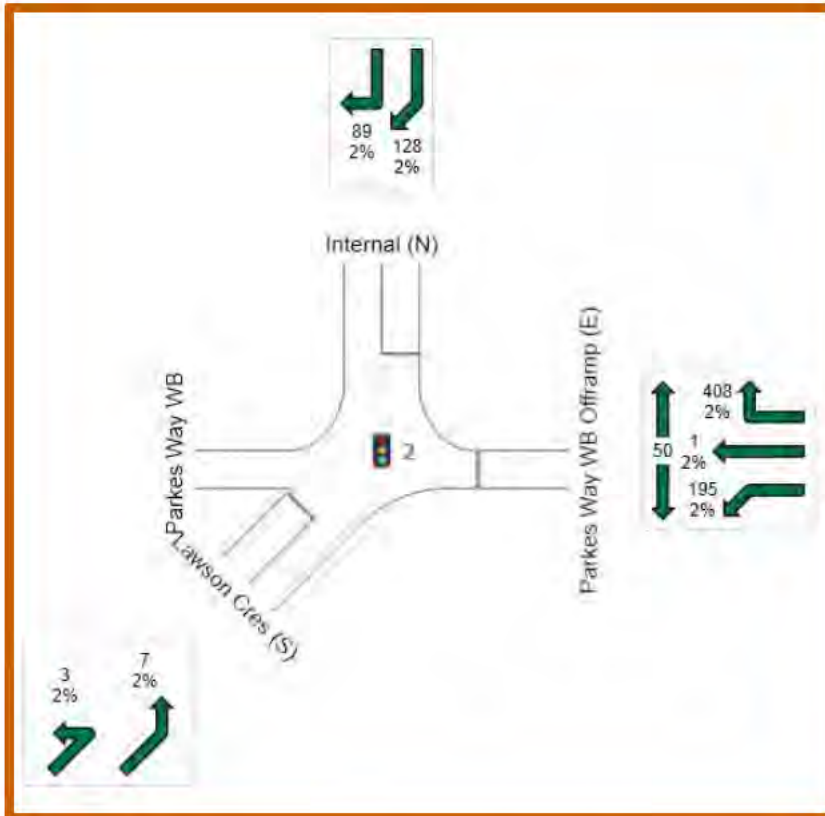


Figure 6: 2021 AM Parkes Way WB – Lawson Crescent Counts (Southern) (Parkes Way Open Scenario)

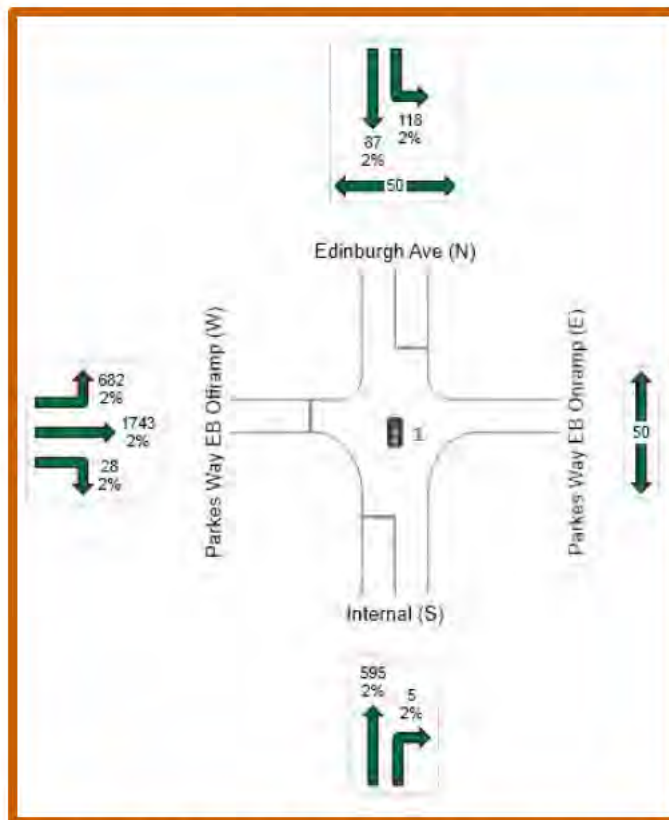


Figure 7: 2021 AM Parkes Way EB – Edinburgh Avenue Counts (Northern) (Parkes Way Closure Scenario)

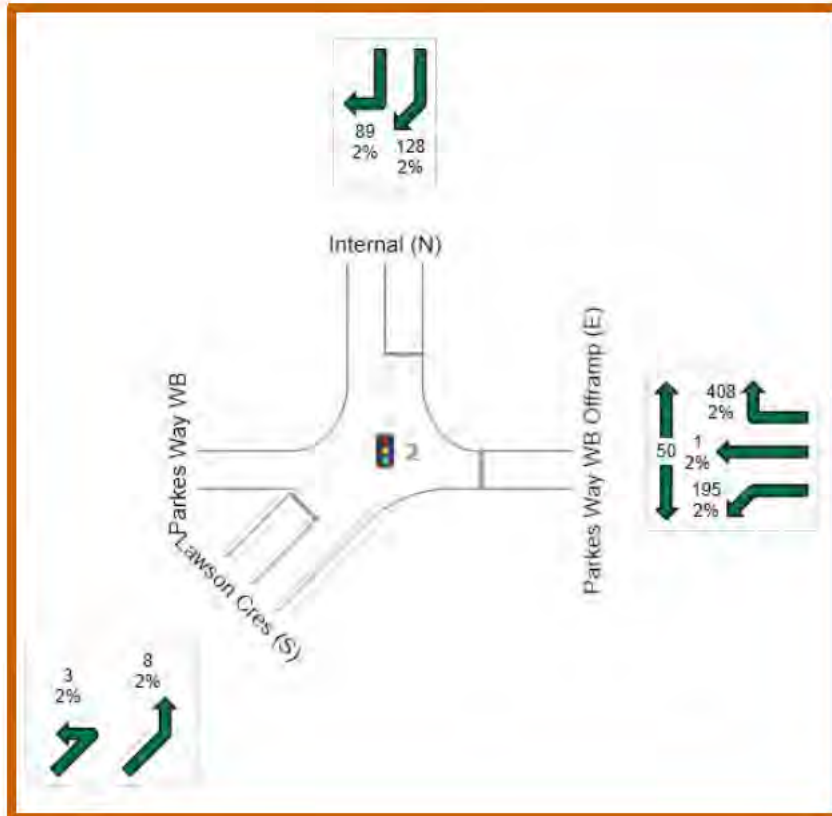


Figure 8: 2021 AM Parkes Way WB – Lawson Crescent Counts (Southern) (Parkes Way Closure Scenario)

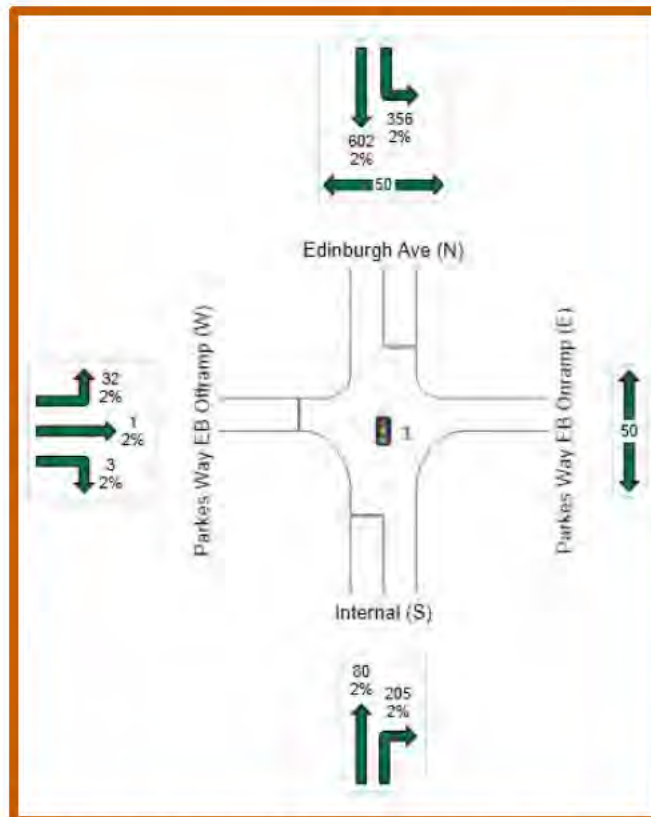


Figure 9: 2021 PM Parkes Way EB – Edinburgh Avenue Counts (Northern) (Parkes Way Open Scenario)

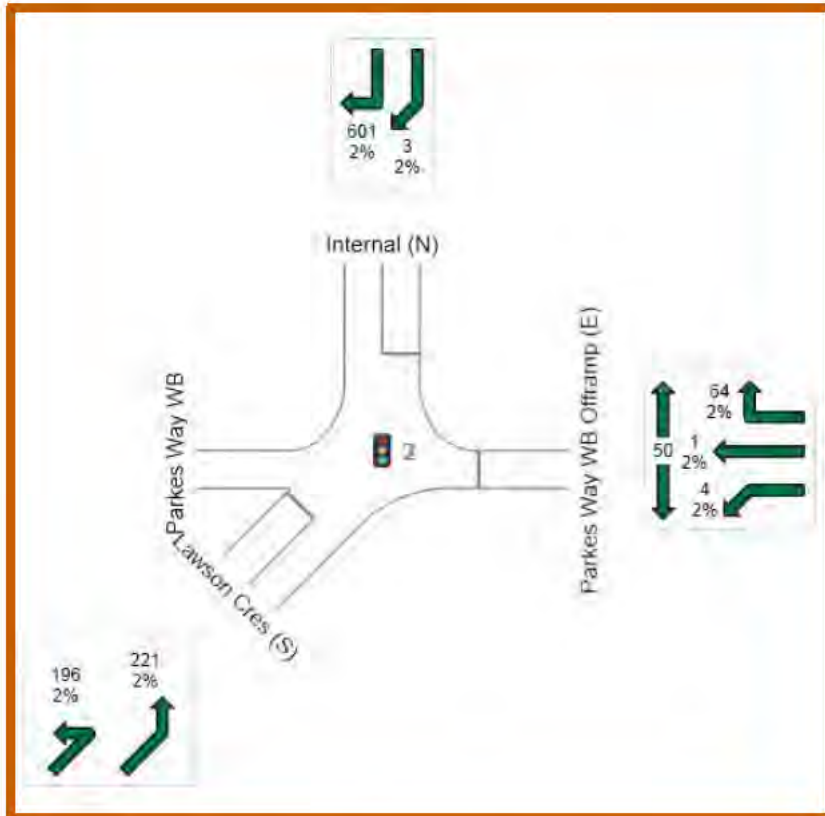


Figure 10: 2021 PM Parkes Way WB – Lawson Crescent Counts (Southern) (Parkes Way Open Scenario)

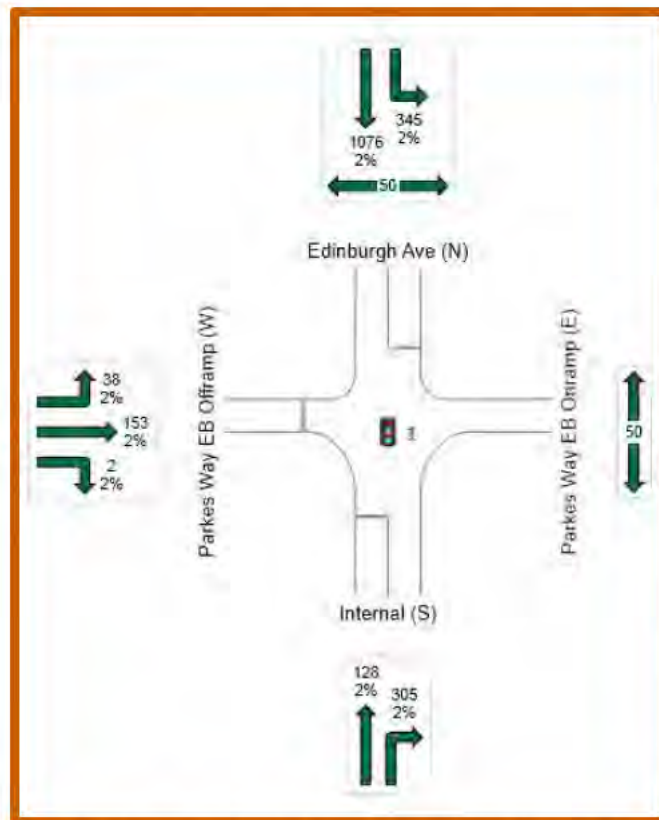


Figure 11: 2021 PM Parkes Way EB – Edinburgh Avenue Counts (Northern) (Parkes Way Closure Scenario)

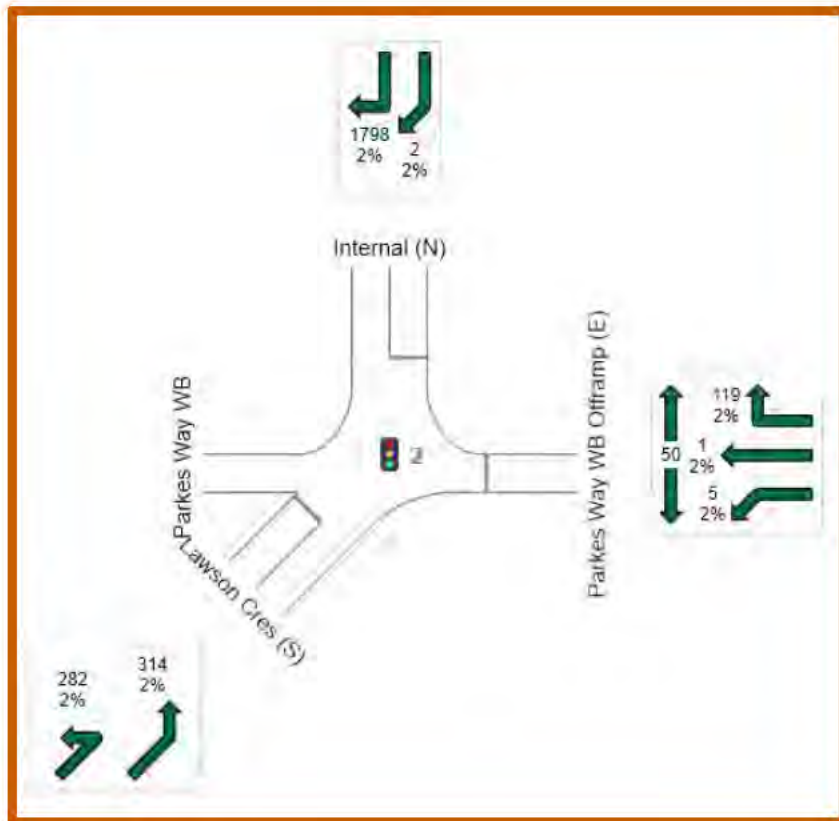


Figure 12: 2021 PM Parkes Way WB – Lawson Crescent Counts (Southern) (Parkes Way Closure Scenario)

1.3 Intersection Performance

The HCM2010 Level of Service criteria by which the intersection performance is assessed are given in Table 1.

Table 1: HCM Level of Service Criteria (Average Delay D in Seconds)

Level of Service	Signals	Give-Way/Roundabout
A	$D < 10 \text{ s}$	$D < 10 \text{ s}$
B	$10 \text{ s} \leq D < 20 \text{ s}$	$10 \text{ s} \leq D < 15 \text{ s}$
C	$20 \text{ s} \leq D < 35 \text{ s}$	$15 \text{ s} \leq D < 25 \text{ s}$
D	$35 \text{ s} \leq D < 55 \text{ s}$	$25 \text{ s} \leq D < 35 \text{ s}$
E	$55 \text{ s} \leq D < 80 \text{ s}$	$35 \text{ s} \leq D < 50 \text{ s}$
F	$D \geq 80 \text{ s}$ or $V/C > 1$	$D \geq 50 \text{ s}$ or $V/C > 1$

Source: Highway Capacity Manual 2010, Exhibits 18-4 (p.18-6), 19-1 (p.19-2) and 21-1 (p.21-1)

The performance for each intersection and the combined result for the intersection, are included below. The intersections have been analysed using the network analysis tool in SIDRA Intersection 6, which replaces the closely spaced method that would previously have been used for this analysis. The network analysis considers the impact of upstream effects, such as queues, on the performance of adjacent intersections, and thus provides more realistic results for the individual intersections.

The through traffic on Parkes Way in the “Parkes Way Open” scenario has been used to determine the weighted average for all traffic using the interchange in that scenario.

Table 2: Parkes Way – Edinburgh Avenue Intersection Performance Results

Peak Period	Location	Parkes Way Open Scenario			Parkes Way Closure Scenario		
		Average Delay [s]	Level of Service	Maximum Queue [m]	Average Delay [s]	Level of Service	Maximum Queue [m]
2021 AM	North	10.2	B	West: 28.7	67.9	E	West: 593.7
	South	37.2	D	East: 114.7	42.3	D	East: 123.1
	<i>Combined</i>	20.2	C		62.7	E	
2021 PM	North	37.7	D	North: 173.8	35.5	D	North: 181.8
	South	12.0	B	South: 50.1	114.3	F	South: 690.7
	<i>Combined</i>	25.9	C		79.8	E	

Re-engineering Parkes Way and Civic's Southern Road Network

Volume 3 – Transport Assessment

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Prepared for the ACT Economic Development Directorate

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APPENDIX A: STRATEGIC TRANSPORT MODELLING ROAD NETWORK ASSUMPTIONS

APPENDIX B: CANBERRA STRATEGIC TRANSPORT MODEL TRAFFIC FLOW DIAGRAMS

APPENDIX C: INTERSECTION TURNING MOVEMENT VOLUMES

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1 INTRODUCTION

In 2013 the ACT Government procured an Urban Design Study for the Linking City Centre to the Lake strategy. This study developed a master plan that consisted of numerous design elements including the requirement to undertake significant civil infrastructure works to re-form the street and arterial road grid from City Hill to the West Basin foreshore.

As a major design and cost element of the urban strategy, the Economic Development Directorate (EDD) identified the need to investigate and identify key project risks concerning the major civil infrastructure works associated with the lowering of Parkes Way and adjustment to other major roads within Civic.

This study aims to develop a strategy to mitigate these risks by developing a feasibility design, undertaking constructability and cost assessment, considering the procurement options in the context of the current construction market, and investigating the implications of the project on the local transport network.

This report forms Volume 3 of 6 of the Feasibility Study for the Re-engineering Parkes Way and Civic's Southern Road Network:

- Volume 1 – Feasibility Design
- Volume 2 – Constructability Assessment
- **Volume 3 – Transport Assessment**
- Volume 4 – Procurement Strategies
- Volume 5 – Project Risk
- Volume 6 – Project Cost Estimate

The Transport Assessment aims to review the implications of the proposed project on the local road network and develop an understanding of how the network will perform as a result of the works. The analysis develops a strategic model for the project and undertakes intersection analysis based on the results of the strategic model. It does this for three scenarios during AM and PM peak periods in 2021 and 2031.

It is noted that independent of the City to the Lake suite of projects, the City Plan and various elements of the National Capital Plan set out objectives for the development of the city centre and the operation of the local road network. In particular, these seek to create a lower speed, reduced traffic environment that discourages through traffic in the city centre and utilises the peripheral arterial road and Parkway systems to convey north-south traffic. The Feasibility Design has been developed consistent with this philosophy, and this transport assessment has been undertaken noting these objectives.

2 MODELLING APPROACH

2.1 Transport Modelling

Our conventional approach to traffic modelling for a project such as this would normally involve three levels of traffic modelling, with each stage feeding into the next.

2.1.1 Strategic Transport Modelling

Strategic transport modelling is used to generate high level forecasts for general traffic movements on major roads. Future models are developed from a base model that has been calibrated to match observed trip generation and cordon volumes, with growth effected internally from changes in land use over time. It is based on assumptions regarding the speed and capacity of each road in the network, and the traffic production and attraction of each zone in the model. The routes chosen by traffic during the assignment are based solely on the cost of travel. Two roads with the same speed limit are generally treated the same, even though in reality the travel behaviour on each may be different. It is often also used to generate inputs for the growth calculations necessary for micro-simulation modelling of future scenarios.

The Canberra Strategic Transport Model (CSTM) that is used by SMEC is a *four step model*, in that it performs the following four steps:

- Trip Generation
- Trip Distribution
- Mode Choice
- Traffic Assignment

2.1.2 Micro-simulation Modelling

Micro-simulation modelling is used to determine the street-level performance of the network. Future models are developed from a base model that has been calibrated to match existing observed turning movement volumes, with growth calculations performed using output from the strategic model. Because of this, with appropriate calibration, the future models can be relied upon to more accurately reflect the travel patterns throughout the road network than in a strategic model. The individual roads and intersections are configured to match the existing configuration or expected design. The operational network capacity and resulting performance are a function of the interaction between the vehicles and the network. It is often also used to generate turning movement volumes for the intersection modelling.

2.1.3 Intersection Modelling

Intersection modelling is used to determine the individual performance of each intersection in the model. Empirical models are generally used, which require knowledge of the existing or expected geometry, intersection behaviour and turning movement volumes. For future models, these volumes can come from a strategic transport model, however ideally they would come from a micro-simulation model.

2.2 Modelling Approach

Previous traffic modelling for the Urban Design Strategy (UDS) employed all three levels of modelling to maximise the accuracy of the final intersection modelling. However, due to the impending development of a mesoscopic model for the project area, direction was given to the project team to bypass the micro-simulation stage of the modelling. The rationale for this decision was based on the fact that it is anticipated that the mesoscopic model would be a

more appropriate tool to use given the scale of the project site being considered, and therefore it would yield results that would supersede those generated by the proposed micro-simulation model. As such, the turning movement volumes used for the intersection models were derived from the strategic model results.

2.3 Model Scenarios

The transport modelling undertaken as part of the Feasibility Study considered the AM and PM peak periods for the 2021 (assumed project opening) and 2031 horizon years. This was done in the context of the three scenarios described below.

2.3.1 Business as Usual

The Business as Usual (BAU) scenario has been developed to create a baseline model for the purpose of comparison with the proposed project scenarios. It assumes the current land development and road upgrades proposed in the National Capital Plan and the Territory Plan, and does not consider any of the development proposed as part of the Linking City to the Lake Strategy or Parkes Way lowering works.

2.3.2 Feasibility Design

The Feasibility Design has been developed to test the feasibility of the proposals contained in the Urban Design Strategy (UDS). It reflects as closely as practicable the design intent of the arrangements proposed in the UDS, whilst providing refinements to address issues that were identified during the study.

2.3.3 Variant 2c

Following on from provision of initial cost estimates of the original Feasibility Design, the need to investigate a reduced scale version of the project was identified. The ambition of the new variant was to reduce the scale and cost of the project, whilst limiting compromises to road network performance and urban design outcomes. To this end, the project team, in conjunction with EDD, utilised value management principles to undertake an investigation into a number of variants of the original Feasibility Design. This limited process identified a preferred alternative, Variant 2c, which has subsequently been developed to a pre-concept design level and included in this Feasibility Study.

2.4 Study Limitations

A micro-simulation model is typically calibrated using observed traffic count data for a particular year and period, and thus it can be relied upon to represent the actual traffic flows for the period in which the traffic count data was surveyed. In contrast, the CSTM generates trips based on land use and distributes them according to attractiveness factors between regions in the model. The assignment of traffic in the CSTM is based on generalised speed and capacity information for roads in the model. The CSTM is calibrated to observed counts, but to "screenline" cordons on a city-wide basis, rather than at an individual turning movement level as is the case of the micro-simulation model. The micro-simulation calibration is typically much more finely detailed, and it's common for a well calibrated micro-simulation model to closely match almost all of the turning movement inputs to within a few percent.

In micro-simulation modelling studies, the CSTM is used to generate future growth rates that are then applied to the calibrated micro-simulation model. These growth rates are a result of land use and road network developments and don't require any special assumptions.

Given the above, we note the likelihood of discrepancy between the traffic volume estimates output by the CSTM and the actual observed counts at individual locations at the site. Indeed, such inconsistencies have been apparent between observed traffic counts and the strategic

model (refer Section 3.3). Due to the scope defined for this study, and in particular the absence of micro-simulation modelling as part of the transport assessment process, the intersection modelling was required to be undertaken based on volumes extracted from the CSTM. However it is anticipated that the future development of a mesoscopic model for the site will more closely calibrate the modelling to observed traffic volumes and allow for a more precise understanding of network and intersection performance.

3 CANBERRA STRATEGIC TRANSPORT MODEL

The latest calibrated Canberra Strategic Transport Model (CSTM) was used to generate the expected turn volumes at each of the considered intersections within the study area.

The network configurations for each of the three scenarios (detailed below in Section 3.2) were coded into the CSTM. The models have been run in 2021 and 2031, for both the AM and PM peak periods. The CSTM is nominally an AM peak model, so the PM peak results have been produced by transposing the trips in the Origin-Destination (OD) assignment matrix that is generated by the AM model, and then reducing the total number of trips by 10%. As such the PM peak model has not been calibrated, and its results should be evaluated in this limited context.

3.1 Road Network and Parking Assumptions

The CSTM includes the road network assumptions listed in Appendix A.

The parking cost assumptions for the modelling are included in Table 1. These costs represent the Central case parking cost scenario that has been approved for use by the ACT Environmental and Planning Directorate.

Table 1: Parking Costs

Year	Work Trips (Daily)		Other Trips (Hourly)	
	City	Other	City	Other
2011	\$11.25	\$5.63	\$2.25	\$1.13
2021	\$18.07	\$11.33	\$4.29	\$2.69
2031	\$19.96	\$12.49	\$4.74	\$2.97

3.2 Road Network Scenarios

A *Business as Usual* scenario, as well as two *Master Plan* scenarios, have been evaluated. The following scenarios were modelled for both the AM and PM peak periods in the 2021 and 2031 horizon years, using the CSTM:

- *Business as Usual*
This scenario includes only committed and expected road- and land-use developments. The road network is shown in Figure 1.
- *UDS Feasibility Design*
This scenario includes the UDS land use and the latest revision of the study area road network from the Feasibility Design. The road network is shown in Figure 2, and includes the following changes compared to *Business as Usual*:
 - Parkes Way Boulevard between Edinburgh Avenue and Coranderrk Street,
 - Parkes Way eastbound to Commonwealth Avenue southbound ramp,
 - Commonwealth Avenue northbound to Parkes Way westbound ramp,

- Allara Street full access intersection with Parkes Way Boulevard.

- **Variant 2c**

This scenario includes the UDS land use and the latest revision of the road network design. The study area road network is shown in Figure 3 and includes the following changes compared to *Business as Usual*:

- Parkes Way Boulevard between Edinburgh Avenue and Coranderrk Street,
- Parkes Way eastbound to Commonwealth Avenue southbound ramp (the westbound ramp in Feasibility Design is not included),
- On-ramp to Parkes Way westbound from Parkes Way Boulevard – Marcus Clarke Street intersection.

The CSTM traffic volume diagrams for each of the scenarios are included in Appendix B.



Figure 1 – Business as Usual Road Network



Figure 2 – UDS Feasibility Design Road Network



Figure 3 – Variant 2c Road Network

3.3 Eastbound Free Flow Ramp between Parkes Way and Commonwealth Ave

Recent observed counts (17 August 2014) at the loop ramp connecting Parkes Way eastbound to Commonwealth Avenue southbound indicate an average weekday AM peak hourly flow of approximately 1,450 vehicles. A test of the 2016 AM model without pay parking in the Parliamentary Zone (considered to be reasonably equivalent to the conditions under which the counts were taken) gives a result of approximately 1,130 vehicles/hour, which is about 20% lower than the 2014 AM observed volume. The observed ramp volume and surveyed ramp speed indicates that the ramp is operating at its theoretical capacity, even without considering its geometry and the presence of a form-one-lane merge. The merging traffic was observed a year ago to be about 450 vehicles/hour in the AM peak, suggesting that the volume downstream of the merge is approximately 1,900 vehicles/hour.

A strategic model is a generalisation of the utility of a road network, and vehicle route choice minimises the cost of travel based on known economic factors. As such multiple roads of equivalent hierarchy, lane count and speed will have equal attractiveness. It is likely that the vehicles that are using this loop ramp have made a choice based on information that is not available to the strategic model. The strategic model is most useful to determine large scale traffic movements, and has been calibrated against screenline cordons situated throughout the network. For example, Lake Burley Griffin forms one of the screenlines, which counts the number of vehicles crossing from North to South and vice-versa. In the model, a volume of 1,900 vehicles/hour downstream of the ramp merge would approximately double the travel time on that link, and this encourages vehicles to find alternative routes.

Notwithstanding the differential between the traffic flows predicted by the model and those recently observed on site, it is clear that this free flow link is critical element of the local road network. As such it was considered a key design feature to maintain this connectivity and as such this free flow ramp has been provided in both the Feasibility Design and the Variant 2c scenarios.

4 INTERSECTION ANALYSIS

The Linking City Centre to the Lake considered intersections are analysed and assessed by using SIDRA Intersection Version 6. These intersections are summarised in Table 2.

Table 2: Parkes Way Re-engineering Analysed Intersections

Intersection	Scenario	Business as Usual	Feasibility Design	Variant 2c
Parkes Way – Edinburgh Avenue		✓	✓	✓
Parkes Way Boulevard – Marcus Clarke Street			✓	✓
Parkes Way Boulevard – New West Road			✓	✓
Parkes Way Boulevard – Commonwealth Avenue			✓	✓
Parkes Way Boulevard – New East Road			✓	✓
Parkes Way Boulevard – Allara Street			✓	
Parkes Way – Coranderrk Street		✓	✓	✓
Parkes Way – Anzac Parade		✓	✓	✓
Commonwealth Avenue – Albert Street		✓	✓	✓
Commonwealth Avenue – London Circuit			✓	✓

4.1 Intersection Layouts

The following figures depict the intersection layouts proposed in each of the scenarios that were used as the basis of the analysis.

4.1.1 Business as Usual

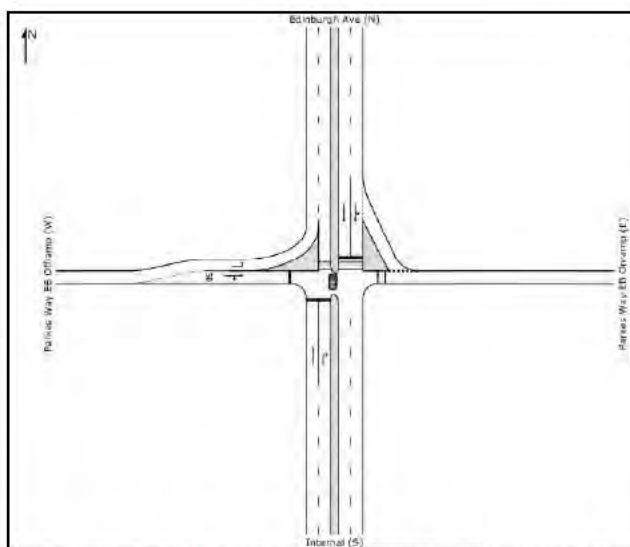


Figure 4 – Business as Usual Parkes Way EB Off-Ramp – Edinburgh Avenue Intersection

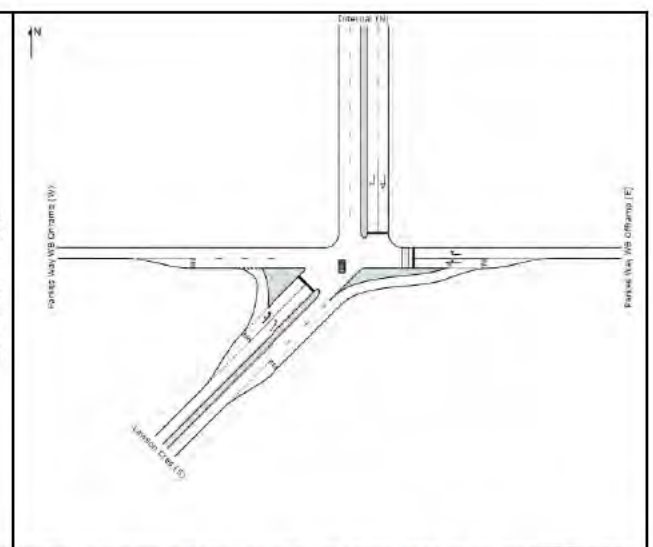


Figure 5 – Business as Usual Parkes Way WB On-Ramp – Lawson Crescent Intersection



Figure 6 – Business as Usual Parkes Way – Coranderrk Street Roundabout



Figure 7 – Business as Usual Parkes Way – Anzac Parade Roundabout

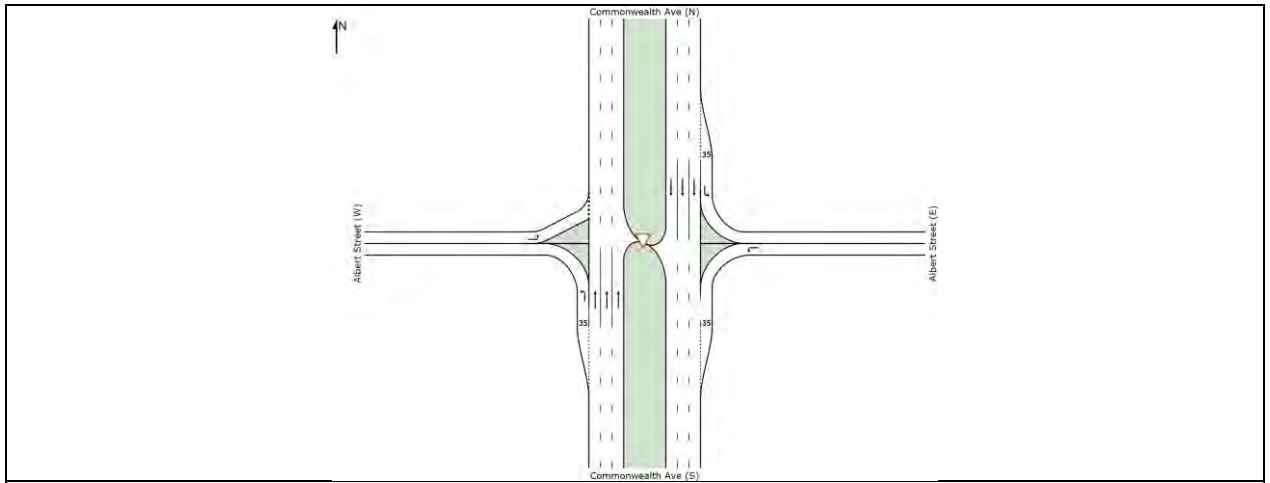


Figure 8 – Business as Usual Commonwealth Avenue – Albert Street Intersection

4.1.2 UDS Feasibility Design

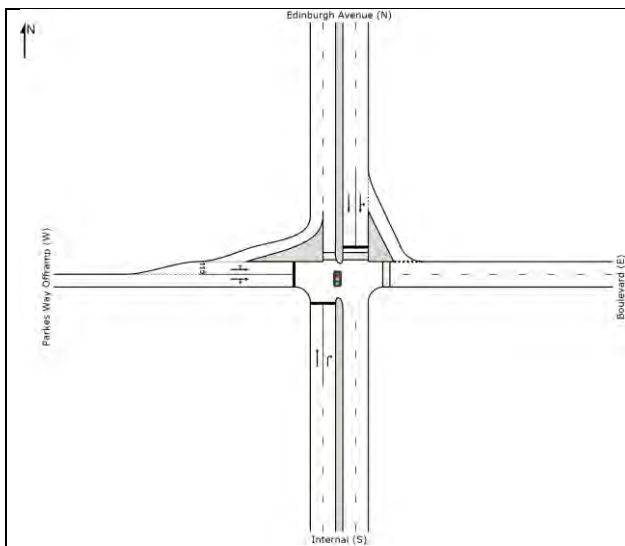


Figure 9 – UDS Feasibility Design Parkes Way Boulevard – Edinburgh Avenue Intersection

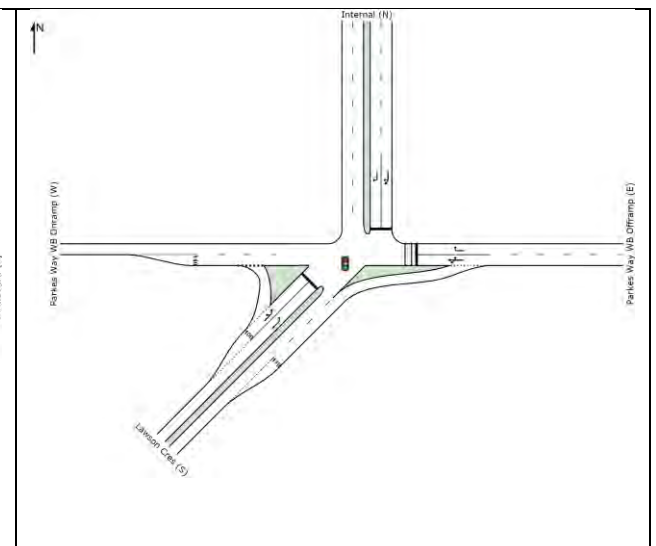


Figure 10 – UDS Feasibility Design Parkes Way Boulevard – Lawson Crescent Intersection

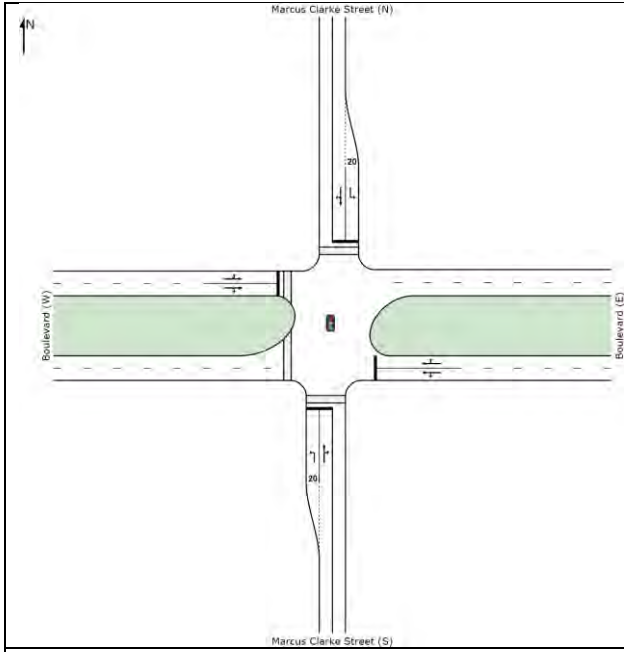


Figure 11 – UDS Feasibility Design Parkes Way Boulevard – Marcus Clarke Street Intersection

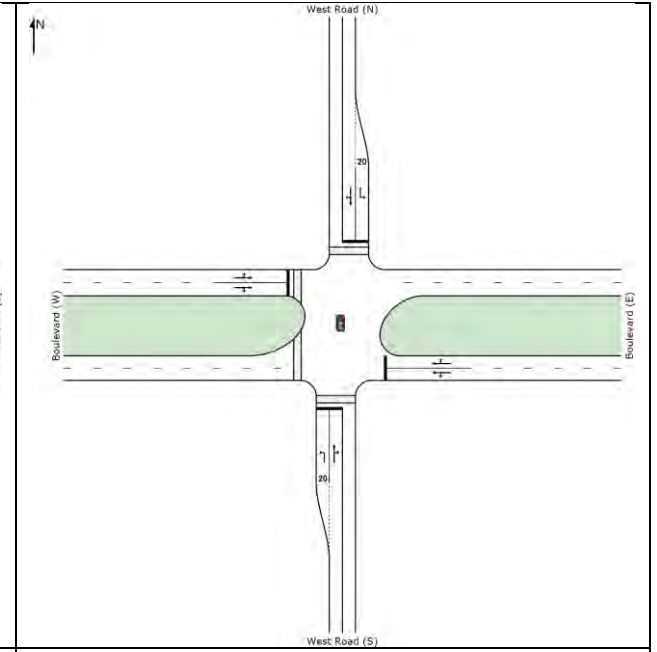


Figure 12 – UDS Feasibility Design Parkes Way Boulevard – West Road Intersection

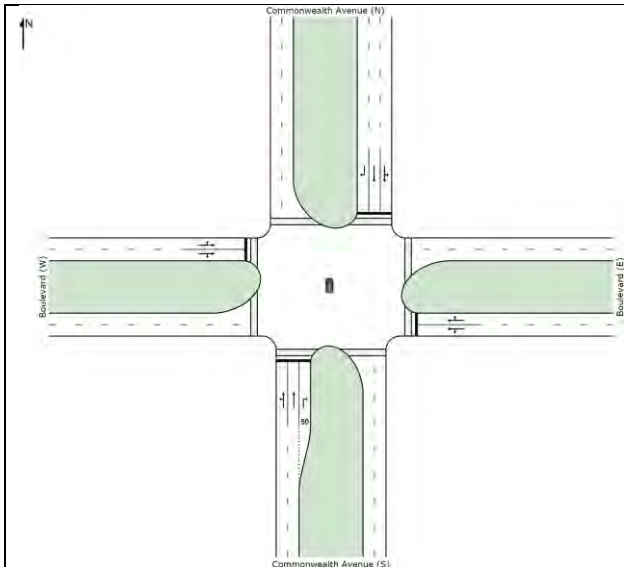


Figure 13 – UDS Feasibility Design Parkes Way Boulevard – Commonwealth Avenue Intersection

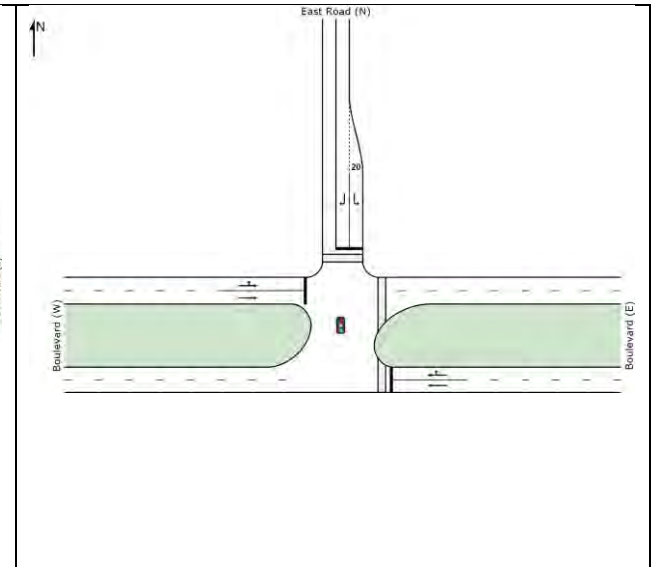


Figure 14 – UDS Feasibility Design Parkes Way Boulevard – East Road Intersection

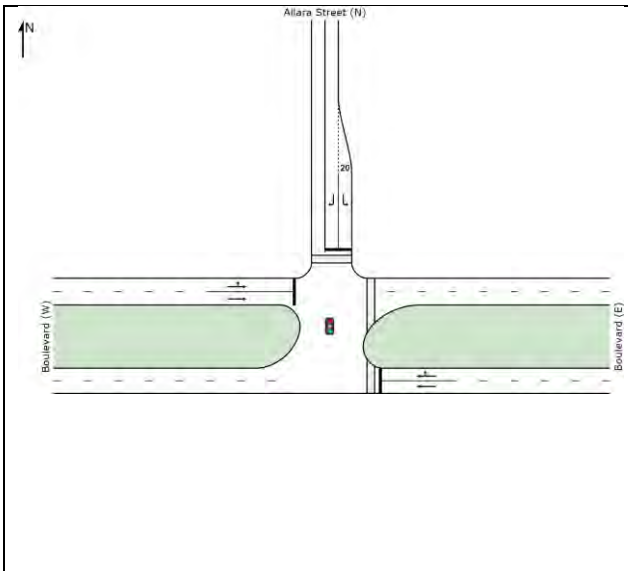


Figure 15 – UDS Fesibility Design Parkes Way Boulevard – Allara Street Intersection

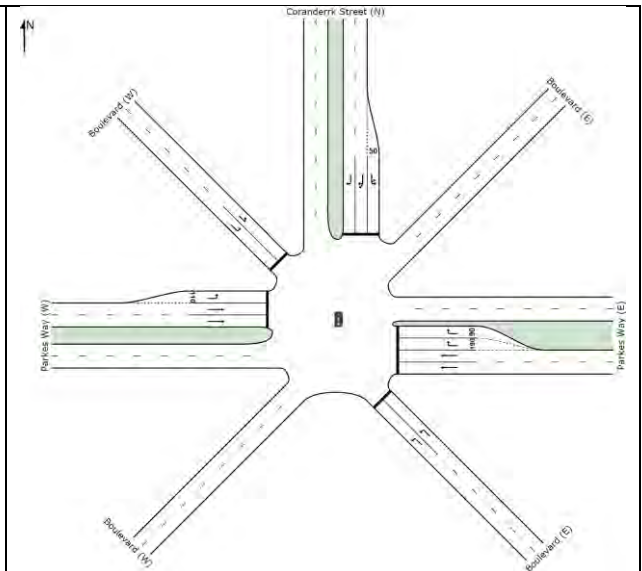


Figure 16 – UDS Fesibility Design Parkes Way - Boulevard – Coranderrk Street Intersection



Figure 17 – UDS Fesibility Design Parkes Way – Anzac Parade Roundabout

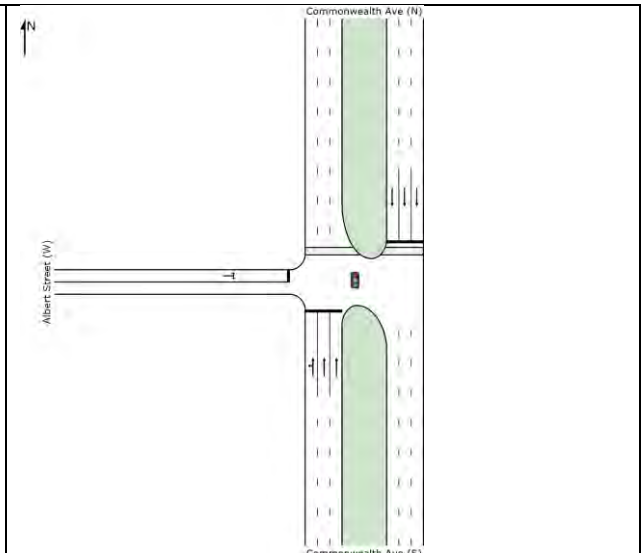
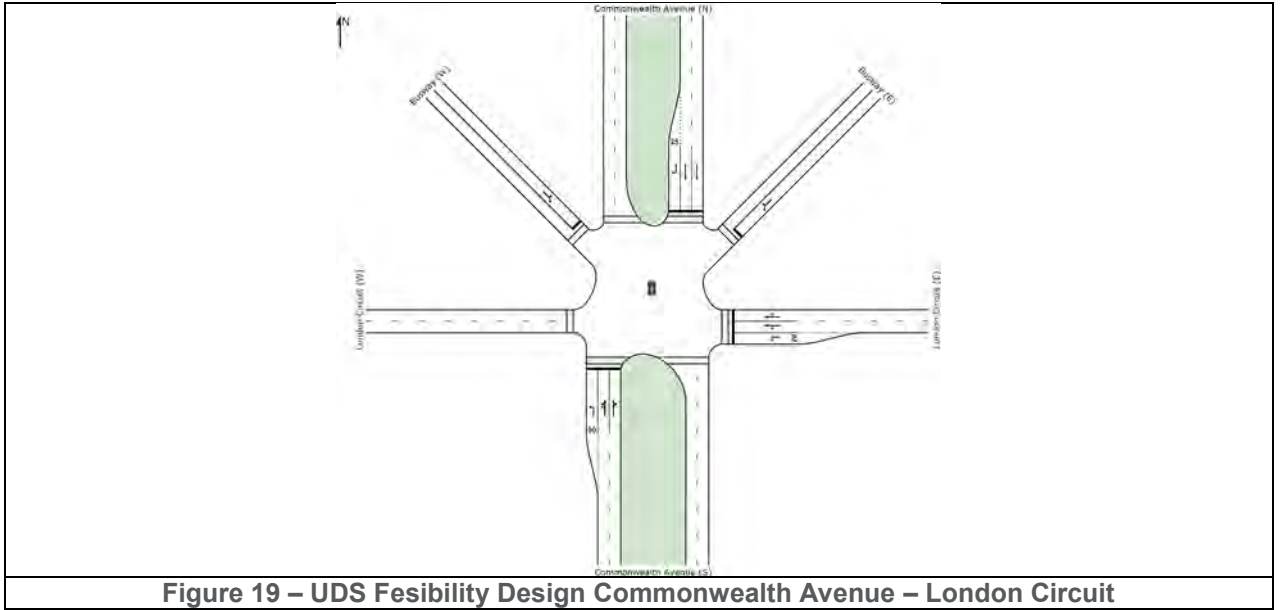
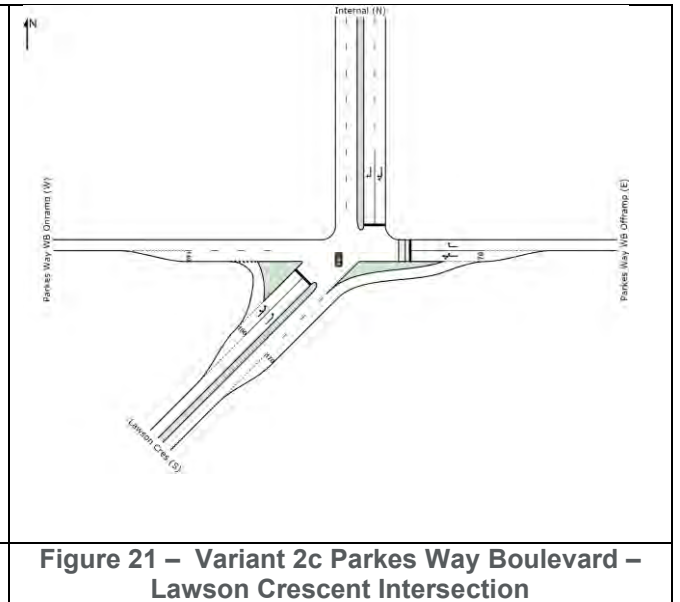
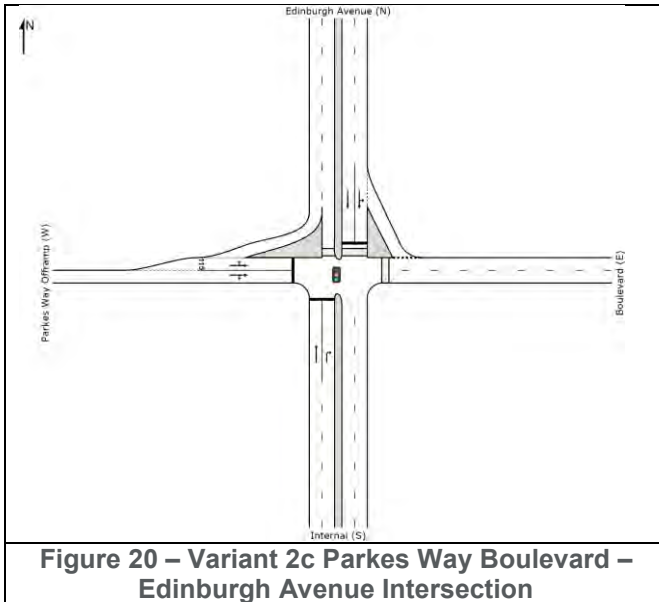


Figure 18 – UDS Fesibility Design Commonwealth Avenue - Albert Intersection



4.1.3 Variant 2c



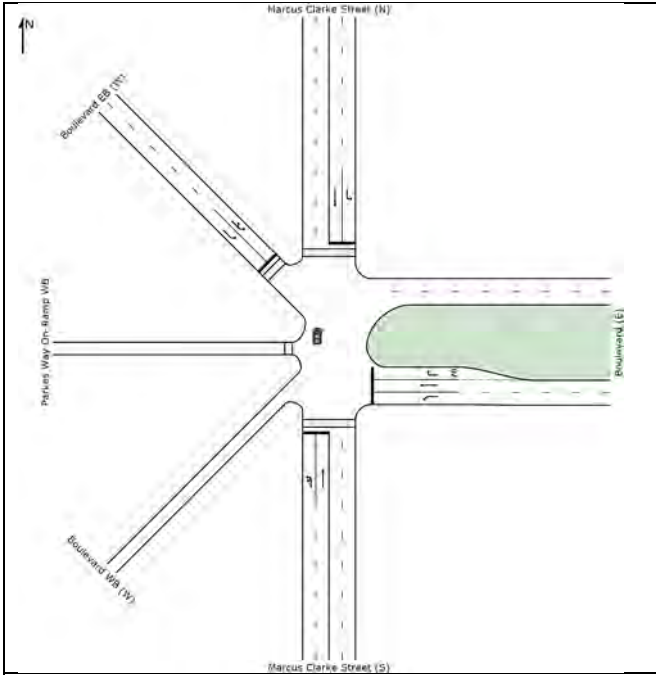


Figure 22 – Variant 2c Parkes Way Boulevard – Marcus Clarke Street Intersection

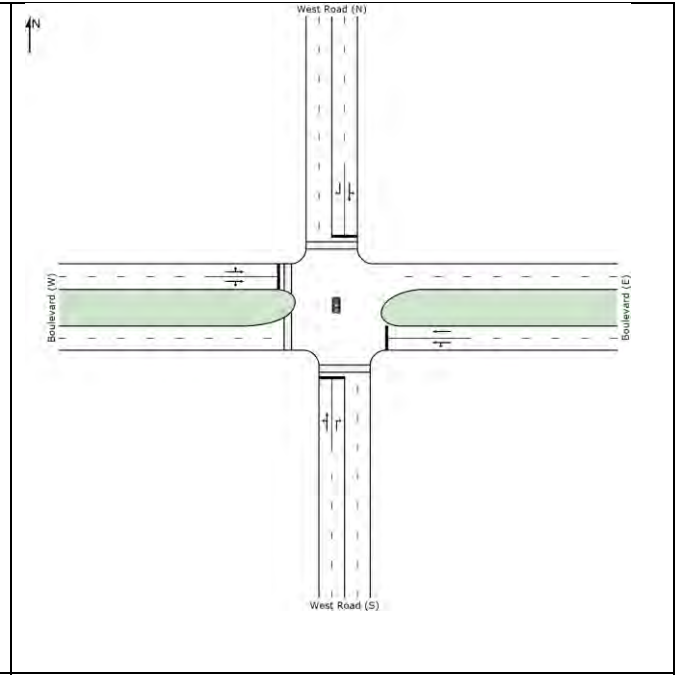


Figure 23 – Variant 2c Parkes Way Boulevard – West Road Intersection

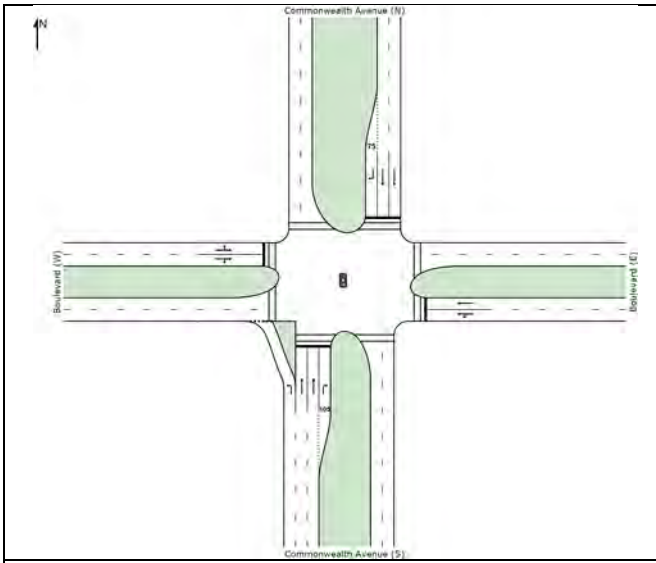


Figure 24 – Variant 2c Parkes Way Boulevard – Commonwealth Avenue Intersection

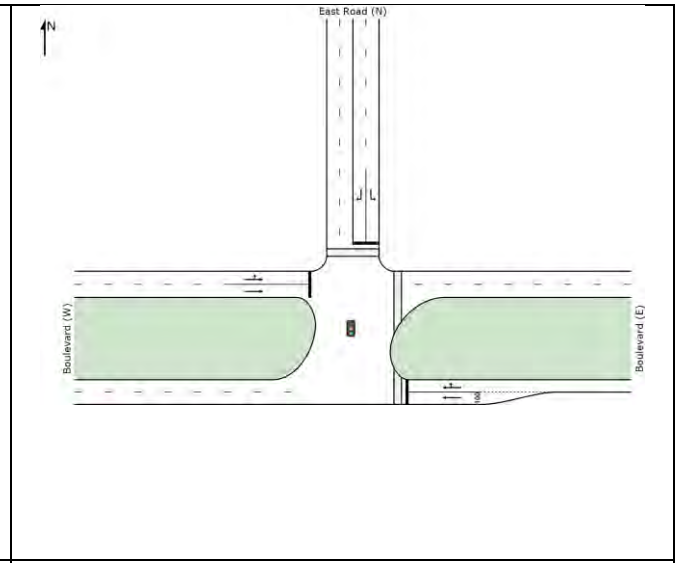


Figure 25 – Variant 2c Parkes Way Boulevard – East Road Intersection

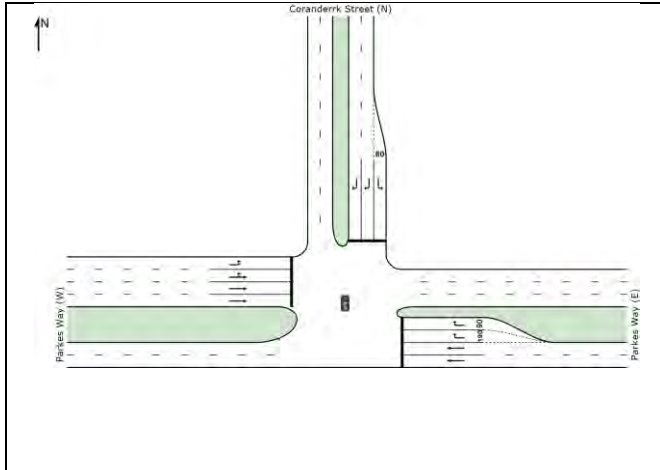


Figure 26 – Variant 2c Parkes Way – Coranderrk Street Intersection



Figure 27 – Variant 2c Parkes Way – Anzac Parade Roundabout

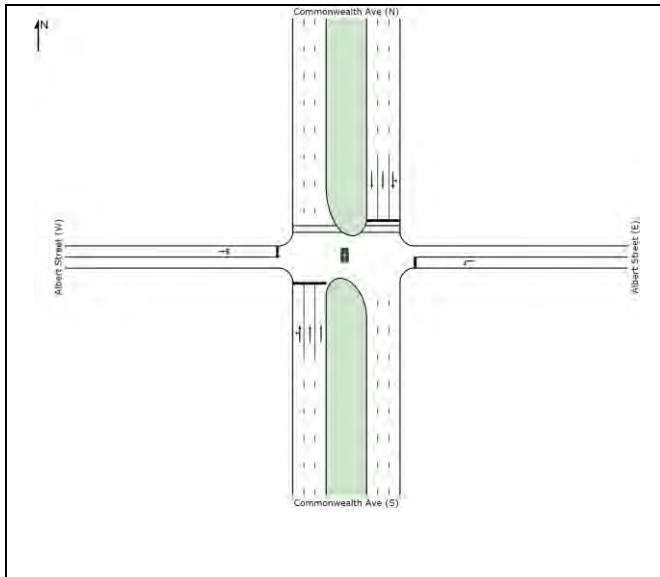


Figure 28 – Variant 2c Commonwealth Avenue – Albert Street Intersection

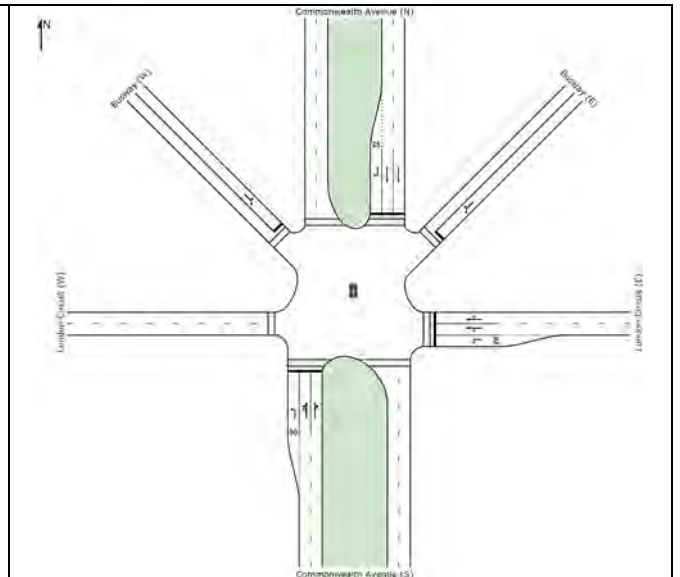


Figure 29 – Variant 2c Commonwealth Avenue – London Circuit Intersection

4.2 Intersection Performance

The intersection turning movement counts are included in Appendix C.

Intersection performance is commonly assessed in terms of *Average Delay*, which is a measure of the additional travel time experienced, on average, by vehicles using the intersection. The Highway Capacity Manual 2010 (HCM2010) criteria used by SIDRA Intersection 6 to determine intersection *Level of Service* from *Average Delay* are included in Table 3.

Table 3: HCM Level of Service Criteria (Average Delay D in Seconds)

Level of Service	Signals	Give-Way/Roundabout
A	$D < 10 \text{ s}$	$D < 10 \text{ s}$
B	$10 \text{ s} \leq D < 20 \text{ s}$	$10 \text{ s} \leq D < 15 \text{ s}$
C	$20 \text{ s} \leq D < 35 \text{ s}$	$15 \text{ s} \leq D < 25 \text{ s}$
D	$35 \text{ s} \leq D < 55 \text{ s}$	$25 \text{ s} \leq D < 35 \text{ s}$
E	$55 \text{ s} \leq D < 80 \text{ s}$	$35 \text{ s} \leq D < 50 \text{ s}$
F	$D \geq 80 \text{ s}$ or $V/C > 1$	$D \geq 50 \text{ s}$ or $V/C > 1$

Source: Highway Capacity Manual 2010, Exhibits 18-4 (p.18-6), 19-1 (p.19-2) and 21-1 (p.21-1)

The average delay in seconds and Level of Service (LoS) for each of the intersections are summarised in Table 4 (2021 AM), Table 5 (2021 PM), Table 6 (2031 AM) and Table 7 (2031 PM.)

4.2.1 2021 AM peak

The 2021 AM peak results shown in Table 4 indicate that the performance of most of the new intersections is not substantially different in the *Feasibility Design* and *Variant 2c* options (Project options). The most noticeable differences in performance in 2021 AM are at Parkes Way – Coranderrk Street and Parkes Way – Anzac Parade.

The Parkes Way volumes are increased substantially in both *Feasibility Design / Variant 2c* options compared to *Business as Usual* due to the reduction in capacity that results from the addition of signalised intersections along Commonwealth Avenue. As such, a large amount of traffic that uses Commonwealth Avenue in Business as Usual is displaced, much of it shifting to Kings Avenue, and it thus continues along Parkes Way instead. This effect can be seen in the 2021 AM flow diagrams included in Appendix B. As a result of this, in the Project options there is a much larger volume of traffic travelling through the Coranderrk Street and Anzac Parade intersections.

Parkes Way – Coranderrk Street is converted to signal control in the Project options, with the *Variant 2c* configuration being considerably simpler, and hence more efficient, than the *Feasibility Design* option.

The Parkes Way – Anzac Parade intersection experiences a particularly large increase in traffic volumes, as shown in Appendix C. This pushes the intersection well over its capacity in the Project options, when it was already expected to be close to capacity in Business as Usual, and it deteriorates from LoS E to LoS F with excessive delays. Possible improvements to the Parkes Way – Anzac Parade intersection have been investigated and are discussed in Section 4.3.

Both Commonwealth Avenue – London Circuit and Commonwealth Avenue – Parkes Way Boulevard operate at LoS F in both Project scenarios. Current traffic demand in this area is very high; Commonwealth Avenue carries approximately 2,400 vehicles/hour in both directions in the AM peak period. In *Business as Usual*, Commonwealth Avenue is effectively free flow between its existing intersections with London Circuit and Coronation Drive, while in the Project Options a number of additional signalised intersections have been added. This necessarily reduces the capacity of Commonwealth Avenue and as a knock-on effect there is a diversion of traffic to Marcus Clarke Street. In *Variant 2c* however the average delay at the Commonwealth Avenue – Parkes Way Boulevard intersection has been reduced noticeably from the *Feasibility Study* design. The Parkes Way Boulevard – Marcus Clarke Street intersection suffers as a result, however a design concept has been adopted that improves the intersection's performance in *Variant 2c* compared to the *Feasibility Design*.

Table 4: 2021 AM Intersection Performance (Delay and Level of Service)

Intersection	Scenario		Business as Usual		Feasibility Design		Variant 2c	
	Delay [sec]	LoS	Delay [sec]	LoS	Delay [sec]	LoS	Delay [sec]	LoS
Parkes Way – Edinburgh Avenue	16.5	B	16.4	B	15.8	B	15.8	B
Parkes Way Boulevard – Marcus Clarke Street	-	-	222.8	F	140.5	F	140.5	F
Parkes Way Boulevard – New West Road	-	-	36.3	D	13.6	B	13.6	B
Parkes Way Boulevard – Commonwealth Avenue	-	-	290.3	F	160.6	F	160.6	F
Parkes Way Boulevard – New East Road	-	-	11.8	B	15.6	B	15.6	B
Parkes Way Boulevard – Allara Street	-	-	14.9	B	-	-	-	-
Parkes Way – Coranderrk Street	11.0	B	424.4	F	19.7	B	19.7	B
Parkes Way – Anzac Parade	70.8	E	1702.9	F	1218.9	F	1218.9	F
Commonwealth Avenue – Albert Street	0.3	A	16.0	B	18.4	B	18.4	B
Commonwealth Avenue – London Circuit	-	-	120.0	F	139.7	F	139.7	F

4.2.2 2021 PM peak

The results for the 2021 PM peak period are shown in Table 5.

The modifications to the Parkes Way – Edinburgh Avenue intersection result in improved performance in the Project options compared to *Business as Usual*.

At the Parkes Way Boulevard – Marcus Clarke Street intersection, a difference in performance is noticeable between the *Feasibility Design* and *Variant 2c* options. This is a result of the removal of the left turn ramp from Commonwealth Avenue northbound to Parkes Way westbound. In *Variant 2c*, a large volume of additional traffic (in the order of 900 vehicles) must use the boulevard to complete this left turning movement. The *Variant 2c* design has focussed on reducing the impact of the additional traffic.

This difference also affects the performance of the Commonwealth Avenue intersection, which shows a slightly increased delay in *Variant 2c* compared to *Feasibility Design*.

The New West Road intersection does not allow right turns from the boulevard. As a result the phasing is simplified and the performance is good even with the additional traffic.

In the 2021 PM peak period the performance of the Parkes Way – Anzac Parade is improved compared to 2021 AM, however it is still LoS F with quite long delays. Improvements to this have been investigated in Section 4.3.

At the Parkes Way – Coranderrk Street intersection, the *Variant 2c* solution remains superior to the *Feasibility Design*, however the performance issues experienced by the latter in 2021 AM are not a concern in 2021 PM.

Commonwealth Avenue – London Circuit and Commonwealth Avenue – Parkes Way Boulevard are congested in 2021 PM, as they were in 2021 AM.

Table 5: 2021 PM Intersection Performance (Delay and Level of Service)

Intersection	Scenario		Feasibility Design		Variant 2c	
	Business as Usual		Delay [sec]	LoS	Delay [sec]	LoS
Parkes Way – Edinburgh Avenue	66.9	E	22.9	C	54.1	D
Parkes Way Boulevard – Marcus Clarke Street	-	-	67.1	E	120.2	F
Parkes Way Boulevard – New West Road	-	-	31.7	C	21.4	C
Parkes Way Boulevard – Commonwealth Avenue	-	-	203.5	F	233.9	F
Parkes Way Boulevard – New East Road	-	-	7.9	A	17.0	B
Parkes Way Boulevard – Allara Street	-	-	17.9	B	-	-
Parkes Way – Coranderrk Street	8.5	A	27.0	C	18.7	B
Parkes Way – Anzac Parade	47.1	D	784.6	F	423.2	F
Commonwealth Avenue – Albert Street	0.2	A	16.8	B	17.7	B
Commonwealth Avenue – London Circuit	-	-	91.2	F	134.2	F

4.2.3 2031 AM Peak

The results for the 2031 AM peak period are shown in Table 6. In general, the results are similar to those of 2021 AM (shown in Table 4,) with an increase in volumes and consequent increase in average delay.

As in 2021 AM, the simpler and more efficient design for the Parkes Way – Coranderrk Street intersection in *Variant 2c* offers a dramatic performance improvement compared to the *Feasibility Design*.

Notable exceptions to this are Parkes Way – Anzac Parade and Commonwealth Avenue – London Circuit. At the Parkes Way – Anzac Parade intersection, the performance in *Variant 2c* is now worse than in the *Feasibility Design*, however an option to improve the performance of this intersection has been investigated in Section 4.3.

At Commonwealth Avenue – London Circuit, the difference in performance can be attributed to the difference in volumes between the two, given the changes in network connectivity.

As in 2021, the intersections of Commonwealth Avenue – London Circuit, Commonwealth Avenue – Parkes Way Boulevard and Parkes Way Boulevard – Marcus Clarke Street are adversely affected by the reduction in capacity along Commonwealth Avenue.

Table 6: 2031 AM Intersection Performance (Delay and Level of Service)

Intersection	Scenario		Feasibility Design		Variant 2c	
	Business as Usual		Delay [sec]	LoS	Delay [sec]	LoS
Parkes Way – Edinburgh Avenue	16.6	B	20.7	C	36.3	D
Parkes Way Boulevard – Marcus Clarke Street	-	-	235.9	F	142.1	F
Parkes Way Boulevard – New West Road	-	-	50.1	D	15.2	B
Parkes Way Boulevard – Commonwealth Avenue	-	-	293.6	F	151.4	F
Parkes Way Boulevard – New East Road	-	-	12.9	B	16.7	B
Parkes Way Boulevard – Allara Street	-	-	16.0	B	-	-
Parkes Way – Coranderrk Street	11.1	B	213.0	F	20.4	C
Parkes Way – Anzac Parade	108.7	F	1145.8	F	1335.9	F
Commonwealth Avenue – Albert Street	0.5	A	19.0	B	18.1	B
Commonwealth Avenue – London Circuit	-	-	98.7	F	176.4	F

4.2.4 2031 PM peak

The 2031 PM peak results are shown in Table 7. As in the AM peak, the 2031 PM peak performance in most cases reflects the increase in volumes compared the 2021 AM peak.

The Parkes Way – Edinburgh Avenue intersection shows a slight improvement in 2031 PM compared to 2021 PM in both *Business as Usual* and *Variant 2c*. The difference in volumes between the two years in the PM peak period is very small, and the CSTM results in Appendix B show the westbound onramp operating at capacity in both years.

The performance at Parkes Way – Anzac Parade, being a roundabout, is very sensitive to the pattern of turning movements once it has progressed into Level of Service F, and so an improvement occurs in 2031 PM for the *Feasibility Design* option compared to 2021 PM despite a slight increase in total intersection volume, while the *Variant 2c* performance becomes worse. As for the other periods, a possible improvement to this intersection is detailed in Section 4.3.

The intersections of Parkes Way Boulevard – Marcus Clarke Street and Commonwealth Avenue – Parkes Way Boulevard are only slightly worse in *Variant 2c* than in the *Feasibility Design*, which can be attributed to the loss of the left turn ramp from Commonwealth Avenue northbound to Parkes Way westbound in the former scenario.

Table 7: 2031 PM Intersection Performance (Delay and Level of Service)

Intersection	Scenario	Business as Usual		Feasibility Design		Variant 2c	
		Delay [sec]	LoS	Delay [sec]	LoS	Delay [sec]	LoS
Parkes Way – Edinburgh Avenue		47.9	D	26.2	C	41.1	D
Parkes Way Boulevard – Marcus Clarke Street		-	-	93.2	F	108.7	F
Parkes Way Boulevard – New West Road		-	-	34.4	C	20.0	B
Parkes Way Boulevard – Commonwealth Avenue		-	-	221.4	F	247.7	F
Parkes Way Boulevard – New East Road		-	-	9.9	A	16.2	B
Parkes Way Boulevard – Allara Street		-	-	16.3	B	-	-
Parkes Way – Coranderrk Street		8.6	A	36.2	D	19.7	B
Parkes Way – Anzac Parade		69.4	E	319.3	F	645.8	F
Commonwealth Avenue – Albert Street		0.4	A	18.2	B	17.6	B
Commonwealth Avenue – London Circuit		-	-	93.1	F	167.7	F

4.3 Parkes Way Boulevard – Commonwealth Avenue Intersection

One of the key sites in the proposed network is the intersection of Parkes Way Boulevard and Commonwealth Avenue. This intersection receives large volumes of traffic in all project scenarios, design years and peak periods, and consistently operates at Level of Service F. The proposed intersection design has attempted to balance the needs of vehicles, pedestrians and cyclists in addition to accommodating possible future light rail, noting that it is a key point for pedestrian connectivity between the city centre and the West Basin foreshore. To this end, the design has attempted to adopt as compact a layout as possible to ensure its attractiveness and functionality for pedestrians.

It is noted that intersection performance at this site could be improved if additional lane or turn slot capacity was provided. It is recommended that the balance of road network performance and pedestrian amenity be reviewed in future phases of the project with due consideration paid to both engineering and urban design requirements for the location.

4.4 Parkes Way – Anzac Parade Signalisation

The existing roundabout at the Parkes Way – Anzac Parade intersection is expected to run very poorly in all periods of both Project options, as shown above. This is a result of the diversion of traffic away from Commonwealth Avenue, due to the addition of signalised intersections on that road.

To improve the performance of the Parkes Way – Anzac Parade roundabout, an option for signalising the roundabout was investigated. This places signal control on the three entry points of the roundabout, controlling both the entering flows from Parkes Way and Anzac Parade and the circulating flows within the roundabout. The average delay and Level of Service results of this investigation are shown in Table 8. It shows that the delay is considerably reduced in all cases of the Project options, in some cases improving the LoS

from F to E or D. The option also offers considerable improvements for *Business as Usual* in the PM peak period.

Table 8: Parkes Way – Anzac Parade Signalised Intersection Comparisons

Scenario	Business as Usual				Feasibility Design				Variant 2c			
	Roundabout		Signalised		Roundabout		Signalised		Roundabout		Signalised	
Year	Delay [sec]	LoS	Delay [sec]	LoS	Delay [sec]	LoS	Delay [sec]	LoS	Delay [sec]	LoS	Delay [sec]	LoS
2021 AM	70.8	E	75.0	E	1702.9	F	182.4	F	1218.9	F	165.5	F
2021 PM	47.1	D	12.4	B	784.6	F	121.0	F	423.2	F	47.5	D
2031 AM	108.7	F	98.9	F	1145.8	F	177.1	F	1335.9	F	188.0	F
2031 PM	69.4	E	13.1	B	319.3	F	107.9	F	645.8	F	68.9	E

5 IMPACTS ON THE PUBLIC TRANSPORT NETWORK

The proposed works will affect the operation of the bus network that serves the Canberra CBD, particularly those routes that enter the CBD on Commonwealth Avenue.

The removal of the existing free-flow ramp system that links Commonwealth Avenue to Parkes Way and London Circuit will decrease travel distances for buses, but add delays at the new, signalised intersections that are created. Bus priority treatment has been proposed for London Circuit in the form of two-way bus lanes, which will form the primary path for buses to move from one side of the CBD to the other.

The new development areas clustered along Commonwealth Avenue between City Hill and the Lake and the proposed street network will present new opportunities for routing buses within the CBD, which have previously been partially constrained by the directional nature of the existing ramps.

New bus stops will be needed to provide access to these areas and their correct placement is fundamental in enabling efficient and legible transfer between services.

The impacts that the project will create fall into two categories:

- Bus routes that travel along Commonwealth Avenue will have their access path into and out of the CBD altered. The new paths that these routes follow will need to be considered in the context of what the route does within and beyond the CBD.
- Other CBD bus routes will not necessarily need to change, but the new road alignments and new development areas may present opportunities for modifying routes to provide greater coverage.

5.1 Existing Situation

5.1.1 Route Network

The ACTION weekday CBD route network is presented in Figure 30.

As of October 2014, 52 urban bus routes operated by ACTION and 4 operated by QCity Transit travel within the Canberra CBD on weekdays. These routes provide a total of 1,737 ACTION services and a further 53 QCity Transit services.

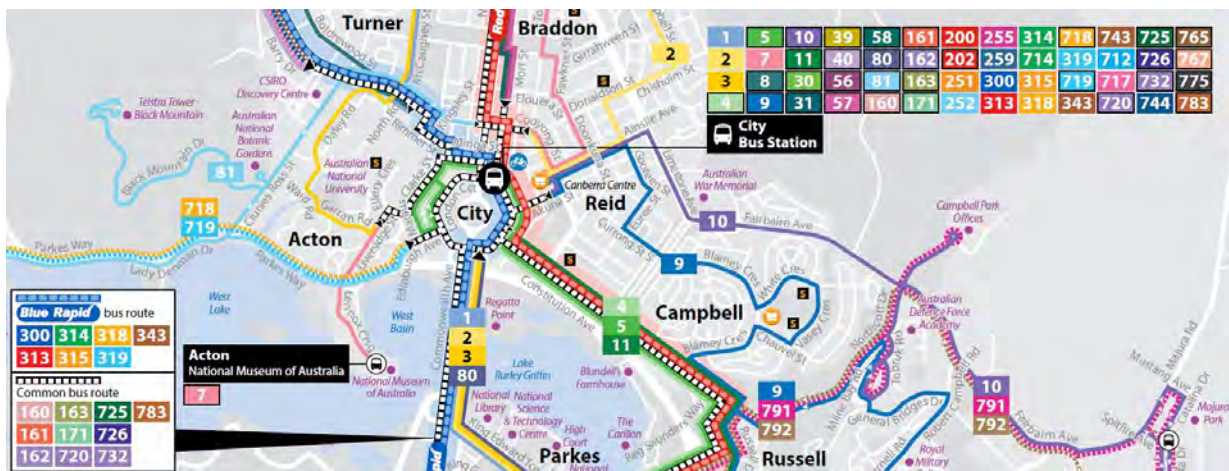


Figure 30: ACTION Weekday Urban Bus Network Operating in Canberra CBD

Buses that enter the CBD do one of three things:

- Continue through and exit the CBD as a through-routed service, such as most Blue Rapid and Red Rapid services. A number of inner-urban local bus routes are also through-routed.
- Terminate at the existing City Bus Station. From there they will either travel to a depot or layover location, or the starting point of a new route (which may be within the CBD or elsewhere).
- Terminate at a peripheral CBD location, adjacent to a layover facility. Many peak-express-only routes currently do this by terminating at the existing City West Layover.

Through-routing can provide passengers with a journey across the city without the need to transfer between services. Operationally, it can be beneficial by reducing the number of buses that terminate within the city centre which create the complexity of needing to reposition to start new trips, or travel to a layover facility. In congested CBD street environments, these repositioning movements are often slow and increase the risk of buses becoming delayed, and the presence of these buses then adds to the congestion.

However, there is a limit to how many services can logically be through-routed, as longer distance through-routed services are more likely to experience delays when departing the CBD, due to congestion experienced on the inbound leg of their journey. Long through-routed routes are only viable when bus priority measures ensure on-time performance, and/or service frequency is high enough that delays are less noticeable due to regular services arriving (if a bus route operates every 5 minutes, but every bus is 5 minutes late, there is no impact on the customer). At present, 46% of weekday buses that travel into the CBD are through-routed.

Terminating a bus route at a location on the periphery of the CBD allows for far-side layover, and has a number of benefits, primarily:

- It is generally easier and cheaper to develop suitable layover facilities on the edge of a CBD than in the city centre itself.
- Having routes travel further through the CBD than they would have if they had terminated at central bus station, extends their coverage over a greater proportion of the CBD area.

The ACT Government is in the process of developing a new City West bus layover at the corner of Barry Drive and Watson Street, replacing the current facility on Marcus Clarke Street. This will create a logical far-side terminus for bus routes that approach the CBD along Commonwealth Avenue or Constitution Avenue.

A second new layover, City East, is being planned for the site bounded by Constitution Avenue, Coranderrk Street and Parkes Way. Initially this may be a temporary facility prior to the site being redeveloped as a stadium. Following stadium construction, an on-site coach parking area would act as a layover outside of event times. This location will be a logical far-side layover for routes that enter the CBD from Barry Drive or Northbourne Avenue.

Consideration of these layover facilities combined with the modified access arrangements into and within the CBD created by the Parkes Way lowering, will act as inputs in the development of the future city centre bus operating pattern.

5.1.2 Bus and Passenger Volumes

Based on the ACTION weekday network operating in October 2014, Figure 31 and Figure 32 present the movements of passengers and buses into and out of the CBD throughout the day, by 15 minute periods. (Patronage data is weekday averages over the period of 15 to 31 October, 2014).

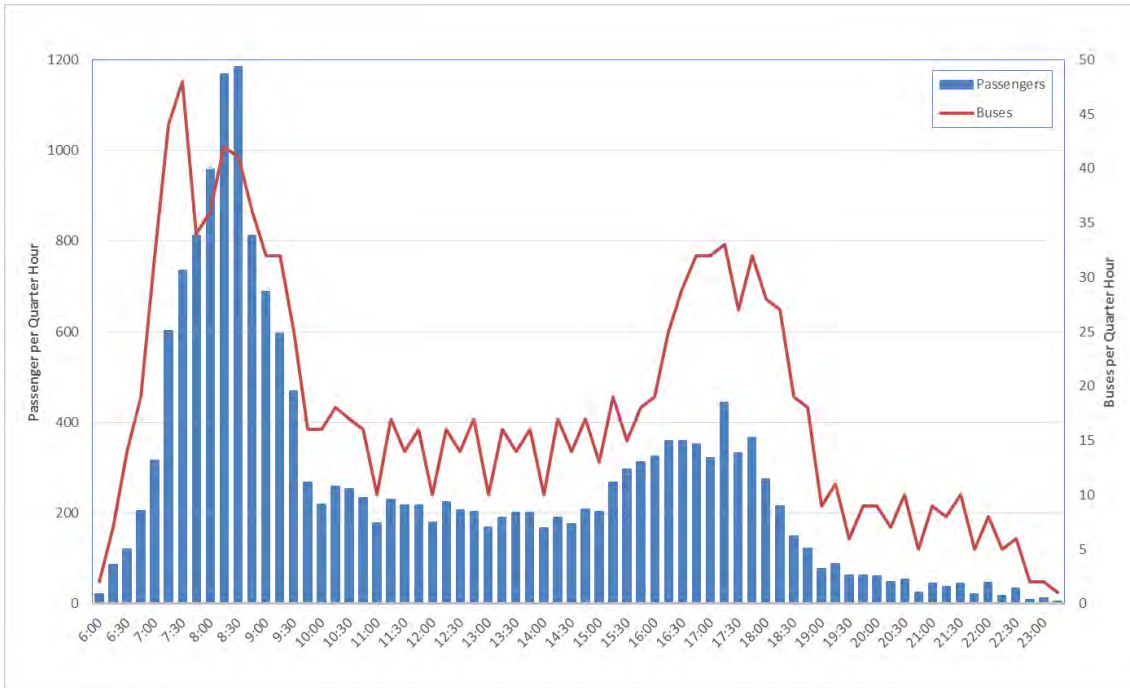


Figure 31: Inbound Urban Bus and Passenger Movements per Quarter Hour (October 2014)

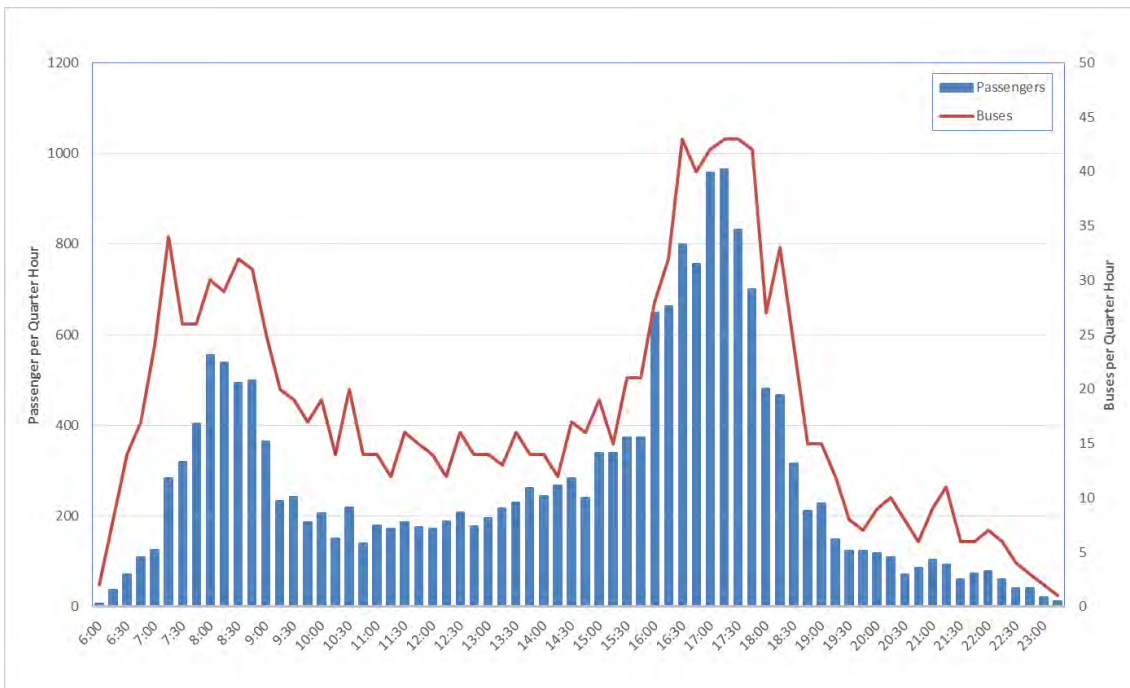


Figure 32: Outbound Urban Bus and Passenger Movements per Quarter Hour (October 2014)

The peak hour for passenger movement is observed as 0800 to 0900, during which 155 ACTION buses enter the CBD carrying approximately 4,120 people, whilst 122 buses depart the CBD carrying 2,090 passengers. In terms of bus movements, the period from 0715 to 0815 yields slightly more bus arrivals with 162 entering the CBD, but fewer departing buses and significantly less passenger activity.

The distribution of these movements by entry point to the CBD during the AM peak hour are shown in Figure 33.

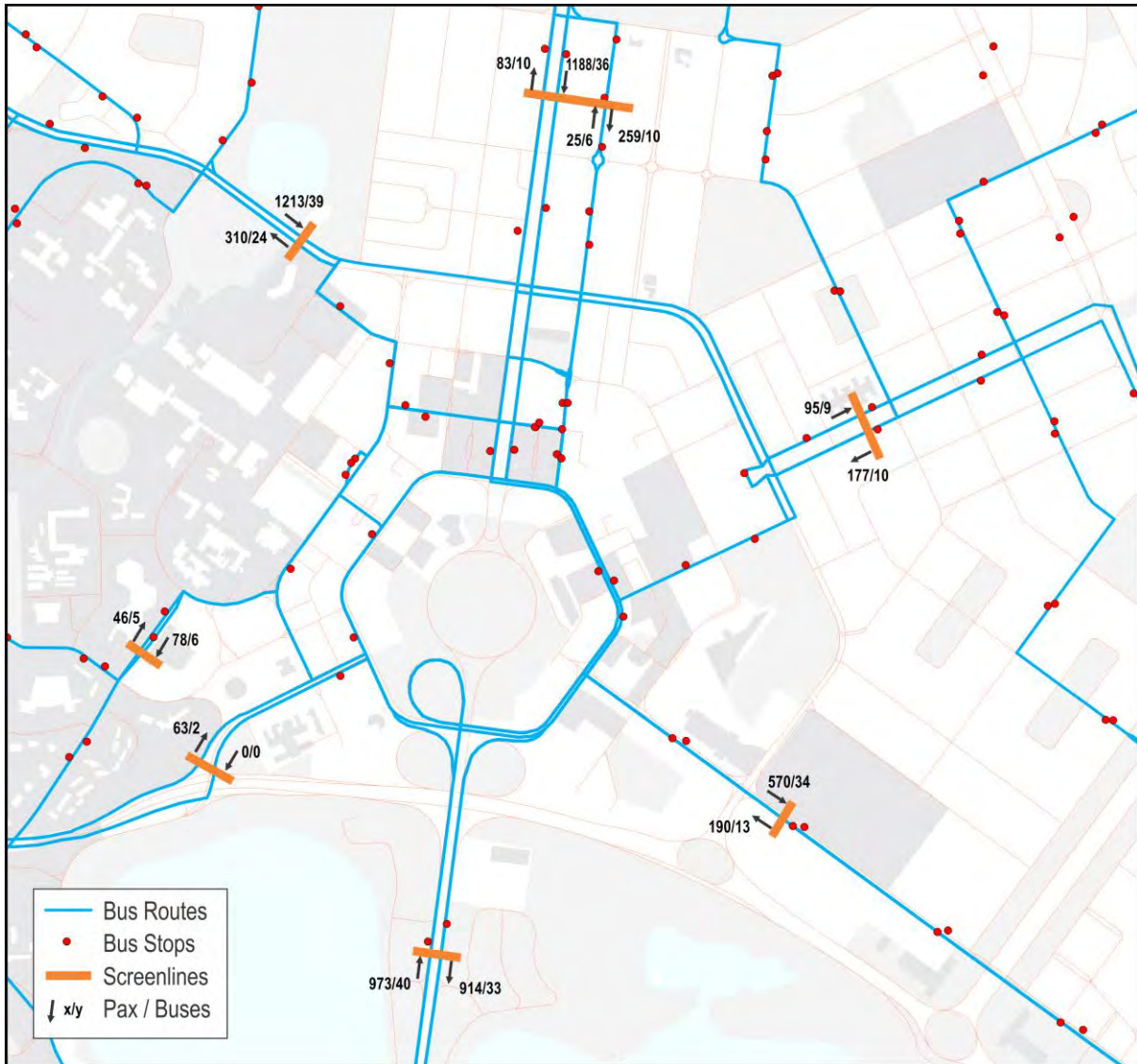


Figure 33: Screenline Cordon Assessment of AM Peak Hour CBD Bus and Passenger Movements (0800-0900, October 2014)

The locations in the CBD where passenger boarding and alighting activity is generated in the AM peak hour is highlighted in Figure 34. The boardings that occur at City Bus Station at this time of day mostly represent transfer activity.

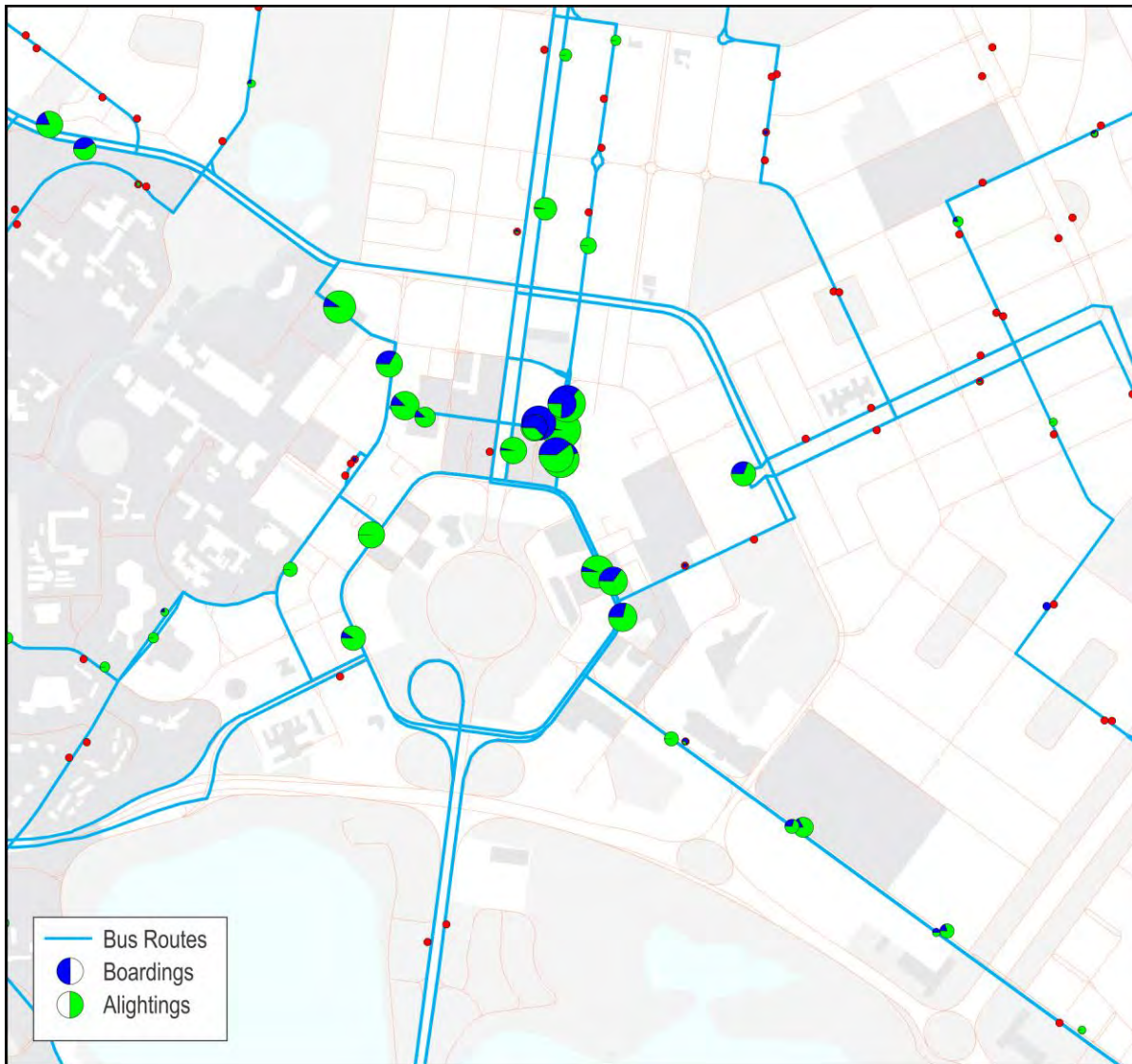


Figure 34: AM Peak Hour CBD Boarding and Alighting Intensity (0800-0900, October 2014)

5.1.3 Commonwealth Avenue Services

The proposed changes to the local road network will affect the way in which buses access the Canberra CBD. No urban bus services travel along the affected section of Parkes Way, but all buses travelling along Commonwealth Avenue will be affected.

Bus and passenger movements entering and departing the CBD via Commonwealth Avenue are summarised for in Figure 35 and Figure 36 respectively.

It is observed that during the AM peak hour (0800 to 0900), 40 buses carrying 973 passengers enter the CBD, and 33 buses depart carrying 914 passengers. The relatively high outbound volume is representative of the demand generated by the Parliamentary Triangle and Woden employment centres.

During the PM peak hour (1645 to 1745), 29 buses enter the CBD carrying 571 passengers, and 47 buses depart carrying 906 passengers.

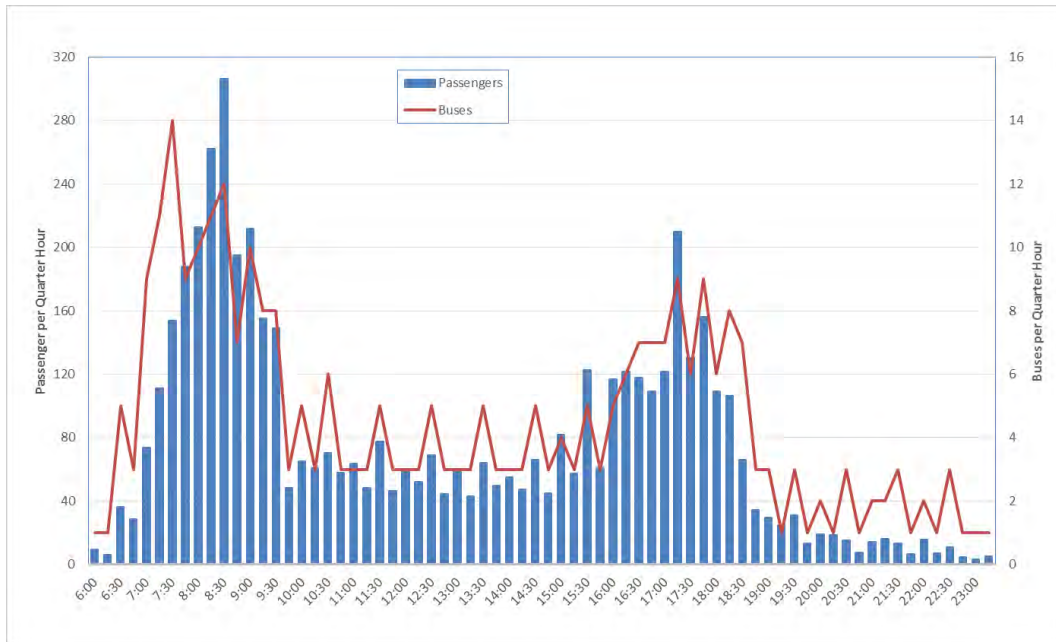


Figure 35: Inbound Commonwealth Avenue Urban Bus and Passenger Movements per Quarter Hour (October 2014)

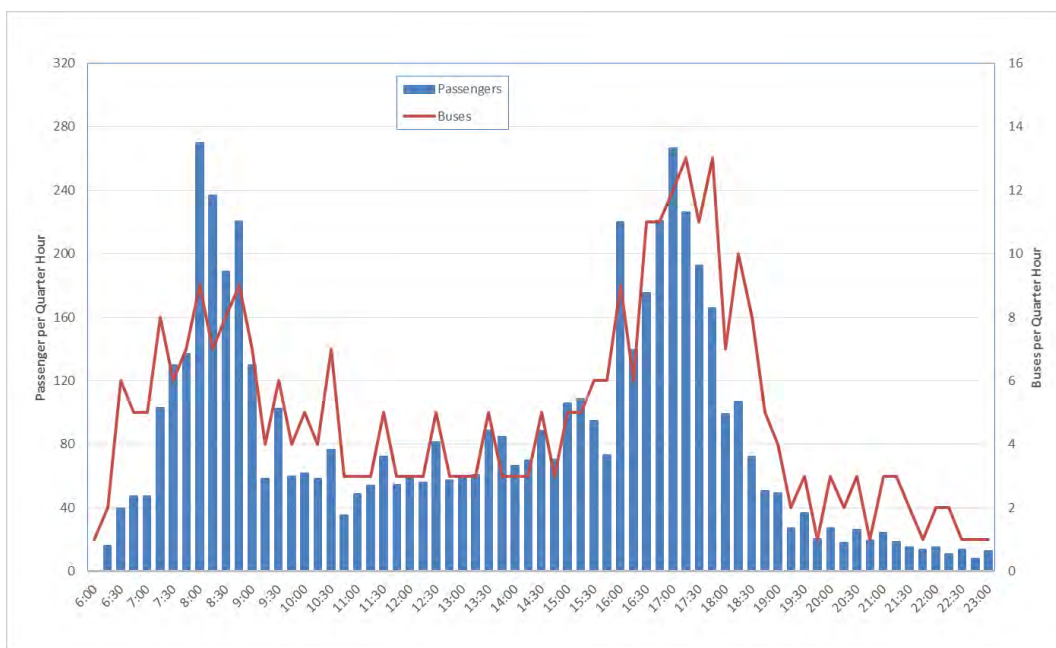


Figure 36: Outbound Commonwealth Avenue Urban Bus and Passenger Movements per Quarter Hour (October 2014)

5.2 Future Planning

5.2.1 Infrastructure Assumptions

Future planning of CBD bus access and operations makes the following infrastructure assumptions:

- The existing City Bus Station will continue to be the primary CBD bus station. All routes will need to pass through the station, which includes platforms located on Northbourne Avenue.
- The proposed new layovers at City West and City East will be operational.
- The proposed Capital Metro Light Rail will be operating from Gungahlin to the CBD, with a terminus stop on Northbourne Avenue at Alinga Street.
- Two-way bus lanes will be constructed on London Circuit.

5.2.2 Network Assumptions

In terms of the bus network that will operate in the future, there is concern that the planning undertaken in 2008 that forms the basis of *Transport for Canberra's* 2031 bus network has become dated, and now underrepresents the likely volume of bus services that will operate in the CBD. For example, this future network did not consider the development of Capital Metro Light Rail (CMLR), nor was the development of West Belconnen considered at that time.

An alternative approach is assumed here:

- The existing bus network will operate, excepting any service that currently operates on Northbourne Avenue north of Antill Street to the CBD, as these routes will be replaced by light rail. This includes the 200-series Red Rapid routes, and the 50-series local routes.
- While local routes 30, 31 and 39 could also potentially be removed, these could also feasibly be re-routed off of Northbourne Avenue and along suburban streets. For operational planning purposes, these are retained as travelling to the CBD.
- Red Rapid services will continue to serve the southern half of the existing corridor, from the CBD to Russell, Barton, Kingston and Fyshwick.
- Rapid and Expresso routes from Molonglo and West Belconnen to the CBD will have been added to the network. From previous planning studies, the following is assumed:
 - + Rapid buses from Molonglo will approach the CBD via Parkes Way, at a peak frequency of 8 per hour in 2031.
 - + Rapid buses from West Belconnen will form part of the Blue Rapid and approach via Barry Drive, at a peak frequency of 8 per hour in 2031.
 - + Expresso buses from West Belconnen will approach via Parkes Way, at a peak frequency of 3 per hour in 2031.
- Relatively little additional residential development will occur in Canberra outside of the corridors served by the CMLR and the new Rapid routes noted above. Background growth in service levels and patronage of 1% per annum has been assumed on the remaining route network.

5.2.3 CBD Operations

The intention of CBD bus network planning is to ensure that adequate service is provided by the all-day network to all areas of the CBD, noting the increased travel demand to the new development areas between London Circuit and the Lake.

Whilst all routes need to serve City Bus Station to ensure connectivity with the CMLR and other bus routes, the path that each route takes through the CBD will depend on which road it enters the CBD on, and whether it is through-routed or terminating.

The temptation to treat London Circuit as a circle and have buses travel around it in a loop needs to be avoided. A partial exception to this is routes that terminate in the CBD, for which extended travel around London Circuit may be necessary in order to reach the most appropriate layover facility.

5.2.3.1 Reconnecting the Red Rapid

The truncation of the Red Rapid will create an undesirable increase in the number of buses that require a layover in the CBD. With the new Rapid route arriving from West Belconnen, there is an opportunity to connect it to the southern section of the Red Rapid, creating through-routing from Barry Drive to Constitution Avenue.

It may also be advisable to do this with other Blue Rapid services that travel from Kippax (313 and 343), routing them southbound out of the CBD on the Red Rapid corridor instead of the Blue Rapid. This is particularly useful given that the Red Rapid services south of the CBD have strong contra-peak demand.

If the required frequency on the southern section of the Red Rapid exceeds that of services travelling to/from Kippax, short-run trips starting at City West Layover will be used.

If the required frequency on the Kippax to CBD section of the Red Rapid exceeds that of services travelling to/from Kingston, short-run trips starting at City East Layover will be used.

5.2.3.2 Parkes Way Routes

Routes that enter the CBD from the west on Parkes Way, including the Molonglo Rapid, are less logical choices to connect to the Red Rapid and would serve a stronger function passing along the southern section of London Circuit, anti-clockwise towards City Bus Station. With no logical through-routing opportunity, they would continue to the City West Layover, serving ANU as the last stop.

5.2.3.3 Rapid Stops at City Station

The current location of the Rapid platforms within City Bus Station is on East Row, requiring buses to deviate from the shortest, fastest path through the CBD.

With the CMLR replacing the Red Rapid from Gungahlin, co-locating the Rapid stops and the light rail stop is critical for allowing easy and legible transfer between the two modes that will be serving the Rapid network.

The most appropriate way to do this is to convert the existing Platforms 10 and 11 on Northbourne Avenue (located between London Circuit and Alinga Street), and/or create new platforms one block further north between Alinga Street and Bunda Street. All Rapid buses will be able to access these platforms regardless of which direction they are travelling through the CBD. Relocating Rapid services out of East Row will release additional platform space, alleviating the current overcrowding experienced at Platforms 8 and 1 in particular.

5.2.3.4 CBD Bus Paths

Figure 37 shows the recommended Rapid route paths in the CBD, which will overlap and serve the southern and eastern sections of London Circuit.

The western section of London Circuit will be served by a combination of through-routed local routes travelling from City Bus Station either to Acton (including the relocation of routes that

currently travel along Marcus Clarke Street), or south via Commonwealth Avenue to Parkes and beyond.

All-day routes that terminate in the CBD, along with peak-period-only services (e.g. Expressos), will use whichever path that best suits its need to progress to City Bus Station, and potentially on to a specific layover.

The current practice for peak-period-only routes to only travel clockwise around London Circuit will be discontinued. Currently, these buses approach City Bus Station in the AM peak from Commonwealth Avenue via the western half of London Circuit, yet when departing in the PM peak, travel along the eastern half of London Circuit. At present, of the 40 buses entering the CBD in the AM peak hour via Commonwealth Avenue, 28 travel east and clockwise onto London Circuit, and the other 12, all of which are peak-period-only routes, travel west and anticlockwise.



Figure 37: CBD Rapid Route Paths and Key Stop Locations

5.2.3.5 Future CBD Bus Volumes

Based on the assumptions presented in Sections 5.2.1 and 5.2.2, the number of buses entering and travelling through the CBD in 2031 has been estimated. The results for each section of London Circuit are presented in Figure 38.

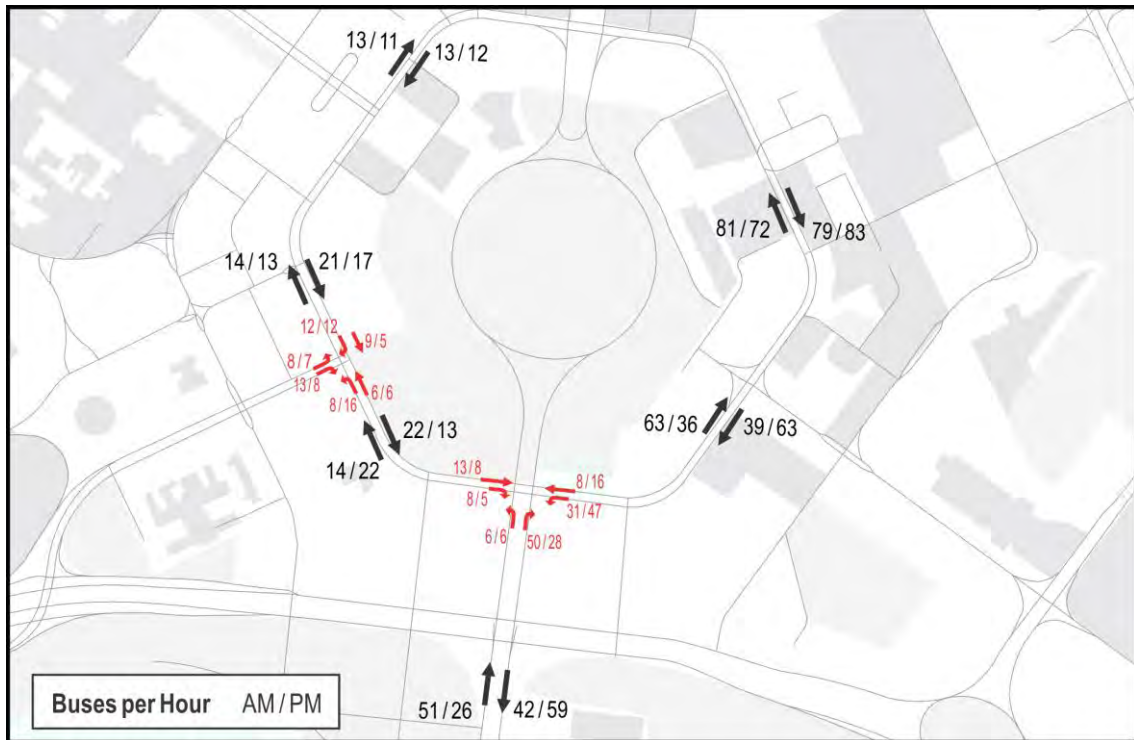


Figure 38: 2031 Forecast Bus Volumes in AM and PM Peak Hours.

5.2.3.6 CBD Stop Placement

Recommended stop placements for key CBD locations are presented in Figure 37. The hexagonal shape of London Circuit creates a geometric challenge for placing stops which needs to take into account the locations of connecting streets. Stops should preferably be located at the departure side of intersections, with adequate clearance to ensure that buses do not queue across the intersection in the instance that the stop is fully occupied.

Stops should be designed to accommodate three buses simultaneously, requiring a length of 50m minimum, plus entry and exit clearance zones. If this length cannot be accommodated, stops will need to be split and routes assigned to a specific stop.

Some existing CBD bus stop locations will need to be reviewed. Existing stops on London Circuit may need to be relocated, and stops on Marcus Clarke Street and Akuna Street could become redundant.

Where London Circuit intersects Commonwealth Avenue and Edinburgh Avenue, stops are required to serve the different directions that buses travel from these T-junctions. These locations will become transfer points between the Rapid and local services, alleviating some of the transfer activity that currently occurs at the City Bus Station. Stops should be located on the departure side of all three legs of the intersection.

5.2.3.7 Bus Lane Configuration

As shown in Figure 39, the proposed layout of London Circuit creates one-way circulation for general traffic in the clockwise direction, and separated two-way bus lanes located on the inside edge of the road (bus lanes shown in red). This proposal is not feasible for the following reasons:

- Where bus stops are created, there will be no safe opportunity for buses to move around a stopped or broken-down bus. This is a critical issue given the high volumes of buses that will operate through the CBD.

- The median separator indicated in the Urban Design Study is only provided at 3.0m width. ACT bus stop design guidelines require a minimum of 3.5 m from the kerb to the rear of a bus shelter. An additional 0.5 to 1.0m would also be required behind at the shelter for an adequate barrier to be constructed to protect the shelter and waiting area from traffic in the adjacent lane.
- For this design to work, bus stops would need to be indented. The indented bus stops would need to be a minimum of 3.0m wide. For the anti-clockwise lane, this indentation could be created within the pedestrian realm if setbacks between the kerb and the property edge are increased. However, for the clockwise lane, the creation of a stop indented into the median would require at least an additional 4.0m of road width.
- The bus stops created in the clockwise direction would leave passengers waiting on a median strip of a busy CBD road. This is unappealing and may be perceived as being unsafe.

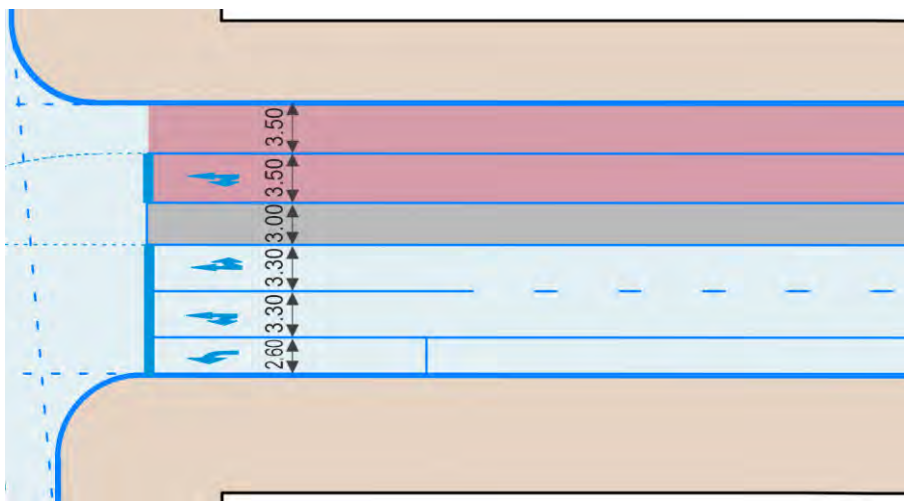


Figure 39: Proposed London Circuit Lane Arrangement

It is recommended that a more traditional approach to providing these bus lanes be taken, as presented in Figure 40.

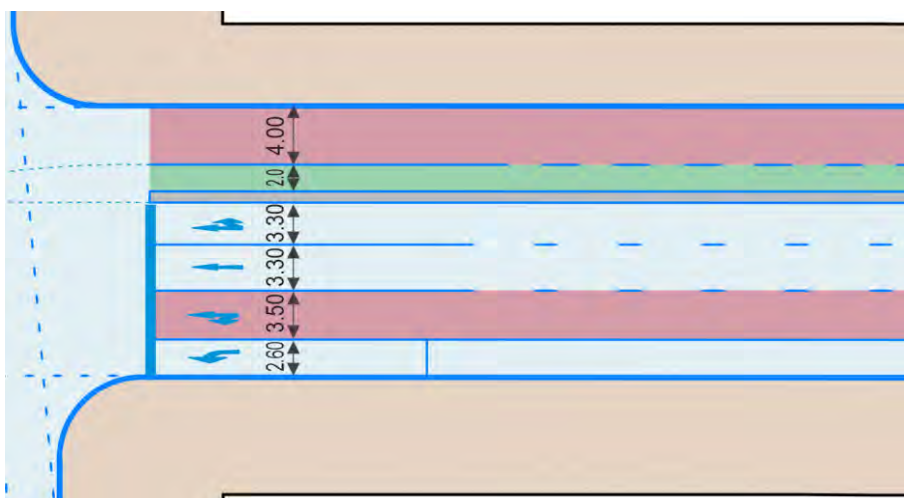


Figure 40: Alternative Lane Arrangement

In the clockwise direction, the bus lane would be located as a standard lane, potentially located outside the parking lane, or as a kerbside lane if a parking lane is not required. Creating bus stops in a parking lane would negate the need for indentation.

In the anti-clockwise direction, the removal of the 3.0m median provides for more than adequate space for the kerbside bus lane to be widened to at least 4.0m. The remaining additional space could be used to create a contraflow bicycle lane of 2.0m width. The benefit of this bicycle lane is that it increases the anti-clockwise lane space to 6.0m, which would provide adequate room for a bus overtake another which had broken down. Bus stops would still need to be indented, but the indentation may be able to be reduced to 2.0m, given the additional width of the bus lane.

APPENDIX A: STRATEGIC TRANSPORT MODELLING ROAD NETWORK ASSUMPTIONS

2011 Road Network Upgrades

Network Item	Description	Model
New Road Between Cotter Road and Dixon Drive	New road from Cotter Road to Dixon Drive	Both
Molonglo Roads Stage 1	New roadway providing access to residential developments	Both
Pialligo Avenue Upgrades	Duplication from Beltana Road to Brindabella Cct Widening of Sylvia Curley Bridge Duplication of Fairbairn Ave (Morshead Dr to Pialligo Ave) Duplication of Morshead Dr (Fairbairn Ave to Dairy Rd) New Signals at Pialligo/Fairbairn (No Impact) New Signals at Monaro/Pialligo (No Impact)	Both
Gungahlin Drive Extension Stage 2	Extension from Barton Hwy to Glenloch Interchange (Complete) Duplication from Barton Hwy to Glenloch Interchange Upgrade of Glenloch Interchange (Complete)	Both
Sandford Street Extension	Connect Sandford Street to Federal Highway	Both
Well Station Drive Extension	Connect Well Station Drive to Horse Park Drive	Both
Flemington Road Upgrades	Duplication of Flemington Rd Extension of Nullarbor Avenue to connect to Flemington Rd Extension of Well Station Drive to connect to Flemington Rd Extension of Mapleton Ave to connect to Flemington Rd Other Franklin internal roads	Both
Horse Park Drive Extension	Extension of sections east and west of Moncrieff Extension from Arrabri Street to Burrumarra Avenue	Both
Forde Internal Roads	New roadway providing access to residential developments	Both
East Lake Internal Roads	New roadways providing access to residential developments	Both
Crace Access (Abena Ave)	New Roundabout on Gundaroo Road to access Crace	Both
Nudurr Drive Extension	Connect Nudurr Drive to Gungahlin Drive	Both
Braybrooke Street Extension	Completion of link from Battye St to Ginninderra Dr	Both
Lanyon Drive Upgrade	Duplication from Monaro Highway to Tomsitt Drive	Both
Tharwa Drive / Drakeford Drive Upgrade	Duplication from Box Hill Ave to Johnson Drive	Both
Clarrie Hermes Drive Extension	Connect Clarrie Hermes Dr to Barton Highway	Both
Kings Highway	Road upgrade (Outside Modelled Area)	Both

Morshead Drive – Russell Drive Intersection Upgrade	Intersection Upgrade (No Impact)	Both
Sutton Road Stage 2	Road upgrade (No Impact on Model)	Both
Parkes Way – Kings Avenue	Grade separation of existing roundabout (No Impact)	Both

2016 Road Network Upgrades

Network Item	Description	Model
Majura Parkway	Connect Monaro Highway to Federal Highway Intersection changes on Pialligo Ave and Fairbairn Ave (No Impact)	Both
Tomsitt Drive Extension	Connect Tomsitt Drive to Yass Road in Queanbeyan	Both
Constitution Avenue Duplication	Duplication including all intersection upgrades	Majura
Constitution Avenue Upgrade	Constitution Avenue Upgrade	Recalibrated
Parkes Way Widening	Extra Lane on Parkes Way (Glenloch to Edinburgh Ave)	Both
Monaro Highway Duplication	Duplication over Canberra Ave through Fyshwick	Both
Cotter Road Upgrade	Duplication from Adelaide Avenue to Molonglo North-South Arterial	Both
Barry Drive – Clunies Ross Street	Intersection Upgrade (No Impact)	Both
Bus Lane Connection	Kingsley Street and Rudd Street (No Impact)	Both
Horse Park Drive Extension	Complete missing section of Horse Park Drive	Recalibrated
Bonner and Jacka Boundary Road	Access to Bonner Area from the Horse Park Drive – Katherine Avenue Intersection	Recalibrated
40km/hr zones in Town Centres	Civic, Gungahlin, Woden, Belconnen and Tuggeranong	Recalibrated

2021 Road Network Upgrades

Network Item	Description	Model
Clunies Ross Street Upgrade	Duplication of Clunies Ross Street	Both
William Slim Drive Upgrade	Duplication from Baldwin Drive to Barton Highway	Both

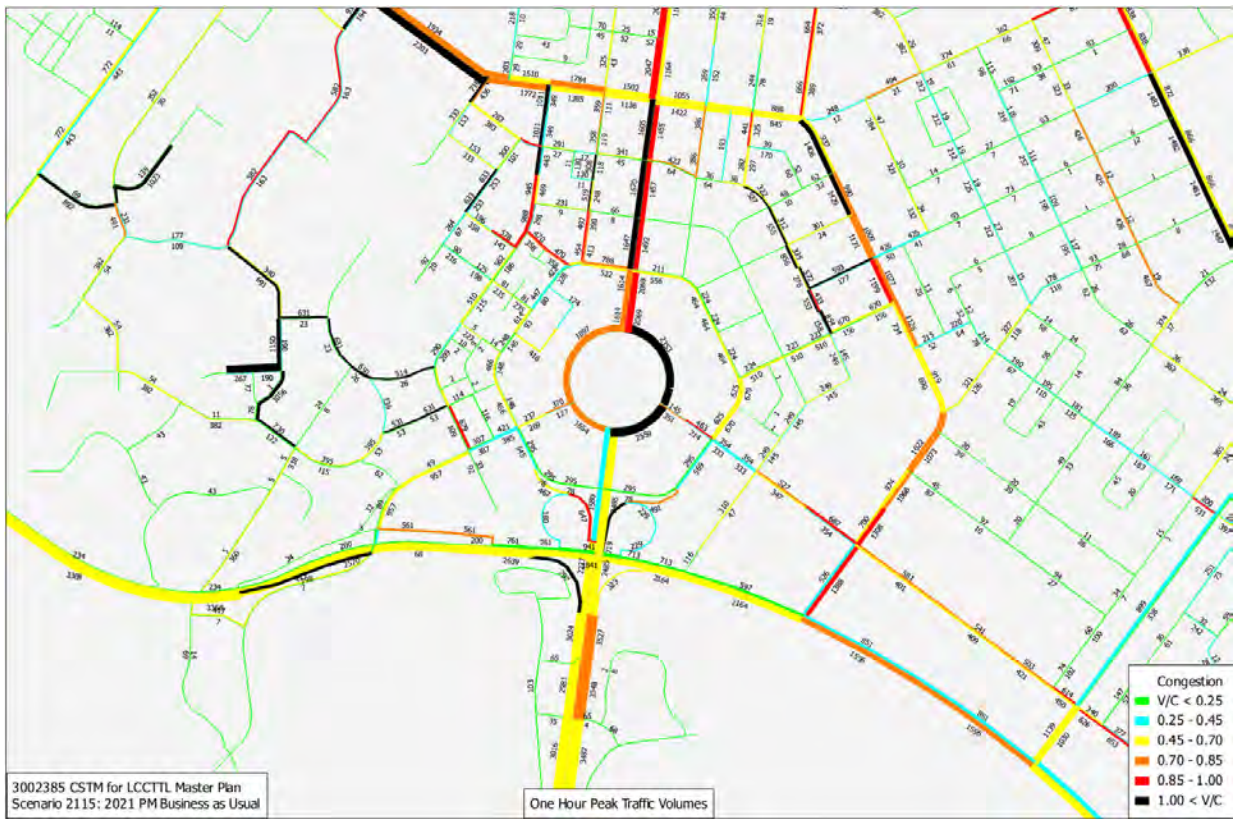
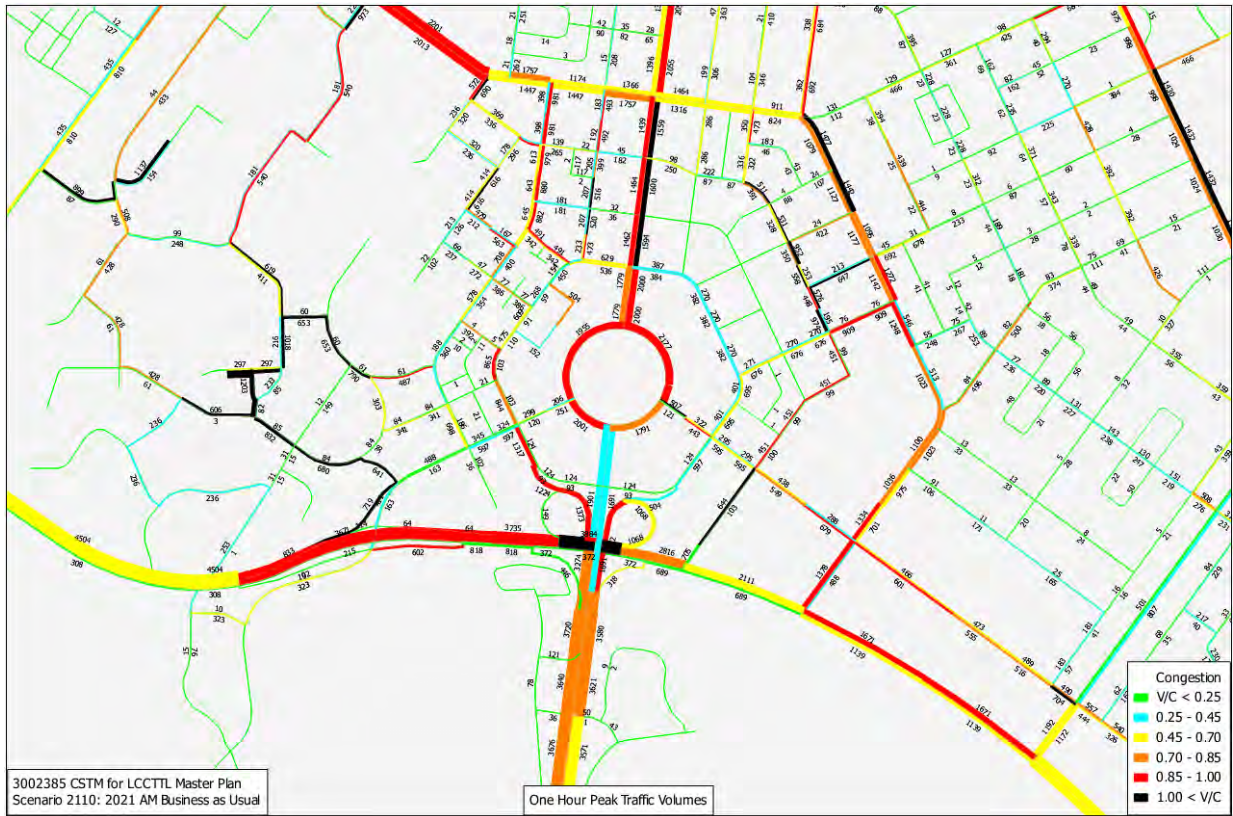
Gundaroo Drive Upgrade	Duplication from Barton Highway to Gungahlin Drive	Both
Horse Park Drive Extension	Complete missing section of Horse Park Drive	Both
Horse Park Drive Duplication	Duplication from Katherine Ave to Federal Highway	Both
Clunies Ross Street – Parkes Way Interchange	Completion of diamond interchange	Both
Airport Northern Access Road	Connect Glenora Dr to Majura Road (Northern Access to RAAF Fairbairn)	Both
Molonglo Roads Stage 2	New roadways providing access to residential development	Both
Abattoir Redevelopment	Access Roads for development of Abattoir (Near Harman)	Both
East Lake Internal Roads	Connection to Newcastle Street / Dairy Road Connection of Mundaring Drive to Newcastle Street	Both
Tennant Street Extension	Connect Tennant Street to Beaconsfield Street	Both
Jerrabomberra Avenue Extension	Connect Jerrabomberra Avenue to Canberra Avenue	Both
Googong / Tralee Link	Connect Googong/Tralee area to Lanyon Dr West of Tomsitt St	Both
Barry Drive – Clunies Ross Street Intersection	Intersection Upgrade (No Impact)	Both
Northbourne Avenue – London Circuit Intersection	Intersection Upgrade (No Impact)	Both
Northbourne Avenue Transit Lane	From London Circuit to Federal Highway, Kerb side; new additional exclusive lane (No Impact)	Both

2031 Road Network Upgrades

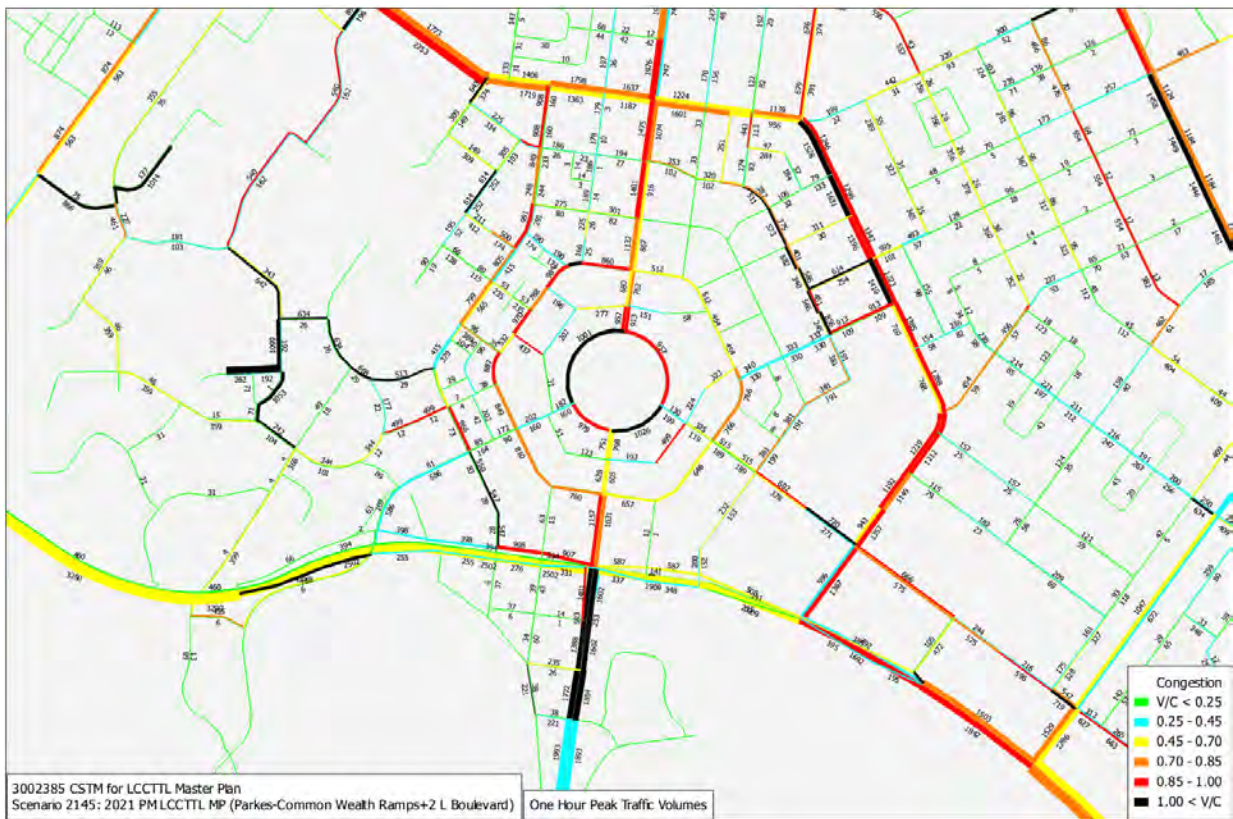
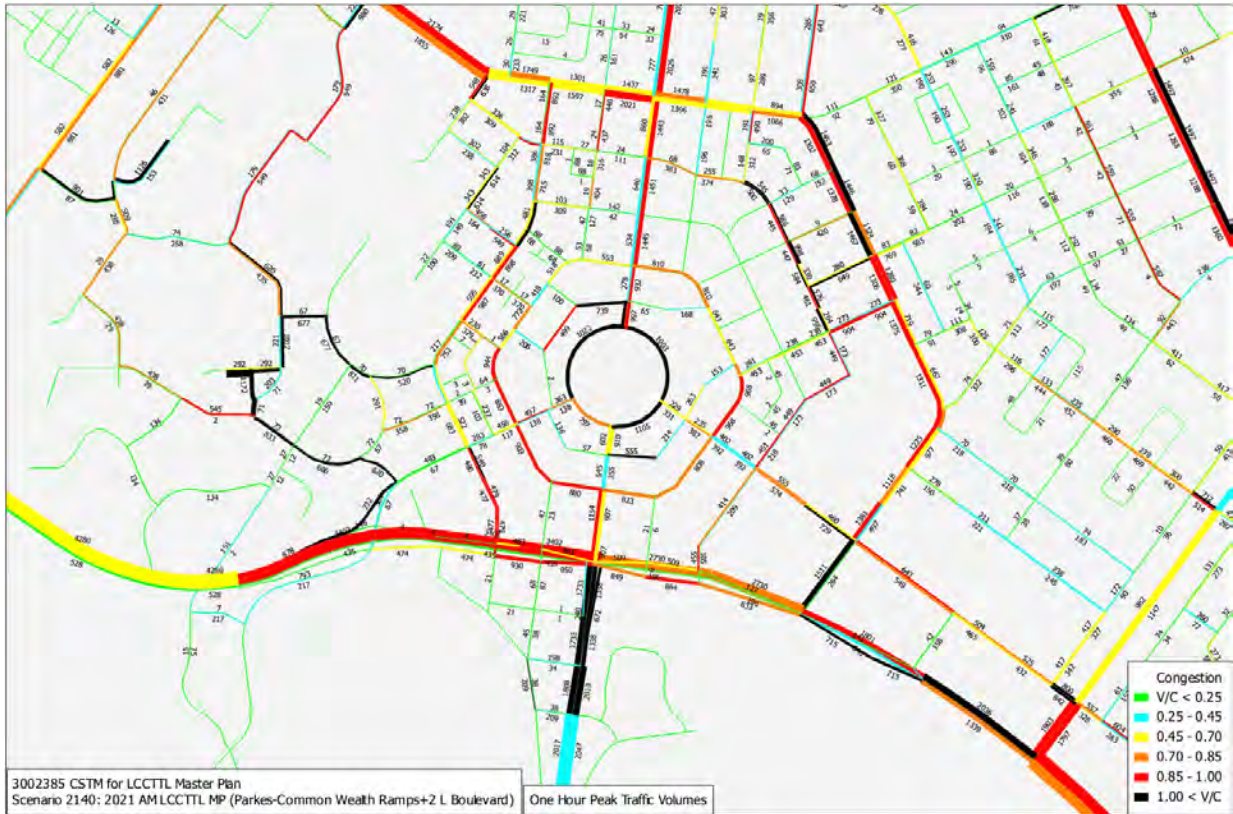
Network Item	Description	Model
William Slim Drive Upgrade	Duplication from Baldwin Drive to Ginninderra Drive	Both
Molonglo Roads Stage 3	New roadways providing access to residential development	Both
East Lake Bridges	Two bridges over Jerrabomberra Creek	Both
Monaro Highway Interchange	Diamond Interchange at Monaro Highway – Isabella Drive / Mugga Lane	Both
Pialligo Avenue Realignment	For airport runway extension (No Impact)	Recalibrated
Fyshwick – Pialligo Link	Connect Tennant Street to Gladstone Street and Kallaroo Road (Undecided alignment)	Both

APPENDIX B: CANBERRA STRATEGIC TRANSPORT MODEL TRAFFIC FLOW DIAGRAMS

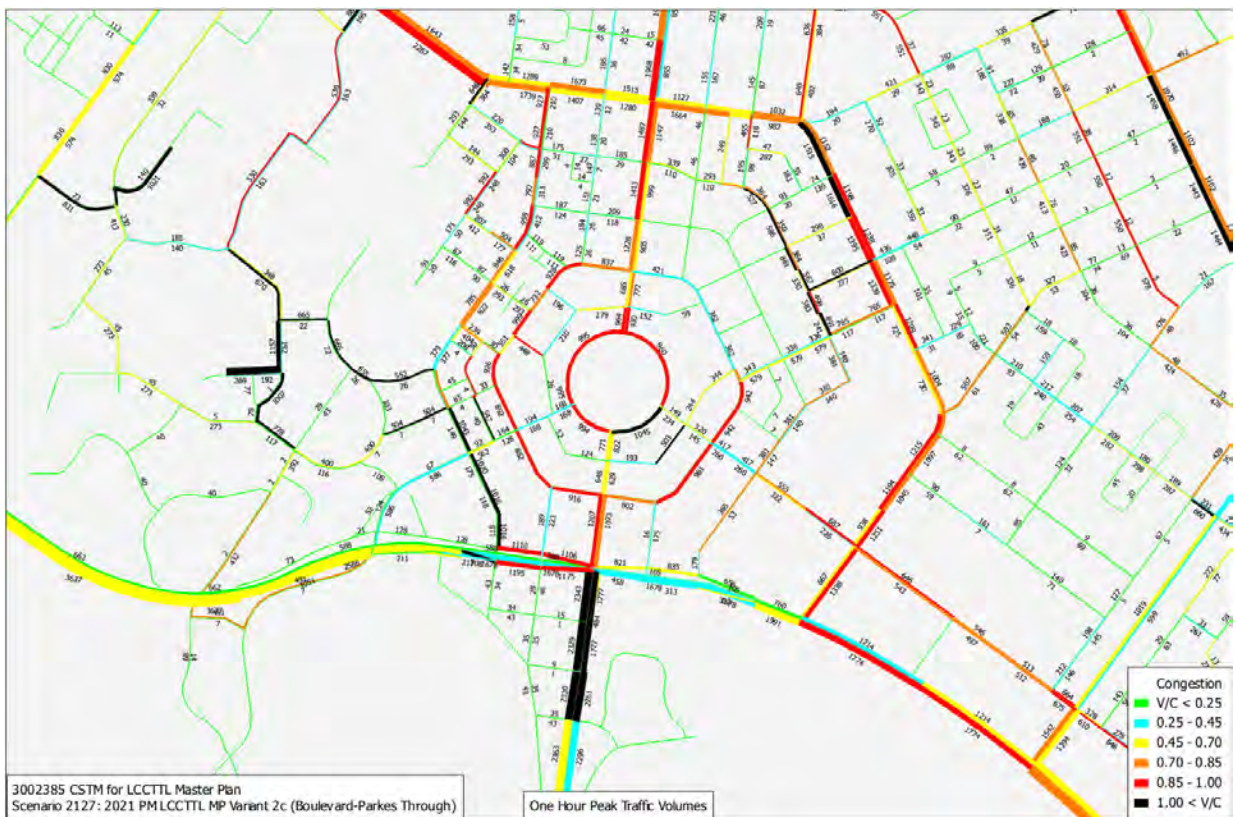
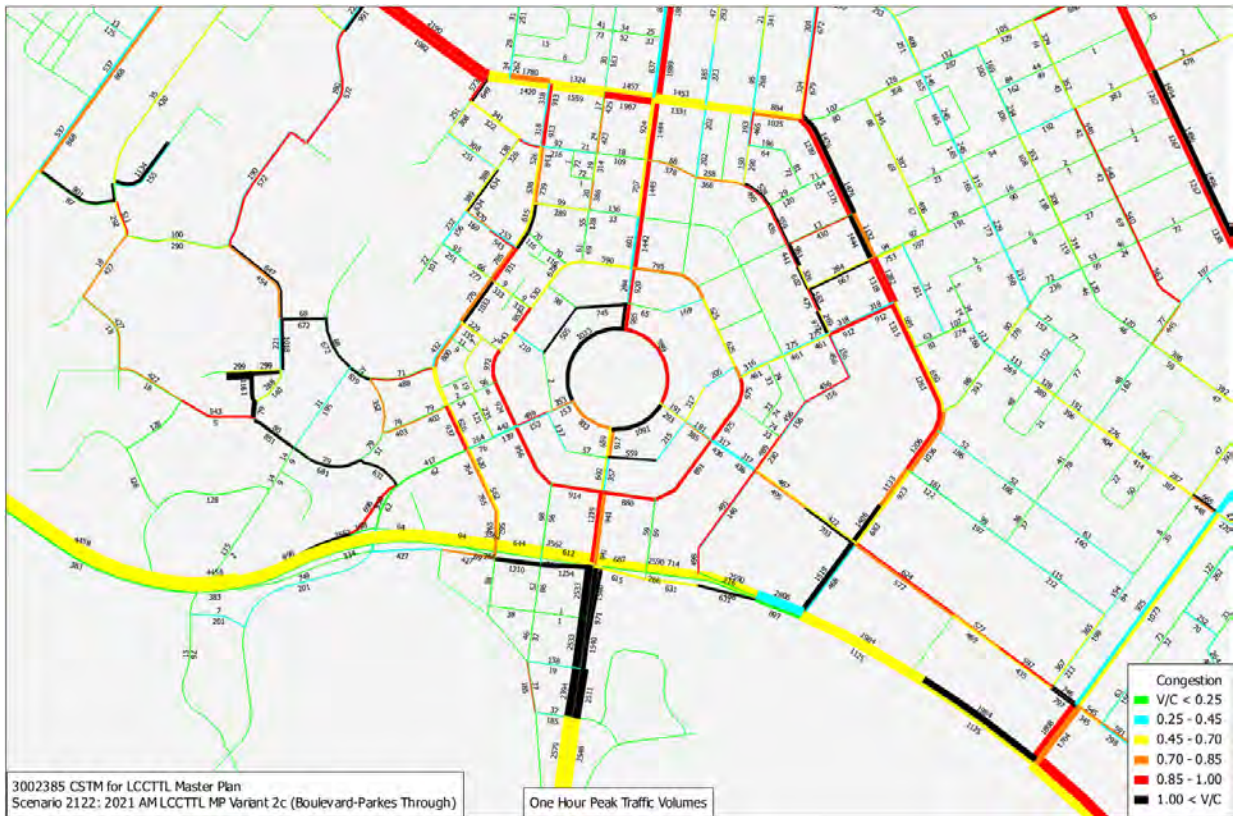
2021 Business as Usual



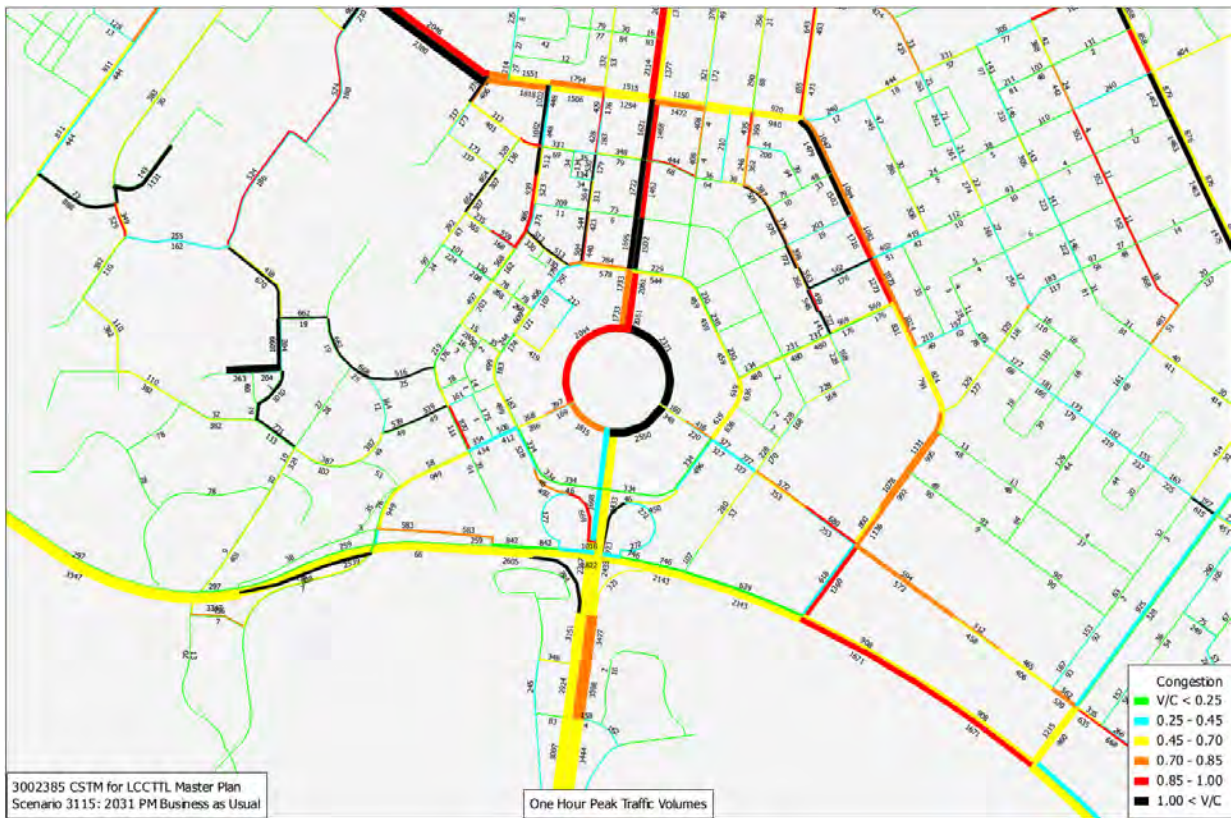
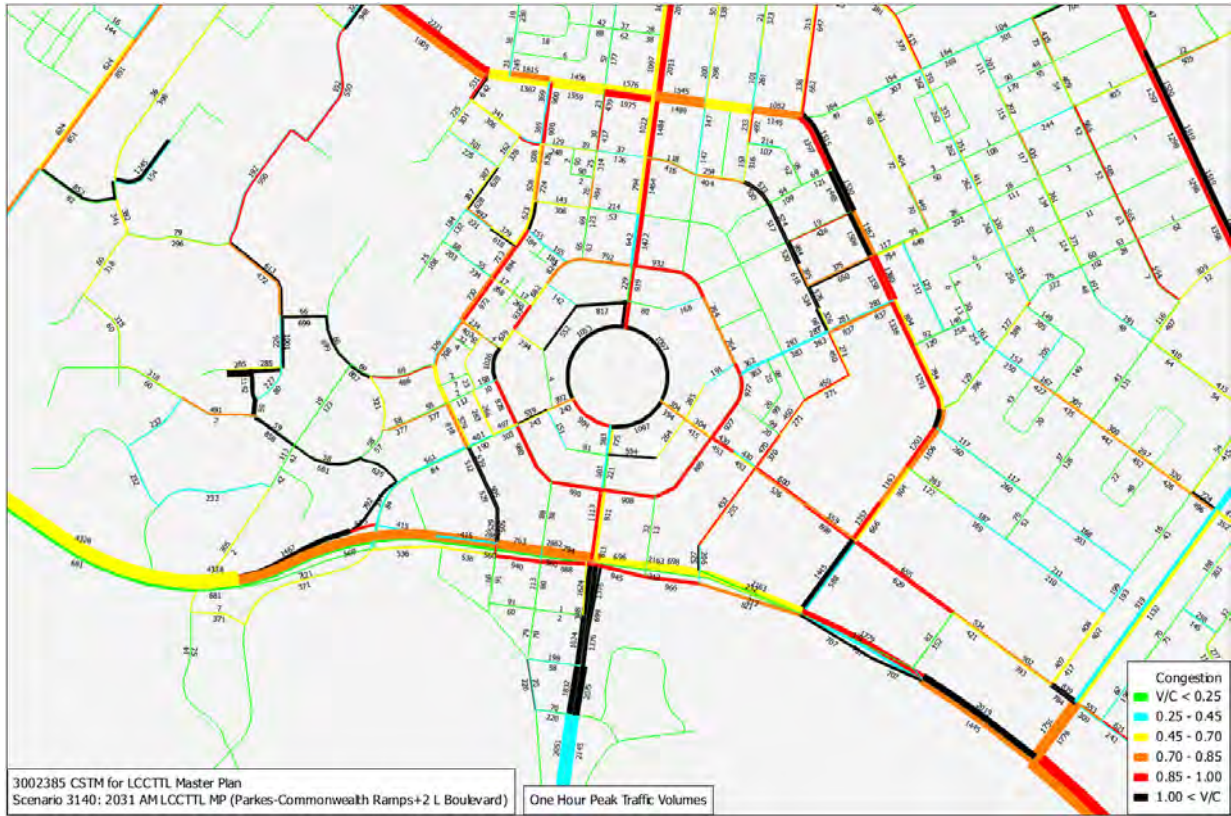
2021 UDS Feasibility Design



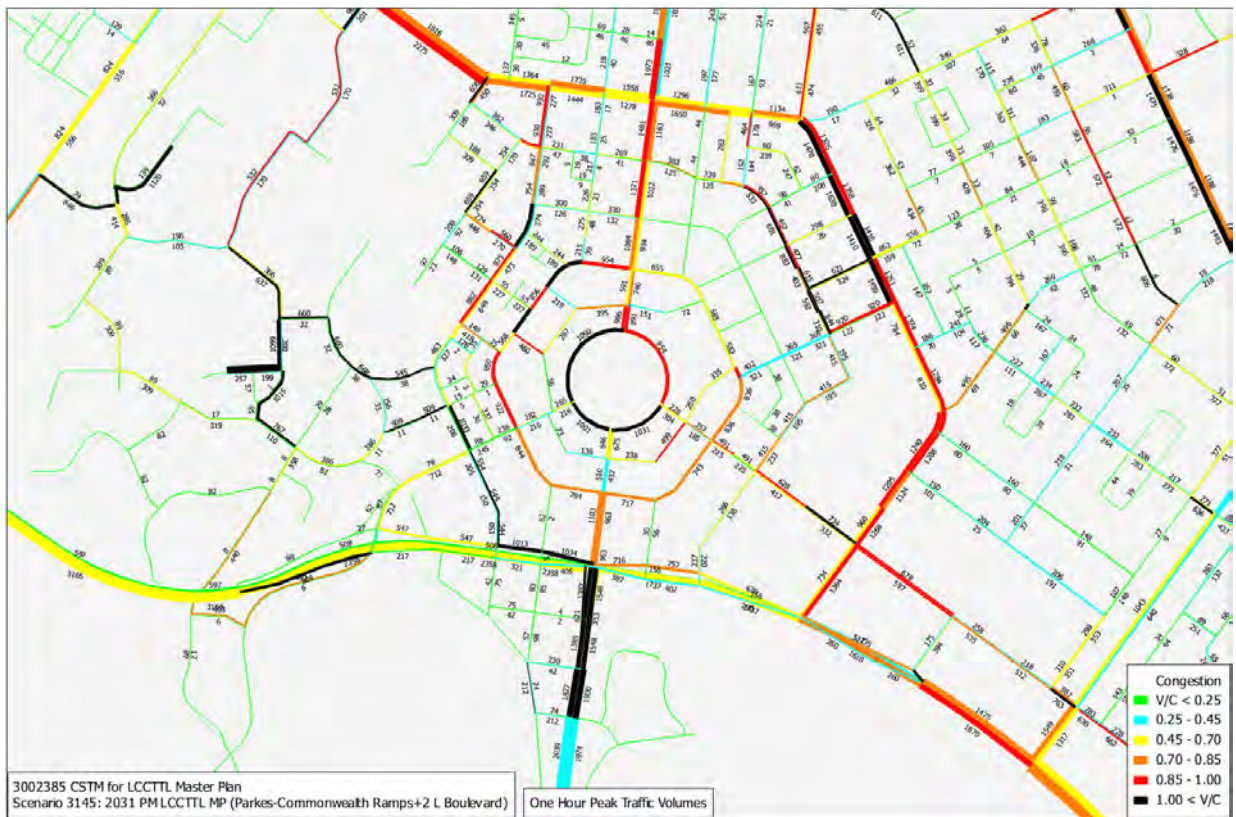
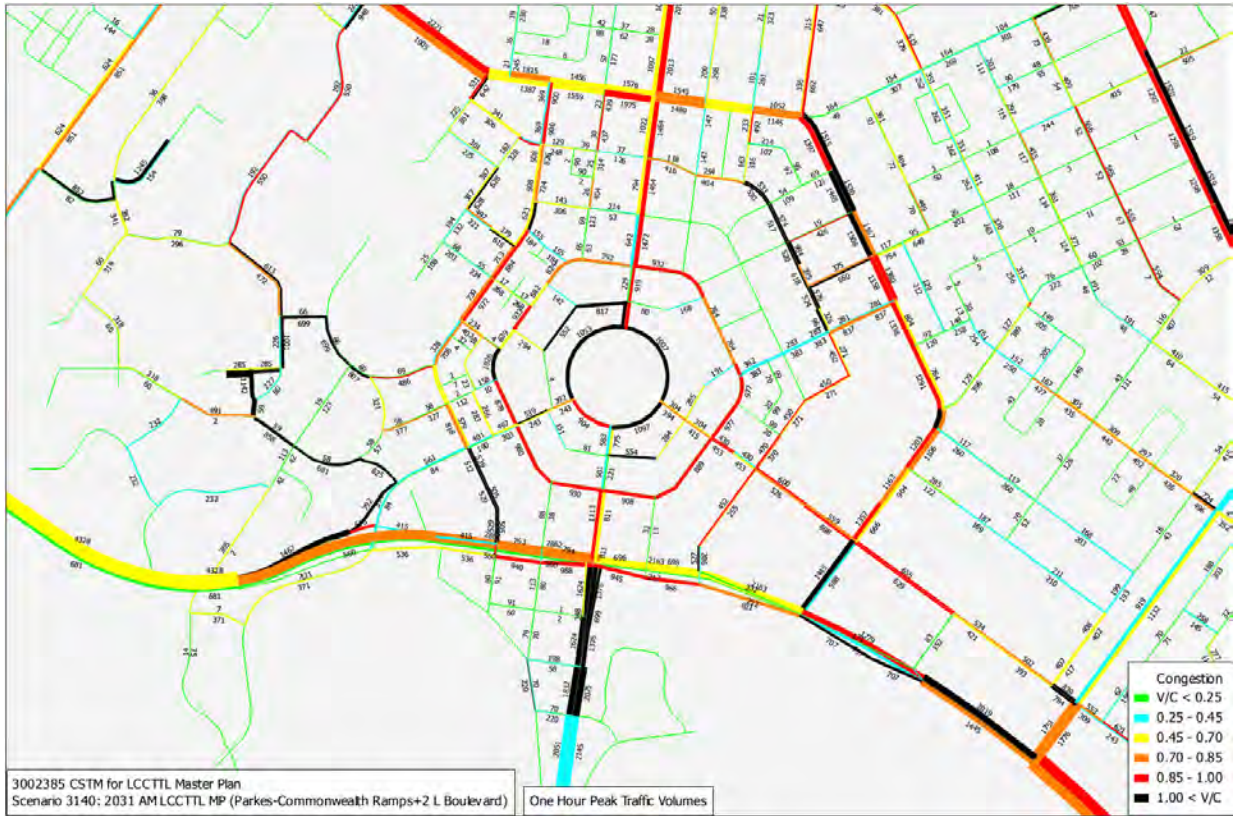
2021 Variant 2c



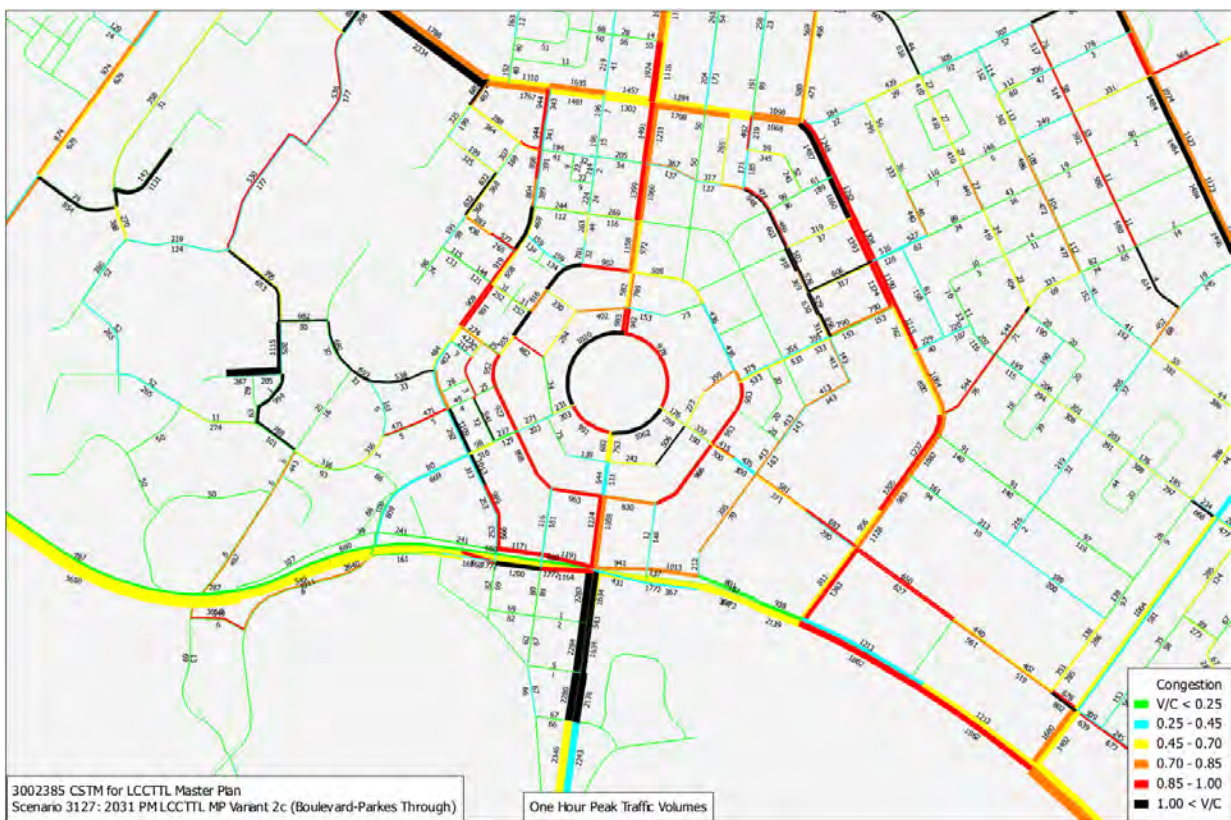
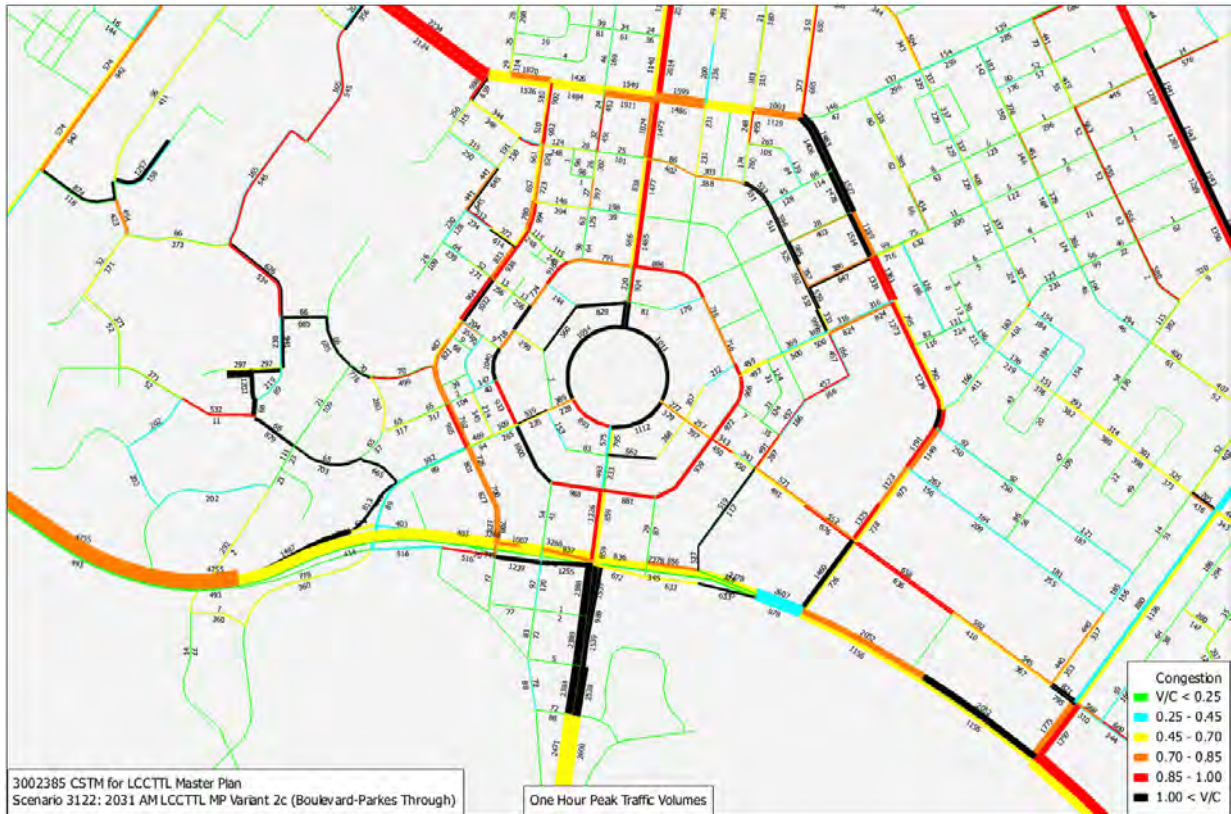
2031 Business as Usual



2031 UDS Feasibility Design



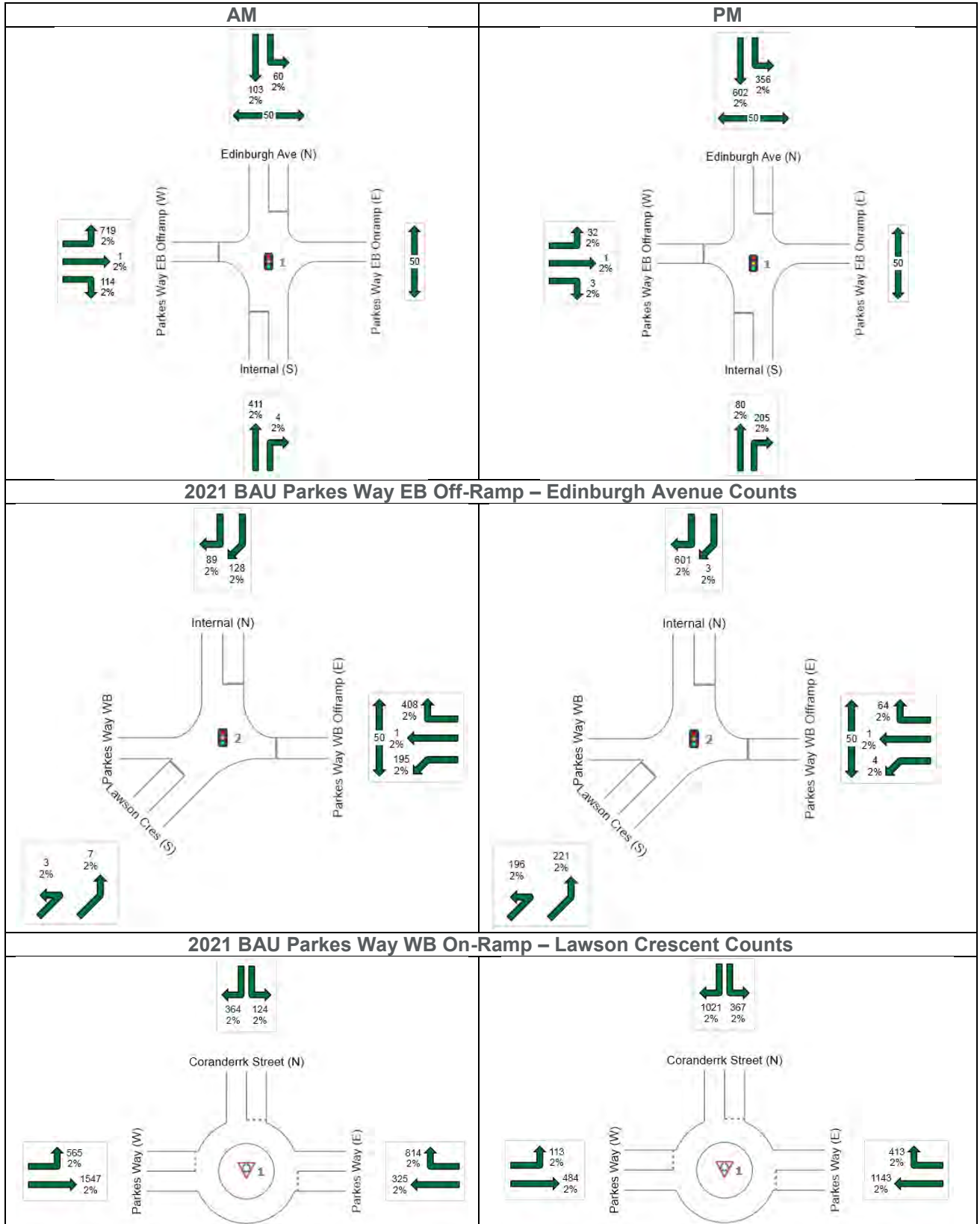
2031 Variant 2c

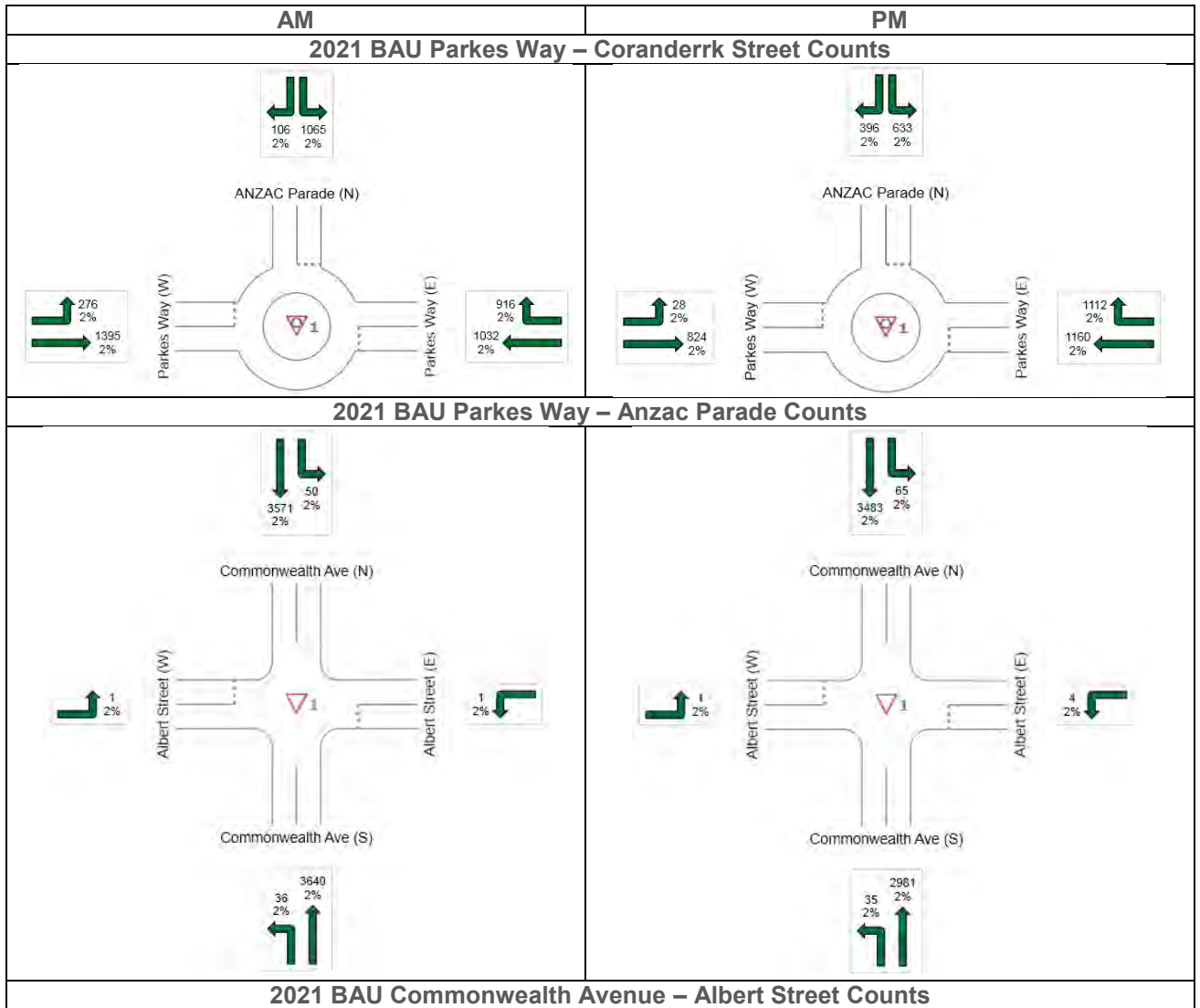


APPENDIX C: INTERSECTION TURNING MOVEMENT VOLUMES

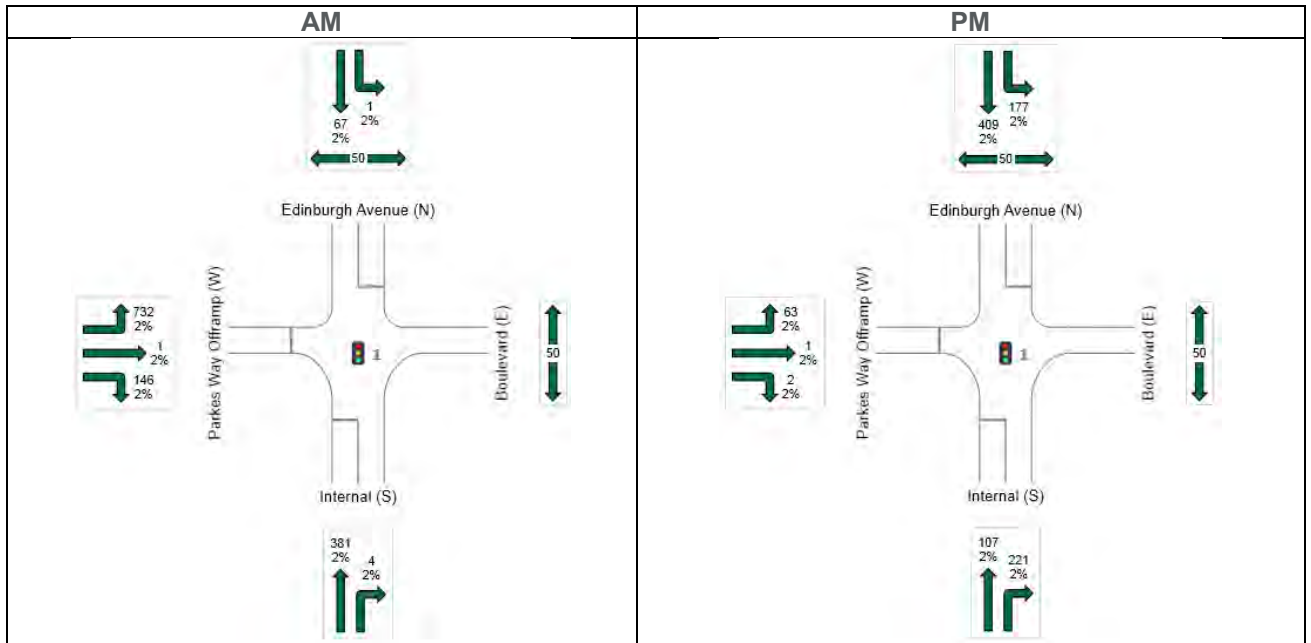
Intersection analysis has been conducted using SIDRA 6. Turning movement for AM and PM peak periods in 2021 and 2031 were extracted from the CSTM. The following subsections show a comparison between AM and PM turn counts for BAU, Feasibility Design and Variant 2c.

2021 Business as Usual

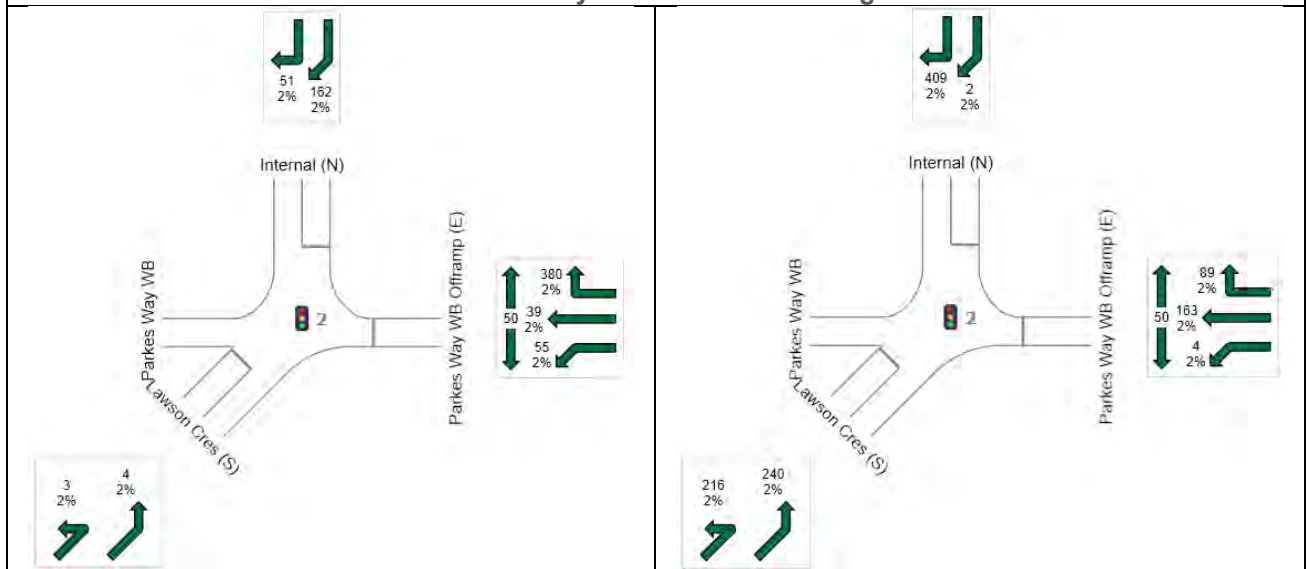




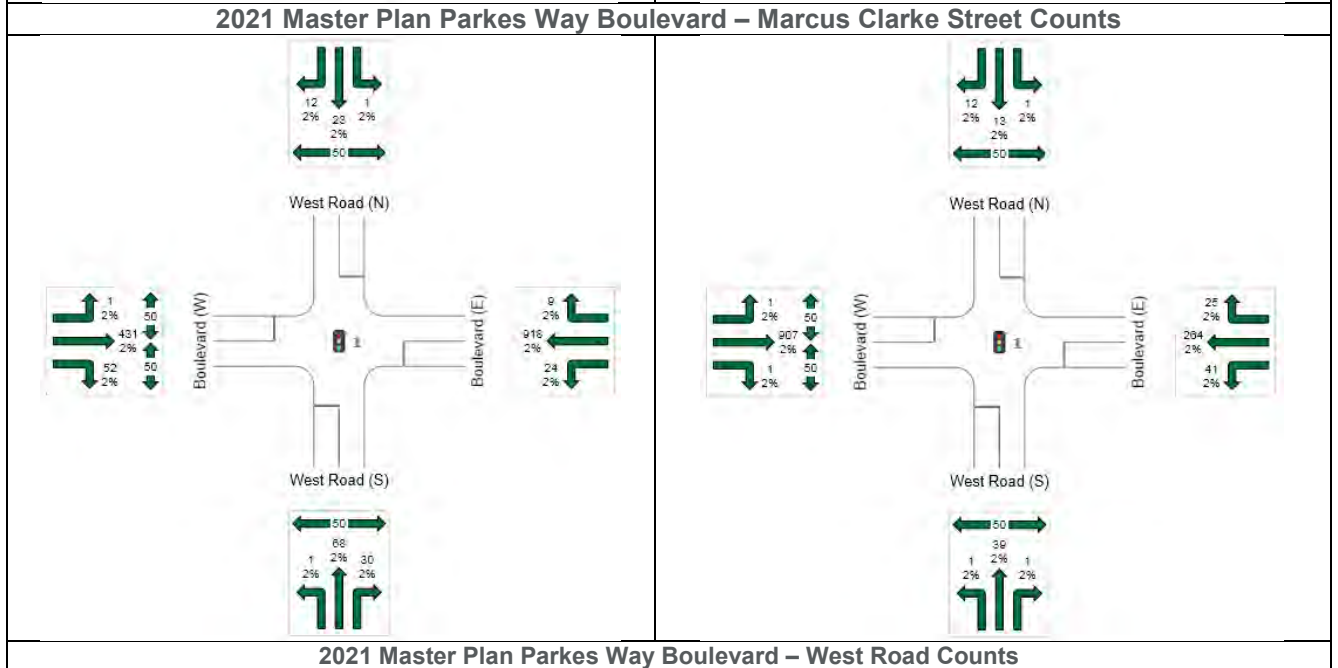
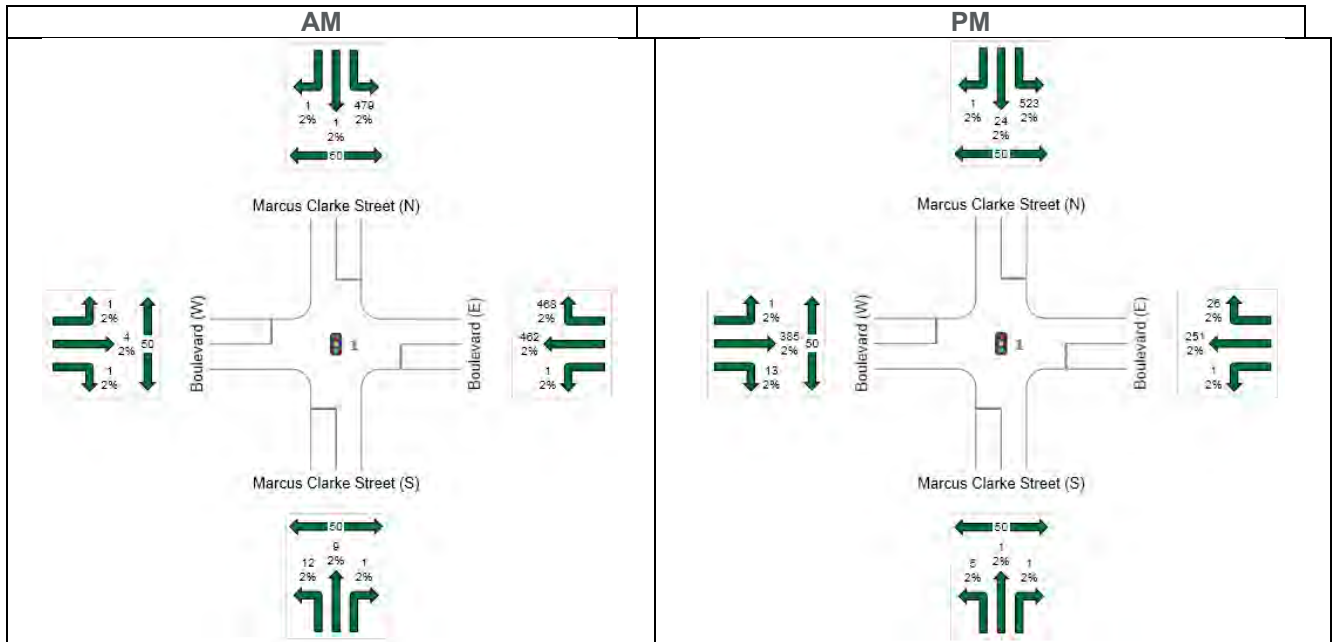
2021 UDS Feasibility Design

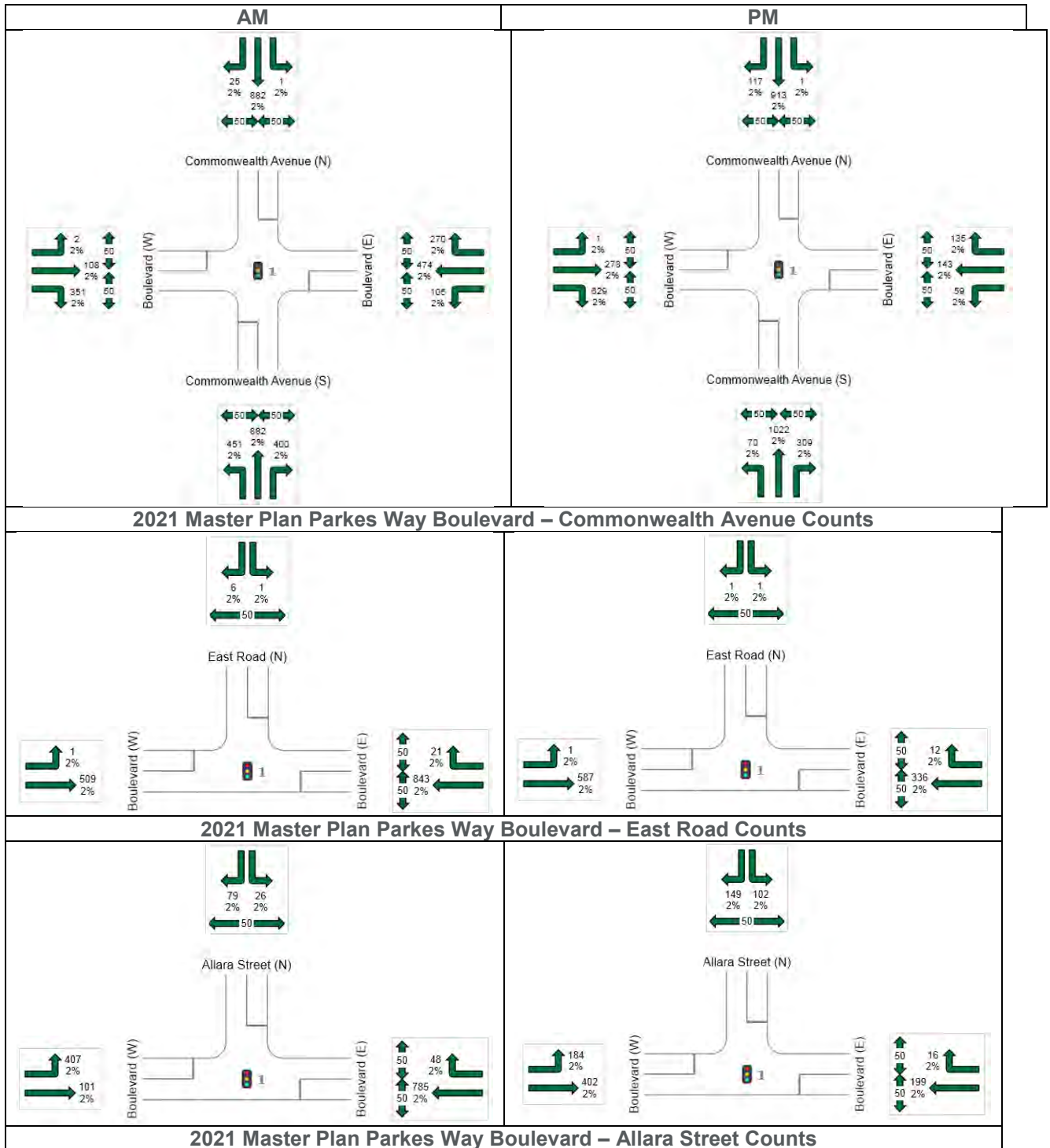


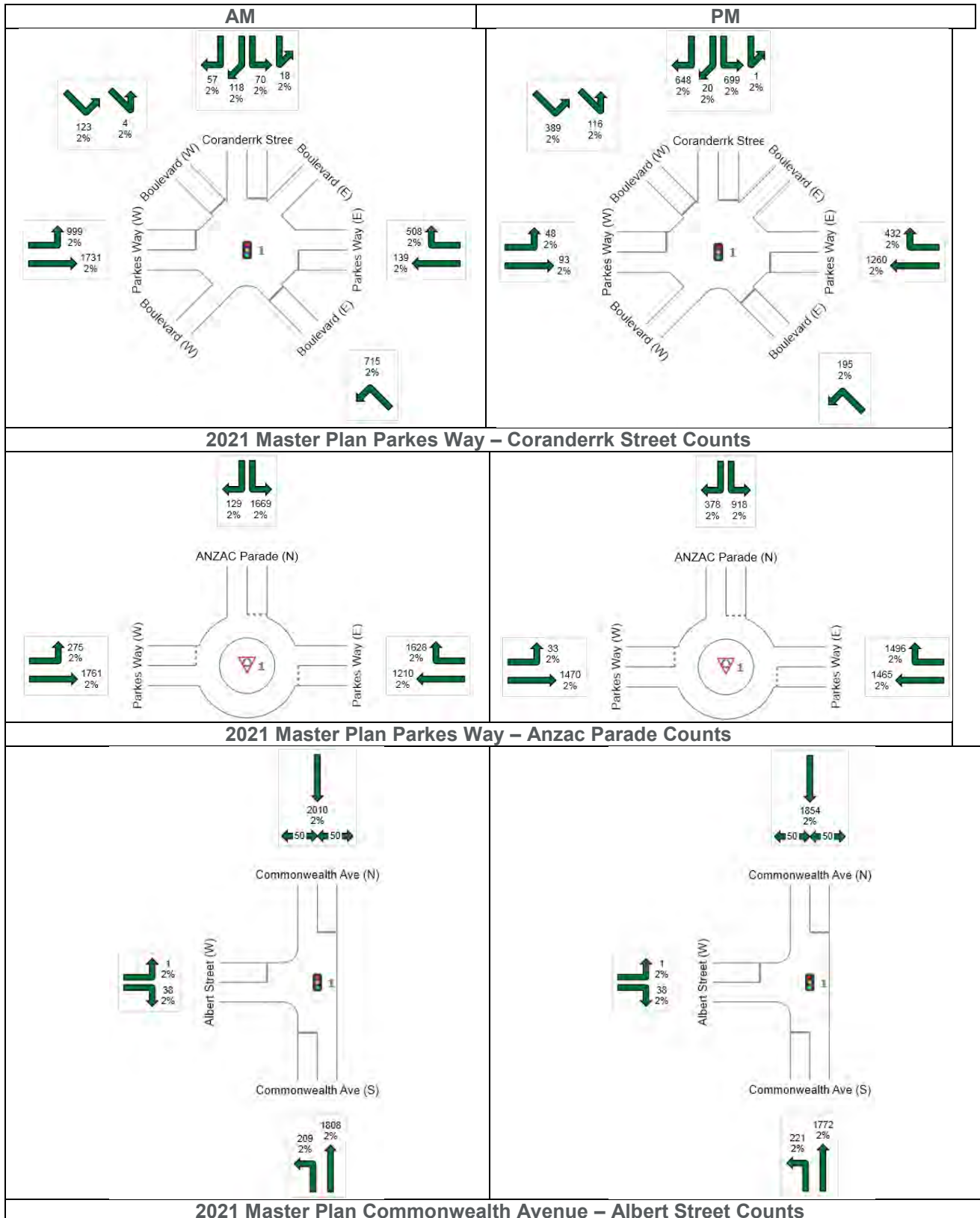
2021 Master Plan Parkes Way Boulevard – Edinburgh Avenue Counts

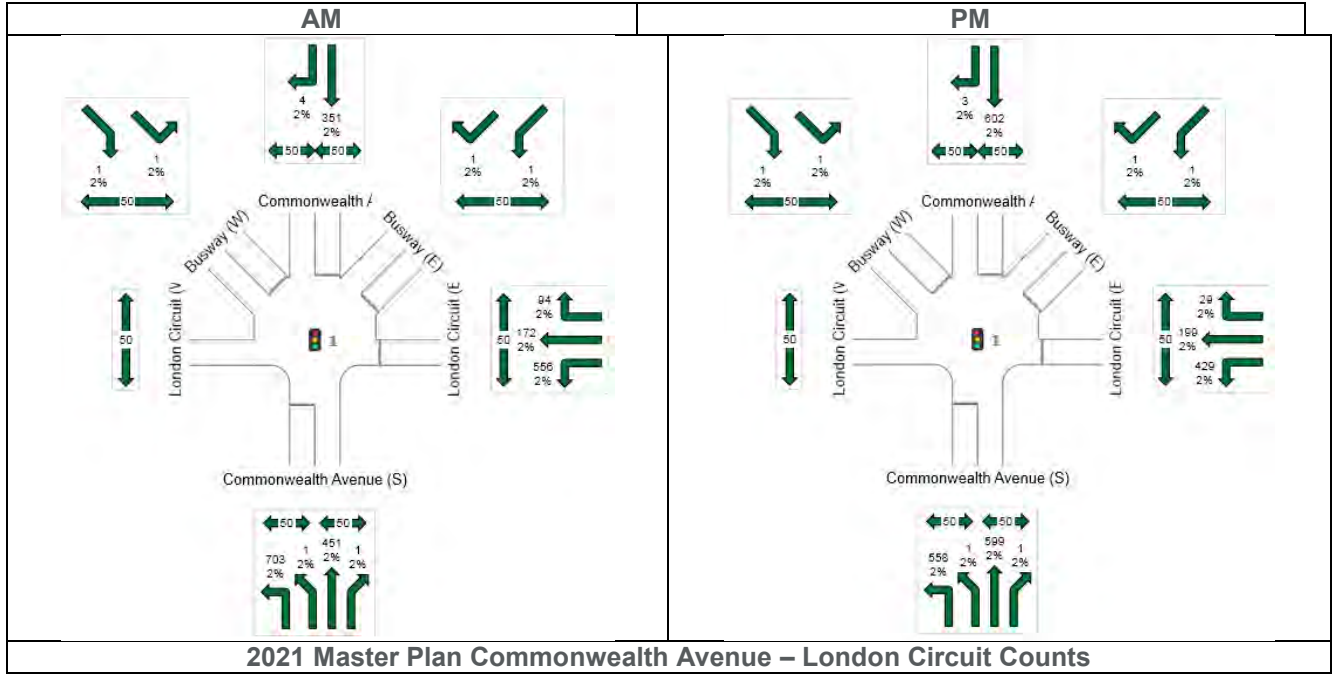


2021 Master Plan Parkes Way Boulevard – Lawson Crescent Counts

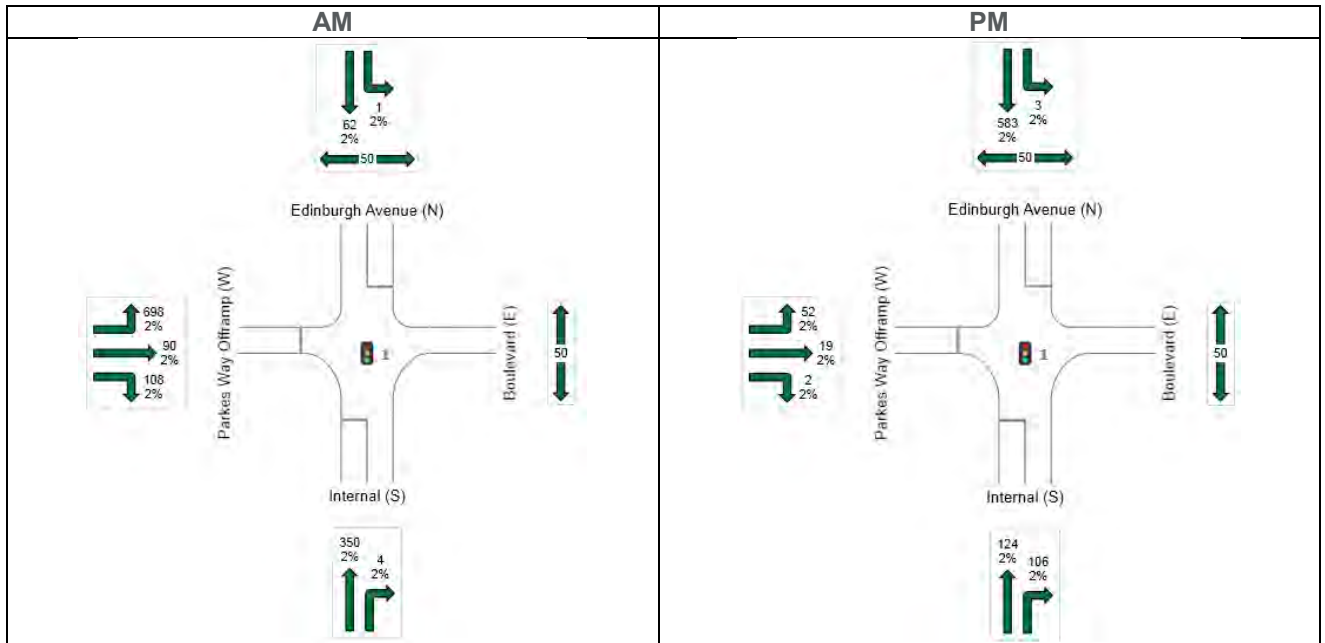




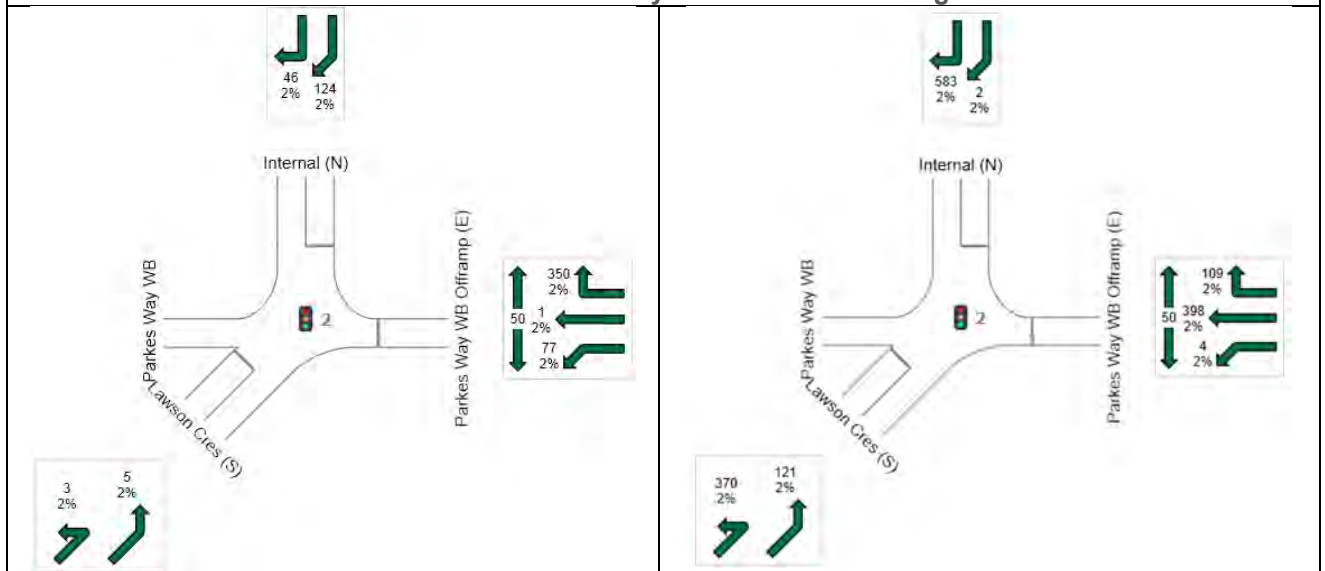




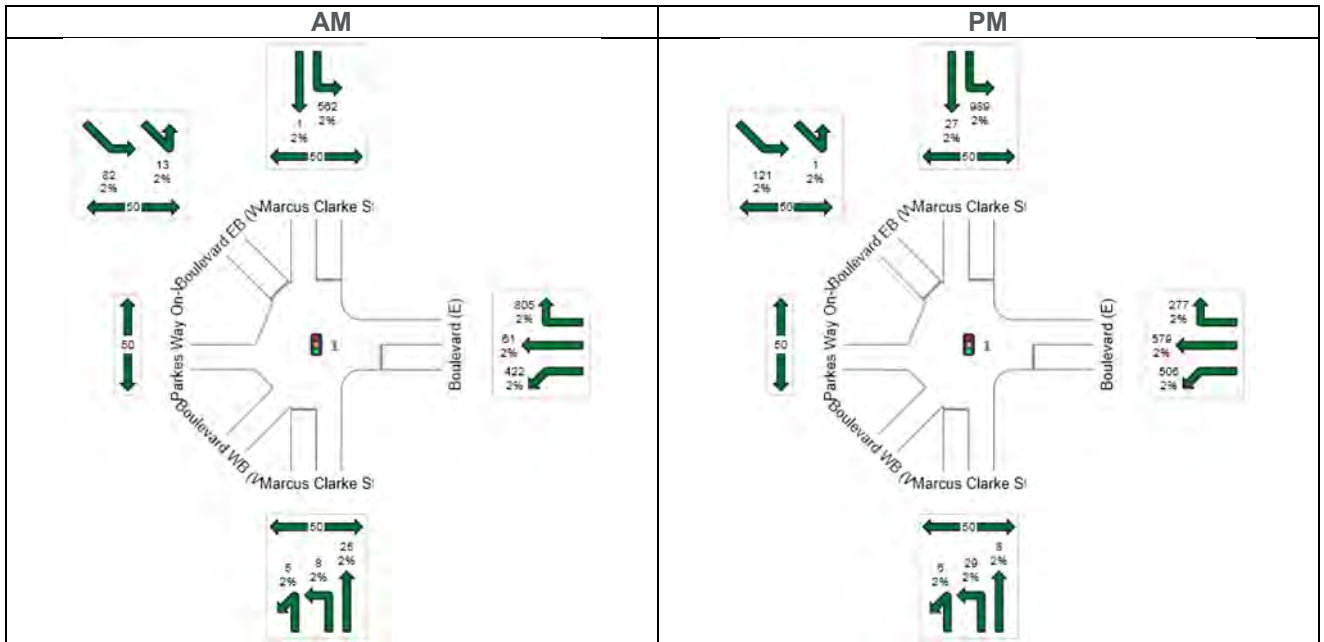
2021 Variant 2c



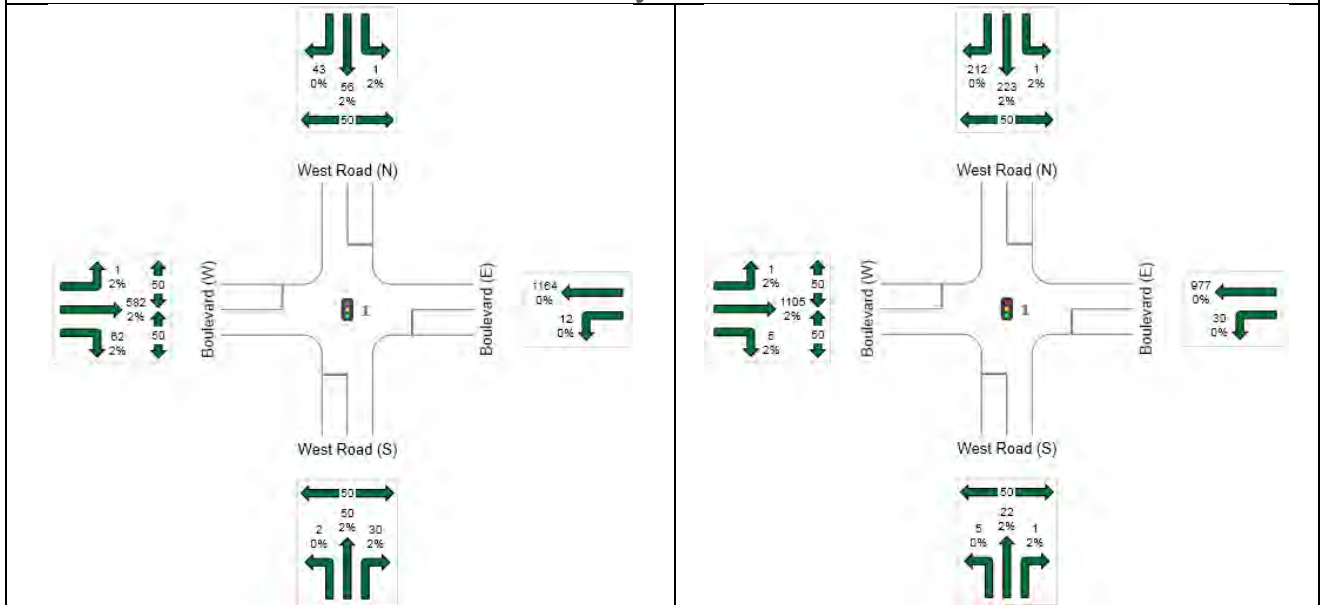
2021 Master Plan Variant 2c Parkes Way Boulevard – Edinburgh Avenue Counts



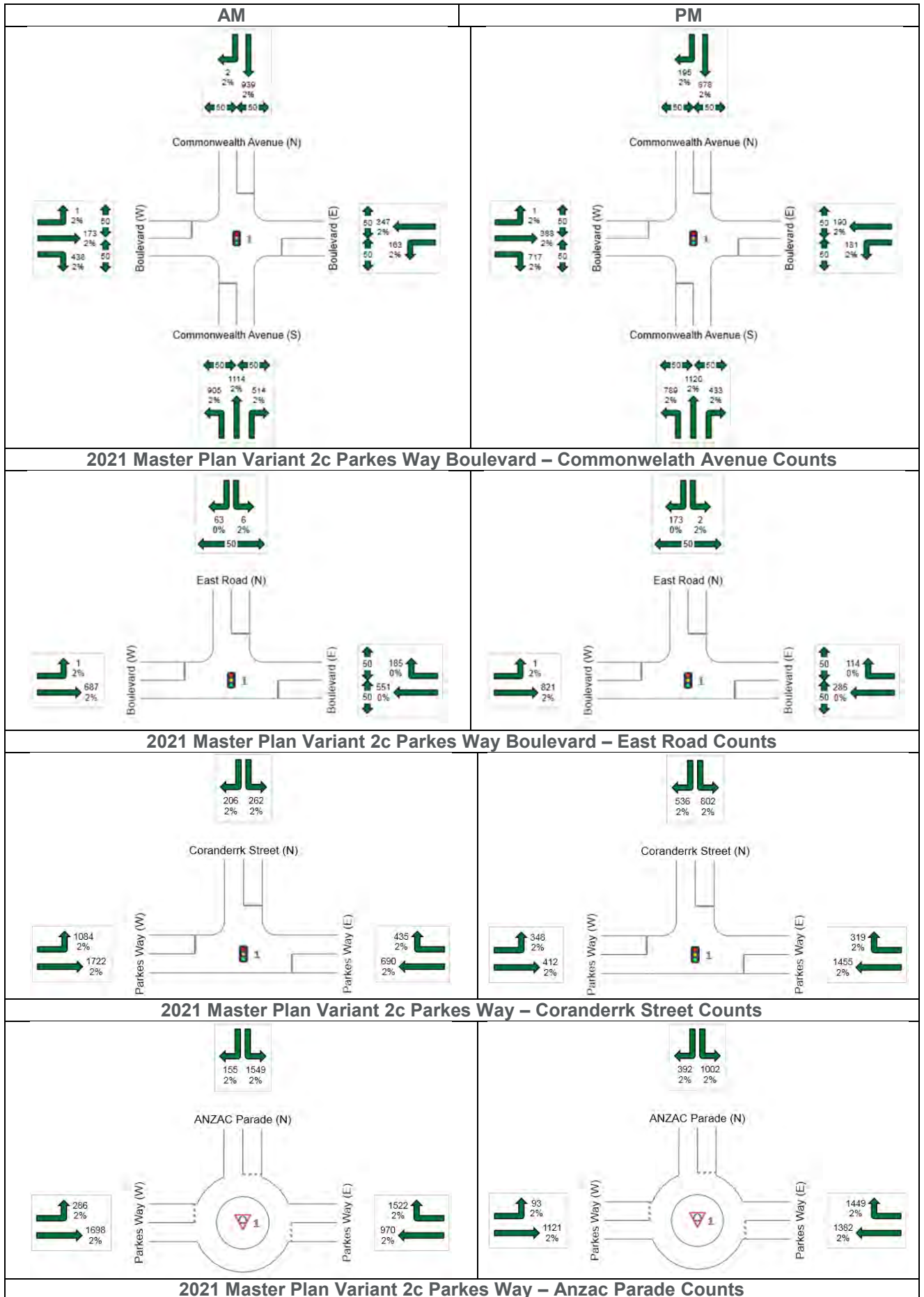
2021 Master Plan Variant 2c Parkes Way Boulevard – Lawson Crescent Counts

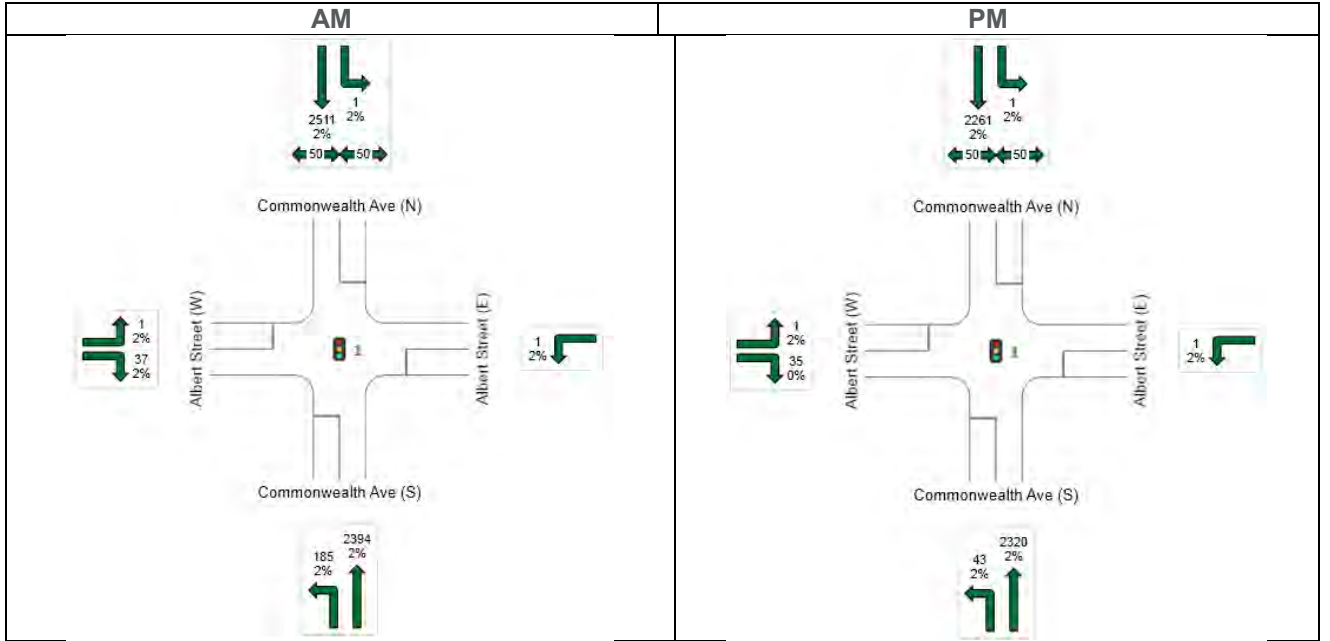


2021 Master Plan Variant 2c Parkes Way Boulevard – Marcus Clarke Street Counts

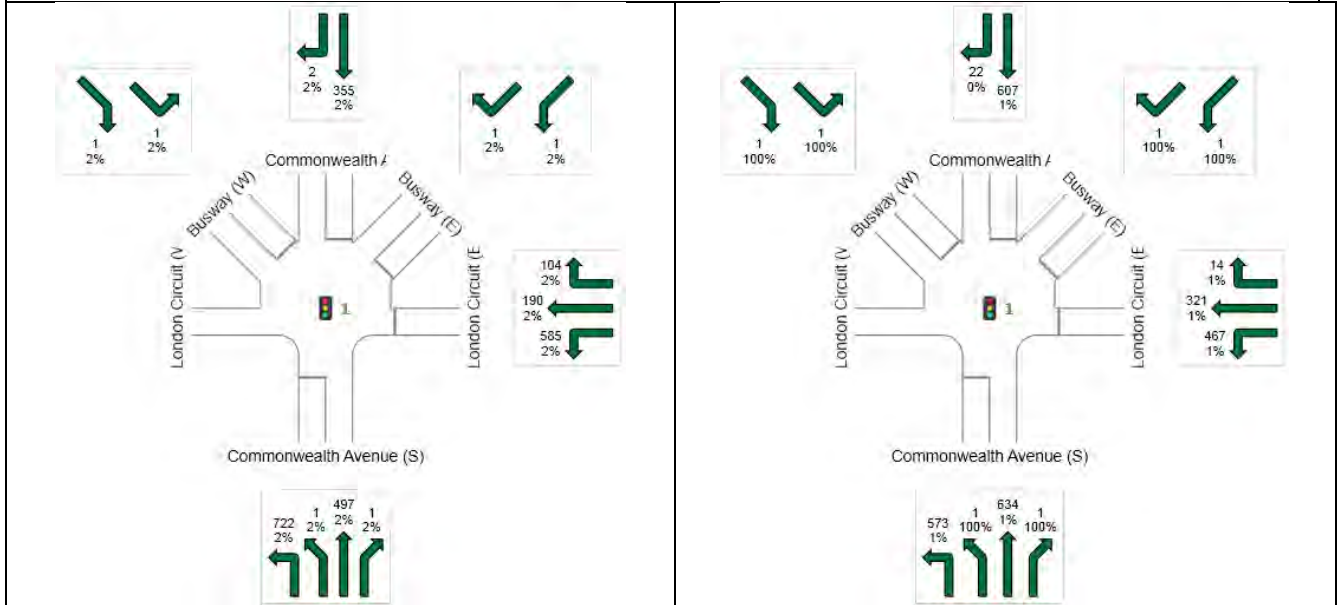


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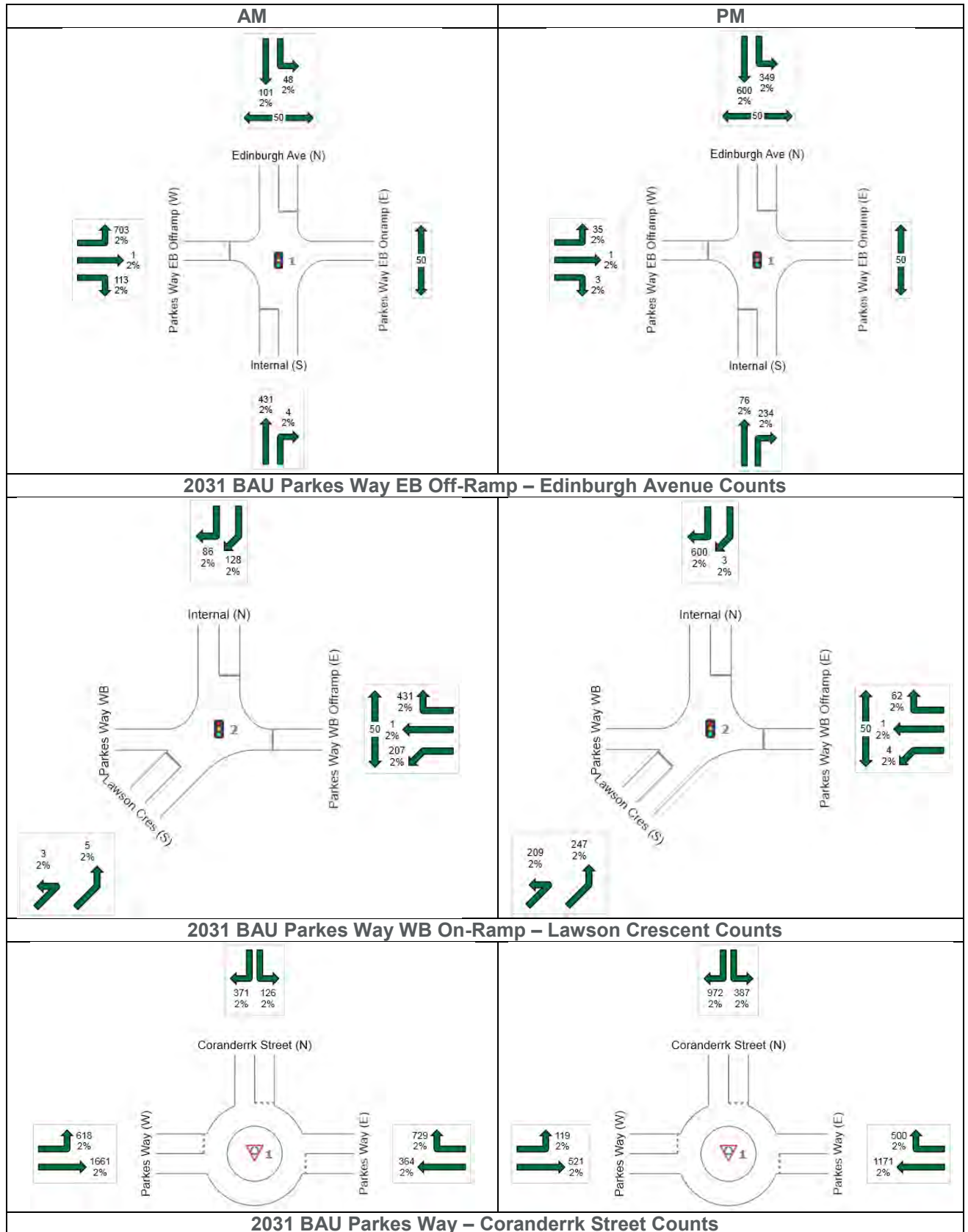


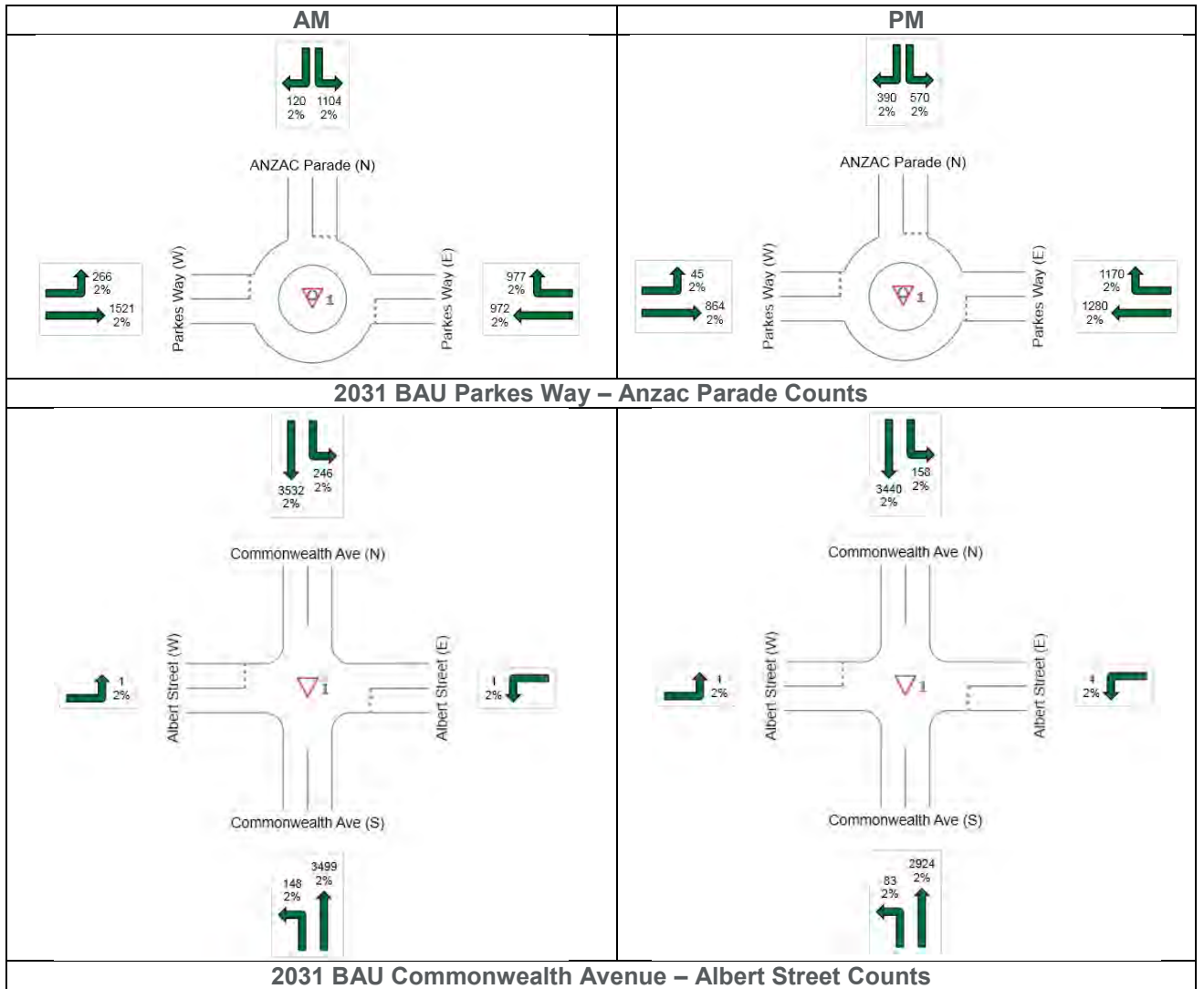
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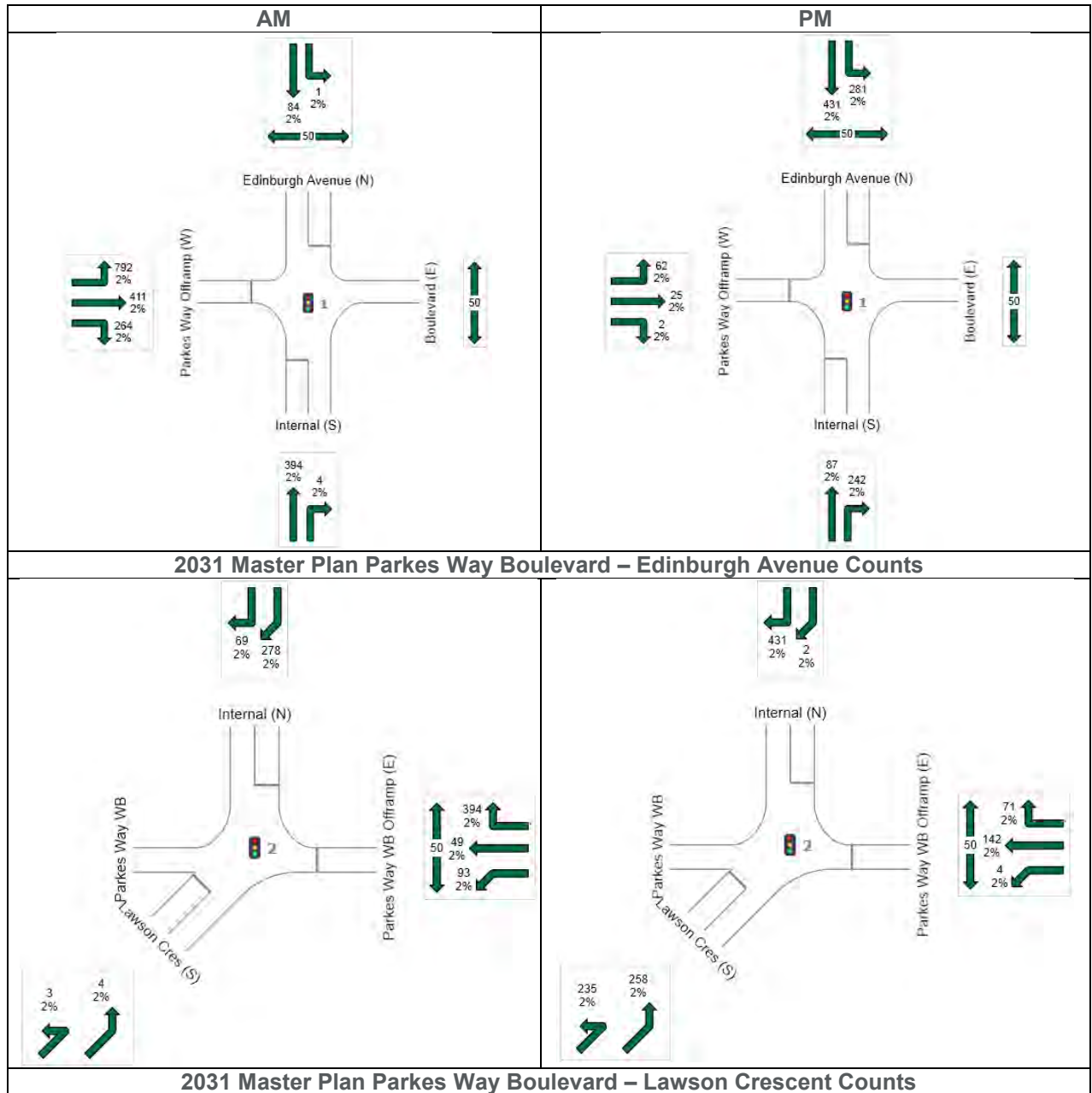
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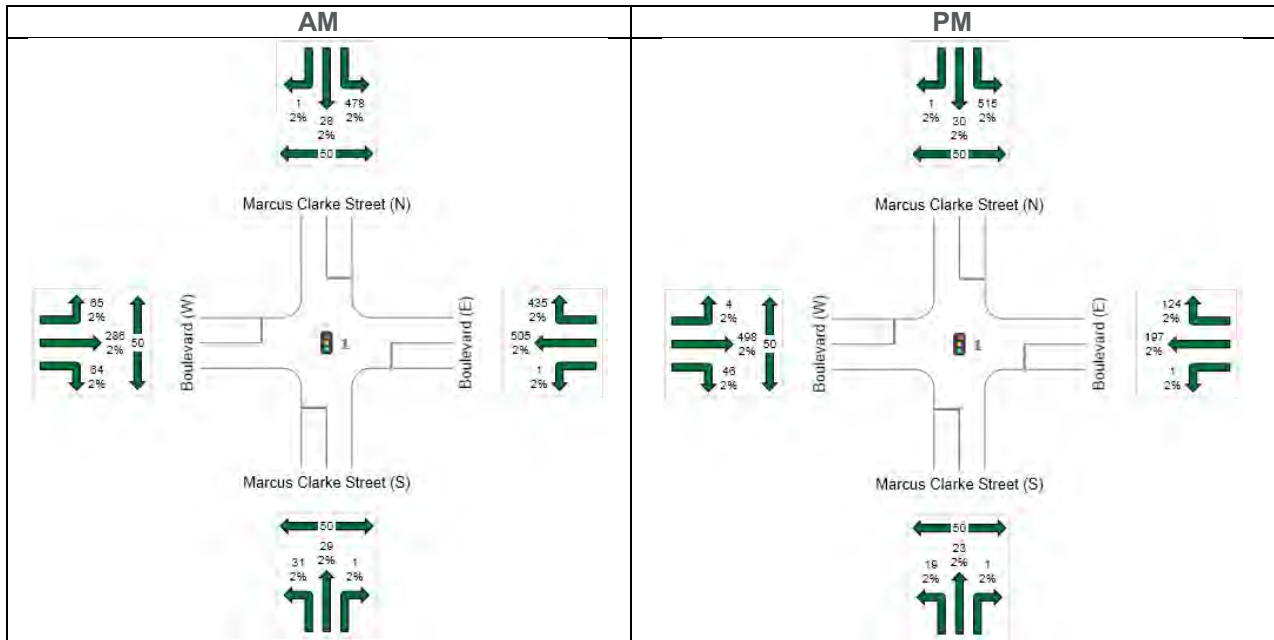
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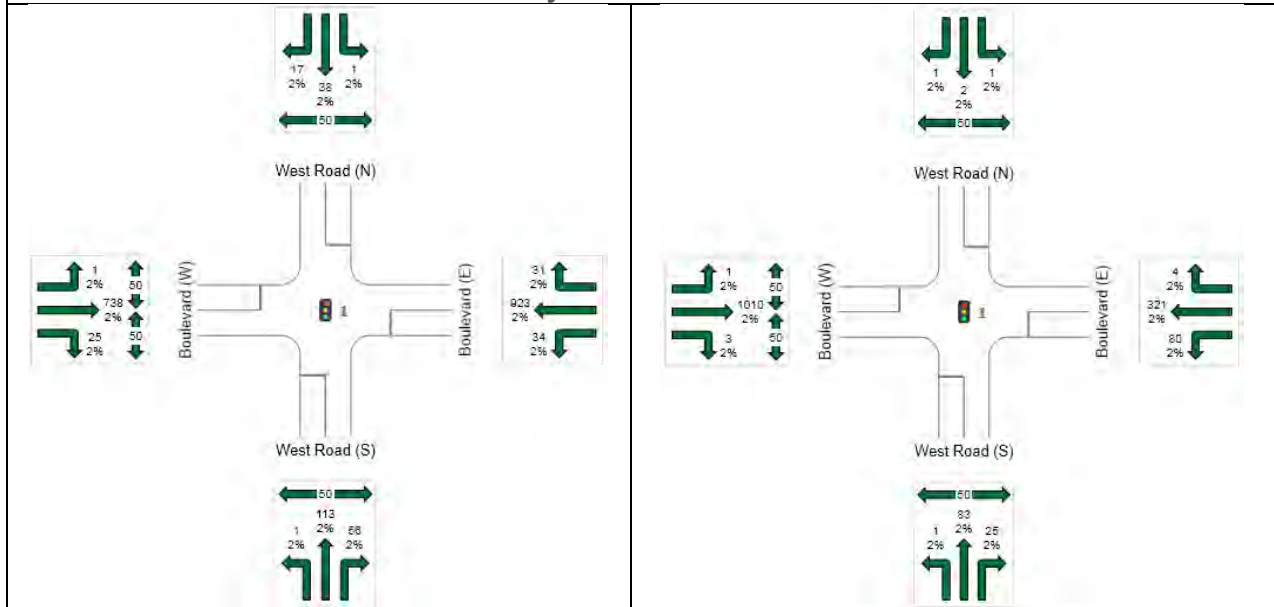


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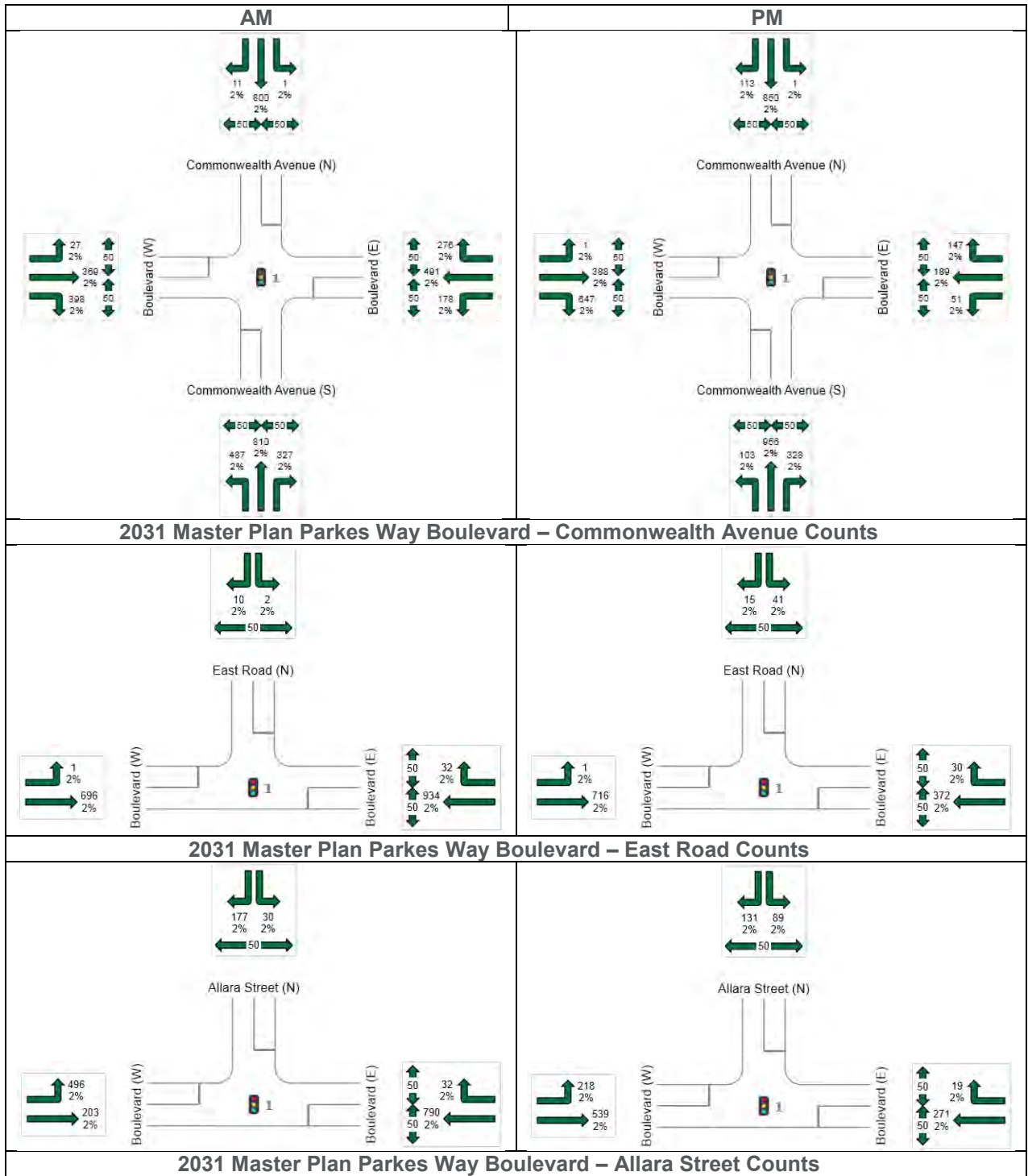


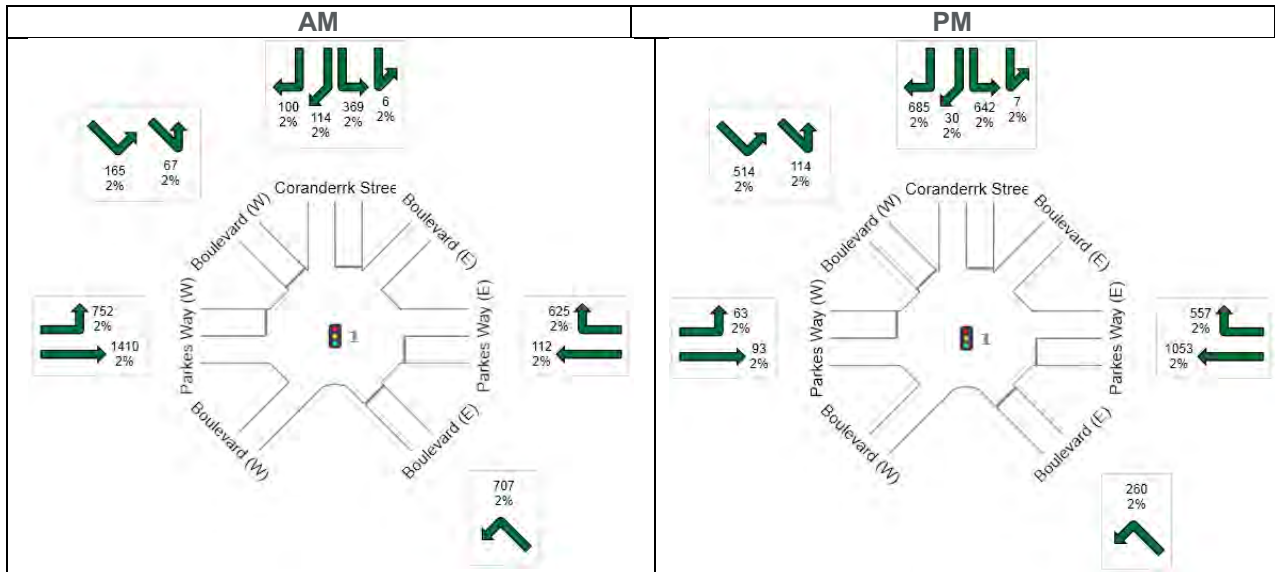


2031 Master Plan Parkes Way Boulevard – Marcus Clarke Street Counts

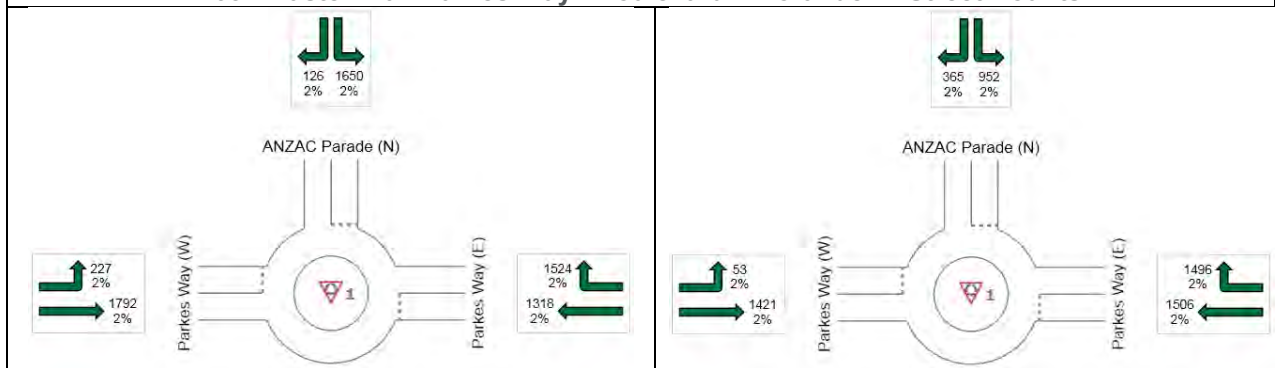


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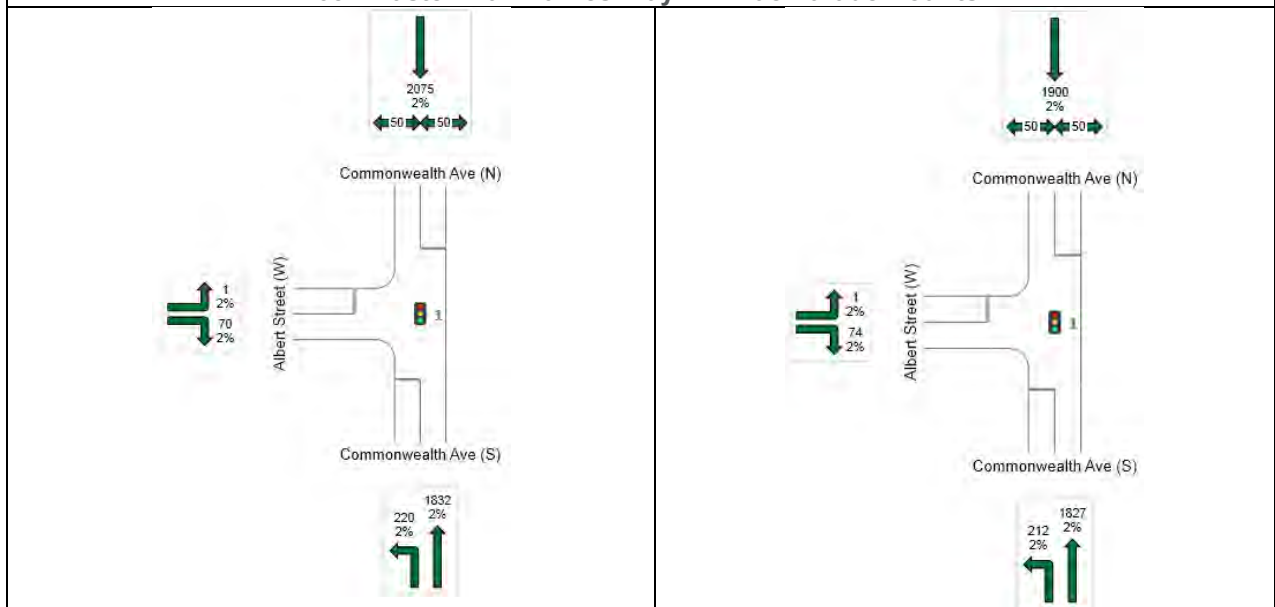




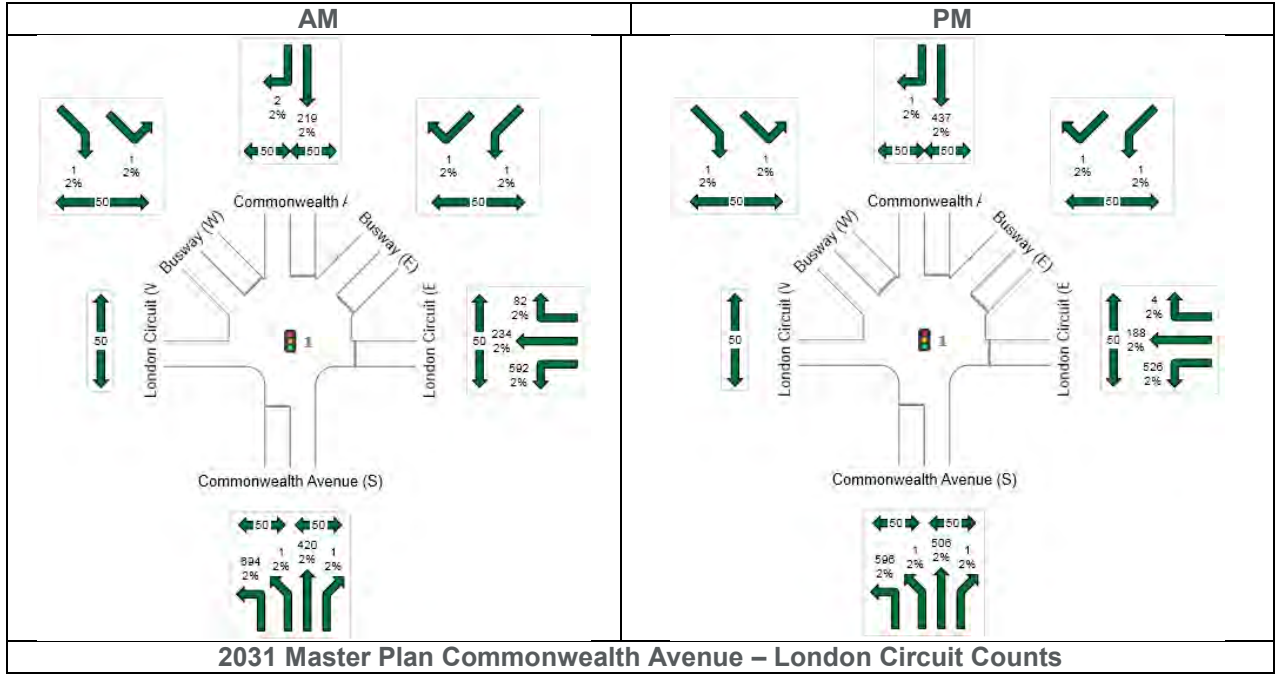
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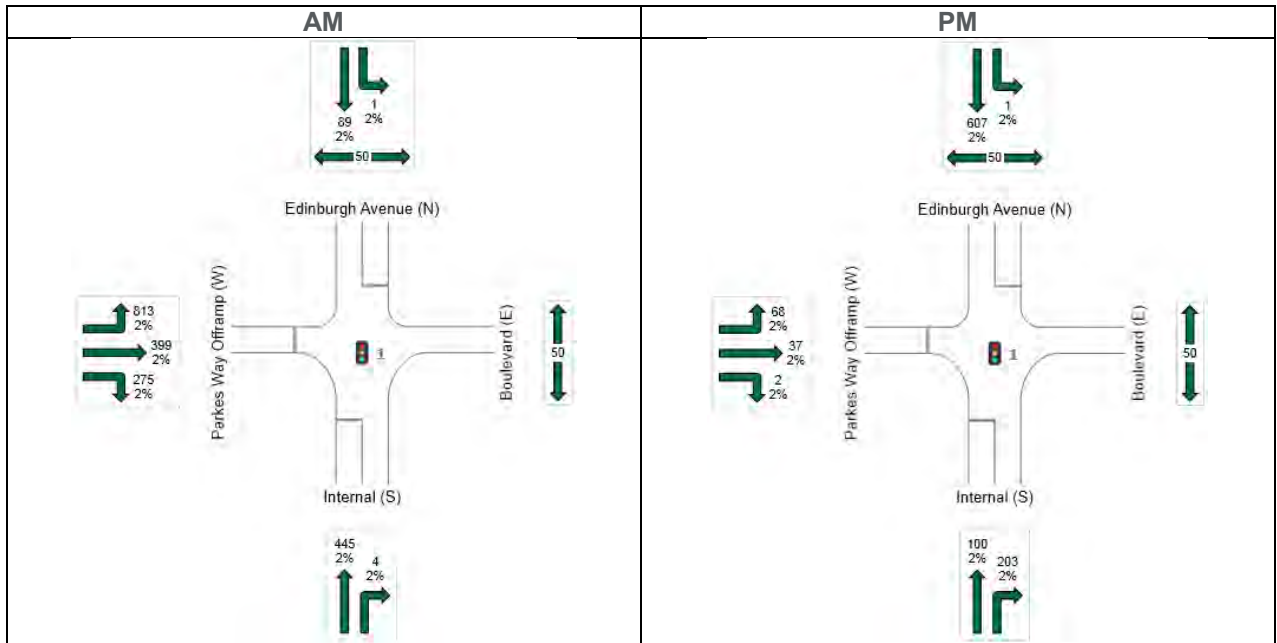
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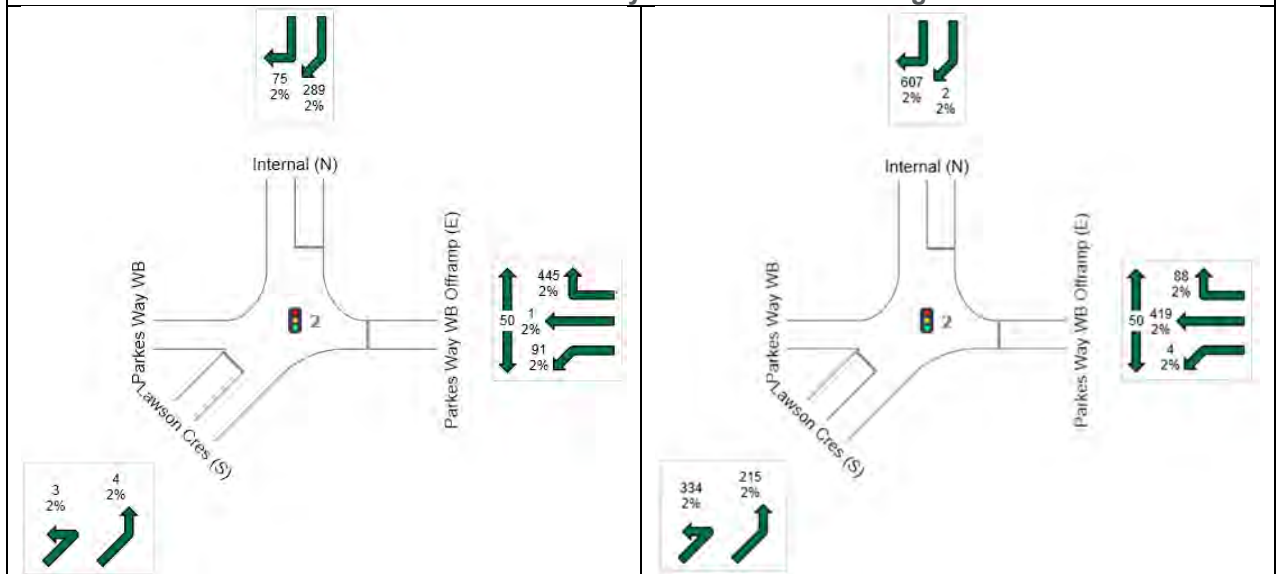
2031 Master Plan Commonwealth Avenue – Albert Street Counts



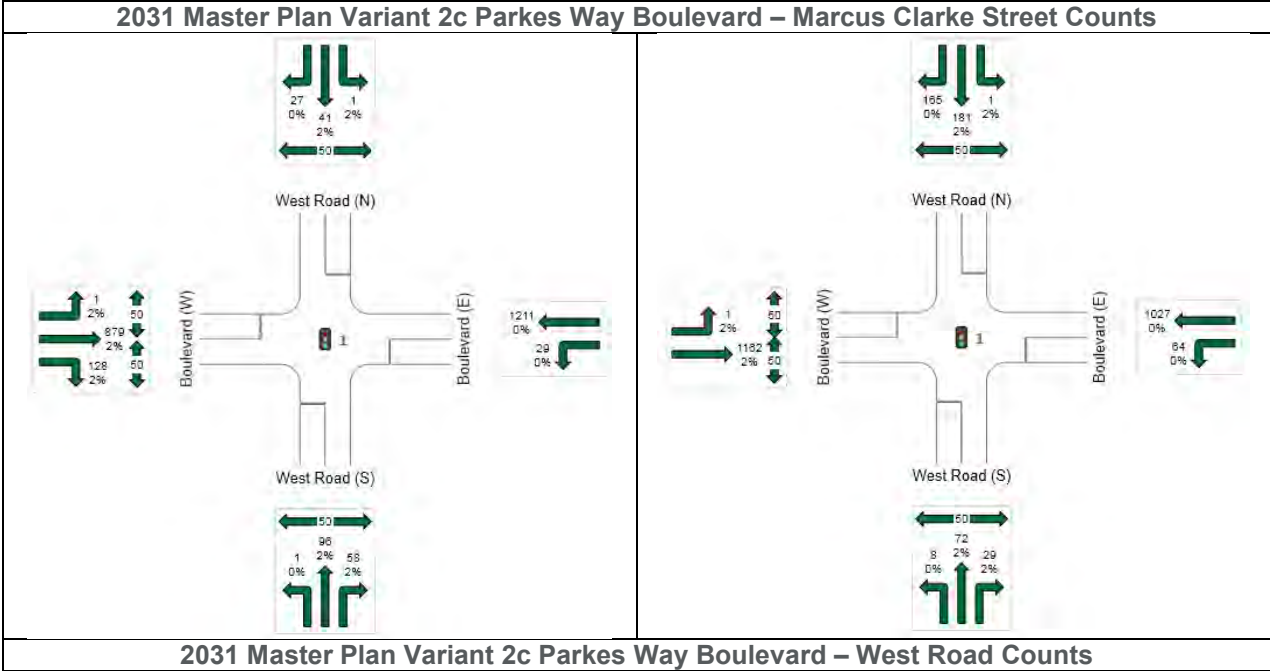
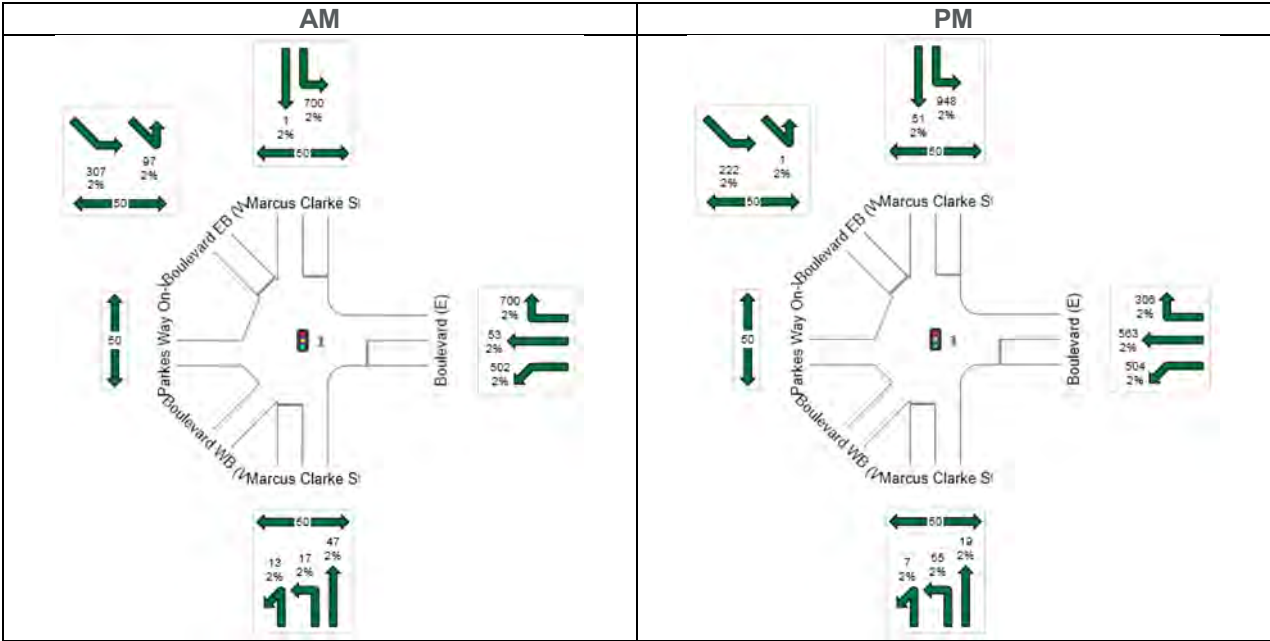
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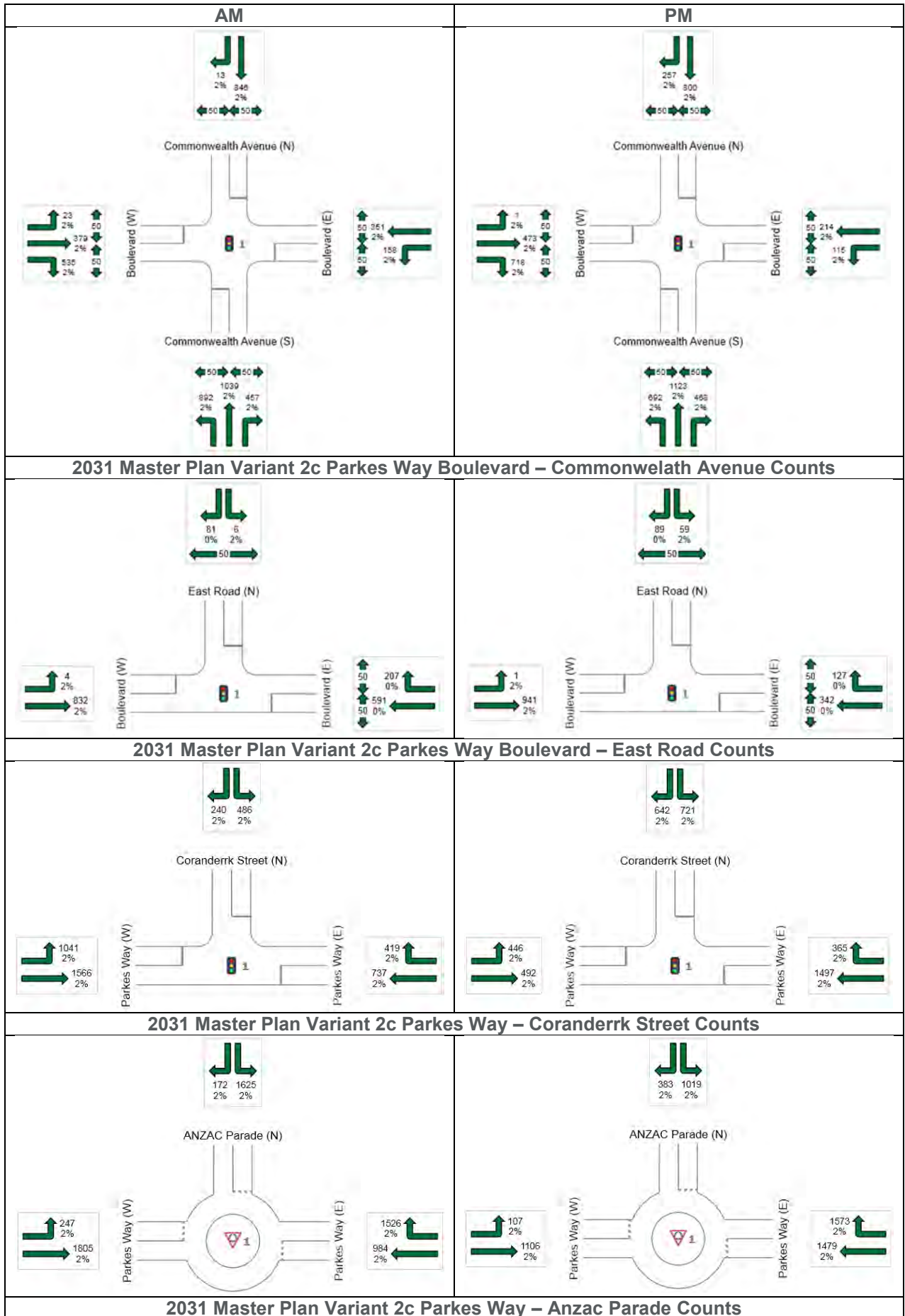


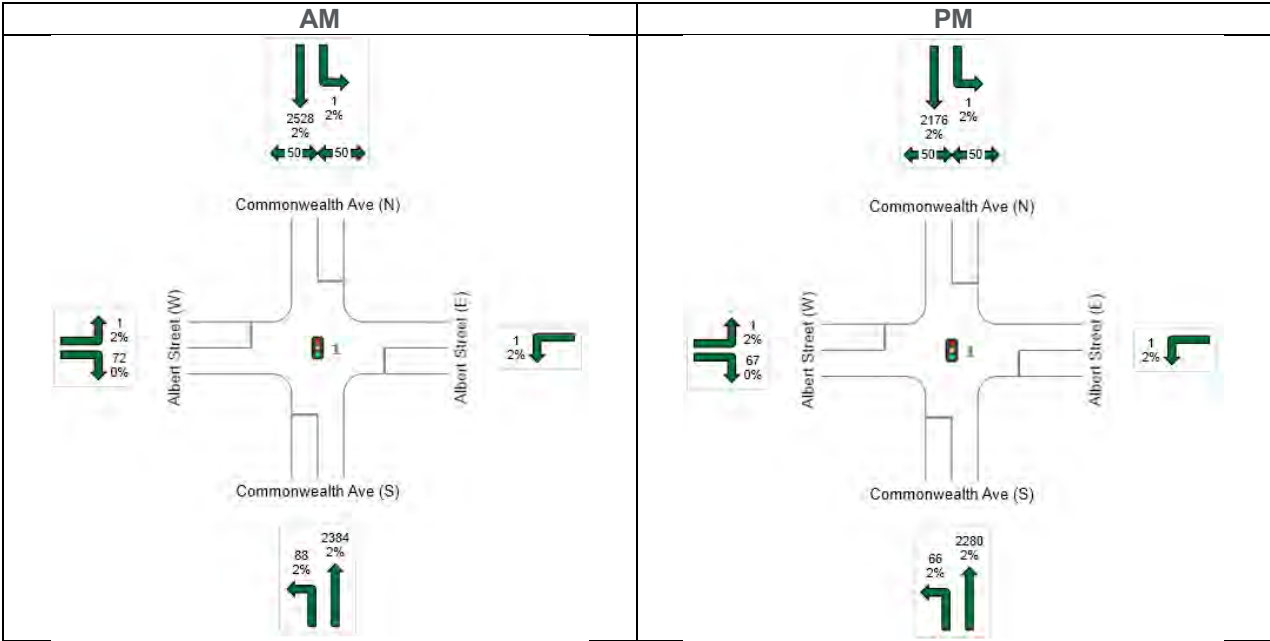
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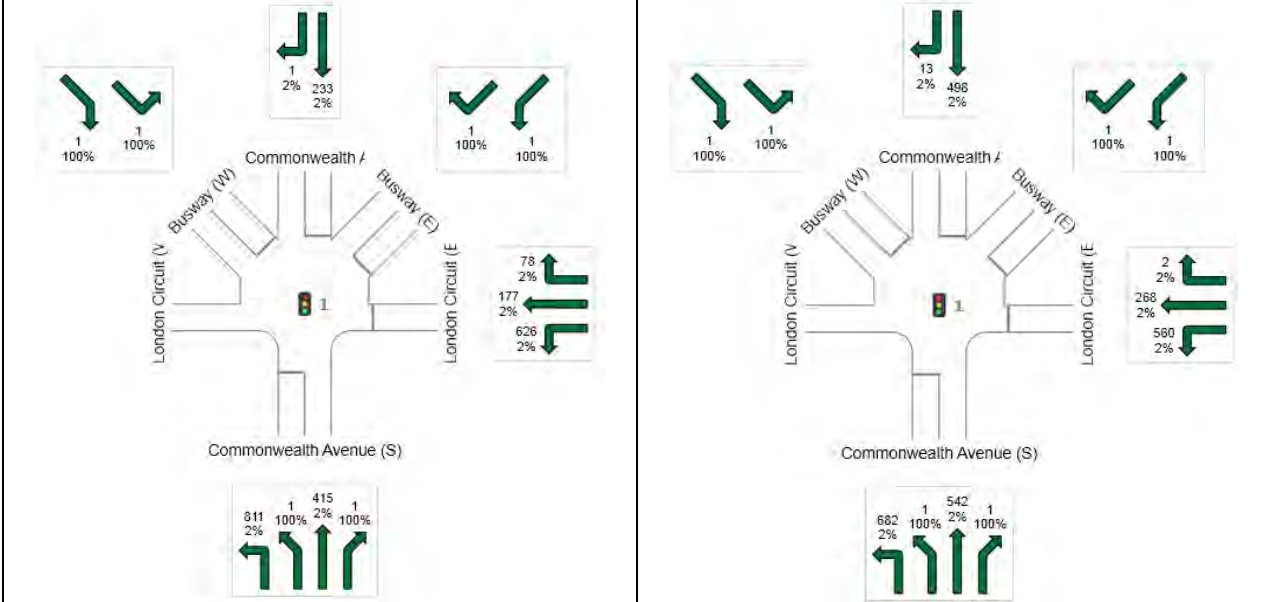
2031 Master Plan Variant 2c Parkes Way Boulevard – Lawson Crescent Counts







2031 Master Plan Variant 2c Commonwealth Avenue – Albert Street Counts



2031 Master Plan Variant 2c Commonwealth Avenue – London Circuit Counts

Re-engineering Parkes Way and Civic's Southern Road Network

Volume 4 – Procurement Strategies

Project Number: 3002385

Contract Number: 2014.23470.110

Prepared for the ACT Economic Development Directorate

10 December 2014



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1. INTRODUCTION

In 2013 the ACT Government procured an Urban Design Study for the Linking City Centre to the Lake strategy. This study developed a master plan that consisted of numerous design elements including the requirement to undertake significant civil infrastructure works to re-form the street and arterial road grid from City Hill to the West Basin foreshore.

As a major design and cost element of the urban strategy, the Economic Development Directorate (EDD) identified the need to investigate and identify key project risks concerning the major civil infrastructure works associated with the lowering of Parkes Way and adjustment to other major roads within Civic.

This study aims to develop a strategy to mitigate these risks by developing a feasibility design, undertaking constructability and cost assessment, considering the procurement options in the context of the current construction market, and investigating the implications of the project on the local transport network.

This report forms Volume 4 of 6 of the Feasibility Study for the Re-engineering Parkes Way and Civic's Southern Road Network:

- Volume 1 – Feasibility Design
- Volume 2 – Constructability Assessment
- Volume 3 – Transport Assessment
- **Volume 4 – Procurement Strategies**
- Volume 5 – Project Risk
- Volume 6 – Project Cost Estimate

The objectives of the Procurement Strategy report are as follows:

- Identify the possible procurement options
- Work package review and selection
- Details on the advantages and disadvantages of alternate procurement models and methodologies
- Feedback on high level market sounding and consultation with construction market
- Recommendations on preferred Procurement Strategy

2. METHODOLOGY

The aim of the Procurement Strategy will be to clearly map out a procurement path for the project consistent with its timing and complexity, taking into account the project's size and market risks and opportunities.

In preparing the Procurement Strategy there are a number of key areas that will be addressed which are described in summary in the table below:

Key area to Investigate	Proposed approach
Project Objectives	The proposed procurement strategy needs to be aligned with the overall Project Objectives and this will require a clear understanding and appreciation of the overall objectives and key project drivers.
Client Requirements and Constraints	In developing the procurement strategy a key requirement is to understand the client requirements and constraints with respect to appetite for risk, funding availability and timing for project completion
Project Attractiveness to the Market	As part of the assessment a limited market sounding will be completed to test the attractiveness of the project to the market, capacity of the market and likely contractors/proponents along with key risks.
Packaging Strategy	Opportunities will be investigated to optimise how the elements of the project can be packaged with respect to synergies and opportunities.
Procurement Methodologies	Once packaging options have been assessed and optimised the next stage to look at alternate procurement methodologies which include Construct Only, Design and Construct, Alliancing, Public Private Partnership or hybrids of the core models.
Market Practice	A review of other similar projects and procurement methods to see what has worked in the past, along with assessment of current and future market appetite and capability
Option Analysis and Recommendations	To optimise the Procurement Strategy it will be necessary to clearly document the process undertaken, and the analysis including the identification of advantages and disadvantages, with a clear recommendation.

3. DELIVERY OBJECTIVES & PROCUREMENT

3.1 Delivery Objectives

The overall proposed delivery objectives of the Parkes Way Lowering project are as follows:

- The project will act as a facilitator project to allow the 'Linking the City to the Lake' key objectives to be achieved
- The urban design will be of a high standard in keeping with the surrounding environment
- The project will be delivered in a safe and sustainable manner
- The project delivery will result in minimal disruption, delay, and inconvenience to road users, residents, business owners and workers of Canberra during construction and commissioning phases
- The project will be competitively bid with the opportunity to maximise innovation from the private sector
- The risk allocation associated with design and delivery will be appropriately allocated to the party best able to manage the risk
- The project will provide value for money to the community

3.2 Procurement Principles

The procurement principles for the Parkes Way lowering will be in accordance with ACT Government Procurement Act 2001 (R17). Furthermore:

- Emphasis will be placed on ensuring maximum competition for the relevant components of the project
- Peer reviews will occur at various milestones as considered appropriate by Government
- Procurement will include probity as a key consideration to ensure a fair and equitable tender process
- The Project procurement will be undertaken with the purpose of delivering value for money to the community
- The procurement strategy for the project will maximise the opportunity for the tenderers to provide innovation in design and delivery to achieve the overall project objectives

4. MARKET SOUNDING AND INDUSTRY CONSULTATION

4.1 Key Findings

Some initial market consultation on the delivery strategy has been undertaken with John Holland and a number of independent infrastructure advisers with specialist skills and experience in procuring large infrastructure projects. The following are the key findings:

4.2 Contractors

- This is an attractive project that would be ideal for a Tier 1 contractor.
- Construction methodology and staging will be as important to achieve value for money as the design with plenty of opportunities to provide innovation.
- Planning Approval is considered a key risk both with respect to cost and program.
- Completion of a detailed 3 D survey of existing road, services and bridges would be essential to allow a confident bid or as initial information for a detailed design.
- Provision of detailed geotechnical information and site investigations as part of tender package would allow tender designs to be refined quickly and allow an appropriate risk transfer

4.3 Approach to Bids

- Preference would be for a short listing through simple expression of interest process
- Ideally two but no more than three bidders
- Recognised form of contract not a bespoke Deed
- Some re-imbursalment of bid costs would be desirable but not essential due to size of contract.

4.4 Program

- The Project will be a multi-staged project over a number of years
- Construction methodology and staging will be a key driver to reduce overall costs
- Time frame is likely to be 3 to 4 years depending on final configuration requirements and extent of disruption the client is willing to accept. Proposed construction program is discussed in further detail in Volume 2 of this study.

4.5 Operations and Maintenance

- Whilst operations and maintenance requirements are likely to be relatively small the contractors would be willing and able to offer a turnkey solution.

- Key challenge would be for the lowered Parkes Way to be considered as a series of underpasses rather than short tunnel.
- Fire and life safety will be a critical area to resolve with local fire services prior to finalising the design.

5. PACKAGING OF INFRASTRUCTURE WORKS

5.1 Process

The first stage of the Procurement Strategy process involves considering the packaging options in the context of the delivery objectives and then considering the appropriate procurement models to develop the procurement strategy.

The overall process for developing a preferred procurement strategy for the Parkes Way lowering is outlined in Figure 1 and this section deals with considering whether the work should be delivered as a single package or split into a number of packages.

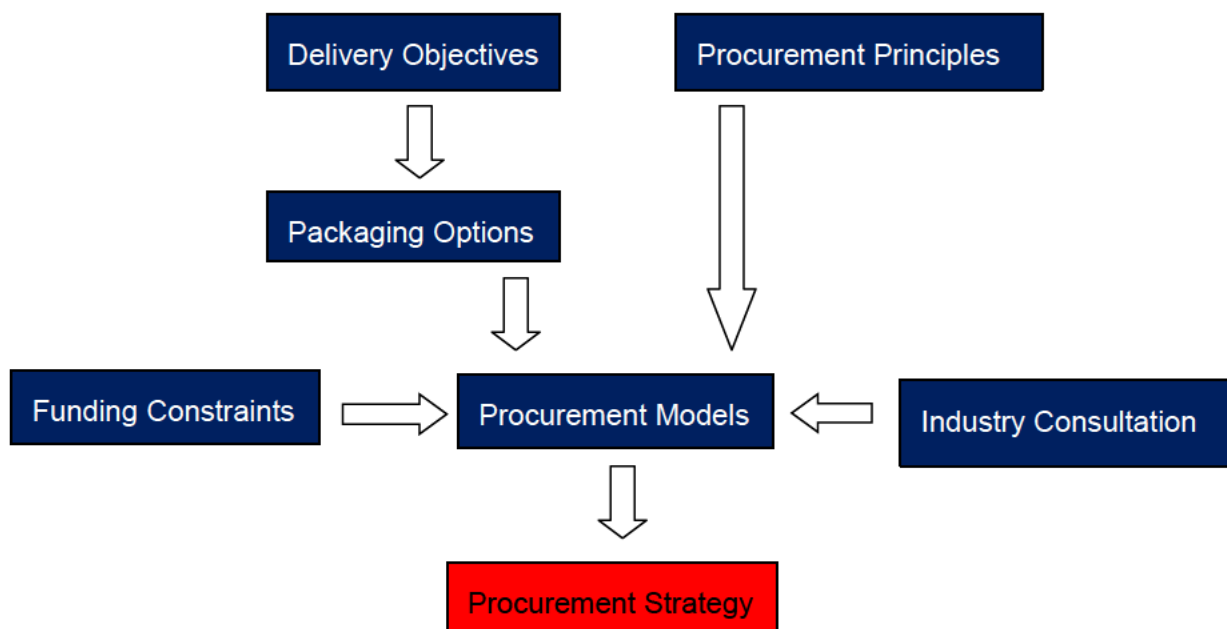


Figure 1 – Procurement Strategy Process

5.2 Packaging Options

When considering whether the project should be delivered as a single package or broken down into a series of packages the following are the key considerations for a multiple packaging strategy:

- Is the project so large there is no single party that could deliver it;
- Is the project a single piece of infrastructure or made up of multiple types;
- Does the project have elements that are so specialist in nature that it would be better to have a specialist directly appointed contractor;
- What is the client's appetite for managing the interface risks of contracting multiple parties;

- What are the opportunities for innovation for the project as a whole, recognising separate packaging will reduce the opportunity for innovation across the whole project.

Recognising this will be a brown field construction project it is recommended that an early Works Investigations Package is undertaken that would include:

- Geotechnical Investigation
- Detailed survey and mapping of existing infrastructure
- Utility Investigation and mapping
- Constraint mapping with respect to utilities and other key infrastructure

With respect to contract size, whilst it is relatively large it is nevertheless suitable for a Tier 1 contractor and is in line with respect to size and value with other major road contracts delivered in Australia by Tier 1 contractors.

The re-engineering of Parkes Way and Civic's Southern Road network is a road project with some structural elements that will involve a staged delivery over a number of years. It is a project where the Feasibility Study has identified a solution but there is recognition that for a project of this nature there is a great opportunity both in the final design and also the construction methodology for innovation and refinement of the solution.

On the basis of the analysis completed it is recommended that there would be significant opportunity for both innovation in design and construction if the project was delivered as a single package of work. As such, the preferred packaging strategy is indicated in Figure 2.

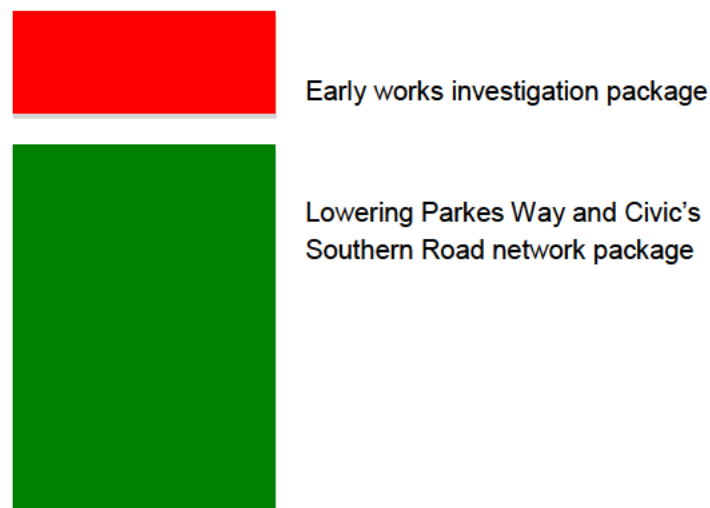


Figure 2 – Recommended Packaging Strategy

An alternate to this approach could be to deliver various elements of the project in a staged approach. For instance, the full delivery of Parkes Section 3 requires realignment of the Coranderrk St, Parkes Way East, and the associated intersection. Similarly, construction of the Australia Forum is likely to require the re-grading of London Circuit to its final vertical alignment. Both these elements of work are relatively independent of the Parkes Way

Lowering, and could be delivered by a lower tier contractor, as traditional Construct-Only packages earlier than the main works. These possible stages are depicted in Figure 3.

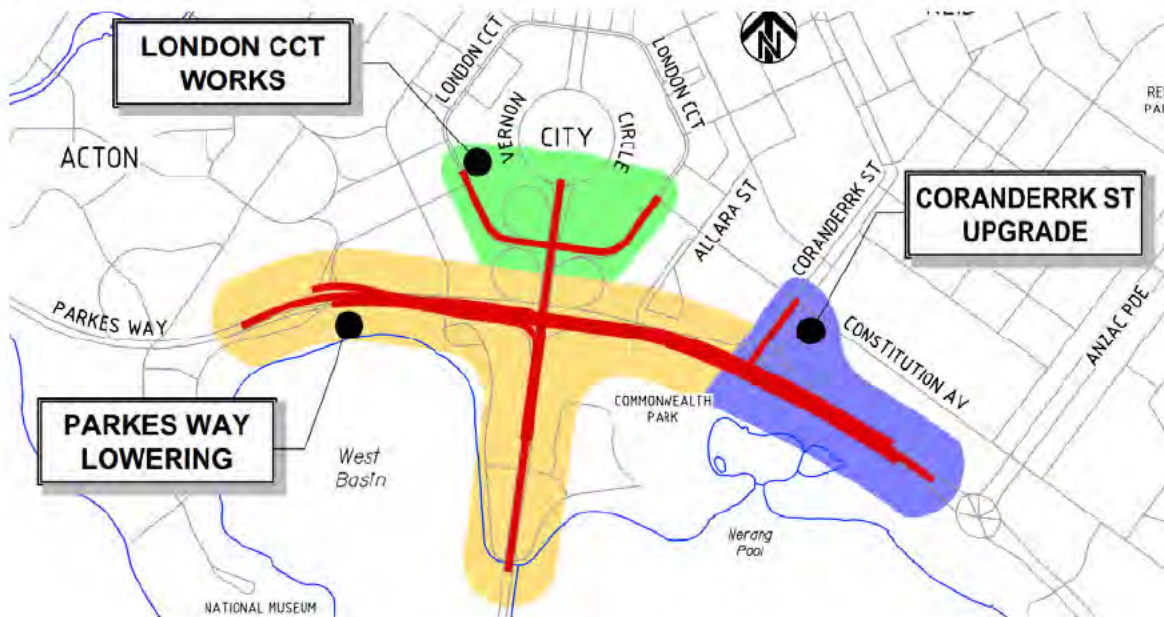


Figure 3 – Possible Construction Stages

This staged approach could be attractive if there was a need to deliver the London Circuit works and/or the Coranderrk St Upgrade works prior to the construction of the Parkes Way Lowering, or if there was a desire to split the overall works up into smaller, less expensive packages to suit the ACT Government's spend profile. A possible staged delivery of construction packages is indicated in Figure 4.



Figure 4 – Staged Packaging Strategy

5.3 Range of Packaging Options

The generic contract models, assuming government funding, identified for delivering the Parkes Way lowering are:

- Engineering, Procurement and Construction Management (EPCM)
- Alliance
- Design then Construct Only, with separate Operations and Maintenance (O&M)
- Design and Construct (D&C), with separate Operations and Maintenance (O&M)
- Design, Build, Operate and Maintain (DBOM)

Each of these generic models:

- is relatively well understood by the market place
- has been used to deliver large scale, complex infrastructure
- could be applied to the Parkes Way lowering
- can be tailored to suit the key project characteristics and delivery.

5.4 Characteristics and Suitable Models

A summary of the generic models, their key characteristics and suitability for the Parkes Way lowering, is given below:

Engineering, Procurement and Construction Management (EPCM)	
Key characteristics	<ul style="list-style-type: none"> ▪ Typically, the EPCM model involves a specialist project management entity to deliver the project in accordance with a design brief. ▪ The EPCM contractor manages a series of contracts that cover design, construction, testing and commissioning on behalf of the ACT Government. ▪ The EPCM contractor would engage sub-contractors to undertake various packages, with the contracts being with the principal. ▪ The EPCM is generally paid based on a percentage of the total estimated capital project costs. ▪ The EPCM contractor takes limited risk in relation to the actual cost, time to complete the project, or performance of the completed project.
Advantages and Disadvantages	<ul style="list-style-type: none"> ✓ Allows for concurrent development of interrelated design streams. ✓ Enables different construction streams to commence before design of other streams is complete and allows for design modifications and principal intervention as the project progresses. ✓ Enables packaging of contracts by trade, skills or other market capabilities where a single construction entity does not have the capacity or the capability to deliver the project. ✓ Avoids reliance on a single construction entity for the full project. ✗ No certainty of cost, time or overall performance outcomes.

	<ul style="list-style-type: none"> ✗ ACT Government carries the risk for design delays and design interface risks. ✗ Whole of life outcomes are generally not a prime focus of the EPCM contractor. ✗ Requires substantial management effort by and of the EPCM contractor.
Suitability for Parkes Way Lowering	In comparison to alternative models a traditional EPCM style contract is less likely to deliver a cost effective outcome for the Parkes Way lowering – Not Recommended

Alliance	
Key characteristics	<ul style="list-style-type: none"> ▪ Typically, the alliance model involves a team of specialist designers, construction, contractors and other service providers working together with the principal (the client) to deliver the project outcomes. ▪ A team of non-owner participants (NOPs) are chosen on the basis of their skills, capability and experience. ▪ The NOPs are embedded with the principal in an integrated team and can influence the project outcomes. ▪ Work is paid based on actual and audited direct costs, on a cost-reimbursable model. ▪ Project budgets are determined after the alliance has formed and developed an accurately scoped target out-turn cost (TOC). The TOC then becomes the metric by which project success is measured. ▪ The objectives of the owner and the NOPs are aligned through the use of a gain-share/pain-share agreement. There is a 'no-blame' principle within the alliance.
Advantages and Disadvantages	<ul style="list-style-type: none"> ✓ The model requires significantly less initial documentation for tendering as there is less risk transfer. ✓ There is more emphasis during tendering on skills, capability and experience than commercial arrangements and fees. ✓ There is a greater commercial alignment focused on project successes. ✓ More flexible and response to changes in project scope. ✓ Provides the principal with detailed ongoing knowledge as the project develops. ✓ Embeds the principal in the project team, heightening industry experience. ✗ There is a large lead-time for alliance consortia to form, proposals to be submitted and evaluated. ✗ The principal relinquishes responsibility for setting the TOC to the alliance. ✗ Good cost outcomes are only encouraged, not assured. ✗ Optimisations between project delivery and operations performance are not

	<p>assured.</p> <ul style="list-style-type: none"> ✗ The principal carries all productivity and delay risks. ✗ There is generally no contractual recourse for one NOP failing to perform. ✗ The principal must relinquish experienced personnel into the alliance to influence project outcomes
<p>Suitability for Parkes Way Lowering</p>	<p>An alliance model is not considered an appropriate option for the Parkes Way lowering as the scope can be fixed from the offset and the risk of design and delivery can be effectively transferred to the private sector – Not Recommended</p>

<p>Design then Construct Only Contract with separate operations and maintenance (O&M)</p>	
<p>Key characteristics</p>	<ul style="list-style-type: none"> ▪ Design then construct only models typically involve the engagement of a consultant to design the works and then contractors to construct the entire project or a part thereof. ▪ Payment for design can be on a lump sum basis or schedule of rates and often a mixture of the two. ▪ Payment for construction is generally made via a fixed lump sum price basis. Incentives can be built into the payment model based on delivered tasks. ▪ The contractor for the construction portion of the project is generally separate from the operator and maintainer of assets. ▪ Sub-packages for the construction works are the responsibility of the appointed entity. ▪ The principal takes responsibility for the design and any errors as far as the construction contractor is concerned and takes the performance risk. ▪ The principal takes responsibility for operations and maintenance of the project, either directly or through another contractor. ▪ The construction contractor generally provides guarantees or warranties for performance during the initial stages of operation, limited by design obligations being with another party. ▪ Tendering typically involves a 2 stage process: <ul style="list-style-type: none"> + Stage 1: an Expressions of Interest (EOI) period enables short listing of suitable contractors to be completed. + Stage 2: request for proposals (RFP) from the pre-selected tenderers. This is a formalised bidding process which enables greater certainty on behalf of the principal and the tenderers
<p>Advantages and Disadvantages</p>	<ul style="list-style-type: none"> ✓ Provides a simple model where operations and maintenance interfaces can be adequately managed by the principal. ✓ Principal can control the detailed design and make changes prior to award of construction that are then competitively priced

<p>Suitability for Parkes Way Lowering</p>	<ul style="list-style-type: none"> ✓ Reduces the risk that contracts are awarded to inappropriate entities ✓ 2 stage tendering process allows detailed proposals to be prepared only by potential consortia and reduces evaluation requirements of the principal. ✓ Has some certainty of time, cost and project definition due to warranties and guarantees on performance but these are split between design and construction. ✓ Disclosure of the preferred tenderers after the EOI stage encourages market competition in detailed proposal. ✗ Requires large amount of time and effort by the principal to manage detailed design ✗ Onus on the contractors to effectively manage delays in between design and construction interfaces ✗ Principal carries the risk for poor management of interfaces between design and construction as well as operations and maintenance ✗ Limited opportunity to obtain innovation from contractors on design or construction methodology. ✗ Limited incentive by designer to minimise capital and O&M costs ✗ Defining construction stages limits opportunity for contractors to provide the smarts in delivery methodology ✗ Allocation of technical risk 'blurred' — designer will claim a construction issue and vice versa. ✗ Principal is subject to contract variations claims from contractors for design errors or omissions. ✗ Greater requirement for preliminary design and project scoping prior to contracts being awarded; Principal will need to engage design contractor. ✗ Principal has limited certainty in regards to whole of project options as they are not the focus of the contractor. <p>Design then Construct Only package is not considered suitable for the Parkes Way lowering given the scale and complexity of the project. This approach would significantly diminish the opportunity for design and construction innovation and the Principal would still need to procure a separate O&M Contractor – Not Recommended</p>
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<p>Design and Construct (D&C), with separate Operations and Maintenance (O&M)</p>	
<p>Key characteristics</p>	<ul style="list-style-type: none"> ▪ Design and construct models typically involve the engagement of a contractor to design and construct the entire project or a part thereof. ▪ Payment is generally made via a fixed lump sum price basis. Incentives can be built into the payment model based on delivered tasks. ▪ The contractor for the D&C portion of the project is generally separate from

Advantages and Disadvantages

- the operator and maintainer of the assets.
- Sub-packages for the design or construction works are the responsibility of the appointed D&C entity.
 - The principal takes responsibility for the operations and maintenance of the project, either directly or through another contractor.
 - The D&C contractor generally provides guarantees or warranties for performance during the initial stages of operation.
 - Tendering typically involves a 2 stage process:
 - + Stage 1: an Expressions of Interest (EOI) period enables consortia to form and shortlisting of suitable contractors to be completed. Also functions as a market scoping exercise and narrows the competitive field of potential contractors.
 - + Stage 2: request for proposals (RFP) from the pre-selected tenderers. This is a formalised bidding process which enables greater certainty on behalf of the Principal and the tenderers.
 - Principal maintains responsibility for managing interfaces between D&C and O&M components.
-
- ✓ Provides a simple model where operations and maintenance interfaces can be adequately managed by the Principal.
 - ✓ Reduces the risk that contracts are awarded to inappropriate entities.
 - ✓ Two stage tendering process allows detailed proposals to be prepared only by potential consortia and reduces evaluation requirements for the Principal.
 - ✓ Provides best opportunity to obtain innovative solutions through competitive tender process with opportunities in design and construction methodology
 - ✓ Has a greater certainty of time, cost and project definition due to warranties and guarantees on performance.
 - ✓ Greater onus on the contractors to effectively manage delays in D&C interfaces.
 - ✓ Greater allocation of technical risk to the D&C contractor.
 - ✓ Disclosure of the preferred tenderers after the EOI stage encourages market competition in detailed proposal.
 - ✓ D&C packages are well understood internationally.
 - ✓ Less management time on behalf of the Principal after awarding contracts
 - ✗ Requires large amount of time and effort by the Principal to analyse proposals and award contracts, as proposals tend to be very detailed.
 - ✗ Principal carries the risk for poor management of interfaces between D&C and operations and maintenance.
 - ✗ Achieving good urban design can be problematic due to difficulty in specifying performance requirements
 - ✗ Less drive by D&C contractor to undertake whole of life cost tradeoffs
 - ✗ Principal has less scope to influence the detailed design without being

	<p>subject to contract variations claims from contractors.</p> <ul style="list-style-type: none"> ✗ Greater requirement for project scoping and key requirements prior to contracts being awarded; ✗ Principal has limited certainty in regards to whole of project options as they are not the focus of the D&C contractor.
<p>Suitability for Parkes Way Lowering</p>	<p>Using a D&C approach for Parkes Way lowering would achieve an outcome and provide industry with the opportunity to innovate, both with respect to design solutions and also construction methodology. The main disadvantage is the risk of long term operating and maintenance that can be managed, but are nevertheless a risk better managed by the appointed contractor – Not Recommended</p>

Design, Build, Operate and Maintain (DBOM) or DBM

<p>Key characteristics</p>	<ul style="list-style-type: none"> ▪ Typically involves engaging a contracted entity to design, construct, maintain and operate the project. ▪ Maintenance and operation may be for a fixed period post-construction or for the project's life. ▪ Payment for construction period is to an agreed proposal. Payment for operation and maintenance are generally based on the operator's profile and degree of agreed risk transfer. ▪ DBM models involve a separate operator to the contractor responsible for designing, building and maintaining the project infrastructure. ▪ Bidding/proposal confirmation can adopt the 2 stage process outlined in the D&C model to manage level of detail and competing consortia, requesting both EOI followed by a RFP. ▪ Requires well defined performance objectives for both operation and construction.
<p>Advantages and Disadvantages</p>	<ul style="list-style-type: none"> ✓ Much greater risk transfer away from the principal than for other models. ✓ Reduces the risk that contracts are awarded to inappropriate entities. ✓ Two stage tendering process allows detailed proposals to be prepared only by potential consortia and reduces evaluation requirements for the principal. ✓ Provides best opportunity to obtain innovative solutions through competitive tender process with opportunities in design and construction methodology ✓ Has a greater certainty of time, cost and project definition due to warranties and guarantees on performance. ✓ Greater onus on the contractors to effectively manage delays in D&C interfaces. ✓ Greater allocation of technical risk to the D&C contractor both for construction and operations phase

	<ul style="list-style-type: none"> ✓ Disclosure of the preferred tenderers after the EOI stage encourages market competition in detailed proposal. ✓ DBOM packages are well understood internationally. ✓ Less management time on behalf of the Principal after awarding contracts ✗ Requires large amount of time and effort by the Principal to analyse proposals and award contracts, as proposals tend to be very detailed. ✗ Achieving good urban design can be problematic due to difficulty in specifying performance requirements ✗ Principal has less scope to influence the detailed design without being subject to contract variations claims from contractors. ✗ Greater requirement for project scoping and key requirements prior to contracts being awarded.
<p>Suitability for Parkes Way Lowering</p>	<p>Using a DBOM approach for Parkes Way lowering would achieve the best risk transfer for the Principal and a whole of life outcome. Further it would provide industry the opportunity to innovate both with respect to design solutions and also construction methodology. The long term operating and maintenance risks will be borne by the contractor and therefore there will be more focus on whole of life costs and long term sustainability – Recommended</p>

5.5 Recommended Contracting Models

Following the assessment of the various models in the context of the procurement objectives, it was concluded that a Design, Build Operate and Maintain would be the most suitable type of contract for the Parkes Way Lowering Project. Whilst there is a degree of complexity in tendering the construction and maintenance as a single package rather than as separate packages, the benefit of being able to get a firm price based on whole of life considerations is considered highly beneficial, especially since this will be a relatively unique piece of infrastructure in ACT with some specialist requirements for operating and maintaining.

6. PLANNING AND ASSET OWNERSHIP

6.1 Planning Context

When identifying the preferred procurement method for the project, the planning framework the project is subject to will be a consideration. Some elements of the site fall under the National Capital Plan that is overseen by the National Capital Authority (Federal Government), whereas other areas on the proposed site fall within the realm of the Territory Plan which is administered by ACTPLA on behalf of the Territory.

For areas that fall within the National Capital Plan, all project proposals will be submitted through the NCA's Works Approval process. For elements of the project that are within the jurisdiction of the Territory Plan, they will be subject to the ACT's Development Application process.

Historically, major road infrastructure projects within the ACT have been delivered through a traditional Construct-only procurement method. This approach ensures that all Works Approval and Development Application submissions have been approved either formally or in-principle prior to contract award.

From a planning perspective this is likely to be the lowest risk but will result in a highly prescribed outcome with limited opportunity to take advantage of the innovation that can be generated by contractors through a competitive tender process. Whilst theoretically there is the opportunity to consider "alternate designs" it is hard to overcome the restrictions in time and potential risk of proceeding with an alternate that has no planning approval.

The balance between planning certainty and maximising innovation from the market continues to be a key issue for Governments across the country. Where there is little room for innovation it is appropriate for Government to obtain the planning approval and to proceed to obtain proposals based on the agreed planning approval, and accept the constraints.

For Parkes Way lowering the feedback from the engineering team, the constructability team and the market more generally, is that it is a project where there is great potential for different solutions to be developed through the competitive tender process with great potential for achieving a superior value for money outcome.

To achieve this superior outcome a 'Design Build Operate Maintain' (DBOM) procurement method is the preferred procurement model. Under this scenario using the traditional approach, the proponent will develop a tender design that whilst sufficient for pricing does not have approval for construction. Furthermore, this tender design is unlikely to contain sufficient detail to gain a formal planning approval.

As such, it can be expected that the planning approval will be granted midway through the design development. This will expose the proponent and/or the Client to risk associated with rejection of elements of the proposed design solution, subsequently carrying with it the risk or rework and unexpected construction requirements / costs. This risk will either be factored into the proponent's price (increasing tender prices) or be claimed by the proponent following contract award.

An alternative approach has been adopted for two major infrastructure projects in NSW in the last few years - Darling Harbour Convention Centre (2012) and NorthConnex Tunnel (2014) - where Preferred Schemes have been selected and then planning approval obtained. A similar approach is recommended for Parkes Way Lowering Project.

6.2 Proposed Planning Approval Approach for Parkes Way Lowering

Based on the recent experience in NSW the following is the proposed approach for obtaining planning approval after a Preferred Scheme has been selected using the DBOM model.

The following are the key elements and the process:

- Client specifies high level requirement;
- Client provides as much information as possible to allow appropriate transfer of risk;
- Client provides a 'Mandatory Requirements and High Level Reference Scheme' rather than detailed Reference Design;
- Client undertakes preliminary work on planning approval;
- EOI process setting out procurement and planning approval strategy;
- Short listing of tenderers;
- Tenderers prepare D&C bids with high level of interaction with client during the tender phase to obtain acceptable bids;
- Tenderers include costs for preparing and obtaining planning approval;
- Bids are evaluated against key criteria such as design, likelihood of getting planning approval, constructability and value for money;
- Interactive phase continues during bid evaluation allowing bids to be refined to meet client requirements and acceptance;
- Preferred Tenderer and Preferred Scheme is selected;
- Preferred Tenderer has to prepare Planning approval documentation in conjunction with the client; and
- Contract is only awarded once planning approval is granted.

To ensure the tenderer is incentivised to get planning approval as efficiently as possible the Client will only underwrite a portion of the costs for preparing and the planning approval documentation up to a capped amount which is only payable in the event that planning approval is not obtained or the process is cancelled.

Recognising that there may be a requirement for changes to the scheme through the planning approval process, the preferred tenderers would be required to bear the initial costs (extent agreed as part of tender process) up to a cap with a sharing mechanism after the cap is

exceeded. The Client is able to withdraw in the event that the costs of obtaining planning approval become unacceptable.

The proposed process allows the Client the benefit of getting a planning approval for the Preferred Scheme and allows the procurement process to commence earlier since the procurement, planning approval and detailed design can be undertaken in parallel. This process is shown diagrammatically in Figure 5.



Figure 5 – Design / Planning Approval Process

6.3 Asset Ownership

In addition to the complexities associated with the planning framework for the project, the current and future ownership of the infrastructure will be a key consideration. Currently, elements of the project site are owned by both the Federal Government, (through the National Capital Authority) and the ACT Government. Specifically, it is understood that Commonwealth Avenue and Parkes Way to the east of Commonwealth Avenue is owned by the Federal Government, and London Circuit, Coranderrk St and Parkes Way to the west of Commonwealth Avenue are owned by the Territory.

Should this pattern of ownership be retained for the planning approval process and during and following construction, it will present significant procurement challenges to the project. These would include:

- Complying with the technical requirements of two asset owners during design development and construction;
- Agreeing terms with two asset owners;
- In the case of a DBOM procurement managing the ongoing operation and maintenance of the infrastructure in consultation with two asset owners.
- Clear lines of accountability
- Funding and decision making

The added complexity associated with two asset owners increases the procurement risk to the project. Possible ways to mitigate the risks associated with the dual ownership of the asset include:

- Transfer ownership of all relevant infrastructure to one of the Government authorities;
- Assembly of a single body representing both the Federal Government and the Territory to oversee the procurement of the project in the form of a Steering Committee.
- Appointment of Independent Project Director that reports to both parties through the Steering Committee.

7. FUNDING OPTIONS

7.1 General

In considering high level funding options, these range from a very conventional approach with Government fully funding the infrastructure, to the cost of infrastructure being offset by land development. There are also opportunities for private sector funding where the public infrastructure is delivered via a PPP and either paid by revenue or through availability payments. There are also a number of hybrid models such as a PPP model with some with land income offsetting some of the capital cost of the infrastructure.

By way of example, for the Darling Harbour Project in Sydney there was a single tender process but with three separate transactions, an availability PPP for the Public Convention, Exhibition and Entertainment Centre, a major commercial development and a hotel development. The funds received from the major commercial development and hotel development offset some of the costs of the public infrastructure.

Other opportunities for funding Parkes Way lowering, depending on traffic and demand, could be the application of some form of toll – though due to the location and nature of the road this is unlikely to be acceptable. However, some form of availability PPP may offer some advantages to Government.

7.2 Potential Opportunity for Private Financing

One of the challenges with the City to the Lake project is that the Parkes Way Lowering Project is not only a facilitator project to achieve the overall objectives but also it will provide a catalyst and value driver, both for the land it releases and the adjacent land. Whilst it would be possible to commence the overall project by releasing and selling some of the land to assist in financing the infrastructure there is a risk that without a positive and meaningful start on the Parkes Way lowering there could be a distinct loss in value capture.

Recognising the conundrum that the release of the land will contribute to the cost of the infrastructure but the value of the land is linked to the provision of the infrastructure, the use of private finance to start the work in advance of land sales may be advantageous.

Based on the preferred DBOM Procurement model the package could be expanded to include private financing. Whilst this may add to the cost to cover the financing aspects there are a number of other advantages to the arrangement, particularly with respect to risk transfer and achieving a more manageable cash flow rather than having to fund the works completely upfront.

Under the suggested PPP model, proponents would be requested to bid for the DBOM and financing of the Parkes Way lowering with re-payments linked to availability criteria of the new road and facilities over, say, a 30 year period.

The advantages and disadvantages of this approach are summarised below:

- ✓ Transfers risk of price certainty, time delays and long-term operational performance to a 3rd party.
- ✓ Encourages whole of life outcomes and high degree of integration

- ✓ Has incentives for ahead of time completion through early availability payments
- ✓ May be opportunities for secondary revenue opportunities built in such as advertising
- ✓ Principal has limited involvement in management during delivery and operation, has potential to engage independent certifiers and auditors for reporting purposes.
- ✓ Generally does not appear on the government balance sheet until completion and debt is due.
- ✓ Principal pays when the service is delivered and not at the time of construction, providing strong incentive to complete on time.
- ✓ Quarterly Service Payments can be fixed over the concession period.

- ✗ Longer lead-time generally than construction contracts.
- ✗ Client will need more specialist advisers and incur greater costs associated with the transaction.
- ✗ Market prices for debt and equity will invariably be higher than those provided by Government.
- ✗ Need for very well defined project and interface.
- ✗ The near complete risk transfer makes it hard to alter project scope or timeframes post-engagement.
- ✗ Once contract has reached Financial Close it is the least flexible of construction only models.
- ✗ Tendering and evaluation process will be longer and involved than other models due to necessary financial closure.

Under conventional PPP models a Public Sector Comparator (PSC) is calculated which equates to the price the Government believes it would cost to complete the design building and operation of the project over the equivalent concession period. This is used as the benchmark for the bidders to better to demonstrate that they have achieved a proposal that offer value for money to Government.

Since the GFC, the difference in the market price for debt and equity between Government and Private sector has increased making it harder to justify private funding particularly over a long concession period. The private sector's appetite for risk has also reduced making it harder to beat the PSC.

A variant introduced by the NSW Government for the Darling Harbour PPP transaction was a concept known as Conditional Debt Pay-Down (CDPD). Under this arrangement, subject to certain conditions being met, Government had the option to pay down a significant portion of the debt a few years after construction completion, achieving the benefit of substantial risk transfer during the design and construction phase and significantly reducing the overall cost of the project.

8. RECOMMENDATIONS

With respect to the Procurement Strategy based on this report the following are the findings and recommendations associated with the delivery of the Re-engineering of Parkes Way and Civic's Southern Road Network (The Project):

1. The recommended packaging strategy for the Project is that it should be delivered as a single package. However, if there was a need to deliver the London Circuit works or the Coranderrk St Upgrade works prior to the construction of the Parkes Way Lowering, or if there was a desire to split the overall works up into smaller, less expensive packages to suit the ACT Government's spend profile the work these could be delivered as separate packages.
2. To ensure there is sufficient information available to allow a firm bid and appropriate transfer of risk an 'Early Work–Investigation Package' to allow information to be gathered, should be undertaken in advance of the tendering process.
3. The Project offers a real opportunity for the selected construction contractor to add value through design and construction methodology and this will be maximised through a competitive tender process.
4. The analysis of the alternate procurement model indicates that for the effective and efficient delivery of the project a Design, Build Operate and Maintain model should be adopted.
5. Consideration should be given to covering a portion of the bid costs in return for the bidder's design Intellectual Property (IP).
6. As part of the procurement process there is a need for more detailed definition around the urban design requirements for the Project and as such it is recommended that a set of detailed urban design guidelines for the Project are developed and form part of the tender documentation.
7. Recognising the risks around fire and life safety, early consultation with the local fire authorities is recommended. Generally in NSW, if an underpass is greater than around 200 metres in length it becomes a short tunnel with associated ventilation and other fire and life safety provisions.
8. To ensure the end product meets the requirements and achieves the overall project objectives, it is recommended that the tender process includes a strong interactive process so that the Preferred Scheme meets all client requirements.
9. The procurement strategy needs to take account of the Planning approval process. The proposed methodology assumes that planning approval will be progressed based on the selection of a preferred tender and preferred scheme as shown diagrammatically in Figure 6:

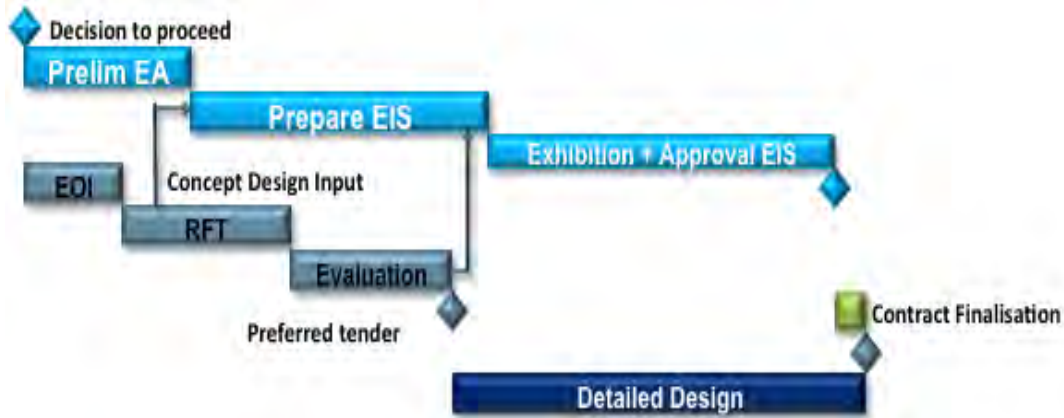


Figure 6 – Design / Planning Approval Process

10. The split ownership of the Assets needs to be carefully managed and resolved to allow the project to be effectively delivered.
11. There is an opportunity for the project to have private financing which may assist in the overall project cash flow requirements.

Re-engineering Parkes Way and Civic's Southern Road Network

Volume 5 - Project Risk

Project Number: 3002385

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APPENDIX A: PRELIMINARY RISK REGISTER

APPENDIX B: PRECINCT DEVELOPMENT RISKS

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1. INTRODUCTION

In 2013 the ACT Government procured an Urban Design Study for the Linking City Centre to the Lake strategy. This study developed a master plan that consisted of numerous design elements including the requirement to undertake significant civil infrastructure works to re-form the street and arterial road grid from City Hill to the West Basin foreshore.

As a major design and cost element of the urban strategy, the Economic Development Directorate (EDD) identified the need to investigate and identify key project risks concerning the major civil infrastructure works associated with the lowering of Parkes Way and adjustment to other major roads within Civic.

This study aims to develop a strategy to mitigate these risks by developing a feasibility design, undertaking constructability and cost assessment, considering the procurement options in the context of the current construction market, and investigating the implications of the project on the local transport network.

This report forms Volume 5 of 6 of the Feasibility Study for the Re-engineering Parkes Way and Civic's Southern Road Network:

- Volume 1 – Feasibility Design
- Volume 2 – Constructability Assessment
- Volume 3 – Transport Assessment
- Volume 4 – Procurement Strategies
- **Volume 5 – Project Risk**
- Volume 6 – Project Cost Estimate

The assessment of Project Risk has attempted to identify key risk areas and items that have the potential to impact on the delivery of arterial road works associated with the development of the City to the Lake precinct. This report summarises the findings of a limited risk identification process, drawing on previous experience, project workshops and a parallel risk analysis activity that has been undertaken for the adjacent West Basin EDP.

This risk assessment process is expected to be a precursor to a more detailed risk analysis that will be undertaken in future phases of the design.

2. SCOPE OF RISK MANAGEMENT

Risk management is an iterative process, and should be managed on an ongoing basis throughout the lifecycle of a project. The objectives of risk management are to increase the probability and impacts of positive events, and to decrease the probability and impacts of events adverse to the project objectives.

Early identification of risk is an important step in the process as it can significantly influence the timing, cost and scope of the project. Where risks are identified late in the project lifecycle, there is reduced likelihood that risks can be designed out or managed without significant rework and/or cost implications.

The ongoing management of risks on a project is an important process in order to achieve the project objectives in terms of time, cost, quality, safety and environmental sustainability. The risk management process should be continued from feasibility stage onwards is part of a systematic way of reviewing areas of risk and consciously determining how each should be treated.

3. RISK ASSESSMENT PROCESS

3.1 General

The Risk Management Process has been developed to ensure that all risks encountered during the development, implementation and finalisation phases of the project life-cycle are taken into consideration and that treatment options are considered to mitigate these risks.

The risk management process shall be generally divided into two phases:

- Risk identification/assessment;
- Risk management action/status.

Risks are identified and tagged under each of the major elements. For each risk the possible consequence, likelihood, impact, risk priority and risk ranking are then addressed.

3.2 Process

A risk management process has been developed based on AS 4360:2004, which will be followed whenever risks are considered or assessed for the project. Figure 1 demonstrates the risk analysis process that has been adopted to develop the risk register. As can be seen from Figure 1 the process involves:

- Establishing the context of the risk;
- Identifying actual risks;
- Analysing and evaluating each risk; and
- Deciding an appropriate risk treatment strategy.

The flowchart highlights the regular monitoring and reviewing of risks as well as the consideration of acceptable risk management strategies. By achieving a high level of understanding and ownership of the risks and treatment strategies, a robust project delivery path can be identified.

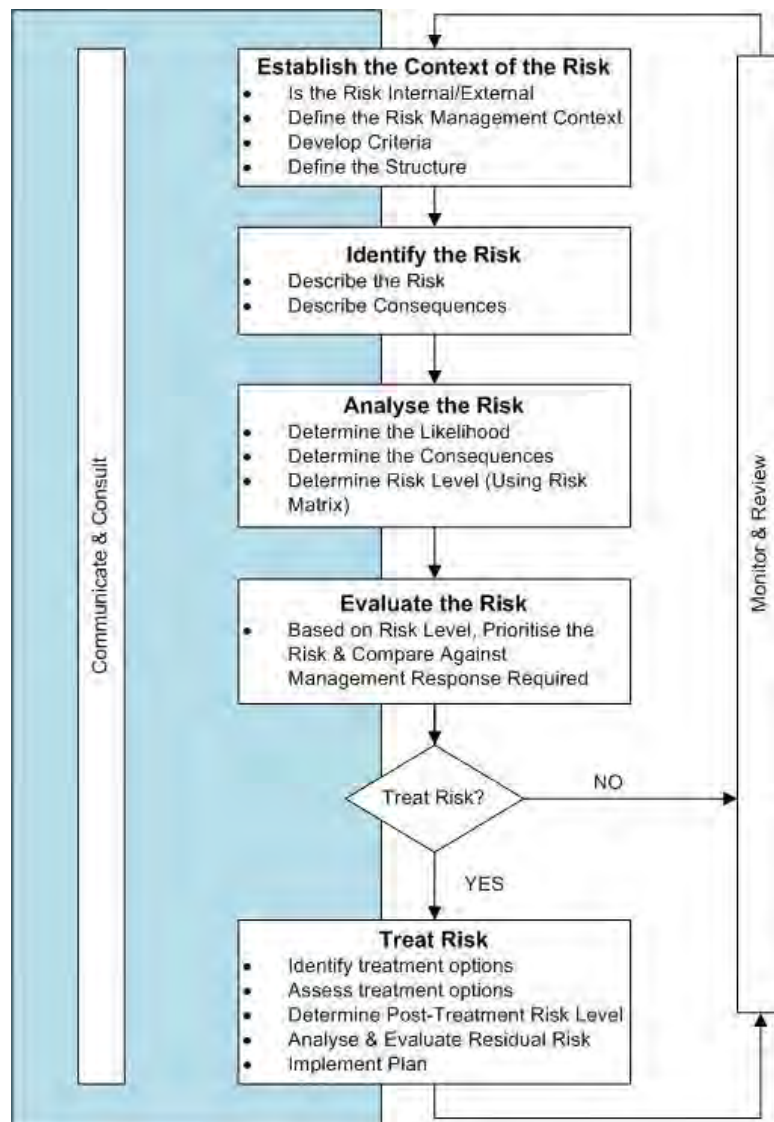


Figure 1 – Risk Management Process

3.3 Potential Hazards & Risks – Major Categories

In the risk identification/assessment process, the risk management plan is divided into major risk elements including:

- Alignment
- Utilities
- Properties/land
- Commercial
- Program
- Project Management
- Constructability
- Urban Design and Landscaping
- Traffic
- Hydrology
- Environment
- Stakeholders and Approvals
- Pavement
- Structures

- Staging
- Operation
- OH&S
- Drainage
- Geotechnical
- Procurement
- Political

3.4 Identify the Risk

This step involves the identification and documentation of risks that may impact the project during its life-cycle that can be realistically predicted at the time. Risks have been identified using techniques such as brainstorming, checklists, past experience, strengths / weaknesses / opportunities / threats (SWOT analysis), scenario analysis and by consulting stakeholders.

In order to create a preliminary risk register, risks will be identified and considered in the following three ways:

- Collation of Territory risks identified by the Territory during the Concept Design Phase;
- Identification of key risks by SMEC discipline leaders during the review and identification of scope stage of the project; and
- Risks identified during workshops.

To identify and properly describe the risks it will be necessary to recognise the uncertainties, threats and opportunities that could influence the objectives and goals of the activity in question (risk descriptor).

A risk must have a consequence, therefore it will be necessary to identify both the prospective cause of the risk as well as the potential effects (impact/consequence) of the specific risk. Once a risk is identified, it will be recorded in the Risk Register.

During the identification of risks, SMEC's design team will also identify key opportunities to be explored, managed and implemented during the design and development of the project.

3.5 Analyse the Risk

As each risk is identified, it is rated by how often it may occur (the "likelihood"), and the magnitude of the consequence (impact/magnitude). The likelihood assessment criteria (Section 3.6) is based on a percentage chance of occurrence. It is important to note that professional judgement was applied during this process.

The risk consequence criteria which ranks the effect or combined effects of an event is also assigned a score. The consequence is assessed against the relevant key areas which include cost, time, quality, community, health & safety, and environment.

3.6 Risk Assessment and Ranking Methodology

As mentioned above, the qualitative risk assessment process adopted for the feasibility study combines estimates of the severity and likelihood of a hazardous event to determine a risk rating. The rating is then used to guide the decision on whether hazards associated with the Project are acceptable or if specific management practices should be adopted to reduce the risk.

The qualitative risk assessment methodology comprises the following stages:

- Hazard identification, which involves identifying potential hazardous events, their causes and outcomes;
- Likelihood estimation, which involves identifying the frequency of the potentially hazardous events and their outcomes;
- Consequence estimation, which involves identifying the consequences of the potential hazardous event outcomes; and
- Risk assessment, which involves determining a risk rating for the various hazardous events using the likelihood and consequence estimations.

Likelihood estimation and scoring for each hazard is undertaken using the following table:

Likelihood Estimation and Scoring for Each Hazard		
	Minimum	Maximum
Likelihood (score)	Very Likely (5)	100%
	Likely (4)	90%
	Possible (3)	70%
	Unlikely (2)	30%
	Very Unlikely (1)	10%

The estimation includes an overall assessment of how likely a potential hazard is to occur. This may be during the design phase of the project for design type risks, construction phase risks, or could be a hazard that is present throughout the lifecycle of the project.

Consequence estimation and scoring for each hazard is undertaken using the following table:

Consequence Estimation and Scoring for each Hazard								
Consequence (score)		Cost	Time	Quality	Quantity	Community	Public & Workforce Safety	Environment
	Very Likely (5)	> \$500k	More than 3 weeks delay to critical path	Failing to meet specs / Unusable / Risk to public health	> 50% shortfall	Extreme negative media coverage / State Government intervention	Death or permanent incapacity	Catastrophic site impact / high local impact / moderate external impact / serious long-term cumulative effect
	Major (4)	\$100k to \$500k	1 to 3 week delay to critical path	Interpolate using judgement	Interpolate using judgement	Significant negative media coverage / Formal council intervention	Major injury / illness	High site impact / moderate local impact / minimal external impact / minor long-term cumulative effect
	Moderate (3)	\$50k to \$100k	2 days to 1 week delay to critical path	Useable but significant KPI based cost penalty	25% shortfall	Critical media coverage / formal council request for information	LTI	Moderate site impact / Minimal local impact / possible long-term cumulative effect
	Minor (2)	\$20k to \$50k	1 to 2 days delay to critical path	Interpolate using judgement	Interpolate using judgement	No. of community complaints above expected average	Minor injury / illness	Minimal site impact / easily controlled
Negligible (1)	<\$20k	< 1 day delay	Breach of one or two minor parameters not in customers' specs	< 5% shortfall	No. of community complaints at expected average	No injury / illness	No impact	

Risk Rating for Each Hazard						
		Consequence (score)				
		Extreme (5)	Major (4)	Moderate (3)	Minor (2)	Negligible (1)
Likelihood (score)	Very Likely (5)	Very High	Very High	High	Medium	Low
	Likely (4)	Very High	High	Medium	Low	Low
	Possible (3)	High	High	Medium	Low	Very Low
	Unlikely (2)	High	Medium	Low	Low	Very Low
	Very Unlikely (1)	Medium	Low	Very Low	Very Low	Very Low

3.7 Evaluate the Risk

The next step is to evaluate the risks after a risk level had been assigned, while providing evidence of the reasoning and rationale. All risks can impact upon the successful delivery of the Project, and as such should be logged, assigned a rating and mitigation measures identified. The end result of the evaluation process is a prioritised list of risks. Following is a guide indicating the level of risk mitigation needed depending on the level of specific risks.

Risk Mitigation Needed Depending on Level of Specific Risks	
Very High	Requires further investigation and the development of specific strategies to address the issue. Consider as "Don't Proceed" issue unless specific strategies have been developed to bring level of risk to acceptable level
High	Project Success Threatening. Requires further investigation and the development of specific strategies to address the issue. May consider as "Don't Proceed" issue unless specific strategies have been developed to bring level of risk to acceptable level
Medium	Requires the development of specific strategies
Low	Generally requires the development of specific action plans
Very Low	Generally document and accept or manage as normal part of project management

3.8 Determine Risk Treatment

Treatment or mitigation methods for high and very high risks were identified to assist in their management during future phases of the design. To effectively manage the risk, a combination of strategies may be required. The selection process is often iterative until the most effective treatment strategy or strategies are developed. The first step in determining the type of risk treatment is choosing one or a combination of the following risk control measures:

3.8.1 Risk avoidance

This may include discontinuing the activity due to the unacceptable risk. This is rarely an option when providing services to the public. Inappropriate risk avoidance may increase the significance of other risks or lead to the loss of opportunities for gain.

3.8.2 Reduce the likelihood

Changing the design, contract conditions, increasing supervision, testing, implementing rigorous internal controls, training and awareness, preventative maintenance, better management and quality assurance are typical options to reduce the likelihood of the risk occurring.

3.8.3 *Reduce the consequence*

Several methods available include contingency planning, disaster recovery planning, contractual arrangements and/or conditions and insurance.

3.8.4 *Risk transfer*

Insurance or organisational structures or instruments, joint ventures and alliances where the other party accepts the risks are examples of risk transfer.

3.8.5 *Risk acceptance/retention*

The decision to accept the likelihood and consequences of an identified risk when the risk level is considered to be low. In rare cases, risks may need to be accepted even though they are considered to be uncontrolled and moderate or high. An example of this is when other methods fail to adequately or fully treat the risk and the project is faced with accepting the entire risk or any residual risk remaining. When this occurs the project is exposed to some degree of impact which must be managed internally. To ensure the initial project budget is not exceeded, it must include sufficient contingency to cover the eventuality. The acceptance of risk should be an informed decision where treatment options have been fully explored.

3.8.6 *Developing the most appropriate option*

Developing the most appropriate option involves implementing measures to reduce the likelihood (using mitigating actions) and/or the consequence/impact (using contingency strategies) of a risk. Assessing the risk treatment options involves balancing the costs of implementing each option against the benefits derived from it in order to select the most appropriate option.

3.8.7 *Once mitigation measures have been developed*

The residual risk is then assessed. Residual risk is assessed in the same way as in the initial risk assessment, which involves reassessing the likelihood, consequences and the overall level of risk after mitigation and contingency actions are taken. Stakeholders and decision makers should be aware of the nature and extent of the residual risk, and it should be subjected to regular monitoring and reporting in future stages of the project.

It is possible for a risk to have a number of equally suitable potential treatments that have varying costs. In these circumstances, the selection of a final treatment must be made on a "value" basis. The cost of managing the risk should be commensurate with the benefits obtained.

3.9 Monitor and Review the Risk

The Risk Register developed as part of the Feasibility Study is expected to be the basis for future risk analysis exercises. Certain factors affecting the likelihood and consequences of identified risks may change over time, therefore it is necessary to regularly review the register and repeat elements of the risk as the project develops and changes. Continual monitoring and control is required to assess the appropriateness and effectiveness of the treatments.

4. RISK ASSESSMENT APPROACH TO FEASIBILITY STUDY

When developing a preliminary risk register for this project, there are a number of considerations that are relevant to the assessment approach. In particular, given the preliminary nature of the feasibility study there are limitations on the available information and level of design information.

The following discussion relates to key considerations that are relevant to the compilation of the preliminary risk register for the project. They provide some context to the development of the register and how the risk management process described above has been applied.

4.1 Feasibility Stage Design

The design presented in the Feasibility Study (both the Feasibility Design and the Variant 2c options), has been developed to a pre-concept level. That is, it is highly preliminary in terms of the level of detail investigated and presented. This, in itself, represents a significant risk to the project as there may be as yet un-identified risks that will only become apparent as design elements and issues are investigated in greater detail.

Furthermore, it also provides limitations in terms of the degree that the risk analysis can be informed by the design and feasibility study. That is, the risk analysis is limited by the available information and as such should be regarded as highly preliminary. As the design develops in future phases of the project, greater detail and design definition will assist in informing future iterations of the risk register.

4.2 Concurrent West Basin EDP Risk Assessment

It is noted that there has been a concurrent risk assessment undertaken associated with the adjacent West Basin Estate Development Plan (EDP) by ISG Projects. Both projects (Re-engineering of Parkes Way and the West Basin Development) are part of the City to the Lake precinct development, and whilst in some respects they have different and discrete risks, it is also noted that there are numerous risks that are common to both element of the City to the Lake development. As such, the risk assessment associated with the West Basin EDP is directly relevant to this Feasibility Study and has been referenced and included in this report.

4.3 Workshops

4.3.1 Design Workshops

Two design workshops were held over the course of the Feasibility Study (22 February 2014 and 6 May 2014) to work through design issues relating to engineering and urban design disciplines. During both these workshops project risks and opportunities were discussed between the project team, Client organisation representatives and other relevant stakeholders.

Risks identified by the group were recorded during these workshops. These risks have been included in the risk register that has been developed as part of this report (see Section 5).

4.3.2 Risk Analysis Workshop

Normally as part of a risk assessment process, the project team would undertake a dedicated Risk Analysis workshop. The purpose of the workshop would be to review a pre-prepared risk

register, agree risk ratings, mitigation measures, determine residual risk ratings and owners, and identify any additional risks that were not previously identified.

It was originally intended that such a workshop would be included as part of the risk analysis for the Feasibility Study. However, direction was received by the project team to reduce the scope of the risk assessment task (inclusive of removal of the risk assessment workshop) based on the following rationale:

- Limited risk assessment activities had already been undertaken as part of preceding design workshops;
- The concurrent West Basin EDP risk assessment would identify many of the same risks and as such there would like be a high degree of duplication between the two studies; and
- Upon receipt of the cost estimate for the Feasibility Design, the need to develop an alternate concept that was more viable in terms of capital costs. As such, it was felt that it would be more appropriate to focus effort towards this end in preference to a more detailed risk assessment.

5. IDENTIFIED PROJECT RISKS

The project risks identified as part of the Feasibility Study are contained in the Preliminary Risk Register included in Appendix A. This register is a compilation of the risks identified in the Design Workshops described above, in addition to risks that the project team are cognisant of based on previous experience on major projects.

Included in the preliminary register are risk ratings assigned to each risk that consider the likelihood and consequence of an event. In addition, existing controls have been identified as part of the register.

It is noted that as part of the standard risk management approach, proposed mitigation measures and subsequent residual risks are evaluated as part of a risk management workshop in consultation with the wider project team, Client organisation representatives, and relevant stakeholders. In the absence of this workshop approach in the Feasibility Study, the identification of mitigation measures and evaluation of residual risks has not been included in the preliminary register. It is anticipated that these items will be addressed in future phases of project development in addition to the evolution of a more comprehensive register based on a more detailed level of design documentation.

6. PRECINCT DEVELOPMENT RISKS

As part of the City to the Lake master planning activities and the associated development of the West Basin EDP (that is happening in parallel to the Feasibility Study), ISG Projects have undertaken a risk assessment process. This risk assessment process was informed by a risk workshop held on 21 May 2014, and produced a Risk Assessment summary on 2 July 2014 that identified the top 15 risks to implementation and proposed mitigation measures for the project.

Whilst many of these risks are specific to master planning and EDP activities for the precinct, there are a number that are directly relevant to the implementation of the Re-engineering of Parkes Way. It is therefore important that risk analysis for the Feasibility Study consider the outcomes of this related risk assessment, and as such it has been included in Appendix B of this volume.

7. SUMMARY AND FUTURE RISK ANALYSIS

Given the scale of the project, the role the site plays in a number of key arterial transport corridors, its urban context and its nationally significant location, it is critical that the project risks are identified and clearly understood.

This Feasibility Study has sought to create an understanding of likely project risks by:

- Developing a pre-concept level Feasibility Design;
- Developing an alternate design (Variant 2c) that scales back the infrastructure works in order to reduce capital costs;
- Investigating the potential construction methodology inclusive of construction approaches and staging;
- Analysing the potential traffic / transport implications of the project;
- Assessing procurement options for the delivery of the project; and
- Undertaking a cost estimate for the project design options.

Further to these assessments, specific risks have been identified and evaluated, and subsequently recorded in the preliminary risk register.

The comprehensiveness of this preliminary risk register is limited however by the level of detail available in this phase of the project. It is anticipated that this preliminary register will be developed in future phases of design when higher levels of design detail become available, and more detailed site investigations are undertaken. It is understood that a number of future activities are currently planned as part of the next phase of the project, including:

- Water Quality Strategies to Replace Coranderrk Pond – An investigation into possible water quality treatments in the City East catchment that could be implemented in order to facilitate the removal of Coranderrk Pond;
- Parkes Way Tunnel Requirements Assessment – An assessment to better understand the infrastructure, tunnel servicing, emergency and dimensional requirements for a possible cut and cover Parkes Way tunnel beneath the Parkes Boulevard; and
- Parkes Way Lowering Concept Design – The next design phase will identify a preferred design solution, develop design detail, identify site constraints (including environmental, utilities, etc.), work through statutory planning implications, help develop a more robust cost estimate, and progress the risk register. Furthermore, it is likely that the concept design will form the basis of a reference design for a D&C contractor or PPP proponent.

Future development of design will inform a more comprehensive risk register that will thoroughly investigate appropriate risk mitigation measures and identify additional risks as they become apparent. It is expected that these future iterations of the risk register will be based on the findings of the preliminary register produced as part of this Feasibility Study, and will be a live document that will be monitored and updated throughout the life of the project until completion.

APPENDIX A: PRELIMINARY PARKES WAY LOWERING RISK REGISTER

Re-engineering Parkes Way and Civic's Southern Road Network
Draft Risk Register

Category number	Risk Identification				Risk Analysis					Risk Treatment					
	Category	Source of Risk	Identified Risks / Hazards (opportunities & threats)	Leading to . . . (implications)	Existing Controls of Identified Risk / Hazard (If any)	Likelihood (1 - 5)	Consequence (1 - 5)	Risk Rating	Is the Risk Significant? Yes ≥8 No <8	Treatments / Actions	Responsibility	Timing	Residual Likelihood (1 - 5)	Residual Consequence (1 - 5)	Residual Risk Rating
1	Construction	Construction	Unpredicted and unforeseen delays during construction, design and approval.	Cost & Time	Adequate design, construction and management QA in place.	3	5	15	YES						
1	Construction	Construction	Timing of works could be contracted to compliment other elements of the City to the Lake development or social / political imperatives	Time	Timing of works	2	3	6	NO						
1	Construction	Contractors	Excessive variations throughout construction.	Cost	Ensure lump sum contract and plans are accurate. Monitor works regularly. Limit scope changes throughout project.	3	5	15	YES						
1	Construction	Contractors	Delays influencing Practical Completion	Time	Regular site meetings and review of programme. Monitor delays and EOT's. Regularly communicate with client and Authorities. Ensure client has sufficient programme lag.	2	3	6	NO						
1	Construction	Contractors	Slow / Delayed Contractor	Time	Ensure liquidated damages are sufficient. Review performance and future inclusion on tender lists.	2	3	6	NO						
1	Construction	Contractors	Inexperienced or unstable contractors.	Cost, Time, Quality & Safety	Preferred tender list to be signed off by client. Ensure bank guarantees are in place.	1	5	5	NO						
1	Construction	Contractors	Relationship with Developer / Superintendent	Quality	Ensure tender list is approved by client prior to tendering.	1	4	4	NO						
1	Construction	Contractors	Environmental Management & OH&S	Cost, Time & Environment	Management plans completed and signed off by contractor and relevant authorities. Superintendent to monitor works.	2	4	8	YES						
1	Construction	Weather / Site Conditions	Unsuitable weather results in delays and cost escalation	Cost & Time	Temporary measures allowed for to enable construction to proceed.	2	3	6	NO						
1	Construction	Weather / Site Conditions	Timing of construction work to seasons	Cost, Time & Quality	Monitor weather and work with contractor to protect site and program appropriate works given climatic condition (e.g. place SMA in warmer months).	2	4	8	YES						
1	Construction	OH & S	Injury to workers or public resulting from construction activities	Cost, Time, Community & Safety	All contractors to have adequate OH&S accreditations and systems.	3	5	15	YES						
1	Construction	Audits	Elec / Water Authority	Cost, Time & Quality	Delays in achieving completion.	2	3	6	NO						
1	Construction	Construction Contracts	Disputes between parties	Cost & Time	Use standard conditions of contracts and specifications familiar to all parties wherever possible	2	4	8	YES						
1	Construction	Ground water draw-down	Damage to neighbouring buildings/property	Cost, Time, Safety, Community & Environment	Ensure comprehensive geotech / groundwater investigation is undertaken prior to commencement of works. Appropriate geotech instrumentation / monitoring during works	2	5	10	YES						
1	Construction	Ground water draw-down	Ground subsidence	Cost, Programme, Quality, Safety	Ensure comprehensive geotech / groundwater investigation is undertaken prior to commencement of works. Appropriate geotech instrumentation / monitoring during works	2	3	6	NO						
1	Construction	Ground water draw-down	Flooding during construction	Cost, Programme, Quality, Safety & Environment	Ensure appropriate dewatering systems and stormwater diversions away from trench are in place.	2	4	8	YES						
1	Construction	Excavation	Hard rock more extensive / shallower than expected	Cost & Time	Ensure comprehensive geotech investigation is undertaken prior to commencement of works.	2	5	10	YES						
1	Construction	Excavation	Hard rock excavation more difficult than expected	Cost & Time	Ensure comprehensive geotech investigation is undertaken prior to commencement of works.	2	5	10	YES						
1	Construction	Excavation	Least efficient option between top down vs. bottom up construction selected	Cost & Time	Ensure comprehensive geotech investigation is undertaken prior to commencement of works. Experienced designer and constructor selected	1	5	5	NO						
1	Construction	Excavation	Blasting is not properly executed	Cost, Time, Community, Safety & Environment.	Ensure comprehensive geotech investigation is undertaken prior to commencement of works. Engage specialist blasting contractor with sufficient experience.	2	5	10	YES						
1	Construction	Specialist contractors	Not available when required	Cost, Time & Quality	Contractor to ensure clear and appropriate programming of works	1	4	4	NO						
1	Construction	Approving Authorities	Temporary works approvals not given	Cost & Time	Contractor to ensure sufficient approval timeframes are allowed	3	3	9	YES						
1	Construction	Services Relations	Unanticipated relocation requirements	Cost & Time	Extensive potholing prior to construction	3	5	15	YES						
1	Construction	Utility Companies	Unresponsive / Not available when required / unclear in their requirements	Cost & Time	Extensive consultation during construction and ongoing liaison during construction	3	5	15	YES						
1	Construction	Sewer	750 mm sewer main in tunnel damaged during construction	Cost & Time	Ensure location of sewer is accurately understood and proposed construction techniques are utilised.	2	4	8	YES						
1	Construction	Design detailing	Insufficient information when required	Cost & Time	D&C / PPP procurement method. Ensure appropriately experienced designer	3	5	15	YES						
1	Construction	National Events	Maintaining access requirements during national and international events (e.g. US President visit)	Cost & Time	Ensure contract document makes allowance for worksite shutdowns.	2	2	4	NO						
1	Construction	Commonwealth Ave Bridges	Demolition risk	Cost, Time & safety	Ensure appropriate protocols and SWMS are in place	1	5	5	NO						
1	Construction	Adjoining Properties	Dust, flooding, disruption of facilities, stakeholder issues, etc.	Cost	Ensure appropriate environmental protective devices are installed and monitored.	2	3	6	NO						
1	Construction	Third Party Damage	Re-work, disruption to programme.	Cost & Time	Contract requirements to include appropriate insurances.	2	3	6	NO						
1	Construction	Adjacent property/land owners	Stakeholder & community interference & complaints	Cost, Time & Community	Appropriate community liaison and public consultation during construction	2	3	6	NO						

Re-engineering Parkes Way and Civic's Southern Road Network
Draft Risk Register

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2	Design	Design	Design proceeding without Authority approval. Modifications of the scope throughout design / construction.	Cost & Time	Discuss implications with client; possibility, costs etc.	2	3	6	NO						
2	Design	Financial	Unpredicted increase in costs.	Cost	Include sufficient contingency and highlight assumptions, data limitations and unknown scope. Ensure consultant has adequate experience and time to prepare design and updated costings.	2	5	10	YES						
2	Design	Authority Negotiation	Negotiations with NCA, ACT Government, Capital Metro	Cost & Time	Preliminary meetings to establish boundaries and road blocks. Continue involvement with Authorities throughout design development.	1	2	2	NO						
2	Design	Adjoining Properties	Access approvals, design requirements, easements.	Cost, Time & Community	Ensure ongoing community consultation during the design phase	2	3	6	NO						
2	Design	Client initiated changes	Modifications of the scope throughout design / construction	Cost & Time	Client to understand implications and provide early advice regarding potential changes.	3	4	12	YES						
2	Design	Schedule / Programme	Delayed / Accelerated release / Splitting of stage/ Stage sequencing	Cost & Time	Client to communicate with project team. Regular coordination meetings.	3	4	12	YES						
2	Design	Water Quality and Hydraulics	Upfront costs associated with the construction of retarding basins and water treatment facilities; wetlands, bio retention, sedimentation ponds etc.	Cost & Time	Preliminary planning & cost forecasting	2	3	6	NO						
2	Design	Water Quality and Hydraulics	Poor master planning resulting in later issues. Coordination with other Linking City to the Lake projects	Cost, Time & Quality	Sound, thorough and Peer reviewed master planning, using experienced design consultants. Ensure ongoing consultation between design teams.	1	3	3	NO						
2	Design	Pavement Design	Inappropriate pavement design, particularly in deep cuts.	Cost, Time & Quality	Comprehensive geotech investigation to inform the design. Utilise pavement designers familiar with tunnel design requirements.	2	4	8	YES						
2	Design	Communications/ Fibre	Location of existing services conflicts with proposed development. Impacts on construction timing.	Cost & Time	Locate existing asset and relocate prior to works or include in contract. Engage with communications providers including both private and government (ACT & Federal).	2	2	4	NO						
2	Design	Gas	Location of existing services conflicts with proposed development. Impacts on construction timing.	Cost, Time & Safety	Locate existing asset and relocate prior to works or include in contract. Liaise with Jemena / ZNX	2	2	4	NO						
2	Design	Water	Location of existing services conflicts with proposed development. Impacts on construction timing.	Cost & Time	Locate existing asset and relocate prior to works or include in contract. ACTEW Water	2	2	4	NO						
2	Design	Electrical	Location of existing services conflicts with proposed development. Impacts on construction timing.	Cost, Time & Safety	Locate existing asset and relocate prior to works or include in contract. ACTEW AGL	2	2	4	NO						
2	Design	Design issues	Incomplete, complicated design results in cost escalation and time delays.	Cost & Time	Designs that consider construction aspects, material availability etc.	2	5	10	YES						
2	Design	Approval and/or mitigation of environmental concerns	May cause time delay and cost escalation	Cost & Time	All contractors to have adequate environmental accreditations and systems. Ensure EMP is approved prior to construction.	1	2	2	NO						
2	Design	Non performance from vendors, sub-contractors and suppliers.	Impact on cost and schedule	Cost, Time & Quality	Ensure suppliers and sub contractors are assessed prior to engagement and have appropriate experience. Head consultants to ensure adequate QA procedures.	1	3	3	NO						
2	Design	Drainage Scheme	Outfall conditions (by others) not suitable for proposed drainage system design	Cost, Time & Quality	Coordination between design / project teams to ensure appropriate information transfer	2	4	8	YES						
2	Design	Wetland / Retarding Basins / Rain garden Design	Poor design based on upfront unknown parameters.	Cost & Time	Establish design criteria with approving authorities	2	3	6	NO						
2	Design	Drainage System - Outfall Services	Timing of works conflicts between various Linking City to the Lake projects.	Cost & Time	Coordination between design / project teams to ensure appropriate information transfer	2	3	6	NO						
2	Design	Drainage System - Outfall Services	Authority Approvals	Time	Coordination between design / project teams to ensure appropriate information transfer	2	3	6	NO						
2	Design	Complete Designs	Inaccurate / incomplete design	Cost & Programme	Utilise full suite of SMEC Services. Utilise established quality control systems.	1	3	3	NO						
2	Design	Poor Design	The Design fails to achieve a high urban design quality or meet the expectations of the community	Quality & Community	Ensure an appropriate and experienced design team is engaged to complete the design.	2	4	8	YES						
2	Design	Insufficient financial resources	"The Design is not Transformational"	Quality & Community	Ensure an appropriate and experienced design team is engaged to complete the design. ACT Government to commit sufficient resources to ensure ambition of the master plan is realised.	3	5	15	YES						
2	Design	Utility Services - Existing conditions	In ground services not where they are expected	Cost & Time	Extensive service authority consultation and potholing prior to construction	3	5	15	YES						
2	Design	Ground water conditions	Water table higher than expected	Cost & Time	Ensure that design is informed by sufficient geotechnical investigation in the early stages of the design process.	2	5	10	YES						
2	Design	Ground water conditions	Ground water inflow greater than expected	Cost & Time	Ensure that design is informed by sufficient geotechnical investigation in the early stages of the design process.	2	5	10	YES						
2	Design	Traffic Engineering	Traffic Congestion resulting from the proposed works is unacceptably high.	Cost & Community	Ensure robust road network design to deal with changed traffic patterns.	3	5	15	YES						

Re-engineering Parkes Way and Civic's Southern Road Network
Draft Risk Register

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2	Design	Traffic Engineering	Assumptions - Inputs not appropriate resulting in worse than anticipated traffic congestion at project opening.	Cost & Community	Undertake sufficient traffic counts as appropriate for local road network. Engage competent transport engineering consultants with understanding of local transport network.	3	5	15	YES						
2	Design	Traffic Engineering	Assumptions - Interpretation not appropriate resulting in worse than anticipated traffic congestion at project opening.	Cost & Community	Engage competent transport engineering consultants with understanding of local transport network.	3	5	15	YES						
2	Design	Traffic Engineering	Future modelling scenarios - 2011 v 2021 v 2031 v 2041 v 2051	Cost, Time & Community	Agree appropriate time horizon between all stakeholders and design team.	2	5	10	YES						
2	Design	Design	Over-design (gold plating)	Cost & Time	ACT Government to participate in design development and input into standard of design. Engage a suitably experienced design consultant team.	2	5	10	YES						
2	Design	Design	"Tunnel design" assumptions not sustainable	Environmental	Engage experienced consultant to investigate likely tunnel requirements. Undertake life cycle cost and environmental investigations on likely tunnel configuration.	2	5	10	YES						
2	Design	Design	"Drained" tunnel assumption is not sustainable.	Environmental	Undertake sufficient geotechnical investigations to understand likely groundwater ingress regime. Engage experienced consultant to investigate likely groundwater pumping requirements. Undertake life cycle cost and environmental investigations on likely tunnel configuration.	1	4	4	NO						
2	Design	Future operations	Parkes Way Flooding	Cost & Community	Engage experienced consultant to investigate likely stormwater pumping requirements inclusive of redundancy arrangements that are consistent with best practice for tunnels.	2	4	8	YES						
2	Design	Future operations	Overland flow paths	Cost & Community	Engage experienced consultant to design overland flow paths that don't jeopardise the operational integrity of the tunnel.	2	4	8	YES						
2	Design	Future operations	Future maintenance - Tunnel ventilation systems too expensive to operate & maintain	Cost	Engage experienced consultant to investigate likely tunnel requirements. Undertake life cycle cost investigations on likely tunnel configuration.	2	5	10	YES						
2	Design	Future operations	Emergency services	Cost & Safety	Engage experienced consultant familiar with tunnel design, mechanical plant and emergency requirements.	3	5	15	YES						
3	Feasibility / Master Planning	Flora & Fauna	Potential for F&F issues to impact layout and project timing / approvals. Net gain implications and specified timing of assessments.	Cost, Time & Environment	Undertake a preliminary F&F assessment. Identify any offsets, net gain implications and survey timing constraints.	1	4	4	NO						
3	Feasibility / Master Planning	Site Contamination	Unknown contamination issues	Cost, Time & Environment	Undertake preliminary desktop investigations and site contamination testing if appropriate	2	5	10	YES						
3	Feasibility / Master Planning	Cultural Heritage	Delays during construction . Additional costs for monitoring / site delays.	Cost, Time & Environment	Undertake a preliminary cultural heritage assessment	1	2	2	NO						
3	Feasibility / Master Planning	Financial	Inaccurate Budget / Estimate	Cost	Review cost estimate regularly	2	5	10	YES						
3	Feasibility / Master Planning	Authority reluctance to realise development potential	Potential road blocks with respect to the rezoning of land or complications with the PSP process	Cost & Time	Management and negotiation with resp. Authorities. Consistent contact.	2	5	10	YES						
3	Feasibility / Master Planning	Existing Services	Existing services not being identified in review.	Cost & Time	Ensure that design is informed by sufficient utilities investigation.	3	5	15	YES						
3	Feasibility / Master Planning	Existing Services	Existing services not being within an easement	Cost & Time	Ensure that design is informed by sufficient utilities investigation.	2	5	10	YES						
3	Feasibility / Master Planning	Existing Services	Existing infrastructure cannot service site or requires upgrade. Large amount and cost of works required to service the site.	Cost & Time	Ensure that design is informed by sufficient utilities investigation.	3	5	15	YES						
3	Feasibility / Master Planning	External Consultants	Provision of accurate and timely advice	Cost & Time	Include in project coordination meetings.	2	4	8	YES						
4	Safety	Design	Pedestrian safety reduced	Safety	Engage experienced consultant with major infrastructure and public realm design.	3	5	15	YES						
4	Safety	Design	Pedestrian & commuter cyclist conflicts	Safety	Engage experienced consultant with major infrastructure and public realm design. Define clear user hierarchies within public space.	3	4	12	YES						
4	Safety	Design	Road safety for traffic during temporary works	Safety	Ensure contractor engages appropriately qualified TCP designers.	3	5	15	YES						
4	Safety	Design	Road safety for traffic (permanent condition)	Safety	Undertake Road Safety Audit at all design and construction stages of the project.	2	5	10	YES						
4	Safety	Design	Emergency egress to/from Parkes Way underpass	Safety	Engage experienced consultant familiar with tunnel design and emergency requirements .	2	5	10	YES						
4	Safety	Design	Emergency egress to/from Commonwealth Ave ramps	Safety	Engage experienced consultant familiar with tunnel design and emergency requirements .	2	5	10	YES						
4	Safety	Design	Projectiles thrown/dropped into the Parkes Way Underpass	Safety	Undertake specific throw screen risk assessment consistent with guidelines.	2	5	10	YES						
4	Safety	Design	Non-compliance of tunnel design (assumptions v reality)	Cost, Time, Quality & Safety	Engage experienced consultant familiar with tunnel design and enact a formal peer / independent review system for the design.	2	5	10	YES						
5	Political	Network Operation	Public transport policies compromised by project	Quality & Community	Undertake a thorough review of transport network implications as part of the concept design development.	2	4	8	YES						

Re-engineering Parkes Way and Civic's Southern Road Network
Draft Risk Register

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5	Political	Design	On street parking shortages	Quality & Community	Consult with relevant stakeholders throughout the design process to ensure that on street parking requirements are achieved.	2	3	6	NO						
5	Political	Future operations	Parking costs	Quality & Community	Consult with relevant stakeholders and agree to appropriate on street parking costs.	1	3	3	NO						
5	Political	Future operations	Traffic Congestion	Community	Ensure robust road network design to deal with changed traffic patterns.	3	5	15	YES						
5	Political	Construction	Disruption during temporary works	Cost & Community	Undertake traffic modelling of construction scenarios	3	5	15	YES						
5	Political	Construction	Project cost overruns	Community	Facilitate an environment for high quality design and ensure engagement of experienced design consultant. Undertake a rigorous tender assessment process and engage an appropriate contractor and construction phase service team.	3	4	12	YES						
5	Political	Design	Project cost magnitude	Community	ACT Government to participate in design development and input into standard of design to ensure acceptable scale of project and budget availability.	2	4	8	YES						
5	Political	Project Procurement	Partial implementation - project is not effectively or well integrated	Quality & Community	Ensure appropriate oversight group for precinct development and that this group targets a high degree of integration between various development elements.	2	4	8	YES						
5	Political	Project Procurement	Change of Government before project commencement with alternate views on precinct development.	Community	Project team (Consultant and Govt.) to ensure that vision for the project is clearly articulated and benefits are well defined	2	4	8	YES						
5	Political	Cost: Benefit Analysis	Does not meet expectation of National Population	Community	Project team (Consultant and Govt.) to ensure that vision for the project is clearly articulated and benefits are well defined. Engage experienced community consultation consultant.	1	2	2	NO						
5	Political	Cost: Benefit Analysis	Does not meet expectation of ACT Population	Community	Project team (Consultant and Govt.) to ensure that vision for the project is clearly articulated and benefits are well defined. Engage experienced community consultation consultant.	2	4	8	YES						
5	Political	Community Perceptions	Don't fix what isn't broke	Community	Project team (Consultant and Govt.) to ensure that vision for the project is clearly articulated and benefits are well defined. Engage experienced community consultation consultant.	2	4	8	YES						
5	Political	Implementation of wider metropolitan initiatives	Impact on Capital Metro	Community	Ensure appropriate oversight group for precinct development and that this group targets a high degree of integration between CMA and other relevant transport stakeholders.	2	5	10	YES						
5	Political	Asset owner	National Capital Authority (NCA) don't/won't give support & approval	Cost & Time	Ongoing consultation with NCA throughout the design process	3	5	15	YES						
6	Financial	Cost Estimating	Cost estimate is incomplete (does not capture 100% of scope of works)	Cost & Community	Engage experienced QS during the design phases of the project.	2	5	10	YES						
6	Financial	Procurement Method	Inappropriate procurement method selected (i.e. design only vs D&C vs PPP)	Cost & Time	Undertake a procurement analysis by a suitably experienced consultant.	2	3	6	NO						
6	Financial	Overall project staging	Local disposal of excavated spoil is not available	Cost & Time	Ensure appropriate oversight group for precinct development and that this group is cognisant of interdependence and efficiencies of project coordination.	3	4	12	YES						
7	Environmental	Removal of Coranderrk Drainage Pond reduces WSUD outcomes	Increased pollution in LBG	Community & Environmental	Ensure that upstream water quality measures in the City East catchment are identified and developed prior to the removal of the Coranderrk Pond	1	3	3	NO						
7	Environmental	Removal of Coranderrk Drainage Pond reduces WSUD outcomes	Ground water contamination	Environmental	Ensure that upstream water quality measures in the City East catchment are identified and developed prior to the removal of the Coranderrk Pond	1	3	3	NO						
8	Post Construction	Bond Return	End of Defects not completed	Time	Sewer & Water Off Maintenance Register & PM Database	2	3	6	NO						
8	Post Construction	Bond Return	Damage by others	Cost & Time	Regular Site Inspections	2	2	4	NO						

Likelihood	Consequence
1 – Very Rare chance of occurrence or causing harm	1 – Insignificant impact or harm
2 – Rare chance of occurrence or causing harm	2 – Minor impact or harm
3 – Moderate chance of occurrence or causing harm	3 – Moderate impact or harm
4 – Above average chance of occurrence or causing harm	4 – Major, but reversible impact or harm
5 – Almost certain chance of occurrence or causing harm.	5 – Catastrophic impact or harm.

APPENDIX B: PRECINCT DEVELOPMENT RISKS



Risk Assessment

Purpose of Risk Assessment:

- Identify the threats to the successful implementation of the Masterplan
- Propose risk mitigation strategies
- Incorporate risk assessment & mitigation strategies into Implementation Plan



Risk Assessment

Risk Assessment Process to Date:

- CTL Risk Workshops - Separate 'Technical' and 'Commercial' Risk Workshops (involving key team members)
- Workshops focused on identification of threats to successful implementation of the Masterplan
- Risks categorised - 11 categories
- ISG ranked risks (AS 4360 method - risk consequences & likelihood rated)
- Mitigation strategies for risks ranked 'high' or 'extreme'
- Top 15 risks identified

Risk Assessment

Top 15 Implementation Risks & Mitigation:

<p>1.0 Increased development and changed urban forms result in reduced quantity and quality of water in the Lake.</p>	<p>Commission 'CTL Water Sustainability Management Plan', informed by environmental risk assessments and establish CTL precinct wide statutory controls for managing drainage and water quality.</p>
<p>2.0 Inadequate cooperation with and coordination of services utilities results in unforeseen scope creep, increased costs potential procurement delays (also affects sequencing and land release programme).</p>	<p>Develop Services Utility Masterplan Scope, informed by existing conditions audits/surveys and agree detailed 'Services Implementation Plan' with each utility . Include 'Services Continuity Strategy'. Enact Act of Parliament to create facilitation, procurement and delivery powers for LDA.</p>
<p>3.0 Capital Metro does not proceed and consequently infrastructure and land use planning within CTL is required to be reconsidered/redesigned.</p>	<p>Assess likelihood of this event occurring. If event possible, develop mitigation strategy, including alternative masterplan which excludes Capital Metro. Assess impact on Masterplan Feasibility.</p>
<p>4.0 Breakdown of negotiations between NCA and ACT Governments with regard to project design, implementation and responsibility.</p>	<p>Develop comprehensive Stakeholder and Communications Management Strategy acknowledging NCA's roles and responsibilities and capturing the NCA's primary objectives, concerns and issues surrounding the project. Maintain NCA's continuous involvement in the development and implementation of the Masterplan. Consider appointing NCA representation onto Masterplan Project Steering Committee.</p>
<p>5.0 Existing business and private sector use of the Lake and surrounding areas do not comply with the CTL plan and its implementation (note: political risk that Gov not prepared to be heavy handed to progress compliance with CTL)</p>	<p>Initiate comprehensive study of existing land uses, identify amenity or land use conflicts with Masterplan and develop strategy for each affected business. Consider need to relocate businesses and/or the need to compensate. Brief Ministers on strategy and the whole-of-territory benefits of implementing the Masterplan. Establish widespread public support for the project through effective communication strategies to provide counter-balance to vested interests.</p>

Risk Assessment

Top 15 Implementation Risks & Mitigation:

6.0	Inability to control quality of urban realm between new buildings.	Establish precinct specific statutory controls to mandate developer investment in public realm design and construction. Establish urban design principles and guidelines for development. Establish statutory design review and approval process. Consider LDA funding & / or delivery of critical catalyst urban realm initiatives.
7.0	Additional works required to mitigate environmental impact or risks	Carry out Environmental Risk Assessment and develop risk mitigation strategy. Establish scope of enabling macro-scale environmental management works to be delivered by LDA and separately identify environmental management works required to be delivered by private sector developers. If required, update Masterplan Feasibility to incorporate cost of environmental management.
8.0	Low investment in enabling infrastructure increases developer's costs and risks, reducing value capture and/or lack of private sector appetite to fund the critical early enabling works.	Demonstrate benefits, including value creation, of the LDA investing in enabling infrastructure. Demonstration to include analysis of reduction in developer's risks and resultant increase in land value. Establish funding strategy to support early investment in enabling works.
9.0	Inadequate flexibility in masterplan for multiple future development options.	Identify where flexibility in land use options is desirable and why. Undertake preliminary feasibility analysis of the consequence of changing land use in specific locations. Where flexibility can be accommodated without detrimentally affecting feasibility or required design outcomes, document a range of permissible uses for specific sites & establish a statutory approval process for future land use planning (eg build req'd flexibility into Masterplan).
10.0	Government refuse to reinvest early revenues back into project to deliver masterplan as per the masterplan feasibility, funding strategy and implementation plan.	Establish a 'CTL Development Fund' under an Act of Parliament which empowers the LDA to hold funds in reserve for future investment in the CTL precinct. Win Ministerial support for this strategy through the 'Masterplan Business Case', demonstrating the areas of critical Government investment required in order to optimise value creation. Emphasise Government's critical role in value creation and facilitating appropriate development which realises the Masterplan vision.

Risk Assessment

Top 15 Implementation Risks & Mitigation:

<p>Disruption to existing infrastructure, including utility services, transport and road infrastructure, as a consequence of construction activities. Impact on Territory productivity and economy. Results in conflict with stakeholders and undesirable political consequences.</p> <p>11.0</p>	<p>Prepare comprehensive 'Business and Operational Continuity Plan' for the Masterplan and for each individual project. Establish Government capability and capacity to assess and manage quality of 'Business and Operational Continuity Plans' to ensure that appropriate planning and strategies are employed to minimise impacts. Business and Operational Continuity Plans will need to incorporate need for temporary infrastructure.</p>
<p>EPBC referrals and EES required, resulting in time delays and costs to meet conditions of approval.</p> <p>12.0</p>	<p>Conduct early assessment of possible permit triggers and prepare detailed Approvals and Compliance Strategy for the Masterplan. Liaise with Environmental Authorities to determine the need for referral, and if required, to agree approvals process and timelines. Incorporate Approvals and Compliance pathway in Masterplan Implementation Program. Initiate required environmental studies as early as possible.</p>
<p>Possible lack of confidence in private investment sector about Government commitment to deliver Masterplan</p> <p>13.0</p>	<p>Prepare strategic Communications Plan specifically focused on briefing potential investors on the opportunity and focused on a consultation strategy with the private sector on the Masterplan Implementation Plan. Demonstrate a commitment by Government to engage and consult with the private sector. Identify and establish the items that signal to the market that Government is committed - eg Establishment of: Statutory Authority for seeking and assessing Development Proposals, Urban Design Principles and Guidelines, funding of enabling infrastructure, public release of Masterplan etc.</p>
<p>Political prioritising dictates timing of sales and or development of land which results in suboptimal timing of benefits, with no long term view of masterplan. Benefits delayed.</p> <p>14.0</p>	<p>Win Ministerial support for Masterplan Staging Strategy through presentation of the 'Masterplan Business Case', demonstrating the benefits and value created through controlling release of land, through controlling land use planning and through early investment in critical enabling works. Emphasise Government's critical role in value creation and facilitating appropriate development which realises the Masterplan vision. Explain the consequences of inappropriate staging or sequencing.</p>
<p>Lack of flexibility in methods of selling land, financing and deal structuring results in loss of control and certainty for future planning of the masterplan to deliver the best overall project solution</p> <p>15.0</p>	<p>Ensure that LDA has delegated powers (through Act of Parliament if necessary) to determine timing of land release and to negotiate with private sector on development and funding agreements. Ensure that 'Masterplan Business Case' incorporates a funding strategy that recognises the need to structure deals with the private sector which optimise value creation for the Territory and maximise private sector funding contributions. Funding Strategy requires sufficient flexibility to allow negotiation with the private sector. Establish central agency (including Treasury) review and approval process for Development Agreements.</p>

Re-engineering Parkes Way and Civic's Southern Road Network

Volume 6 - Project Cost Estimate

Project Number: 3002385

Contract Number: 2014.23470.110

Prepared for the ACT Economic Development Directorate

10 December 2014



DOCUMENT CONTROL

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APPENDIX A COST ESTIMATION SPREADSHEETS – FEASIBILITY DESIGN

APPENDIX B COST ESTIMATION SPREADSHEETS – VARIANT 2C DESIGN

DISCLAIMER

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1. INTRODUCTION

In 2013 the ACT Government procured an Urban Design Study for the Linking City Centre to the Lake strategy. This study developed a master plan that consisted of numerous design elements including the requirement to undertake significant civil infrastructure works to re-form the street and arterial road grid from City Hill to the West Basin foreshore.

As a major design and cost element of the urban strategy, the Economic Development Directorate (EDD) identified the need to investigate and identify key project risks concerning the major civil infrastructure works associated with the lowering of Parkes Way and adjustment to other major roads within Civic.

This study aims to develop a strategy to mitigate these risks by developing a feasibility design, undertaking constructability and cost assessment, considering the procurement options in the context of the current construction market, and investigating the implications of the project on the local transport network.

This report forms Volume 6 of 6 of the Feasibility Study for the Re-engineering Parkes Way and Civic's Southern Road Network:

- Volume 1 – Feasibility Design
- Volume 2 – Constructability Assessment
- Volume 3 – Transport Assessment
- Volume 4 – Procurement Strategies
- Volume 5 – Project Risk
- **Volume 6 – Project Cost Estimate**

The cost estimate has been undertaken primarily by Tier 1 contractor John Holland. The findings of the estimate are based on experience gleaned on numerous similar major civil construction projects throughout the country. The estimate is based on the construction methodology and staging proposed in Volume 2 of the Feasibility Study.