Economic Development Queensland

Greater Flagstone
Priority Development Area
Infrastructure Plan Background Report

Effective July 2022

Queensland Government

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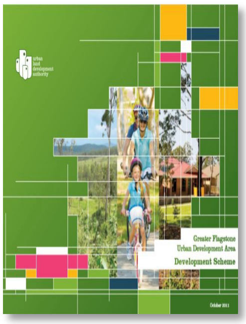
1 Background

1.1 Greater Flagstone Priority Development Area

The Greater Flagstone Priority Development Area (PDA) was declared on 8 October 2010 under the *Urban Land Development Act 2007* (since repealed and replaced with the *Economic Development Act 2012*). Covering 7,188 hectares, the Greater Flagstone PDA is within the Logan City Council area and is located west of the Jimboomba and Mount Lindsay Highway, along the Brisbane-Sydney rail line.

1.2 Key infrastructure planning regulations and documents

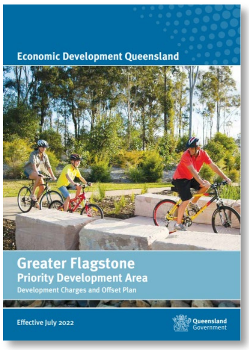
The following summarises key infrastructure planning documents specific to the Greater Flagstone PDA. Further information on these documents can be found at www.dsdmip.qld.gov.au.



Development Scheme

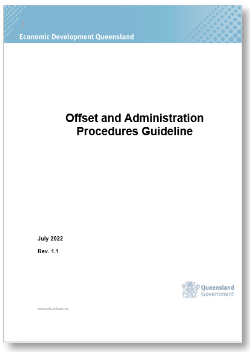
The Greater Flagstone PDA Development Scheme (the Development Scheme) commenced on 8 October 2011 and provides the regulatory framework for planning, implementing, coordinating and controlling land development within the PDA.

The Scheme provides the vision, a land use plan, an infrastructure plan and an implementation strategy for the Greater Flagstone PDA.



Development Charges and Offset Plan

A Development Charges and Offset Plan (DCOP) identifies the infrastructure contributions, how these charges are calculated, levied, and administered, and the trunk infrastructure required to service the PDA.



Offset and Administration Procedures

To be included once complete

1.3 Purpose of Infrastructure Planning Background Report

The purpose of the Infrastructure Planning Background Report (IPBR) is to provide background information that has informed inputs and assumptions into the Greater Flagstone Development Charges and Offsets Plan (DCOP). The report will assist users of the infrastructure plan within the DCOP to understand how infrastructure planning has been undertaken and how development charges were determined. The IPBR includes further detail on:

- Growth projections
- Infrastructure demand projections
- Desired standards of service
- Infrastructure planning
- Infrastructure costs
- Financial inputs and charge calculation

2 Growth projections

2.1 Introduction

Growth projections for the years 2016 – 2066 have been prepared by SGS Economics & Planning for the PDA and include analysis of the future residential growth, summarised below. Full analysis on growth projections is provided in Appendix E.

2.2 Growth projection years

The Greater Flagstone PDA growth projection years are:

- 2020 – the base year
- 2026 – projection year
- 2031 – projection year
- 2041 – projection year
- 2066 – ultimate development.

2.3 Potential development capacity

The ultimate potential development capacity for the Greater Flagstone PDA is based on an ultimate persons per household rate of 2.7 in 2066. This has been determined by the dwelling mix based on Logan City Council's forecasts of attached and detailed dwellings. The persons per household rate have been forecast to decline from higher rates in 2016. Further information on the approach to determining the persons per household rate is provided in Appendix E.

2.4 Development constraints

Development constraints across the Greater Flagstone PDA were considered in the Development Scheme taking into consideration known development constraints and current approvals which may limit the potential yield of land.

Consideration was given to strategic plans to identify possible development constraints.

2.5 Growth rates

The rate and location of growth for residential development was determined based on recent dwelling approvals, developer feedback data (where provided), assumptions on the timing of development and further refined in the *Demographic Analysis for Three Priority Development Areas* by SGS Economics and Planning, February 2020.

2.6 Growth projections summary

The Greater Flagstone PDA is forecast to experience notable growth in population, employment and residential dwellings from the base year (2020) to the ultimate development year (2066). Tables 2.6.1 and 2.6.2 identify the source information, and revised projections of population, employment, and dwellings for the area which have informed the DCOP planning assumptions.

Table 2.6.1 Growth projections for the Greater Flagstone PDA – Identified within SGS Demographic Analysis Report

	2020 DCOP Base Date	2026 Projection year	2031 Projection year	2041 Projection year	2066 Ultimate development
Population	3,990	20,312	35,741	70,548	145,099
Employment (jobs)	1,683	5,187	8,797	16,942	34,387
Average household (occupancy rate)	2.97	2.94	2.91	2.77	2.68
Residential dwellings	1,343	6,914	12,265	25,484	54,145

Following preparation of the SGS Demographic Analysis, planning processes identified that an additional 10 primary school sites, and 5 secondary school sites were necessary, requiring an additional 130 hectares of land. In order to appropriately reflect the ultimate capacity of the PDA, the following adjustments were made to the growth projections:

- Non-residential yield – *No change*. Additional school sites assumed to be required in residential areas;
- Residential yield – *Reduction* to ultimate residential dwelling yield of 2,600 dwellings to accommodate the 130 hectares required for additional school sites, at an assumed residential density of approximately 20 dwellings per hectare.
- This capacity reduction is not anticipated to impact the growth rate identified in the Demographic Analysis, and on this basis has been applied only to the 2066 ultimate development

Table 2.6.2 Growth projections for the Greater Flagstone PDA – Adopted for DCOP

	2020 DCOP Base Date	2026 Projection year	2031 Projection year	2041 Projection year	2066 Ultimate development
Population	3,990	20,312	35,741	70,548	138,131
Employment (jobs)	1,683	5,187	8,797	16,942	34,387
Average household (occupancy rate)	2.97	2.94	2.91	2.77	2.68
Residential dwellings	1,343	6,914	12,265	25,484	51,545

3 Demand projections

Demand projections have been informed by the Demographic Analysis for Three Priority Development Areas Report (SGS Demographic Study), with consideration given to the charge distribution in the current EDQ Infrastructure Funding Framework (IFF) between residential and non-residential uses.

3.1 Cost Apportionment Unit

In order to retain consistency in infrastructure charges applied under former charging frameworks, DCOP has established a Cost Apportionment Unit (CAU) as a basis for the equitable distribution of infrastructure cost across the varying residential and non-residential use types. A CAU represents the level of demand placed on the network by a single detached dwelling (using charge rates as the common measure) and has been determined on the following basis.

3.1.1 CAU Inputs

The CAU calculation utilises the following inputs:

- Dwelling projections prepared within the SGS Demographic Study
- Realistic gross floor area (GFA) targets for non-residential development categories as prescribed within the Development Scheme;
- Development Charges applicable under the IFF;
- EDQ reporting of charges collected to date and unused offsets currently held by developers

3.1.2 CAU Methodology

The timing of non-residential GFA growth has been proportionally assigned, consistent with the rate of residential growth within the SGS Demographic study;

Table 3.1.2.1 Non-residential GFA projections

Non-residential use	2020 DCOP Base Date	2026 Projection year	2031 Projection year	2041 Projection year	2066 Ultimate development
Retail	6,339	32,267	56,777	112,071	230,500
Commercial	2,984	15,189	26,726	52,753	108,500
Community[1]	3,055	15,552	27,366	54,018	111,100
Industry	23,100	117,588	206,909	408,414	840,000

The following proportional dwelling mix is applied to all dwelling growth.

[1] No CAUs for community uses have been calculated, as these uses are typically associated with public schools or other community-based services which do not normally attract an infrastructure charge.

Table 3.1.2.2 Residential dwelling mix

Residential dwelling type	Proportion
Small Dwelling	5%
Medium Dwelling	8%
Large Dwelling / Lot	87%

The most recent IFF charges are applied to all projected residential and non-residential development, to establish an estimated future revenue for each time period and at ultimate development. This assessment is separately calculated for residential and non-residential revenue for:

- Catalyst charge;
- Public Transport charge;
- Balance municipal charge (by individual network)
- State charge
- Implementation charge

For the parks and community facilities networks, the *residential* revenue for each year is divided by the charge rate for a single detached dwelling to determine CAU's for that year;

For all other networks and charge components, the *total* revenue for each year is divided by the charge rate for a single detached dwelling to determine the CAU's for that year.

A summary of the demand in CAU's for each network and charge component are identified in Table 3.1.2.3 below.

Table 3.1.2.3 Infrastructure Demands (CAU)

Charge Category	Network	2021	2026	2031	2036	2041	2066 Ultimate Development
Municipal Charge	Catalyst Charge	1,552	6,558	11,951	18,552	25,276	51,545
	PT Charge						
	Water Supply	1,693	7,356	13,443	20,716	28,277	57,458
	Sewerage	1,693	7,356	13,443	20,716	28,277	57,458
	Transport	1,693	7,356	13,443	20,716	28,277	57,458
	Public Parks	1,523	6,289	11,424	17,710	24,111	49,124
	Local Community Facilities	1,523	6,289	11,424	17,710	24,111	49,124
State Charge	State Community Facilities	1,533	6,380	11,602	17,994	24,504	49,941
Implementation Charge		1,523	6,289	11,424	17,710	24,111	49,124

4 Desired standard of service (DSS)

Below are the DSS adopted for each infrastructure network. The DSS referenced outlines the standards to which infrastructure should be planned, designed and delivered within the Greater Flagstone PDA.

4.1 Water Supply

The water supply network is as per the DSS contained in the Logan Water Infrastructure Alliance's Water Master Planning 2019 (Logan WIA Task PI-214) (referred to as the Logan Water WMP).

Table 4.1.1 identifies the key extracted DSS criteria from the Logan Water WMP, with further information provided in Appendix D.

Table 2.1.1 Extracted key criteria of water supply network desired standards of service adopted

Water Network Desired Standards of Service (DSS)				
Parameter	**Criteria**			
Water demand				
Average Day Demand (ADD)	On demand areas – 190 L/EP/d. Based on 165 L/EP/d residential consumption + allowance for leakage/losses (25 L/EP/d)			
Peaking factors	**Category**	**MDMM/AD**	**MD/AD**	**PH/AD**
Guidance Note: Peaking factors are to be applied to the residential component of demand, i.e. 165 and 120 L/EP/d. Leakage/loss levels will remain constant throughout all demand categories and should only be appended after any peaking escalation has occurred	Residential detached	1.3	1.7	3.1
	Residential attached	1.3	1.6	2.6
	Commercial	1.2	1.3	2.0
	Industry	1.2	1.3	1.7
	Parks/Open space	1.2	1.3	1.7
Bulk supply and reticulation	3 days of MDMM. Reservoirs to have a net positive inflow and capable of continuous operation and not fall below the emergency level. 3 days of MD. Reservoirs should not fall below the emergency level. 5 days of AD. Reservoirs should fill from empty to full.			
Pump supplying a ground level reservoir	MDMM over 20 hrs			
Minimum operating pressure at PH	On demand areas – 22 m at the property boundary based on reservoir at minimum operating level (MOL). MOL defined as 15% of storage height or top of emergency storage			

More information is provided in Appendix D of this report.

4.2 Sewerage

The sewerage supply network is as per the Logan Water WMP. Table 4.2.1 identifies the key criteria adopted, with further information provided Appendix D.

Table 4.2.1 Sewerage network desired standards of service adopted

Sewerage network desired standards of service (DSS)	
Average Dry Weather Flow (ADWF)	165 L/EP/day
Peak Wet Weather Flow	1000 L/EP/day

Maximum depth of flow	75% for planned pipes Up to 1m below MH surface level and no spillage through overflow structures for existing pipes
Pump station and rising main analysis	Maximum velocity: 3 m/s
Emergency Storage analysis	Minimum storage volume equivalent to 2 hours PDWF

4.3 Stormwater

Stormwater Quality and Quantity does not qualify as trunk works under the DCOP. Such works are required to be conditioned upon future development and should be consistent with the desired standards of service and overall strategy provided in Appendix D.

4.4 Transport

The DSS provided in Appendix D are adopted for the transport network and are summarised in Table 4.4.1 and Table 4.4.2.

Table 4.4.1: Greater Flagstone PDA DSS Road Requirements

PDA Guideline No. **06**		
PDA street network	**Number of lanes (both directions)**	**Daily traffic volume, vpd**
Urban Arterial	2 lanes	7,500 – 23,500*
	4 lanes	23,500 - 40,000*
Trunk Connector	2 lanes	7,500 - 18,000
	4 lanes	18,001 - 30,000

*In the absence of EDQ Policy standard industry practice has been applied, these values are estimates of the range for maximum vpd

Table 4.4.2 Trunk intersection DSS – Maximum degree of saturation

Intersection Type	**Maximum Degree of Saturation (DOS)**
Priority control	0.80
Roundabout	0.85
Traffic signals	0.90

For priority-controlled intersections, the Level of Service (LOS) should not exceed a maximum threshold of D for worst movement delays.

More information on the DSS adopted is provided in Appendix D.

4.5 Active transport

For active transport, the DSS adopts the Level of Traffic Stress (LTS) methodology.

The LTS methodology was developed by TMR and is a method for understanding the level of stress experienced by cyclists in different on-road and off-road environments. If the goal is for a transport network to facilitate and encourage cyclist trips for a high mode share, the transport infrastructure should not force cyclists into high stress environments. As such, LTS 1 or 2 is the desired standard of service for active transport infrastructure within trunk road corridors and for off-road pathways. Each type and its characteristics are outlined in Table 4.5.1.

Table 4.5.1 Level of Traffic Stress categories

LTS	Viability of cycling as a realistic mode choice	Proportion of people willing to cycle
LTS 1	Minimal traffic stress and requires less attention, making this suitable for all bicycle riders. This includes children trained to safely cross the road unsupervised (typically a 10-year old), or younger children under supervision of parents.	63% to 75%
LTS 2	A little traffic stress that requires more attention than young children can handle. It is suitable for most teen and adult bicycle riders with adequate bicycle handling skill.	
LTS 3	Moderate traffic stress that would require higher levels of cycling skill and confidence to interact with traffic using cycle lanes on roads with lower traffic speeds or volumes	12% to 28%
LTS 4	High level of traffic stress only suitable for very skilled bicycle riders with confidence to interact with traffic on busy roads with minimal or no on-road cycle facilities	5% to 7%

4.6 Parks and open space

The DSS adopted for parks and open space is generally aligned to the DSS specified in EDQ's Park Planning and Design PDA Guideline No. 12 (Guideline 12). However, the DSS was slightly adjusted to incorporate feedback received from stakeholders. It was also adjusted based on consideration of the quantity of parks and the area that would be required for the projected population in the Greater Flagstone PDA.

The DSS adopted for rates of provision, minimum area, and accessibility is detailed in Table 4.6.1

DSS relating to all other aspects of planning and design remain consistent with Guideline 12. This includes:

- Shape, frontage and location;
- Active recreation spaces
- Slopes, batters and retaining walls;
- Flood and stormwater management;
- Lakes and other permanent water bodies;
- Managing access;
- Shade cover;
- Embellishments;
- Engineering design and construction.

Table 4.6.1 Rates of provision, minimum area and accessibility requirements

Park Type	Rates of Provision		Minimum Area	Accessibility Requirements
	Land (ha/1,000 popn)	No. of parks per popn		
Local recreation park	0.0 – 0.2	NA	0.05 ha	NA
Neighbourhood recreation park (1)	0.5 – 1.1	1/1,000-1,500	0.5 ha	90% of dwellings within 400m of a neighbourhood recreation park or other park providing equivalent informal recreation opportunities
Local linear park (2), (3)	0.0 – 0.8	NA	NA	NA
District recreation park (4)	0.5 – 1.0	1/10,000-15,000	5 ha	90% of dwellings within 2.5km, must comply with location criteria in Guideline 12
Regional recreation park (5)	0.5 – 1.0	1/20,000+	10 ha	Must comply with location criteria in Guideline 12
Major linear park (3)	0.0 – 0.5	NA	NA	NA
District sports park	0.75 – 1.2	1/10,000-20,000	7.5 ha	90% of dwellings within 4km, must comply with location criteria in Guideline 12
Regional sports park	0.5 – 1.0	1/25,000+	15 ha	Must comply with location criteria in Guideline 12
Community land (6)	0.2	NA	NA	NA

Notes:

(1) Includes allowance for civic parks in neighbourhood centres.

(2) A local linear park is within or adjoining a predominantly residential neighbourhood.

(3) The actual rate of provision for linear parks may exceed the indicated maximum rate, particularly in areas with extensive waterway or other environmental corridors. The allocation in the table sets the parameters for determining the contribution of linear parks to offsetable park area.

(4) This is the base requirement of parks for neighbourhood or local area planning purposes (e.g. context plans) for areas that do not include a designated higher order recreation or sports park. Local parks must be provided within or adjacent to the neighbourhoods they serve and cannot be offset by contributions elsewhere within the PDA.

(5) Includes allowance for civic parks in district centres.

(6) Refer to PDA Guideline 11: Community Facilities for more information

More information on the DSS criteria can be found in Appendix D.

4.7 Community facilities

The DSS for community facilities adopted was a combination of the DSS specified in EDQ's Community Facilities PDA Guideline No. 11 (Guideline 11) and Logan City Council's DSS within the LGIP.

Community facilities are split between facilities provided from the State facilities and provided from the local government. The DSS adopted for both State provided facilities and local government facilities are detailed in Table 4.7.1 and Table 4.7.2 below.

Table 4.7.1 DSS for State provided facilities

Facilities	Hierarchy of Provision	No. of Facilities (pop. Triggers)	Indicative site/ facility area
Ambulance	District – depends on a range of factors including current and projected population, planned future development, hazard and risk assessment, road network, incident profile for area.	1:25,000 Consider response time profile, case load per day, proximity to existing ambulance stations and health services.	Site: 3,000 m^2
Fire & Rescue	Depends on response time and incident history, proximity to existing facilities and population forecasts.	Over 25,000 people	• Site: 3,000-4,000 m^2 (auxiliary station) • 3,000-6,000 m^2 (permanent station) • 10,000-20,000 sqm (permanent with specialist facilities)
Health Care Centre	Community Health Centre	1:20,000 – 30,000	GFA: 2,000 – 4,000 m^2 Site: up to 1.6 ha
	Community Care Hub	1:30,000 – 100,000	GFA: 4,000 – 8,000 m^2 Site: 1.6 – 3.2 ha
	Community Care Precinct	1:100,000 – 300,000	GFA: 8,000 – 10,000 m^2 Site: 3.2 – 4 ha (including parking)
Hospital – Public	Based on local planning and need analysis	Likely to serve a catchment of over 100,000 people	10-15 ha depending on level of service
Police	Main road location preferred by ingress and egress must offer left & right turns Security important Best location in town centre/shopping centre	1:20,000 – 30,000	Police Station Site: 4,000-5,000 m^2 GFA varies according to local needs – shopfronts, rented space, stations
Primary School - State		1:3,000 dwellings	6.5 ha -7 ha GFA: 5,500 m^2 for 700-900 P-7 students[2]
Secondary School - State		1:8,000 dwellings	12 ha GFA: 16,870 m^2 for 1,500-1,800 students

[2] As per the Department of Education New School Site Selection Guideline or as otherwise specified in the latest version of this guideline.

Table 4.7.2 Local government provided facilities

Community Infrastructure Type	Hierarchy	Rate of Provision (Facility: Population)	Accessibility (km)	Minimum Land Area / GFA
Community / Civic Facilities				
General Community Space (provided in greenfield areas only)	Local	1:10,000	2	1,000 m^2 / 400 m^2
Community Centre	District	1:50,000	5	3,000 m^2 / 900 m^2
Convention/Exhibition Centre	Metro	1:250,000 (1 city-wide)	LGA (15)	40,000 m^2 / 15,000 m^2
Arts and Cultural Facilities				
Library	District	1:40,000	5	3,000 m^2 / 1,500 m^2
	Metro	1:100,000	LGA (15)	7,500 m^2 / 4,000 m^2
Art Gallery or Dedicated Art Space	District	1:50,000	5 km	2,000 m^2 / 600 m^2
	Metro	1:250,000	LGA (15)	4,000 m^2 / 1,200 m^2
Performing arts facility or space	District	1:50,000	5-7	3,000 m^2 / 1,000 m^2
	Metro	1:250,000 (1 city wide)	LGA (15)	40,000 m^2 / 15,000 m^2
Sport and Recreation Facilities				
Indoor Sports Facility	District	1:50,000	5	10,000 m^2 / 5,000 m^2
	Major District	1:150,000	15	15,000 m^2 / 7,500 m^2
Aquatic Centre	District	1:50,000	5	10,000 m^2 land
	Major District	1:150,000	15	15,000 m^2 land
Leisure Centre (combined indoor sports facility and aquatic centre)	District	1:50,000	5	15,000 m^2 land
	Major District	1:150,000	15	25,000 m^2 land

More information on the DSS criteria can be found in Appendix D.

5 Infrastructure planning

5.1 Planning horizon

The infrastructure plans for the Greater Flagstone PDA have been prepared to reflect the ultimate development outcome (nominally 2066). This is based on the ultimate dwelling yield, informed by the total number of potential dwellings in the PDA at full build out.

5.2 Water Supply

The SEQ Water Supply and Sewerage Code, EDQ standard of service, as well as the Water Supply Code of Australia (WSA 03-2011) are the basis of hydraulic modelling and network planning outlined in this report and were followed throughout the design process.

The network DSS were used for assessing existing network deficiencies and for sizing new infrastructure.

Land acquisition requirements have been identified on the following basis:

- 500m² land requirement per pump station site;
- 5,000m² land requirement per reservoir site.

The timing of infrastructure is based on the growth of the population in the Greater Flagstone PDA. Population projections have been broken down into 183 transport zones[3]. When the population in these zones reach 50 EP, servicing infrastructure is required which determines the timing.

The proposed trunk water supply infrastructure plan (ultimate) is provided in the DCOP mapping. Further information regarding infrastructure staging and non-trunk network outcomes are contained in Appendix D.

5.3 Sewerage

The SEQ Water Supply and Sewerage Code (SEQ WS&S D&C Code), EDQ standard of service and the Sewer Supply Code of Australia (WSA 03-2011) formed the basis of the hydraulic modelling and network planning and were followed throughout the design process.

Land acquisition requirements have been identified on the following basis:

- 500m² land requirement per pump station site;

The timing of infrastructure is based on the growth of the population in the Greater Flagstone PDA. When the population in the transport zones reach 50 EP, servicing infrastructure is required which determines the timing.

The proposed trunk sewerage supply infrastructure plan (ultimate) is provided in the DCOP mapping. Further information regarding infrastructure staging and non-trunk network outcomes are contained in Appendix D.

[3] The SGS Demographic projections (provided in Appendix E) break down the population and employment projections for the Greater Flagstone PDA into 183 VLC travel zones.

5.4 Transport

The timing of infrastructure is based on the growth of the population in the Greater Flagstone PDA. Population projections have been broken down into 183 transport zones. When the population in these zones reaches 50, servicing infrastructure is required, determining the timing of the infrastructure. The proposed trunk transport infrastructure plan (ultimate) is provided in the DCOP mapping. Further information regarding infrastructure staging and non-trunk network outcomes are contained in Appendix D.

5.4.1 Cross-sections

When considering the mid-block cross section requirements of the PDA, alignment with Guideline No. 6 Movement Network was maintained where possible.

However, to minimise corridor impacts on adjacent land parcels and to provide efficient staging of roads that ultimately go to four lanes, a variation was made. This adjustment was made to the requirements of the four-lane trunk connector and urban arterial. Specifically, to accommodate a two-way 3m separated cycle track on one side in the interim, the clearance abutting the kerb used for tree planting and stormwater pits, was reduced from 2m to 1.5m. This allowed the ultimate corridor width to remain the same, even with the addition of 1.0m to one of the one-way cycle tracks. The proposed typical cross sections are shown in below figures. A detailed schedule of cross-sections, including non-standard cross sections, is provided in Appendix B.

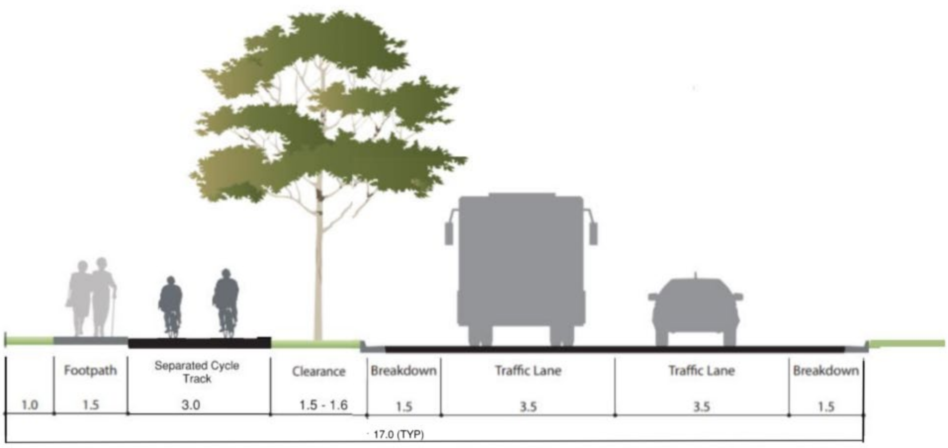


Figure 5-1 Interim four-lane urban arterial (two-lane no parking)

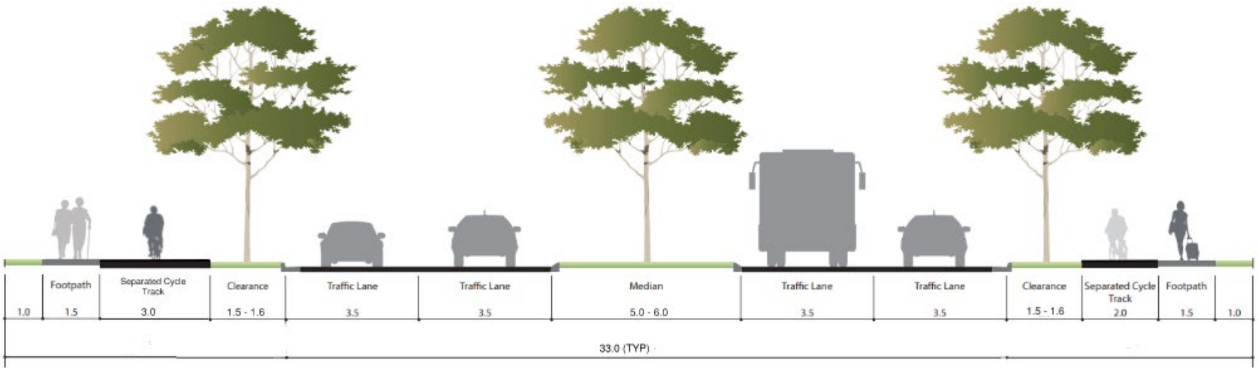


Figure 5-2 Ultimate four-lane urban arterial (no parking)

Figure 5-3 Ultimate two-lane trunk connector (no parking)

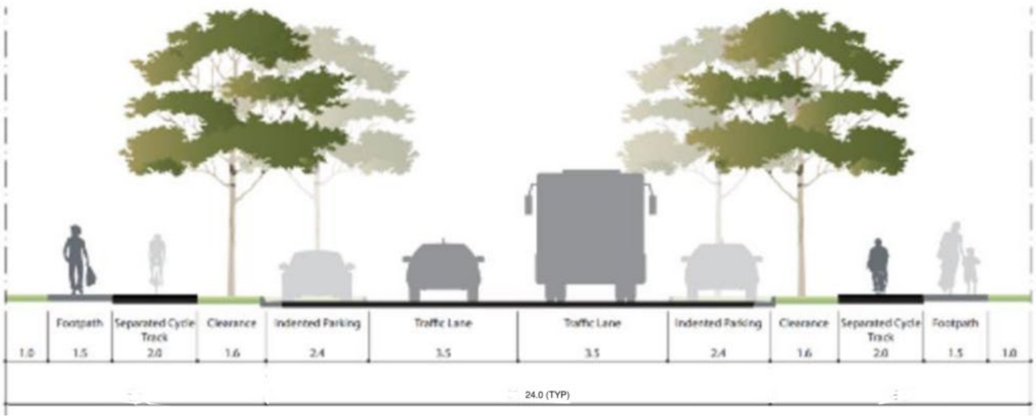


Figure 5-4 Ultimate two-lane trunk connector (with parking)

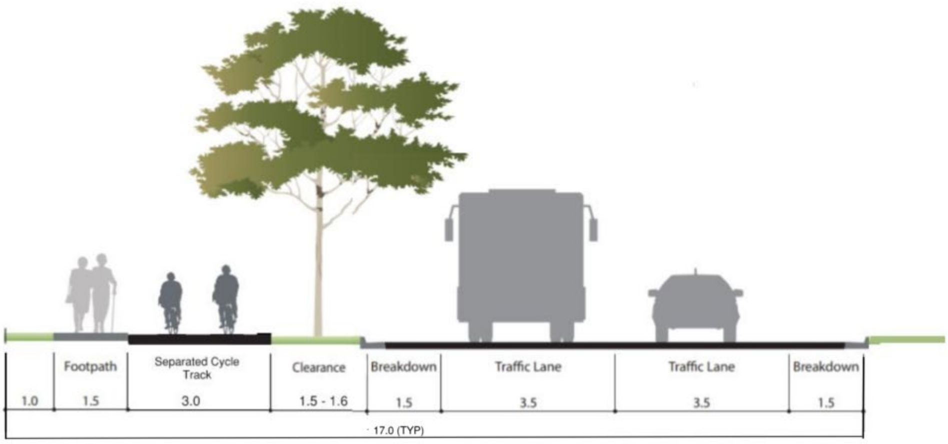


Figure 5-5 Interim four-lane trunk connector (two-lane no parking)

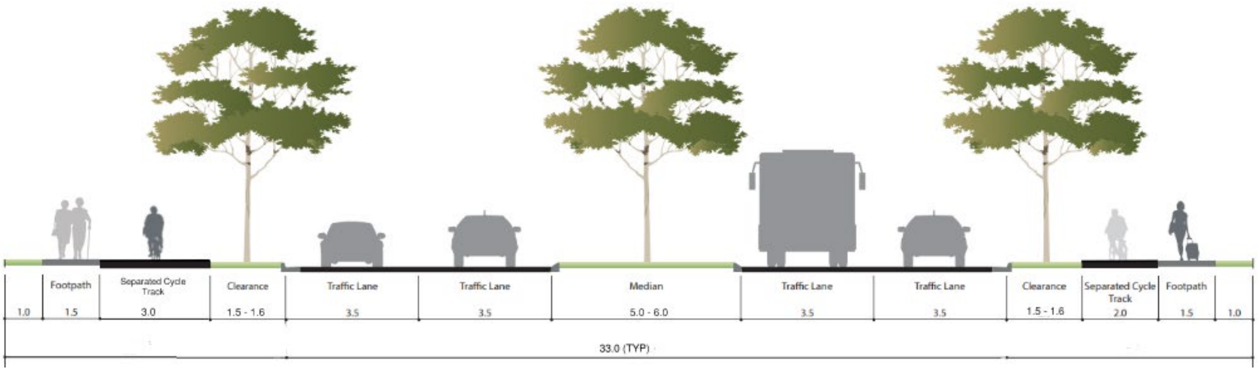


Figure 5-6 Ultimate four-lane trunk connector (no parking)

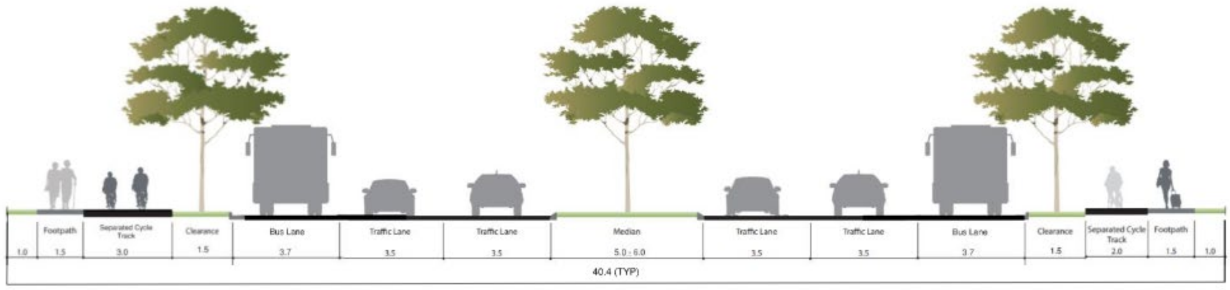


Figure 5-7: Ultimate four-lane trunk connector (with bus lanes)

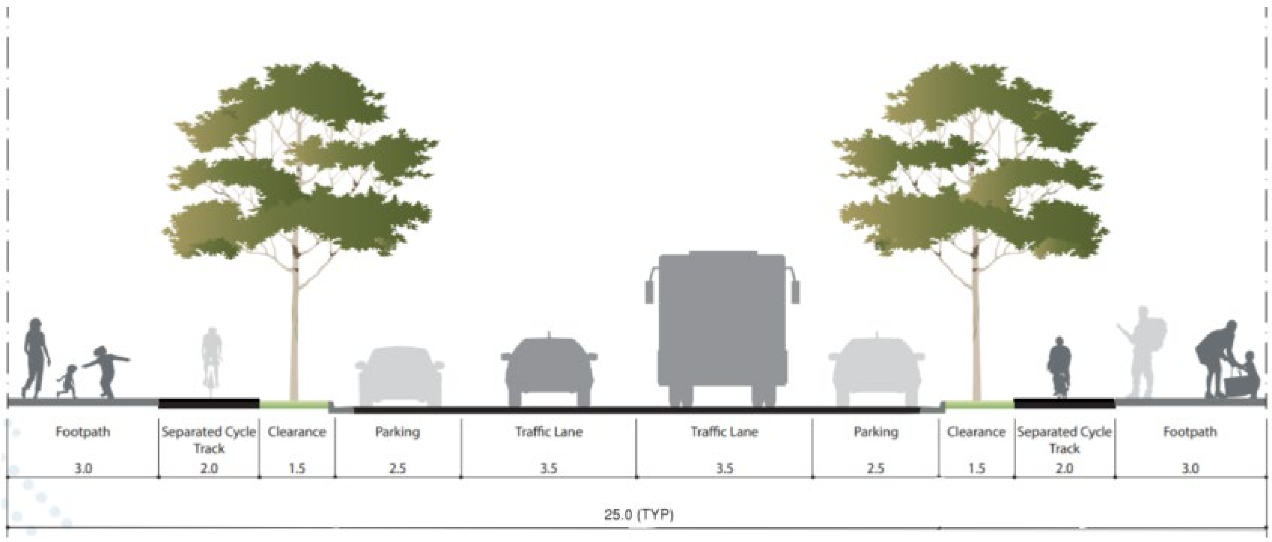


Figure 5-8 Ultimate two-lane centre connector (with parking)

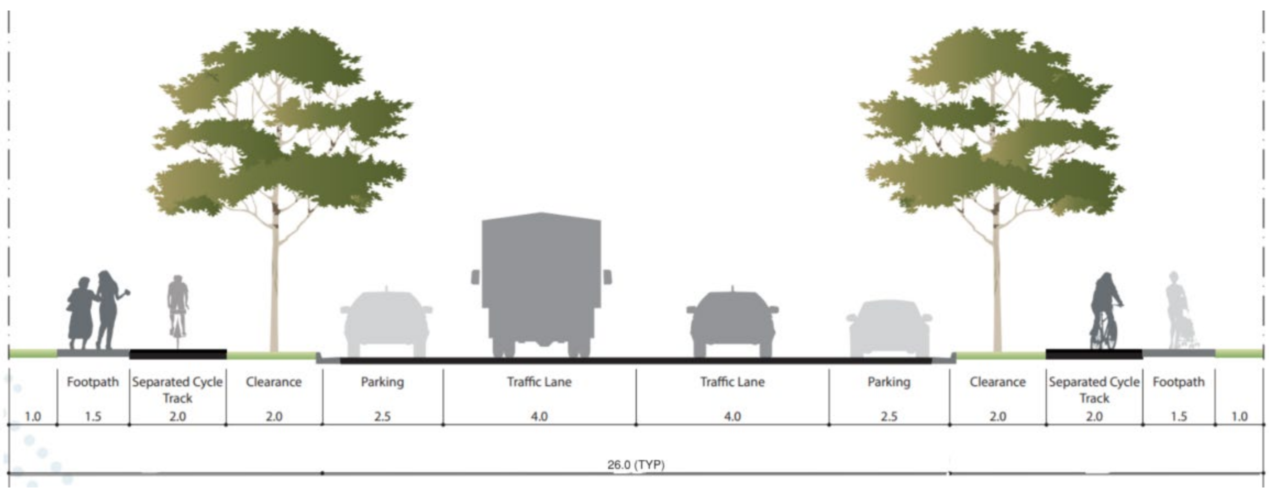


Figure 5-9 Ultimate 2 Lane Centre Connector (with parking)

5.4.2 Intersections

A summary of the different staging for the intersections is provided in Table 5.5.2.1. To minimise the cost of upgrades a maximum of three intersection upgrades has been allowed for at each intersection.

Table 3Trunk intersection requirements and staging

Asset ID	Design cohort	Control	Intersection legs	Major flow through lanes	Bus provisions
RI001	2026 - 2031	Priority	3	2	No
	2031 - 2041	Signalised	4	2	No
	2041 - 2066	Signalised	4	4	No
RI002	2031 - 2041	Signalised	4	2	No
	2041 - 2066	Signalised	4	4+2T2	Yes
RI003	2031 - 2041	Signalised	3	2	No
	2041 - 2066	Signalised	3	4	No
RI004	2031 - 2041	Priority	3	2	No
	2041 - 2066	Signalised	3	4+2T2	Yes
RI005	2026 - 2031	Priority	3	2	No
	2031 - 2041	Signalised	4	2	No
	2041 - 2066	Signalised	4	2	No
RI006	2031 - 2041	Signalised	3	2	No
	2041 - 2066	Signalised	3	4+2T2	Yes
RI007	2031 - 2041	Signalised	3	2	No
	2041 - 2066	Signalised	3	4	No
RI008	2031 - 2041	Signalised	4	2	No
	2041 - 2066	Signalised	4	4	No
RI009	2026 - 2031	Priority	3	2	No
	2031 - 2041	Signalised	3	2	No
	2041 - 2066	Signalised	4	4	No
RI010	2026 - 2031	Signalised	4	2	No
	2031 - 2041	Signalised	4	2	No
	2041 - 2066	Signalised	4	4	No
RI011	2031 - 2041	Signalised	3	2	No
	2041 - 2066	Signalised	4	4	No
RI012	2041 - 2066	Signalised	3	2	No
RI013	2031 - 2041	Signalised	4	4	No
	2041 - 2066	Signalised	4	4	No
RI014	2041 - 2066	Signalised	4	4	No
RI015	2026 - 2031	Priority	3	2	No
	2031 - 2041	Signalised	3	4	No
	2041 - 2066	Signalised	3	4	No
RI016	2031 - 2041	Priority	3	2	No
	2041 - 2066	Roundabout	3	2	No
RI017	2041 - 2066	Signalised	3	4	No
RI018	2026 - 2031	Priority	4	2	No
	2031 - 2041	Signalised	4	2	No
	2041 - 2066	Signalised	4	2	No
RI019	2026 - 2031	Priority	3	2	No
	2031 - 2041	Signalised	3	2	No
	2041 - 2066	Signalised	3	4+2T2	Yes
RI021	2026 - 2031	Priority	4	2	No

Asset ID	Design cohort	Control	Intersection legs	Major flow through lanes	Bus provisions
	2031 - 2041	Signalised	4	2	No
	2041 - 2066	Signalised	4	4	No
RI022	2031 - 2041	Signalised	3	2	No
	2041 - 2066	Signalised	3	4	No
RI023	2026 - 2031	Priority	3	2	No
	2031 - 2041	Signalised	3	2	No
	2041 - 2066	Signalised	3	2	No
RI025	2041 - 2066	Signalised	4	4	No
RI026	2041 - 2066	Signalised	3	2	No
RI027	2031 - 2041	Priority	3	2	No
	2041 - 2066	Signalised	3	4	No
RI028	2026 - 2031	Signalised	4	2	No
	2031 - 2041	Signalised	4	2	No
	2041 - 2066	Signalised	4	4+2T2	Yes
RI029	2026 - 2031	Priority	3	2	No
	2041 - 2066	Signalised	3	4+2T2	Yes
RI030	2021 - 2026	Signalised	4	2	No

Should development occur out of sequence from what has been modelled (using the latest demographics), this may result in a change in intersection treatment and upgrade horizon.

The proposed trunk transport infrastructure plans (ultimate) are provided in the DCOP mapping. Further information regarding infrastructure staging and non-trunk network outcomes are contained in Appendix D.

5.4.3 Land acquisition

The land acquisition requirements for trunk road infrastructure are derived from the intersection of the natural surface with the embankment slopes in the carriageway, less any existing road corridor areas.

5.5 Active transport

The timing of the active transport network is underpinned by the growth of population, which in turn drives the timing of transport infrastructure.

With the majority of the trunk road network proposed to have cycle tracks on both sides of the road, the following methodology has been applied for when there will be an interim stage before the ultimate road is constructed (typical scenario is a two-lane road that is upgraded to four-lane road). Indicative cross-sections of the staged infrastructure delivery have been provided in Section 5.6.1 below.

The staging of the active transport infrastructure is largely to correspond with the road network. The active transport network planning was undertaken to identify where future infrastructure should go as part of the expansion of the area (i.e. new developments and road upgrades), and did not assess potential deficiencies throughout existing development.

5.5.1 Staged cycle infrastructure cross-sections

Interim Cycle Infrastructure

Road side 1	Road side 2
• 1.5m footpath (minimum) • 3m two-way cycle track on single side of road • 1.5m vegetation clearance	• No infrastructure

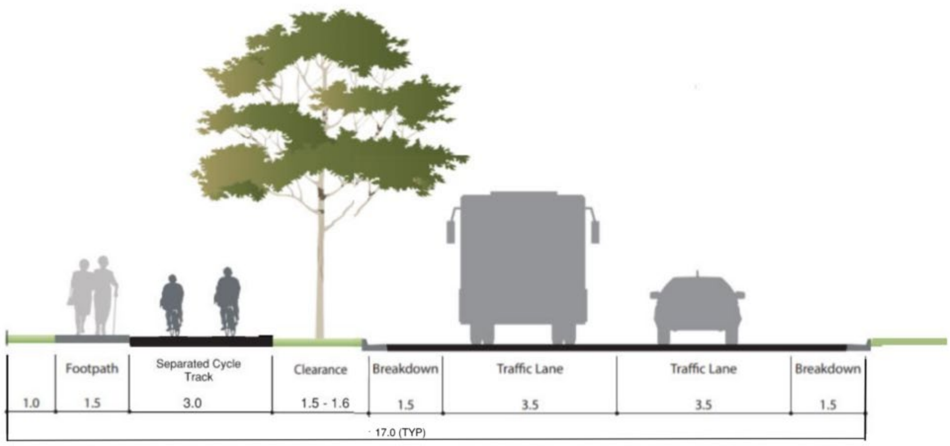


Figure 5-10 Interim staging of active transport infrastructure

Ultimate Cycle Infrastructure

Road side 1:	Road side 2
• Interim infrastructure remains • Convert 3m two-way cycle track to 3m one-way cycle track.	• 1.5m footpath (minimum) • 2m one-way cycle track • 1.5m vegetation clearance

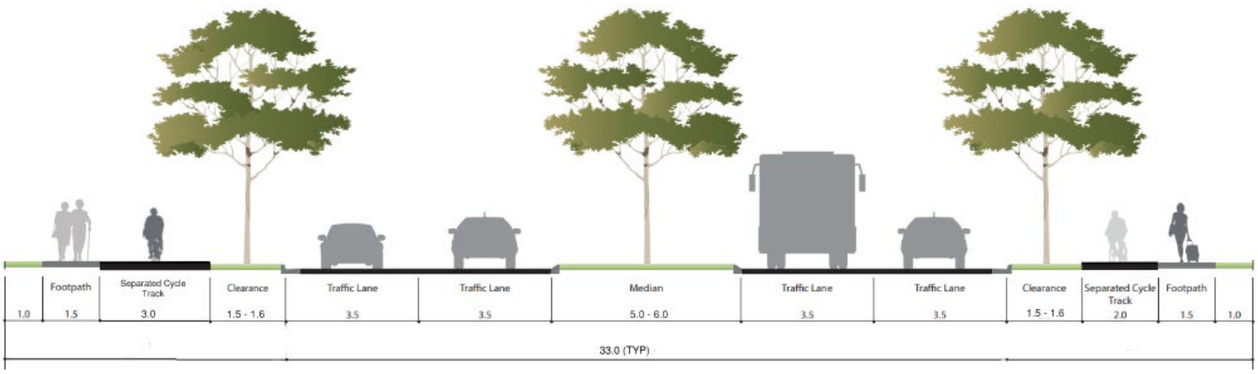


Figure 5-11 Ultimate staging of active transport infrastructure

Interim Cycle Infrastructure – North South arterial road

Road side 1:	Road side 2
• Two-way cycle track	• No infrastructure

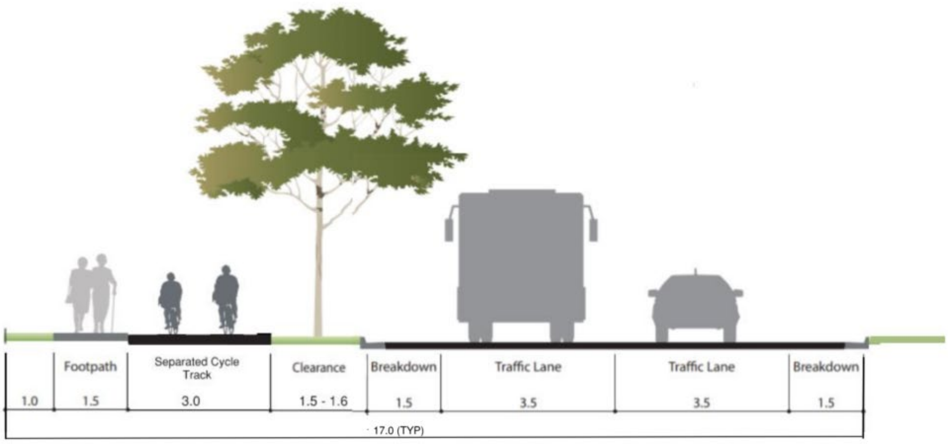


Figure 5-12 Interim staging of active transport infrastructure for North South arterial road

Ultimate Cycle Infrastructure – North South arterial road

Road side 1:	Road side 2
• Two-way cycle track	• Two-way cycle track

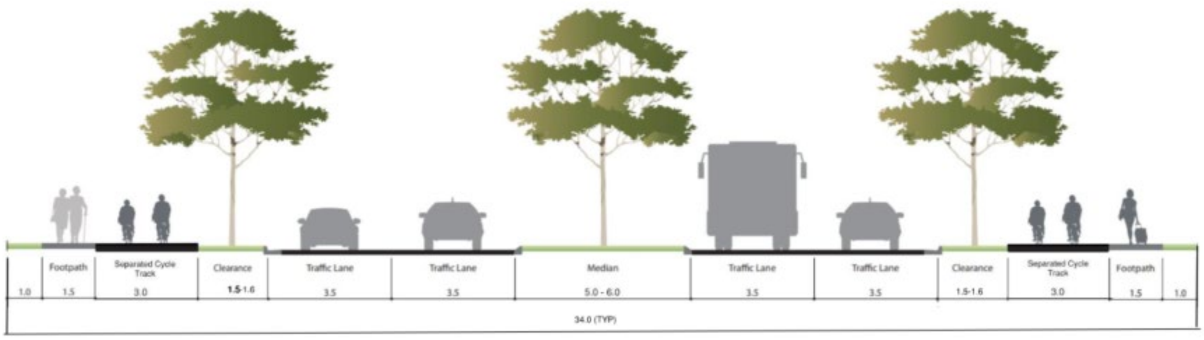


Figure 5-13 Ultimate staging of active transport infrastructure for North South arterial

For shared paths, it is recommended that the interim cycle infrastructure (i.e. road side 1) is built on the side of the road that will form part of the ultimate road cross-section.

While the guideline does indicate a 2m minimum clearance to traffic lanes for higher order roads, a 1.5m clearance was adopted for the above scenarios where cycle tracks are staged. To support this, reference has been made to the Selection and Design of Cycle Tracks Guideline (TMR, October 2019) and the clearance requirements from static objects.

5.6 Parks and open space

The parks and open space infrastructure requirements have been determined based on the projected population growth, with reference to the DCOP DSS. Indicative sequencing of open space has been determined having regard to:

- Population projections and the timing of when population benchmarks are likely to be reached
- A balanced delivery of park typologies and uses in line with the DSS
  - This ratio of delivery is often organically achieved and controlled through the context planning approval process and the construction delivery phasing determined through conditional development approvals
- The projected areas of population density and establishing what catchments within the open space network will be most utilised.
- The surrounding road network, acknowledging that access to the site will need to be provided before parks can be operational. Additionally, areas with topography restrictions and access constraints may trigger earlier, indirect park location sequencing.

Key environmental corridors have been identified along existing watercourses and tributaries within the PDA. These are inclusive of:

- Biodiversity areas;
- Revegetation areas;
  - Minor (local) corridors up to 35m width (17.5m each side of waterway);
  - Major corridors up to 70m width (35m each side of waterway).
- Linear park areas
  - Minor (local) linear parks up to 15m width (7.5m each side of waterway);
  - Major linear parks up to 30m width (15m each side of waterway).

Figure 5-14 shows an environmental corridor cross section.

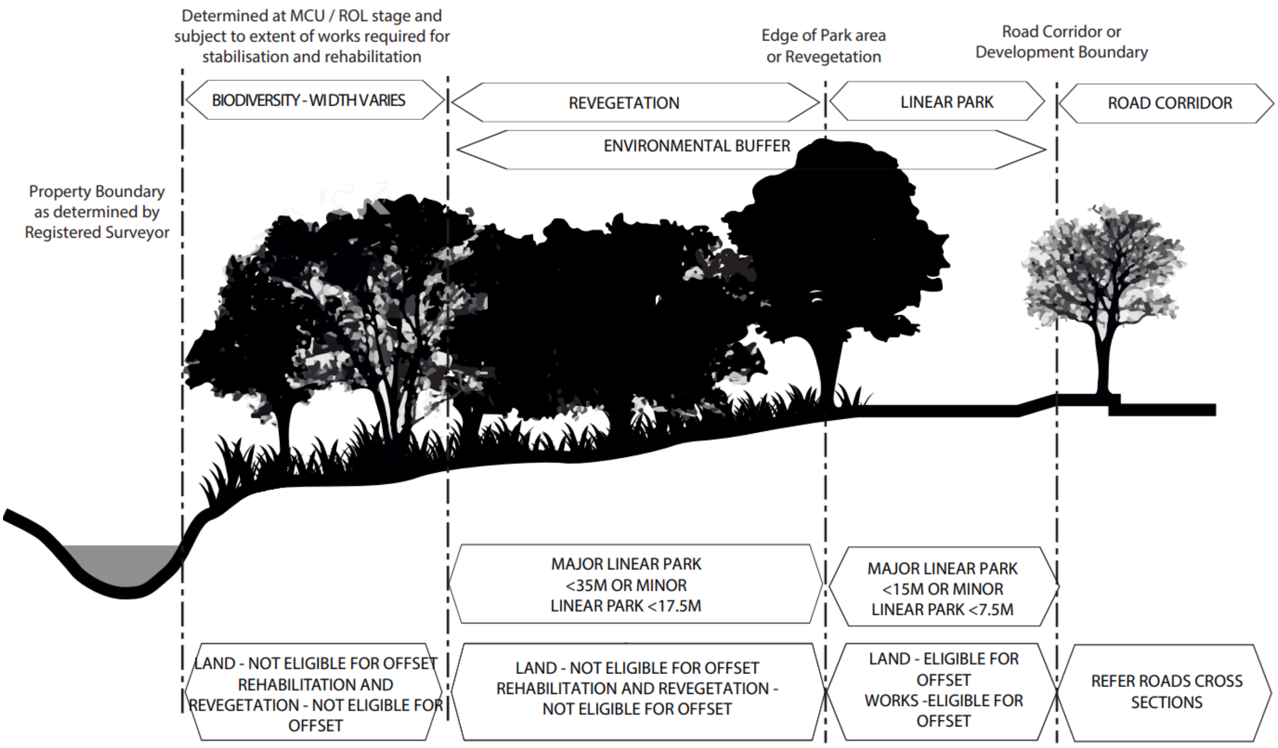


Figure 5-14 Environmental corridor cross section

5.7 Community facilities

The community facilities infrastructure requirements have been determined based on the projected population growth, with reference to the DCOP DSS. Indicative sequencing of community facilities has been determined having regard to:

- Population projections and the timing of when population benchmarks are likely to be reached
- Input from relevant state agencies
- The projected areas of population density and establishing what catchments within the community facilities network will be most utilised.
- The surrounding road network, acknowledging that access to the site will need to be provided before facilities can be operational. Additionally, areas with topography restrictions and access constraints may trigger earlier, indirect location sequencing.

5.8 Innovation

Innovation analysis was also undertaken as part of the strategic trunk infrastructure review of existing Infrastructure Charging Offset Plans for the Greater Flagstone PDA. Provided in Appendix D are infrastructure innovations that can be applied and aspired to over the developable life of the PDA.

6 Infrastructure valuation methodology

As the Greater Flagstone DCOP is a live document currently under implementation, it is necessary to account for existing, partially complete and future DCOP Items. These different cost methodologies are schematically depicted in Figure 6-1, with detailed descriptions for each approach outlined in the next sections.

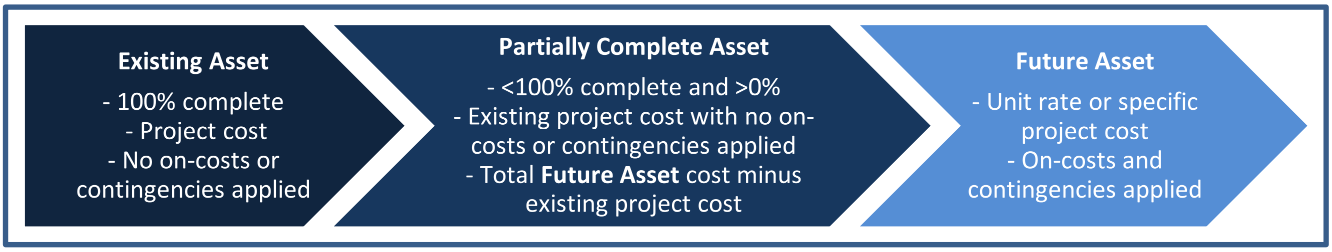


Figure 6-1 Method to determine asset costs

6.1 Existing Assets

Offsets that have been approved by EDQ were identified for any DCOP items that have been provided across the DCOP networks. For DCOP items completed in their entirety, the offset value has been assigned as a "project cost" against that asset, with no on-costs or contingencies applied as the approved offset amount is considered to be inclusive of such costs.

6.2 Future Assets

For DCOP items only partially completed, an approved offset value for the works completed has been identified, and this value has been:

- Included as an existing infrastructure cost; and
- Subtracted from the total establishment cost of the future asset (calculated based on construction of the complete asset).

As with the existing assets above, no on-costs or contingencies are applied to the "project cost" for completed works, however they are applied to the future establishment costs for the asset (refer to Figure 1).

$$Remaining\ Future\ Asset\ Establishment\ Cost = Total\ Future\ Establishment\ Cost - Value\ of\ offsets\ provided\ to\ date$$

Future asset costs are calculated using either unit rates or specifically identified project costs and are subject to on-costs and contingencies.

All partially completed and future DCOP assets and their costs have been identified for each infrastructure network within the cost schedules for the presented in Section 4.1 of the DCOP.

As the charging framework and infrastructure policy has changed over time (from LIP to ICOP to DCOP), it is recognised that EDQ has committed to provide offsets for the provision of several infrastructure items that no longer meet the DCOP definition of trunk infrastructure. These items have been included as 'Prior Committed Offsets' and are included as a future expense to the DCOP within the DCOP cost schedules.

All costs included within the DCOP are presented as an Establishment Cost, which is reflective of the costs associated with building the asset for the 'first time', with consideration for any factors affecting construction costs such as terrain or ground conditions or construction method. Figure 6-2 below outlines the typical cost build-up approach which is presented within the Cost Schedules. Further detail regarding each of the relevant inputs, as well as any cost apportionment and financial considerations have been provided in the following sections of this extrinsic material report.

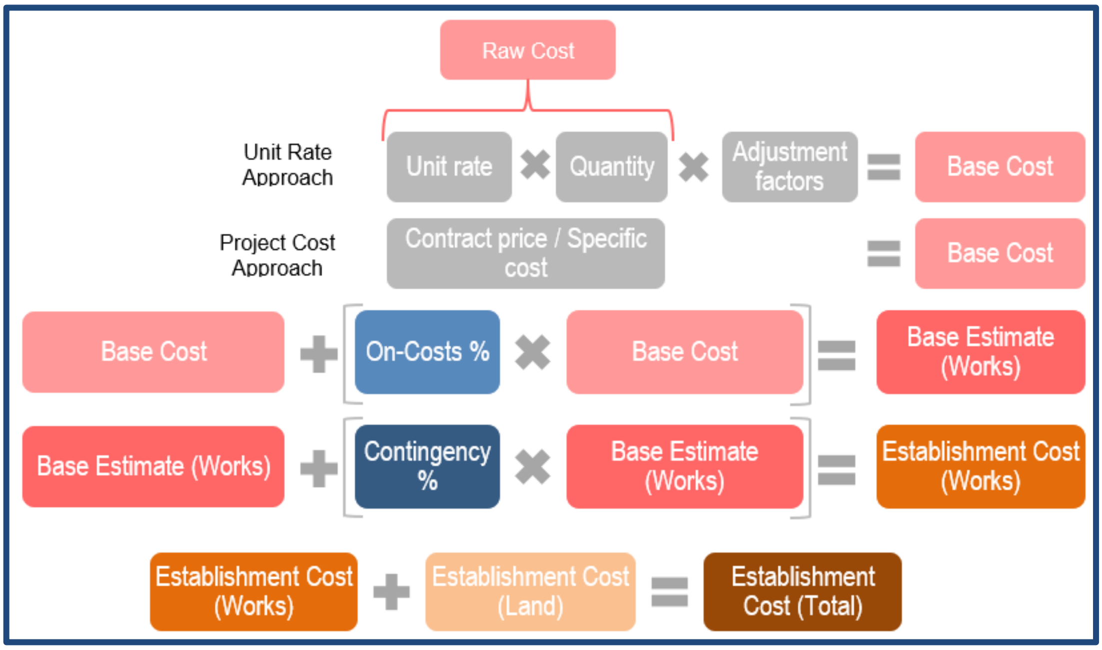


Figure 6-2 Establishment cost build-up

6.3 Determination of Establishment Costs (Works)

6.3.1 Base Costs

As depicted within Figure 2 above, the base costs for DCOP assets have been determined using either unit rates or specific project costs, having consideration for any adjustment factors necessary to reflect the construction method, location or site conditions.

Any works or land not specifically identified within the base cost inclusions outlined for each infrastructure network below are to not considered offsetable, unless otherwise determined at the discretion of the MEDQ.

6.3.2 Unit Rate Benchmarking

As part of the DCOP preparation, a unit rate benchmarking assessment was undertaken, based on feedback provided by developers and engineers currently operating within the Greater Flagstone PDA. This assessment included review and rationalisation of the responses provided, into a consistent format that could inform unit rates that are more reflective of the current construction costs within the local industry. Specifically, this included:

- For the water supply and sewer networks, identification of main construction cost, typical fittings, manholes, bridging structures, and the cost impacts of factors such as rocky soil, trench depth, micro-tunnelling and traffic management;

- For the transport network, identification of component costs, allowing specific costs to be estimated for each relevant cross-section type (including non-standard cross sections), in addition to typical costs associated with preliminaries, and the cost impacts of factors such as service relocations and traffic management;
- For open space and community facilities networks, identification of embellishment and site preparation component costs, allowing specific costs to be estimated for each relevant park hierarchy, and site preparation costs to be estimated for different community facility types.
- For all networks, identification of typical professional fees/on-costs associated with construction.

The feedback from the developer group was utilised in addition to previous ICOP unit rates and cost reporting prepared by RLB, to determine median infrastructure construction costs for the DCOP unit rates. Network specific costs and inclusions are outlined in more detail below.

6.3.3 Water Supply and Sewerage

Base works costs for all municipal water supply mains, sewer mains, and sewer manholes included within the DCOP have been based on unit rates, selected as the ***median*** rate from the following sources:

- ICOP unit rates, indexed to July 2021 using the ABS PPI (RBC) index;
- Developer unit rates, provided as part of the unit rate benchmarking assessment;
- RLB unit rates, as identified within Opinion of Cost assessment and detailed cost breakdowns.

These rates are outlined in Tables 6.3.3.1, 6.3.3.2 and 6.3.3.3 below and presented in July 2022 dollars.

Table 6.3.3.1 Water Supply Main Unit Rates

Water Supply	
Diameter	**Rate $/m**
225	$370.16
250	$395.87
300	$448.48
375	$730.04
450	$1,001.96
525	$1,094.57

<u>*Notes:*</u>
- *All costs are presented in July 2022 dollars*
- *Pipe diameters identify the minimum internal diameter*
- *Includes allowance for valves/fittings*

Table 6.3.3.2 Sewerage Main Unit Rates

Sewerage		
Diameter	**Asset Type**	**Rate $/m**
225	Gravity Main	$413.35
300	Gravity Main	$567.21
375	Gravity Main	$595.38
450	Gravity Main	$800.78
525	Gravity Main	$917.18
600	Gravity Main	$1,052.39

675	Gravity Main	$1,508.28
225	Rising Main	$334.17
250	Rising Main	$426.72

Note:
• *All costs are presented in July 2022 dollars*
• *Pipe diameters identify the minimum internal diameter*
• *Assumes average depth of 1.5m to 3.0m*

Table 6.3.3.3 Sewerage Manhole Allowance

Sewerage			Note
Diameter	**Asset Type**	**Rate $/m**	
1050	Sewer Manhole	$156.94	Applied to GM up to and including 600mm dia
1200	Sewer Manhole	$275.90	Applied to GM over 600mm dia

Notes:
• *All costs are presented in July 2022 dollars*
• *Assumes 1 manhole every 75m*

Project Costs have been based on the Opinion of Cost assessment prepared by RLB. These have been applied to the following asset types:

- Water pump stations;
- Water reservoirs; and
- Sewer pumps stations;

Adjustment factors are applied to assets where additional costs are anticipated due to known site characteristics, soil/terrain types or construction method factors. For example, a 1.4 terrain factor has been applied to sewer gravity mains for possible trenching in rock or unsuitable material. The applicable adjustment factors employed within the cost build-up for the Water Supply and Sewerage network are presented in Table 6.3.3.4.

Table 6.3.3.4 Water Supply and Sewerage Adjustment Factors

Network	Asset Type	Application / Reason	Adjustment Factor
Water Supply	Water Main	PDA-wide – Rocky Soil	1.25
Water Supply	Water Main	PDA-wide – Micro-Tunnelling	5.00
Sewerage	Gravity Main	PDA-wide – Soil/Terrain	1.40
Sewerage	Gravity Main	PDA-wide – Micro-Tunnelling	5.00
Sewerage	Rising Main	PDA-wide – Soil/Terrain	1.25

6.3.4 Transport and Pathways

Base costs for transport infrastructure have been determined using unit rates and specific project costs.

Unit rates for roads have been created using a nominal Bill of Quantity assessment for each cross-section type. Where alternative (non-standard) cross sections are known to be required, these have been identified so that an adjusted unit rate value could be determined.

The cost of each cross-section component is based on the median of the following:

- ICOP background reporting (Cost Build Ups, Variations and Infrastructure Planning Assumptions – Greater Flagstone PDA LIP & SRIP – Final draft, 14 May 2018, Cardno), indexed to July 2021 using the ABS PPI (RBC) index;

- Developer unit rates, provided as part of a unit rate benchmarking assessment;
- RLB unit rates, as identified within background data to the Opinion of Cost assessment

The road unit rates are inclusive of the following:

- Typical cross-sections as identified within Section 5.5.1 and Appendix B;
- Non-standard cross-sections area identified within Appendix B;
- 2m cut/fill balance across the full cross section for each road type;
- Allowance for Bus stop bays (excluding Translink shelter infrastructure).

Off-road Pathway unit rates are based on those provided within the RLB Opinion of Cost assessment, which closely align to the developer unit rate feedback for the road construction costs. These are based on the delivery of the pathway construction only, as it is assumed to be located within an existing road reserve or linear park. Allowances for minor earthworks, drainage, pathway furniture and surface marking are included within the linear park costs (see Appendix C) Intersection costs are provided as specific costs for each DCOP item, as identified within the RLB Opinion of Cost assessment. Where intersections have been identified in addition to those in the RLB Opinion of Cost assessment, EDQ have applied costs based on similar intersection arrangements assessed by RLB.

Table 6.3.4.1 Road Unit Rates

Roads			
Code	**Cross-section Type**	**Description**	**Rate $/m**
2L	Standard	Ultimate 2 lane with parking + cycle	$4,886.41
2L	Non-Standard 1	Ultimate 2 lane with parking + cycle	$4,485.23
2L	Non-Standard 2	Ultimate 2 lane with parking + cycle	$4,608.25
2L	Non-Standard 3	Ultimate 2 lane with parking + cycle	$3,988.81
2L	Non-Standard 4	Ultimate 2 lane with parking + cycle	$4,608.25
2L	Non-Standard 5	Ultimate 2 lane with parking + cycle	$4,511.92
2L	Non-Standard 6	Ultimate 2 lane with parking + cycle	$4,866.25
2L	Non-Standard 7	Ultimate 2 lane with parking + cycle	$5,237.68
2L	Non-Standard 8	Ultimate 2 lane with parking + cycle	$5,210.28
2L	Non-Standard 9	Ultimate 2 lane with parking + cycle	$5,057.61
2L	Non-Standard 10	Ultimate 2 lane with parking + cycle	$5,353.24
2L	Non-Standard 11	Ultimate 2 lane with parking + cycle	$5,057.61
2L	Non-Standard 12	Ultimate 2 lane with parking + cycle	$5,225.89
2L	Non-Standard 13	Ultimate 2 lane with parking + cycle	$5,727.73
2L	Non-Standard 14	Ultimate 2 lane with parking + cycle	$4,485.23
2L	Non-Standard 15	Ultimate 2 lane with parking + cycle	$6,963.87
2Li	Standard	Interim 2 lane + cycle	$3,901.54
2Li	Non-Standard 1	Interim 2 lane + cycle	$4,080.86
2Li	Non-Standard 2	Interim 2 lane + cycle	$3,934.10
2Li	Non-Standard 3	Interim 2 lane + cycle	$3,901.54
4L	Standard	Ultimate 4 lane + cycle	$7,173.46
4Lu	Standard	Upgrade for additional 2 lanes	$7,173.46
4Lu	Non-Standard 1	Upgrade for additional 2 lanes	$6,272.57
4Lu	Non-Standard 2	Upgrade for additional 2 lanes	$6,512.64
4Lu	Non-Standard 3	Upgrade for additional 2 lanes	$6,438.84
4Lu	Non-Standard 4	Upgrade for additional 2 lanes	$6,219.81
4Lu	Non-Standard 5	Upgrade for additional 2 lanes	$7,023.31

4Lu	Non-Standard 6	Upgrade for additional 2 lanes	$7,098.38
4Lu	Non-Standard 7	Upgrade for additional 2 lanes	$7,427.85
4Lu	Non-Standard 8	Upgrade for additional 2 lanes	$7,311.02

Notes:
- *All costs are presented in July 2022 dollars*
- *Unit rates for 'upgrades' identify the ultimate cross-section cost (i.e. inclusive of the cost of any interim works).*
- *Includes 2m cut/fill balance across road corridor*
- *Includes allowance for bus stop infrastructure*
- *Excludes temporary/sacrificial works for interim infrastructure*
- *All cross-section details are summarised in Appendix B*

Table 6.3.4.2 Intersection Project Costs

Intersections		
DCOP ID	**Intersection Type**	**Base Cost**
RI001A	Priority Controlled	$76,482
RI001B	Signalised	$1,329,390
RI001C	Signalised	$12,747
RI002A	Signalised	$1,160,753
RI002B	Signalised	$362,832
RI003A	Signalised	$779,151
RI003B	Signalised	$295,781
RI004A	Priority Controlled	$38,241
RI004B	Signalised	$803,839
RI005A	Priority Controlled	$38,241
RI005B	Signalised	$1,658,977
RI005C	Signalised	$359,646
RI006A	Signalised	$660,240
RI006B	Signalised	$76,482
RI007A	Signalised	$507,277
RI007B	Signalised	$242,192
RI008A	Signalised	$583,759
RI008B	Signalised	$823,375
RI009A	Priority Controlled	$76,482
RI009B	Signalised	$676,369
RI009C	Signalised	$305,927
RI010A	Signalised	$1,033,284
RI010B	Signalised	$229,445
RI010C	Signalised	$38,241
RI011A	Signalised	$931,308
RI011B	Signalised	$822,725
RI012	Signalised	$711,228
RI013A	Signalised	$1,288,223
RI013B	Signalised	$839,660

Intersections		
DCOP ID	**Intersection Type**	**Base Cost**
RI015A	Signalised	$516,642
RI015B	Signalised	$831,934
RI016A	Stop Controlled	$1,281,199
RI016B	Roundabout	$397,529
RI017	Signalised	$762,216
RI018A	Priority Controlled	$38,241
RI018B	Signalised	$752,851
RI018C	Signalised	$152,963
RI019A	Priority Controlled	$38,241
RI019B	Signalised	$698,481
RI019C	Signalised	$165,710
RI021A	Priority Controlled	$76,482
RI021B	Signalised	$676,369
RI021C	Signalised	$191,204
RI022A	Signalised	$762,216
RI022B	Signalised	$127,470
RI023A	Priority Controlled	$114,723
RI023B	Signalised	$1,182,865
RI023C	Signalised	$270,964
RI025	Signalised	$1,096,498
RI026	Signalised	$787,710
RI027A	Priority Controlled	$38,241
RI027B	Signalised	$698,481
RI028A	Priority Controlled	$76,482
RI028B	Signalised	$740,104
RI028C	Signalised	$152,963
RI029A	Priority Controlled	$38,241
RI029B	Signalised	$507,277

RI014	Signalised	$1,415,692		RI030	Signalised	$897,568

Notes:
• *All costs are presented in July 2022 dollars*
• *Base costs identified prior to the application of on-costs and contingencies*

Table 6.3.4.3 Pathway Unit Rates

Pathways		
Description	**Typical Width**	**Rate $/m²**
Shared Path	2.5m – 4.0m	$92.54
Separate Cycle Path and Footpath	5.0m	$92.54
On-Road Cycle Lanes / Shared Path	4.0m	$128.53
Shared Path Bridge	6.0m	$856.86

Notes:
• *All costs are presented in July 2022 dollars*
• *Base costs identified prior to the application of on-costs and contingencies*

Unit rates for bridges is based on the median of the following:

- ICOP background reporting (Cost Build Ups, Variations and Infrastructure Planning Assumptions – Greater Flagstone PDA LIP & SRIP – Final draft, 14 May 2018, Cardno);
- Developer unit rates, provided as part of a unit rate benchmarking assessment;
- RLB unit rates, as identified within background data to the Opinion of Cost assessment

Table 6.3.4.4 Bridges and Culvert Unit Rates

Road Bridges and Culverts		
Asset Type	**Rate**	**Unit of Measure**
Bridge	$4,524.21	Per m² of Deck Area
Bridge over Railway	$5,346.79	Per m² of Deck Area
Culvert	$2,459.56	Per m² of Deck Area

Notes:
• *All costs are presented in July 2022 dollars*
• *Base costs identified prior to the application of on-costs and contingencies*

6.3.5 Parks and Open Space and Local Community Facilities

Base costs for the embellishment of land for parks and community facilities have been created on a first principles basis, incorporating the required level of embellishment for a standard size park identified within EDQ Guideline 12, and the median of:

- Developer unit rates for embellishment items and park works, provided as part of a unit rate benchmarking assessment;
- Indicative embellishment item costs identified within the RLB Opinion of Cost assessment (where available); and
- Where no other sources were available, nominal amounts as agreed by EDQ.

Base costs for local and major linear parks have been determined from the same benchmarking exercise, with the required works and embellishments determined based on the cross-section in figure 5-14.

All works associated with biodiversity and revegetation are excluded from the DCOP linear park costs.

For local community facilities, the included scope of works in the base costs includes:

- Clearing and grubbing;
- Bulk earthworks (one metre cut to fill allowance) and grassing suitable for the site purposes;
- Service connections including potable water, sewerage, telephony, broadband, stormwater and electricity;
- Service connection to non-potable water, if adjacent to a supply system;
- Half construction of a Neighbourhood Access Road cross section, along a single frontage, including a 2.5m wide pathway. The maximum frontage lengths allowed for in the cost build up are as follows:
    - community facility (local) – 125m per ha of site area provided
    - community facility (district) – 83m per ha of site area provided
    - community facility (citywide) – 67m per ha of site area provided

A 12 month maintenance and establishment period is included for all parks and open space.

A summary schedule of inclusions for all parks and community facilities has been provided in Appendix C.

All costs for parks and community facilities have been converted to a 'per m²' rate for inclusion in the DCOP, identified in Table 6.3.5.1.

Table 6.3.5.1 Parks and Local Community Facility Embellishment Unit Rates

Parks and Community Facilities Embellishments		
Asset Type	**Size Range (ha)**	**Rate $/m²**
District Recreation Park	All sizes	$42.78
Major Recreation Park	All sizes	$39.45
Regional Recreation Park	All sizes	$48.39
City Park / Town Square	All sizes	$119.95
District Sports Ground	All sizes	$87.03
Regional Sports Ground	All sizes	$82.70
Local Linear Park*	All sizes	$37.89
Major Linear Park*	All sizes	$23.56
Local Community Facility - Local	All sizes	$52.99
Local Community Facility - District	All sizes	$35.42
Local Community Facility - Citywide	All sizes	$30.23

Note: All costs are presented in July 2022 dollars
** Local Linear Park embellishments limited to a maximum width of 15m (valued on the provision of a pathways on either side of the corridor/waterway), in accordance with Figure 5-14.*
** Major Linear Park embellishments limited to a maximum width of 30m (valued on the provision of a pathways on either side of the corridor/waterway), in accordance with Figure 5-14.*

6.3.6 State Government Facilities

Base costs for the preparation of land for state community facilities have been created on a first principles basis, based on the required works for the standard land area identified within background planning, assuming a regular shaped block, and the median of:

- Developer unit rates for all site preparation works, provided as part of a unit rate benchmarking assessment;
- Indicative site preparation works costs identified within the RLB Opinion of Cost assessment (where available).

This cost has been converted to a 'per hectare' rate for inclusion in the DCOP.

The included scope of works in the base costs includes:

- Clearing and grubbing;
- Bulk earthworks (one metre cut to fill allowance) and grassing suitable for the site purposes;
- Service connections including potable water, sewerage, telephony, broadband, stormwater and electricity;
- Service connection to non-potable water, if adjacent to a supply system;
- Half construction of a Neighbourhood Access Road cross section, along a single frontage, including a 2.5m wide pathway. The maximum frontage lengths allowed for in the cost build up are as follows:
    - community facility (state) – 100m per ha of site area provided
    - community facility (primary school) – 300m per school site
    - community facility (secondary school) – 300m per school site

Additionally, the scope of works for school sites also includes:

- Provision of up to 2 bus bays;
- Safety fencing in the road reserve, if required, up to a length of 300m;

A detailed schedule of inclusions has been provided in Appendix C.

Table 6.3.6.1 State Government Facilities Site Works Unit Rates

State Government Facility Embellishment Cost	
Asset Type	**Rate $/m²**
Ambulance Station	$40.62
Fire & Rescue Station	$40.62
Police Station	$40.62
Health Care Centre	$40.62
Health Precinct	$40.62
State Primary School	$27.69
State Secondary School	$22.00

Note: All costs are presented in July 2022 dollars

6.3.7 Other Provisions

A portion of the Municipal charge has been identified as necessary to assist the capital funding of sub-regional infrastructure, to a value of $66.8 million (July 2022). This equates to a charge of $1,297 per residential lot (July 2022) which is included as part of the Catalyst charge.

In accordance with the Greater Flagstone PDA Development Scheme, the PDA is planned to be serviced by early public transport that is safe and equitable for all members of the community, supporting the delivery of the PDA Vision and PDA-wide criteria.

EDQ will lead and manage the service which will be delivered by TransLink. To fund this service, a public transport charge of $1,940 per residential lot (July 2022) will be applied. This charge comprises a portion of the municipal charge which will be quarantined to ensure the availability of funding under a funding agreement.

The public transport charge will be collected up to a total value of $21.15 million (July 2022), representing the total cost of TransLink's ten-year public transport service for the PDA. Cross-crediting of municipal works against the public transport charge is not permitted.

6.4 Determination of Establishment Costs (Land)

6.4.1 Allowances for Land Valuation Costs

Base costs for land have been determined using the land costs defined in the *Taylor Byrne Land Value Estimates – Greenfield Sites (2011)* for various flood immunity levels (i.e. land locations). The land categorisation for each DCOP item is to be applied as follows:

- Based on the pre-development flood immunity for any land dedicated for DCOP infrastructure
- For parks and open space, including linear parks, the maximum rate to be applied is the *'Greater than Q20 & less than Q100'*.
- For State community facilities ***not*** identified as 'additional' within the DCOP mapping and Schedule of Works (i.e. those facilities in excess of the facilities identified in the Greater Flagstone Infrastructure Charging Offset Plan, June 2020);
    - The DCOP schedule of works identifies the maximum rate to be applied and funded through the DCOP is the 'Greater than Q100' pre-development flood immunity;
- For State community facilities identified as 'additional' within the DCOP mapping and Schedule of Works
    - No provision for funding is included within the DCOP
    - The relevant State agency may enter a commercial agreement with the land-owner to acquire the 'additional' land;
    - The relevant State agency is responsible for funding through normal budgetary processes.

Table 6.4.1.1 Land valuation allowances

Land Location	Rate $/m²	Rate $/ha
Less than Q20	$2.43	$24,317
Greater than Q20 & less than Q100	$4.26	$42,556
Greater than Q100	$24.32	$243,173

Notes: All costs are presented in July 2022 dollars
• Land cost for local and major linear parks is based on the assumption that it will be provided with between Q20 and Q100 flood immunity.

6.5 On-Costs

On-costs are applied to the base costs for infrastructure in order to properly account for the project owner's costs such as project management, contract supervision, survey and design fees. The on-costs are applied as a percentage against the works base costs determined for each DCOP item and have been identified by EDQ on the basis of previous infrastructure delivery costs within the PDA. On-costs are not applied to the following:

- Existing DCOP asset costs (i.e. previously committed/provided offsets);
- DCOP items included under the categories 'Public transport', 'Other Provisions'; or
- Land costs.

Table 6.5.1 Application of on-costs across all DCOP networks

On-cost percentages applied				
Water Supply and Sewerage	Transport and Paths	Parks and Community Facilities	State Government Facilities	Other Provisions
15%	15%	15%	15%	n/a

6.6 Contingencies

To account for any potential cost increases to DCOP infrastructure resulting from future unknowns, such as asset location / extent, design, construction method etc, the DCOP has applied contingencies to all future assets. The procedure used for calculating the contingency amount is on a percentage basis, applied against the base estimate (works) (refer to figure 6-2 in section 6.2 above).

Table 6.6.1 presents the contingency percentages that have been applied to infrastructure in the current DCOP. Contingencies do not apply to the following:

- Existing DCOP asset costs, including partial infrastructure items (i.e. previously committed/provided offsets);
- DCOP items included under the category 'Other Provisions'; or
- Land costs.

Table 6.6.1 Application of Contingencies – All DCOP networks

Contingency percentage used				
Water Supply and Sewerage	Roads and Intersections	Other Transport and Paths	State Government Facilities	Parks and Community Facilities
20%	15%	20%	10%	10%

7 DCOP Infrastructure

Table 7.1 identifies the criteria that was used in identifying DCOP infrastructure. This table should be read in conjunction with the remainder of the IPBR document to determine:

- Scope of planned infrastructure (i.e. Infrastructure Planning, IPBR section 5);
- Scope of inclusions in infrastructure delivery cost (i.e. Infrastructure Valuation methodologies, IPBR section 6); and
- Trunk infrastructure items (i.e. DCOP Infrastructure, Table 8.1);

DCOP infrastructure is identified at the discretion of MEDQ, and in addition to the criteria below, consideration may also be given to the overall network function to deliver a coherent, contiguous network. This may include alternative and innovative infrastructure solutions that provide an equivalent level of service at a lower cost to the community (e.g. efficient staging of works, or alternative design/alignment).

Table 7.1 DCOP Infrastructure Criteria

Network	Asset Type	Infrastructure Criteria
Water Supply	Water Main	• Mains with 225mm internal diameter and greater • Mains with an internal diameter less than 250mm, where providing a critical link/loop function to ensure the function and continuity of the wider DCOP network, and identified in the DCOP mapping
	Pump Station	• All water pump stations identified in the DCOP mapping servicing a catchment greater than 2,500 EP.
	Reservoirs	• All reservoirs identified in the DCOP mapping servicing a catchment greater than 2,500 EP.
Sewerage	Gravity main	• Gravity mains with 300mm internal diameter and greater • Mains with an internal diameter less than 300mm, where providing a critical link/loop function to ensure the function and continuity of the wider DCOP network, and depicted in the DCOP mapping
	Rising main	• All rising mains associated with DCOP pump stations
	Pump station	• All pump stations identified in the DCOP mapping servicing a catchment greater than 2,500 EP.
Transport	Roads	• Arterial and connector roads with cross-sections consistent with those in section 5.4.1 of this document, where also identified within the transport model as carrying greater than 7,500 vehicle trips per day
	Intersection	• Signalised intersections (at ultimate) where two or more DCOP roads intersect • Roundabout intersections (at ultimate) where two or more DCOP roads intersect • Signalised intersections (at ultimate) where a DCOP road intersects with a non-DCOP road (as qualified above), and where the following applies:

<table>
<tr><th>Network</th><th>Asset Type</th><th>Infrastructure Criteria</th></tr>
<tr><td rowspan="4"></td><td></td><td>Signalised intersections exceeding a Degree of Saturation (DOS) of 0.9 at the ultimate; and
Provides for a rationalised access (e.g. service road) to the trunk road network; and
Does not provide direct access from a development premises or private property (i.e. front gate works).</td></tr>
<tr><td>Bridge</td><td>Bridges located on DCOP roads, as qualified above</td></tr>
<tr><td>Culverts</td><td>Culverts located on DCOP roads, as qualified above</td></tr>
<tr><td>Off-road pathway</td><td>Pathways, 4.0m wide, servicing the PDA, where depicted in the DCOP mapping</td></tr>
<tr><td rowspan="4">Parks</td><td>Recreation Park</td><td>District recreation parks
Major recreation parks</td></tr>
<tr><td>Sports Park</td><td>District sports parks
Major sports parks</td></tr>
<tr><td>Linear Park</td><td>Linear parks located on the corridors identified in DCOP mapping (note: this excludes biodiversity and rehabilitation areas within the environmental corridors)</td></tr>
<tr><td>Special Function Park</td><td>City Park/Town Square</td></tr>
<tr><td rowspan="2">Community Facilities</td><td>Land and basic site works for local community facility</td><td>Sites identified in the DCOP mapping for:
Local community facilities
District community facilities
Citywide community facilities
Types of local community facilities include:
Art gallery
Civic centre
Community centre
Indoor sports centre
Library
Performing arts centre
Swimming pool</td></tr>
<tr><td>Land and basic site works for state community facility</td><td>Sites identified in the DCOP mapping for:
Ambulance facilities
Fire & rescue facilities
Police facilities
Health facilities
Primary schools
Secondary schools
Rail corridors</td></tr>
<tr><td>Implementation</td><td>Implementation Works</td><td>Implementation works</td></tr>
</table>

8 Financial Modelling Inputs and Assumptions

8.1 Indexation and Escalation of Costs

There are a number of price adjustments applied within the cost modelling to ensure the costs presented in the cost schedules are reflective of values. As several costs have been sourced from data prepared prior to July 2020, these have been indexed to bring into alignment with the modelled base year (i.e. July 2020). Table 8.1.1 identifies the price adjustments applied to the various cost elements in the modelling and the basis for their calculation. Increases in all costs, unit rates, and charges between the modelled base year and the current financial year for presentation within the DCOP and IPBR have been made in accordance with the DCOP indexation methodology.

Table 8.1.1 Cost Alignment Assumptions – Existing Values

Application	Basis for calculation
Alignment of Land and Works Costs	PPI Index (RBC, Queensland), smoothed based on the 3-yearly moving average quarterly percentage change between financial quarters. Indexed from the date of valuation to the July 2020 quarter.

As part of the discounted cashflow methodology for the charge calculation, it is necessary to identify the following financial assumptions:

- Future escalation of land and works;
- Future inflation of levied charge rates;
- Weighted Average Cost of Capital (WACC).

These assumptions have been identified in Table 8.1.2

Table 8.1.2 Financial Input Assumptions – Future Expenditures and Revenues

Application	Rate per annum	Basis for calculation
Escalation of Works Costs	1.74%	10-year average of PPI (RBC, Queensland), as at July 2020
Escalation of Land Costs	1.74%	10-year average of PPI (RBC, Queensland), as at July 2020
Inflation of Levied Charge	1.74%	10-year average of PPI (RBC, Queensland), as at July 2020
Weighted Average Cost of Capital (Nominal)	3.31%	A risk free rate of 1.81%, based on the QTC 10-year 20-day Average Bond Rate (as at 30 June 2020), plus a risk margin of 1.5%
Weighted Average Cost of Capital (Real)	1.54%	Based on the Nominal WACC rate, adjusted for inflation using the Fisher Equation

8.2 Delivery Timing for Financial Model

The modelled timing of infrastructure was adjusted for financial modelling purposes based on a consistent methodology to appropriately reflect a more likely and realistic expenditure profile. Key issues that have made this approach necessary are:

- Engineering assessment of timing identifies a trigger point, while the delivery of relevant infrastructure may occur over a longer period of years;
- The engineering assessment of timing is considered optimistic, and in some cases inefficient from a delivery perspective. This would require a substantial increase in development activity from what has been observed at the time of DCOP preparation on several development fronts, and results in a forward-focussed delivery profile, which is not currently reflected in the projected demands.
- Under the discounted cashflow and user pays methodology (discussed in section 8.3) modelling a realistic expenditure profile is necessary to ensure the resultant charge rate is appropriate. Delivery profiles which assume a higher rate of expenditure in the forward years results in higher charge rates under this approach due to the increased funding risks.

The adjustments to infrastructure timing for financial modelling are identified in Table 8.2.1 below.

Table 8.2.1 Timing for Financial Modelling

Delivery Cohort	Adjustment Applied	Notes
2021-2026 *Under construction*	No change	Assets known to be under construction. No change required.
2021-2026 *All others*	Expenditure assumed over approximately twice the identified timeframe	Identified expenditure, annualised, was approximately double that currently being delivered. It is not considered likely that all of the identified infrastructure could be delivered within the 5-year timeframe.
2027-2031	Expenditure distributed equally over the 2027 – 2066 timeframe	Identified expenditure was heavily weighted over the first 20 years, with minimal expenditure in the last 20. It is expected that expenditures is more likely to show alignment to the modelled demands, and therefore will be more evenly distributed across this period.
2032-2041		
2042-2066		
2021-2066		

8.3 Charge Method Approach

The current modelling approach employs a discounted cashflow and the user pays method for calculation of the charge for DCOP Infrastructure items. This approach ensures that all infrastructure investment is recovered across all users, regardless of where within development horizon they arrive. This approach is represented in the following formula.

$$User\ Pays = \frac{Existing\ Infrastructure\ Cost\ +\ NPV\ (Nominal)\ of\ Future\ Infrastructure\ Cost}{Existing\ Infrastructure\ Demand\ +\ NPV\ (Real)\ of\ Future\ Infrastructure\ Demand}$$

Table 8.3.1 Charge Method

DCOP Network	Cost apportionment basis
Water and Sewer	User pays
Transport and Paths	User pays
Parks, Open Space and Local Community Facilities	User pays
State Government Facilities and Other Provisions	User pays

8.3.1 Municipal charge - Catalyst component

In order to facilitate development within the PDA, EDQ has brought forward the funding for key items of infrastructure through a loan facility, which must be repaid over a shorter horizon than the projected ultimate DCOP development (i.e. before all of the revenues have been received). To facilitate the repayment of this loan, a catalyst charge has been separated from the remainder of the municipal charges. The catalyst charge is based on the necessary repayments to the loan facility, and is comprised of the following:

- A 'bring forward' premium, being the additional cost associated with the delivery mechanism (loan facility) as opposed to a business-as-usual approach (through development conditions, charges, and offsets over the life of the plan); plus
- A quarantined portion of the total calculated balance municipal charge, to make up the required loan repayment amount.

Once the catalyst loan facility has been repaid in full, the quarantined component of the charge will return to the balance municipal charge, and the premium associated with bringing the infrastructure forward will no longer apply. In practical terms, this means that:

- The catalyst charge will no longer apply;
- The balance municipal charge will increase by the amount that is currently quarantined for the purposes of the catalyst charge;

The quarantined value currently comprises approximately 90% of the catalyst charge, however this amount may vary over time depending on the rate of development, as this will have a direct impact on the rate at which the loan facility is able to be repaid.

9 Infrastructure cost summaries

Summaries of infrastructure costs for each network servicing the Greater Flagstone PDA are detailed below in Table 19. Detailed schedules of DCOP infrastructure are provided within the DCOP document and mapping (section/s)

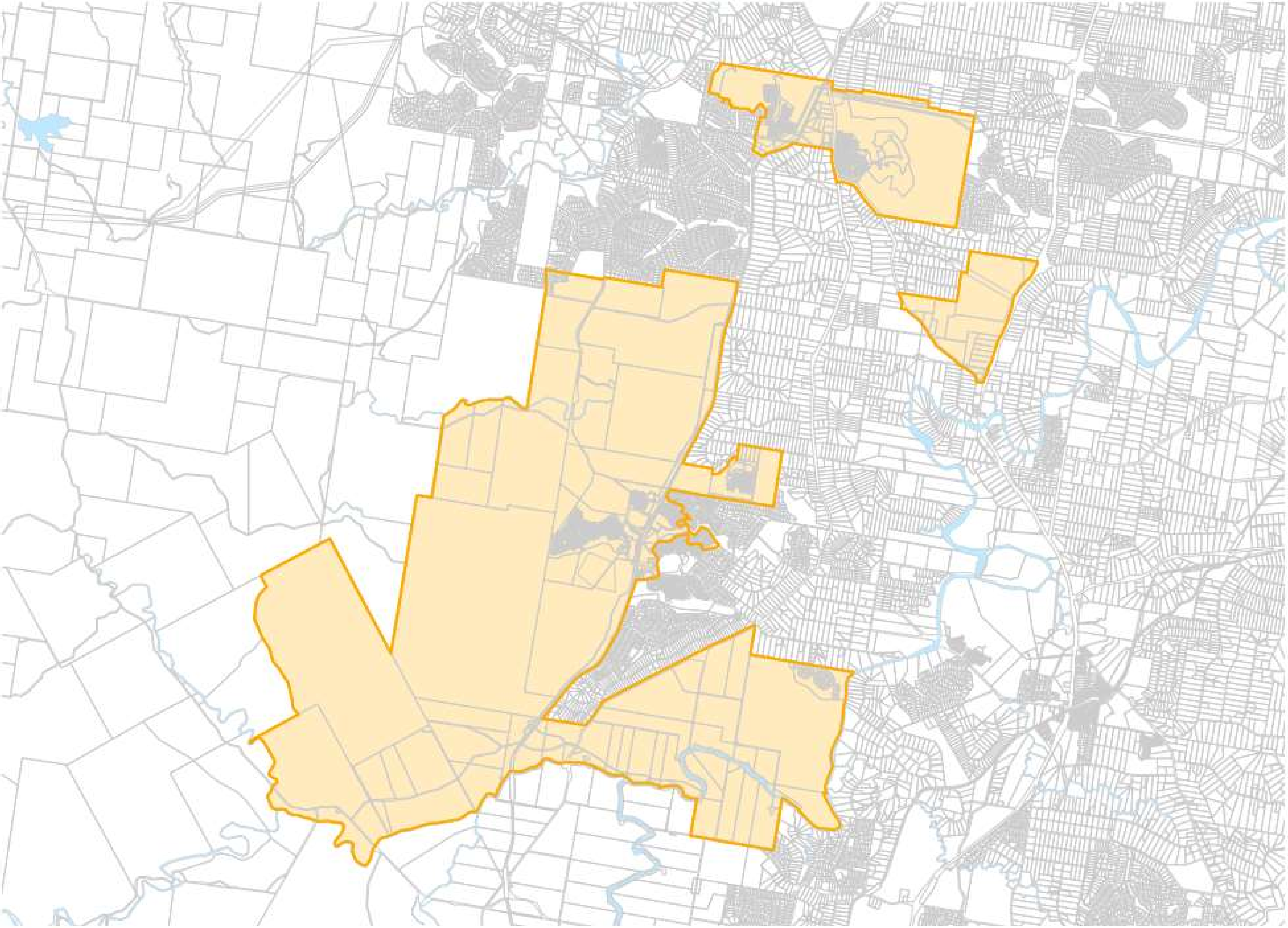
Table 4 Infrastructure Schedule of Works costs

Infrastructure	Existing ($)	2026 ($)	2031 ($)	2041 ($)	2066 ($)	Total ($)
Water supply	$1,151,883	$8,966,691	$16,542,526	$18,738,347	$21,212,340	$66,611,787
Sewerage	$10,150,823	$11,597,344	$19,747,458	$20,939,164	$22,820,317	$85,255,106
Transport	$16,398,263	$51,466,911	$136,253,082	$193,863,140	$243,883,337	$641,864,733
Parks and open space	$5,157,335	$14,206,277	$63,786,387	$104,842,732	$138,824,310	$326,817,041
Local community facilities	$0	$132,086	$1,681,527	$3,151,715	$4,338,433	$9,303,762
State community facilities	$0	$2,526,106	$10,967,421	$19,613,468	$28,617,663	$61,724,659
Total	**$32,858,305**	**$88,895,415**	**$248,978,400**	**$361,148,567**	**$459,696,401**	**$1,191,577,088**

Notes: all values presented in July 2022 dollars as incremental costs per reporting period, inclusive of Catalyst Infrastructure values

Appendix A PDA Boundary

Greater Flagstone DCOP
PDA Boundary



Legend

- Development Area (PDA) Boundary
- Waterways
- Easements
- Property Boundary

N

0 0.5 1 2 3

Kilometers

Map created at: A3

Projection: GDA 1994 MGA Zone 56
Coordinate system: GCS GDA 1994
Datum: GDA 1994
Projection: Transverse Mercator
Map produced by the Department of State Development, Infrastructure, Local Government and Planning
Spatial Services Unit, 4/02/2022

Appendix B Road cross sections

Greater Flagstone

Code	Cross-section	Clearance	Footpath	Cycle Path	Clearance	Breakdown	Bus Lane	Travel Lane	Median	Travel Lane	Bus Lane	Breakdown	Clearance	Cycle Path	Footpath	Clearance	Total Corridor Width	Total Pavement Width	Carriageways
2L	Standard	1	1.5	2	1.6	2.4	0	3.5	0	3.5	0	2.4	1.6	2	1.5	1	24	11.8	1
2L	Non-Standard 1	1	1.5	0	2	2.4	0	3.5	0	3.5	0	2.4	2	3	0	1	22.3	11.8	1
2L	Non-Standard 2	1	0	2.5	2	2.5	0	4	0	4	0	2.5	2	0	1.5	1	23	13	1
2L	Non-Standard 3	1	0	3	1.5	1.5	0	3.5	0	3.5	0	1.5	1.5	0	1.5	1	19.5	10	1
2L	Non-Standard 4	1	0	2.5	2	2.5	0	4	0	4	0	2.5	2	0	1.5	1	23	13	1
2L	Non-Standard 5	1	1.5	2	1.5	1.5	0	3.5	0	3.5	0	1.5	1.5	2	1.5	1	22	10	1
2L	Non-Standard 6	1	0	3	2.5	2.4	0	3.5	0	3.5	0	2.4	2.5	0	1.5	2.5	24.8	11.8	1
2L	Non-Standard 7	1	1.5	2	2	2.5	0	4	0	4	0	2.5	2	2	1.5	1	26	13	1
2L	Non-Standard 8	0	3	2	1.5	2.5	0	3.5	0	3.5	0	2.5	1.5	2	3	0	25	12	1
2L	Non-Standard 9	1	1.5	0	2	1.5	0	3.5	4	3.5	0	1.5	2	3	0	1	24.5	10	2
2L	Non-Standard 10	1	1.5	2	1.5	1.5	0	3.5	3.5	3.5	0	1.5	1.5	2	1.5	1	25.5	10	2
2L	Non-Standard 11	1	1.5	0	2	1.5	0	3.5	4	3.5	0	1.5	2	3	0	1	24.5	10	2
2L	Non-Standard 12	5.5	0	0	0	1	0	3.5	4	3.5	0	1	3.5	4	0	0	26	9	2
2L	Non-Standard 13	1	1.5	2	1.6	2.4	0	3.5	3.5	3.5	0	2.4	1.6	2	1.5	1	27.5	11.8	2
2L	Non-Standard 14	1	1.5	0	2	2.4	0	3.5	0	3.5	0	2.4	2	3	0	1	22.3	11.8	1
2L	Non-Standard 15	1	3	2	2	0	0	7	5	7	0	0	2	2	3	0	34	14	2
2Li	Standard	0	0	0	0	1.5	0	3.5	0	3.5	0	1.5	1.5	3	1.5	1	17	10	1
2Li	Non-Standard 1	4	0	0	0	0	0	3.5	0	3.5	0	0	2	3	1.5	2	19.5	7	1
2Li	Non-Standard 2	1.5	1.5	0	2	0	0	3.5	0	3.5	0	0	1.5	3	1.5	0	18	7	1
2Li	Non-Standard 3	0	0	0	0	1.5	0	3.5	0	3.5	0	1.5	1.5	3	1.5	1	17	10	1
4L	Standard	1	1.5	2	1.5	0	0	7	6	7	0	0	1.5	3	1.5	1	33	14	2
4Lu	Standard	1	1.5	2	1.5	0	0	7	6	7	0	0	1.5	3	1.5	1	33	14	2
4Lu	Non-Standard 1	1	1.5	2	1.5	0	0	7	0	7	0	0	1.5	3	1.5	1	27	14	2
4Lu	Non-Standard 2	1	1.5	2	2	0	0	7	2	7	0	0	2	2	1.5	1	29	14	2

Code	Cross-section	Clearance	Footpath	Cycle Path	Clearance	Breakdown	Bus Lane	Travel Lane	Median	Travel Lane	Bus Lane	Breakdown	Clearance	Cycle Path	Footpath	Clearance	Total Corridor Width	Total Pavement Width	Carriageways
4Lu	Non-Standard 3	1	1.5	0	2	0	0	7	5.5	7	0	0	1.5	3	0	1	29.5	14	2
4Lu	Non-Standard 4	1	1.5	2	1.5	1.5	0	3.5	5.5	3.5	0	1.5	1.5	3	1.5	1	28.5	10	2
4Lu	Non-Standard 5	1	1.5	2	1.5	0	0	7	5	7	0	0	1.5	3	1.5	1	32	14	2
4Lu	Non-Standard 6	1	1.5	2	1.5	0	0	7	5.5	7	0	0	1.5	3	1.5	1	32.5	14	2
4Lu	Non-Standard 7	1	1.5	2	1.5	0	0	7	5.5	7	0	1.5	1.5	3	1.5	1	34	15.5	2
4Lu	Non-Standard 8	1	1.5	3	1.5	0	0	7	5.5	7	0	0	1.5	3	1.5	1	33.5	14	2

(blue)	Standard Cross-section
(yellow)	Varied from standard cross-section

Appendix C Open space and community facilities embellishments

Facility Type / Hierarchy	Typical Size (m^2)	Earth works		Amenities													Sports Facilities					Landscaping				Infrastructure												
		Minor earthworks/ levelling	Bulk earthworks	BBQ (Electric)	Play Equipment	Shade Structure	Shelter	Rotunda	Rubbish Bin	Table and Bench set	Bench Seating	Toilets	Water Bubbler	Signage Set - Small	Signage Set - Large	Fitness Node	Playing Field Surface Turf	Tennis, Netball, Basketball Courts	Basketball Half-court	Grandstand	Spectator Mound	Mulching & Planting	Shade Trees	Turf - Seeding	Turf	Irrigation	Lighting	Fencing	Bollards	Post and rail	Service Connections (incl. WiFi)	Pathways (concrete)	Paved plaza area	Internal Access Road	Bicycle parking facilities	Bitumen (Carpark)	Verve works - Half Road	Bus Indent Bay
Neighbourhood Recreation	5,000 -10,000		x		x	x	x		x	x			x	x					x			x	x	x			x	x	x	x	x	x			x			
District Recreation	50,000		x	x	x	x	x	x	x	x		x	x		x	x			x			x	x	x			x	x	x	x	x	x		x	x	x		
Major Recreation	100,000		x	x	x	x	x	x	x	x		x	x		x	x			x			x	x	x			x	x	x	x	x	x		x	x	x		
Regional Park and Garden	100,000		x	x	x	x	x	x	x	x		x	x		x				x			x	x		x	x	x	x	x	x	x	x		x	x	x		
Town Centre Plaza	5,000		x				x	x		x				x													x					x	x		x			
District Sport	75,000		x		x	x	x		x	x	x	x	x		x		x	x		x	x		x		x	x	x	x	x	x	x	x		x	x	x		
Regional Sport	150,000		x		x	x	x		x	x		x	x		x		x	x		x			x		x	x	x	x	x	x	x	x		x	x	x		
Local Linear	10,000	x									x													x								x						
Major Linear	10,000	x								x	x		x											x								x						
State Community Facility	10,000		x																												x						x	
Local Community Facility - Local	4,000		x																												x						x	
Local Community Facility - District	15,000		x																												x						x	
Local Community Facility - Citywide	30,000		x																												x						x	
Primary Education Facility	70,000		x																									x			x						x	x
Secondary Education Facility	120,000		x																									x			x						x	x

Appendix D Technical report

Economic Development Queensland

Greater Flagstone Priority Development Area

Appendix D: Technical Report

July 2022

Queensland Government

The Department of State Development, Infrastructure, Local Government and Planning connects industries, businesses, communities and government (at all levels) to create place-based solutions that leverage regional strengths and unlock sustainable growth.

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1 Introduction

The analysis contained in this Technical Report (the Report) is to inform the Development Charges and Offset Plan (DCOP) that supports growth within the Priority Development Area (PDA).

The objective of this Report is to detail infrastructure opportunities and constraints based on current and projected future infrastructure demands within the Greater Flagstone PDA. The scope of this analysis was including but not limited to:

- A review of all existing Infrastructure Charging Offset Plan (ICOP) and Infrastructure Management Plans (IMP's),
- Engage with Key Stakeholders to receive, analyse and include changes to their respective Desired Standards of Service (DSS),
- Review and critic new policy implications,
- Migrate, analysis and modelling of all offsetable trunk infrastructure with emphasis on innovative thought and application,
- Estimate the staging and sequencing of the collective offsetable trunk infrastructure, and
- Calculate the cost of the above offsetable trunk infrastructure.

When undertaking the above, significant effort was invested into identifying innovative opportunities that can be applied or aspired to over the developable life of the PDA. For the purposes of this Report, innovation practices are categorised by the following two terms:

Innovation by design: approaches using proven, currently available technologies and/or construction methods to achieve innovative outcomes (e.g. provision for charging stations of electric cars, like the Tesla models, incorporated into street, carparking and building infrastructure).

Innovation by aspiration: approaches using conceptual or cutting-edge technologies and/or construction methods to achieve innovative outcomes (e.g. preparing for autonomous vehicles by installing conduit or similar in road infrastructure).

Innovation by design has been expanded upon within each of the relevant chapters. Aspirational innovation has been expanded upon within Chapter 11.

Limitations

While the analysis is based on best available data, where limitations have occurred, these are detailed in the relevant chapter and should be noted.

2 Demographic Analysis

2.1 Introduction

The Greater Flagstone Priority Development Area (PDA) forms part of the Logan South Region and is a key greenfield development area within Southeast Queensland. Logan City Council (LCC) is working with Economic Development Queensland (EDQ) to plan, design and deliver all Sub-Regional infrastructure that will service the PDA into the future.

In 2019, EDQ commissioned SGS Urban to revisit the demographic projections for the Greater Flagstone PDA. The land use projections were produced using a method that combines a 'top down' with a 'bottom up' approach if to ensure a robust set of projections.

2.2 Methodology Overview

The key 'top down' data input is the Southeast Queensland (SEQ) population projections produced by SGS. These account for the total demand for future housing and where that housing is likely to take place. These are informed by State Government and Australian Bureau of Statistics (ABS) population projections and relevant data on the economic performance of SEQ.

The 'bottom up' input data includes Census data, building approvals data, information from developers in the PDAs, Council population projections and transport model land use data. Each of these datasets has its own strengths and weaknesses, which have been assessed.

These various data sources are brought together to create a coherent view of the growth in dwellings, population and employment over the next 50 years.

Some of the key aspects and assumptions of our 'top down' approach with a 'bottom up' methodology is summarised below.

2.2.1 Dwellings

The ultimate dwelling yield has been estimated as the total number of potential dwellings at full build out. The ultimate dwelling yield is based around the expected dwelling densities and the amount of net developable land. Full build out is assumed to be 2066 for Greater Flagstone PDA.

Forecast dwelling timing between 2019 and 2031 has been informed by the feedback provided by developers. In Greater Flagstone SGS has applied a 5 per cent reduction to the total dwelling yield in each year to account for the likelihood that not all of the dwellings planned by developers are achieved in that year. This reduction was informed by SGS' SEQ population projection model which assesses potential residential growth across the whole of SEQ. Effectively, this means that developers are slightly optimistic (5 per cent) about the number of dwelling they could sell each year.

2.2.2 Population

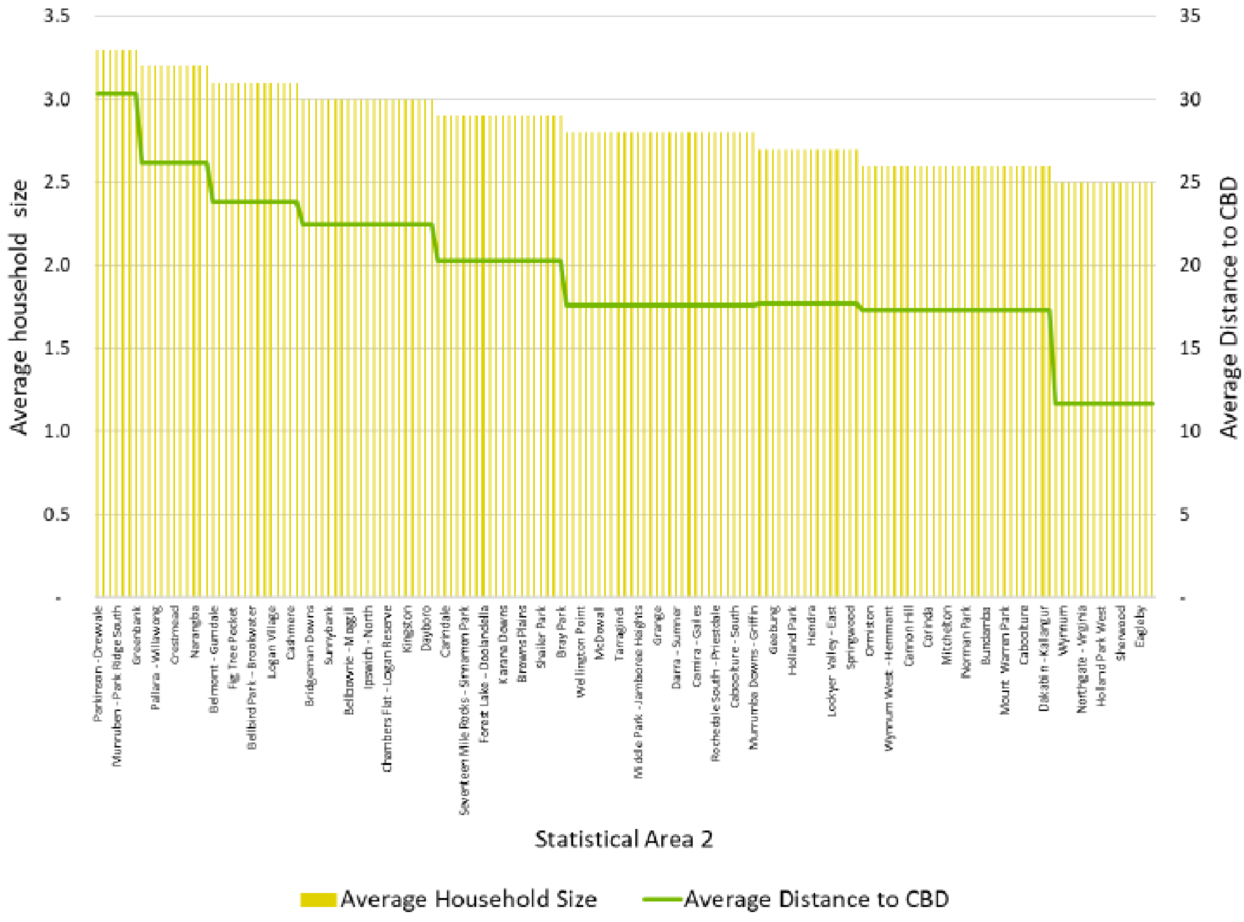
The population projection is based on applying an average person per household to the dwelling projections. This has been informed by the dwelling mix based on Council forecasts of attached and detached dwellings, and the average household size expected in a greenfield area adjusted to account for variations in dwelling mix (e.g. detached houses or medium density).

Figure 2-1 Average Household Size by the Average Distance to the Brisbane CBD (SA2)below presents the average distance to Brisbane CBD and average household size grouping. The purpose of this figure is to illustrate that, in general, as distance to the CBD increases, the average household size increases1. Locations like Springfield, Coomera and North Lakes all have average household sizes between 3.0-3.2 persons per household.

For Greater Flagstone an average household size of around 3.0 could be expected. This will vary within the PDAs as popular product mix change over time.

This analysis is supported by the average household size used by VLC and Logan City Council. In the long term, the average person per household does decline as the first generation of children born in the PDA, move out of home and their parents remain. Although even in the later years of the analysis the PDA average person per households is still above State average of 2.6.

The age profile is derived from the population projection. After a review by SGS, the QGSO projections for share of population in each age group was used to create the age breakdowns.



Source: SGS Economic and Planning from ABS Census data 2016

Figure 2-1 Average Household Size by the Average Distance to the Brisbane CBD (SA2)

Note: This figure compares the average household size of the SA2 with the average distance of the SA2 from the CBD, not the actual distance. For example, the average household size of Dakabin-Kallangur SA2 is 2.6 persons per households. Typically, areas with an average household size of 2.6 persons are located 17km from the CBD, which is closer than the actual distance of the SA2 to the CBD. This illustrates that Dakabin-Kallangur SA2 has a lower household size than other SA2s of a similar distance from the CBD.

2.2.3 Employment

The bulk of the employment which will be located in the Greater Flagstone PDA will be population serving. To produce a projection of future employment, a set of job to population ratios have been utilised and applied to the projected population.

The Table 2-1 below presents the assumed employment growth for population serving based on the historical averages for greenfield areas. Using these numbers, the rate of employment growth is between 0.6 to 0.7 jobs per new household in Greater Flagstone.

Table 2-1 Population Serving Employment Assumptions (Greater Flagstone and Yarrabilba)

Industry	Jobs per 1,000 new Residents
Construction	20
Retail Trade	20
Accommodation and Food Services	15
Financial and Insurance Services	5
Rental, Hiring and Real Estate Services	7
Professional, Scientific and Technical Services	25
Administrative and Support Services	10
Public Administrative and Safety	15
Education and Training	30
Health Care and Social Assistance	75
Arts and Recreation Services	9
Other Services	3
Total Population Servicing Employment	**234**

Source: SGS Economics and Planning based on ABS Census (1996 – 2016)

2.3 Comparison of Forecasts

2.3.1 Dwellings

Table 2-2 below highlights the variation in dwelling forecasts for the City of Logan between the State Government's ShapingSEQ, QGSO 2018 projections, Council's own figures as well as VLC's Strategic Transport Modelling for the LGA. The values for 2016 vary slightly, whereas the variation increases for projections in 2041 and 2061. Logan CC and the ShapingSEQ forecast similar dwelling numbers in 2041, with 198,000 dwellings. The 2061 forecast varies by 5,545 dwellings between Logan CC and VLC. ShapingSEQ and QGSO do not currently have forecasts specific to the PDA for 2061.

Table 2-2 Logan City Council Dwelling Forecasts

Projection Source	2016	2041	2061	Growth 2016 – 2061
ShapingSEQ	108,770	198,670	N/A	N/A
QGSO 2018 Projections	108,770	192,533	N/A	N/A
Logan City Council	111,484	198,579	292,498	181,014
VLC Forecasts	110,216	196,593	286,953	176,737

Source: ShapingSEQ, Logan City Council, VLC Transport Modelling, QGSO Forecasts 2018

Feedback was received from each developer in Greater Flagstone on their ‘realistic’ and ‘aspirational’ dwelling yields per year to 2031. These are summarized in Table 2-3 below. Annual dwelling yield is expected to be between 44 and 365 dwellings per year across the developer areas in Greater Flagstone.

This information has been used to inform SGS’ dwelling forecasts, specifically the timing and location of dwelling growth to 2031. In some cases, data was provided on the dwelling mix (detached vs attached dwellings), and where relevant this has been used to inform the population projections in the following chapter.

This reduction was informed by SGS SEQ population projection model which assessing potential residential growth across the whole of the SEQ. Effectively, this means that developers were slightly optimistic (5 per cent2) about the number of dwellings they could sell each year.

Table 2-3 Greater Flagstone Developer Expected Dwellings in 2031

Developer Area	Realistic 2031 Dwellings	Realistic Dwellings per year	Aspirational 2031 Dwellings	Aspirational Dwellings per year
Celestino	875	67	1,900	146
Mirvac	2,701	265	2,961	291
Peet Flagstone City	4,751	365	6,500	500
Pioneer Fortune	1,399	108	1,749	135
Wilsons New Beith	569	44	946	73
Flinders Land Holdings	3,357	258	4,465	343
Villa Green	1,502	116	1,502	116
Total	**15,154**	**1,223**	**20,023**	**1,604**

Source: Greater Flagstone Developers 2019

Recent development in the Greater Flagstone PDA has been slow, with issues relating to infrastructure provision delaying residential development.

Table 2-4 below shows the dwelling forecasts for the Greater Flagstone prepared by SGS, compared to those prepared by Logan CC and VLC. SGS forecasts total dwellings in Greater Flagstone PDA to reach 54,000 dwellings at ultimate development in 2066. This is broadly in line with Logan CC and VLC forecasts for 2061. By 2066 it is expected that 19 per cent of dwellings in Logan LGA will be located in Greater Flagstone.

Table 2-4 Greater Flagstone PDA Dwelling Forecasts

Projection Source	2016	2041	2066	Growth 2016 – 2066
SGS	236	25,484	54,145	53,910
Logan City Council	272	24,182	54,597*	54,325*
VLC	248	23,683	54,586*	54,338*

Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling
** Note These are 2061 estimates*

SGS forecasts in 2041 are slightly higher than VLC and Logan CC forecasts due to the different datasets and assumptions used by SGS. As shown in Table 2-4 Greater Flagstone PDA Dwelling Forecasts, SGS forecasts are slightly above the VLC and Logan CC forecasts up to 2046, due to the use of developer feedback data. Beyond 2046 SGS forecasts are lower than VLC and Logan CC as development is expected to occur at a slower rate, with both reaching 54,000 dwellings by 2066.

These forecasts assume that major infrastructure would have been provided and a number of sub-precincts would have been planned and activated.

Table 2-5 below presents SGS' forecasts of dwellings by developer area within the Greater Flagstone PDA. Areas with the largest forecast dwellings include Peet Flagstone City, Pioneer Fortune, Wilsons New Beith, Flinders Land Holdings, Celestino and Mirvac. These forecasts have been informed by the developer feedback provided by each of the large developers on their realistic and aspirational dwelling yields to 2031.

Table 2-5 Greater Flagstone PDA Dwelling Forecasts by Developer

Developer Area	2016	2041	2066	Growth 2016 – 2061
Celestino	-	2,807	6,643	6,643
Mirvac	-	3,018	3,114	3,114
Peet Flagstone City	-	6,581	14,121	14,121
Pioneer Fortune	-	2,920	7,533	7,533
Wilsons New Beith	-	3,219	7,463	7,463
Flinders Land Holdings	-	4,398	7,673	7,673
Villa Green	-	1,411	1,427	1,427
Gittins	-	-	1,861	1,861
Flagstone East	149	481	1,046	897
Flagstone South	8	8	2,377	2,369
Flagstone Southeast	54	64	301	247
Greenbank (Flagstone)	10	12	13	3
Logan City Council	1	1	1	0
North Mclean Industrial	12	12	13	1
Orchard (Pebble Creek)	-	552	558	558
Wearing Co	1	1	1	0
Barham / Lawrence	-	-	-	-

Developer Area	2016	2041	2066	Growth 2016 – 2061
Total Greater Flagstone PDA	235	25,485	54,145	53,910

Source: SGS Economics and Planning 2019,

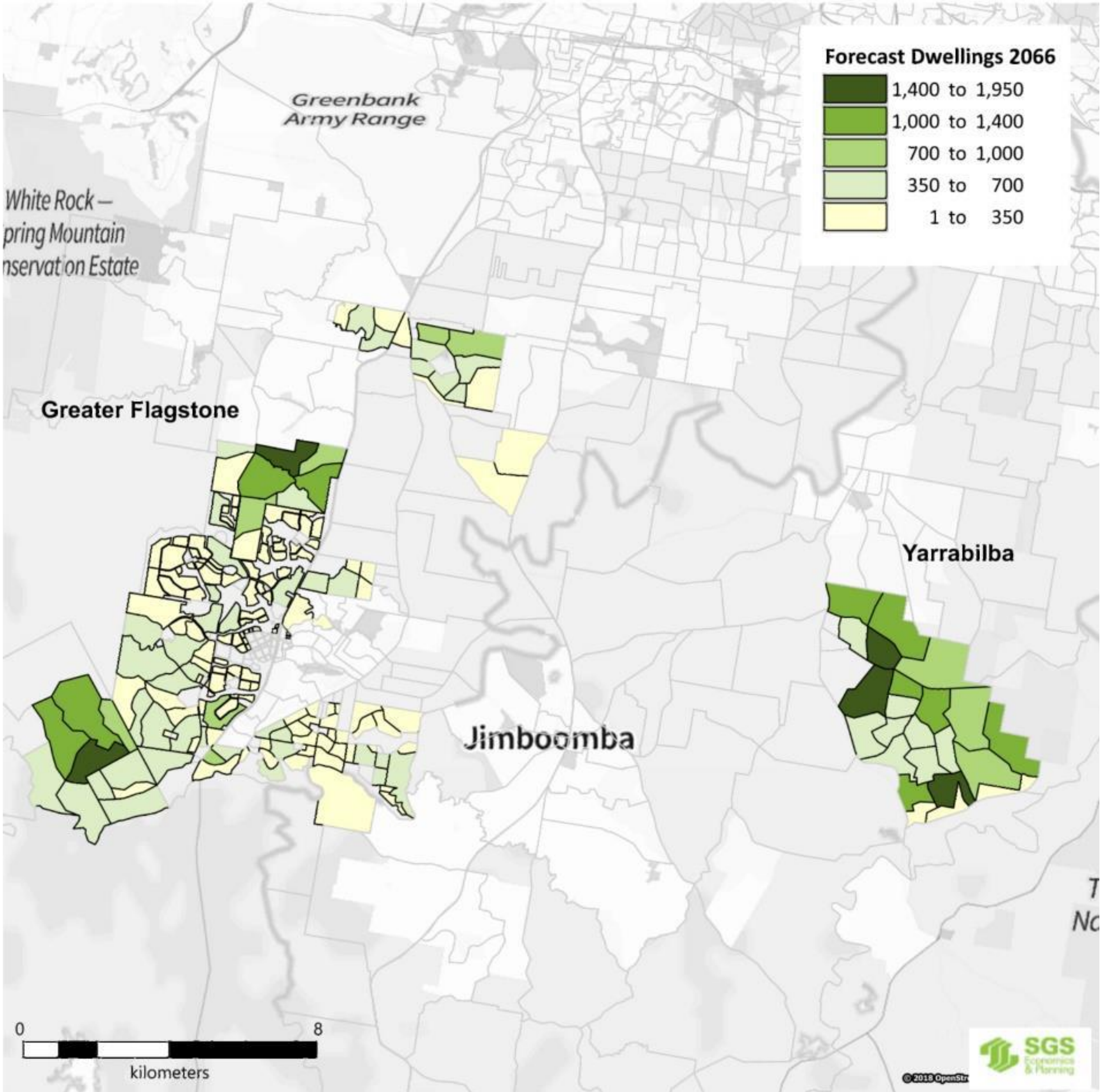


Figure 2-2 Greater Flagstone PDA Dwelling Forecast for 2066

Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

2.3.2 Population

Table 2-6 below highlights the variation in population forecasts for the City of Logan between ShapingSEQ, QGSO 2018 projections, Council's own figures as well as VLC's Strategic Transport Modelling for the area. While values are similar in 2016, there is considerable variation in forecasts for 2041. Logan CC and VLC have the same values whereas QGSO and ShapingSEQ are projecting more people in the Logan LGA by 2041 (i.e. a faster rate of population growth).

Table 2-6 Logan Local Government Area Population Forecast

Projection Source	2016	2041	2061	Growth 2016 – 2061	Average household size 2016	Average household size 2061
Shaping SEQ	313,800	586,000	NA	NA	2.9	NA
QGSO 2018 Projections	313,785	554,327	NA	NA	2.9	NA
Logan City Council	313,846	548,628	782,821	468,975	2.8	2.7
VLC Forecasts	313,846	548,628	782,821	468,975	2.8	2.7

Source: ShapingSEQ, Logan City Council, VLC Transport Modelling, QGSO Forecasts 2018

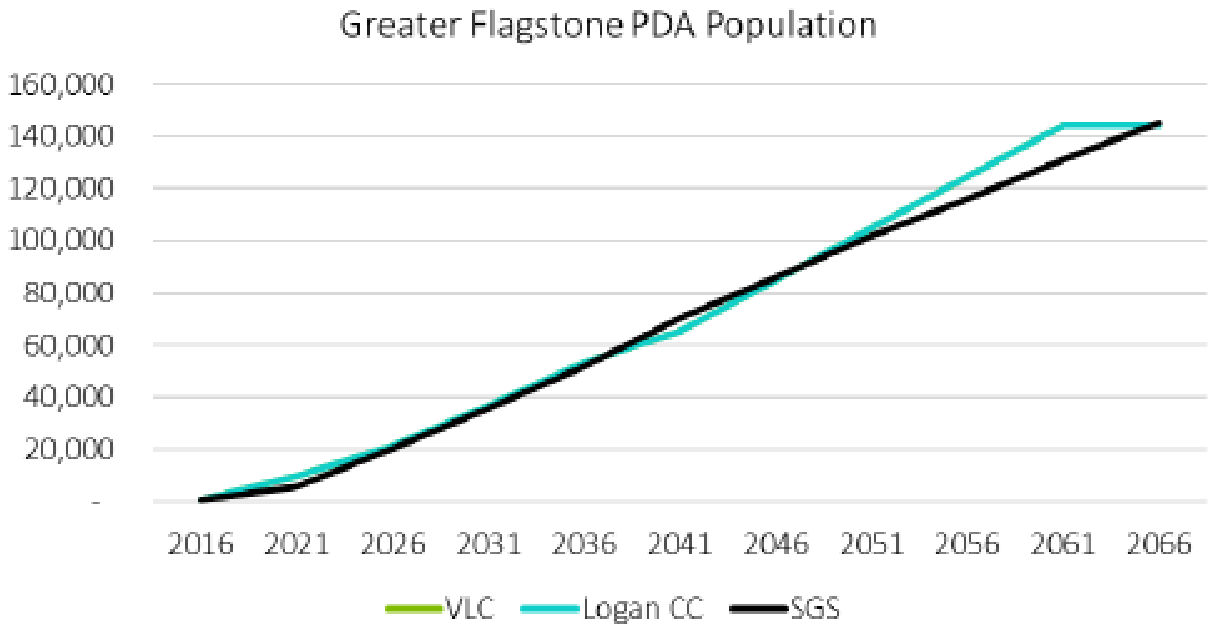
As shown in Table 2-7 below, an estimated 145,000 residents are forecast for the PDA in 2066, based on an average household size of 2.7 persons per household. This aligns with Logan CC and VLC's forecasts of population.

Table 2-7 Greater Flagstone PDA Population Forecasts

Projection Source	2016	2041	2066	Growth 2016 – 2066
SGS	775	70,548	144,738	143,963
Avg household size	3.3	2.8	2.7	-0.6
Logan City Council	819	65,394	144,335*	143,516*
Avg household size	3.0	2.7	2.6	-0.4
VLC	816	65,391	144,332*	143,516*
Avg household size	3.3	2.8	2.6	-0.6

Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling,

As shown in Forecasts below, SGS forecasts of population are slightly above the VLC and Logan CC forecasts up to 2046, in line with our dwelling forecast. Beyond 2046 SGS forecasts are lower than VLC and Logan CC as growth is expected to occur at a slower rate.



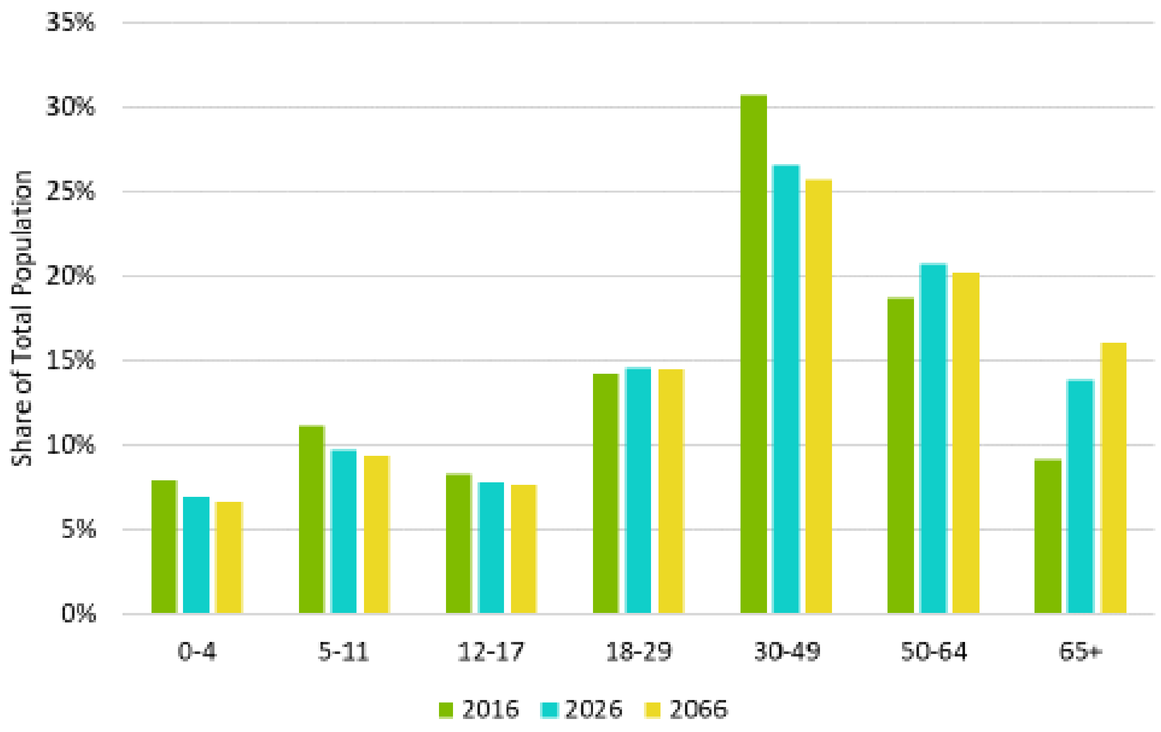
Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

Figure 2-3 Greater Flagstone PDA Population Forecasts

SGS forecasts a decline in average household size, from a high of 3.3 in 2016, to 2.9 by 2031 and 2.7 in the longer term beyond 2046. This trend is seen in older growth areas that have already developed.

Average household size tends to be higher in the early development stages as families with children move in to detached dwellings. This is expected to decline in the longer term due to more apartments being built and changing age profiles, with more older people less school aged people. Greater Flagstone household size is still expected to remain slightly above the QLD average household size of 2.6 persons per household.

Population forecasts by age group have been prepared for Greater Flagstone using the QGSO population by age forecasts for the SA2 in which it is located (Greenbank SA2). It has been assumed that as the PDA develops there will be a changing age profile of residents. The proportion of older age people (50 to 64 and 65+) is forecast to increase in 2036 and 2066 as shown in the Figure 2-4 below. This is in line with state-wide trends of an ageing population.

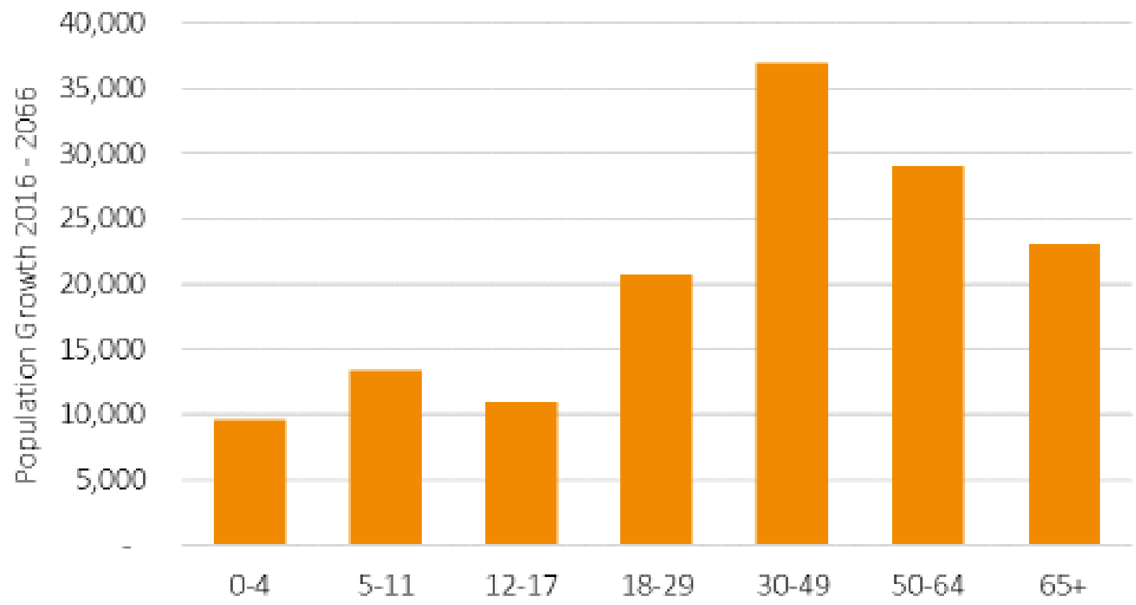


Source: SGS Economics and Planning 2019, QGSO 2018

Figure 2-4 Greater Flagstone PDA Population by Age – Share of Age Group

As also shown in the Figure 2-5 below, the number of primary school aged children (5-11 years) living in Greater Flagstone is forecast to increase by 13,400 people to 2066. The number of secondary school aged children (12-17 years) is forecast to increase by 11,000 people to 2066.

The largest amount of population growth is forecast for the 30-49 and 50-64 age group.



Source: SGS Economics and Planning 2019

Figure 2-5 Greater Flagstone PDA Population – Forecast Growth by Age Group

There is of course a high degree of uncertainty regarding the future age breakdown of the PDA. This is particularly the case for school aged children. The size of this age group clearly has implications for future school provision. Looking at the existing shares of school aged children for SA2 across Greater Brisbane provides an indication of a possible future range for the PDA (using 2016 ABS Census data).

For children aged 5-11 years, the percentage can be as high as 13 per cent (for example the North Lakes - Mango Hill SA2 is 13.1 per cent). Other SA2 with a similar percentage of children aged 5-11 include the Redbank Plains SA2 (13.5 per cent), Narangba SA2 (13.2%) and Goodna (12.7%). On average, 9.3 per cent of the population across Greater Brisbane were aged 5 to 11 years (in 2016).

Applying this 13 per cent to the PDA projections provides an indication of a future with a very high percentage of primary school aged children. The Table below compares the baseline forecast of primary school aged children in Greater Flagstone PDA (aged 5 to 11 years), with a high scenario forecast.

Table 2-8 Primary School Aged Children – High Scenario

Population aged 5-11 years	2016	2026	2036	2046	2056	2066	Growth 2016-66
Baseline Forecast	86	1,966	4,829	8,052	10,805	13,536	13,450
Share of total population	11%	10%	9%	9%	9%	9%	
High scenario	86	2,437	6,729	10,357	13,899	17,412	17,326
Share of total population	11%	12%	13%	12%	12%	12%	

Source: SGS Economics and Planning based on ABS Census data 2016

For secondary school children, the current (2016) percentage of the population aged 12-17 years can be as high as 10 per cent (for example the Marsden and Crestmead SA2 are 10.1 per cent). Other SA2 with a similar percentage of children aged 12-17 years include the North Lakes – Mango Hill SA (9.3 per cent), Goodna SA2 (9.2%) and Wakerley (9.2%). On average, 7.6 per cent of the population across Greater Brisbane were aged 12 to 17 years (in 2016).

Applying this 10 per cent to the PDA projections in 2036 provides an indication of a future with a very high percentage of secondary school aged children. Table 2-9 compares the baseline forecast of secondary school aged children in Greater Flagstone PDA (aged 12 to 17 years), with a high scenario forecast.

Table 2-9 Secondary School Aged Children – High Scenario

Population aged 12-17 years	2016	2026	2036	2046	2056	2066	Growth 2016-66
Baseline Forecast	64	1,582	3,940	6,570	8,816	11,044	10,980
Share of total population	8%	8%	8%	8%	8%	8%	
High scenario	64	1,828	5,177	7,768	10,424	13,059	12,995
Share of total population	8%	9%	10%	9%	9%	9%	

Source: SGS Economics and Planning based on ABS Census data 2016

2.3.3 Employment

Table 2-10 below compares total employment forecasts for the Logan Local Government Area (LGA) prepared by three sources (Shaping SEQ, Logan CC and VLC transport modelling). All three sources are broadly in line, with employment in Logan LGA forecast to reach 168,000 by 2041 and 272,000 by 2066. VLC forecasts are slightly higher than Logan in 2066 by a small amount.

Table 2-10 Logan Local Government Area Employment Forecasts

Projection Source	2016	2041	2066	Growth 2016 – 2066
ShapingSEQ	101,980	168,125	N/A	N/A
Logan City Council	103,129	168,313	272,020	168,891
VLC	103,164	168,544	272,251	169,087

Source: ShapingSEQ, Logan City Council, VLC Transport Modelling,

SGS' forecasts for total employment in Greater Flagstone PDA to reach 16,900 jobs by 2041, and 34,400 jobs by 2066 (ultimate development). This represents 0.6 additional jobs per additional household in Greater Flagstone.

By 2066 it is expected that 12 per cent of jobs in Logan LGA will be located in Greater Flagstone. The majority of these jobs are expected to be population serving industries including retail, accommodation and food services, health, education and construction.

SGS forecasts are slightly higher than VLC and Logan CC forecasts due to the different method used by SGS. SGS employment forecasts are linked to the projected population growth, which is also higher than VLC and Logan,

Table 2-11 Greater Flagstone PDA Employment Forecasts

Projection Source	2016	2041	2066	Growth 2016 – 2061
SGS	409	16,942	34,387	33,978
Logan City Council	1,044	12,719	29,339	28,295
VLC	409	12,915	29,535	29,126

Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling,

Table 2-12 below presents SGS' forecasts of total employment by developer area within the Greater Flagstone PDA. Areas with the largest forecast number of jobs include Peet Flagstone City, North Mclean Industrial, Wearing Co, Pioneer Fortune and Wilsons New Beith.

Table 2-12 Greater Flagstone PDA Employment Forecasts by Developer

Developer Area	2016	2041	2066	Growth 2016 – 2066
Celestino	6	985	1,559	1,554
Mirvac	1	259	674	673
Peet Flagstone City	25	8,407	15,991	15,967
Pioneer Fortune	14	831	2,305	2,291
Wilsons New Beith	37	631	2,136	2,100
Flinders Land Holdings	14	524	1,582	1,568
Villa Green	2	79	70	68

Developer Area	2016	2041	2066	Growth 2016 – 2066
Gittins	2	3	400	398
Flagstone East	27	56	296	269
Flagstone South	6	8	106	101
Flagstone Southeast	9	12	22	13
Greenbank (Flagstone)	250	1,141	1,013	763
Logan City Council	4	5	4	1
North Mclean Industrial	1	3,970	4,224	4,224
Orchard (Pebble Creek)	12	31	27	16
Wearing Co	0	0	3,976	3,976
Barham / Lawrence	0	1	1	0
Total Greater Flagstone PDA	**409**	**16,942**	**34,387**	**33,978**

Source: SGS Economics and Planning 2019

2.4 Implications on Water and Sewer Modelling

The current EDQ (SGS) projections for the Greater Flagstone PDA are similar (±10%) in total to that used by Logan Water for the 2019 strategy for the future growth horizons, as shown in Table 2-13 below.

Table 2-13 Comparison of Revised Growth Projections for Greater Flagstone with Logan Water's 2019 Strategy Projections

Year	2019 Strategy EP1	SGS Population EP	SGS Jobs EP	Total SGS PDA EP	Difference %
Existing (2018)	3,919	944	1,046	1,989	-49%
2021	14,728	5,791	2,002	7,792	-47%
2026	25,082	20,312	5,187	25,499	2%
2031	41,835	35,741	8,797	44,538	6%
2036	58,555	51,765	12,547	64,312	10%
2041	95,933	70,548	16,942	87,490	-9%
2046		86,312	20,631	106,943	
2051		101,586	24,205	125,791	
2056		115,827	27,537	143,365	
2061		131,318	31,162	162,480	
Ultimate 2066	165,357	145,099	34,387	179,486	9%

Note: Logan South Water and Sewerage Strategy Update (LoganWIA Task LS-025, 2019)

The basis for allocation of non-residential development projections was unclear in the Logan Water strategy where projections for gross floor area, which were the basis of equivalent person (EP) estimation, were not apparent. The SGS projections provide for non-residential growth in terms of jobs and the assumption of 1 EP per job has been used in this study to generate the total EP load.

The revised PDA ultimate population projections are within 10% of each other and follow a very similar trajectory of growth over the planning horizons. While this variance is unlikely to have a material impact on the municipal water and wastewater infrastructure that is the subject of this study, it may have an impact on Sub-Regional infrastructure such as water and wastewater treatment plant capacity, timing and cost. However, the most significant discrepancy in growth forecasts is at the ultimate planning horizon and therefore there is sufficient time to adjust the planning and staged upgrades of these facilities if required.

Another issue to note is that the difference in population projections between the SGS projection and that used by Logan Water for the 2019 strategy is primarily due to a significant increase (around 70%) in the non-residential EP as a result of the more conservative assumption of 1 EP per job. As greater clarity is gained on the nature of non-residential growth in the PDA, this assumption should be reviewed, and any specific impacts of this assumption be addressed in further stages of planning.

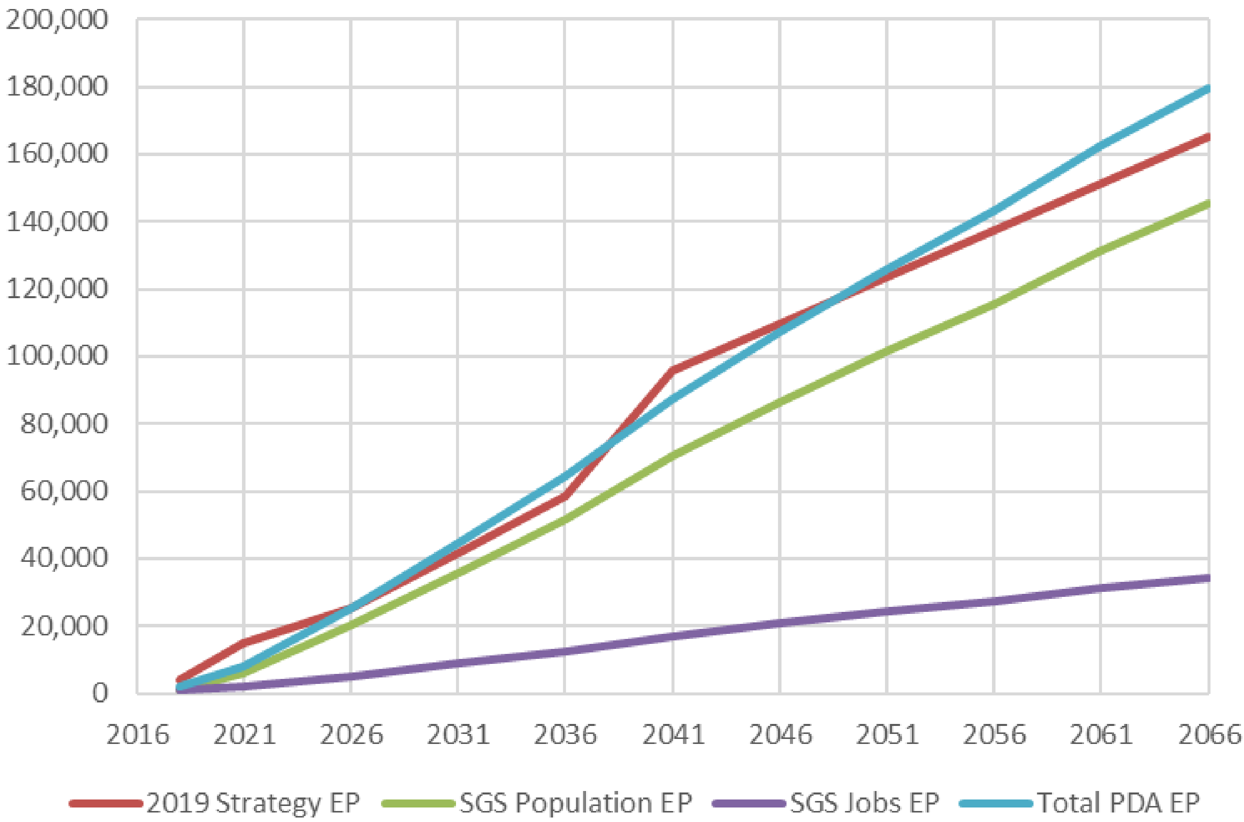


Figure 2-6 Greater Flagstone PDA Population and Employment Projections

The SGS demographic projections break down the population and employment projections for the Greater Flagstone PDA into 183 VLC travel zones. The analysis assumed when the zone population reached 50, servicing infrastructure was required which then determined the timing of servicing infrastructure. Figure 2-7 shows the resultant timing of development across the Greater Flagstone PDA.

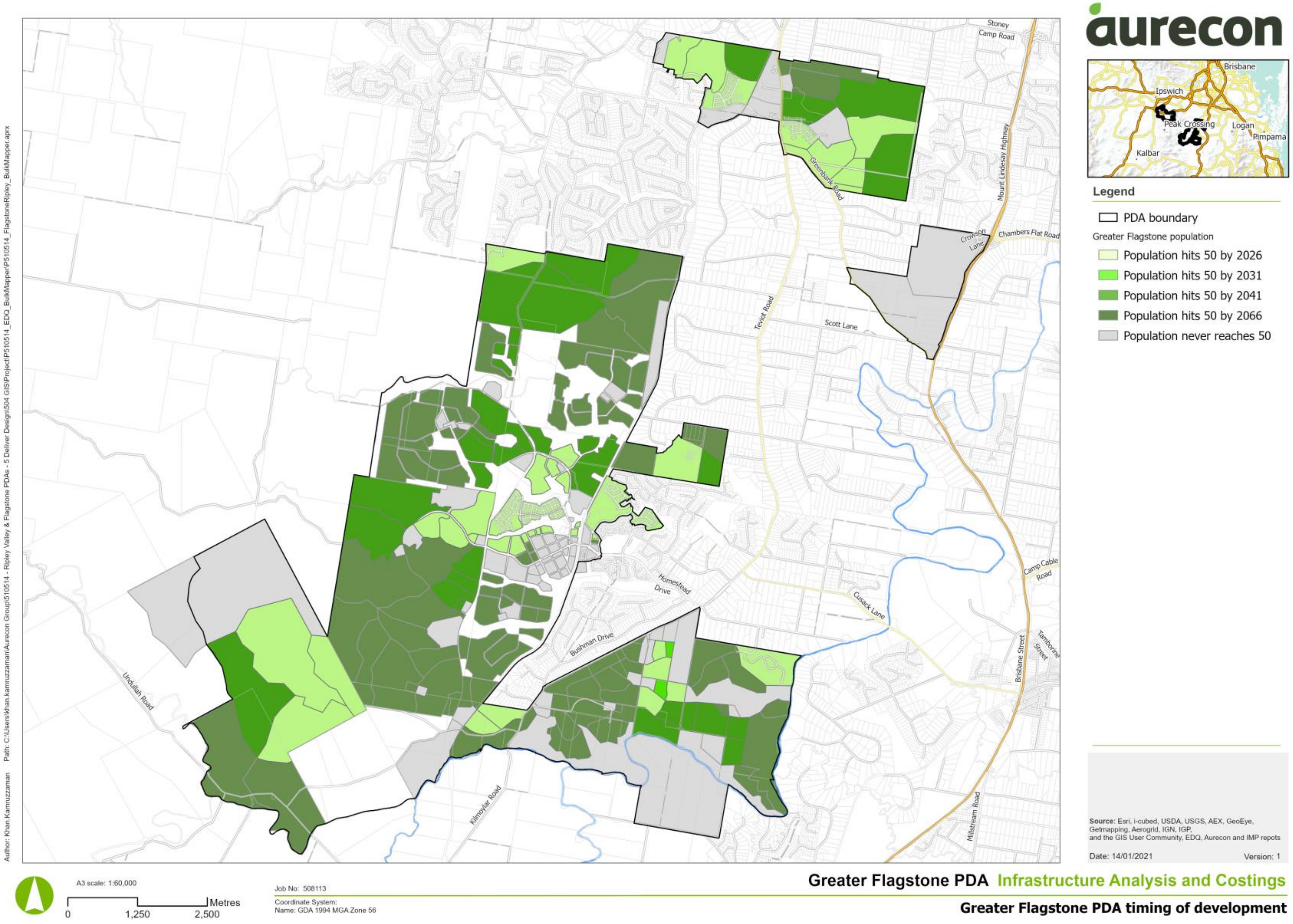


Figure 2-7 Greater Flagstone PDA Timing of Development

3 Water Supply

The water servicing strategy for the Greater Flagstone PDA prepared by Logan Water in 2019 has been reviewed to ensure that the identified infrastructure is adequate to service the forecasted growth to 2066 (ultimate scenario).

The review generally agreed with the proposed augmentations based on Logan Water's published Water Network Desired Standards of Service, which specifies design demand, pressures, storage and peaking factors. The planned network identified by Logan Water was then updated to incorporate the available Infrastructure Master Plans (IMP) for the available developments to provide a more detailed/up to date planned network.

There are currently four Water Supply Zones (WSZ) in the Southern Water Plan Area (WPA). These include:

- Spring Mountain
- Travis Road
- Round Mountain
- Woodhill.

Currently the Round Mountain Reservoir services the entire southern supply region. Therefore, Spring Mountain, Travis Road and Woodhill WSZs are all fed by the Round Mountain Reservoir WSZ. The Southern WPA study area, WSZs and major development areas are shown in Figure 3-1

Figure 3-1. A map of the southern WPA existing water network and water supply zones is presented in Figure 3-2Figure 3-2. A schematic of the water supply network is also provided in Figure 3-3Figure 3-3.

Figure 3-1 Southern WPA Study Area, WSZs and Major Development Areas

Note: Flinders Balance is not part of the Greater Flagstone PDA but will be supplied via infrastructure within the PDA.

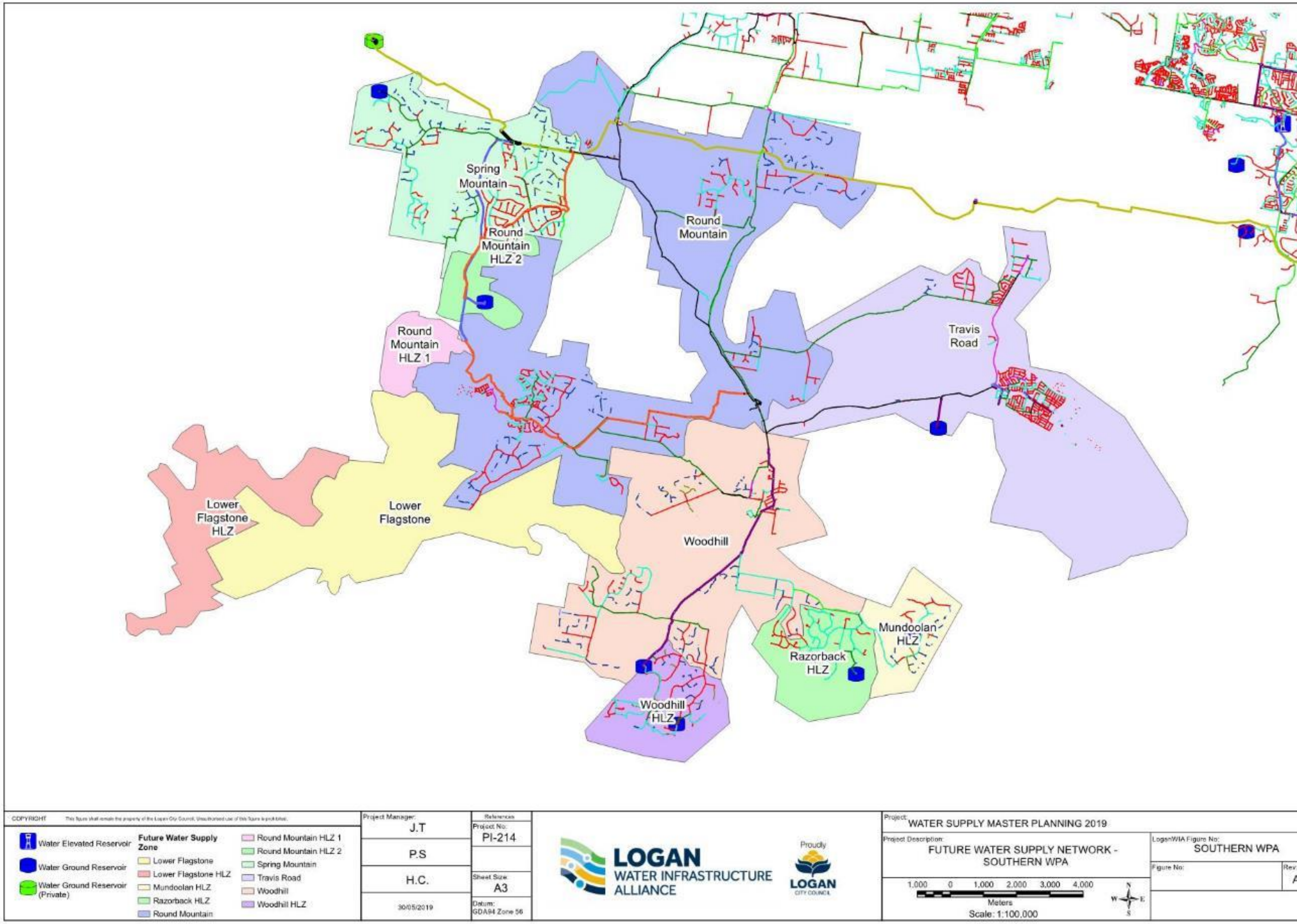


Figure 3-2 Southern Water Planning Area Existing Water Network and Water Supply Zone Map

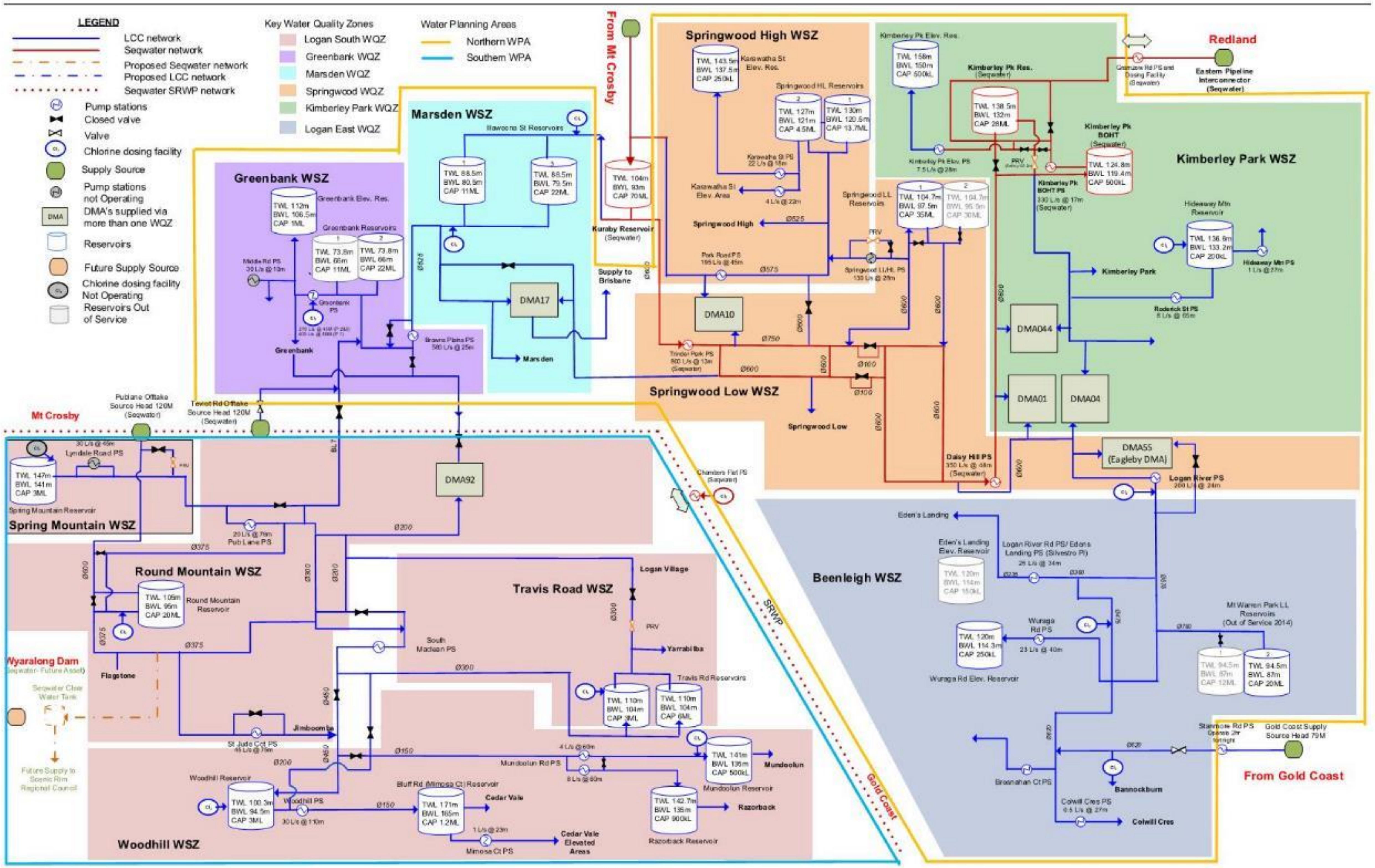


Figure 7-1: Water Network Schematic

LOGAN WATER INFRASTRUCTURE ALLIANCE

Figure 3-3 Logan Water Supply Network Schematic

3.1 Reference Standards

The following standards were referenced for the purposes of planning the Municipal water supply infrastructure in the Greater Flagstone PDA:

- Water Supply Code of Australia Version 3.1, April 2011, last updated August 2018 (WSA 03-2011)
- Southeast Queensland Water Supply and Sewerage Design and Construction Code, July 2013 (SEQ Code)
- Logan Water Desired Standards of Service (DSS) as defined in the Logan Water Desired Standards of Service Review, December 2018.

3.2 Past Reports and Development IMPs

The following Logan Water servicing strategies and reports have been referenced in this analysis:

- Infrastructure planning reports undertaken by Logan Water:
- Logan South Water and Wastewater Strategy Update (LoganWIA Task LS-025, 2019)
- Logan South Local Area Plan (LoganWIA Task PI-176, 2019)
- Logan South - Greenbank Water Servicing Strategy (LoganWIA Task LS-021, 2018)
- Logan South - Water Servicing Strategy Review (LoganWIA Task LS-018, 2018)
- Water Mater Planning 2019 (LoganWIA Task PI-214, 2019)
- Water Master Planning (LWA Task 90-13-08, 2015).
- Infrastructure master plans (IMPs) prepared for the major developments:
- Flagstone City IMP (April 2014)
- Flinders IMP (March 2018)
- Greenbank, Mirvac IMP (April 2020)
- Jimboomba, Celestino IMP (April 2017)
- New Beith IMP (October 2019)
- Teviot Village, Covella IMP (July 2020)
- Orchard Pebble Creek IMP (August 2018)
- Undullah IMP (December 2016).

It is noted that a number of the IMPs have been superseded by the Logan South Water and Wastewater Strategy Update (November 2019) that provides the latest version of the servicing strategy for Flagstone PDA.

3.3 Desired Standards of Service

The Logan Water Desired Standards of Service (DSS) were used for assessing existing network capacities and for sizing new infrastructure. The DSS were sourced from a Review of the Desired

Standards of Service (LoganWIA 2018). The key criteria for the water supply infrastructure planning are detailed in Table 3-1.

This review concluded that unit demands are conservative with a unit EP demand of 165 L/EP/day plus a leakage allowance 25 L/EP/day (15%). The average residential consumption for Southeast Queensland was 169 L/p/d (1 July 2015) with the majority internal demand and the median state-wide leakage of 5.1%. In conclusion the adopted demand assumptions are assessed as reasonable.

Table 3-1 Greater Flagstone PDA water network planning parameters

<table>
<tr><th colspan="5">Key Elements from The Water Network Desired Standards of Service (DSS)</th></tr>
<tr><th>Parameter</th><th colspan="4">Criteria</th></tr>
<tr><th colspan="5">Water demand</th></tr>
<tr><td>Average Day Demand (ADD)</td><td colspan="4">On demand areas – 190 L/EP/d. Based on 165 L/EP/d residential consumption + allowance for leakage/losses (25 L/EP/d)</td></tr>
<tr><td>Peaking factors</td><td>Category</td><td>MDMM/AD</td><td>MD/AD</td><td>PH/AD</td></tr>
<tr><td rowspan="5">Guidance Note:
Peaking factors are to be applied to the residential component of demand, i.e. 165 and 120 L/EP/d. Leakage/loss levels will remain constant throughout all demand categories and should only be appended after any peaking escalation has occurred</td><td>Residential detached</td><td>1.3</td><td>1.7</td><td>3.1</td></tr>
<tr><td>Residential attached</td><td>1.3</td><td>1.6</td><td>2.6</td></tr>
<tr><td>Commercial</td><td>1.2</td><td>1.3</td><td>2.0</td></tr>
<tr><td>Industry</td><td>1.2</td><td>1.3</td><td>1.7</td></tr>
<tr><td>Parks/open space</td><td>1.2</td><td>1.3</td><td>1.7</td></tr>
<tr><td>Bulk supply and reticulation</td><td colspan="4">3 days of MDMM. Reservoirs to have a net positive inflow and capable of continuous operation and not fall below the emergency level
3 days of MD. Reservoirs should not fall below the emergency level
5 days of AD. Reservoirs should fill from empty to full</td></tr>
<tr><td>Pump supplying a ground level reservoir</td><td colspan="4">MDMM over 20 hrs</td></tr>
<tr><td>Minimum operating pressure at PH</td><td colspan="4">On demand areas – 22m at the property boundary based on reservoir at minimum operating level (MOL). MOL defined as 15% of storage height or top of emergency storage</td></tr>
</table>

3.4 Stakeholder Engagement

The water servicing strategy presented in this report was developed in consultation with EDQ and Logan Water, both of which provided a significant amount of information and data to reference in this study.

Two stakeholder engagement workshops were held with EDQ and Logan Water. These were:

- Workshop 1 – Wednesday, 29 January 2020 – Aurecon reported back to EDQ and Logan Waters on progress in obtaining and collating all the relevant water planning information and data and discuss any gaps
- Workshop 2 – Monday, 24 February 2020 – present progress on water network planning, discuss outstanding gaps and issues and present draft innovation opportunities.

In addition to these structured workshops, regular communication and collaboration occurred with EDQ and Logan Water to confirm approaches and assumptions and to resolve issues as planning progressed.

3.5 Innovation by Design

Given the majority of innovation by design options available to water supply, sewerage and stormwater are collectively known as Integrated Water Management, these have been consolidated and expanded upon within Chapter 6.

3.6 Sub-Regional Water Supply Strategy

Currently the Round Mountain Reservoir services the entire southern supply region and is currently supplied from a 600mm pipeline connection to the Southern Regional Water Pipeline (SRWP) through the New Beith offtake. The Round Mountain Reservoir and trunk main augmentations in Logan South completed prior to 2015 provide significant capacity to facilitate initial growth in the area.

The SEQ water bulk water supply masterplan includes the integration of the Wyaralong WTP as a source of supply into Logan South including Greater Flagstone PDA and the water grid is proposed to be implemented in four phases:

- Phase 1 – pre-Wyaralong WTP (2021 to 2027)
- Phase 2 – Wyaralong WTP stage 1 (2027 to 2036)
- Phase 3 – Wyaralong WTP stage 2 (2036-2046)
- Phase 4 – Wyaralong WTP stage 3 (post 2046).

The four phases of the Logan South / Beaudesert bulk supply strategy, which includes Greater Flagstone PDA, were identified and are described below.

3.6.1 Phase 1 – Pre-Wyaralong WTP (2021 to 2027)

Infrastructure identified for Phase 1 includes a pipeline connecting the Logan South network to clear water storage tanks (total volume 18 ML) located on the Wyaralong WTP site. Water will then be pumped to the Beaudesert network. Once the pipeline is complete, the existing Beaudesert WTP will be decommissioned. Supply to both the Logan South and Beaudesert network during this phase will be from the Southern Regional Water Pipeline (SRWP) connection at New Beith.

3.6.2 Phase 2 – Wyaralong WTP stage 1 (2027 to 2036)

During this phase, Stage 1 of the Wyaralong WTP (sized to 30 ML/day) will supply both Beaudesert and the Round Mountain Reservoir supply zones. Based on current projections, this will have sufficient capacity to meet the projected Logan South (Round Mountain reservoir) and Beaudesert demands until 2036. The timing of the Wyaralong Stage 1 WTP has been scheduled to be delivered by 2027 due to Seqwater asset planning and funding rules as outlined in the Asset Portfolio Master Plan (APMP) 2019.

3.6.3 Phase 3 – Wyaralong WTP stage 2 (2036-2046)

This phase increases the size of the Wyaralong WTP to 75 ML/day. Flows from the Wyaralong WTP will supply Beaudesert, the Round Mountain Reservoir and a new Lower Flagstone Reservoir (11 ML). Excess water will be exported to the SRWP. The Wyaralong Interconnector Pipeline (WIP) will also be constructed as part of this stage.

3.6.4 Phase 4 – Wyaralong WTP stage 3 (post 2046)

This phase increases the size of the Wyaralong WTP to 120 ML/day. Flows from the Wyaralong WTP continue to supply Beaudesert, the Round Mountain and Lower Flagstone Reservoirs, with excess water exported to the SWRP.

It is also anticipated that a new SRWP offtake at Chambers Flat Road to supply Travis Road reservoir will be required in 2024 to support the growth within the Yarrabilba PDA.

The proposed ultimate water supply strategy for Logan South is shown in Figure 3-4Figure 3-4.

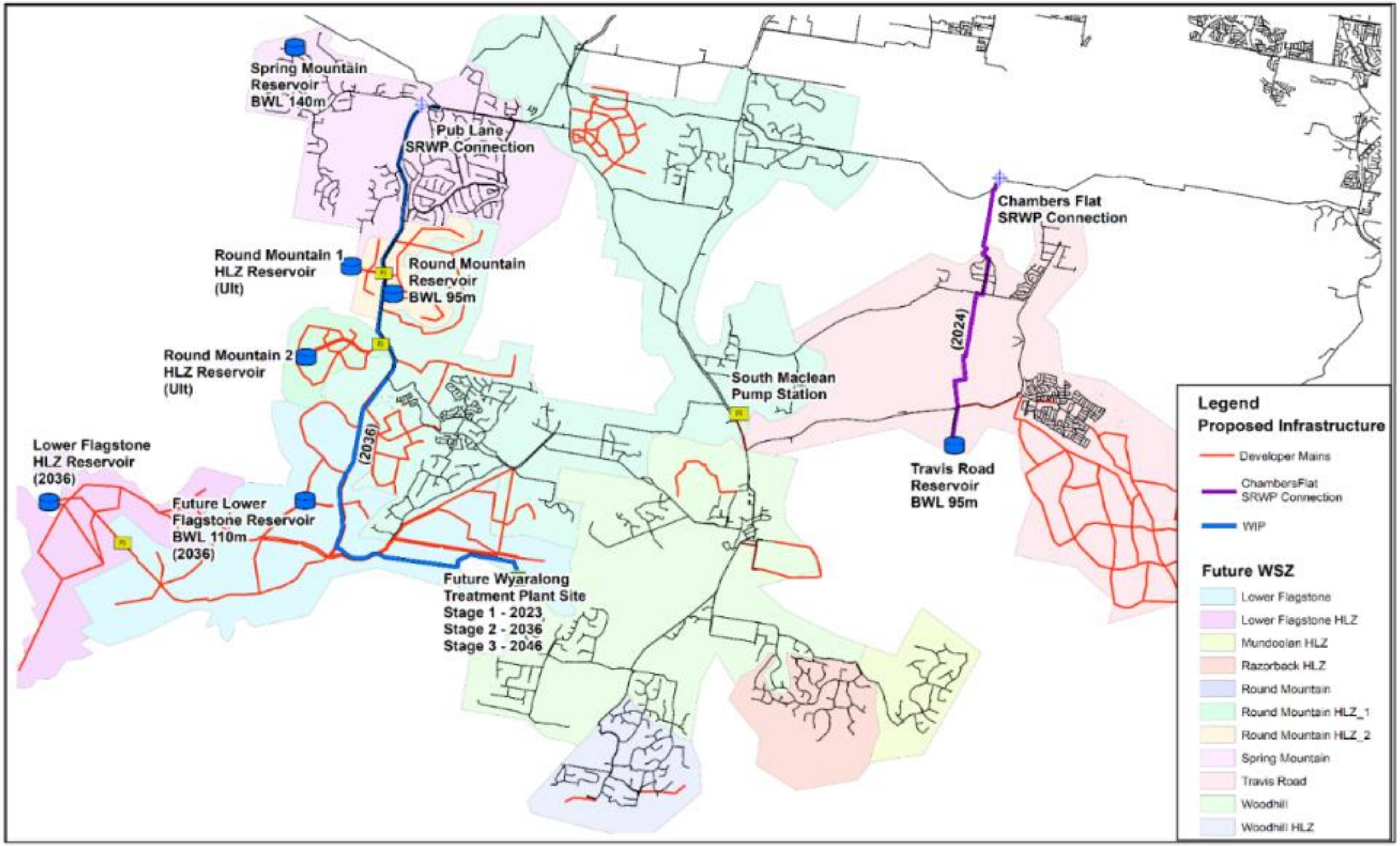


Figure 3-4 Proposed Ultimate Water Supply Strategy for Logan South

3.7 Servicing Strategy

Supply to the Greater Flagstone PDA as outlined above is from the regional water grid pipeline running through the PDA. Initial supply is from the Southern Regional Water Pipeline connection to the north of the PDA. This supply will be progressively augmented from the development of the proposed Wyaralong WTP to the south of the PDA as part of the regional water grid.

Greater Flagstone PDA is currently supplied from Round Mountain Reservoir and ultimately will be supply by five discrete zones servicing the PDA (see Figure 3-4Figure 3-4 above):

- Round Mountain
- Round Mountain HLZ_1
- Round Mountain HLZ_2
- Lower Flagstone
- Lower Flagstone HLZ

In addition to the five major supply zones, a local boosted zone from the Round Mountain supply, Pub Lane Boosted Zone, will be established to service the high-level zone within Greenbank area as identified in the Greenbank Water Servicing Strategy report (LoganWIA LS-021).

The downstream infrastructure, including pumps, high-level zone (HLZ) reservoirs and trunk distribution pipelines in the PDA are identified as Municipal infrastructure servicing the PDA. The proposed Municipal water network is based on the proposed water supply network in Logan Water's 2019 servicing strategy, updated with the inclusions of the developments IMPs that provide more detailed/up to date information.

The approach to infrastructure staging involved overlaying the ultimate water network on the timing of development across the Greater Flagstone PDA based on the population projections. The population and employment projection for Greater Flagstone is distributed into 183 VLC transport zones. The water network planning analysis assumed that when the zone population reached 50, servicing infrastructure is required. This assumption then determined the timing of the infrastructure.

Generally, the analysis bought forward some works associated with development of the north and east of the PDA and deferred some works in the centre and south of the PDA. Further review is recommended to consider proposed developer IMP sequencing. The main supply infrastructure remained unchanged in timing given the alignment in population projections.

Table 3-2 summarises the Municipal water pipeline infrastructure required at each planning horizon while Table 3-3 captures the Municipal water reservoirs and pump stations timing.
The DCOP excludes the following:

- Existing infrastructure that has been implemented through to 2020.
- Reticulation infrastructure, including pipes which are less than 225 mm nominal diameter water main sizes.
- Sub-regional infrastructure (as identified in the Sub-Regional Infrastructure Agreement) and bulk supply (Seqwater) assets that provide a broader strategic servicing function within and/or beyond the extent of the PDA.

Table 3-2 Greater Flagstone Valley PDA – Municipal water pipeline requirements and timing

Nominal Diameter	Quantity (m)				
	2026	2031	2041	Ultimate	Total
225	5,965	817	9,397	4,588	20,767
250	6,019	1,371	7,094	5,233	19,717
300	5,973	2,781	5,063	6,712	20,529
375	8,664	0	2,012	3,716	14,392
450	0	0	1,167	721	1,888
525	0	0	579	0	579
600	0	0	0	0	0
Total	**26,621**	**4,969**	**25,312**	**20,970**	**77,872**

Table 3-3 Greater Flagstone PDA – Municipal Water Reservoirs and Pump Station Timing

Item	2026	2031	2041	Ultimate
Flow Control & Pressure Reduction Valves	-	-	1 (PRV)	-
Water Pump Station1	3	-	5	3
Flinders HLZ Reservoir	-	-	1.5ML	-
Round Mountain HLZ_1 Reservoir	-	-	-	3ML
Round Mountain HLZ_2 Reservoir	-	-	-	4ML

Notes: 1. Water pump stations:

- 2026 = 2 x 5kW, 1 x 14kW ; 2041 = 2 x 12kW, 1 x 17kW, 1 x 26kW, 1 x 40kW; 2066 = 2 x 5kW, 1 x 40kW

3.8 Adopted Water Network

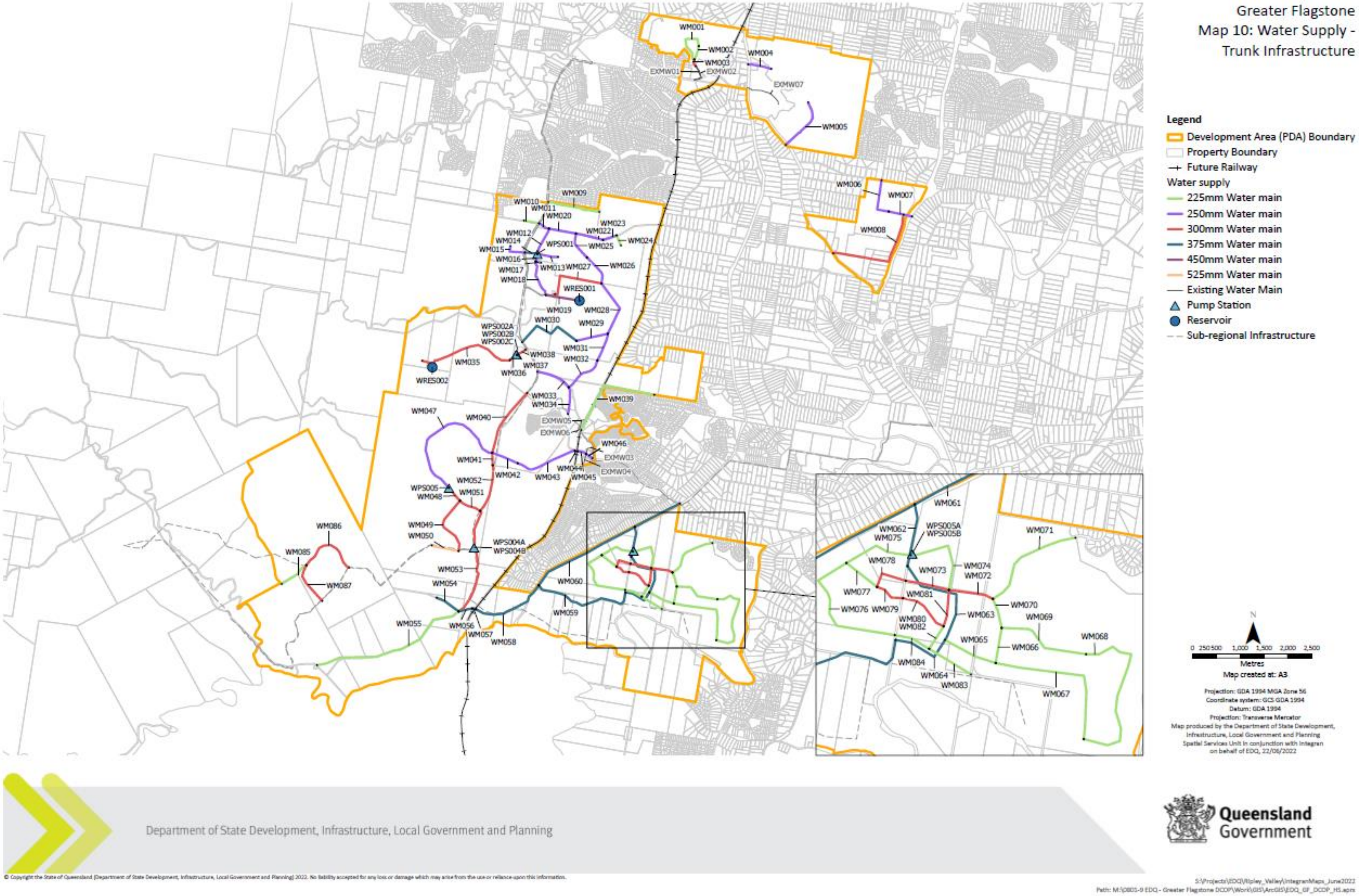


Figure 3-5 Greater Flagstone PDA Water Network

3.9 Opinion of Cost

Rider Levett Bucknall (RLB) were engaged to develop an opinion of the cost of water infrastructure to service the Greater Flagstone PDA. The quantities of water infrastructure were derived from the updated network plan developed as part of this study. Municipal costs for Greater Flagstone PDA were then extracted from the RLB estimates and inserted into the Financial Offset Model per planning horizon, the summaries of which can be found within the Schedule of Works containing within the body of this Infrastructure Planning Background Report (IPBR)

3.10 Cost Apportionment

Water supply infrastructure for the Greater Flagstone PDA falls within two main supply zones, being Round Mountain WSZ and Lower Flagstone WSZ that are fed by the Seqwater grid network.

Grid infrastructure by Seqwater is not directly funded by development contributions but recovered through water use by customers. All Sub-Regional infrastructure is apportioned to the PDA by percentage of ultimate population using the infrastructure. Municipal infrastructure that is to service growth within the PDA, including that within the local high-level zones, is anticipated to be delivered by the developers and fully apportioned to the PDA. It is noted that there is the opportunity to rationalize the Municipal network to the south-west of the PDA to provide capacity for the Flinders Balance area (urban area outside the PDA). It is recommended that further discussion be held with Council to explore this option and relative cost apportionment.

4 Sewerage

Greater Flagstone Priority Development Area (PDA) lies within Logan City Council's sewerage servicing area. The existing communities within the PDA are currently serviced by the Cedar Grove Wastewater Treatment Plant (WWTP). A schematic layout of the current Logan South Wastewater Network, including Cedar Grove WWTP, is presented in Figure 4-1.

The sewerage servicing strategy for the Greater Flagstone PDA identified in the regional strategy report prepared by Logan Water in 2019 has been reviewed to ensure the that the identified infrastructure is adequate to service the forecasted growth to 2066 (ultimate scenario).

The review generally agreed with the proposed augmentations based on Logan Water's published Water Network Desired Standards of Service, which specifies design demand, peaking factors and system performances. However, the planned network identified by Logan Water has been updated to incorporate the available infrastructure developments master plans that provide more detailed/up to date information.

4.1 Reference Standards

The following standards were referenced for the purposes of planning the Municipal sewerage infrastructure in the Greater Flagstone PDA:

- Gravity Sewer Supply Code of Australia Version 3.1, July 2014 (WSA 02-2014)
- Southeast Queensland Water Supply and Sewerage Design and Construction Code, July 2013 (SEQ Code)
- Logan Water Desired Standards of Service (DSS) as defined in the Logan Water Desired Standards of Service Review, December 2018.

4.2 Past Reports and Development IMPs

The report has been informed by the following studies:

- Infrastructure planning reports undertaken by Logan Water:
- Logan South Water and Wastewater Strategy Update (LoganWIA Task LS-025, 2019)
- Logan South Local Area Plan (LoganWIA Task PI-176, 2019)
- Wastewater Pump Station to Cedar Grove WWTP - Detailed Planning and Preliminary Design LS-007 FC2
- RB1 and RB2 Wastewater Pump Stations to Cedar Grove WWTP - Detailed Planning and Preliminary Design LS-014 FL1
- Greenbank Wastewater Servicing Strategy Review LS-020
- Wastewater Master Planning. PI-215 2019
- Greenbank, Flinders, Riverbend and Flagstone Temporary WWTPs LS-002
- Cedar Grove WWTP Effluent Management Strategy LS-003
- Economic Development Queensland, Infrastructure Charges Offset Plan (ICOP) 2019
- Infrastructure master plans (IMPs) prepared for the major developments:

- Flagstone City–IMP (April 2014)
- Flinders IMP (March 2018)
- Greenbank, Mirvac IMP (April 2020)
- Jimboomba, Celestino IMP (April 2017)
- New Beith IMP (October 2019)
- Teviot Village, Covella IMP (July 2020)
- Orchard Pebble Creek IMP (August 2018)
- Undullah IMP (December 2016).

It is noted that a number of the IMPs have been superseded by the Logan South Water and Wastewater Strategy Update (November 2019) that provides the latest version of the servicing strategy for Flagstone PDA

4.3 Desired Standards of Service

The Logan Water Desired Standards of Service (DSS) were used for assessing existing network capacity and for sizing new infrastructure. The DSS are sourced from Review of Desired Standards of Service (LoganWIA 2018). The key criteria for the infrastructure planning are detailed in Table 4-1.

Table 4-1 Greater Flagstone PDA Sewer Network Planning Criteria

Parameter	Criteria
Average Dry Weather Flow (ADWF)	165 L/EP/day
Non-residential demand	1 job = 1 EP
Peak Wet Weather Flow (PWWF)	1000 L/EP/day
Maximum depth of flow	75% for planned pipes Up to 1m below MH surface level and no spillage through overflow structures 100% for existing pipes
Pump station and rising main analysis	Maximum velocity: 3m/s
Emergency Storage analysis	Minimum storage volume equivalent to 2 hours PDWF*

**Based on the previous version of DSS for simplicity (as considered adequate for the level of planning and size of PSP catchments)*

4.4 Stakeholder Engagement

The sewerage servicing strategy presented in this report was developed in consultation with EDQ and Logan Water, both of which provided a significant amount of information and data to reference in this study.

Two stakeholder engagement workshops were held with EDQ and Logan Water. These were:

- Workshop 1 – Wednesday, 29 January 2020 – Aurecon reported back to EDQ and Logan Waters on progress in obtaining and collating all the relevant water planning information and data and discuss any gaps
- Workshop 2 – Monday, 24 February 2020 – present progress on water network planning, discuss outstanding gaps and issues and present draft innovation opportunities.

In addition to these structured workshops, regular communication and collaboration occurred with EDQ and Logan Water to confirm approaches and assumptions and to resolve issues as planning progressed.

4.5 Innovation by Design

Given the majority of innovation by design options available to water supply, sewerage and stormwater are collectively known as Integrated Water Management, these have been consolidated and expanded upon within Chapter 6.

4.6 Regional Sewerage Strategy

The sewerage strategy updated in 2019 by Logan Water to service Logan South, including the Greater Flagstone PDA, was reviewed to accommodate the revised SGS growth projections to 2066.

The review generally agreed with the proposed augmentations based on Logan Water's published Water Network Desired Standards of Service, which specifies design demand, peaking factors and system performances. However, the planned network identified by Logan Water has been updated to incorporate the available infrastructure developments master plans that provide more detailed/up to date information.

Current Sub-Regional sewerage infrastructure identified to service the Greater Flagstone PDA is shown in Figure 4-1. The infrastructure includes Stage 1 infrastructure, delivery of which commenced in 2018, and future works proposed at various planning horizons to service the various development areas within the PDA. The trigger for these works is based on trigger levels of population growth within the PDA and revised SGS population projections are within 10% of Logan Water's projections so the timing of these regional and sub reginal works is not expected to change.

The first stage of Cedar Grove WWTP, which has a capacity of 20,000 EP, has being commissioned in July 2020. The catchment previously serviced by the temporary Flagstone WWTP have been diverted to Cedar Grove and the temporary plan is being decommissioned. All future growth within the Greater Flagstone PDA will also be serviced by Cedar Grove.

Based on current growth forecasts, a second stage of the WWTP will be required by 2024. To ensure the second stage caters for a reasonable period of growth a capacity of 40,000 EP has been assumed. This will cater for about 10 years of growth, including the diversion of the Jimboomba catchment in 2026.The Cedar Grove WWTP will be progressively upgraded to an ultimate treatment plant capacity will be 196,700 EP (32.4 ML/day ADWF) which will be constructed in five stages.

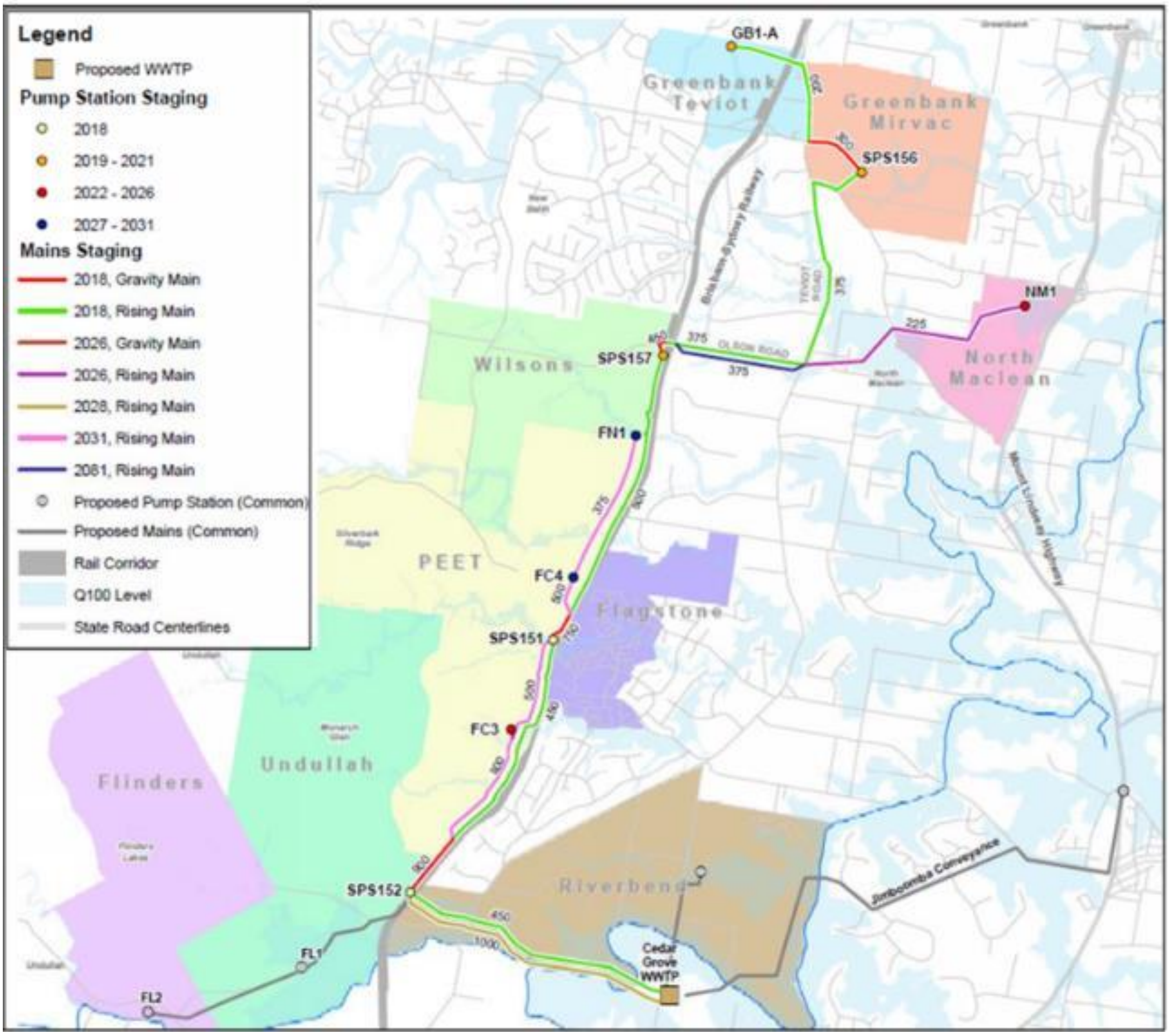


Figure 4-1 Greater Flagstone PDA current and proposed sewer network

4.7 Growth Distribution and Network Layout

The SGS demographic projections broke down the population and employment projections for Greater Flagstone PDA into 183 VLC transport zones.

The assumption that 1 job is equal to 1EP has been applied for the sewer demand model. This assumption has been considered acceptable based on the limited proportion of employment over the residential component (approximately 10%).

The sewer network planning analysis assumed when the zone population reached 50, servicing infrastructure is required which then determined the timing of the infrastructure.

Figure 4-2 below shows the proposed Greater Flagstone PDA Municipal sewer network overlaid on the resultant timing of development across the Greater Flagstone PDA based on the SGS projections.

The sewer network presented here is based on the proposed sewer network in Logan Water's 2019 servicing strategy. The timing of infrastructure within the PDA was modified to match the new development timings.

Generally, the analysis brought forward some works associated with development of the north and east of the PDA and deferred some works in the centre and south of the PDA. The main supply infrastructure remained unchanged in timing given the alignment in population projections.

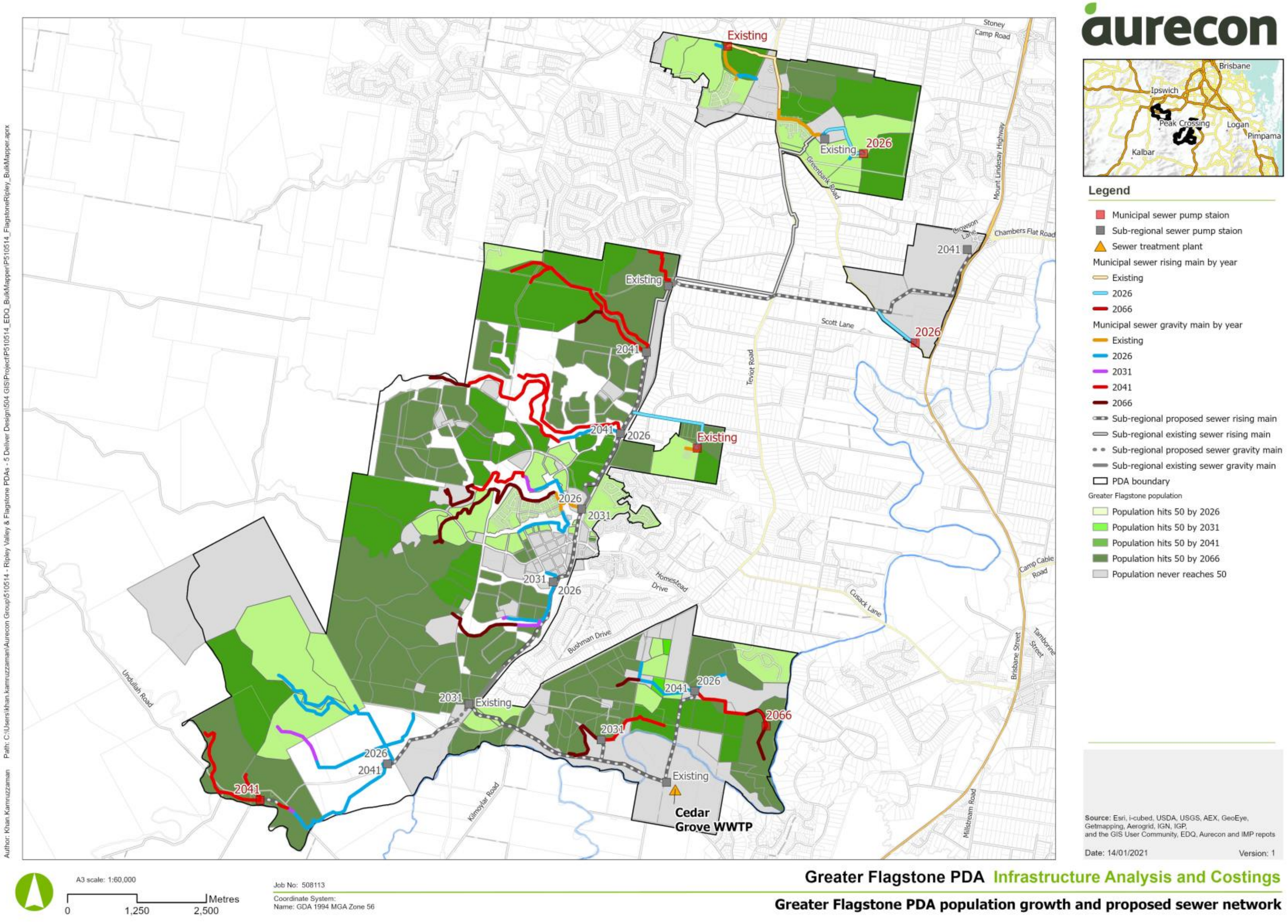


Figure 4-2 Greater Flagstone PDA Population Growth and Proposed Sewer Network

4.8 Catchment Analysis (Characteristics and Constraints)

There are currently two WWTP catchments in Logan South, these are:

- Cedar Grove
- Jimboomba.

By ultimate development there will be several changes to these catchments, due to expansion of the urban footprint and inter-catchment diversions. Changes to the catchments include expansion of Cedar Grove WWTP to service the entirety of the Greater Flagstone PDA, the urban development area west of the PDA and Jimboomba and the decommissioning of the existing Jimboomba WWTP. The Cedar Grove WWTP catchment that services the Greater Flagstone PDA and surrounding areas is shown in Figure 4-3.

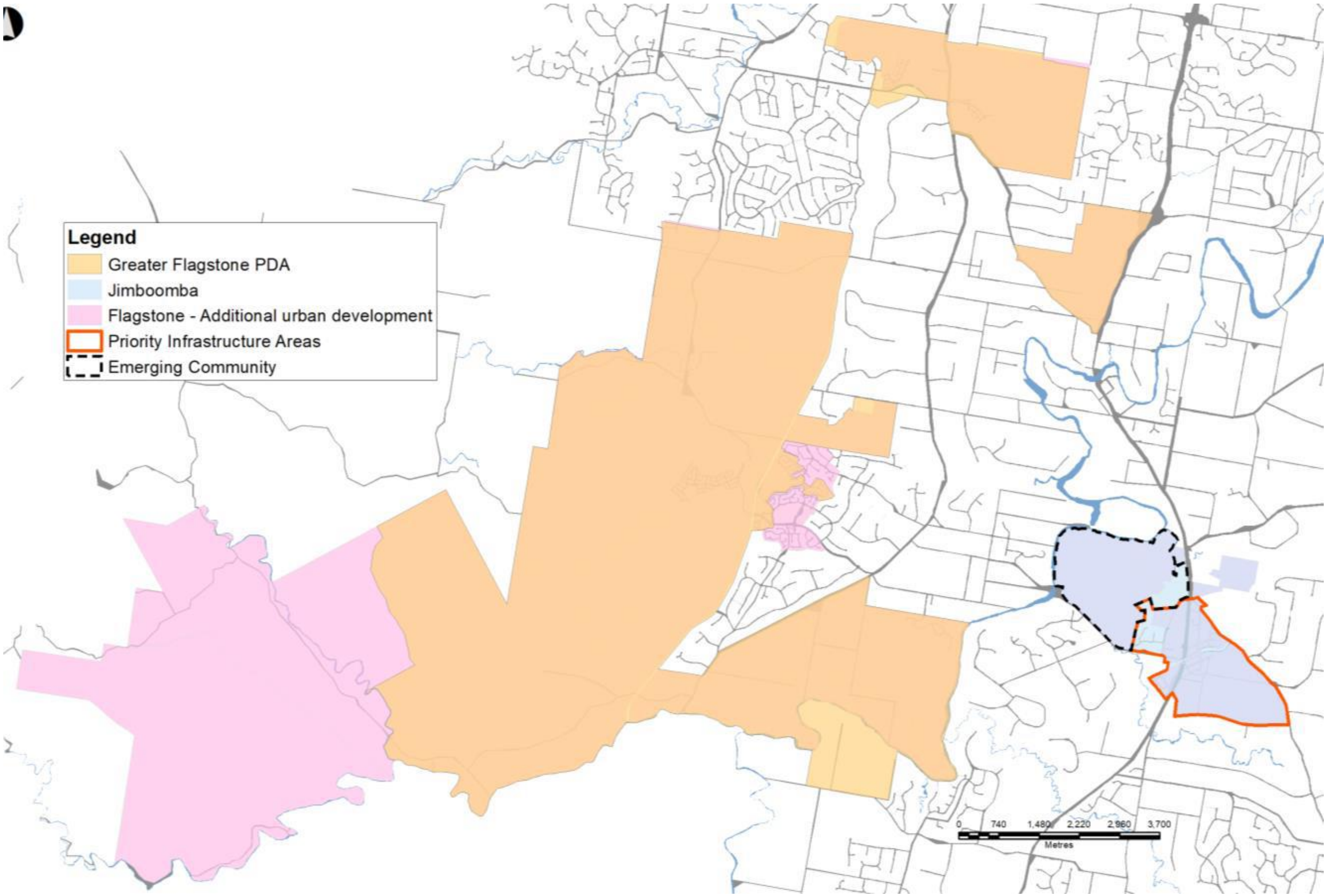


Figure 4-3 Cedar Grove WWTP Ultimate Service Area and Sewerage Catchments

4.9 Servicing Strategy

The sewerage strategy identified by Logan Water in 2019 has been reviewed and confirmed. The proposed network layout to service the Greater Flagstone PDA at ultimate scenario is shown in Figure 4-3. The key infrastructure (Sub-Regional Infrastructure) as outlined in Logan Water Wastewater Master Planning PI-215 and update in LS 025 are summarised below.

4.9.1 2021 Sub-Regional Network

Key infrastructure in the Cedar Grove catchment by 2021 includes:

- Stage 1 works connecting the Greater Flagstone PDA communities (Greenbank and Flagstone City) to the Cedar Grove WWTP. This includes 5 pump stations and associated rising and gravity mains. These works have been completed in 2020

4.9.2 2026 Sub-Regional Network:

Key infrastructure that is required in the Cedar Grove catchment by 2026 includes:

- Construction of the FL1 and RB1 pump stations and associated rising mains and receiving gravity mains to provide service for growth within the Flinders Lakes and Riverbend areas. FL1 will discharge to SPS152(RB2) and RB1 will inject into the SPS152(RB2) rising main
- Construction of FC3 and FC4 Pump Station and associated rising main to service growth in the central areas of the PDA.

Construction of NM1 pump station and rising main to service growth in the North Maclean portion of the PDA. This Pump Station will inject into the GB2(SPS156) rising main.

4.9.3 2031 Sub-Regional Network: Key infrastructure that is required in the Cedar Grove catchment by 2031 includes:

- SPS151, SPS152, SPS157 and FC3 SPSs upgrades to cater for continued growth and expansion of the Flagstone PDA.
- Construction of RB2-2 pump station, rising main and receiving gravity system to provide service for growth the south-eastern area of the Flagstone PDA. This Pump Station will inject into the RB2-1(SPS152) rising main.

4.9.4 2036 Sub-Regional Network

Key infrastructure that is required in the Cedar Grove catchment by 2036 includes:

- FL1 and RB1 SPSs upgrades to cater for continued growth
- Construction of FL2(PS8) Pump Station, rising main and receiving gravity system to provide service for growth in the Flinders portion of the Flagstone PDA. This pump station will discharge to the gravity system upstream of the FL1 pump station.

4.9.5 2041 Sub-Regional Network

Key infrastructure that is required in the Cedar Grove catchment by 2041 includes:

- Construction of FN1 pump station and rising main to cater for in the northern areas of the Flagstone PDA. This pump station will be injected into the FN2(SPS157) rising main and then be transferred to the receiving gravity system upstream of the FC4 pump station.

- FC4, FN1 and NM1 SPSs upgrades to cater for continued growth.

4.9.6 Municipal Infrastructure

Table 4-2 to Table 4-3 summarises the Municipal sewer infrastructure required at each planning horizon. The DCOP does not include the following:

- Existing infrastructure that has been implemented through to 2020
- Reticulation infrastructure including the following:
- Gravity sewer pipes which are less than 300mm nominal diameter
- Sewer pump stations and rising mains servicing a catchment of less than 2,500EP.
- Sub-regional infrastructure that provides a strategic servicing function within and/or beyond the extent of the PDA as identified in the Sub-Regional Infrastructure Agreement (SRIA).

Table 4-2 Greater Flagstone PDA – Municipal Sewer Pipeline Requirements and Timing

Nominal Diameter	Quantity (m)				
	2026	2031	2041	Ultimate	Total
225[1]	374	-	-	-	374
300	8,034	1,440	4,210	5,669	19,353
375	1,494	77	5,748	4,269	11,589
450	2,860	5	5,162	-	8,028
525	1,372	372	1,373	-	3,117
600	213	-	2,841	-	3,054
675	396	-	-	-	396
750	1,963	118	178	-	2,259
825	548	-	-	-	548
Total	**17,255**	**2,012**	**19,512**	**9,938**	**48,718**

Note: 1. Municipal sewer excludes pipes less than 300mm nominal diameter. This DN225 is an exception that has been included as part of the Municipal network due to its Municipal function for connectivity and capacity to servicing the Greenbank Central area.

Table 4-3 Greater Flagstone PDA – Municipal Sewer Pump Station Requirements and Timing

	2026	2031	2041	Ultimate	Total
Wastewater Pump Stations[1]	2	-	1	1	4
Emergency Storages	-	-	-	-	-

Note: 1. Wastewater pump stations: 2026 = 22kW SPS & 30kW SPS, 2041 = 116kW SPS, 2066 = 32kW SPS

Table 4-4 Greater Flagstone PDA – Municipal Rising Main Requirements and Timing

Nominal Diameter	Quantity (m)				
	2026	**2031**	**2041**	**Ultimate**	**Total**
225	2,654	-	-	349	3,003
250	1,063	-	-	-	1,063
300	-	-	-	-	-
375	-	-	-	-	-
450	-	-	-	-	-
600	-	-	-	-	-
Total	**3,717**	**-**	**-**	**349**	**4,066**

4.10 Adopted Sewer Network

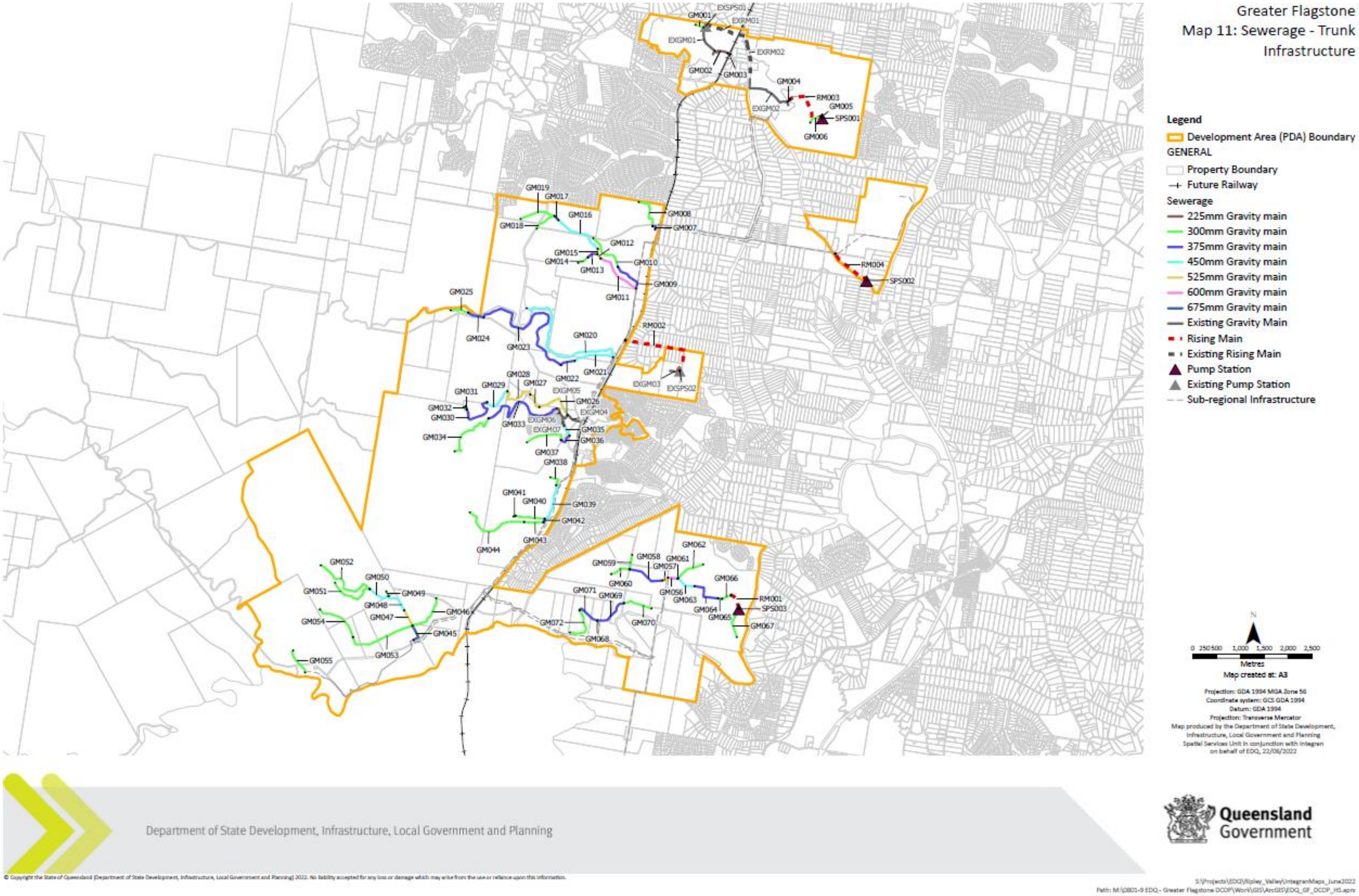


Figure 4-4 Greater Flagstone PDA Adopted Sewer Network

4.11 Opinion of Cost

Rider Levett Bucknall (RLB) were engaged to develop an opinion of the cost of sewerage infrastructure to service the Greater Flagstone PDA. The quantities of sewerage infrastructure were derived from the updated network plan developed as part of this study. Municipal costs for Greater Flagstone PDA were then extracted from the RLB estimates and inserted into the Financial Offset Model per planning horizon, the summaries of which can be found within the Schedule of Works containing within the body of this Infrastructure Planning Background Report (IPBR).

4.12 Cost Apportionment

There are a number of Municipal sewer assets subject to cost apportioning as they are proposed to service both PDA and non-PDA development in regard to the Flinders Balance area (beyond the south-west extent of the PDA boundary). This includes the following Municipal assets, which are located upstream of the FL1 Sub-Regional pumping station:

- Wastewater pump station - PS8_USMH (including associated rising main)
- DN525 sewer gravity main – 315m
- DN600 sewer gravity main – 1,815m
- DN750 sewer gravity main – 2,260m
- DN825 sewer gravity main – 548m

The cost apportioning for these Municipal assets is estimated to be approximately 30% (PDA) and 70% (non-PDA). For the purposes of the DCOP the entire cost of these assets (100%) has been included within the Financial Offset Model (FOM).

Cost apportionment for the Sub-Regional Cedar Grove WWTP between PDA and non-PDA is broken down into four distinct areas:

- Greater Flagstone PDA
- Jimboomba
- Additional Urban Development (Flinders)
- Existing Flagstone.

There is other Sub-Regional sewer infrastructure located within the boundary of the PDA. Apportionment of costs for this Sub-Regional infrastructure is subject to negotiation between EDQ and Council and is beyond the scope of this report.

5 Stormwater

5.1 Reference Standards

For the Greater Flagstone Priority Development Area (PDA), Economic Development Queensland (EDQ) have developed a guideline with engineering standards for the design and construction for service infrastructure including stormwater infrastructure, PDA guideline no.13, May 2015. The document lists legislative and reference standards in relation to quantity and quality management, as follows:

- Quantity:
  - The Queensland Urban Drainage Manual (QUDM)
  - Australian Rainfall and Runoff Guideline (ARR)
- Quality:
  - Queensland Environmental Protection (Water) Policy 2009
  - Queensland State Planning Policy 2013 – water quality
  - Water by Design: Concept Guidelines for WSUD 2009
  - Water by Design: WSUD technical guidelines in SEQ 2006
  - Water by Design: Bioretention Technical Guidelines 2011
  - Water by Design: Framework for the Integration of Flooding and Stormwater Management.

The guideline states that this is a starting point for the development scheme and the development applications may specify a different standard where innovative solutions can be proposed in consultation with the Minister for Economic Development Queensland (MEDQ).

The PDA area sits within the Logan City Council local government area (LGA). The EDQ guidelines for stormwater, which refer to the guidelines listed above (as in PDA Guideline no 13) take precedent over local Council standards. Logan City Council's standards are however more comprehensive than EDQ guidelines. Where EDQ guidelines do not specify a requirement the Local Council standards are applied. Augmentation to these standards based on incorporation of innovative total water cycle management (TWCM) principles should be considered as these solutions evolve. Details of potential TWCM solutions are outlined in Chapter 11 covering innovation.

The Logan City Council local government infrastructure plan (LGIP) identifies trunk infrastructure necessary to service urban development at a desired standard of service (DSS). Part 4 of the Logan Planning Scheme stipulates the projected demand and DSS.

The document refers to several sub-sections of the planning scheme and best practice and industry standard guidelines, being:

- Quantity:
  - Institute of Public Works Engineering Australasia (2017), Queensland Urban Drainage Manual, Fourth Edition (QUDM)
  - Logan City Council, Planning Scheme Policy, Section 4.4.3.

- Quality:
  - Institute of Public Works Engineering Australasia (2017), Queensland Urban Drainage Manual, Fourth Edition (QUDM)
  - Logan City Council, Planning Scheme Policy, Section 4.4.3.

Secondary documents and data sources referenced include:

- Quality
  - Water by Design (2010), Deemed to Comply Solutions - Stormwater Quality Management (Southeast Queensland)
  - Water by Design (2010), Deemed to Comply Worked Solutions and Examples, Stormwater Quality Management (Southeast Queensland)
  - Healthy Waterways (2006), Water Sensitive Urban Design- Technical Guidelines for Southeast Queensland.

Additional data sources:

- Google Maps aerial imagery
- Topographic LIDAR data sourced from the Australian Government, Department of Industry, Science, Energy and Resources and ANZLIC Foundation Spatial Data Framework (FSDF).

5.2 Previous Reports and Developer IMP's

Several existing strategic/master planning documents and Infrastructure Master Plans (IMPs) apply across the PDA, including:

- Economic Development Queensland, Infrastructure Charges Offset Plan Maps 2019
- Greater Flagstone Local Infrastructure Plan (LIP) Version 16
- Developer infrastructure master plans.

Within the Greater Flagstone PDA there are several existing Developer Infrastructure Master Plans (IMPs) that include proposed local stormwater management infrastructure. The IMPs have been submitted for consideration from a stormwater compliance perspective and would form part of the PDA. The infrastructure proposed in these IMPs will be paid for, designed and constructed by the developer and is local infrastructure.

The PDA area currently includes areas of completed development, areas with development plans (IMPs) in place and undeveloped areas where specific plans are yet to be submitted. While the developer IMPs are in various stages of the approval process and are not yet binding on EDQ, they have been referred to as indicative of the extents of development in the PDA for the staging and catchment analysis. The IMPs have also been used to understand current planning for local stormwater management within planned developments and to identify opportunities for regional stormwater management, integration with other services and/or potential sites to incorporate innovative solutions.

The available IMPs for the Greater Flagstone PDA are presented in Figure 5-1and have been prepared by various consultants and have varied levels of detail relating to proposed stormwater quantity and quality management infrastructure. Table 5-1 summarises the IMP reports made available and the layout plans from each IMP used to support catchment analysis.

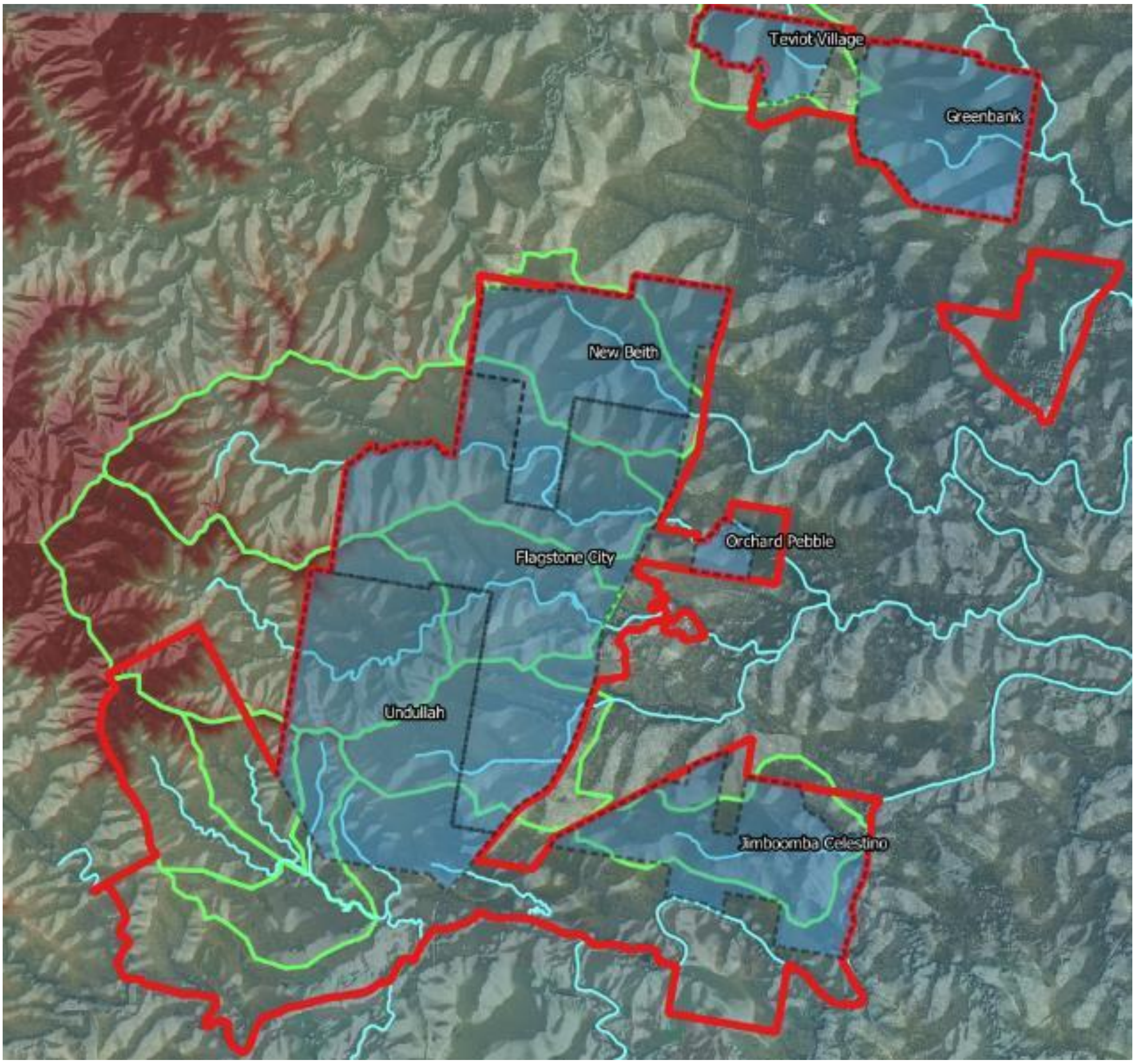


Figure 5-1 Locations of IMPs in the Greater Flagstone PDA

Table 5-1 Greater Flagstone PDA - Developer Areas, IMPs and Context Plans

Developer Name	Document Title	IMP Document	Approved or pending
Flagstone City	Flagstone City – Stormwater Infrastructure Master Plan (April 2014)	"Endorsed Stormwater Network IMP.pdf"	Approved
Flinders	Infrastructure Master Plan -Stormwater (March 2018)	"ENDORSED – Stormwater IMP_As Amended in Red.pdf"	Approved
Greenbank	Stormwater Master Plan – Teviot Road, Greenbank (November 2016)	"Approved Stormwater Master Plan.pdf"	Approved
Jimboomba Celestino	Jimboomba Celestino Master Planning Concept Stormwater Management Plan (April 2017)	"811 Approved Stormwater IMP.pdf"	Approved
New Beith Road	New Beith Road, New Beith Stormwater Infrastructure Master Plan (August 2019)	"ENDORSED Stormwater IMP.pdf"	Approved
Teviot Village	Teviot Village – Concept Stormwater Management Plan and Flood Investigation (December 2016)	"831 Approved – Concept Stormwater Management Plan and Flood Investigation.pdf"	Approved
Orchard Pebble Creek	Flood Assessment and Stormwater Management Plan (August 2018)	"5964-01_R01_V01_Flood Assessment and Stormwater Management Plan_RPEQ signed"	Approved
Undullah	Undullah (Rice, Dairy and Wyatt Roads, Undullah) – Stormwater Infrastructure Master Plan (December 2016)	"FOR ENDORSEMENT Stormwater IMP_as amended in red"	Approved

5.3 Desired Standards of Service

The desired standard of service for stormwater management for the Greater Flagstone PDA has been adopted to observe the reference standards listed in the EDQ, PDA Guideline No.13, May 2015, as well as those required by the Logan City Council. The Council requires stormwater quality and quantity standards to be maintained from pre to post development conditions at each time horizon. This is in accordance with guidelines and standards and the targets set out in the Logan City Council Planning Scheme Policy.

The Logan City Council's guidelines and compliance standards are considered a suitable benchmark for the PDAs as they represent standards that are adopted throughout Southeast Queensland and beyond. They require a high level of performance from any stormwater management measures proposed. This includes:

- Achieving a no worsening standard for stormwater quantity compared to the pre-development baseline.
- Meeting pollution reduction targets for post development stormwater runoff.

This PDA represents an opportunity to 'raise the bar' with regards to setting standards for managing stormwater. Observing the principles of integrated stormwater and total water cycle management while meeting stormwater quantity and quality requirements represents an opportunity to manage stormwater in an innovative way and provide additional benefits to the community, such as public amenity, ecological benefits, improved aesthetics in urban design and/or integration with water and wastewater infrastructure. Details of innovative approaches that could deliver these additional benefits to the future communities of Greater Flagstone PDA are outlined in Chapter 6, covering innovation.

Realising these additional benefits is likely to require careful consideration of the trade-offs with additional costs of development. The Logan City Council's guidelines are based on the Queensland Urban Drainage Manual (QUDM). QUDM was developed to strike a balance between stormwater management outcomes and cost to serve. The targets in QUDM represent the point where additional investment would lead to diminishing returns in terms of performance. Therefore, the Logan City Council's guidelines and compliance standards have been adopted for the purposes of this DCOP and the economic viability of innovations to deliver increased service outcomes should be assessed further in feasibility studies as part of the next stage of planning.

Consistent with the standards set out in QUDM, the following desired standards of service are detailed in the Logan City Planning Scheme.

- Quantity:
  - The stormwater network is to collect and convey stormwater flows for both minor and major flood events in a manner that minimises risk to property, life and reduces cost of flood damage.
  - Stormwater quantity network to be in accordance with conveyance standards:
    - Minimum capacity of combined overland and underground trunk infrastructure to be the 2% Annual Exceedance Probability (AEP) or 50yr Annual Recurrence Interval (ARI)
    - Minimum capacity of underground trunk drainage system to be the 50% AEP/2yr ARI, to be increased to 10% in some cases where flood immunity of nearby utility and living areas of dwellings is required.

  - Aboveground conveyance to be positioned to cater for flows that exceed the underground network
  - Road crossing structures to be provided to provide immunity in accordance with latest QUDM, Council's planning scheme policy and other local planning instruments.

- Quality:
  - The stormwater network is to be designed on the assumption that development achieves the water quality objectives of receiving waters at all times.
  - Retain natural waterways, wetlands and riparian corridors and observe natural channel design principles where works are required.

5.4 Stakeholder Engagement

For the preparation of this chapter, stakeholder consultation was carried out with EDQ for collation of IMP reports and collection of available master planning and development information.

Feedback from EDQ was also received regarding the required formatting of mapping and GIS outputs from the analysis completed for this report e.g. locations of proposed regional stormwater infrastructure with proposed time horizon and other attribute data attached.

The concept for the proposed methodology for identifying regional infrastructure locations and developing an opinion of costs for the updated DCOP was presented to EDQ on 10 February 2020. Feedback provided was taken into consideration in the preparation of this report, particularly around identifying the potential physical constraints that will form part of the feasibility assessment proposed for Phase 2 works.

5.5 Innovation by Design

Given the majority of innovation by design options available to water supply, sewerage and stormwater are collectively known as Integrated Water Management, these have been consolidated and expanded upon within Chapter 6.

5.6 Stormwater Infrastructure Classification

Consideration of potential infrastructure for stormwater management has been split into local measures and regional measures. The terms regional and trunk infrastructure are interchangeable terms for the purpose of this report. It has been assumed that local infrastructure would be paid for, designed and constructed by the developers with the rollout of each individual development within the PDA area. Regional infrastructure opportunities are those that could be used as an alternative to local solutions where they may be more cost effective or deliver better outcomes than several local solutions. They would be costed for estimation of financial offset contributions from developers in instances where local infrastructure treatment is not applied.

Sections 5.7 and 5.8 give an overview of typical stormwater management infrastructure that is considered as either local or regional/trunk infrastructure.

5.7 Local Infrastructure

Local stormwater infrastructure is that infrastructure that would be designed by the developer were proposing the development of an area within the PDA. Examples of this infrastructure exists within

IMPs that have been submitted to the Logan City Council for development assessment and approval. The existing IMPs are varied and contain some examples of local stormwater management infrastructure though not necessarily an exhaustive list of examples of potential measures. Typical local stormwater management features include:

- Longitudinal drainage infrastructure along roads, e.g. pits, pipes and culverts,
- Local detention basins
- Stormwater harvesting infrastructure
- Localised Water Sensitive Urban Design (WSUD) infrastructure, such as:
    - Bioretention basins
    - Rainwater tanks
    - Street side swales
    - Street tree pits and infiltration basins
    - Infiltration swales and terraces
    - Green roofs and permeable pavements.

Longitudinal drainage is the drainage infrastructure that runs adjacent to the roads within the PDA area. Cross drainage locations are locations where bridges or large culverts are positioned on waterways and drains under arterial and/or local roads.

The remaining listed typical local infrastructure including stormwater harvesting infrastructure and WSUD measures are further discussed in Chapter 6.

5.8 Regional Infrastructure

For the purpose of managing stormwater quality and quantity, the following regional infrastructure is considered appropriate:

- Constructed wetland treatment systems
- Stormwater detention basins
- Large scale stormwater treatment swales
- Waterway rehabilitation works
- Combinations of these elements.

Regional infrastructure opportunities could be funded by developer contributions in lieu of implementing local scales infrastructure.

5.9 Catchment Analysis

The catchment analysis has consisted of a desktop assessment of available information and has focused identifying potential locations for regional stormwater management infrastructure.

The purpose of this infrastructure is either for stormwater quality treatment via bioretention or wetland treatment and/or stormwater quantity control through detention.

There are two stages of planning required for the identification of appropriate regional infrastructure sites and solutions. This assessment focuses on the first stage whereby a list of potential sites has been identified for consideration. Section 5.9.2 details the methodology adopted for Phase 1 planning completed in this study.

It is recommended that the next stage of planning includes a more detailed feasibility assessment of each site and potential works. Section 5.9.4 outlines recommendations for Phase 2 planning to refine potential sites and develop a short list of practical and cost-effective regional infrastructure solutions.

5.9.1 Background Information

The available IMP documents, in combination with available spatial data, were used as the primarily sources of information. The IMPs contain many proposed sites for stormwater management at a local scale, which have also been considered in the analysis to determine if they could be considered for augmentation as a regional stormwater management facility. They also contain information relating to potential locations of parks and sporting facilities which could be integrated with regional stormwater infrastructure management solutions.

The following information was incorporated into Phase 2 planning:

- IMP development areas as indicated in the IMP reports as listed in Table 5-1
- Proposed local stormwater management infrastructure as indicated in the IMP reports listed in Table 5-1
- Details of proposed parks and open spaces as indicated in the IMP reports listed in Table 5-1
- 5m topographic LIDAR layer sourced from the Australian Government, Department of industry, Science, Energy and Resources and ANZLIC FSDF
- Google Maps aerial imagery.

5.9.2 Phase 1 – Identification of Potential Regional Infrastructure

Proposed sub-regional locations for stormwater management infrastructure have been determined by overlaying various layers of existing information. With the overlay of information, some assumptions have then been made regarding the likely staging of the construction of regional infrastructure based on the SGS growth projections discussed in Chapter 1. An analysis of the stormwater catchments contributing to each location has been used for approximate sizing of infrastructure.

The collation of data in GIS included:

- Proposed 'local' stormwater management infrastructure from IMP reports listed in Table 5-1,
- PDA boundaries as indicated in the IMP reports in Table 5-1,
- Publicly available topographic information as per the FSDF for determination of stormwater sub-catchment boundaries, and
- Google Maps aerial imagery.

Locating feasible areas for regional stormwater infrastructure, based on the following criteria:

- Locations near waterways that drain a significant catchment area,
- Locations that are nearby significant existing or proposed development,

- Locations that overlap with proposed parks and open spaces as indicated in the IMP reports as listed in Table 5-1,
- Opportunity to integrate with potential effects-based management of sewer wet weather flows and/or wastewater treatment effluent nutrient offset locations proposed by Logan City Council,
- Consideration of potential additional development areas in the PDA (i.e. with no existing IMP or proposed development plans), and
- Is there space for the regional system and is the terrain conducive, i.e. is there enough flat area where capture of significant oncoming flow can be captured and treated?

Once a list of locations was identified, analysis to determine the most suitable type of regional stormwater infrastructure was undertaken, e.g. a detention basin for quantity management, a regional swale or waterway rehabilitation opportunity for quality management, or a wetland for both water quantity and quality management.

Potential locations were mapped in GIS and a preliminary footprint size for each element was determined.

5.9.3 Phase 2 – Preliminary Sizing of Regional Infrastructure

For the purpose of estimating costs for the DCOP, preliminary sizing of regional stormwater infrastructure was undertaken. Noting that the proposed regional locations could be a water quantity (detention) and/or water quality (biofiltration or wetland) structure, an assumption was made to adopt a uniform approach to sizing.

Two potential methods for preliminary sizing of regional stormwater infrastructure sizing were considered and are listed below.

Method 1 – Sizing regional infrastructure for water quality compliance

Method 1 for sizing is based on water quality compliance. This is where a rule of thumb regarding the sizing for the active surface area of bioretention basin to reach to target pollutant reduction targets. Filtration areas are typically set between 1.5% and 2.0% of the contributing catchment area. This is based on studies completed to monitor bioretention system performance (swales and basins) across Southeast Queensland. A summary of the findings of these studies is presented in the healthy Waterways Water Sensitive Urban Design Guidelines (2006).

The guideline states that for typical bioretention configurations, and to reach the recommended pollutant removal targets e.g. 80% TSS, 60% TP and 45%TN, filtration areas of at least 1.5% of the contributing catchment area were required. It is also noted that for filtration areas of greater than 2.0% of the contributing catchment size, the rate of additional pollutant reduction reduces dramatically, representing a point of diminishing returns.

The application of this method would therefore consider the location of the regional infrastructure and nominate a required footprint to be at least 1.5% of the contributing catchment size.

Method 2 – Sizing regional infrastructure for water quantity compliance

Method 2 is based on water quantity compliance. This is where detention of the increase in runoff volume from the contributing catchment as a result of development is to be captured and slowly released. To determine the increase in peak runoff the rational method is used with some assumptions around pre and post development conditions. These flows are then taken and applied to a high-level basin sizing method, as proposed in QUDM 2006, to account for capturing the additional runoff volume created.

The application of this method requires assumptions to be made regarding contributing catchment conditions in the pre and post development condition, regarding extent of develop

It is noted that with both proposed options there are limitations to their reliability for use in the absence of rigorous design procedure, with feasibility assessment and stormwater modelling to verify performance. The method of applying the 1.5% rule for water quality is typically used for sizing of bioretention systems for smaller urbanised catchments. Similarly, the reliability of the rational method is noted to reduce for larger and rural catchment applications. These methods have been considered suitable in this instance as a preliminary guide to sizing.

Comparison of the estimated size from each method at one of the proposed regional infrastructure locations found that Method 2 estimated a larger required footprint area. Method 2 was therefore adopted, on the assumption that a system of a size sufficient to satisfy the water quantity standard would also be able to satisfy the water quality requirement.

Note that this approach is preliminary only and is not considered to be a substitute for more appropriate sizing based on detailed stormwater modelling, which we recommend be undertaken in the next stage of planning.

For the application of the Method 2 preliminary basin sizing the following assumptions were made:

- A maximum basins depth of 1m was adopted for operational safety reasons.
- No embankment width or batters were considered for footprint sizing.
- All catchments contributing to the regional infrastructure location have been assumed to be greenfield (0% impervious) for existing case and completely developed (75% impervious) for the developed case scenario.
- Regional catchment sizes have been estimated using 5m resolution publicly available topography DTM information.

Table 5-2 indicates an initial estimated footprint size for each of the potential regional infrastructure locations. Noting that this is a conservative starting point for sizing, to establish a high-level estimate of potential construction cost across the PDA.

Figure 5-2 presents the proposed regional stormwater management infrastructure locations as well as the proposed local treatment/detention basin locations from available IMPs and context plans.

Table 5-2 Potential Regional Stormwater Management Infrastructure Locations

ID	Source	Location	Proposed management approach	Estimated footprint (Hectares)
F01	Master Plan	Flagstone City Master Pan Area. Located within parkland and open space.	Detention	10.02
F02	Master Plan	Flagstone City Master Pan Area. Located within parkland and open space.	Detention	5.02
F03	New Location	Downstream of Flagstone City Master Planning Area Located within parkland and open space.	Detention	3.35
F04	New Location	Flagstone City Master Pan Area.	Detention and Bioretention	3.54

ID	Source	Location	Proposed management approach	Estimated footprint (Hectares)
		Located within parkland and open space.		
F05	New Location	Flagstone City Master Pan Area. Located within parkland and open space.	Detention and Bioretention	6.00
F06	Master Plan	Flagstone City Master Pan Area. Located within parkland and open space.	Detention and Bioretention	2.85
F07	New Location	Undullah IMP Area. Located within parkland and open space.	Detention and Bioretention	9.12
F08	New Location	Jimboomba Celestino IMP. Located within parkland and open space.	Wetland and Detention	10.07
F09	IMP Proposed/New Location	Flinders IMP Area. Located within parkland and open space.	Wetland and Detention	24.08
F10	New Location	No IMP or Master planning study. Located within parkland and open space.	Wetland and Detention	3.62
F11	New Location	New Beith IMP area. Located within parkland and open space.	Detention and Bioretention	7.14
F12	New Location	Greenbank IMP area. Located within parkland and open space.	Detention and Bioretention	3.08
F13	IMP Location	Teviot Village IMP area. Located within parkland and open space.	Detention and Bioretention	1.71
F14	New Location	No IMP or Master planning study.	Detention and Bioretention	5.37

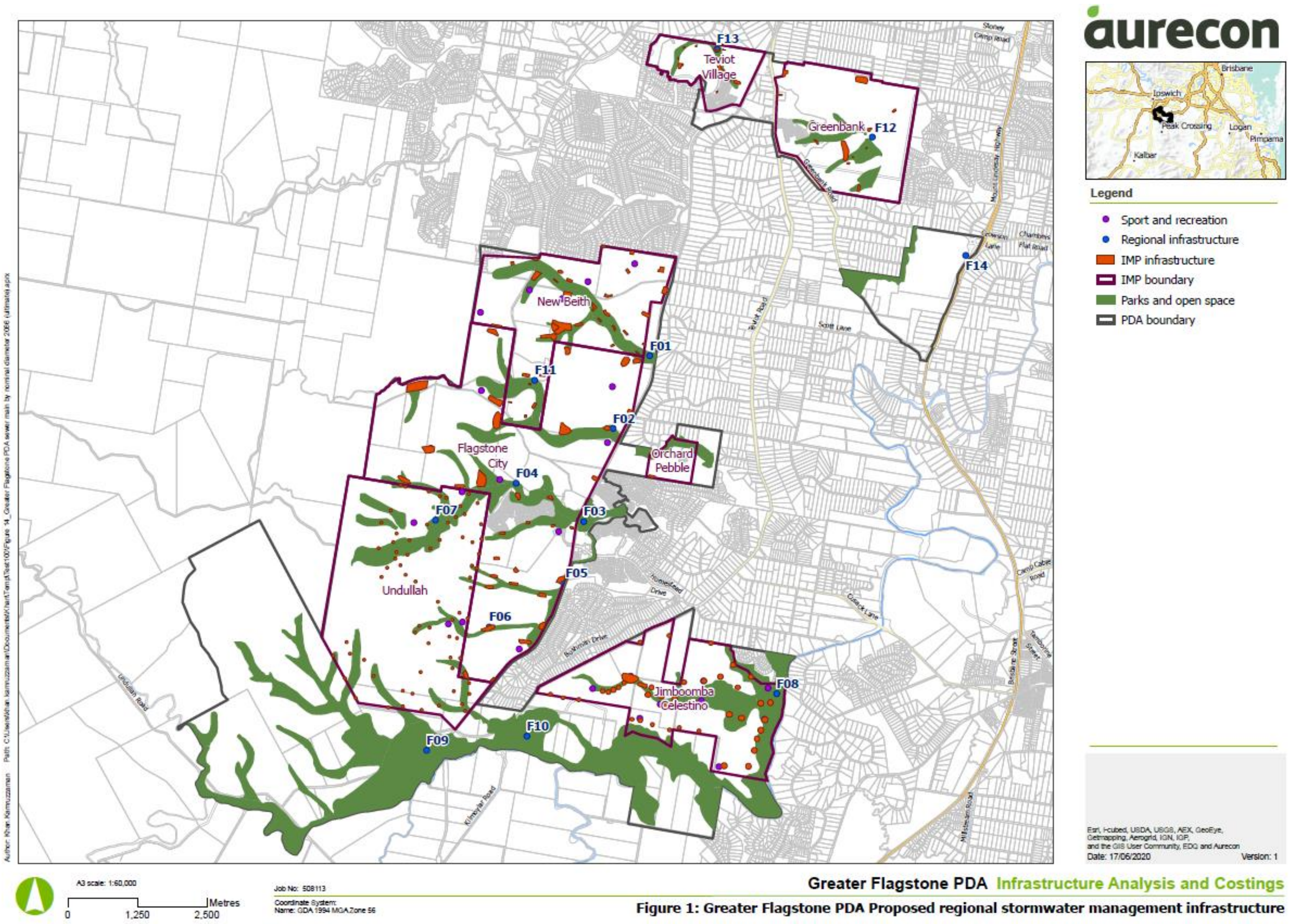


Figure 5-2 Proposed Greater Flagstone PDA Regional Stormwater Management Infrastructure

5.9.4 Phase 3 – Feasibility Assessment

The identification and sizing of potential regional stormwater management infrastructure in Phases 1 and 2 has been based on a high-level desktop assessment. Potential locations were identified but no detailed modelling or design work was undertaken. It is recommended that feasibility assessment of the identified sites be undertaken before they are progressed as viable options. It is anticipated that the number of locations identified in Phase 1 will be reduced and refined through detailed feasibility assessment in Phase 3.

Consultation with Council representatives has identified several potential physical constraints for consideration across each PDA area, including presence of dispersive/erodible soils, and ecologically sensitive locations that would need to be consider as part of the feasibility assessment. This is not an exhaustive list of constraints and the functionality of each proposed location would be subject to further analysis in the context of the broader PDA area and balancing local and regional infrastructure measures.

The proposed sub-regional infrastructure locations identified in this study were developed based on the current IMP developer areas. It is acknowledged that developer proposed IMP layouts may change over time. In the next stage of planning, collaboration with EDQ, developers and Council regarding stormwater management and compliance requirements for the broader PDA will provide opportunities for efficiency in infrastructure delivery and may improve the cost effectiveness of stormwater management within the PDA.

It is proposed that the Phase 3 feasibility assessment includes the following:

- Consideration of the proposed location in terms of:
    - Physical constraints, for example is there existing buried infrastructure, contaminated land, dispersive soils or areas of ecological and cultural significance?
    - Is the site reasonable from a topographic point of view, for example is there enough free low-lying space and can it be positioned to capture and discharge catchment runoff in a suitable manner?
- Detailed modelling to assess how the potential locations function in terms of hydraulic performance of the watercourses they discharge into?
    - Will the implementation of regional detention features have a negative impact on flood risk from the point of view of timing of flood peaks in the Flagstone Creek, Sandy Creek, Sandy Gully, Teviot Brook and/or the Logan River and their tributaries?
    - Modelling will enable refinement of the area required for each location and consideration of the integration of the proposed works with the surrounding environment.
- Consideration of the ongoing maintenance and failure risks associated with regional options.
- Comparison of how the regional options perform in comparison to local stormwater management opportunities:
    - Does a regional opportunity use land that could otherwise be developable?
    - Would a local approach mean that stormwater management infrastructure is better positioned to take advantage of innovation opportunities such as locating near basins near or within more proposed parks, sports fields and community open spaces?
    - Does the regional option provide an opportunity for developments to tailor their layouts to take advantage of a regional stormwater management location?

There are multiple innovative stormwater management options presented Chapter 6. These opportunities should be considered in the Phase 2 Feasibility Assessment to address integrated and total water cycle management principles.

5.10 Planning Horizons

Demographics analysis has been carried out by EDQ to estimate the likely population densities and land uses through time as the PDA area develops. Development at various planning horizons has been assessed including 2026, 2031, 2041 and 2066. These years have been considered in terms of three development categories for regional stormwater management infrastructure, the near term (2026), interim horizons (2031 & 2041) and the ultimate development (2066).

It has been assumed that development could proceed in any order, with regards to the rollout of the existing approved developer IMPs and associated Development Approvals (DAs). Infrastructure locations that are nearby (downstream) of existing development have been prioritized for construction timing and have been flagged for the nearest time horizon, 2026. This is to prioritize treatment where impacts to regional stormwater quantity and quality may already be occurring.

Stormwater management infrastructure locations nearby approved IMPs containing detailed layout plans, that are yet to be constructed, have been flagged with the intermediate time horizons, considered to represent 2031 or 2041. An indication of the planning horizon has been given for the intermediate time periods based on the demographic analysis, but this is indicative only.

Locations that have been identified to be consistent with sites identified in master planning documents only (without detailed development layouts) have been flagged for ultimate development, the 2066 planning horizon.

Comments have been added on rationale for locating assets and planning horizons in Table 5-3.

Staging of regional stormwater management infrastructure in relation to these planning horizons is acknowledged to be very difficult. Interaction with developers to identify interim solutions in relation to the timing of regional infrastructure will be required. Potential options include the use of land within developments in the short term as a stormwater treatment location, and release of these sites for rehabilitation and development once the regional stormwater infrastructure solution is delivered. This would defer the need for a regional solution to be constructed until development had progressed to a point where it is financially viable, while freeing up this land for development at a later date. It may also reduce the number of local stormwater basins required within the development, creating more developable land.

Table 5-3 Estimated Time Horizons for Rollout of Regional Stormwater Infrastructure

ID	Comment	Estimated time horizon for construction
F01	Downstream of approved IMPs	2031
F02	Downstream of approved IMPs	2031
F03	Downstream of existing development	2026
F04	Master Planning Area (no approved IMPs)	2066
F05	Master Planning Area (no approved IMPs)	2066

F06	Downstream of approved IMPs	2031
F07	Downstream of approved IMPs	2031
F08	Downstream of approved IMPs	2031
F09	Downstream of existing development	2026
F10	No approved IMPs	2066
F11	Master Planning Area (no approved IMPs)	2066
F12	Downstream of existing development	2026
F13	Downstream of existing development	2026
F14	No approved IMPs	2066

5.11 Opinion of Cost

The proposed locations for regional stormwater management infrastructure have been provided for estimating the cost of construction. The limitations of the preliminary analysis conducted in this stage of planning should be noted. Detailed feasibility assessment is recommended for the next stage of planning.

Rider Levett Bucknall (RLB) were engaged to develop an opinion of the cost of stormwater infrastructure to service the Greater Flagstone PDA. The quantities of stormwater infrastructure were derived from the updated network plan developed as part of this study. Municipal costs for Greater Flagstone PDA were then extracted from the RLB estimates and inserted into the Financial Offset Model per planning horizon, the summaries of which can be found within the Schedule of Works containing within the body of this Infrastructure Planning Background Report (IPBR).

6 Integrated Water Management

In South-East Queensland alone, the population is projected to grow from 3.5M to 5.3M by 2042. To accommodate this growth will require 800,000 new homes and 950,000 new jobs (ShapingSEQ 2017).

At the same time as this population and development growth is occurring, there is significant change anticipated across a range of factors, including climate, technology, demographics, community expectations and the world of work. Climate change predictions for South-East Queensland by 2030 indicate a 0.6-1.3 oC, increasing to as much as 1.3-3.3oC by 2070. South-East Queensland is likely to experience more days exceeding 35oC annually and more frequent and extreme heatwave events (State of Queensland 2019).

Future challenges like urban heat have been discussed frequently over the last decade. However, these temperature changes became very real in 2020, with heat waves and bushfires occurring across the country. Where temperatures were measured in Sydney, urban ambient air temperatures reached up to 50 degrees, with radiant heat from bitumen nearly up to 80oC. Media headlines started describing areas of Sydney that would be 'unliveable' within decades, covering the health impacts associated with high temperatures (https://www.abc.net.au/news/science/2021-01-24/heatwaves-sydney-uninhabitable-climate-change-urban-planning/12993580).

With the challenges faced in the last year, Australian awareness of climate, heat waves, floods, droughts and bushfires is at an all-time high. This awareness, coupled with the significantly different ways that we have been living our lives during Covid, is leading to some fundamental shifts in the concept of homes, how homes are constructed and how people view their neighbourhoods and cities.

Globally, the latest health research is also showing the importance of considering cooling strategies and green spaces with respect to physical and mental health of the community. In an Epidemiology study looking at health data from 1988 to 2009 in Brisbane, Tong et al. (2014) found that there was a significant increase in mortality associated with heat, particularly in the female population and in age groups over 75. The research found that up to 68 deaths per summer could be attributed to high temperatures (Tong et al. 2014).

Similarly, green spaces have been found to be important for mental well-being, with access to and use of green space leading to reduced stress, improved mental health and behaviour and decreased psychological distress, particularly in children and adolescents (Engemann et al. 2019, Zhang et al. 2020). A nation-wide study in the USA, covering more than 900,000 people, found that children who grew-up with the lowest levels of green space had a 55% higher risk of developing a psychiatric disorder (Engemann et al. 2019). The benefits of green space are considered to be wide-ranging, with living near green space contributing to an increasing frequency of exercise, reduced perceptions of noise, increased social activity and relaxation (Douglas & Douglas 2021).

Creating innovative Green and Blue Spaces in Queensland urban developments provides an opportunity to mitigate the challenges that changing climate, increasing population and demand for housing pose on our region, while providing for improved community liveability, connectivity and resilience. The trends influencing our community, choices relating to where people live and what types of homes, they purchase are provided to give context for future development and neighbourhood design options.

This section focuses on Innovative and Aspirational Integrated Water Management (IWM) Design solutions, to support future developments, suburbs and cities to deal with issues, such as urban heat, water scarcity, flooding and droughts, while also responding to societal changes in energy use, water use and living patterns. The Figure 6-1 below is from the IWM Framework for Victoria and provides a visual representation of how solutions can be applied across scales to achieve better outcomes for community and the environment.

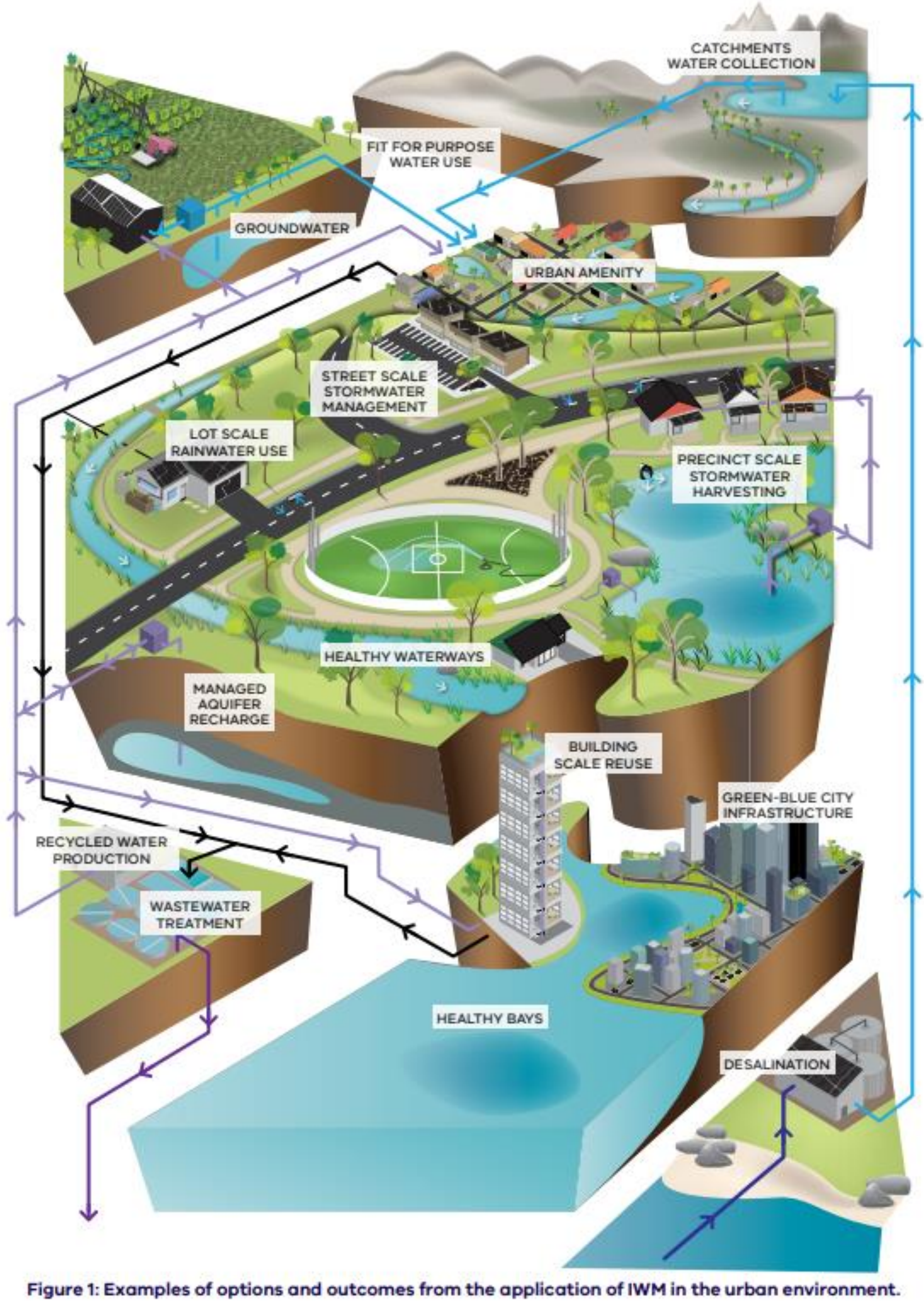


Figure 6-1 IWM Framework for Victoria

Source: Government of Victoria
https://www.water.vic.gov.au/__data/assets/pdf_file/0022/81544/DELWP-IWM-Framework-FINAL-FOR-WEB.pdf

Some benefits of implementing these solutions are outlined below.

6.1 Benefits to Developers

- Client-centric housing designs that provide for changing needs of home buyers,
- Developments that are popular with future buyers,
- Affordable housing,
- Award-winning designs that will allow developers to build their national brand,
- Ease of approvals in providing what is important to Local Governments, and
- Flexible designs, with end products that cater for a range of future scenarios.

6.2 Benefits to Local Government

- Planning for climate changes,
- Creating desirable places to live,
- Improving community health,
- Reduction in lifecycle costs associated with assets,
- Creating cities and neighbourhoods that are cooler,
- Creating cities and neighbourhoods that are more resilient to extreme events,
- Improving carbon footprint,
- Creating green spaces and corridors for people to recreate,
- Preserving biodiversity,
- Ensuring human safety with respect to air quality and use of waterways,
- Developing agile, resilient infrastructure,
- Attractive to people moving from overseas and inter-state, and
- Revival of suburbs and neighbourhoods.

6.3 Benefits to Homeowners

- Affordable housing, with affordable water and energy costs,
- Sustainable homes, with modern designs and materials,
- Healthy living,
- Easy access to green and blue spaces for family activities and recreation,
- Friendly, safe neighbourhoods with a strong sense of community,
- Smart homes, neighbourhoods and digital services, with a range of real time data to make informed decisions,
- Walking & cycling friendly suburbs,

- Cool, green suburbs that are designed and built with droughts, floods, heat and bushfires in mind,
- Flexible home infrastructure options, enabling connection of the latest solar, battery, water and waste technology over time,
- Fast connectivity speeds and access to the latest technology, within homes, public transport and ride sharing opportunities,
- Work from home options and local co-working spaces for connecting with other remote team members and clients for meetings,
- Local maker-hubs, with shared access to 3D printers, graphic designers, tech expertise and other innovative thinkers,
- Access to fast, last mile delivery options for online shopping, and
- Local produce options, with access to community gardens, organic food and farmer's markets.

6.4 Planning for the Future

In 2020, everyone watched as the world changed overnight. The way that people use their homes, work remotely and connect with their neighbourhoods has fundamentally changed and will likely never return to post-covid patterns.

Many of the changes that we have seen in the last 12 months were underway prior to Covid, particularly changes relating to technology and the way we work. However, Covid has accelerated the speed of this change.

Given the lag time associated with planning timeframes and subsequent developments, it is important to look at the longer-term trends relating to how we live and work, to help design cities, suburbs, developments and homes that reflect the demand from consumers over the next decade.

With all this change around us, the concept of a home is changing, the way in which we use our homes and neighbourhoods is changing and the way in which homes are being constructed is changing. As described by AIA (2020), this is being influenced by a range of factors, including pandemics, population growth, shortage of affordable housing, sustainability and construction industry changes.

Table 6-1 below provides a summary of innovative IWM designs and the scales at which they can be applied to address the challenges we face in the future. The different innovations are discussed in more detail following sections.

Table 6-1 Implementation of Innovations at Lot, Precinct and Regional Scale

Ref	Innovation	Lot	Precinct	Regional
By Design				
0	Green Streets	✓	✓	✓
6.5.2	WSUD Street Trees		✓	
6.5.3	Combined Trenching/Trenchless Technology		✓	✓

Ref	Innovation	Lot	Precinct	Regional
6.5.4	Household first flush diversion	✓		
6.5.5	Stormwater harvesting – rainwater tanks	✓		
6.5.6	Stormwater Harvesting – large lots		✓	
6.5.7	Beyond Impervious Surfaces	✓	✓	✓
6.5.8	Sustainable Home/Building Ratings	✓		
6.5.9	On-site Use of Nutrients	✓		
6.5.10	Flood Resilient Building Design	✓		
6.5.11	Water Efficient Fixtures	✓		
6.5.12	Drainage & Green Space Easements		✓	
6.5.13	Bioretention Basins & Rain Gardens	✓	✓	
6.5.14	Swales		✓	
6.5.15	Vertical & Roof Top Gardens	✓		
6.5.16	Stormwater Offset & Water Quality Credits		✓	✓
6.5.17	Walkable & Water Enabled Neighbourhoods		✓	✓
6.5.18	Verge Gardens	✓	✓	
6.5.19	Gutter Guards	✓		
6.5.20	Rates & Levies	✓		
Aspirational				
11.5.1.7	Wastewater Treatment & Re-use Systems		✓	✓
11.5.1.8	Household Greywater Reuse Systems	ü	ü	
11.5.1.9	Sustainable Neighbourhoods – water energy share		✓	
11.5.1.10	Integrated Water Servicing – Smart Systems	✓	✓	✓
11.5.1.11	Recycled water distribution through stormwater drainage network	✓	✓	✓
11.5.1.12	Distributed storage and smart systems		✓	✓
11.5.1.13	Green waste reuse for energy/water generation		✓	✓

Ref	Innovation	Lot	Precinct	Regional
11.5.1.14	Biogas Generation from Wastewater for Energy			✓
11.5.1.15	Aquifer Storage & Recovery			✓
11.5.1.16	New Pipe Technology		✓	✓
11.5.1.17	Rapid Water Treatment Systems		✓	✓
11.5.1.18	End of Pipe Treatment Systems		✓	✓
11.5.1.19	Smart City/Monitoring Systems	✓	✓	✓
11.5.1.20	Integrated Flood Detention Systems		✓	✓
11.5.1.21	Integrated stormwater management – decentralised stormwater capture	✓	✓	✓

6.5 Innovation by Design

The opportunity to 'raise the bar' and set a new benchmark for the integrated management of water for the Greater Flagstone PDA area through each time horizon is considered to exist via the collaboration with EDQ, developers and the Logan City Council. This is where options assessments are completed to determine the appropriate balance of local and or regional water, sewer and stormwater infrastructure while implementing, where possible, the principles of IWM and TWCM.

Positioning regional infrastructure within parks and open space areas increases the potential to consider stormwater harvesting and sewer mining as an opportunity for providing additional community benefits through integrated water management. Typically, these decentralized systems consist of the capture of non-potable water and use for irrigation in public open spaces such as parks and sports fields, providing dual benefits of reduced discharge of water to the environment and reduced potable water usage in irrigation of public open space. These opportunities will need to be explored further with individual developers and largely dependent upon the financial viability of the schemes.

In addition to local distributed recycled water supply opportunities the new Cedar Grove treatment plant is in the Southeast adjacent to the PDA and will treat the regions sewage. The plant will generate significant quantities of high-quality water that could also be recycled also for uses as identified above

Provided below are descriptions of innovations by design that currently exist within Australian urban communities. Examples are provided of locations that have implemented these innovations in place of business-as-usual infrastructure and provide developers and authorities with on the ground outcomes that they can duplicate in the local context.

Developers are encouraged to implement one or more of the design innovations in consultation with EDQ. Early consultation with EDQ, local governments and future asset owners is essential for realisation of benefits and to mitigate asset-ownership challenges.

6.5.1 Green Streets

Water sensitive urban design strategies that prioritise the retention of water and vegetation in urban areas have been demonstrated to provide cooling and improved human thermal comfort (Broadbent et.al., 2018; Bowler et.al., 2010),

Reducing areas of extreme heat and providing cool refuges in urban areas can be achieved through targeted water-sensitive urban design strategies at lot, street, precinct scale. These include:

- Passively irrigated street trees and green facades shade streetscapes and public areas,
- Porous surfaces (e.g. permeable paving) and waterbodies to provide surface cooling and evaporative cooling, and
- Irrigated public greenspace using stormwater harvesting/recycled water for surface cooling and evaporative cooling.

Figure 6-2 Illustration of Green Streets using WSUD Features in Medium Density

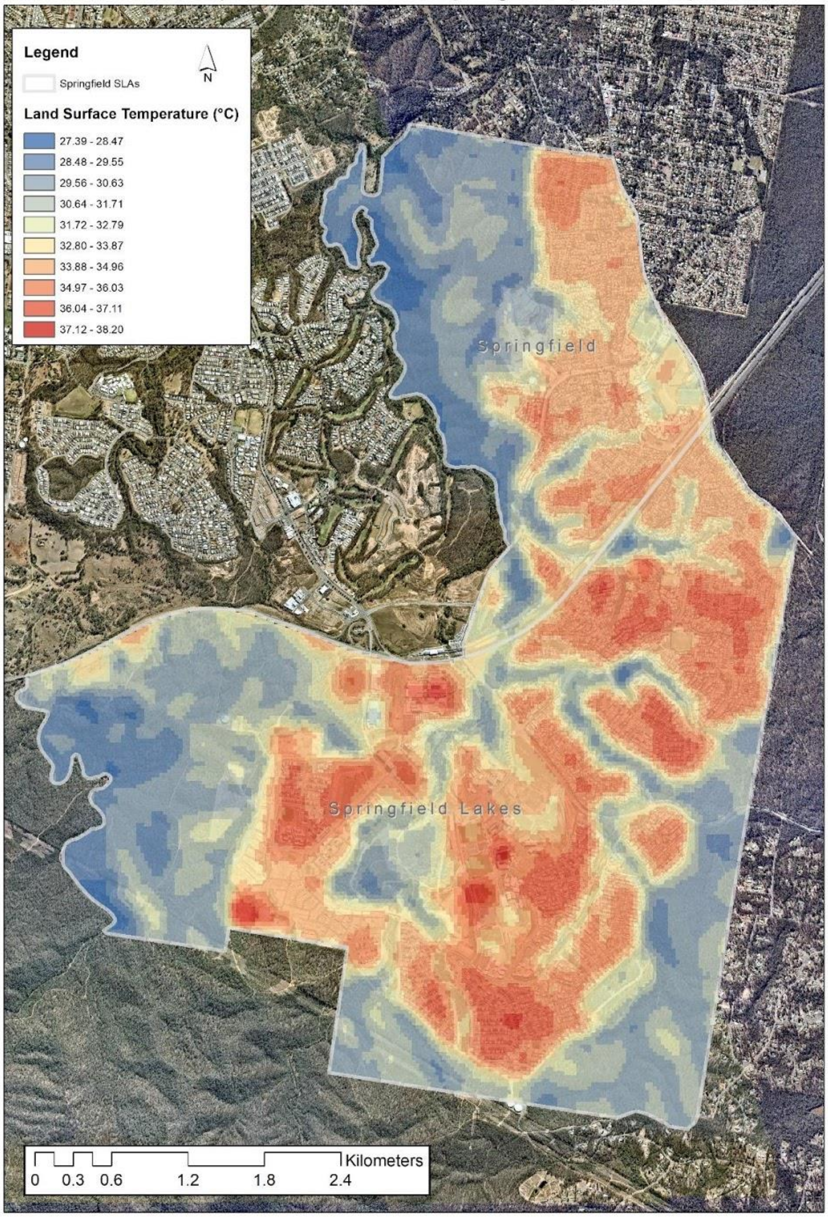
Source: Bligh Tanner

Technical Aspects

- Scenario modelling for greenfield precincts enables testing of proposed development typologies at lot/precinct scale. Modelling costs and methodologies vary depending on accuracy, precision, availability of climate data, and
- Images below show distribution in land surface temperature, measured at 15m grid resolution from Landsat 8 thermal infrared imagery at Springfield Lakes, a master-planned community in South-East Queensland on a hot day in 2018 (maximum daytime temperature

32 degrees). They demonstrate, even at a coarse resolution, the “cool island” effect of WSUD and vegetated elements within the urban fabric.

Land Surface Temperature - Greater Springfield (3/11/2018)



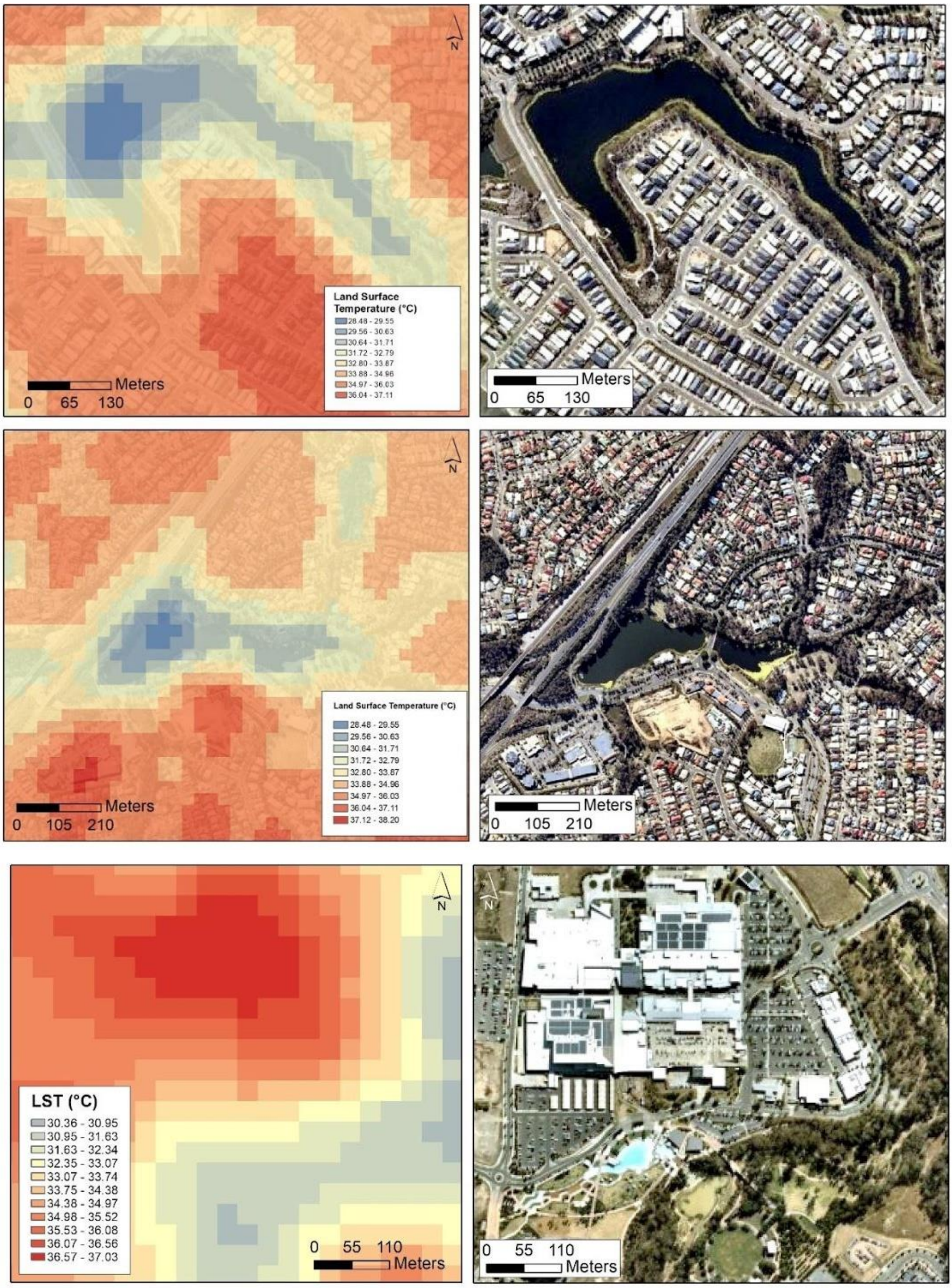


Figure 6-3 Heat mapping demonstrates efficacy of WSUD

Source: Bligh Tanner

Benefits

- Multiple-benefit strategy, including stormwater water quality/quantity improvement, potable water demand reduction, streetscape amenity and climate sensitive building design) (Coutts et.al., 2012),
- Enables prioritisation of investment to maximise cooling and other benefits e.g. Dubbo Urban Heat Island Amelioration Project, CRCWSC ,
- https://watersensitivecities.org.au/wp-content/uploads/2019/04/190429_V7_CRCWSC-Dubbo-Case-Study.pdf,
- Health benefits associated with reduced heat related illness and morbidity/mortality during heatwave events,
- Economic benefits, including optimisation of electricity usage for cooling,
- Facilitates active transport in more shaded areas, and
- Improves streetscape and public amenity values.

Challenges

- High upfront cost, depending on resolution of mapping/modelling.

Application

The image below illustrates effective urban cooling strategies for humid sub-tropical climates, such as those experienced in South-East Queensland (Cooperative Research Centre for Low Carbon Living 2017). It shows shading, healthy canopies and high-albedo building materials.

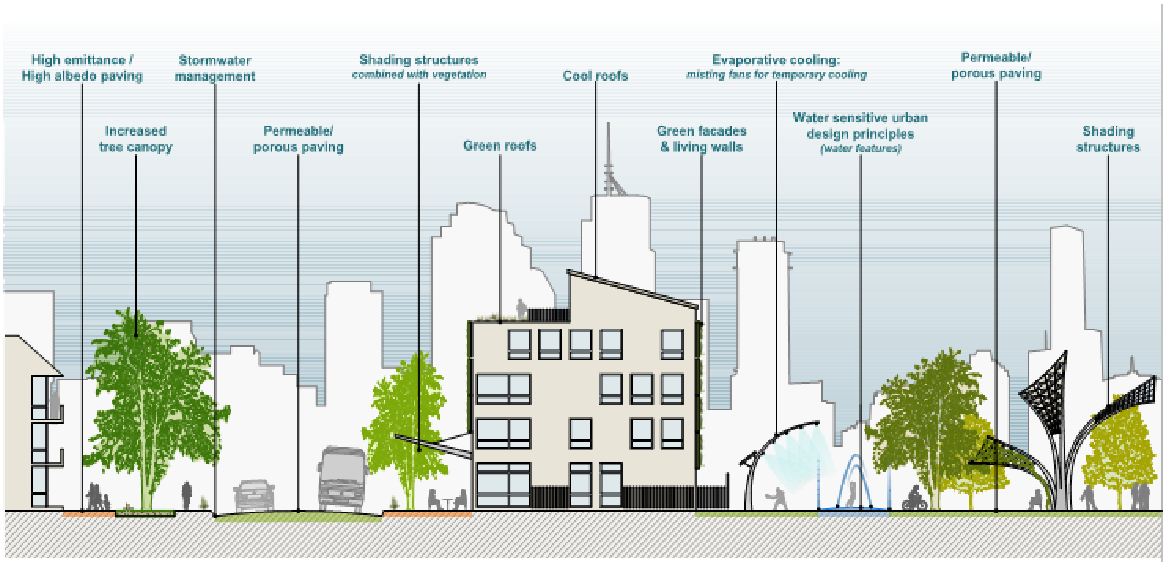


Figure 6-4 Cooling strategies using WSUD design

Source: CRC Low Carbon Living 2017

Melbourne's Quarter Sky Park, Docklands is one example of how green walls and rooftop gardens can be implemented (CRC WSC, 2020). In this location, Melbourne plans to provide 10ha of urban green infrastructure in high-density urban areas by 2021. Passive irrigation and adequate space for tree roots can facilitate growth of urban canopies, shading streetscape and public areas.

6.5.2 WSUD Street Trees

WSUD Street Trees are small biofiltration systems that are built into the footpath in place of traditional street trees. They are designed to receive stormwater from roads, providing a water supply for the tree over time, as well as providing some filtration of water from the road surface.

Figure 6-5 WSUD street trees

Images: Bligh Tanner

Technical Aspects

WSUD Street Trees are used widely by Local Governments across Australia, with designs being continually improved over time. Where monitoring has been undertaken, street tree growth has proven to be significantly better with the additional water supply and there is a reduced cost of tree watering for Councils.

Benefits

- Improved street tree establishment, growth and survival,
- Increased water efficiency and reduced cost of street tree watering,
- Some water quality filtration benefits,
- Useful bioretention option where there is constrained space, and
- Amenity and cooling.

Challenges

- Cost of design, installation and maintenance is higher than a traditional street trees, and

- Depending on design, debris blockages can occur in the curb inlets, reducing the water supply to trees.

Application

- Brisbane City Council Street Tree Program, and
- Healthy Land & Water – Water by Design – Water Wise Street Trees.

6.5.3 Combined Trenching and/or Trenchless Technology

Underground services like water, sewer, communications and electricity are able to be located in a common trench in community title developments. However, in public road reserves, these are often located in separate trenches due to different timing of construction and specific buffer requirements associated with each service. However, separate trenches lead to more expensive construction, less efficient use of the constrained footpath space and limited flexibility for future streetscape designs.

Figure 6-6 Trenchless technology cross section

Source: Bligh Tanner

Technical Aspects

- Common trenching is regularly used in the US and Canada, as well as being utilised in community title developments in Queensland for many years. Energex publishes a standard for common trenching in such developments,
- Utility providers in Sydney have agreed on a common trenching standard for Western Sydney,

- Directional drilling and trenchless technology are increasingly being utilised for installation of underground utilities, rather than open trenching, and
- Most utilities and local authorities publish standard alignments for underground services in road reserves. Approaches vary across locations and require each service provider to lodge their ‘as constructed’ plans in a central location. From a holistic perspective, common trenching would provide a more flexible long-term outcome for Local Governments.

Benefits

- Extension of asset life. Existing pipes and utilities will not need to be disturbed as frequently for other works to be undertaken. Modern pipe materials have a significant service life and rarely need to be excavated. New water, sewer and stormwater pipes are unlikely to need full replacement within 50 - 100 years. Currently, many old sewers are re-sleeved in-situ or replaced using trenchless technologies. With water and sewer pipes, repairs are typically needed at specific points along the pipe and not along the entire length. More frequently, excavations are needed across the service alignment and having services in a common trench makes this a simpler activity,
- Reduced excavation required. Communications and power are supplied in conduits, allowing new cable to be pulled through them without full excavation. This is how the NBN is mostly being delivered,
- Extra space within the verge can create greater root volume for street trees, which leads to healthier trees and less chance of future disturbance to root systems,
- Increased verge space for other urban benefits, such as at-source stormwater management (streetscape raingardens), thus minimising the problems associated with large end-of-pipe bioretention systems,
- Potential for reduction in verge widths, up to 1.9 m and 2.35 m on each side of the road, and
- Reduced likelihood of accidental damage to underground services if they are all installed in a single compact footprint.

Challenges

- The potential marginal future cost involved in replacing a service within a common trench—compared to in a separate trench—is far outweighed by the present-day benefits, and
- Current guidelines and standard drawings for each service would need to be reviewed, particularly the buffer requirements.

Application

- Energex Standard Drawing for Community Title Development, and
- New Trenchless Design Technology (Zilper Trenchless https://www.zilpertrenchless.com/).

6.5.4 Household First Flush Diversion

Downpipe diverters are a simple way of adapting existing downpipes, so that rainfall can be used to water gardens. This uses water that would otherwise create excess stormwater and instead provides irrigation and nutrients for gardens. Devices are low cost and have wide applicability in that they are easily retrofittable.

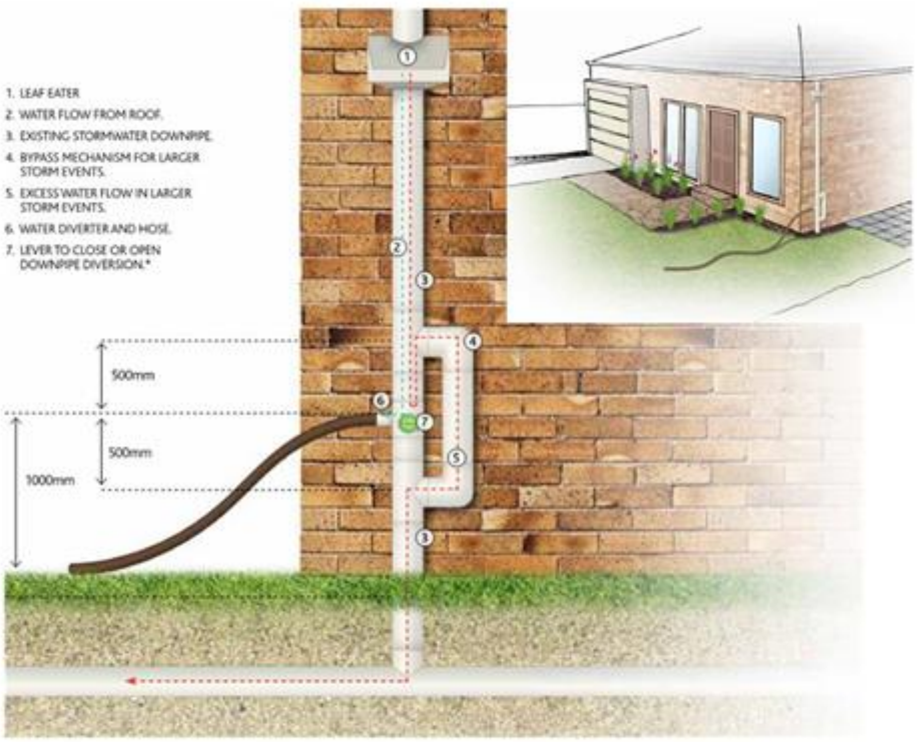


Figure 6-7 Typical First Flush Device in Residential Building

Source: City of Port Phillip

Runoff from minor rainfall events can add up to a significant portion of annual runoff volumes. Preventing this runoff from entering waterways helps preserve natural waterway hydrology and reduces overall pollutant loads into waterways. Downpipe diverters use this water as a form of passive irrigation.

Technical Aspects

A robust design has recently been developed by Melbourne Water and Master Plumbers, with system packages provided to residents via local government. The devices cost $135 each, with installation costs varying depending on whether devices are installed during initial house construction or as a retrofit. A number of these systems have been installed as part of a pilot project in Melbourne.

Alternative options include directly discharging downpipes to pervious areas or removing guttering altogether, which is a common practice in high rainfall areas like Darwin.

Benefits

- Low cost & simple to install,
- Good reuse of water for sustaining gardens, and
- Inbuilt overflow, so water is directed to stormwater pipes during large storms.

Challenges

- Depending on the diverter, these systems can block and require regular maintenance, and
- There is not a lot of data available on actual effectiveness of these systems for nutrient removal.

Application

- City of Port Phillip (https://www.portphillip.vic.gov.au/media/1tcd5vel/e27210-19-city-of-port-phillip-wsud_guidelines-final.pdf)

6.5.5 Stormwater Harvesting – Residential Rainwater Tanks with Smart Metering

Rainwater tank installation for each house, with smart meters to measure & monitor water levels and quality. Rainwater can be reused in the garden or filtered for reuse within the household (toilets, washing machine) or filtered for reuse as hot water.

Technical Aspects

Rainwater capture at the lot scale can increase drought resilience of each home, providing water for the garden and toilets on-site. It also reduces water flow to the stormwater network and can provide local water for bushfire management.

Roof rainwater harvesting can be treated and reused for hot water use on-site, reducing reliance on mains drinking water for hot water. For this purpose, rainwater is treated on site, undergoing screening, filtration, ultraviolet and heat treatment before supplying to showers, baths, laundry, and kitchen. The hot water system can be supplemented with drinking water when rainwater is not available. Where dual reticulation from a recycled water network is available, rainwater tanks are often not used.

Smart metering allows more effective measurement of individual water levels in each tank and ensures that water quality is appropriate for use on site. This can cost approximately $2,000/10,000L for a poly tank, with extra cost in sensors and software as a service. There can also be additional costs associated with energy use over time, so these integrated lifecycle costs should be included in any long-term cost comparisons.

Benefits

- Effective capture & reuse option at the household scale,
- Increases household climate resilience, and
- When implemented in conjunction with a recycled water scheme, this can reduce reliance on mains drinking water by up to 70%.

Challenges

- Additional cost to developers or householders,
- Ongoing maintenance and energy costs,
- Some poly tanks are not fire resistant, and
- Maintenance of the systems is ongoing to ensure that health requirements are met. In the Aquarevo development, Southeast Water simplify monitoring and maintenance of the systems by using smart technology.

Application

- Aquarevo, Rainwater hot water supply system ([https://watersensitivecities.org.au/wp-content/uploads/2017/09/Case_Study_Aquarevo_FORWEB_170912.pdf)](https://watersensitivecities.org.au/wp-content/uploads/2017/09/Case_Study_Aquarevo_FORWEB_170912.pdf) and
- Currumbin Ecovillage Rainwater Harvesting.

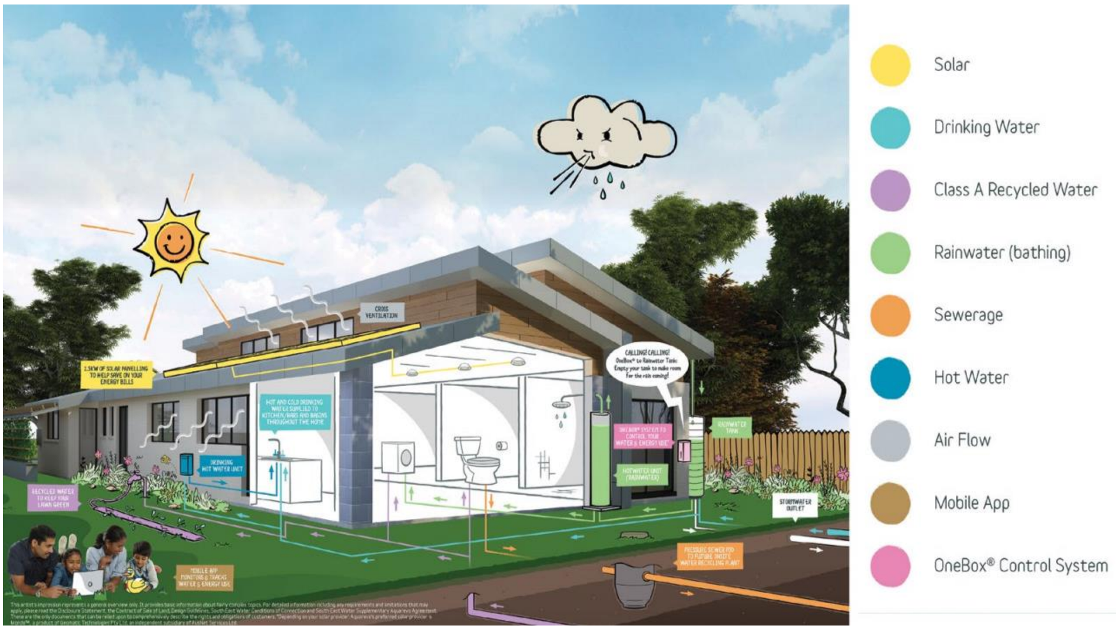


Figure 6-8 Residential Water & Energy Management

Source: Water Sensitive Cities

6.5.6 Stormwater Harvesting – Large Lots

Large Lot stormwater harvesting is the collection, storage and treatment of rainwater on a site for later reuse.

Technical Aspects

Larger scale stormwater harvesting can be undertaken on commercial or industrial sites, as well as large recreational areas like sporting fields. These systems can be diverse, ranging from harvesting of roof water, through to harvesting of overland flow or mining from stormwater pipes. Storage solutions can range from standard tanks, through to underground tanks or storage basins.

Benefits

- Effective capture & reuse option at the household scale,
- Increases household climate resilience, and
- When implemented in conjunction with a recycled water scheme, this can reduce reliance on mains drinking water by up to 70%.

Challenges

- Additional cost to developers or householders,
- Ongoing maintenance and energy costs,
- Some poly tanks are not fire resistant, and

- Maintenance of the systems is ongoing to ensure that health requirements are met. In the Aquarevo development, Southeast Water simplify monitoring and maintenance of the systems by using smart technology.

Application

- Aquarevo, Rainwater hot water supply system, and
- Currumbin Ecovillage Rainwater Harvesting.

Figure 6-9: Stormwater Harvesting, Fitzgibbon Chase, Brisbane

Source: Bligh Tanner

The Fitzgibbon Chase project is recognised internationally as a new model for hybrid centralised/decentralised water supply systems, estimated to achieve a 60% savings on normal mains water use. Bligh Tanner created an innovative new water management model for a 114-hectare housing community in Brisbane, allowing local water supply to grow as the population increases.

This project features a non-potable stormwater harvesting system (the FiSH) and potable roof water harvesting system (PotaRoo). The FiSH diverts, filters and disinfects urban stormwater runoff to supply non-potable water for irrigation, toilet flushing, laundry and outdoor uses. The PotaRoo harvests roof water from approximately 500 homes in Fitzgibbon Chase, which is pumped to a central water treatment plant to produce water of potable quality.

6.5.7 Beyond Impervious Surfaces

Impervious surfaces or hard surfaces directly increase stormwater runoff, contributing to flooding, waterway erosion and increased stormwater pollution. These surfaces can be minimised at the lot or suburb scale, through the use of porous pavement and green surfaces.

Permeable pavements can be designed with underdrainage systems that collect water for reuse or discharge, but more commonly, allow water to infiltrate into the subsoil. They can be designed for a range of traffic loadings, varying from pedestrian foot traffic through to trucks. Like any pavement, poor engineering design that fails to provide adequate structural support for heavy vehicles can lead to uneven subsidence.

There are a broad range of paving technologies that allow water to permeate through a trafficable surface. Four main categories of permeable paving are listed below:

- Porous asphalt (PA): Porous asphalt is similar to conventional asphalt, except the fines are removed to create greater void space. Additives and higher-grade binders are typically used to provide greater durability and prevent breakdown.
- Pervious concrete (PC): Pervious concrete is produced by reducing the fines in the mix to maintain interconnected void space. This has a coarser appearance than standard concrete.
- Permeable interlocking concrete pavement (PICP): PICP is made of interlocking concrete pavers that maintain drainage through aggregate-filled gaps between the pavers. The pavers themselves are not permeable.
- Grid pavement systems (plastic or concrete): Grid pavement systems are modular grids filled with turf and/or gravel. Open-celled concrete or plastic structural units are typically filled with small uniformly graded gravel that allows infiltration through the surface.
- Plastiphalt: sustainable asphalt product that incorporates waste plastics from used containers. It can be utilised in a number of asphalt mixes for range of solutions.

A number of Local Governments in Australia already manage the amount of impervious area at the large lot and/or suburb scale. Various trials of porous pavement are also underway in a number of Council areas across Australia and internationally. Many jurisdictions in the US have impervious area levies to provide a user-pays approach to stormwater management.

Technical Aspects

Impervious areas, like roofs, carparks, and concrete paths, can significantly increase nutrient flows to stormwater due to both a reduction in filtration capacity (from lack of grass and vegetation) and a build-up of nutrients and contaminants on the hard surfaces over time. When compared to green surfaces, there are also significantly higher temperatures associated with impervious surfaces.

Rainfall falling on the surface infiltrates into the voids between the pavement elements, allowing primary stormwater treatment by filtration at source. This can obviate the need for additional drainage or flood detention systems in some locations, hydrates soils in urban areas and leads to additional water supplies for street trees, and recharges local aquifers.

Permeable pavements are best suited for low traffic loads, which are subject to direct rainfall only, rather than receiving runoff from high sediment areas. As such, car parks, driveways, and pedestrian areas are well suited for this technology. Further discussion of traffic design can be found in Chapter 6 of the DCOP.

There is a large range of costs, depending on the paving system and sub-grade needed for a particular site ($5 - $430 /m2 depending on type of surface installed).

Benefits

- Reduction in hard surface decreases temperatures and limits urban heat island effects
- Additional filtration capacity leads to lower levels of sediment, nutrients and contaminants flowing to stormwater

- Reduced stormwater run-off volumes and increased flood mitigation
- Increased visual amenity and health benefits from additional green spaces
- Increased infiltration to aquifers, supporting low flows in local waterways
- Well suited to carparks, pedestrian areas

Challenges

- Some porous pavements can block over time, so have a limited life span
- Maintenance is essential to keep pores clear – vacuuming and sonication have been found to be very effective
- Current porous pavements are not as strong & durable as traditional hard options

Application

- Sydney Olympic Park
- Russell Family Park, Montville
- Sunshine Coast, Pervious Pavement Trials with Recycled Materials
- Brisbane City, Pervious Pavement Trials & Road Surface Trials with Recycled Materials

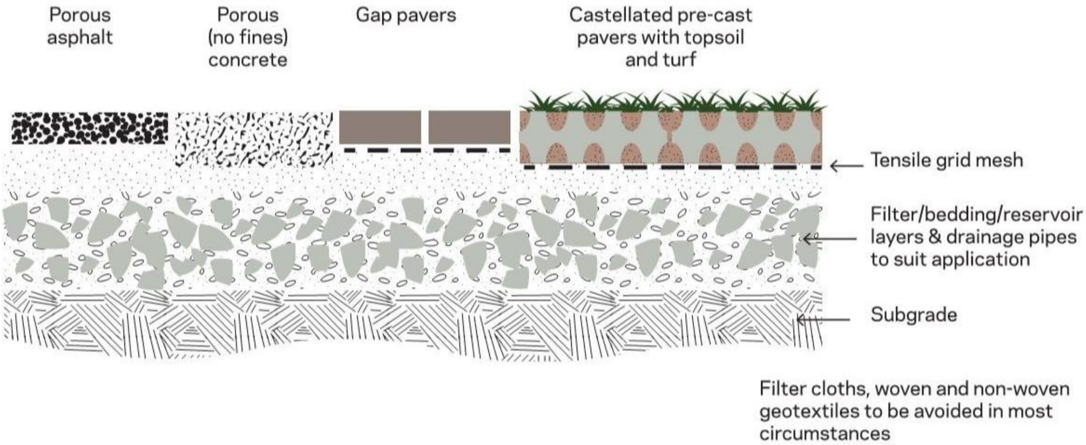


Figure 6-10: Porous Surfaces

Source: Bligh Tanner

6.5.8 Sustainable Home/Building Rating Systems

A sustainable home rating system for all homes and commercial buildings to ensure the highest quality energy, water, waste and sustainability outcomes within the development.

These rating systems have been used in a range of developments across diverse Local Government areas in Australia. The ratings allow for a base standard of sustainable building, as well as enabling buildings that go ‘above and beyond’ to achieve sustainable outcomes.

Technical Aspects

There are a range of existing rating systems including: NABERS (National Australian Built Environment Rating System), which is used for offices, shopping centres, hotels, data centres and apartment blocks; NatHERS (Nationwide House Energy Rating Scheme), which determines energy efficiency for a home; and Green Star, which captures features like interior fit-out and construction, precinct planning & development, and performance across categories like energy, transport, water, materials and land use.

Benefits

- Higher quality building and sustainability outcomes across the developments
- Lower energy use, water use and improved waste management over time
- Circular economy principles incorporated
- Improved visual amenity for residents
- Health benefits associated with reduced temperatures and increased green spaces for residents

Challenges

- Higher upfront building costs associated with meeting more stringent building code
- Ongoing maintenance costs usually borne by the landowners or body corporate

Application

- NABERS
- NatHERS
- Green Star
- BASIX (NSW)

6.5.9 On-site Use of Nutrients

Nutrients from green waste, such as lawn clippings, and excessive use of fertiliser in yards can contribute to increased nutrients in stormwater and local waterways. Options range from composting green waste at home, through to effective fertiliser management within each yard.

A number of Local Governments around Australia have a range of community programs associated with green waste management and effective use of fertilisers. Some Councils even provide rebates on the purchase of compost tumblers and worm farms.

Technical Aspects

There is an increasing number of people across Australia who are using home composting and sustainable gardening to reduce their organic waste and carbon footprints, while improving their own garden and local soils. The support for householders can include guidelines on how to design a sustainable garden, planting plans to assist with suitable species selection, composting and mulching instructions and pruning/mowing guidelines.

Costs of rebates can be up to $70 per household, usually providing for the purchase of worm farms, compost bins or other equipment for use on-site.

Benefits

- Low cost and simple
- Benefits to both waste and water management goals
- Negligible costs

Challenges

- Voluntary measure, so no guarantee that the measures will be implemented
- Neighbourhood outcomes are challenging, as each individual landholder may use different approaches

Application

- Brisbane City Council Compost Rebate Program (https://www.brisbane.qld.gov.au/clean-and-green/green-home-and-community/sustainable-gardening/compost-and-organic-waste-recycling/compost-rebate-program)
- Melbourne City Compost Revolution (https://compostrevolution.com.au/melbourne/)

6.5.10 Flood Resilient Building Design & Flood Preparedness

Flood resilient building design works on the principle that flooding can be expected on a floodplain, so buildings in flood zones should be designed with that in mind. It can include a range of community preparedness programs and building options, such as: building aspects in relation to flow, height of buildings, types of building materials, community education programs etc. I

Flood resilient building design and community preparedness can increase resilience and significantly decrease the cost of building repair after floods. A number of Local Governments across Australia are implementing this approach, with education programs and grants available to homeowners in some flood zones.

Technical Aspects

In Melbourne alone, it is estimated that flooding costs the ratepayers an average of $736M a year, in addition to the stress and disruption it causes (Melbourne Water 2021). Melbourne Water (2021) estimates that resilience and preparedness programs can reduce the impact of this flooding by up to 80%.

Preparedness programs can vary from retrofitting your home (e.g. raising power points, tilting floors, changing building materials in lower floors, reconfiguring your home, raising your home etc), creating an emergency plan for a community, developing community early warning programs, preparing emergency flood kits, providing sandbags for the community and working with insurers to support good outcomes in flood zone.

Benefits

- Enables building construction within some flood zone categories where building was previously prohibited
- Increases resilience of buildings and preparedness of residents in flood zones
- Can reduce insurance costs for homeowners who are implementing preventative measures

- Proactively increases community resilience to droughts, floods, bushfires and other natural disasters
- Reduces long-term flood damage to buildings and infrastructure
- Low cost of implementation

Challenges

- Costs are largely borne by homeowners
- Program is voluntary, so uptake across a local area can vary

Application

- Brisbane City Council Flood Resilient Homes Program (https://www.citysmart.com.au/floodwise/)
- Melbourne Water Flood Resilience Program (https://www.melbournewater.com.au/water-data-and-education/water-facts-and-history/flooding/being-prepared-flooding
- Resilience NSW Program Grants (https://www.emergency.nsw.gov.au/grants)

6.5.11 Water Efficient Fixtures & Fittings

Water efficient fixtures can be installed in homes, commercial and industrial buildings and are usually a mandatory requirement of any sustainability rating system. These fixtures could include water efficient taps, dual flush toilets, smart metering and a range of other options.

Many Local Governments around Australia have water efficiency programs in place, with rebates available for retrofitting and most new homes constructed with all water efficiency measures in place.

Technical Aspects

In domestic buildings alone, water efficiency measures have been shown to save from $7,295 – 28,785 per building occupant in domestic buildings and can provide water savings of up to 78.5% (Tam & Brohier, 2013).

The Australian Government has estimated that Australians could save $2B by 2030 (an average saving of $175 per household per year). This saving is the result of combined savings from 65% of avoided water heating costs (from reduced electricity and gas costs) and 35% from reduced water bills (DISER 2021 - https://www.energy.gov.au/households/water-efficiency).

For industrial sites, up to 100% of water can be saved and reused on site (XXXX Brewery, Brisbane). This results in significant decreases in water costs, improved water quality for site reuse and can have additional energy benefits. In some cases, surplus water can also be available for sale or sharing to other water users in the local area.

Benefits

- Minimising water use within buildings and lots can result in a significant reduction in water use, especially considering the cumulative effect across a whole town or city,
- Low cost, and
- Reduced water uses in homes.

Challenges

- Reduction in water flow can be seen as problematic by local residents
- Under current legislation in some areas, sharing of surplus water with others can result in a business being viewed as a 'water provider', which triggers additional costs and licencing requirements.

Application

- City of Melbourne Council House 2 – Australia's first 6-star Green Star Building
- East Melbourne Library
- Lion Nathan XXXX Brewery, Brisbane

6.5.12 Drainage & Green Space Easements

Easements and covenants can be retained for sections of lots that serve a broader purpose, such as utility access, waterway movement, overland flow paths and valuable habitat areas.

Technical Aspects

Landscape and natural features that extend across lot boundaries (e.g. overland flow paths) can be challenging to manage as a system unless there is some control retained over what is constructed in those areas or how they are managed. Easements can provide access for Local Governments and can also enable stipulations relating to use of those areas. In designated easements and covenant areas, the local landholder has use of the land but Local Government and other designated organisations have the right to access that land.

Benefits

- Provides access and flexibility for managing utilities and drainage or wildlife corridors
- Allows for managing natural, inter-connected systems that require connection across lot boundaries

Challenges

- Creates restrictions on landholders who have the easements or covenants on their properties
- Can become common areas that are not maintained by any of the interested parties

Application

- Logan City Council, Brookhaven Development
- Designing Liveable Places – Water as an Enabler. CRC for Water Sensitive Cities, Brisbane.

6.5.13 Bioretention Basins & Rain Gardens

Bioretention Basins and rain gardens are used to filter nutrients, sediments and contaminants from overland flow before water from a site or roadway enters the stormwater system. These are regulatory design measures that are used widely by Local Governments across Australia. In some situations, they can be combined with flood detention.

Figure 6-11 Bioretention basins and rain gardens

Images: Bligh Tanner

Technical Aspects

Dedicated filtration basins & gardens are constructed at strategic locations within large lots, usually greater than 1000 or 2000m2.

There are a number of guidelines available for bioretention design in Australia, including Water-by-Design Guidelines (Healthy Land & Water 2019), WSUD guidelines (Melbourne Water 2013), Urban Typologies and Stormwater Solutions (Sydney Water 2019) and WSUD Engineering Procedures (CSIRO 2005).

Benefits

- Improved removal of nutrients, contaminants and sediments from stormwater
- Improved visual amenity, where systems are designed effectively
- Increase in urban habitat, when compared to traditional drainage options
- Benefit to urban cooling, from both vegetation and water within the landscape

Challenges

- Ongoing maintenance requirements

- If not designed or maintained effectively, these basins can provide reduced visual amenity, weed sources, mosquito and odour issues for local residents. However, if they are designed and maintained effectively, these issues can be minimised. For examples, mosquitos require very specific physio-chemical conditions and duration of water depths for breeding. If a bioretention system is designed correctly and maintained effectively, there will not be suitable conditions for mosquitos to breed. It is also recommended that the latest sensor technology be utilised within these systems to measure water depths and trigger maintenance when required rather than on a set time period.
- If not designed effectively, can be fenced off from community use, resulting in loss of functional green space
- If not designed at a suitable scale, can result in thousands of distributed gardens that become challenging to maintain
- If not accompanied by educational signage, can be misunderstood by the community and seen as a waste of space

Application

- Melbourne City Docklands
- Brisbane City Council Creek Filtration Program (https://waterbydesign.com.au/case-study/creek-filtration-systems-brisbane-city-council)

Figure 6-12 Creek filtration systems, Brisbane City Council

Source: Water by Design

6.5.14 Swales

Swales are shallow vegetation infiltration channels used to slow water flow and filter nutrients, sediments and contaminants from stormwater. They are a common design feature for managing overland flow and water quality in urban areas, often used as a regulatory design measure that are used widely by Local Governments across Australia.

Figure 6-13 Swales

Images: Bligh Tanner

Technical Aspects

There are numerous standard drawings and standards to support quality swale design. These include the Design & Construction Standards for Public Infrastructure (Melbourne 2013) and the Water-by-Design Guidelines (Healthy Land & Water 2019).

Benefits

- Low cost
- Improved infiltration of water
- Improved runoff water quality

- If carefully designed, can provide visual amenity and open space areas for local residents
- Added benefits of urban cooling and urban habitat

Challenges

- If not designed carefully and in the right location, can result in property access issues for landholders
- If not maintained well, can provide weed sources, odour and mosquitos for local residents
- If not accompanied by educational signage, can be misunderstood by the community and seen as a waste of space
- If not accompanied by educational programs, can be misunderstood by Council maintenance teams, who attempt to mow the swales and consequently create boggy areas for machinery

Application

- Townsville City Council – Swale Design
- Melbourne Water – Standards & Specifications

6.5.15 Vertical Gardens & Roof Top Gardens

Green walls (or vertical gardens) and roof top gardens are increasingly being used in cities around the world.

Figure 6-14 Vertical and roof top gardens

Images: Bligh Tanner

These gardens are utilised by a number of Local Governments across Australia and are a common feature of Sustainable building design to achieve Sustainability ratings.

Technical Aspects

These can be used in areas with limited space or to ensure multiple benefits from available space. Depending on the design and location, they can provide multiple benefits at a site, such as cooling, visual amenity, food production and nutrient removal.

Benefits

- Increased visual amenity
- Reduced impervious area and heat on roof tops
- Visual elements of green spaces like these are increasingly thought to have health benefits for local residents

Challenges

Plants in these systems require maintenance according to specifications in order to ensure plant survival. This maintenance is generally weekly during plant establishment and then less frequently as the plants become established. Overall, this maintenance regime is normal for any vegetated system and not considered ‘high maintenance’ when compared to traditional lawns and manicured gardens.

Application

- Melbourne Quarter Sky Park, Docklands
- Sydney Central Park Development

6.5.16 Stormwater Offsets & Water Quality Credit Programs

Offsets are a financial contribution provided by developers to Government Agencies to pool funds and undertake works in alternative location, in order to ‘offset’ stormwater impacts that are not treated within individual developments.

Offsets are being increasingly used in multiple jurisdictions across Australia and there are existing policies for Stormwater Offsets in Queensland. They are seen as an option for ensuring that nutrient targets are met, even for highly constrained sites, as well as providing a mechanism for combining funds and creating Sub-Regional solutions rather than attempting to reach water quality targets within each lot.

New water quality credit programs are also emerging, providing new incentive mechanisms for landholders to manage soil, vegetation, and waterways in high value catchments.

Technical Aspects

Many offset schemes operate as an all or nothing approach, whereby developers either meet their full stormwater treatment obligations on site or do no on-site works and pay an offset. The most economically efficient approach involves partial offsets, whereby developers undertake on site to the extent that it is economical to do so, and then use offsets to ‘top-up’ any residual shortfall.

Streambank rehabilitation is one type of offset being used by developers that are unable to meet nutrient & sediment targets at the lot scale. To implement these offsets, waterways can either be defined as trunk infrastructure via the LGIP or investment can be managed via a broader catchment management planning process.

Water Quality Credit programs are being used within the Great Barrier Reef catchments. These programs can be used as an offset, with landholders being paid according to the nutrients and/or sediment that they retain on their farm. Alternatively, they can be utilised within new agricultural business models whereby landholders can obtain economic benefits from the soil and vegetation on their property.

Benefits

- Provides a mechanism for achieving water quality targets, even on highly constrained sites
- Regional water quality targets and waterway health benefits can be achieved with investment of offset money in strategic waterway locations
- Mechanism for achieving least cost water quality management
- Avoids creating problematic single-function stormwater quality assets
- Offset projects can be designed to deliver a broader set of public interest outcomes, such as recreation or natural area restoration.

Challenges

- If the area where money is being invested is outside the catchment where the development impact occurs, there can be a local reduction in water quality near the development
- If all key water quality parameters are not considered in the assessment, only a few of the parameters will be offset, resulting in a local and overall reduction in water quality for parameters not being considered (e.g. metals)
- Investing offset money at the waterway equates to investing at the end of system, which is not the most effective location for dealing with cumulative catchment impacts
- Costs vary depending on local government pricing scheme and market supply and demand.

Application

- Melbourne Water Stormwater Quality Offset Scheme
- Ipswich City Council – Small Creek Rehabilitation Project
- Urban Utilities, Queensland – Logan River Rehabilitation Project
- Port of Brisbane – Laidley Creek Rehabilitation Project
- Reef Credits Program - Great Barrier Reef, Queensland

6.5.17 Walkable Neighbourhoods & Water Enabled Neighbourhoods

Designing future developments within a landscape context, considering important corridors, green spines, overland flow paths, urban heat and topographic features can enable more resilient and sustainable outcomes for the area.

A number of local Councils around Australia and globally are trialling different development footprints and lot layouts to increase long-term resilience and sustainability.

Technical Aspects

These neighbourhoods can include Sub-Regional scale design features, like nationally important vegetation corridors and development layouts, down to a precinct scale, with the incorporation of shade ways, boulevards and parks.

Buildings can be positioned on lots and designed in such a way to accommodate overland flow paths and improve overall sustainability outcomes.

Positioning buildings on a lot and across lots can be undertaken in such a way as to enable effective functioning of overland flow paths, maximise access to green spaces and shade, increase solar capture and minimise energy requirements.

It is more cost-effective to design with the landscape initially rather than attempting to retrofit suburbs to incorporate some of these landscape features at a later date.

Benefits

- Increased flood, drought and bushfire resilience across the new development area
- Improved ecological outcomes
- Reduction in urban heat island effects
- More accessible and connected green spaces for the community

- More cost-effective approach to managing natural systems across the landscape
- Increased resilience and sustainability of buildings
- Improved energy efficiency of buildings

Challenges

- This approach can reduce developable land and overall profit for developers
- Requires effective and early master planning
- Requires additional coordination for both the spatial and temporal aspects of developments
- Often requires construction staging and/or developers working across lot boundaries to create effective outcomes to be scaled

Application

- Logan City Council – Brookhaven/Bahrs Scrub Developments
- CRC for Water Sensitive Cities – 'Greening the Pipeline', Williams Landing, Melbourne

6.5.18 Verge Gardens

Verge land between the private property and the road can provide a valuable buffer between yards and the gutter.

Technical Aspects

This verge serves as a filter for nutrients and contaminants, provides some habitat for wildlife and creates green space for tree planting, cooling and other uses. A number of Local Governments across Australia have Verge Garden policies, enabling the adjoining landholder to plant community gardens, ranging from vegetable patches to bird habitats.

Benefits

- Multiple benefits, from community food production, through to urban cooling, urban habitat and nutrient filtration
- Low cost
- Builds local ownership of the verge space

Challenges

- Often not coordinated across boundaries, so can end up with visually and functionally contrasting gardens along each road
- Verge space is highly contested, with multiple utility services also provided within the verge. Gardens need to consider any potential impacts on power lines and the pipe network.

Application

- Brisbane City Council - Verge Garden Guidelines
- City of Melbourne - Street Garden Guidelines

- City of South Perth - Street Verge Landscape Guidelines

6.5.19 Gutter Guards

Gutter guards can be used on residential gutters to minimise leaf capture.

Technical Aspects

Gutters can capture and store leaf litter, resulting in a build-up of nutrients that are washed into either the stormwater system or into the rainwater tank. This leaf build-up can also increase fire susceptibility for the home.

Numerous Local Governments across Australia recommend the use of gutter guards. Costs can vary from $5-108/m, depending on solution selected.

Benefits

- Reduce leaf build-up in gutters
- Reduce nutrients to stormwater/rainwater
- Reduce fire susceptibility of home

Challenges

- Additional cost to homeowner for installing gutter guard
- Ongoing maintenance still required

Application

- The Southport School, Queensland – Reducing Costs, Decreasing Ceiling Flooding & Improving OHS (https://bluemountainmesh.com.au/field-notes/case-studies/case-study-reducing-costs-ohs-risks-with-gutter-mesh/)

6.5.20 Rates & Levies

A dedicated levy can form part of the rates paid by each individual landholder to Local Government. These levies can be for stormwater, environment or other important matter that requires dedicated funding.

Technical Aspects

Levies can be implemented proactively to increase funding for important environmental areas or improving stormwater management, or they can be used as a tax that is imposed according to the land use or impervious area on each lot. These mechanisms are used widely by Local Governments across Australia.

Benefits

- A good option for targeted funding, including innovation initiatives, with flexibility in how money is spent
- When used as a tax, it can be a powerful incentive for landowners to take specific management actions on a site, such as minimising impervious area

Challenges

- Requires political support, which requires strong support from the community to implement

Application

- Queensland Government Waste Levy
- Brisbane City Council Bushland Preservation Levy
- North Sydney Council Environmental Levy
- Melbourne Strategic Assessment (Environment Mitigation Levy)

7 Transport

7.1 Introduction

This chapter is intended to identify the ultimate and interim year staging of infrastructure the transport related elements of development within the Greater Flagstone Priority Development Area (PDA). This chapter should be read in conjunction with all infrastructure reports that form the Infrastructure Planning Background Report (IPBR).

Specifically, this chapter details the transport related trunk infrastructure requirements and the timing of these items. To ensure a robust and connected transport network is provided within the PDA, the relevant authority should ensure the requirements of this chapter are reflected within development approvals.

The information contained within this chapter was current at the time of development (June 2020). Background information referenced was current as of December 2019 and does not account for new applications or changes to existing development applications and approvals.

7.2 Reference Standards

In developing the DCOP several existing reference standards were considered to ensure the requirements set out in the DCOP provided alignment with existing EDQ policy and industry best practice. The standards that guided this document are summarised below.

Street and Movement Network PDA Guideline No. 06 | February 2019

EDQ's Street and Movement Network document, provides the standards required for the planning and design of street and movement networks within PDAs.

The specific standards used for this analysis were:

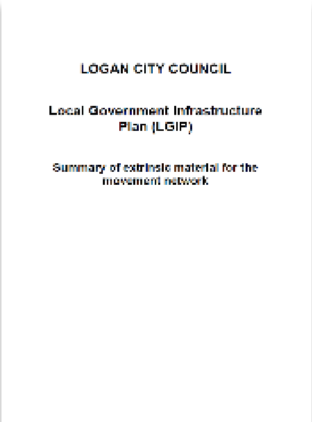
1. Street types and specifications
2. Corridor requirements
3. Carriageway requirements
4. Active transport requirements.

The guideline encourages interconnectivity between communities and neighbourhoods.

A key requirement of the guideline is one-way 2.0m separated cycle tracks on both sides of the corridor for higher order roads.

Whilst all effort was made to maintain the requirements of this guideline, to overcome challenges associated with staging of the cycle provisions, some alternative outcomes have been adopted for Greater Flagstone PDA. This is detailed in Section 7.

Local Government Infrastructure Plan (LGIP) Summary of Extrinsic Material for the Movement Network | June 2014

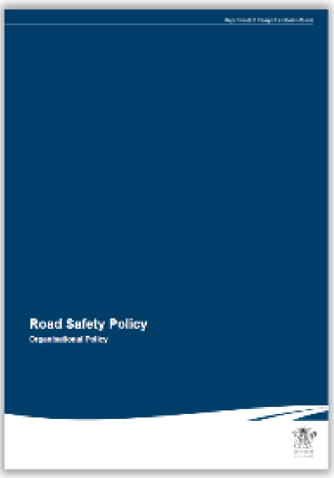


Logan City Council's (Council) LGIP Extrinsic Material identifies the future trunk network required to accommodate the forecast demand of population and employment.

It is noted that the current LGIP planning identifies the ultimate development year of 2051. Current projections for Greater Flagstone anticipate an ultimate development year for the PDA of 2066 (15 years post the LGIP planning).

The LGIP extrinsic material also details the desired standard of service (DSS) requirements for the future trunk network.

Road Safety & Operational Policy | July 2017



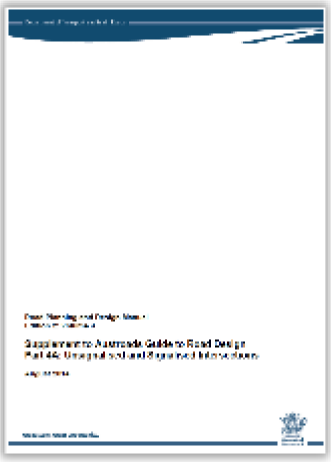
The Road Safety Policy published by the Department of Transport and Main Roads (TMR) focuses on implementing Safe System principles, processes and practices that have the can contribute to better road safety outcomes. This is aimed to assist with the State Government's vision of zero road deaths and serious injuries. The policy assists with maximising the alignment with best practice road safety management.

The specific items within this policy that informed the analysis and intersection design were:

Provisions for vulnerable users and where demand exists or may develop, pedestrian crossings on all approaches at signalised intersections

The requirement to avoid unsignalised left turn slip lanes at intersections

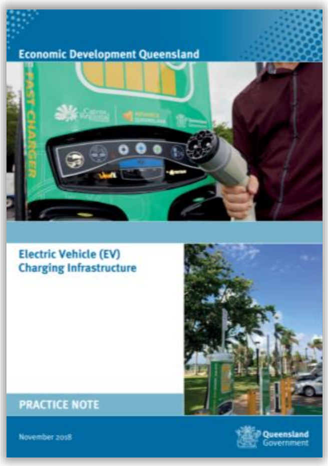
Road Planning and Design Manual (RPDM) Edition 2 Part 3 | August 2014



The RPDM is a TMR document that is supplementary to the Austroads Guide to Road Design Part 4A. The purpose of the document is to provide additional information that is specific to intersection design for TMR's network.

It is acknowledged that the PDA's future asset ownership will likely sit with Council, however Austroads Part 4a is an industry accepted best practice guide, with reference given to the additional TMR requirements due to the Queensland context. It also gives guidance on the warrants for major road turn treatments. This has been used to inform the design of the unsignalized intersections on the trunk network of the PDA.

Economic Development Queensland's Electric Vehicle Charging Infrastructure Practice Note | November 2018



The Practice Note outlines the principles for planning electric vehicle (EV) charging infrastructure in Priority Development Areas (PDAs) in Queensland, to support the selection of the right type of infrastructure at the right location. It is intended to assist government authorities, town planners, developers and landholders looking at installing EV charging infrastructure. This Practice Note does not replace or override any applicable local planning laws, building codes and Australian standards.

7.3 Past Reports

Table 7-1 List of Past Reports Considered

Document title and author	Description	Will it be superseded by DCOP?
Draft Proposed ICOP (October 2019) Department of State Development, Tourism and Innovation	Sets out the infrastructure contributions that may be offset against the Greater Flagstone Priority Development Area (PDA) charges.	Yes
Greater Flagstone Urban Development Area Development Scheme (October 2011) Urban Land Development Authority	Establishes the vision, land use and infrastructure planning for the Greater Flagstone Urban Development Area.	No (Amendment to Development Scheme is required)
Demographic Analysis for Three Priority Development Areas (January 2020) SGS Economic Planning	The report provides land use projections for the Greater Flagstone, Yarrabilba and Ripley Valley Priority Development Areas (PDA).	Yes
Model Development and Network Apportionments (October 2019)	This report outlines key inputs to the South Logan Strategic Transport Model (SLSTM) model and presents capacity results consumed by trips to and from and within Greater Flagstone.	No

Document title and author	Description	Will it be superseded by DCOP?
Veitch Lister Consulting (VLC)		
Bicycle Network Plan (May 2017) VLC	Develops an active transport plan for Greater Flagstone. Provides guidance to EDQ and Logan City Council to ensure a consistent and high-quality approach is taken in delivering active transport facilities within the PDA.	Yes
Logan Cycle Network Plan (2015) Logan City Council	Alignments for trunk cycle infrastructure according to the Logan Planning Scheme 2015.	No
PDA Guideline No.6: Street and Movement Network (February 2019) Economic Development Queensland	This guideline sets out the standards for the planning and design of street and movement networks within PDAs.	Yes
Local Infrastructure Plan (July 2016) Cardno	LIP outlines the principle assumptions that were previously applied in the local transport plan for the PDA.	Yes
Infrastructure Master Plans (IMPs) Various	There are multiple existing IMPs over the Greater Flagstone PDA. These were reviewed, with consideration given to the details contained within them. In some instances, a better network outcome could be achieved by the DCOP provisions. Therefore, there may be some misalignment that should be resolved during the ongoing approval process.	Yes
Context Plans and Development Applications / Approvals Various	Several existing lodged and approved Context Plans and Development Applications sit over the Greater Flagstone PDA. Whilst there is no ability within the planning framework to change approvals, consideration should be given to the content within the IPBR when deciding live applications.	No

7.4 Desired Standards of Service and Road Network Usage Allocations

This section outlines the Desired Standards of Service (DSS) requirements for roads and intersections within the Greater Flagstone PDA. The requirements for cycle and pedestrian networks can be found in Section 8.2.

The DSS requirements are provided to inform the performance of roads and intersections that will be accepted within the PDA. These requirements have been taken from EDQ's Guideline Number 06 and in the absence of EDQ policy, best practice.

These defined measures will ensure there is a resilient transport network that supports the PDA's growth. It is also intended to accept a certain level of congestion during peak times given the urban nature of the PDA.

7.4.1 DSS Requirements for Trunk Roads

A review of the EDQ and Council DSS requirements for roads was undertaken. As can be seen in Table 7-2 there are some disparities between the naming conventions and daily thresholds for the trunk network.

Table 7-2 Trunk Road DSS annual average weekday traffic

PDA Guideline no. 06			Council LGIP Extrinsic Material		
PDA street network	**Number of lanes (both directions)**	**Daily traffic volume, vpd**	**Link function**	**Number of lanes (both directions)**	**Daily capacity threshold, vpd**
Urban Arterial	2 lanes	NA	Arterial	2 lanes	20,000 - 22,000
	4 lanes	NA		4 lanes	44,000 - 48,000
Trunk Connector	2 lanes	7,500 - 18,000	Collector	2 lanes (median divided)	14,000 - 15,000
	4 lanes	18,001 - 30,000		4 lanes	30,000 - 33,000

To facilitate the delivery of a resilient transport network, trunk roads within the PDA will have the DSS standards applied as presented in Table 7-3:

Table 7-3 Greater Flagstone PDA DSS Road Requirements

PDA Guideline No. **06**		
PDA street network	**Number of lanes (both directions)**	**Daily traffic volume, vpd**
Urban Arterial	2 lanes	7,500 – 23,500*
	4 lanes	23,500 - 40,000*
Trunk Connector	2 lanes	7,500 - 18,000
	4 lanes	18,001 - 30,000

**In the absence of EDQ Policy standard industry practice has been applied, these values are estimates of the range for maximum vpd.*

7.4.2 DSS Requirements for Trunk Intersections

There are several different metrics that can be used in assessing the performance of an intersection. Table 7-4 identifies the maximum peak hour control delays for trunk intersections from Council's extrinsic material.

Table 7-4 Council's Trunk Road DSS Maximum Peak Hour Intersection Control Delays

Column 1 Locality	Column 2 Maximum control delay for type of intersection (seconds)		
	Signal controlled intersection	Roundabout	Sign controlled intersection
Activity centres and on multi-modal routes	80	70	50
Urban out-of-centre	55	50	35
Non-urban and on freight routes	35	35	25

In the absence of EDQ policy, best practice has been applied for the DSS requirements of trunk intersections within the PDA. These requirements are for maximum Degree of Saturation (DOS) thresholds of:

- 0.90 for traffic signals
- 0.85 for roundabout
- 0.80 for priority control.

We note that the ultimate year for the PDA is 2066 and that means there is some uncertainty around travel patterns and behaviours for this ultimate year. There may also be emerging technologies which will allow for more capacity to be gained out of existing infrastructure. Therefore, some consideration will be given for signalized intersections exceeding the DOS of 0.90 in the ultimate year of 2066. This will be considered and approved on a case-by-case basis.

7.5 Stakeholder Engagement

A key requirement of the DCOP process was collaborative engagement between EDQ and other key authority stakeholders. For Greater Flagstone transport this was TMR and Logan City Council.

The purpose of this engagement was to ensure the requirements set out in this chapter were aligned with the future demands and timings of both the PDA and external networks and drivers.

In addition to ongoing discussions, the two key workshops delivered are detailed in Table 7-5.

Table 7-5 Greater Flagstone DCOP Workshops

Workshop	Date	Overview	Attendees
1	Monday, 9 December 2019	To detail and gain agreement on the DCOP transport scope and project path to success.	EDQ Council
2	Thursday, 30 January 2020	Provide detail on: Review and consolidation of existing information Alignment of the PDA and DCOP requirements with other local and state policy Constraints and opportunities analysis Recommendations on updates to existing strategies	EDQ TMR Council

In addition to the above targeted stakeholder sessions discussions were held with Translink to discuss the future public transport requirements of the PDA. These discussions will continue to occur to ensure public transport services can be provided as the demand increases.

Ongoing engagement on the outcomes of the analysis has occurred to ensure the DCOP provisions as presented in this IPBR report are consistent with the intent of the PDA and aligned with stakeholder requirements.

Further engagement with both authority and developer stakeholders will continue as further revisions of the DCOP occur.

7.6 Innovation by Design

Innovation by design as previous defined includes approaches using proven, currently available technologies and/or construction methods to achieve innovative outcomes. These innovations currently exist within the Australian context of urban development and can be readily implemented within the Ripley Valley PDA.

Design Innovations enable new development and infrastructure in each PDA to showcase already tested innovations that are progressing to business as usual in other locations. These innovations require the development industry’s desire to showcase leading design innovations as part of new urban development.

The following list of Design Innovations currently exist within Australian urban communities. These innovations provide examples of locations that have implemented these innovations in place of BAU infrastructure and provide developers, landowners and local governments with on the ground outcomes that they can duplicate in the local context of Ripley Valley. Developers are encouraged to implement one or more of the Design Innovations in consultation with EDQ and local government and help progress these innovations to business as usual.

7.6.1 Smart Poles

Smart poles have been installed in major cities to help local councils collect data. Smart poles can be used for public safety lighting, pedestrian and cyclist detection, traffic and construction noise monitoring, Wi-Fi, USB charging, general power outlets (E-bikes) and climate monitoring. The poles are approximately 8m tall and transmit collected data to a Central Management System (CMS). Brisbane City Council have a plan to install 20 smart poles, with a lifespan of 40 years, across Brisbane to collected data on how the city functions.

Image sourced: thedailytelegraph.com

Figure 7-1 Image example of a Smart Pole

Key considerations

Smart poles are primarily used to gather data for future planning and development. Smart poles must be placed in strategic locations, predominantly high trafficked areas (people and vehicles), to ensure data collected has maximin inputs from each location. Significant supporting infrastructure to manage and process data acquisition, related to monitoring, surveillance and user statistics/modelling is also required as without it, the source data has limited value. These inputs enable a network of data on travel systems, destination, route, services accessed, technology and connections. The costs associated with ongoing operation and maintenance of the infrastructure should also be considered.

Implementation recommendations

Moderate: Smart poles can perform various activities as they provide power, lighting, charging options, monitoring and Wi-Fi, hence their location must be well placed within the urban environment. Positions within activity centres, at PT hubs and Sub-Regional open space would maximise their return data and informational inputs.

Ownership and operation

Funded and owned by local government as landowner ongoing operations can be outsourced. For example, for over 2 years now Ipswich City Council has implemented smart poles in the form of streetlights and Brisbane City Council awarded Sydney- based company ENE HUB the contract for the supply and installation of the smart poles and 10 years of operation and maintenance.

Procurement complexity

High: Installation, operation and ongoing maintenance would remain with local government. Subject to local government policy position and budget allocation. Opportunities to trade data may offset costs.

Further information

- Ipswich: https://www.ipswichfirst.com.au/humble-street-light-heart-ipswichs-smart-city-evolution/
- Brisbane City Council: https://www.brisbane.qld.gov.au/about-council/governance-and-strategy/vision-and-strategy/smart-connected-brisbane/brisbane-smart-poles

7.6.2 Adaptive Signaling

Machine learning has been applied to traffic signalling to improve efficiencies. These signalised systems receive information from intersections at short intervals, allowing them to adjust split, offset and cycle times to suit the current conditions. Video detection also allows for speed and mode of transport to be identified, resulting in benefits such as the prioritisation of emergency vehicles. Arcadis' 'Smart Corridor' in Atlanta and the 'Scoot System' in Monterey are examples of where adaptive signalling is producing substantial results.

Image sourced: Arcadis.com

Figure 7-2 Example of adaptive signalling

Outcomes include more efficient signalised networks, which reduce waiting times, improve safety (35% collision reduction along the smart corridor) and result in less emissions from vehicles. Other innovations in signalling include changing the display of the signal itself, such as showing the time left of a certain signal.

Key considerations

Due to the highly autonomous nature of these systems, there is potential for harmful errors if not implemented properly. Therefore, expertise and experience of key personnel is critical for safe operations, including a regular monitoring and maintenance systems.

Implementation recommendations

Low: These automated systems are still evolving their mainstream application due to their interface with potentially hazards human activities and their artificial intelligence. Options for these solutions require significant engagement with state government road authorities as the ultimate owner and manager responsible for these assets.

Ownership and operation

As traffic lights remain a Department of Transport and Main Roads asset resource allocations into Adaptive signalling would need to be adopted by the state government. Both projects outlined were government funded, with each one's respective design firm tasked with supporting a local team in day-to-day operations.

Procurement complexity

High: Due to the risks associated with the application of this technology widespread implementation will be a long-term investment for the state government and will only be mainstreamed once associated risks are within acceptable levels.

Further information

- Smart corridor, Atlanta USA: https://www.arcadis.com/en/global/what-we-do/our-projects/north-america/united-states/creating-an-intelligent-transportation-system-for-atlanta-s-first-smart-corridor/
- Scoot system, Monterey USA: https://www.westernsystems-inc.com/project/scoot-adaptive-traffic-control/

7.6.3 Electric Vehicle Charging

Increase in electric vehicle (EV) use has created a demand for public EV charges to be supplied in on street and off-street parking locations. Public EV charging spaces have a varying price range depending on the location and time of day. At most, the cost of using a public charging station is typically less than the cost of charging the vehicle at home. Available chargers around the city can be found via apps which can also be used to make payment. Contactless payment is progressively being added to chargers.

Image sourced: Waverley Council

Figure 7-3 Electric vehicle charging

Public EV charging spots are usually in priority spaces, painted green or red with a white EV charging symbol and/or easily locatable by signage and large charging station. EV charging spots found in hotels and other commercial buildings may require drivers to bring their own charging cables and adapters and will only be charged that base parking rate for all car types.

Key considerations

For EV charging to be productive the position of the charger relative to the car parking space must be considered in the context of locational demand for EV charging. Engagement with surrounding stakeholders of parking infrastructure like hotels, shopping centres and local governments in also required as well as the BCR for installation.

Implementation recommendations

Moderate: Incentive packages in collaboration with solar and residential battery providers and manufacturers would assist in maximising opportunities for domestic EV charges to be provided within individual properties, and car parks. Public EV charging points should be provided in public car parks.

Ownership and operation

There are numerous Queensland examples including at the Northshore Hamilton PDA. The Bowen Hills development scheme requires EV readiness, as does Yeronga PDA. The Carseldine village design guidelines require all dwelling garages to be EV ready. The public EV charging stations in Waverly Council are supplied by JET Charge and were jointly funded by three councils (Waverly, Woollahra and Randwick), as part of their joint commitment to reduce carbon emissions. Users can book and pay for the charging stations via the Chargefox app.

In Brisbane the EV charging stations are in a privately-owned car park, where users of the stations pay half price (casual parking rates) for parking and charge for free during business hours.

Procurement complexity

Low: Where new public car parks are created, or existing parking areas refurbished local government can install charging stations as part of a sustainable approach to carbon reduction. Private car parking areas in shopping centres/activity centres could also be required to provide EV charging parks through planning policy and/or incentives.

Further information

EDQ's Electric Vehicle Charging Infrastructure Practice Note outlines the principles for planning electric vehicle (EV) charging infrastructure in Priority Development Areas (PDAs) in Queensland, to support the selection of the right type of infrastructure at the right location. It is intended to assist government authorities, town planners, developers and landholders looking at installing EV charging infrastructure: https://www.dsdmip.qld.gov.au/resources/guideline/pda/practice-note-electric-vehicle-charging.pdf

The Queensland Electric Super Highway charging stations use green energy either through direct green energy credits or offsets, making them a carbon-neutral and pollutant-free transport option: https://www.qld.gov.au/transport/projects/electricvehicles/future/super-highway

Waverley, Woollahra and Randwick Councils in Sydney's eastern suburbs have installed public on-street electric vehicle (EV) charging stations in key destination hotspots from Coogee to Double Bay. These are the first on-street public charging stations of this type in Sydney, and local government-backed on-street charging infrastructure in NSW. The charge stations allow for universal charging, meaning they will be accessible to all electric vehicle makes and models. EVs will need to adhere to normal parking restrictions that apply at each site: https://www.waverley.nsw.gov.au/environment/sustainable_transport/electric_vehicle_charging_station

In Brisbane CBD, free electric car recharge is available during business hours. King George Square Car Park is the only car park in the city with this facility, promoting the reduction of carbon dioxide and pollution. Specially marked bays are on Level B for this service: https://www.brisbane.qld.gov.au/traffic-and-transport/parking-in-brisbane/car-parks/king-george-square-car-park#electric

7.6.4 Recycled Paving

While there are several products on the market that provide the same benefits and methodologies of manufacturing, Fulton Hogan has begun conducting large scale trials of their product, Plastiphalt made from recycled plastic, that would otherwise go to landfill. This environmentally friendly asphalt has been successfully implemented in projects such as the Christchurch Airport Fire Station, where 3100 four-litre plastic oil containers were used. Like various other recycled goods, once used and showcased a greater demand for recycled products will arise from Plastiphalt wide scale adoption.

Image sourced: The Age

Figure 7-4 Plastiphalt ingredients

Key considerations

Currently the associated cost increase with using Plastiphalt compared to common asphalt is around 7%. Therefore, without the incentive of a government subsidy, wide scale implementation will be difficult.

Implementation recommendations

High: The opportunity to replace a standard well used product with an equally as good alternative that has a sustainable footprint should be pursued. The widespread use of asphalt for road construction and footpaths enables a straightforward replacement product to be widely implemented through new infrastructure.

Ownership and operation

Currently Fulton Hogan has patented the 'Plastiphalt' product but given its current success it is reasonable to assume that many similar products will be available to the market soon.

Procurement complexity

Moderate: As the product is more expensive than asphalt some financial incentives or concessions could be applied through government grants/subsidy to developers where use is implemented as part of their standard road construction. Subject to both local and state government road authority's acceptance of the 'Plastiphalt' surface as adequate for their road's capacity.

Further information

- Christchurch Airport, New Zealand: https://www.fultonhogan.com/trial-recycles-plastic-containers-asphalt/
- Castle Road, Glanville, South Australia:https://www.fultonhogan.com/plastic-recycled-into-asphalt-in-adelaide/
- St Kilda Road, Victoria: https://www.theage.com.au/national/victoria/recycled-plastic-hits-the-road-in-st-kilda-20190918-p52sjl.html

7.7 Review and Comparison of Adopted Demographics

A comparison of the demographic analysis undertaken and described within Chapter 1 was compared against what sat in the transport model. The purpose of this comparison was to quantify the difference in dwelling projections at a transport zone level.

The comparison of horizons 2031 and 2066 are presented below.

The results illustrate the minimal differences between the dwelling assumptions that underpin the existing VLC transport model and the recent SGS numbers. The majority of Greater Flagstone sees a difference between -50 to 50, which is expected would not have any impact on the outputs of the transport model. There are several zones that see a difference of less than -50 or more than 50, which would also likely have a negligible impact on the outputs of the modelling.

Figure 7-6 illustrates similar results to 2031, with the extent of changes typically sitting between -200 to 200 differences. The overall ultimate dwelling provisions remain closely aligned between SGS and the VLC transport model. When considering the total provision of 55,000+ dwellings, the differences of less than 200 +/- represents a change of less than 1%. Following discussions with VLC it was agreed that the changes in demographics would have a negligible impact on the outputs of the transport model.

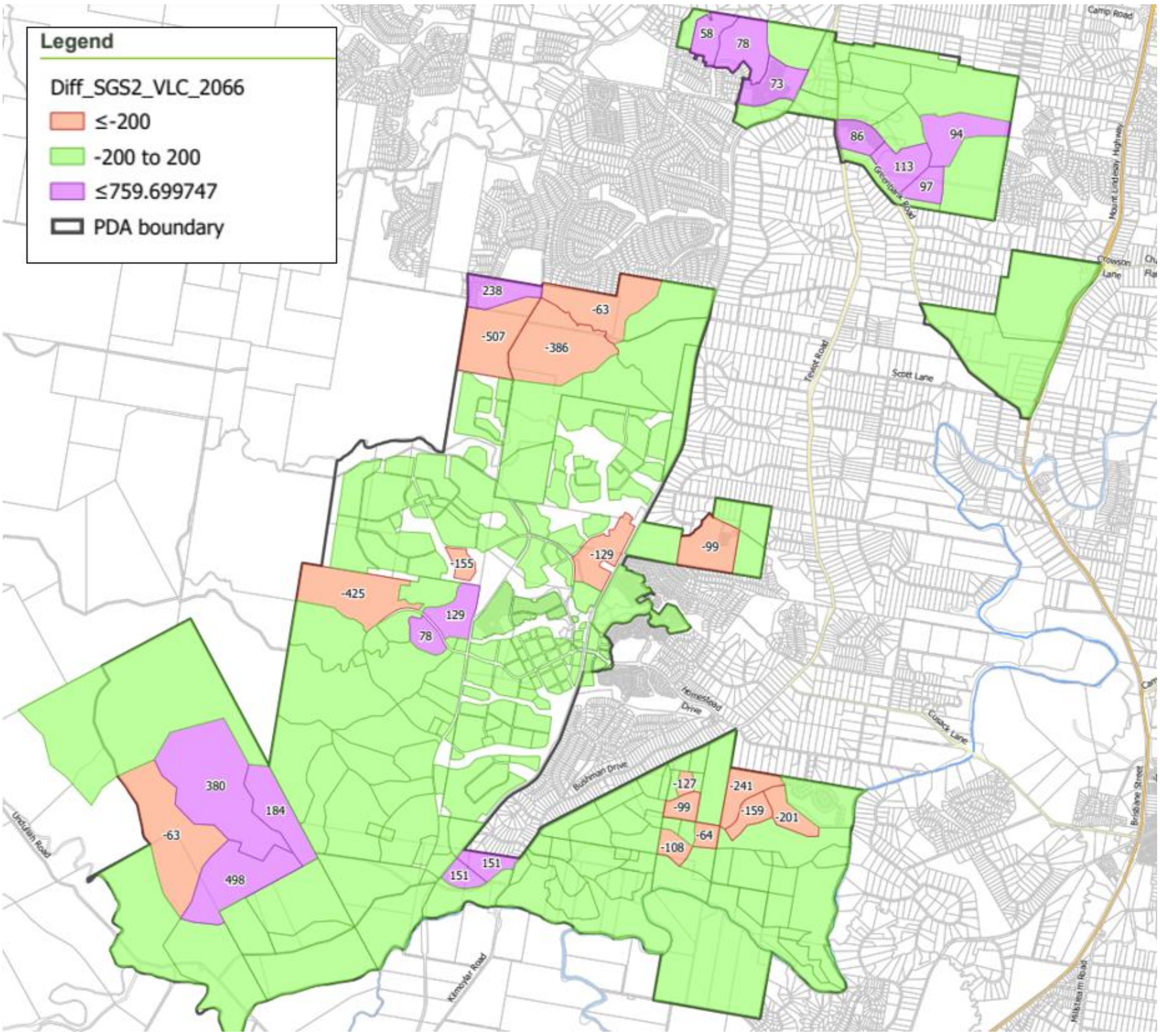


Figure 7-5 2031 Dwelling Comparison SGS vs VLC

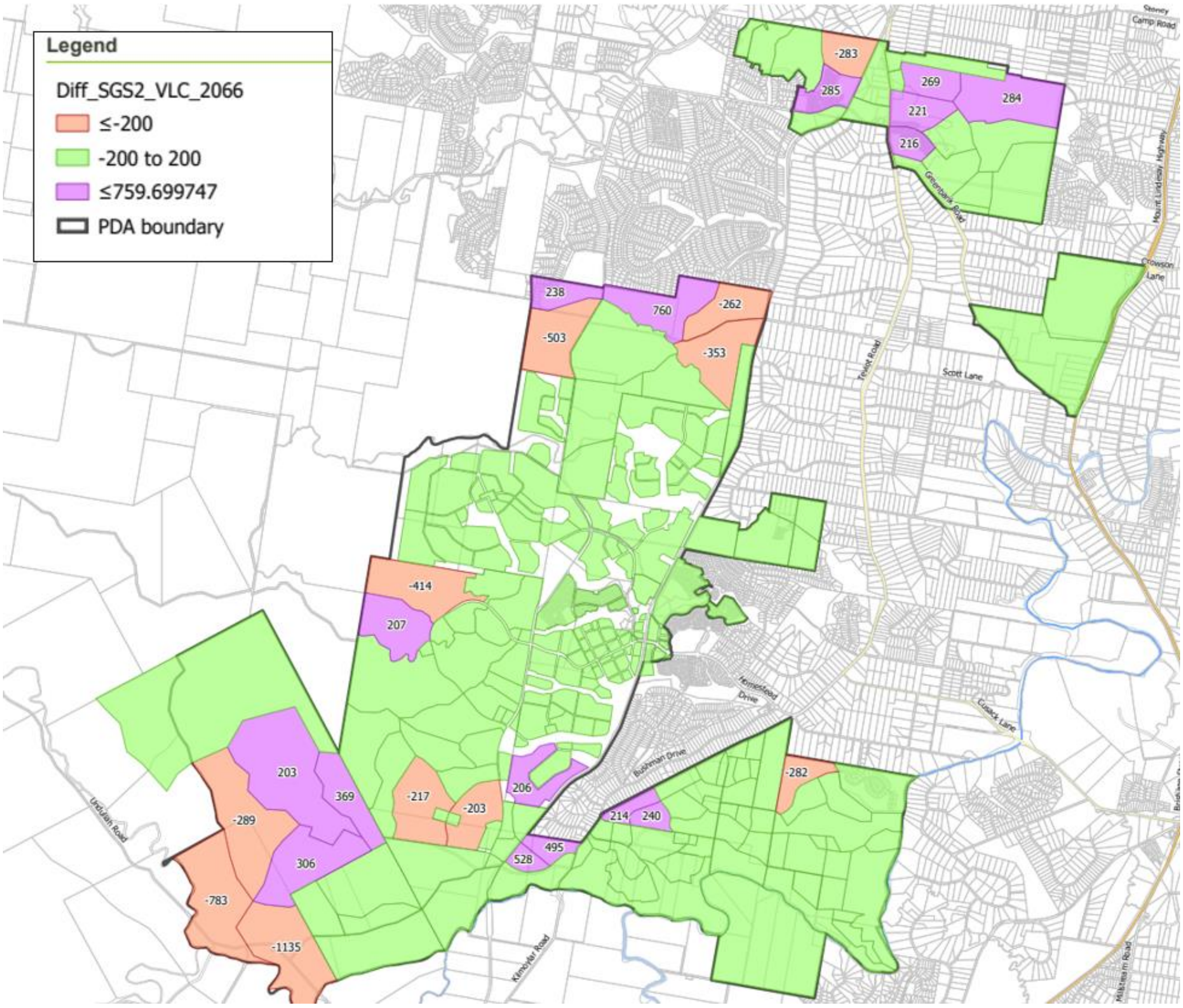


Figure 7-6 2066 Dwelling Comparison SGS vs VLC

7.8 Planning Horizons

The planning horizons and demographics used to inform the DCOP analysis are detailed at the transport zone level following, with Table 7-6 summarising the data.

These assumptions provide the best guidance at this time. As the progressive development of the PDA occurs, there will be natural movement of these numbers, particularly at the transport zone level.

When considering an ultimate horizon of 2066, consideration should be given to the emergence of new technologies including autonomous vehicles, personalised mobility solutions, mobility as a service (MAAS) and other new technologies and travel patterns. These changes in travel behaviours over the coming decades cannot be reflected in current modelling. As the progressive updates of the DCOPs occur, and more certainty is known around these new technologies, these other factors will increasingly be included in the analysis.

Table 7-6 Greater Flagstone Planning Horizons and Adopted Demographics

Horizon	Population	Dwellings	Jobs
2026	20,312	6,914	5,187
2031	35,741	12,265	8,797
2041	70,548	25,484	16,492
2046	86,312	31,797	20,631
2066	145,099	54,145	34,387

Source: 20190482 SGS Forecasts Greater Flagstone Yarrabilba_171219

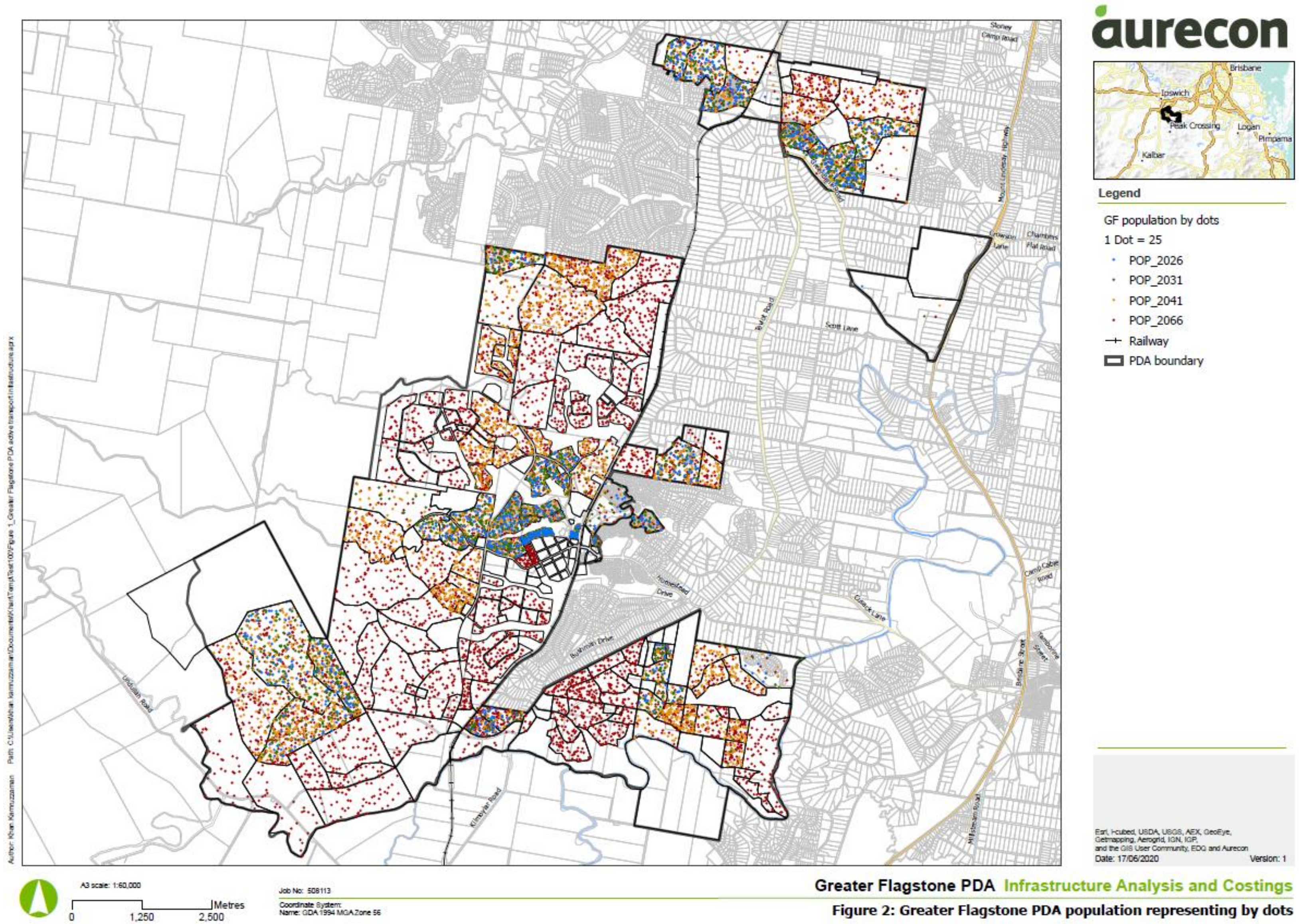


Figure 7-7 Greater Flagstone Demographics – Population

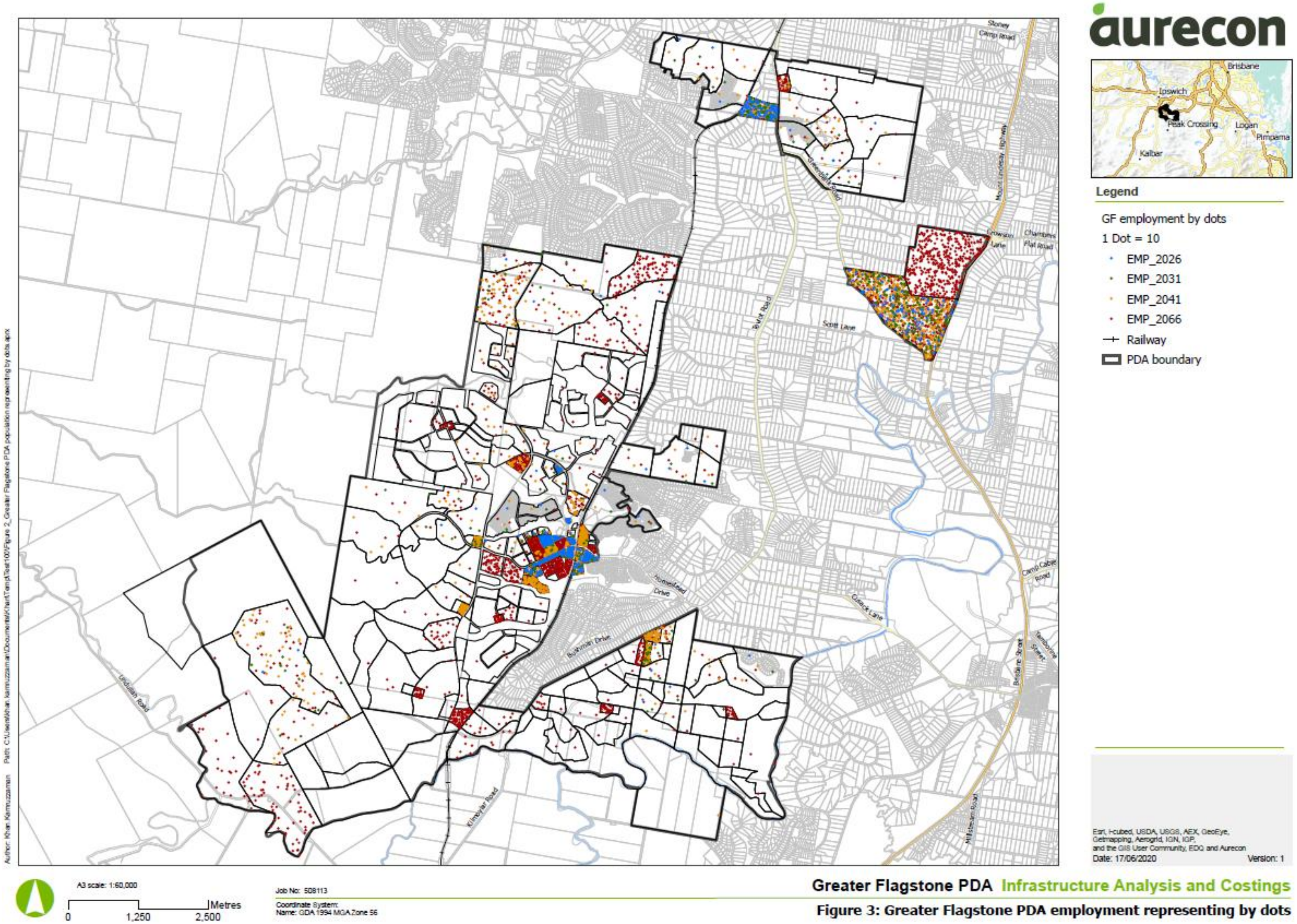


Figure 7-8 Greater Flagstone Demographics – Employment

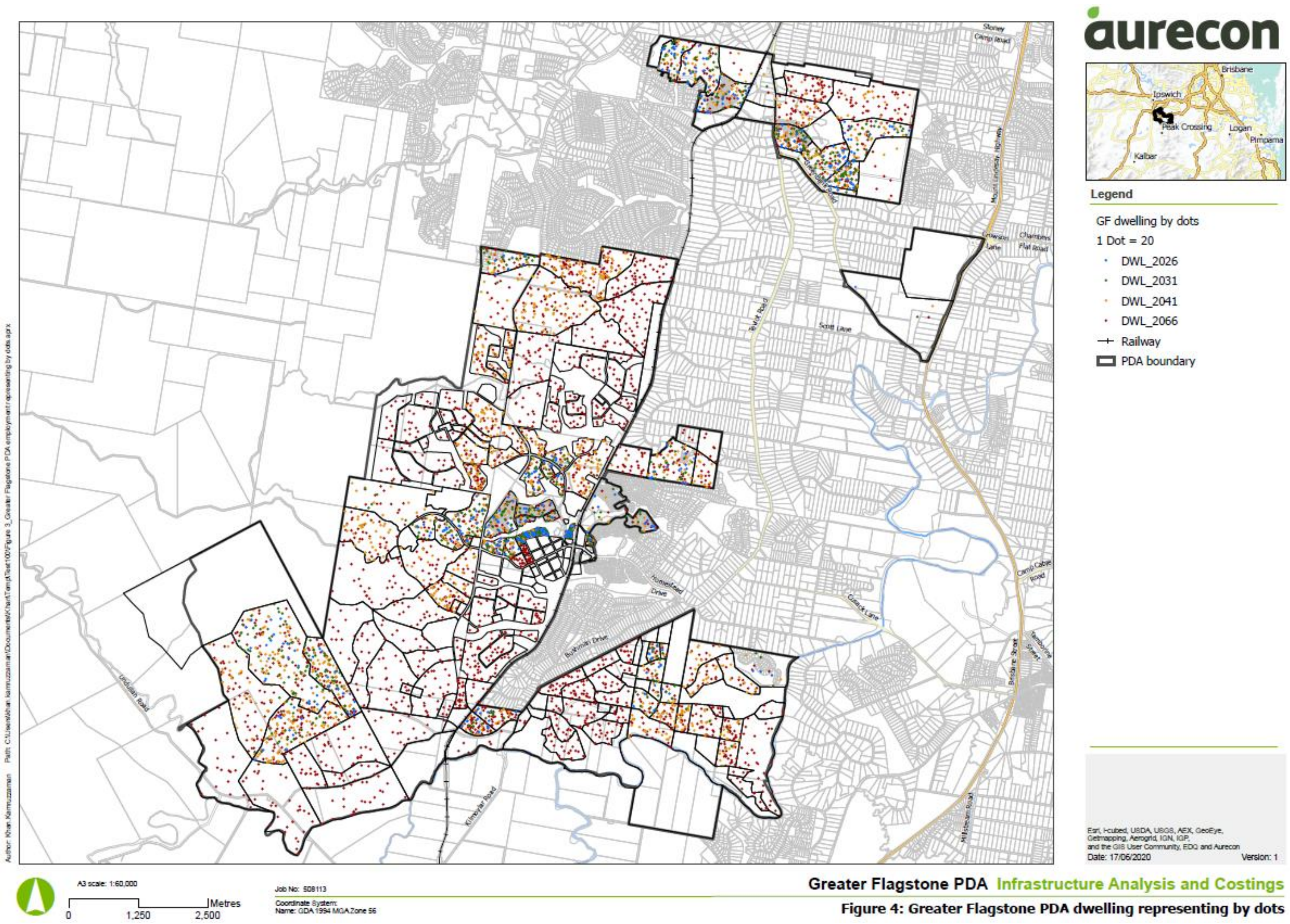


Figure 7-9 Greater Flagstone Demographics – Dwelling

7.9 Interim and Ultimate Planning Horizon Analysis and Results

The turn movement volumes used to inform this analysis were derived from VLC's updated South Logan Strategic Transport Model (SLSTM). This model covers both Greater Flagstone and Yarrabilba PDAs. The link volumes and volume to capacity (V/C) ratios were provided for the 2031 and 2066 horizons as illustrated in Figure 7-10 and Figure 7-11.

The outputs of the transport model indicate that in 2066 (ultimate horizon), the network outside of the PDA is under pressure with several links exceeding the 1.3 V/C ratio. However, within the PDA the links are expected to operate satisfactorily, although there will be some peak hour pressure experienced which will be further illustrated in the outcomes of the intersection analysis.

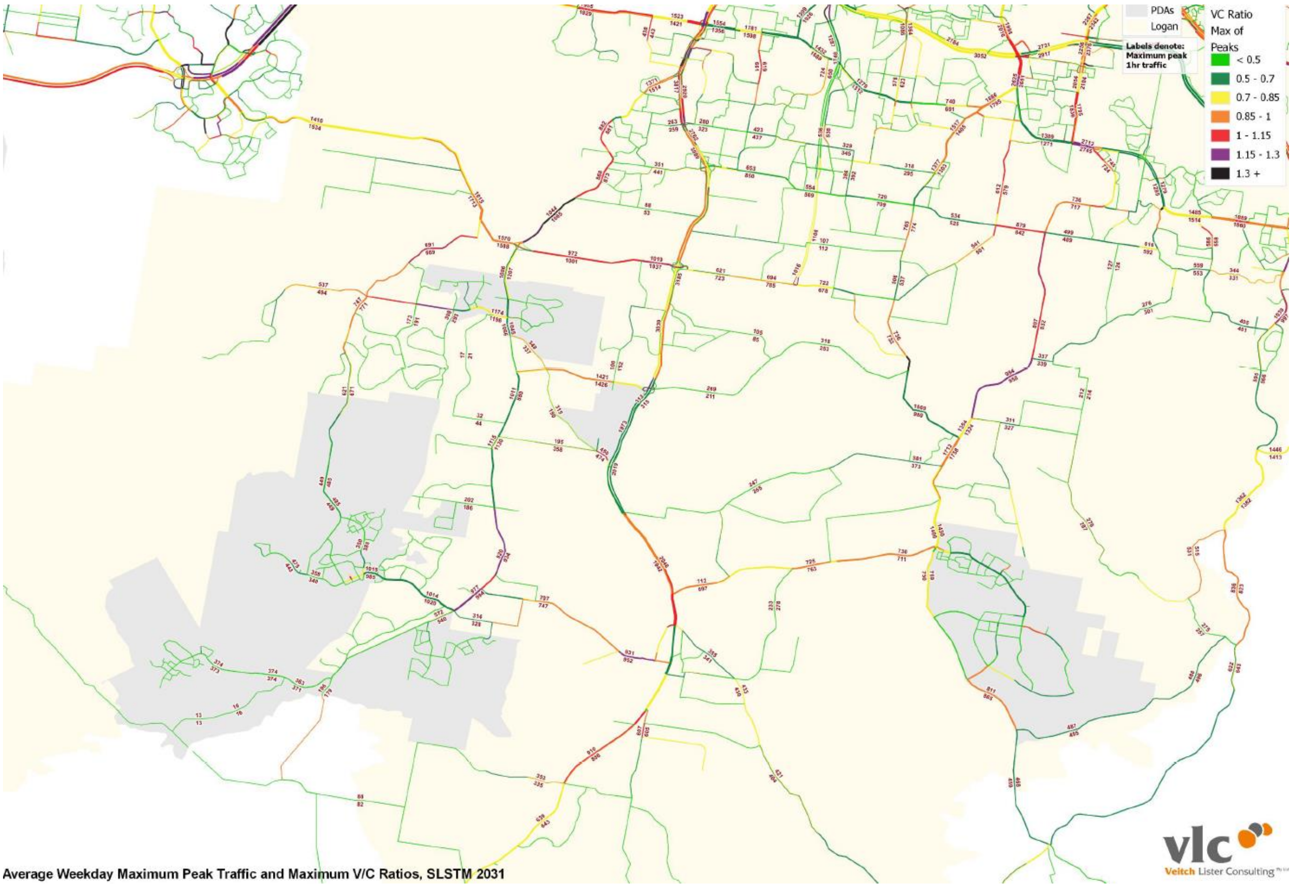


Figure 7-10 2031 Greater Flagstone and Surrounds Transport Model Outputs

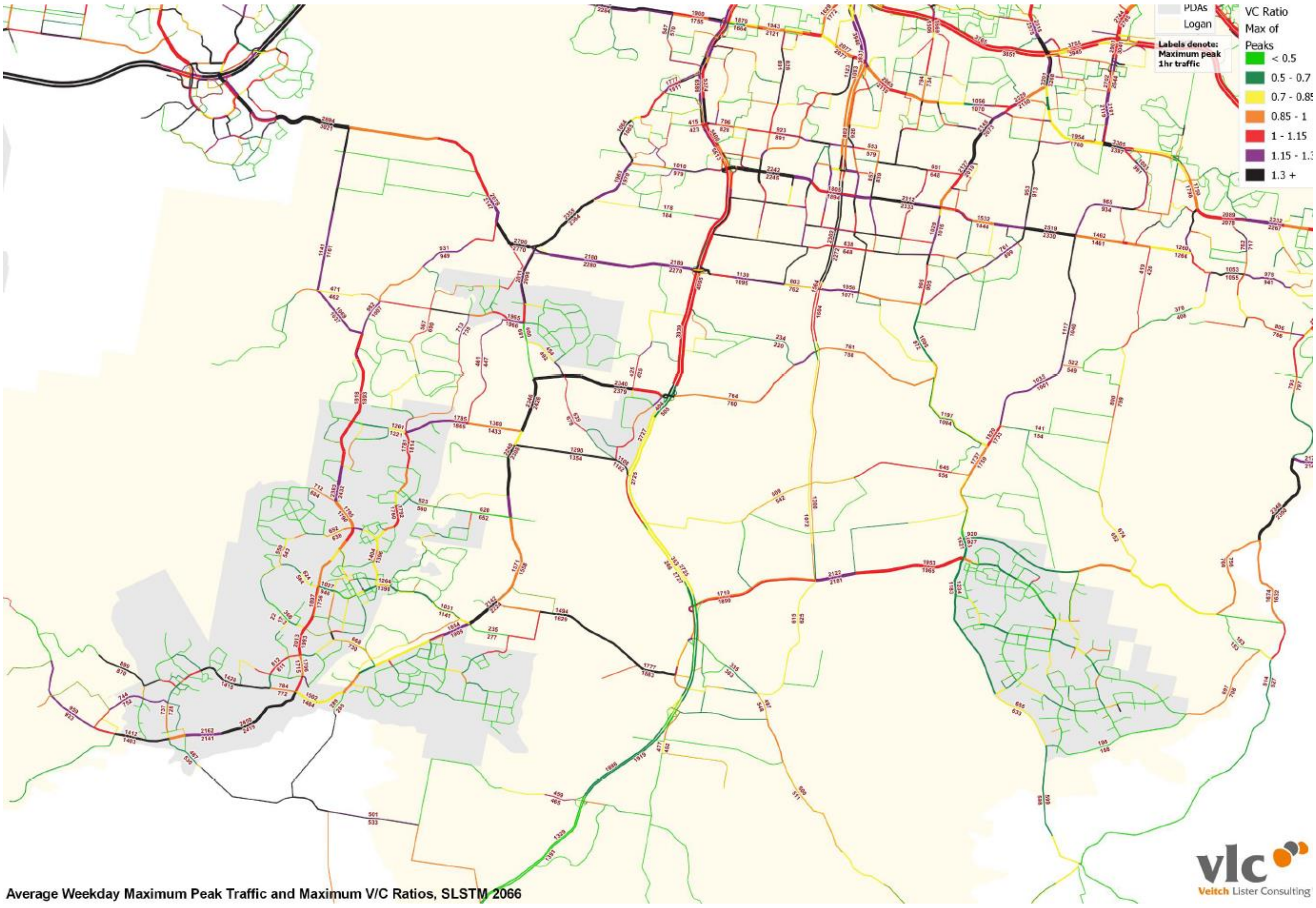


Figure 7-11 2066 Greater Flagstone and Surrounds Transport Model Outputs

7.10 Functional Road Hierarchy

The trunk network Greater Flagstone Road hierarchy is presented below in Figure 7-12. A review of the previous ICOP hierarchy confirmed that no changes to the hierarchy were required, with the relevant corridors sufficiently accommodating anticipated demand.

7.11 Adopted Road Network

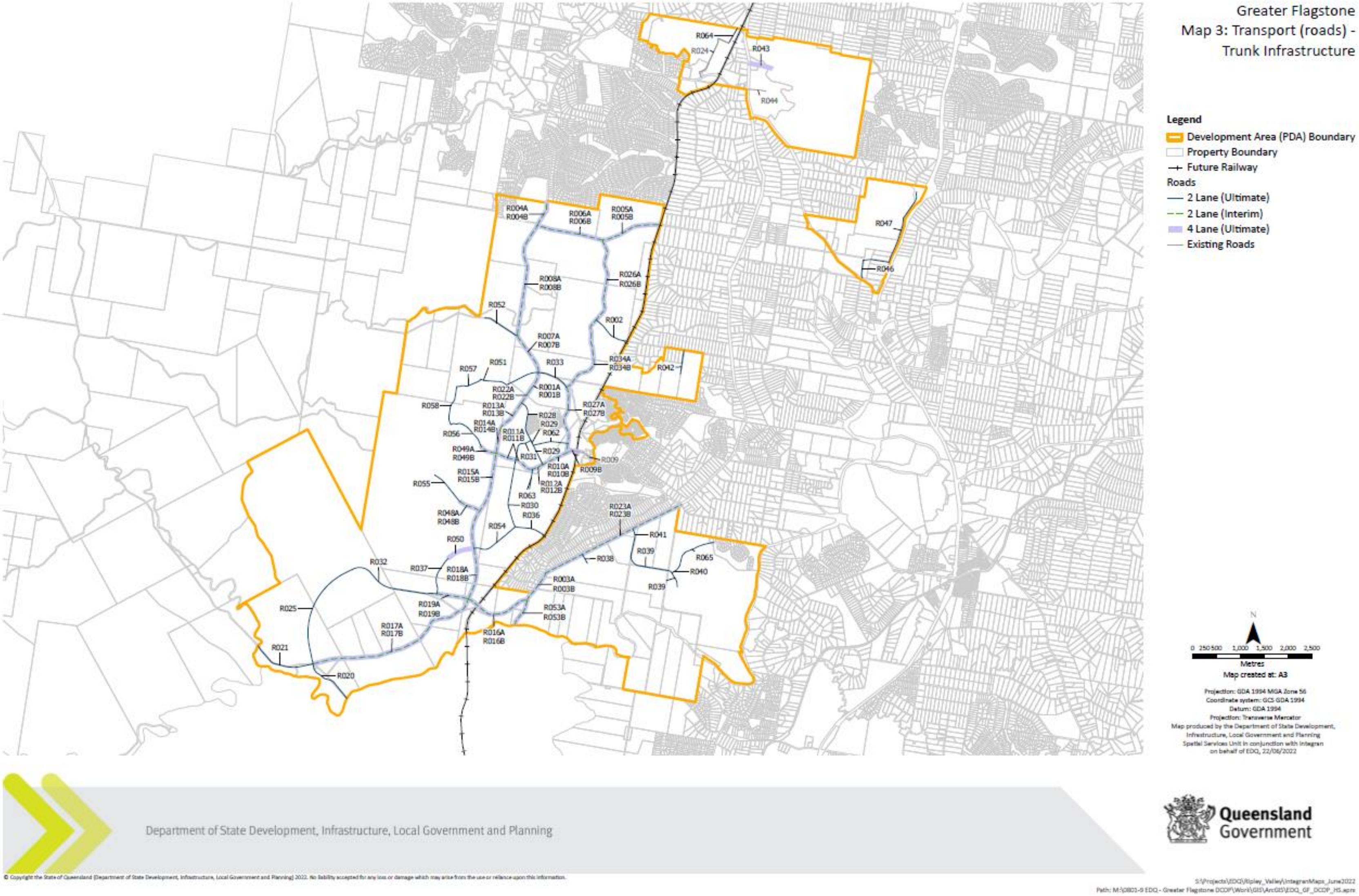


Figure 7-12 Greater Flagstone PDA Adopted Trunk Road Network

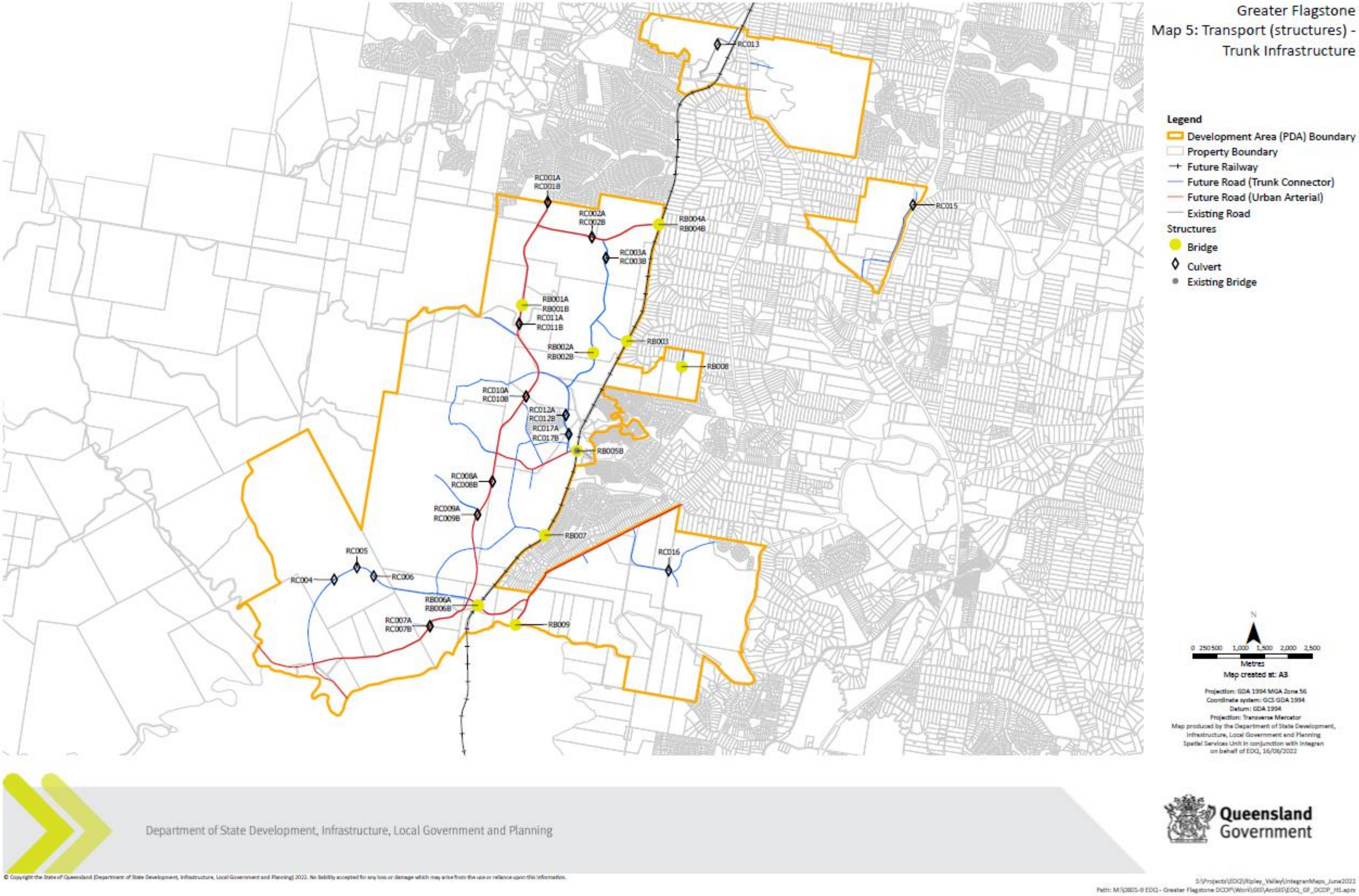


Figure 7-13 Greater Flagstone PDA Adopted Trunk Road Bridge and Culverts

7.12 Adopted Cross Sections

When considering the mid-block cross section requirements of the PDA alignment with Guideline No. 6 Movement Network was maintained where possible.

However, to minimise corridor impacts on adjacent land parcels and to provide efficient staging of roads that ultimately go to 4 lanes, some variation was made. This adjustment was made to the requirements of the 4-lane trunk connector and urban arterial. Specifically, to accommodate a two-way 3m separated cycle track on one side in the interim, the clearance abutting the kerb used for tree planting and stormwater pits, was reduced from 2.0m to 1.5m. This allowed the ultimate corridor width to remain the same, even with the addition of 1.0m to one of the one-way cycle tracks. The proposed typical cross sections are shown in below figures.

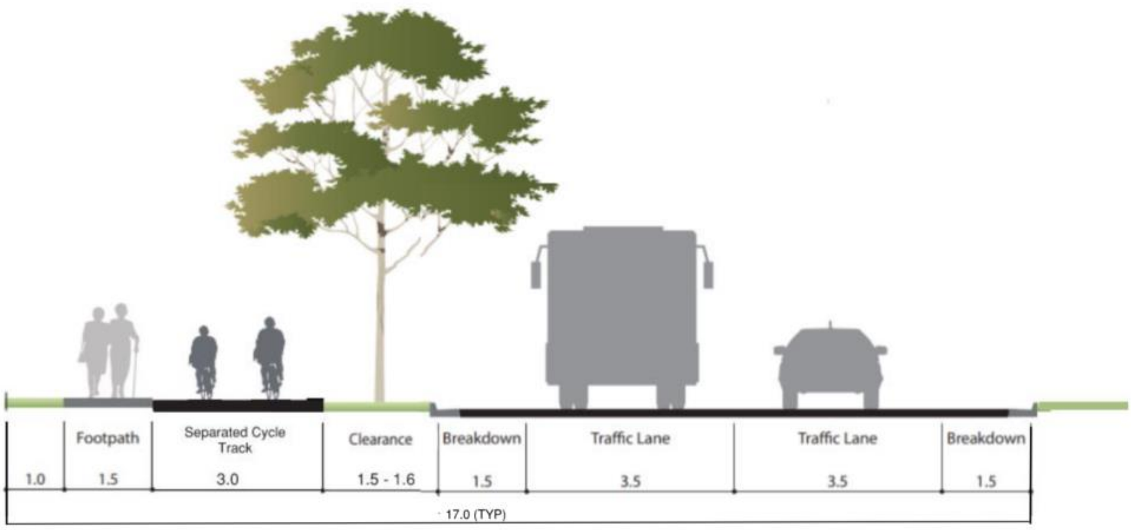


Figure 7-14 Interim 4 Lane Urban Arterial (2 lane no parking)

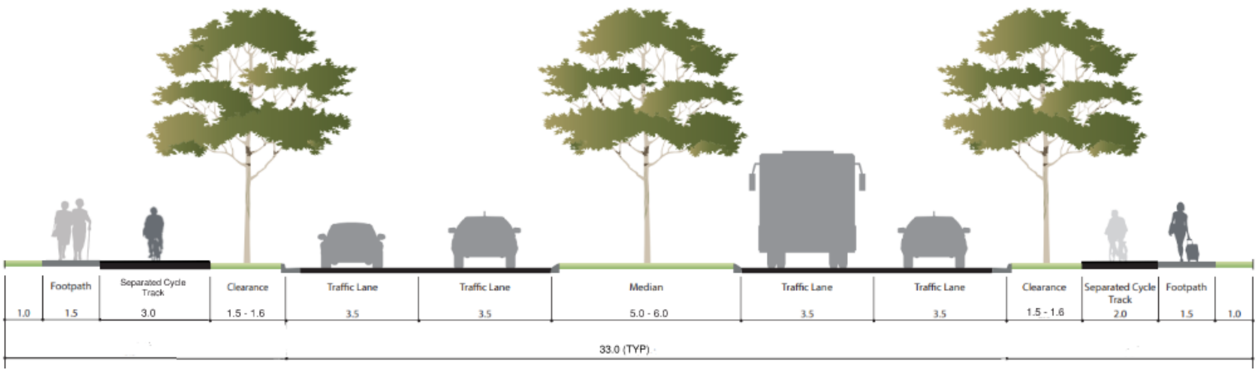


Figure 7-15 Ultimate 4 Lane Urban Arterial (no parking)

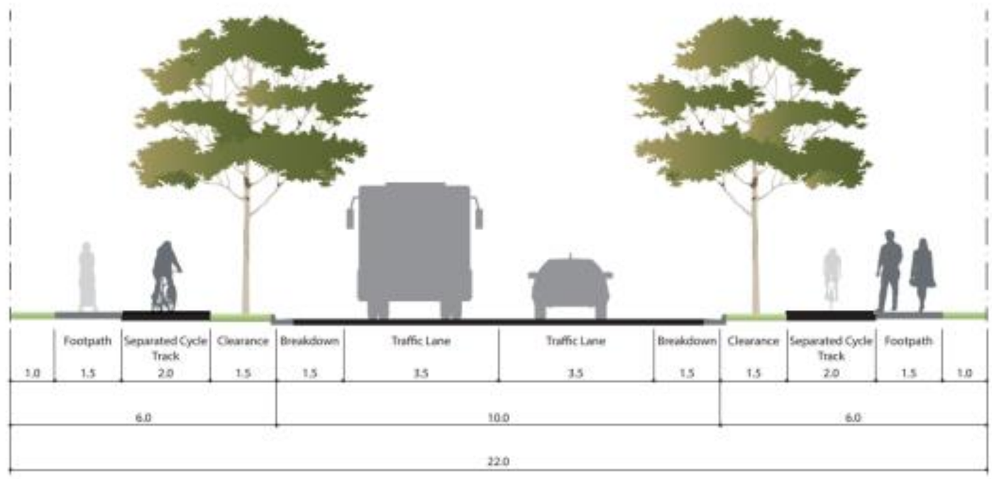


Figure 7-16 Ultimate 2 Lane Trunk Connector (no parking)

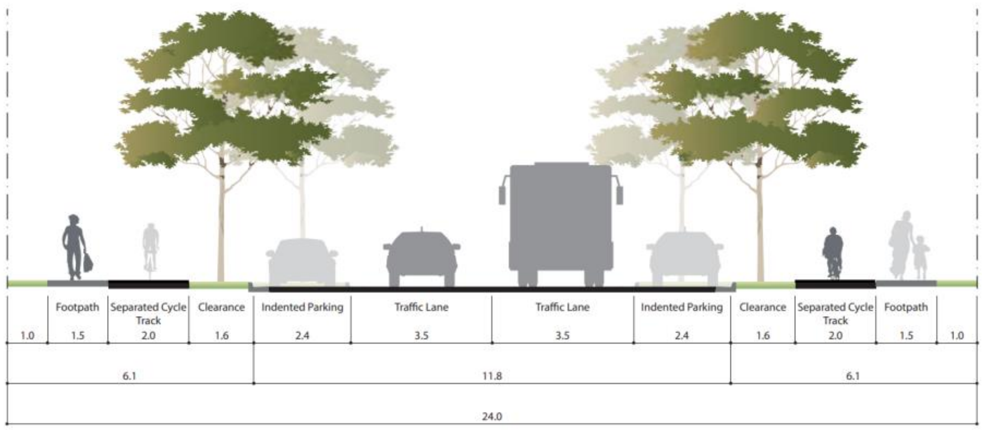


Figure 7-17 Ultimate 2 Lane Trunk Connector (with parking)

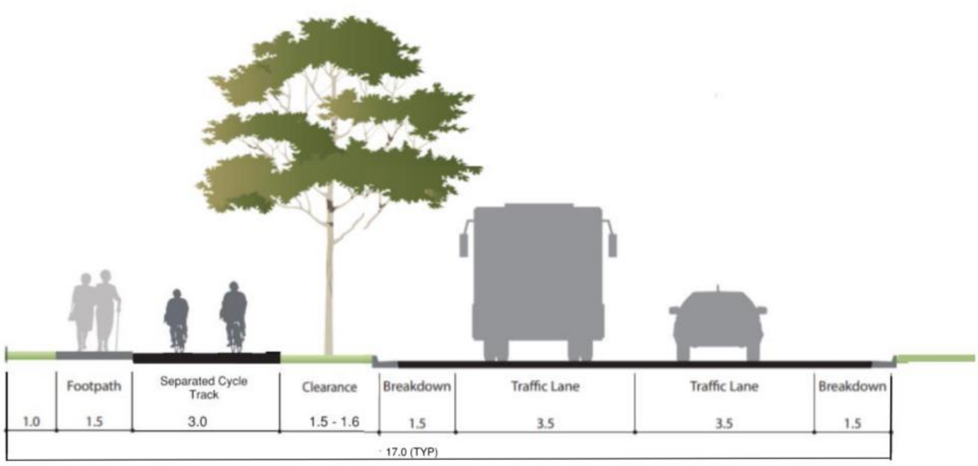


Figure 7-18 Interim 4 Lane Trunk Connector (2 lane no parking)

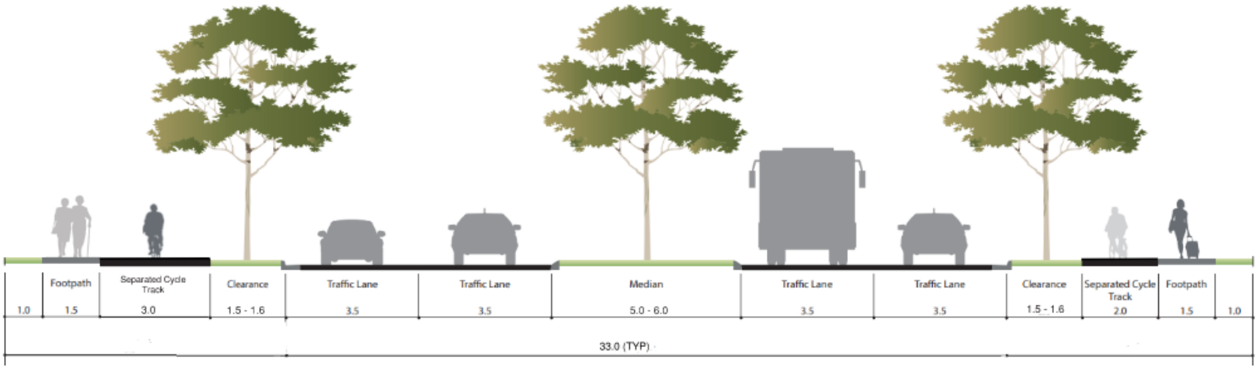


Figure 7-19 Ultimate 4 Lane Trunk Connector (no parking)

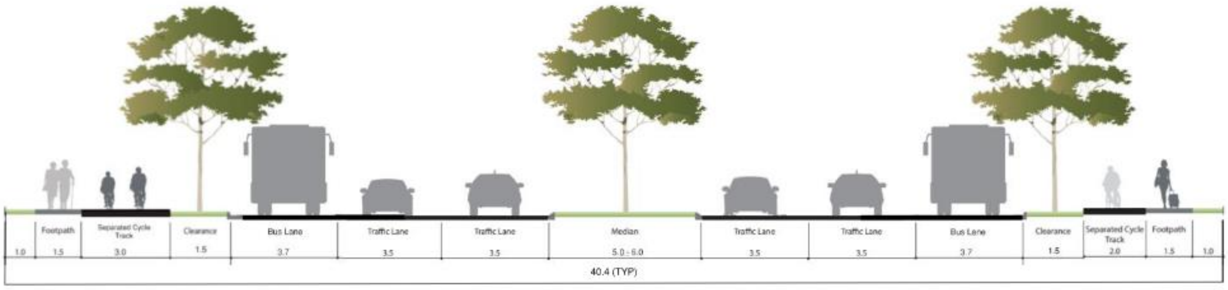


Figure 7-20: Ultimate 4 Lane Trunk Connector (with bus lanes)

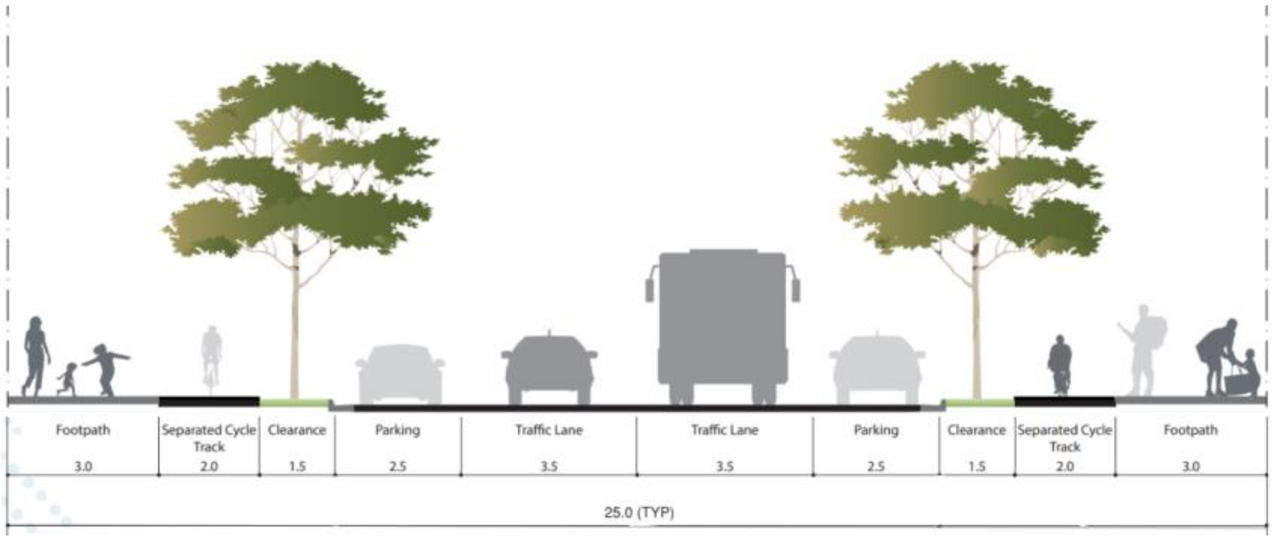


Figure 7-21 Ultimate 2 Lane Centre Connector (with parking)

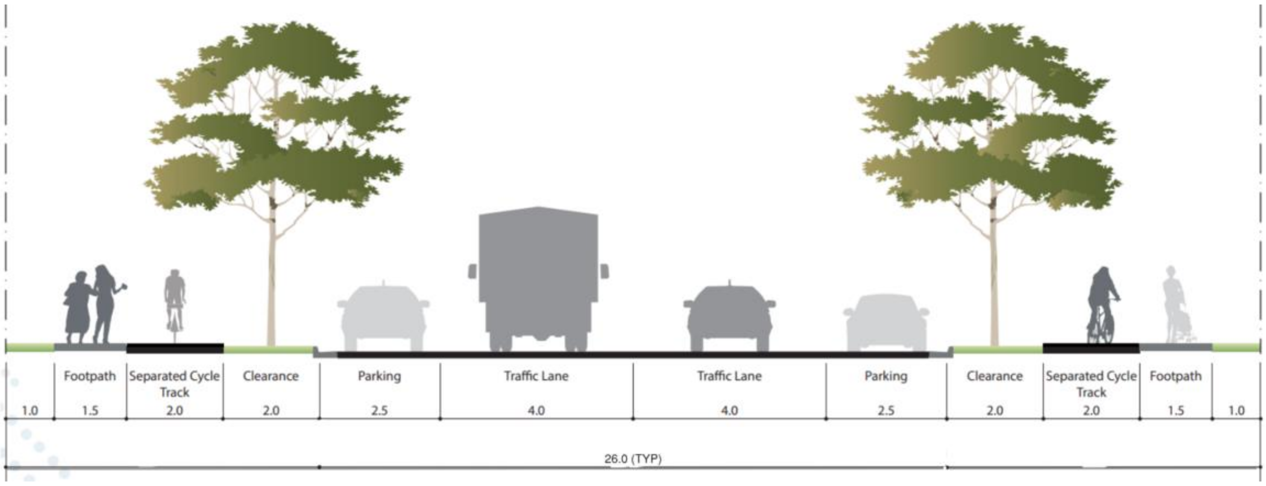


Figure 7-22 Ultimate 2 Lane Centre Connector (with parking)

7.13 Adopted Intersection Requirements and Staging

The detailed intersection requirements can be found in the Transport Infrastructure Costings Tables. A summary of the different staging for the intersections is provided in the Table 7-8. To minimise the cost of upgrades a maximum of three intersection upgrades has been allowed for at each intersection.

Should development occur out of sequence from what has been modelled (using the latest demographics), that may result in a change in intersection treatment and upgrade horizon.

A summary of the form and sequencing of the trunk intersections is provided in Figure 7-23.

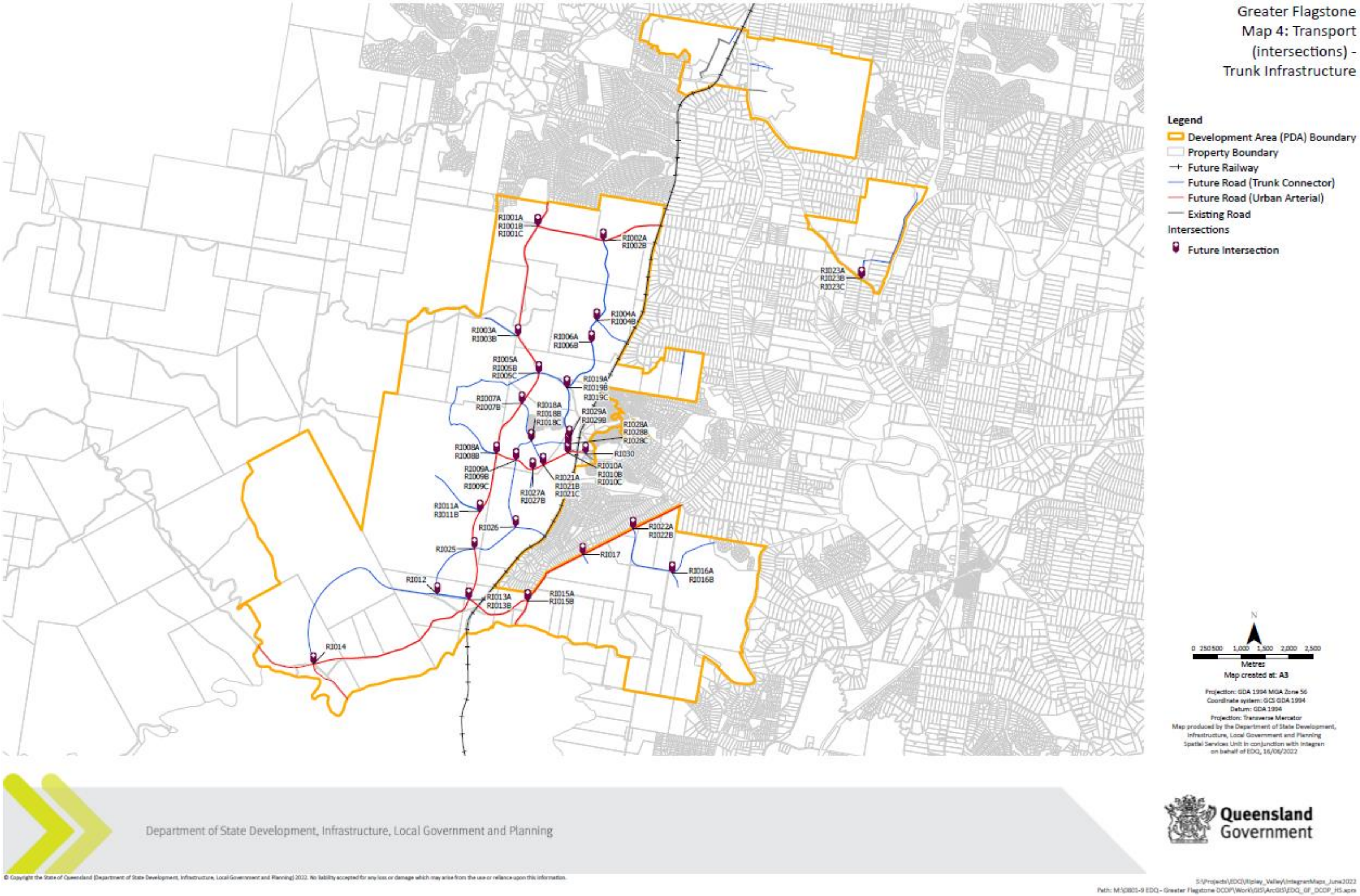


Figure 7-23 Greater Flagstone PDA Adopted Trunk Intersections

The SIDRA intersection layouts are provided in Appendix A. The turning volumes used for the SIDRA analysis were taken from the VLC transport model for each horizon. When undertaking the analysis, the following was implemented in SIDRA:

- In accordance with the latest TMR safety guideline, left turn slip lanes were avoided
- Signalised intersections were analysed as isolated independent intersections
- Cycle times were permitted to optimise to a maximum of 150 seconds
- Staged pedestrian crossing was provided where excessive crossing distances exist
- Filtered right turns were avoided at the majority of signalised intersections to improve safety.

Degree of Saturation (DOS) is defined as the ratio of demand to capacity at any given intersection. A DOS of 1.0 indicates the intersection is at full capacity, and above 1.0 is oversaturated, resulting in undesirable queuing and delays. In practice, a DOS of 1.0 would result in unstable flows, thus there is a practical DOS which represents the target maximum saturation dependent on the intersection type.

The practical DOS for different intersection types is summarised in Table 7-7.

Table 7-7 Practical Degree of Saturation

Intersection type	Practical DOS[1]
Signalised	0.90
Roundabout	0.85
Unsignalised	0.80

Table 7-8 reports the worst DOS, and overall control delay for each intersection. Individual approaches or lanes may report better results than what is presented below. For unsignalised intersections, where SIDRA does not report an overall delay, the worst movement delay has been recorded. For all intersections both the AM and PM peaks have been modelled, however only the worst peak traffic measures have been presented

Table 7-8 Summary of Greater Flagstone PDA Trunk Intersection Requirements and Staging

Asset ID	Design year	Control	Inter-section legs	Major flow through lanes	Degree of saturati	Control delay(s)	Protected active provisions	Bus provisions
RI001	2031	Priority	3	2	0.683	32.2	Yes	No
	2041	Signalised	4	2	0.843	28.54	Yes	No
	2066	Signalised	4	4	0.904	59.7	Yes	No

[1] Source: Austroads Guide to Traffic Management Part 3, 2017

Asset ID	Design year	Control	Inter-section legs	Major flow through lanes	Degree of saturati	Control delay(s)	Protected active provisions	Bus provisions
RI002	2041	Signalised	4	2	0.77	26.8	Yes	No
	2066	Signalised	4	4	0.878	42.1	Yes	Yes
RI003	2041	Signalised	3	2	0.792	19.9	Yes	No
	2066	Signalised	3	4	0.9	28.7	Yes	No
RI004	2041	Priority	3	2	0.603	28	Yes	No
	2066	Priority	3	4	0.874	28.2	Yes	Yes
RI005	2031	Priority	4	2	0.559	17.5	Yes	No
	2041	Signalised	4	2	0.906	41.45	Yes	No
	2066	Signalised	4	2	0.901	63.73	Yes	No
RI006	2041	Signalised	3	2	0.869	24.8	Yes	No
	2066	Signalised	3	6	0.864	31.5	Yes	Yes
RI007	2041	Signalised	3	2	0.864	21.3	Yes	No
	2066	Signalised	3	4	0.797	22.9	Yes	No
RI008	2041	Signalised	4	2	0.854	40.4	Yes	No
	2066	Signalised	4	4	0.872	45.9	Yes	No
RI009	2031	Priority	3	2	0.310	10.9	Yes	No
	2041	Signalised	3	2	0.745	35.4	Yes	No
	2066	Signalised	4	4	0.878	59	Yes	No
RI010	2031	Signalised	4	2	0.864	25.9	Yes	No
	2041	Signalised	4	2	0.806	31	Yes	No
	2066	Signalised	4	4	0.896	50.9	Yes	No
RI011	2041	Signalised	3	2	0.919	32.5	Yes	No
	2066	Signalised	4	4	0.894	44.6	Yes	No
RI012	2066	Signalised	3	2	0.824	26.2	Yes	No
RI013	2031	Priority	3	2	0.210	10.9	Yes	No
	2041	Signalised	4	2	1.225	81	Yes	No
	2066	Signalised	4	4	0.891	51.1	Yes	No

Asset ID	Design year	Control	Inter-section legs	Major flow through lanes	Degree of saturati	Control delay(s)	Protected active provisions	Bus provisions
RI014	2066	Signalised	4	4	0.899	52.6	Yes	No
RI015	2031	Priority	3	2	0.436	18.2	Yes	No
	2041	Signalised	3	2	0.856	25.8	Yes	No
	2066	Signalised	3	4	0.675	16.9	Yes	No
RI016	2041	Priority	3	2	0.173	8.5	Yes	No
	2066	Roundabout	3	2	0.514	10.3	Yes	No
RI017	2066	Signalised	3	4	0.883	29.5	Yes	No
RI018	2031	Priority	4	2	0.272	12.2	Yes	No
	2041	Signalised	4	2	0.676	21.5	Yes	No
	2066	Signalised	4	2	0.897	38.9	Yes	No
RI019	2031	Priority	3	2	0.195	7.8	Yes	No
	2041	Signalised	3	2	0.886	32.1	Yes	No
	2066	Signalised	3	6	0.876	27.9	Yes	Yes
RI020	2031	Signalised	4	2	0.865	24.9	Yes	No
	2041	Signalised	4	2	0.935	52.1	Yes	No
	2066	Signalised	4	4	0.933	51.9	Yes	No
RI021	2031	Priority	4	2	0.408	21.6	Yes	No
	2041	Signalised	4	2	0.742	26.4	Yes	No
	2066	Signalised	4	4	0.865	31.2	Yes	No
RI022	2031	Priority	3	2	0.154	6.2	Yes	No
	2041	Signalised	3	2	0.831	25.7	Yes	No
	2066	Signalised	3	4	0.858	27.2	Yes	No
RI023	2031	Priority	3	2	0.685	10.1	Yes	No
	2041	Signalised	4	2	0.788	17.6	Yes	No
	2066	Signalised	4	2	0.896	32.5	Yes	No
RI024	2031	Signalised	3	4	0.590	10.1	Yes	No

Asset ID	Design year	Control	Inter-section legs	Major flow through lanes	Degree of saturati	Control delay(s)	Protected active provisions	Bus provisions
	2041	Signalised	4	4	0.879	37.2	Yes	No
	2066	Signalised	4	4	0.880	41.3	Yes	No
RI025	2066	Signalised	4	4	0.891	34.7	Yes	No
RI026	2066	Signalised	3	2	0.893	26.4	Yes	No
RI027	2041	Priority	3	2	0.628	19.4	Yes	No
	2066	Signalised	3	4	0.823	32.6	Yes	No
RI028	2031	Signalised	4	2	0.823	25.4	Yes	No
	2041	Signalised	4	2	0.865	31.7	Yes	No
	2066	Signalised	4	6	0.871	48.7	Yes	Yes
RI029	2031	Signalised	3	2	0.259	11.5	Yes	No
	2041	Signalised	3	2	0.520	35.8	Yes	No
	2066	Signalised	3	6	0.574	12.3	Yes	Yes

The information provided in this section is to guide the sequencing and infrastructure requirements of the trunk intersections within the PDA. These requirements have been developed using a whole of PDA assessment. Any deviation from these provisions and timings should ensure that there are no negative impacts to the broader network.

7.14 Corridor Requirements and Staging

Table 7-9 presents the interim and ultimate mid-block staging requirements for the road network. The provisions are in accordance with the requirements detailed in the standard cross sections using design parameters provided in Section 7.17. The sections also identify the PT/bus provisions that have been accommodated within the road reserve (PT provisions are further detailed in the following section).

Should development occur out of sequence from what has been modelled (using the latest demographics), that may result in a change to the upgrade horizon.

The information provided in this section is to guide the sequencing and infrastructure requirements of the trunk roads within the PDA. These requirements have been developed using a whole of PDA assessment with special consideration given to PT and active transport provisions. Any deviation from these provisions and timings should ensure that there are no negative impacts to the broader networks and their integration with other facilities and key trip attractors.

Table 7-9 Road Requirements and Staging

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
R001A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R001B	Urban Arterial (4 lane)	1	1.5	3	1.5			7 (3.5 *2)	5	7 (3.5 *2)			1.5	3	1.5	1	33	1	Int
R002	Trunk Connect or	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24		
R003A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R003B	Urban Arterial (4 lane)	1	1.5	2	1.5			7 (3.5 *2)	5.5	7 (3.5 *2)		1.5	1.5	3	1.5	1	34	1	Int
R004A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R004B	Urban Arterial (4 lane)	1	1.5	2	1.5			7 (3.5 *2)	5.5	7 (3.5 *2)			1.5	3	1.5	1	32.5	1	Int

[2] 3m shared path

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
R005A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	2	Int
R005B	Urban Arterial (4 lane)	1	1.5	2	1.5			7 (3.5 *2)	5.5	7 (3.5 *2)			1.5	3	1.5	1	32.5		
R006A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	1	Int
R006B	Urban Arterial (4 lane)	1	1.5	2	1.5			7 (3.5 *2)	5.5	7 (3.5 *2)			1.5	3	1.5	1	32.5	1	Int
R007A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R007B	Urban Arterial (4 lane)	1	1.5	3	1.5			7 (3.5 *2)	5.5	7 (3.5 *2)			1.5	3	1.5	1	33.5		
R008A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	2	Int
R008B	Urban Arterial (4 lane)	1	1.5	3	1.5			7 (3.5 *2)	5.5	7 (3.5 *2)			1.5	3	1.5	1	33.5		
R009A		4	0	0	0	0		3.5		3.5		0	2	3	1.5	2	12.5	1	Int

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
R009B	Urban Arterial (4 lane)	1	1.5	2	1.5	1.5		7 (3.5 *2)	5.5	7 (3.5 *2)		1.5	1.5	3	1.5	1	35.5		
R010A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	1	Int
R010B	Urban Arterial (4 lane)	1	1.5	2	1.5			7 (3.5 *2)	5.5	7 (3.5 *2)			1.5	3	1.5	1	32.5		
R011A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R011B	Urban Arterial (4 lane)	1	1.5	2	1.5			7 (3.5 *2)	5.5	7 (3.5 *2)			1.5	3	1.5	1	32.5		
R012A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R012B	Urban Arterial (4 lane)	1	1.5	2	1.5			7 (3.5 *2)	5.5	7 (3.5 *2)			1.5	3	1.5	1	32.5		
R013A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	1	Int
R013B	Urban Arterial (4 lane)	1	1.5	3	1.5			7 (3.5 *2)	5	7 (3.5 *2)			1.5	3	1.5	1	33		

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
R014A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R014B	Urban Arterial (4 lane)	1	1.5	3	1.5			7 (3.5 *2)	5	7 (3.5 *2)			1.5	3	1.5	1	33		
R015A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	3	Int
R015B	Urban Arterial (4 lane)	1	1.5	3	1.5			7 (3.5 *2)	5	7 (3.5 *2)			1.5	3	1.5	1	33		
R016A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R016B	Urban Arterial (4 lane)	1	1.5	2	1.5			7 (3.5 *2)	5	7 (3.5 *2)			1.5	3	1.5	1	32		
R017A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5		9		
R017B	Urban Arterial (4 lane)	1	1.5	2	1.5			7 (3.5 *2)		7 (3.5 *2)			1.5	3	1.5	1	27		
R018A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	2	Int

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
R018B	Urban Arterial (4 lane)	1	1.5	3	1.5			7 (3.5 *2)	5	7 (3.5 *2)			1.5	3	1.5	1	33		
R019	Trunk Connect or (2 lane)	1	1.5	2	1.5	1.5		3.5		3.5		1.5	1.5	2	1.5	1	22	1	Int
R020	Urban Arterial (2 lane)	1	1.5	2	1.5	1.5		3.5		3.5		1.5	1.5	2	1.5	1	22		
R021	Urban Arterial (2 lane)	1	1.5	2	1.5	1.5		3.5		3.5		1.5	1.5	2	1.5	1	22		
R022A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R022A	Urban Arterial (4 lane)	1	1.5	3	1.5			7 (3.5 *2)	5	7 (3.5 *2)			1.5	3	1.5	1	33		
R023A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	3	Int
R023B	Urban Arterial (4 lane)	1	1.5	2	1.5			7 (3.5 *2)	5.5	7 (3.5 *2)		1.5	1.5	3	1.5	1	34		

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
R024A		1	0	3 (Shared path)	2.5	2.4		3.5		3.5		2.4	2.5		1.5	2.5	17.8		
R024B	Trunk Connector (2 lane)	1		3 (Shared path)	1.5	1.5		3.5		3.5		1.5	1.5		1.5	1	19.5		
R025	Trunk Connector (2 lane)	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24	3	Int
R026A	2 Lane Trunk Connector					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	2	Int
R026B	4 Lane Trunk Connector + 2 Bus Lane	1	1.5	2	1.5		3.7	7 (2.5*2)	6	7 (2.5*2)	3.7		1.5	3	1.5	1	40.4		
R027A	2 Lane Trunk Connector					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R027B	4 Lane Trunk Connector + 2	1	1.5	2	1.5		3.7	7 (2.5*2)		7 (2.5*2)	3.7		1.5	3	1.5	1	34.4	2	Int

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
	Bus Lane																		
R028	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24		
R029	Centre Connector (2 lane)	0	3	2	1.5	2.5 (Parking)		3.5		3.5		2.5 (Parking)	1.5	2	3	0	25		
R030	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4	1.6	2	1.5	1	24		
R031	Trunk Connector -2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4	1.6	2	1.5	1	24		
R032	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24	3	Int
R033	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4	1.6	2	1.5	1	24		
R034A	Trunk Connect					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	2	Int

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
	or - 2 Lane																		
R034B	4 Lane Trunk Connector + 2 Bus Lane	1	1.5	2	1.5		3.7	7 (2.5*2)	6	7 (2.5*2)	3.7		1.5	3	1.5	1	40.4		
R035	Industrial Connector - 2 Lane	1		2.5 (Shared)	2	2.5 (Parking)		4		4		2.5	2		1.5	1	23		
R036	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4	1.6	2	1.5	1	24		
R037	Trunk Connector (2 lane)	1	1.5	2	1.5	1.5		3.5		3.5		1.5	1.5	2	1.5	1	22	2	Int
R038	Trunk Connector 2 lane	1	1.5	2	1.5	1.5		3.5	3.5	3.5		1.5	1.5	2	1.5	1	25.5		
R039	Trunk Connector 2 lane	1	1.5	2	1.6	2.4 (Parking)		3.5	3.5	3.5		2.4	1.6	2	1.5	1	27.5	1	Int

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
R040	Trunk Connector - 2 lane	1	1.5		2	2.4 (Parking)		3.5		3.5		2.4 (Parking)	2	3 (Shared path)		1	22.3	2	Int
R041	Centre Connector	1	3	2	2			7 (3.5*2)	5	7 (3.5*2)		-	2	2	3		34	1	Int
R042	Trunk Connector - 2 Lane	1	1.5		2	2.4 (Parking)		3.5		3.5		2.4	2	3 (Shared)		1	22.3		
R043	Trunk Connector - 4 Lane	1	1.5		2	1.5		7 (3.5*2)	4	7 (3.5*2)			2	3 (Shared path)		1	30	1	Int
R044A	2 lanes	5.5	0	0	0	1		3.5	4	3.5		1	3.5	4 (Shared path)			19	1	Int
R044B	Trunk Connector - 2 Lane	1	1.5	-	2	1.5		3.5	4	3.5		1.5	2	3 (Shared path)		1	24.5		
R046	2 Lane industrial collector	1		2.5 (Shared)	2	2.5 (Parking)		4		4		2.5 (Parking)	2		1.5	1	23		

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
R047	2 Lane industrial collector	1		2.5 (Shared)	2	2.5 (Parking)		4		4		2.5 (Parking)	2		1.5	1	23.00		
R048A	Trunk Connector - 2 lane					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10		
R048B	Trunk Connector - 4 lane	1	1.5	2	1.5			7 (3.5*2)	5	7 (3.5*2)			1.5	3	1.5	1	32		
R049A	Trunk Connector - 2 lane					1.5		3.5		3.5		1.5	1.5	3	1.5	1	10	1	Int
R049B	Trunk Connector - 4 lane	1	1.5	2	1.5			7 (3.5*2)	5	7 (3.5*2)			1.5	3	1.5	1	32		
R050	Trunk Connector - 4 lane	1	1.5	2	2			7 (3.5*2)	5	7 (3.5*2)			2	2	1.5	1	32		
R051	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24		

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
R052	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24		
R053A	Urban Arterial (2 lane)					1.5		3.5		3.5		1.5	1.5	3 (Shared)		1	8.5		
R053B	Urban Arterial (4 lane)	1	1.5		2			7 (3.5 *2)	5.5	7 (3.5 *2)			1.5	3 (Shared)		1	29.5		
R054	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24		
R055	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24	3	Int
R056	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24	1	Int
R057	Trunk Connector - 2 Lane	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24		
R058	Trunk Connect	1	1.5	2	1.6	2.4 (Parking)		3.5		3.5		2.4 (Parking)	1.6	2	1.5	1	24		

Asset ID	Hierarchy	Clearance (m)	Foot path (m)	Cycle track (m) 2	Clearance (m)	Breakdown (m)	Bus Lane width (m)	Travel Lane (m)	Median (m)	Travel Lane (m)	Bus Lane width (m)	Breakdown (m)	Clearance (m)	Cycle track (m)	Foot path (m)	Clearance (m)	Total corridor width (m)	No of bus stops	Bus stop type
	or - 2 Lane																		
R061	Trunk Connect or - 2 Lane	1	2.5 (Share d)		2	2.4 (Parking)		3.5		3.5		2.4	2		1.5	1	21.8		
R062	Centre Connect or (2 lane)	0	3	2	1.5	2.5 (Parking)		3.5		3.5		2.5 (Parking)	1.5	2	3	0	25		
R063	2 Lane industria l collector	1	1.5	2	2	2.5 (Parking)		4		4		2.5 (Parking)	2	2	1.5	1	26		
R064	Trunk Connect or - 2 Lane major collector	1	1.5		2	1.5		3.5	4	3.5		1.5	2	3 (Share d path)		1	24.5		

7.15 Civil Servicing Requirements

The trunk servicing requirements needing to be accommodated within the road verges was considered. This was to confirm that the verge and corridor widths were sufficient to accommodate any service mains. The following provisions have been made:

- Where co-location of trunk services results in additional corridor width, location of services on opposite sides of the road will be accepted.
- Sewer main to be installed under the footpath concrete slab.
- Water main (non-trunk) to be installed within the 1.5m tree clearance zone.
- Trunk water main to be installed under the cycle track, whilst it is acknowledged the water utility owner usually prefers the potable water mains to be installed outside of the footpath /cycle track for ease of maintenance this is not achievable in the PDAs cross sections. However, in this constrained space, it is considered acceptable to install the trunk water main under the cycle track. All the trunk water main pit lids located within the cycle track will be designed to be cyclist safe.
- Communication mains to be installed within the 1m wide strip between the footpath and property boundary.
- Electricity main to be installed along each side of the verge and is no larger than:
  - Ø80mm for LV, 11kV
  - Ø100mm for HV, 33kV
- Communication main installed along each side of the verge and is no larger than:
  - Ø100mm communications in a combined trench with electricity in the verge on high side of the road
  - Multiple Ø100mm communication conduits in the verge on the low side of the road
- No overhead electricity provision has been made and street lighting poles are to be installed within the tree clearance zone.
- Lighting pole and tree centrelines are to be located nominally 0.75m from the nominal kerb face.
- Gas main to be located within the tree clearance zone, with the gas centreline located 0.6m from nominal kerb face (localised typical deflection of gas main may be required behind a lip in line stormwater gully).

The above points are presented graphically in Figure 7-24 below.

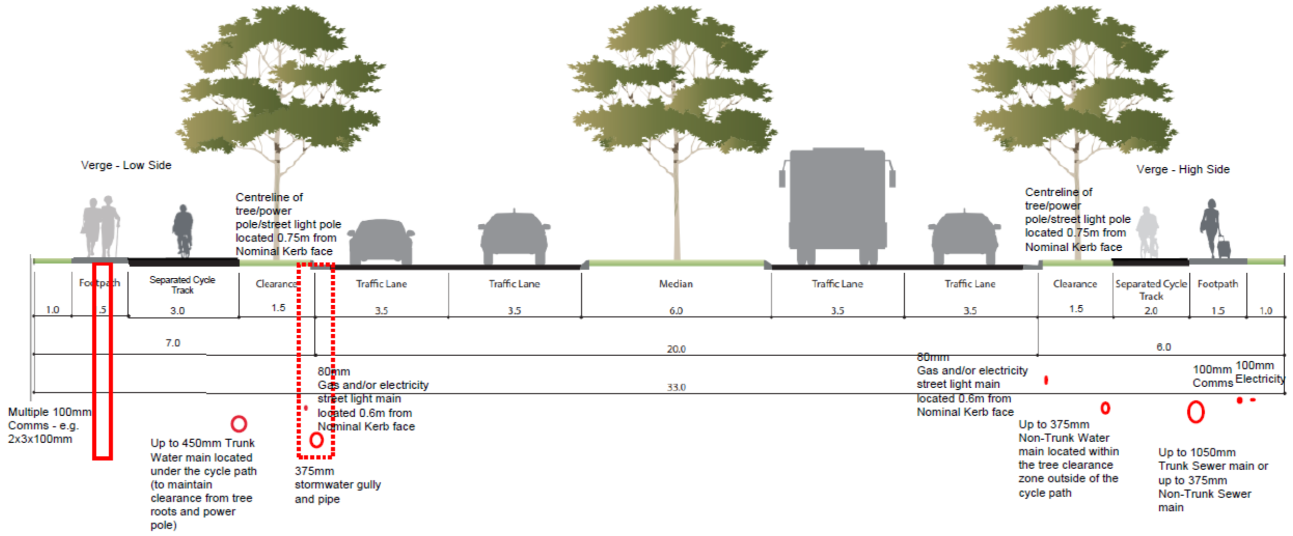


Figure 7-24 Trunk Servicing within Road Corridor

For a common trench, the typical minimum horizontal clearances between services must be maintained. Consultation with the utility owners (particularly water and sewer) may also need to be undertaken during the detailed design.

7.16 Public Transport | Bus Servicing Requirements

In reviewing the future bus requirements, consideration was first given to approvals that provided indicative bus stop locations along trunk routes. Once this was mapped the trip attractors (i.e. community facilities, centre precincts) were overlaid to identify any gaps in the network. Additional locations were then added adjacent to these attractors and generators whilst maintaining an approximate spacing of 400m between stops for the key corridors and 800m for other locations.

When considering the infrastructure requirements of the bus stops the following was applied:

- Infrastructure requirements to align with the Public Transport Infrastructure Manual Chapter 5 (Department of Transport and Main Roads, March 2016).
- Premium Stops at the town centres – includes embayment, large shelter and hardstand
- Intermediate stops along trunk routes – includes embayment, small shelter and hardstand
- Regular stop not included – no embayment or shelter, more aligned with lower order roads located within residential areas.

The location of the PT/bus provisions is illustrated in Figure 7-25.

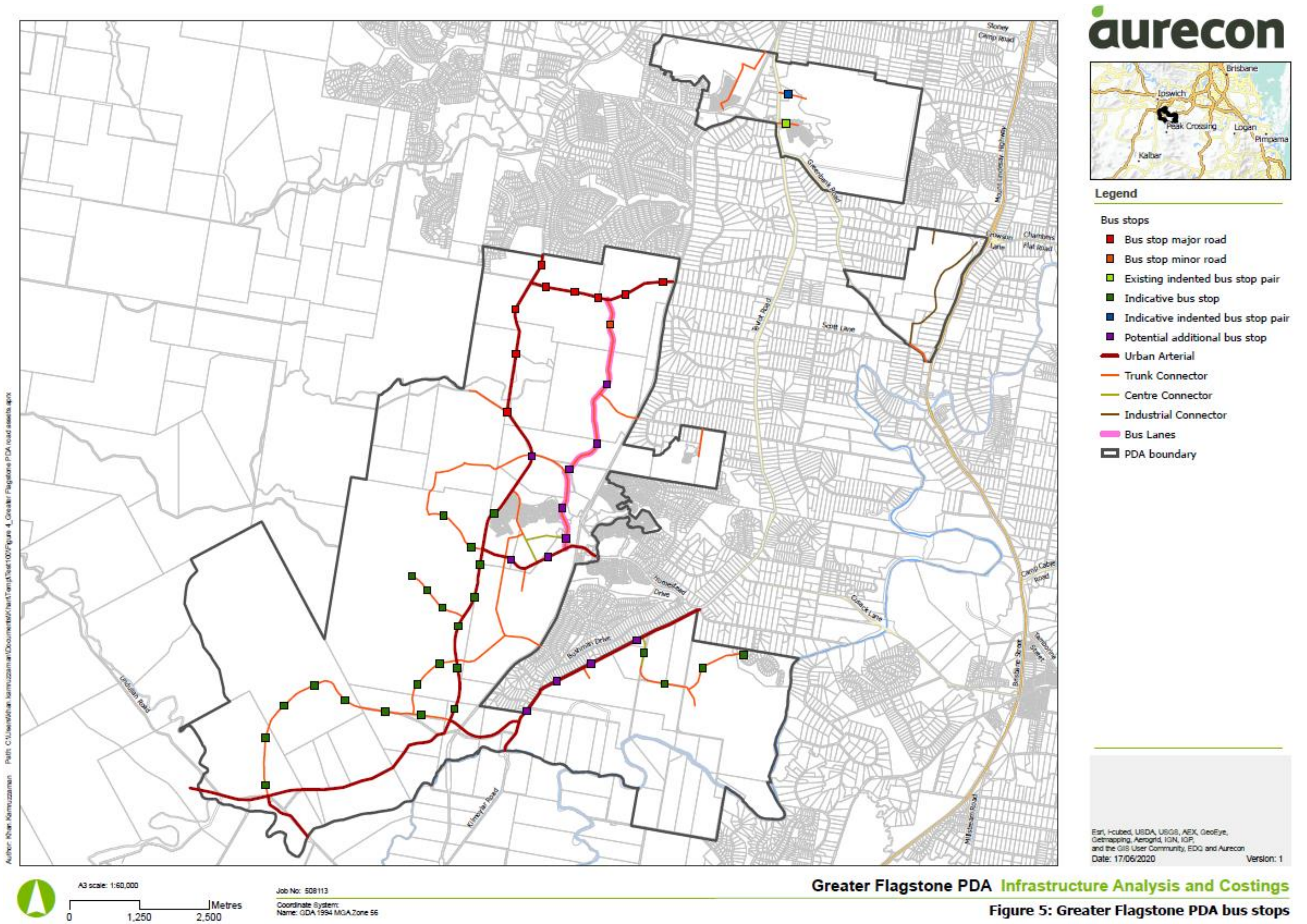


Figure 7-25 Bus Service Provisions on Trunk Network

7.17 Road and Interchange Design

Aurecon developed a high-level road and interchange design for the ultimate design configuration for each road in Flagstone. The process included:

- Develop 2d layouts in 12d software using existing road centrelines and typical sections for the nominated trunk roads using ultimate cross sections for existing roads
- Develop 2d layouts in 12d software using GIS alignments and typical sections for the nominated trunk roads using ultimate cross sections for new roads
- Develop road vertical alignments by fitting into the terrain
- Run cut and fill batters to generate volumes and the intersection lines with the natural surface.
- Include buffer zones as per Section 7.18.
- Output the design into roll plans to determine the ultimate road footprint

Allowances for land acquisition are based on the intersecting line of the batter slopes and the natural terrain, plus the buffer zone. The resultant intersection line is not straight as it depicts the natural topography intersecting with an engineered slope.

7.18 Design Parameters

The following table summarises the design parameters used for this task:

Design Element	Proposed Design Parameter/ Design Approach
Horizontal Alignment	
Existing Roads	Using existing road centreline Use ortho-corrected aerial images of the area for digitising the road centreline No curve widening applied Formation width only (no lane lines) No sightline checks including intersection sightlines
New Roads	Using GIS alignment of the roads Curve design using 70km/h design speed values No curve widening applied Formation width only (no lane lines) No sightline checks including intersection sightlines
Vertical Alignment	
Existing Roads	Fit into the existing terrain No sightline checks including intersection sightlines

Design Element	Proposed Design Parameter/ Design Approach
New Roads	Fit into the existing terrain with proposed vertical grade of: 6% preferred max 10% absolute max 0.5% minimum No sightline checks including intersection sightlines Vertical design to fit to terrain
Vertical clearance	5.5m unless noted otherwise in a cross section
Cross Section	
Existing and New Roads	Only using EDQ supplied ultimate cross sections for various trunk roads Batters cut/fill – 1 on 2 3% nominal crossfall/ superelevation Formation width only (no lane lines)
Buffer Zone – Brownfield areas	4m from the toe of batter
Buffer Zone – Greenfield areas	7.5m from the toe of batter
MISC	
Road surface	2 coat bitumen seal
Road pavement	400mm
Lighting	Only at intersections unless provided for in cross section(s)
Design speed	Varies

7.19 Opinion of Cost of Adopted Interim and Ultimate Planning Horizons

Rider Levett Bucknall (RLB) were engaged to develop an opinion of the cost of transport infrastructure to service the Greater Flagstone PDA. The quantities of transport infrastructure were derived from the updated network plan developed as part of this study. Municipal costs for Greater Flagstone PDA were then extracted from the RLB estimates and inserted into the Financial Offset Model per planning horizon, the summaries of which can be found within the Schedule of Works containing within the body of this Infrastructure Planning Background Report (IPBR).

8 Active Transport

This chapter is intended to inform the active transport related elements of development with the Greater Flagstone Priority Development Area (PDA), for pedestrians and cyclist provisions. This chapter should be viewed in conjunction with all infrastructure reports that form the Infrastructure Planning and Background Report (IPBR).

8.1 Reference Standards

The reference standards that guided the analysis and development of the active transport requirements for the Greater Flagstone PDA are summarised below.

Street and Movement Network PDA Guideline No. 06 | February 2019

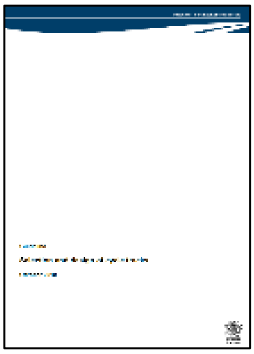
EDQ's Street and Movement Network document provides the standards required for the planning and design of street and movement networks within PDAs.

A key requirement of the guideline is one-way 2.0m minimum separated cycle tracks on both sides of the corridor for higher order roads. The typical requirement for pedestrians is a 1.5m minimum footpath on both sides of the road. For roads which are staged, a 3m cycle track on one side (interim) and 2m on the other side (ultimate) is required.

Local Government Infrastructure Plan (LGIP) Summary of Extrinsic Material for the Movement Network | June 2014

The desired standard of service (DSS) will be used in conjunction with the other reference documents as it outlines key planning and design standards for the movement network. The service requirements adopted are outlined in the next section.

Selection and Design of Cycle Tracks | October 2019



The Department of Transport and Main Roads' Guideline for the Selection and Design of Cycle Tracks outlines the standards required for the development of cycle tracks, particularly on where and how to separate bicycle traffic from general traffic at intersections and mid-block locations on urban roads in new and retrofit situations. This document supplements information provided in the Austroads guides to Road Design and Traffic Management.

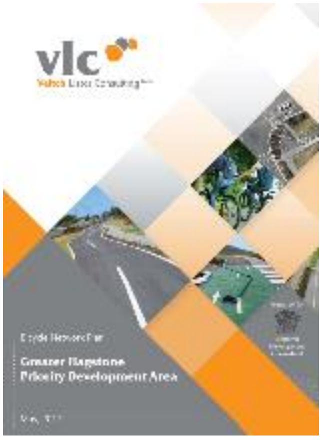
The rationale behind the preference of individual infrastructure elements and their configuration is considered closely. In particular, this relates to the configuration for one-way and two-way cycle tracks at intersecting roads.

Cycling Aspects of Austroads Guides | June 2017

This publication contains key information that relates to the planning, design and traffic management of cycling facilities and is sourced from Austroads Guides, primarily the Guide to Road Design, the Guide to Traffic Management and the Guide to Road Safety.

8.2 Past Reports

Greater Flagstone Priority Development Area Bicycle Network Plan | May 2017



A cycle network has been developed specific to the PDA, considering trip generators and attractors, the proposed road network and topography. This also considers the latest information associated with developments and their status at the time. This study forms the basis for the active transport network to be developed in further detail as part of the IPBR.

The plan proposes a dense cycle network with a vast expanse of high-quality cyclist facilities. The majority of the network is made up of cycle tracks, with preference to a one-way cycle track on each side of the road rather than a two-way track on a single side. For the key north south arterial, a two-way track on both sides of the road is recommended. No on-road cycle facilities are recommended (i.e. cycle lanes), which corresponds with providing a network that supports cyclists of all ages and abilities. While the plan has a strong focus on separated cyclist facilities, some shared cyclist and pedestrian facilities are recommended. Where cyclist only facilities are indicated, it assumes that a pedestrian network will be also made available, which aligns with the requirements within PDA Guideline no.6 (EDQ, February 2019).

The Cycle Plan forms the basis of this study and so emphasis on remaining aligned with this plan where is prioritised.

Model Development and Network Apportionments | October 2019

This report outlines key inputs to the South Logan Strategic Transport Model (SLSTM) model and presents capacity results consumed by trips to and from and within Greater Flagstone. This is covered in more detail in the Transport Section.

The modelling report was cross-referenced to the Bicycle Network Plan (VLC, May 2017), and since it is more recent, any changes to the road network could then be carried over to the active transport network for consistency.

Draft Infrastructure Contribution Offset Plan (ICOP) | 2019

The Draft ICOP outlines the trunk road network and the major off-road shared path for the PDA. Much of the active transport network proposed in the Bicycle Network Plan is within the road corridor, so it matches up well with the trunk road network in the ICOP. The trunk active transport network was developed based on this, to align with the trunk road network.

Additionally, the major off-road shared path is presented, which is located outside of the road corridor. However, there appears to be an unnecessary overlap between this and that provided within the trunk road network.

Infrastructure Master Plans (IMPs) | Various

To understand what planning has previously been done for the movement network, an assessment has been undertaken into what cycle and pedestrian facilities are proposed in the IMPs. A total of seven IMPs were made available, and cover the developments outlined below.

- Riverside Celestino

- Flinders
- Mirvac
- Mountain Ridge
- Flagstone City (PEET)
- Tarnbrae (not yet endorsed)
- Undullah.

The level of consistency between the IMPs and the Bicycle Network Plan is summarised below in Figure 8-1. Overall, there is poor alignment between both planning mechanisms. While the Bicycle Network Plan has a preference towards one-way cycle tracks on both sides of the road, the IMPs more often show a two-way track on a single side of the road. This discrepancy was identified and further discussed with Department of Transport and Main Roads (TMR), and the outcome was to show a one-way cycle track on both sides of the road where appropriate. This is because two-way tracks tend to complicate traffic signal control, force users to cross the road more (increasing delay and safety risks) and increase the likelihood of conflict when crossing intersections and driveways. Where there is no red or green arrow, this is a location with no IMP that defines the active transport infrastructure.

It should be noted that DA applications also take precedence over the IMPs (see next section).

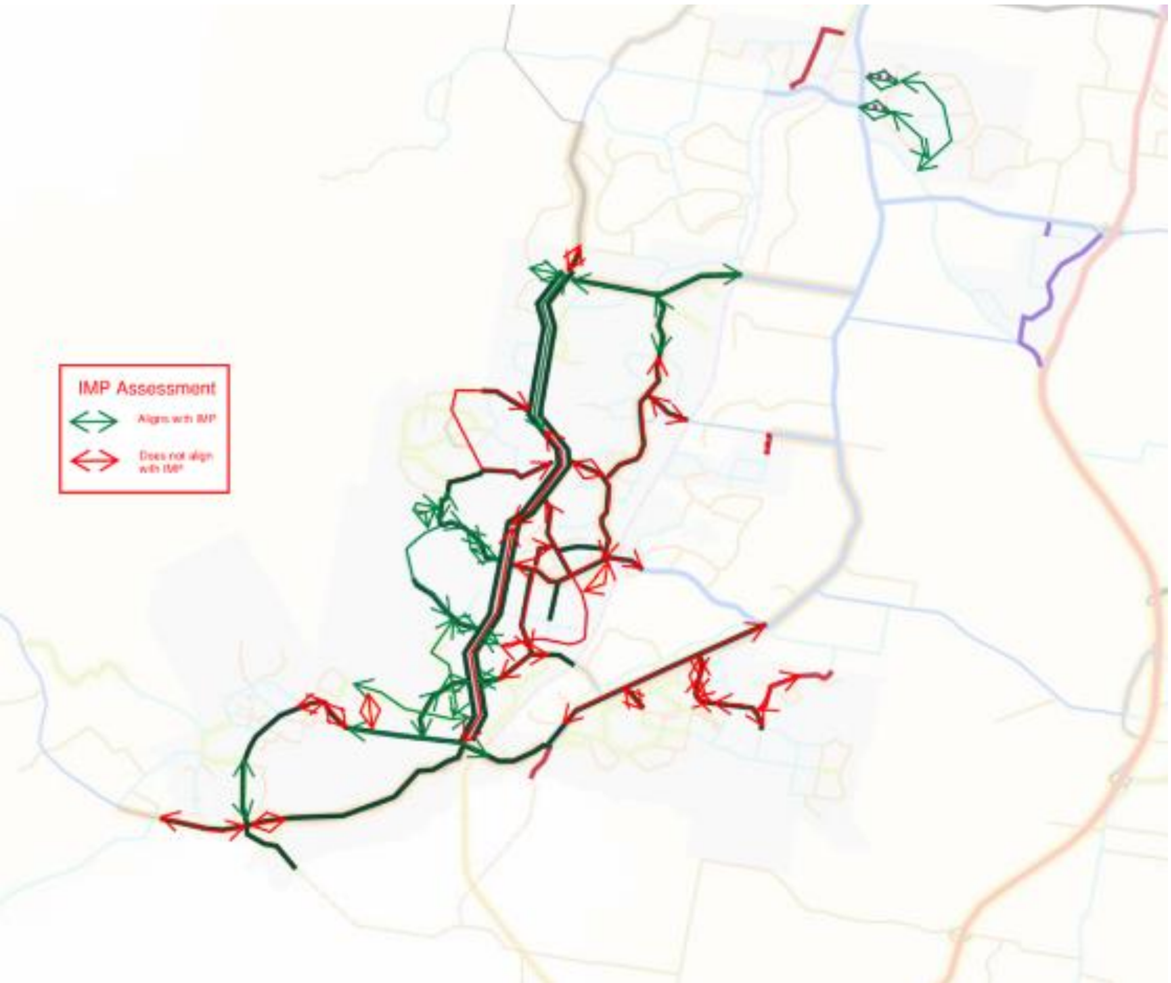


Figure 8-1 Assessment of Alignment with IMPs and Trunk Active Transport Network

8.3 Context Plans and DA Applications

To understand the progress of development in the PDA, the Context Plans and DA applications for Reconfiguring A Lot (RAL) were compared with the active transport network planning. If any changes were to be made to what had been planned to date, it had to be understood how progressed this was. If an RAL was approved, there is little room to move in amending what was planned. However, retrofitting may still be possible. A lodged plan had more potential to make changes if necessary, and a context plan was still reasonable to expect changes. As shown in Figure 8-2, there are some pockets with RALs approved, but most of the area is still without approval.

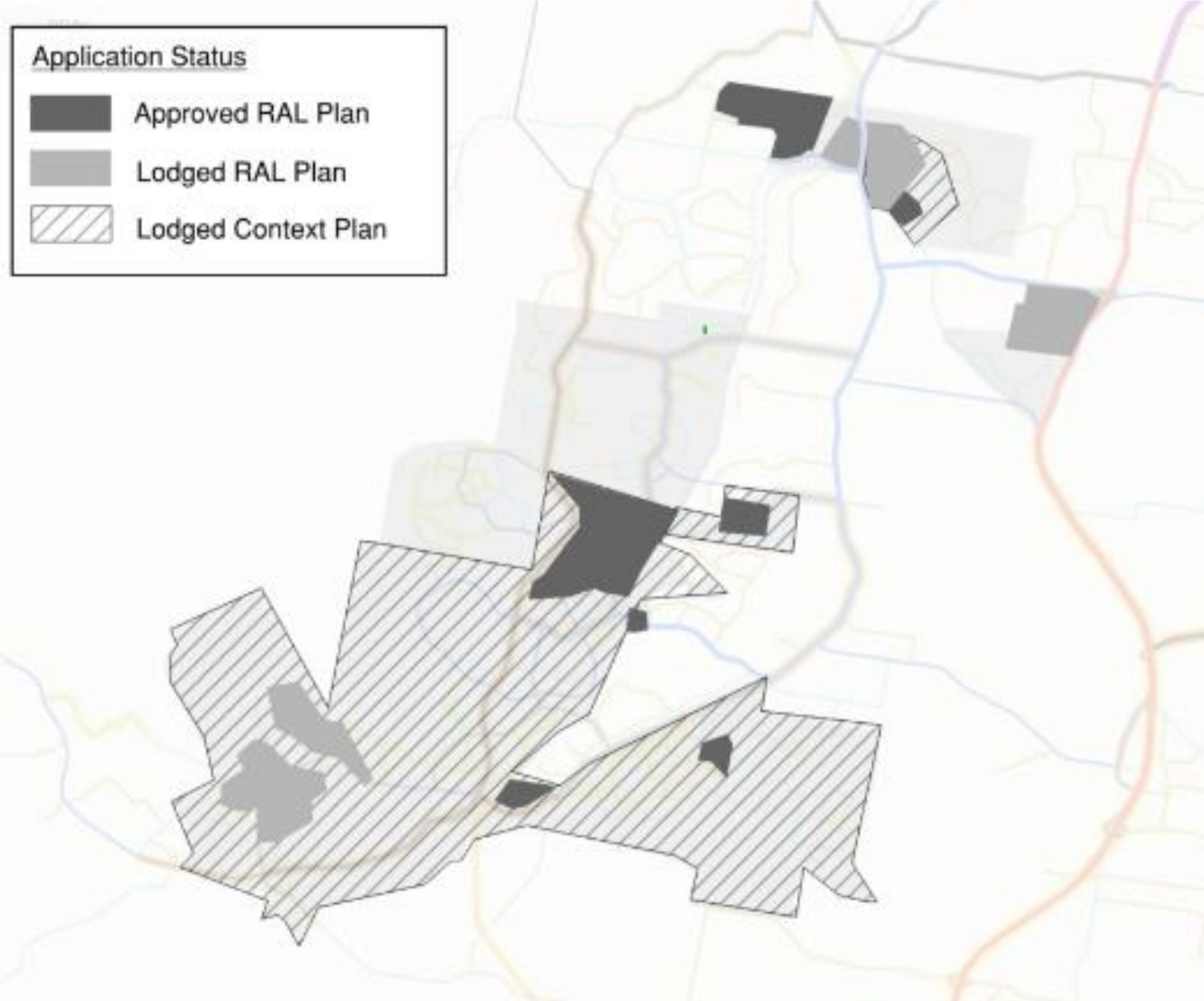


Figure 8-2 Application Status in PDA

8.4 Desired Standards of Service

To develop an understanding for the standard of service which should be provided for the active transport infrastructure in the PDA, the Level of Traffic Stress (LTS) methodology has been applied.

The LTS methodology was developed by TMR and is a method for understanding the level of stress experienced by cyclists in different on-road and off-road environments. If we want to aim for a transport network which facilitates and encourages cyclist trips for a high mode share, the transport infrastructure should not force cyclists into high stress environments. As such, LTS 1 or 2 is the desired standard of service. Each type and its characteristics are outlined in Table 8-1. As show, LTS 3 and 4 are unlikely to attract a high number of cyclists.

Table 8-1 LTS Categories and Descriptions

LTS	Viability of cycling as a realistic mode choice	Proportion of people willing to cycle *
LTS 1	Minimal traffic stress and requires less attention, making this suitable for all bicycle riders. This includes children trained to safely cross the road unsupervised (typically a 10-year old), or younger children under supervision of parents.	63% to 75%
LTS 2	A little traffic stress that requires more attention than young children can handle. It is suitable for most teen and adult bicycle riders with adequate bicycle handling skill.	
LTS 3	Moderate traffic stress that would require higher levels of cycling skill and confidence to interact with traffic using cycle lanes on roads with lower traffic speeds or volumes.	12% to 28%
LTS 4	High level of traffic stress only suitable for very skilled bicycle riders with confidence to interact with traffic on busy roads with minimal or no on-road cycle facilities.	5% to 7%

Source Draft Queensland LTS Method

8.5 Stakeholder Engagement

On 30 January 2020, a stakeholder workshop was undertaken to present the existing planning that had been undertaken to date for the active transport network in the PDA. An understanding of Logan City Council's position on the proposed infrastructure from the Bicycle Network Plan (VLC, May 2017) was sought. Overall, there was support shown for providing a dense off-road cycle and pedestrian network.

8.6 Innovation by Design

Innovation by design as previous defined includes approaches using proven, currently available technologies and/or construction methods to achieve innovative outcomes. These innovations currently exist within the Australian context of urban development and can be readily implemented within the Greater Flagstone PDA.

Design Innovations enable new development and infrastructure in each PDA to showcase already tested innovations that are progressing to business as usual in other locations. These innovations require the development industry's desire to showcase leading design innovations as part of new urban development.

The below provides a list of Design Innovations that currently exist within Australian urban communities. These innovations provide examples of locations that have implemented these innovations in place of BAU infrastructure and provide developers, landowners and local governments with on the ground outcomes that they can duplicate in the local context of Greater Flagstone.

Developers are encouraged to implement one or more of the Design Innovations in consultation with EDQ and local government and help progress these innovations to business as usual.

8.6.1 Wayfinding

Image sourced: Sedg.org

Figure 8-3 Example of a wayfinding information sign

Wayfinding is an information system that guides people through cities and streets and are commonly implemented in complex built environments such as major airports, healthcare precincts, shopping centres and universities.

Generally, Wayfinding involves visual cues that assist people to navigate around, such as maps, street signage and information systems. These built environment features can assist people in high-stress and/or complex environments and can improve safety and security.

Very strong Wayfinding developed as part of the resurfacing of footpaths provides a positive experience for all users as it can incorporate images and distances along their chosen path, without the need to refer to a device.

Key considerations

Wayfinding is about assisting people to find a destination more seamlessly. To ensure it is effective, the following design principles are recommended to be considered:

- Establish signs/symbols at decision points
- Minimise the level of information, display necessary information - direction, distance etc.
- Incorporate landmarks into the imagery to provide orientation cues.

Implementation recommendations

High: Traditional Wayfinding (street signs) will be implemented in accordance with local government requirements; however, these systems can be enhanced through the addition of imagery and distance to destination. Footpath Wayfinding can also be incorporated to support residents and services and reinforce ‘Living Local’ community benefits.

Ownership and operation

Generally, minimal operation is required other than maintenance. However, if digital Wayfinding is used, then third party IT operators are required. Traditional Wayfinding in the public domain is owned by the local authority, while in private space, e.g. shopping centres, it is owned by the shopping centre owner.

Procurement complexity

Low: Subject to local government policies and budget. Additional imagery and distance information would require minimal additional cost to street signs. Wayfinding imagery on footpaths would add additional minimal cost to developer at installation. Wayfinding signage for activity centres, subject to size and complexity of centre, are not likely to be required until 10-15-year time frame.

Further information

- Legible London: http://appliedwayfinding.com/projects/legible-london/
- Indooroopilly Shopping Centre: https://www.indooroopillyshopping.com.au/wayfinding

8.6.2 Real-Time Bikeway Counters

Bicycle counters and speed monitors are used along trunk routes to assist with the planning of future active transport facilities. Bicycle counters use infrared sensors and an inductive loop in the bikeway or footpath to count the number of cyclists. The count is then displayed on the bikeways via electronic display boards. Displaying the number of bike riders, speed, their contribution to reduced traffic congestion and act as an incentive to keep participating in active transport options.

Image sourced: Brisbane City Council

Figure 8-4 Example of real-time bikeway counters

Key considerations

The usefulness of the data obtained from these devices depends on their placement. Counters are placed in strategic locations to track the usage of bikeways over time and to advise future active transport planning. Analysis of bikeway speeds informs councils of locations which would benefit from the installation of speed controlling measures or separation of cycling lanes or routes, such as commuter cyclists, versus recreational cyclists.

Implementation recommendations

Moderate: Subject to incorporation of bikeways within each development. As local streets support cyclists the use of bikeway counters would only be applicable where bikeways are created to facilitate quick and efficient paths into transport hubs or activity centres. Where access to PT is not within 1km bikeways should be implemented to ensure active transport habits support PT and use levels are recorded through bikeway counters to inform network decisions.

Ownership and operation

Bikeway counters are generally funded by local governments or state governments as the road authority and owner. They provide valuable data on road and cycle use, trip journey, desirable routes and destinations which inform strategic active transport network planning and assets.

Procurement complexity

High: Subject to bikeway locations, counters are only required where they are within a high use high activity area, such as along transport corridors (rail/arterials) or in commercial centres. A cost share approach between developers, local and state government would reduce costs and provide a good data source to support future active transport and PT decisions.

Further information

- Brisbane City Council: https://www.brisbane.qld.gov.au/traffic-and-transport/roads-infrastructure-and-bikeways/current-bikeway-and-pathway-projects/real-time-bikeway-counters

8.6.3 Active Transport Infrastructure

Image sourced: Brisbane City Council

Figure 8-5 Image of Brisbane's city cycle, an example of active transport

Active transport is a key focus for cities across the world looking to reduce traffic congestion and encourage an active and healthy lifestyle for their communities. Infrastructure which supports active transport includes:

- Bike or E-bike dock less sharing schemes
- Bike docking stations for share schemes. Including incorporated charging facilities for e-bikes
- Bike repair stations
- E-bike charging stations implemented at key traffic generators, including docks or end-of-trip facilities
- High quality end-of-trip facilities.

Brisbane's bike sharing scheme, City Cycle, has 140 stations (each with 20 bikes). Most stations are in the road shoulder or behind the kerb and are serviced by a single pay station. For commuters who chose to use their own bike, public end-of-trip facilities can be provided at a varying cost to the user. End of trip facilities range from open or caged bike parking to facilities with showers, lockers, e-bike charging and laundry services.

The introduction of charging docks or services at end-of-trip facilities would potentially provide a location for E-bike charging, while bike repair stations are located along bikeways and paths to provide a variety of tools Allen keys, levers and a small pump to enable bike servicing.

Key considerations

Success of active transport infrastructure is dependent on location. To maximise use of facilities they must be in highly trafficked locations and activity centres. Regular maintenance needs to occur to ensure the infrastructure is operating adequately.

Ensuring enough docking stations are adequate along popular routes is essential for a successful bike sharing system. A balance of available bikes and parking spots must be decided based on demand at each station. Bike sharing schemes must abide by strict operating conditions imposed by local councils and road authorities.

Implementation recommendations

High: Subject to incorporation of bikeways and paths within each development. Where bikeways or paths are created in high amenity areas such as activity centres, and along river or nature-based corridors bike repair stations should be provided. End of trip facilities should be provided within activity centres and at PT hubs. Bike sharing schemes would be subject to demand within a local government area not just a PDA.

Ownership and operation

Active transport infrastructure is funded by local governments or state governments as the road authority and landowner. They provide valuable assets to the broader community supporting active lifestyles and wellbeing. Opportunities exist to incorporate with bikeway path construction by developers, however maintenance will remain with local government.

Procurement complexity

Moderate: Subject to bikeway locations, required where they are in high use corridors or activity centres. A cost share approach to construction between developers and local government would reduce costs. Ongoing maintenance would remain a cost to local government.

Further information

- Brisbane City Council: http://www.citycycle.com.au/index.php
- Lime Electric Assist Bikes in Sydney: https://www.li.me/electric-assist-bike
- https://www.timeout.com/sydney/news/will-the-new-lime-green-electric-bikes-survive-sydney-111318
- Bewegen in Summit County: https://bewegen.com/en/bike-share-case-studies/summit-county
- Cycle2City, King George Square, Brisbane: http://cycle2city.com.au

8.6.4 Glowing Cycle Paths for Self-Illumination

In locations with poor visibility, minerals which absorb ultraviolet light and emit a soft glow at night can be used to illuminate cycle and pedestrian paths. This innovation in wayfinding provides cyclists and pedestrians with a sustainable light source in an otherwise dark location and helps create a positive experience for the user. A notable example of this is the 'Van Gough' bike path in the Netherlands, which lights up like the 'Starry Night' attracting significant use and interest from the broader community.

Image sourced: Trendcity.org

Figure 8-6 Example of glowing cycle path

Key considerations

Engagement with local government and state government road authorities to implement this approach to lighting and illumination of their assets. Regular cleaning of these paths is required along with clearance from tree canopy and shade, to maintain enough light absorption during daylight hours to enable maximum after hours 'glow' during the evening.

Implementation recommendations

High: Subject to incorporation of bikeways and paths within each development. Where bikeways or paths traverse dark environments such as parks, open space networks and along corridors (natural or transport) glowing cycle paths should be provided to support 24-hour use of active transport assets, commuter cyclist activities and enhance safety and surveillance for pedestrians.

Ownership and operation

Footpaths and cycle paths are owned by local governments or state governments as the road authority and landowner. They provide valuable assets to the broader community supporting active lifestyles and wellbeing. Opportunities exist to incorporate within footpath and cycle path construction by developers, however maintenance will remain with local government.

Procurement complexity

Low: Subject to local government and state government policies, the addition of minerals to footpath and cycle paths would require minimal additional cost. Footpath and cycle path construction is required by each developer as part of their local infrastructure delivery this would add minimal additional cost to developers at installation. Ongoing cleaning maintenance, replacement and reconstruction would be incurred by local government and/or state government.

Further information

- TMR, Logan City Council, Brisbane City Council examples: https://moondeck.com.au/projects
- Gosford, NSW: https://www.trendingcity.org/glow-footpath-gosford
- Lidzbark Warminski, Poland: https://www.sustainability-times.com/clean-cities/a-sun-powered-bicycle-path-glows-in-the-dark-in-poland/
- Eindhoven, Netherlands: https://www.citylab.com/transportation/2014/11/this-dutch-city-built-a-glowing-van-gogh-bike-path-for-psychedelic-cyclists/382761/

8.6.5 Children's Bicycle Skills and Pump Track

Children's Skills Tracks typically consist of asphalt path circuits with pavement markings and signage simulating an urban traffic environment. This encourages youth to cycle (typically younger than 6 years of age) and develop their skills in a safe and confined environment.

Pump Tracks typically consists of circular loops with smooth dirt mounds and beams that cyclist can ride around in a pumping motion. This encourages people of all ages to cycle for recreational use.

Image sourced: Cityofswan.wa.gov.au

Figure 8-7 Example of children's bicycle track

Key considerations

High use is observed at these facilities if implemented at centrally located parks within suburban areas. High use has also resulted in community demand for supporting facilities such as toilets, shelter, water supply and parking, due to the destination nature of this infrastructure.

Implementation recommendations

High: Opportunities for specific playground experiences should be implemented at Sub-Regional or well-placed district level parks in association with other district level facilities. Access to these activity-based parks should be integrated within open space networks of each PDA so that bikeways, cycle paths and shared paths connect across suburbs to maximise community access and user experience.

Ownership and operation

Developer contributions can be collected in areas immediately surrounding facilities to contribute to capital costs, however nexus should be clearly defined given ability of activity to draw users from a district/Sub-Regional community. Ownership remains with local government along with ongoing operational costs.

Procurement complexity

Moderate: Installation may form part of a district or Sub-Regional level park within a PDA subject to local government catchment requirements for recreational facilities. Construction and installation may be required by a developer or through the DCOP as part of district park facilities. The Stratton Youth Space approximate capital cost was around $60k.

Further information

- Stratton Youth Space, Western Australia: https://www.swan.wa.gov.au/Your-Community/Kids/Sporting-facilities/Parks-with-bike-paths/Parks-with-bike-paths-list

8.7 Review and Comparison of Adopted Demographics

An extensive review of the demographics was undertaken as part of Section 2. Since the majority of active transport network lies within the road network, this aligned with the demographic outcomes in Section 7.7 of this Report.

8.8 Planning Horizons

The Greater Flagstone PDA includes planning horizons of 2026, 2031, 2041 and 2066 (ultimate year). Demographics such as population, dwellings and employment are provided for these horizons for identifying future infrastructure requirements and analysis. Like above, this aligns with the Transport Section and its outcomes (see Adopted Interim and Ultimate Planning Horizon Analysis and Results

An analysis was undertaken initially for the ultimate planning horizon, which was then followed by the interim stages. The methodology for the assessment in this section is as outlined below:

- Assess the planned network for Level of Traffic Stress.
- If any changes are required, cross-check with the status of approvals in the area, and update the ultimate network.
- Detail individual elements for the cross-sections in line with the applicable guidelines (see Reference).
- Stage for the interim horizons.

8.9 Level of Traffic Stress Assessment

To develop an understanding for the standard of service which should be provided for the active transport infrastructure in the PDA, the Level of Traffic Stress (LTS) methodology has been applied. A summarised form of the LTS tool is outlined in Table 8-2. This shows how infrastructure type, clearance from traffic, road function and traffic speed affect the LTS score. LTS 1 and 2 are acceptable for attracting higher proportions of cyclists, whereas LTS 3 and 4 are more act as barriers to choosing to cycle. It is noted that the LTS methodology considers additional variables to those summarised below.

Table 8-2 LTS Methodology (summarised)

Type	Road function	Other features	Road speed (km/h)					
			30	40	50	60	70	>70
1	Off-road (more than desirable clearance)	Separated path*	1	1	1	1	1	1
		Shared path	1	1	1	1	1	1
2	Off-road (less than desirable clearance)	Separated path*	1	1	1	2	2	3
		Shared path	1	1	1	2	2	3
3	Local road	Cycle lanes*** (<2000 AADT)	1	2	2	3	4	4
		Cycle street (<200 AADT	1	2	4	4	4	4
		Shared zone/ Bicycle Awareness Zone (<750 AADT)	1	2	3	4	4	4
		No cycling facility/mixed (<750 AADT)	1	2	3	4	4	4
4	Collector	Cycle lanes***	3	3	3	3	4	4
		Cycle street	4	4	4	4	4	4
		Shared zone/ BAZ	4	4	4	4	4	4
		No cycling facility (mixed)	4	4	4	4	4	4
5	Arterial	Cycle lanes***	4	4	4	4	4	4
		Cycle street	4	4	4	4	4	4
		Shared zone/ BAZ	4	4	4	4	4	4
		No cycling facility (mixed)	4	4	4	4	4	4

*Includes cycle track

**If shared path is less than 3m then drops to LTS2

***Cycle lanes are separated by painted line

The assessment was undertaken first for the trunk network, to understand if there were any shortcomings. The trunk network performed well with either LTS 1 or 2 due to it being mostly off-road infrastructure. However, two on-road slow-street environments were proposed in the Bicycle Network Plan (VLC, May 2017). The following inclusions have been made:

- Trunk connector to the Covella development (northern circle highlighted below (see Figure 8-8) Because of changes to the road network, traffic volumes and speeds would likely result in an LTS 4 for this road. It is recommended to change this link from a slow street to 3m shared path. It is noted that the adjacent development is approved, however this may already have a shared path included. It is recommended to investigate making the change and if it is not already included in the approved plan provide a retrofit solution.
- Trunk connector to the Mountain Ridge development (southern circle highlighted below (see Figure 8-8) Because of changes to the road network, traffic volumes and speeds would likely result in an LTS 4 at this location if it remained a slow street. It is recommended to change

this to a 3m shared path. It is noted that the adjacent development is approved, and therefore investigate changing or retrofitting the road with a 3m shared path.

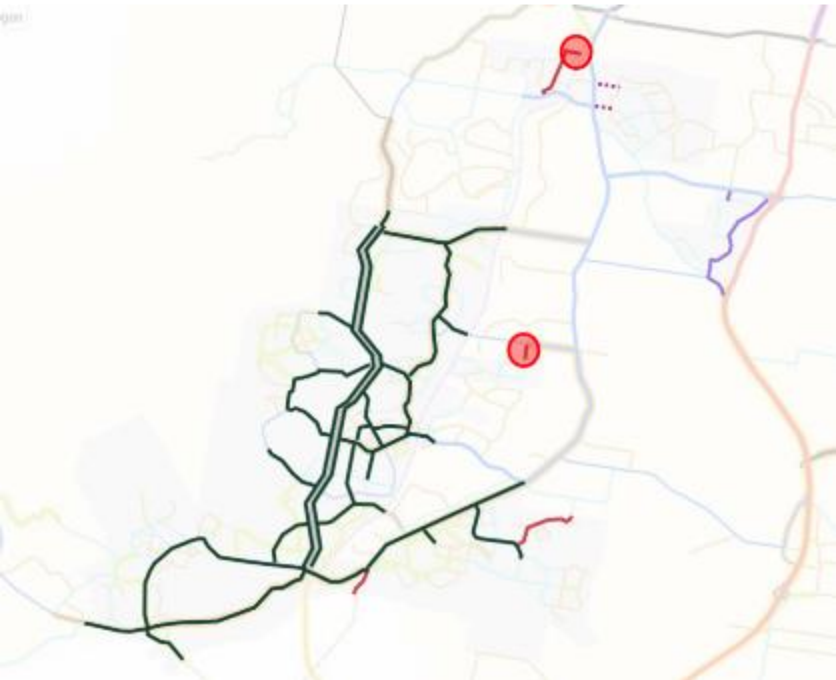


Figure 8-8 Required amendments from LTS assessment (see red circles)

The local network also scored well, with the majority at LTS 1. This is due to the dense network of off-road infrastructure. Two slow streets were proposed, however these are proposed with 30km/hr streets and lower traffic volumes (i.e., less than 2,000 vehicles per day), and so appear appropriate. These should be checked again at the later stages of planning to ensure that this still applies.

The final LTS scores are shown below (see Figure 8-9). Since this was an iterative process, the changes based on the outcomes from the development and staging (see following sections) are also incorporated here. Given the focus of the LTS methodology, off-road infrastructure outside of the road corridors and not part of the trunk network is not detailed below.

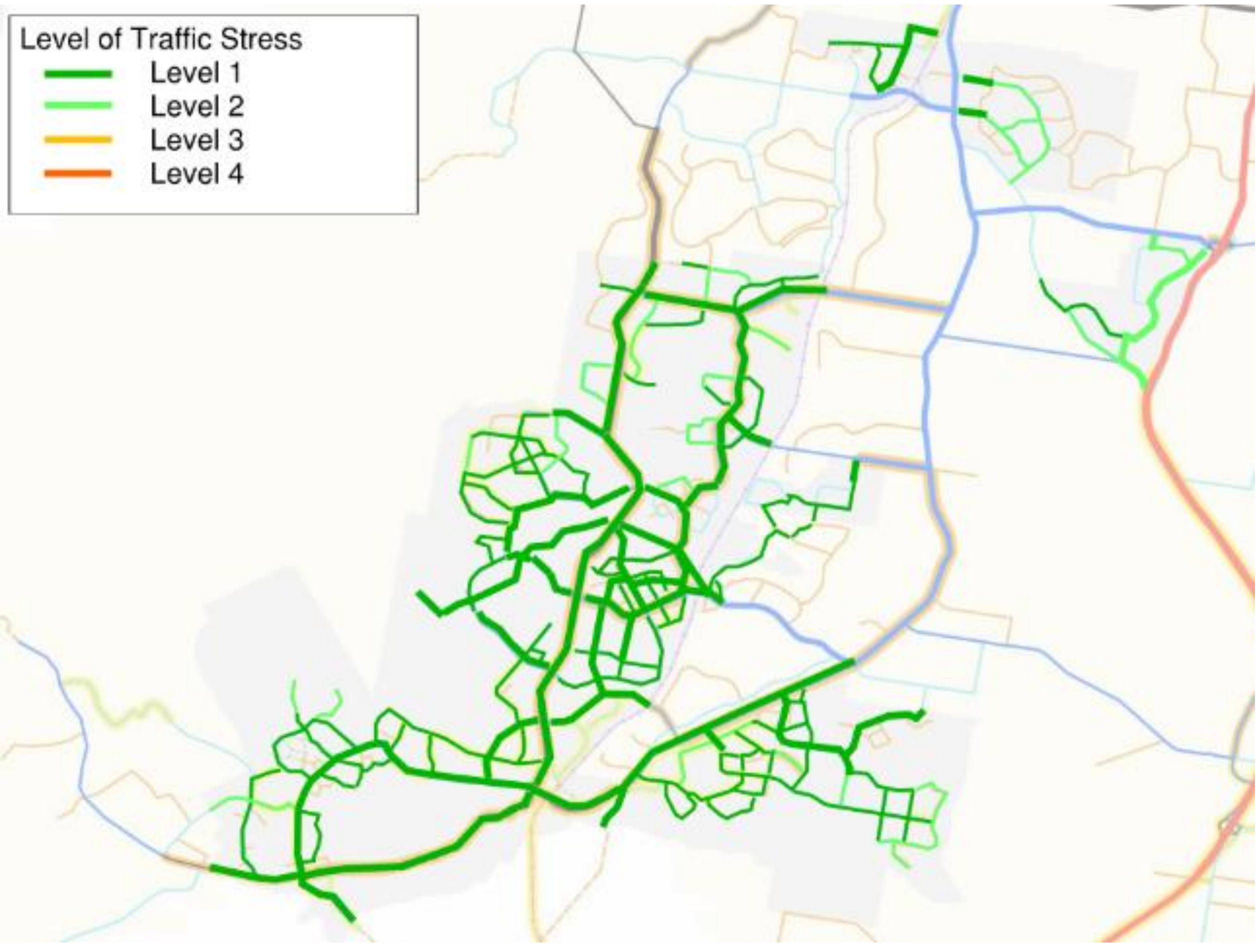


Figure 8-9 Final LTS score for the PDA

8.10 Network Development

Some minor changes were also made to align the active transport with the latest road network (according to the Model Report and ICOP). Some slight rationalisation was also undertaken as part of this. In particular, the off-road shared path identified in the ICOP and Bicycle Network Plan appears to have unnecessary legs. This is outlined further below.

The off-road shared path spans through the middle of the PDA in a north-south direction, as well as two east-west spurs from the centre (see Figure 8-10). The north-south leg follows the trunk road network, and the east and west legs deviate from the road corridor at some sections. Since a two-way cycle track and parallel footpath is proposed along both sides of the north-south arterial, the inclusion of the off-road shared path here provides no benefit to the network. Therefore, the outcome is as per below:

- Removal of the north and south legs of the off-road shared path (see red circles in Figure 8-10), since pedestrian and cyclist infrastructure along the road corridor would make it redundant.

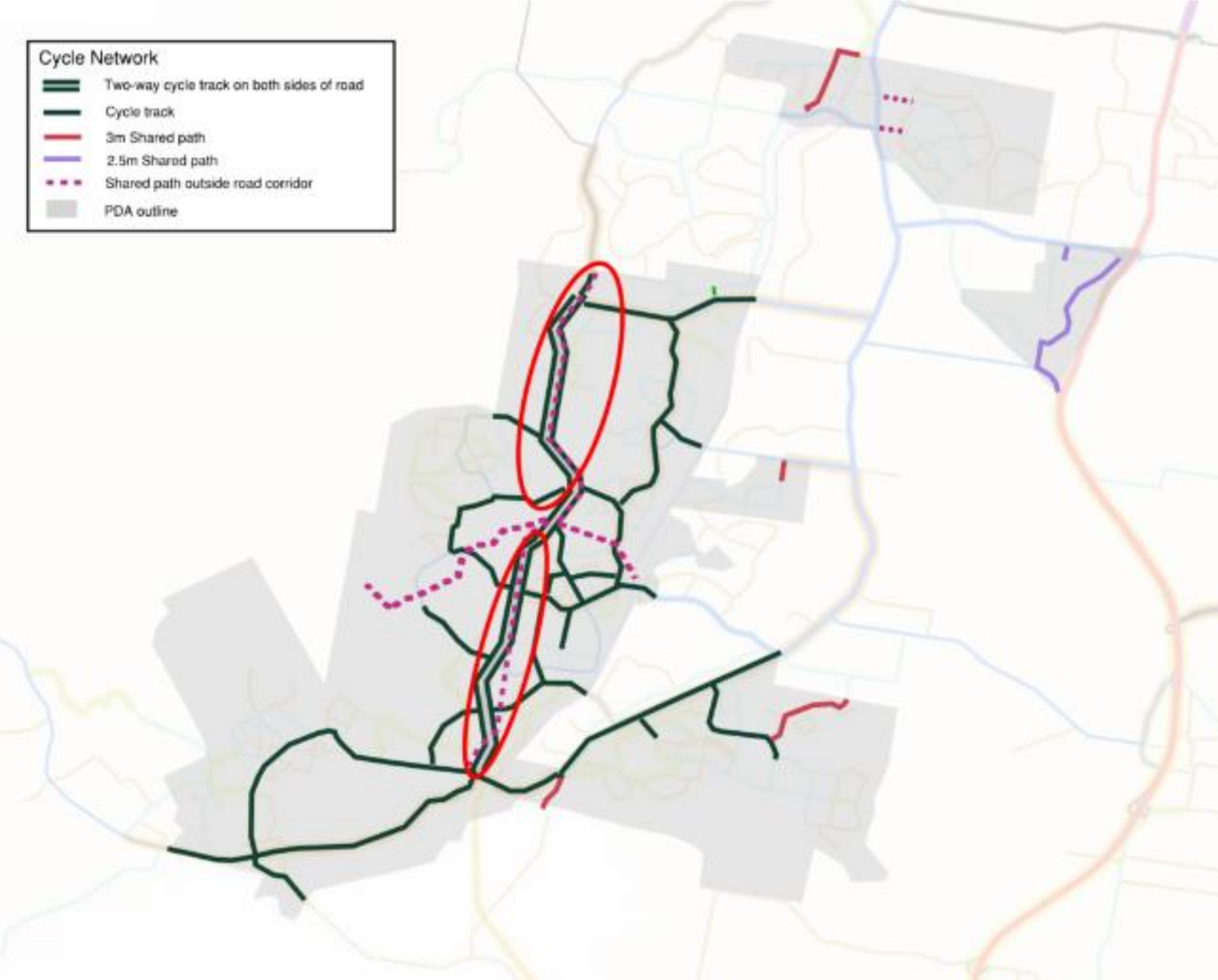


Figure 8-10 Required amendments for off-road shared path (see red circled)

The final trunk network is as per Figure 8-11 made up of two-way and one-way cycle tracks, 2.5m and 3m shared paths. In addition to this, it is proposed that the off-road shared path is provided with a width of 4m. Note that this does not show the local network, or infrastructure outside of the PDA (e.g. along the rail corridor). Overall, this is a high-quality active transport trunk network, which provides strong connections between trip generators and attractors.

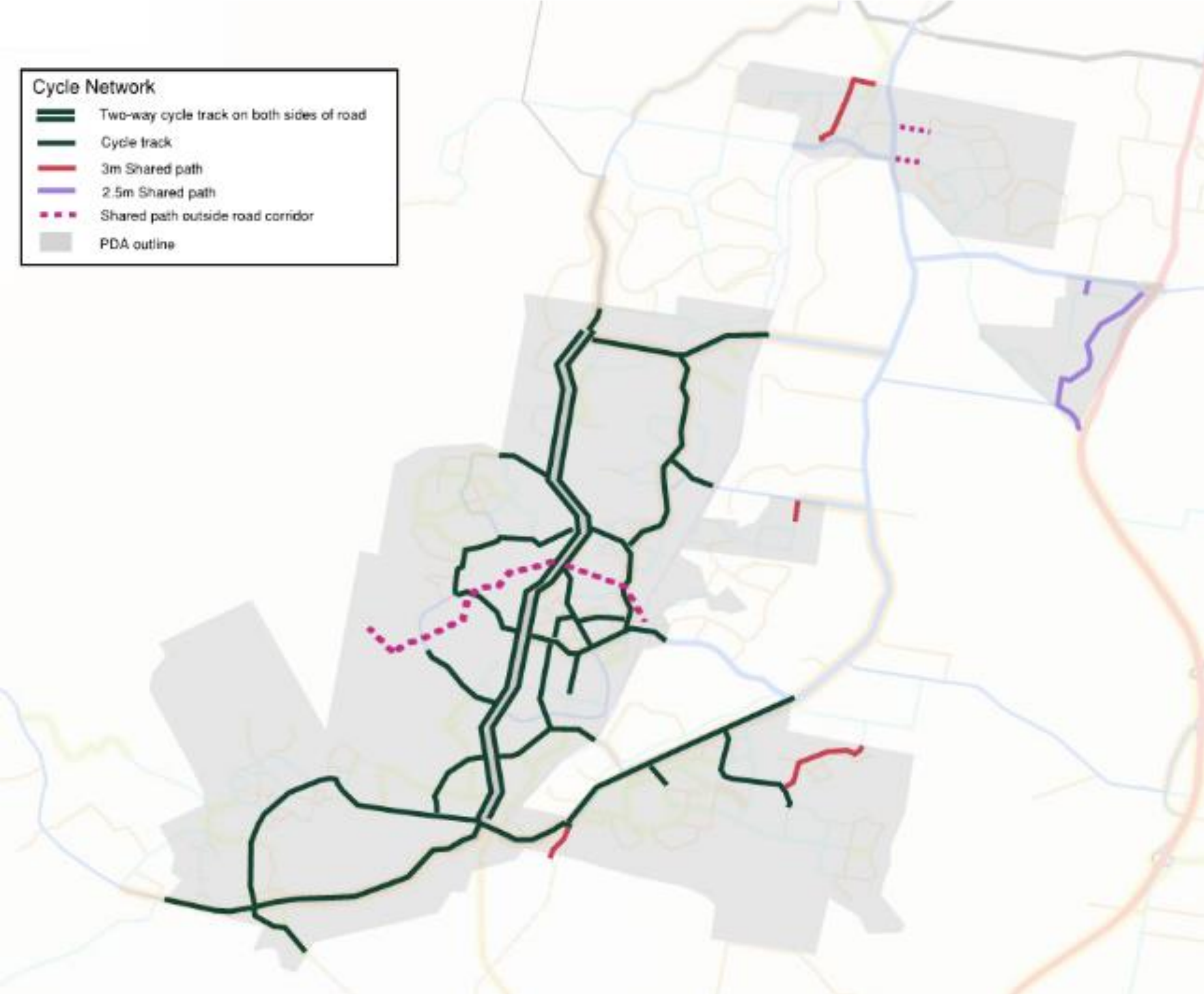


Figure 8-11 Final trunk cycle network for the PDA

It should be noted that the Bicycle Network Plan also identified potential locations for grade separated crossings, that should be investigated further. At this stage, the proposed network is deemed sufficient to cater for crossings as part of the proposed intersections (see next section). This should be revisited as the PDA develops to understand if there were any pertinent issues that would warrant grade separated facilities. With reference to Figure 8-11, the shared path outside the road corridor and where it intersects with the trunk network should be considered as part of this.

8.11 Cross-Sections

Development of the cross-sections for the trunk network is detailed below for the roads and intersections.

8.11.1 Roads

The lateral clearance of cyclist and pedestrian infrastructure is provided in PDA Guideline No.6 according to street type and adjacent uses (e.g. parking, breakdown area etc). This is summarised in Table 8-3 in addition to the adjacent road elements. The minimum spatial requirements for the active transport infrastructure are listed below:

- 3m shared path

- 2m one-way cycle track
- 3m two-way cycle track

Figure 8-12 below illustrates the proposed typical cross section for trunk collector roads

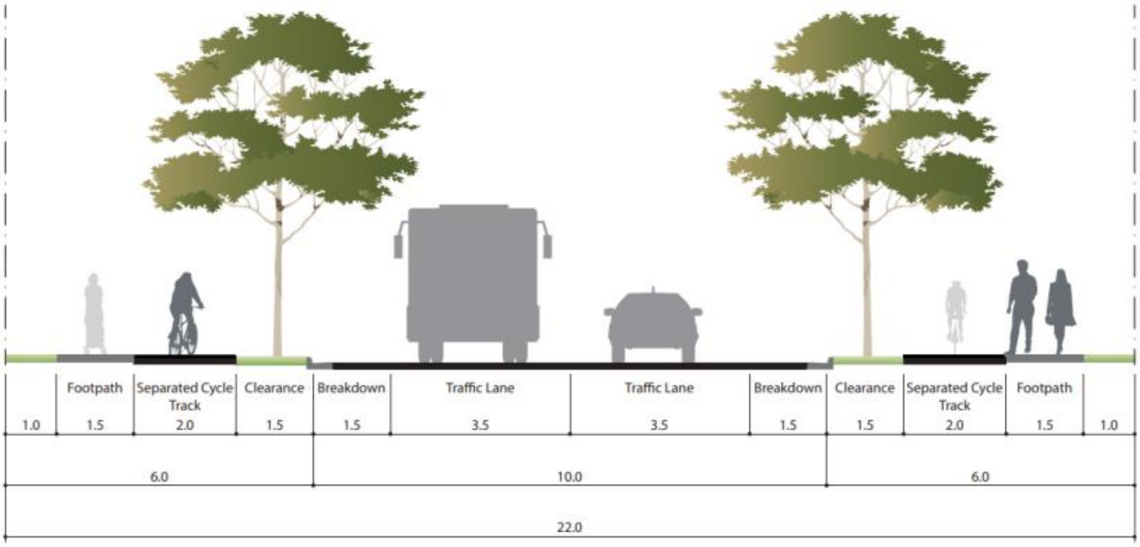


Figure 8-12 Example Road Cross Section for Trunk Connector

Table 8-3 PDA Guideline No.6 Spatial Requirements

Street type	Width				Vegetation clearance		
	Footpath (minimum)	Parking	Breakdown	Boundary	Indented parking	Traffic lane (with breakdown shoulder)	Traffic lane (without breakdown shoulder)
Trunk connector	1.5m	2.4m	1.5m	1	1.6m (cycle track) 2m (shared or footpath)**	1.5m (cycle track)	2m (cycle track)
Centre connector	3m	2.5m		0	1.5m (cycle track)		2m (cycle track)
Industrial connector	1.5m	2.5m		1	2m (cycle track) 2m (footpath)		
Urban arterial*	1.5m	2.5m		1	2m	1.5	2m (cycle track) 2m (footpath)**

**Not stipulated in PDA Guideline (assumed only)*

*** Applied to every location*

While Urban Arterials are not outlined in the guideline, the above requirements where assumed and applied, relating to the worst cases outlined. The above rationale has been applied to develop the cross-section for the trunk network.

With alignment to current guidance, no separation is required between cycle and pedestrian infrastructure. However, some current delineation methods may cause a trip hazard, and so alternative methods to vertical methods is explored later in this section (see Edge Treatment Methods).

Whilst a 1.5m minimum is detailed for pedestrian provisions for both sides of Urban Arterials, Trunk Connectors, Neighbourhood Connectors and Industrial Connectors, where space permits, a minimum 1.8m should be considered for provision.

8.11.2 Intersections

Selection and Design of Cycle Tracks (TMR, October 2019) outlines the most relevant requirements for intersection layouts for the trunk network. This outlines suitable options for each intersection type, in addition to retrofit examples.

A typical intersection for one and two-way cycle infrastructure and pedestrian facilities at a signalised intersection is shown below. As per below, a 2m storage is desirable for pedestrians and cyclists waiting to cross. This is also desirable along the entire approach and so is adopted, however it can be reduced if constrained (i.e. tapered).

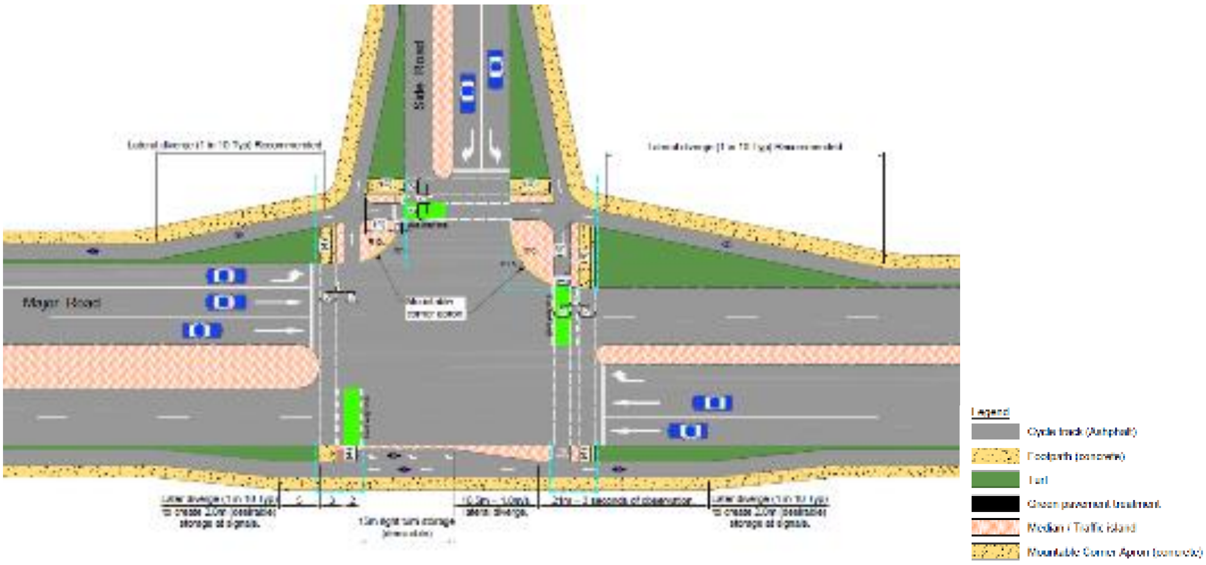


Figure 8-13 Typical Layout at Signalised T-Intersection

Source: Figure B4.01 – Selection and Design of Cycle Tracks, TMR

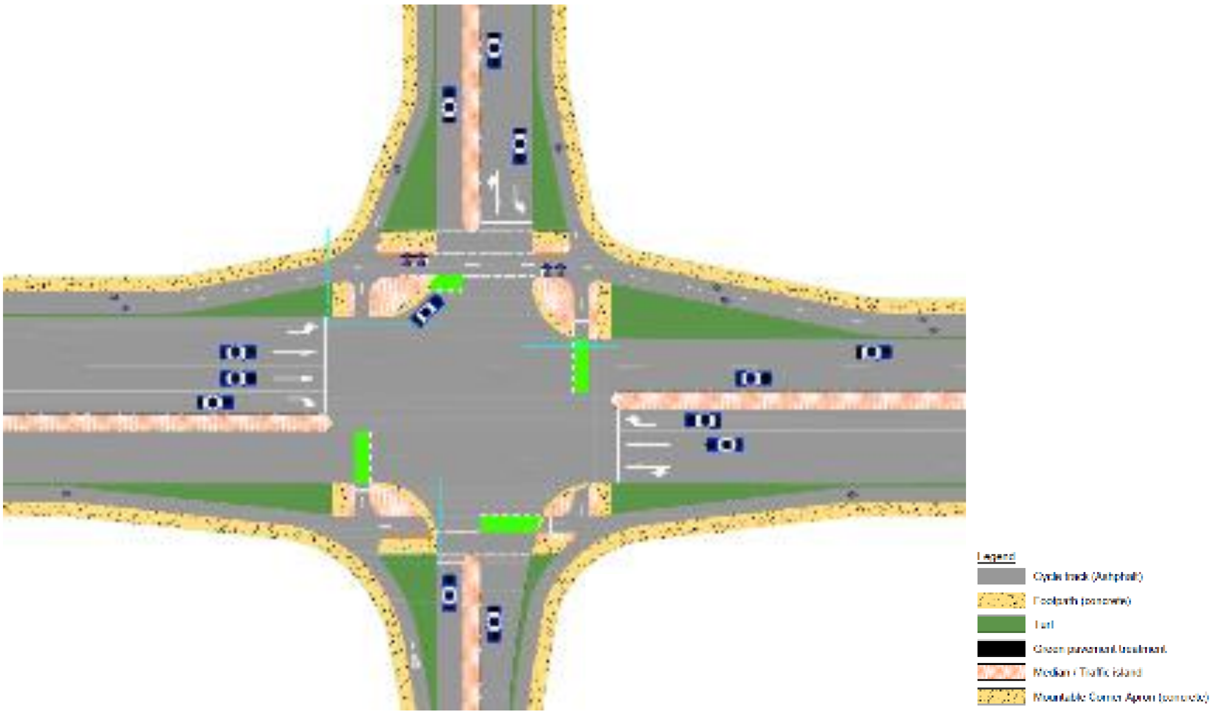


Figure 8-14 Typical Layout at Signalised 4-way Intersection

Source: Figure B4.02 – Selection and Design of Cycle Tracks, TMR

A typical roundabout configuration that accommodates cycle and pedestrian infrastructure is as per below.

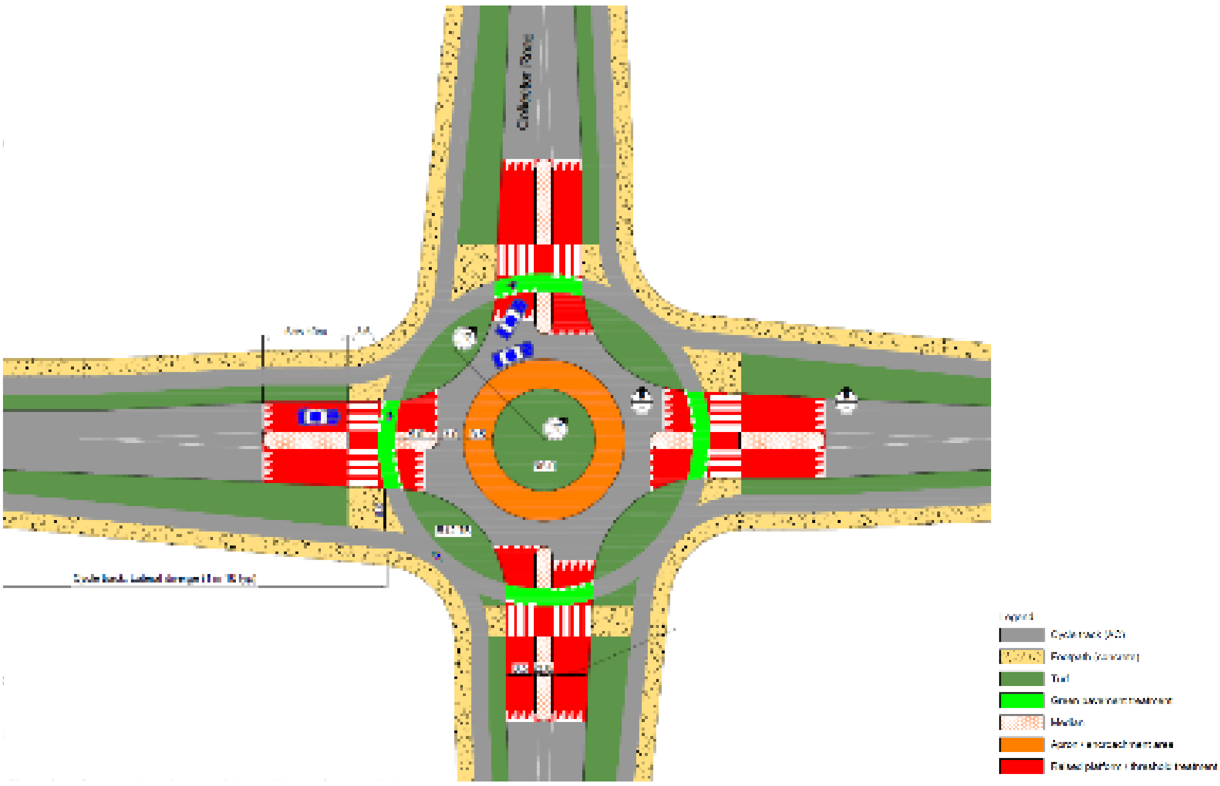


Figure 8-15 One-Way Cycle Track and Footpath at a Single Lane Roundabout

Source: Figure B3.02 – Selection and Design of Cycle Tracks, TMR

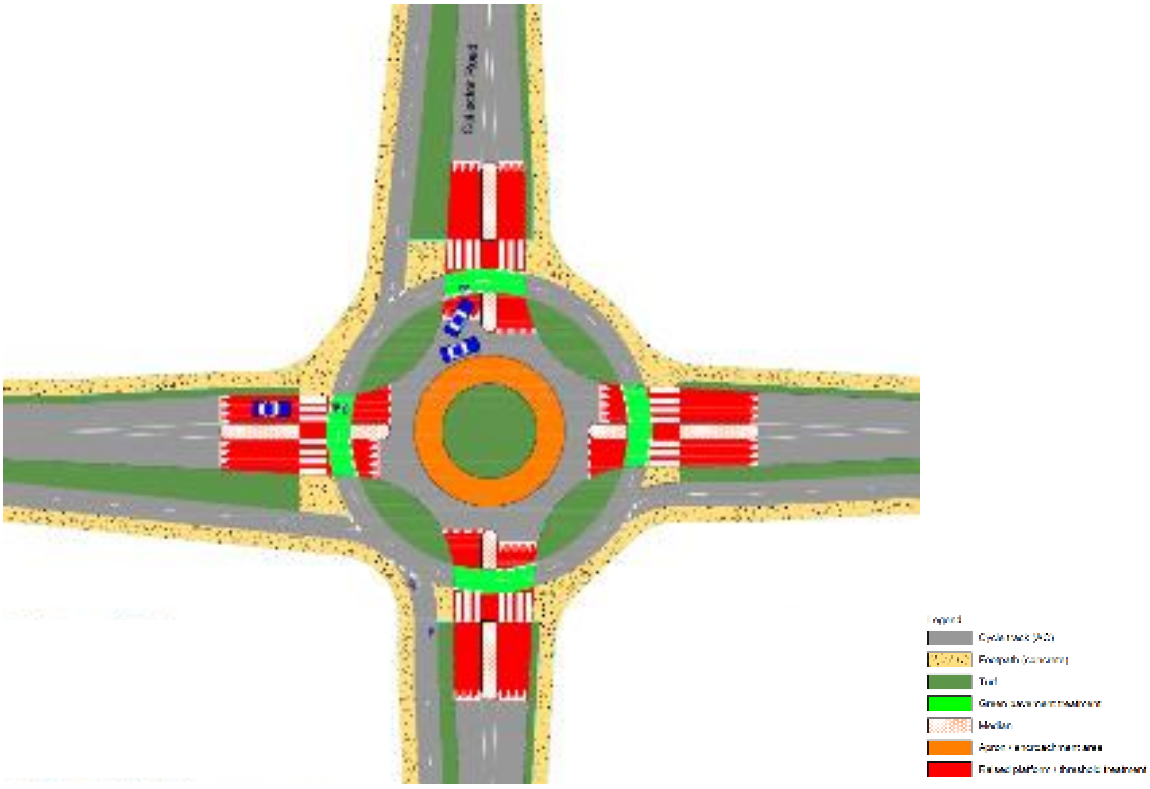


Figure 8-16 Two-Way Cycle Track and Footpath at a Single Lane Roundabout

Source: Figure B3.03 – Selection and Design of Cycle Tracks, TMR

Typical priority control intersections also make up part of the trunk network as part of the interim stages. These intersections will be upgraded to roundabouts or signalised intersections in future stages, as established in the Transport Section. For the intersecting lower order roads, it is recommended that cyclists have priority alongside the through moving traffic. For these situations, in addition to other lower order side roads, a treatment should be implemented with an arrangement like below (see Figure 8-17 and Figure 8-18). The pedestrian and cyclists crossing provisions should be constructed at the time of the intersecting/side road being constructed. Side roads which are not part of the trunk network are not offset-able.

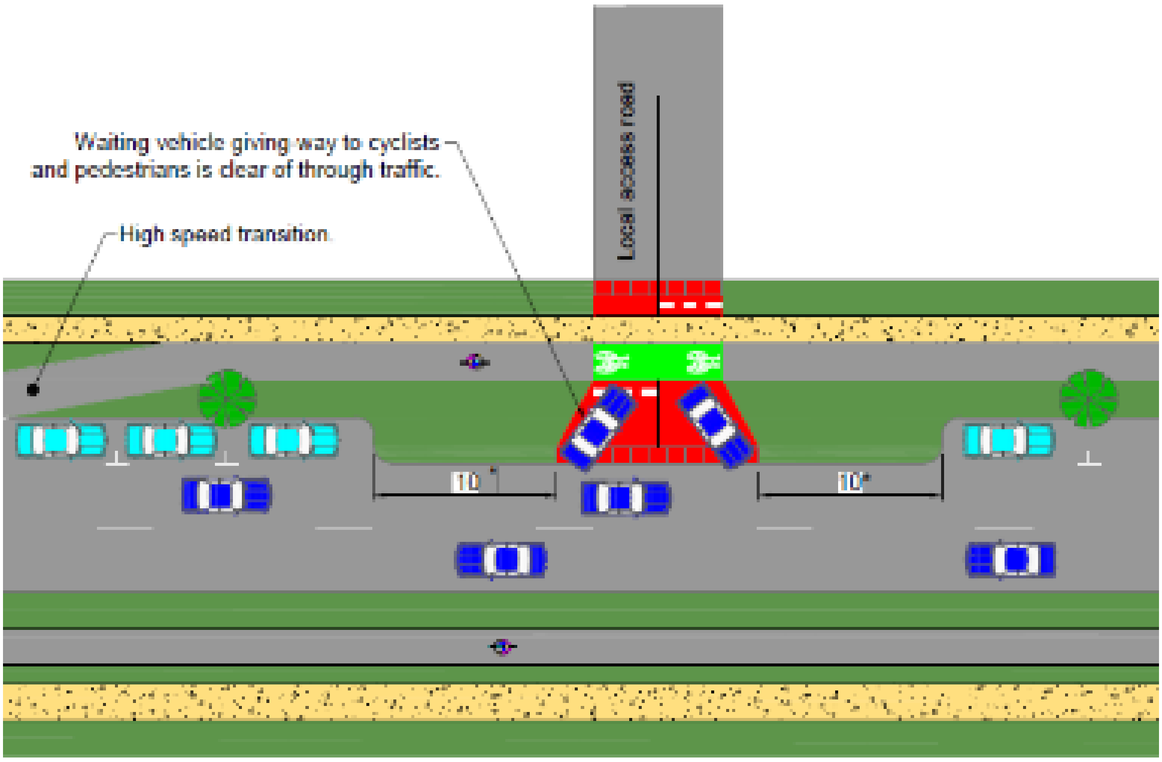


Figure 8-17 One-Way Cycle Track and Footpath at Side Road

Source: Figure B2.01 – Selection and Design of Cycle Tracks, TMR

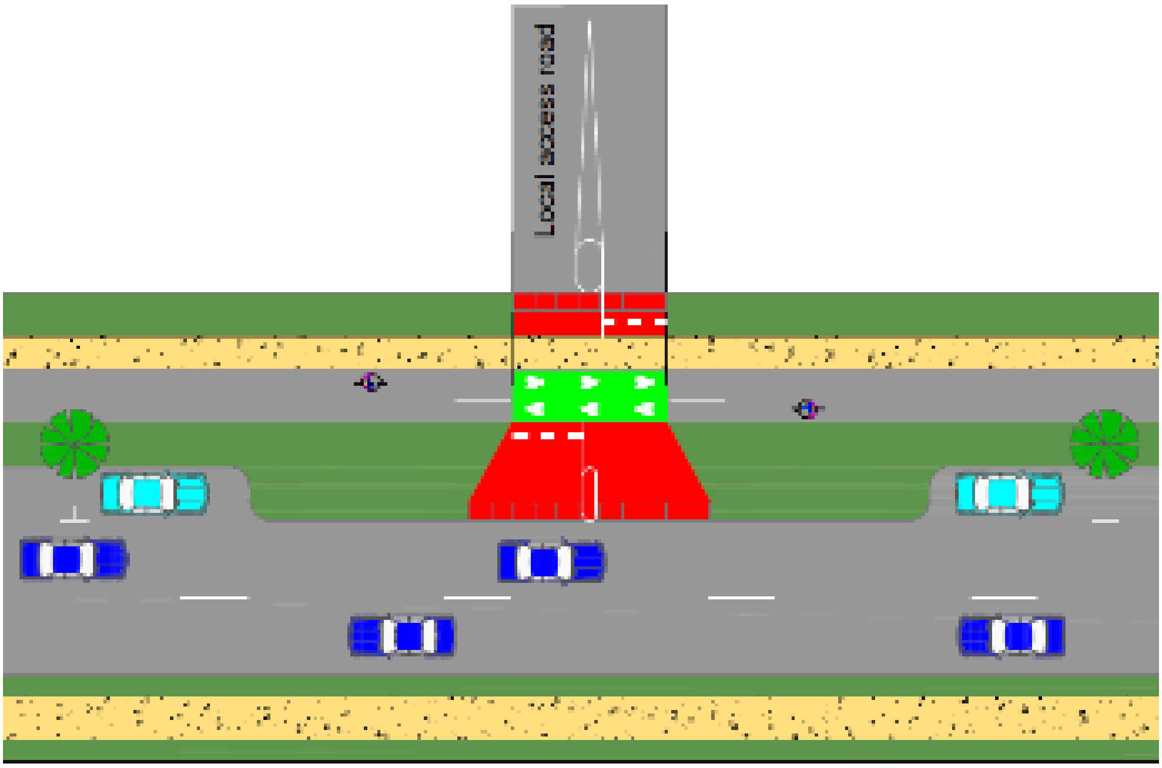


Figure 8-18 Two-Way Cycle Track and Footpath at Side Road

Source: Figure B2.01 – Selection and Design of Cycle Tracks, TMR

8.11.3 Staging

The above cross-sections also need to consider the staging requirements for the network. Future upgrades to road infrastructure need to be considered closely to optimise the amount of land take and redundant infrastructure. For consistency and ease of construction (minimize construction disruption and lower costs), the active transport infrastructure be built at the time of the trunk road infrastructure. If this is built after travel behaviours of the residents are ingrained, it may be difficult to encourage a mode shift to active modes.

A network-wide approach has been undertaken for establishing the active transport network at each time horizon, so a consistent type of infrastructure is provided along each route. This is particularly relevant for the North South Urban Arterial.

Cycle Tracks Network

With the majority of the trunk road network proposed to have cycle tracks on both sides of the road, the following methodology has been applied for when there will be an interim stage before the ultimate road is constructed (typical scenario is a 2-lane road that is upgraded to 4-lane road).

Interim

- **Roadside 1**:
  - 1.5m footpath (minimum)
  - 3m two-way cycle track on single side of road
  - 1.5m vegetation clearance
- **Roadside 2:**
  - No infrastructure

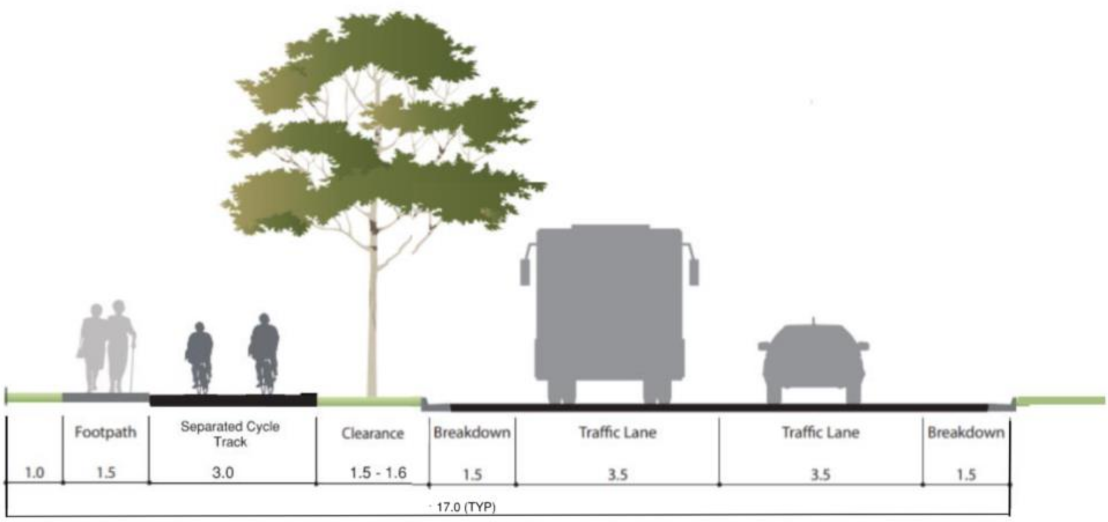


Figure 8-19 Interim Staging of Active Transport Infrastructure in Verges

Ultimate

- **Roadside 1:**
  - Interim infrastructure remains
  - Convert 3m two-way cycle track to 3m one-way cycle track to 3m one-way cycle track. If a level edge between the footpath and cycle track is used (see Edge Treatment Method below), there may be opportunity to redistribute some of the space for pedestrians, if the pedestrian volumes are substantial (i.e. 2m one-way cycle track and 2.5m footpath).
- **Roadside 2:**
  - 1.5m footpath (minimum)
  - 2m one-way cycle track
  - 1.5m vegetation clearance

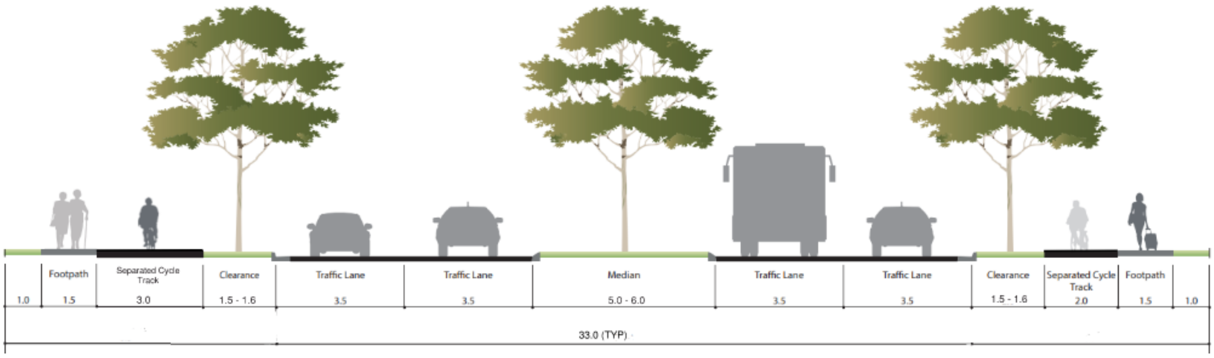


Figure 8-20 Ultimate Staging of Active Transport Infrastructure in Verges

For shared paths, it is recommended that is built in the interim on the side that will also be applicable to the ultimate stage (i.e. Road-side 1 from above).

While the guideline does indicate a 2m minimum clearance for higher order roads, a 1.5m clearance was adopted for the above scenarios where cycle tracks are staged. To support this, reference has been made to the Selection and Design of Cycle Tracks Guideline (TMR, October 2019) and the clearance requirements from static objects. As shown in Table 8-4, a maximum of 1m clearance is required. In addition to this, where there is on-street parking or vehicle speeds are above 60 km/h adjacent to the cycle track, a 1.0m separator is recommended (TMR, October 2019).

Table 8-4 Clearance Requirements for Cycle Infrastructure and Static Objects (TMR, Oct 2019)

Feature	Minimum clearance	Desirable clearance
One-way cycle track with no car parking adjacent	0 m	1.0 m desirable for arterial roads
Parked cars adjacent to one-way cycle track	0 m	0.75 m desirable
Parked cars adjacent to two-way cycle track	0 m	0.40 m desirable
Bus stop, railing, crash barrier, poles, bollards, street tree, wall or fence	Refer to Austroads *Guide to Road Design* Part 6A Section 7.7	

Off-Road Shared Path

Staging for the off-road shared path has been undertaken with consideration to the timing of the surrounding trip attractors. This includes schools, parks and open space, commercial precincts and other community facilities (Urbis, May 2020). Where the time horizon does not show trips attractors which would drive the need for the section of the off-road shared path, this section has been nominated for a following period when these facilities are present. This information is outlined in Transport Infrastructure Costings Tables.

Edge Treatment Methods

With reference to the Dutch study "Road safety of curbs follow-up research" (Ministry of Infrastructure and Environment, March 2017) there are three typical treatments to consider for edge treatments. A vertical edge, a gradual edge, or no edge (i.e. no vertical difference). According to the study, it concludes that except for high vertical edges, every kerb type below is sufficient in achieving cycle and pedestrian safety, with consideration to the following.

- Vertical edge: Can create a tripping hazard for pedestrians and cyclists. Typically, not preferred for high pedestrian traffic (greater than 200 pedestrians per hour).
- Diagonal edge: must be sufficiently slanting to be forgiving (such as below 45 degrees but extra research is required to confirm precise angle).
- No edge (no vertical difference): requires a distinctive edge by means of single line marking and used of different materials to distinguish each path. Pedestrians are more likely to walk on cycle track. Signage does not contribute to more separation or safety.
- It is noted that the research states that the preferred option is highly dependent on local circumstances.

As such, there appears to be merit in considering a forgiving diagonal edge (below left), or no edge with line marking and distinguishable surfacing (below right). Therefore, consider both the diagonal edge and gradual edge treatments, and the balance between the trip hazard risk vs the conflict risk. Remain up to date with the latest guidance on the matter. TMR's latest guidance has 1:8 grade across 150mm on the footpath side to minimise pedal strike and reduce trip hazards.

Figure 8-21 Diagonal Edge and No Edge Treatment for Pedestrian Path/Cycle Track Transition

8.12 Adopted Active Transport Network

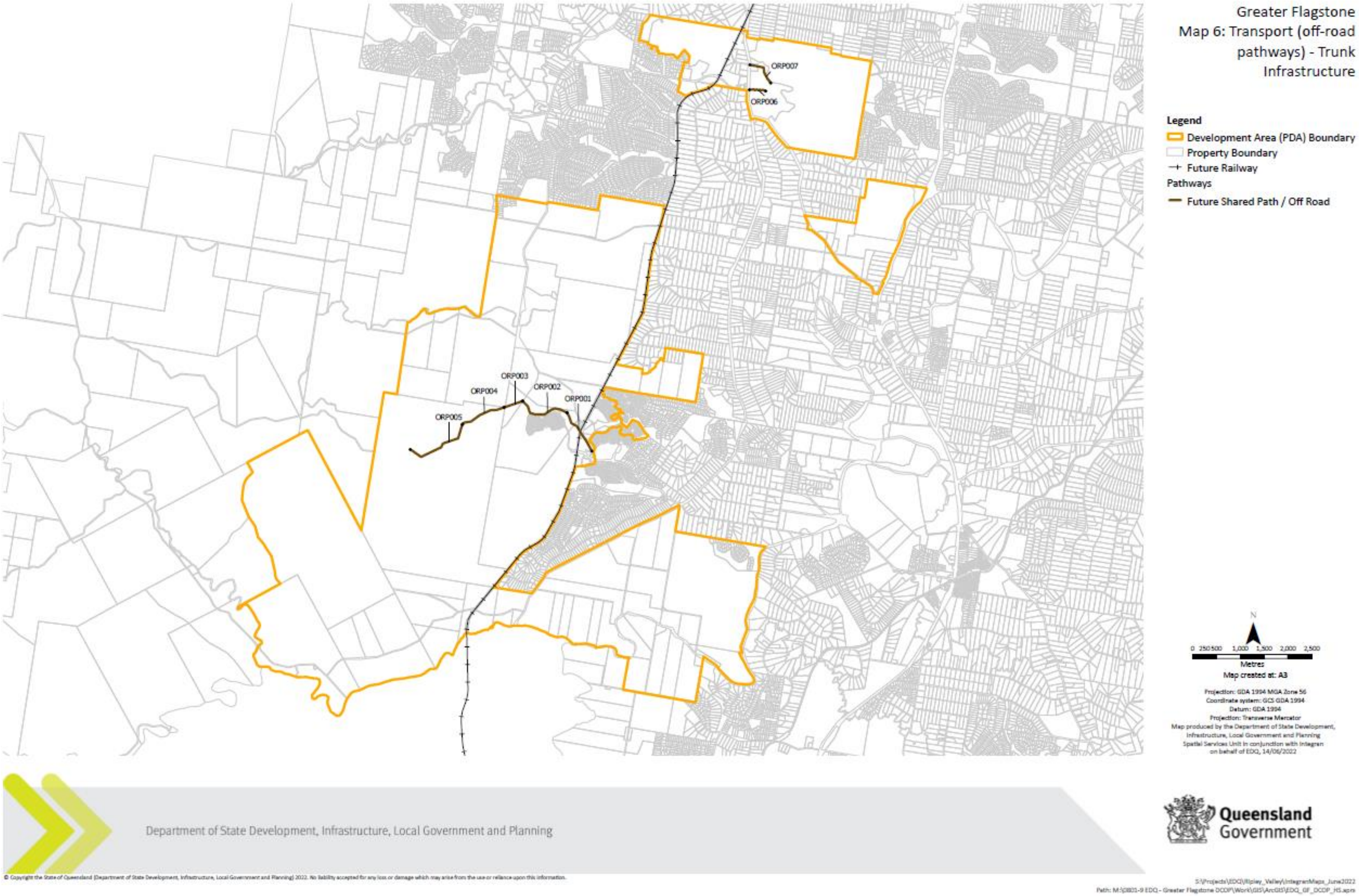


Figure 8-22: Greater Flagstone PDA Adopted Active Transport Network

8.13 Opinion of Cost of Adopted Interim and Ultimate Planning Horizons

Rider Levett Bucknall (RLB) were engaged to develop an opinion of the cost of active transport infrastructure to service the Greater Flagstone PDA. The quantities of active transport infrastructure, which is located outside of the trunk road corridor, and instead within the PDA's linear parks were derived from the updated network plan developed as part of this study. To avoid duplication with the costing for Parks and Open Spaces, the equivalent paths lengths have been removed from the specific linear parks. Municipal costs for Greater Flagstone PDA were then extracted from the RLB estimates and inserted into the Financial Offset Model per planning horizon, the summaries of which can be found within the Schedule of Works containing within the body of this Infrastructure Planning Background Report (IPBR).

9 Parks and Open Space

9.1 Introduction

A key basis for the development of the Development Charges and Offset Plan (DCOP) was a demographic study as outlined in Chapter 1. The study found:

- Greater Flagstone Priority Development Area (PDA) would be fully developed by 2066, with 54,000 dwellings and 145,000 people, and
- This is in increase in population from the 120,000 people and 50,000 dwellings anticipated in the Greater Flagstone Urban Development Area Development Scheme.

This chapter outlines the research and consultation undertaken to review the Infrastructure Charges and Offset Plan (ICOP, June 2020) Greater Flagstone Priority Development Area (hereafter referred to as the ICOP) with respect to Parks and Open Space. This process involved:

- Consideration of the demand imposed by revised population projections, estimated using the Desired Standards of Service (DSS) in Economic Development Queensland's (EDQ) Park Planning and Design PDA Guideline No. 12 (referred to hereafter as Guideline 12),
- Consideration of stakeholder input, including feedback from state and local government as well as the development industry, and
- Consideration of emerging policy trends with respect to Parks and Open Space planning.

This chapter provides:

- A review of the amended population growth figures against Guideline 12 to identify Open Space network impacts,
- Preliminary review of Guideline 12 standards through a comparative benchmarking assessment to identify which standards remain valid and which may warrant updating in the new DCOP,
- Consideration of workshop and consultation feedback on current shortcomings and areas for improvement for this network,
- Development of recommendations, following this PDA specific assessment, with respect to Guideline 12 benchmarks that remain valid and those that may benefit from updating, and
- Provision of advice on a revised Open Space Network, including sequence, innovation and cost.

9.2 Reference Standards

9.2.1 Sampling Open Space Provision

Research on emerging practice in open space provision revealed trends toward the provision of open space on qualitative, rather than quantitative, measures. This is discussed in further detail below.

Therefore, acknowledging the differences between Guideline 12 and LCC DSS provision, a wider sample of open space provision rates from other Queensland locations was taken. DSS rates used included those from:

- Brisbane City Council
- Redlands City Council
- Sunshine Coast Regional Council
- Logan City Council
- Ipswich City Council
- Moreton Bay Regional Council
- EDQ Guideline 12

Results of this comparison are summarised below in Table 9-1. While the categorisation, size and description of parks in the hierarchy did vary, it was possible to categorise parks in a manner that aligned with the Guideline 12 parks to some degree and enable an aggregate area of park provision to be calculated.

Analysis of aggregate open space provision in benchmarked DSS served to identify the relatively high provision of open space that EDQ Guideline 12 requires.

Emerging policy from other states3 identifying that accessibility and service provision should drive open space design, rather than quantitative provision alone. Therefore, review started with accessibility to derive required park numbers. By considering accessibility, development constraints in the PDA and comparison with other DSS, an aggregate rate of provision of open space of 3ha/1000people was considered appropriate. Key findings included:

Current DSS benchmarking in Phase 1 indicating a far high level of service than what is currently being implemented on the ground (i.e. minimum size parks).

Catchment/accessibility analysis undertaken for all parks to determine whether additional parks area required

Accounting for approved Context Plans only providing minimum size in contrast to the ICOP providing a high level of service

Taking into account endorsed IMPs shows significant under-provisioning against Guideline 12 but good accessibility.

Table 9-1 DSS Comparison

Comparison DSS	Moreton Bay Regional Council	Redland City Council	Logan City Council	Ipswich City Council	Sunshine Coast Council	Brisbane City Council	EDQ Guideline 12
Aggregate area provision ha/1000popn	3.8	4.3	3.9	2.4	4	2.8	4.6

[3] [3] *Liveable Neighbourhoods,* Western Australian Planning Commission, 2009

[3] *Draft Greener Places Design Guide*, NSW Government Architect, 2020.

[3] *Guidelines for Precinct Structure Planning in Melbourne's Greenfields,* Victorian Planning Authority, 2020

In developing recommendations, the comparison DSS parameters formed a key element of consideration to form a view on any revisions to current open space new benchmarks. Review of emerging state level policy identified that open space provision should be designed on user needs and service quality taking priority over quantitative measures. This review sought to balance this emerging practice with current policy approach by highlighting accessibility as a key driver.

9.3 Desired Standards of Service

The assessment and stakeholder discussion relating to parks and open space involved consideration of the quantity of parks and area that would be required for the projected population of 145,000 people, considering a revised rate of overall provision. The overall rate of open space provision was split across the parks hierarchy at the same proportions as the existing EDQ Guideline 12. This quantitative analysis is provided below in Table 9-2.

Table 9-2 Quantitative Analysis

Park Type	Qty	Area (ha)
District/major recreation parks		
District recreation	10	66
City park/town square	3	2
Major recreation	5	75
Sub total	***18***	***143***
Sport parks		
District sport park	9	80
Major sport park	5	90
Sub-total	14	170
Major linear park	N/A	73
Sub-total	***N/A***	***73***
Local parks		
Local recreation park	Not creditable	
Neighbourhood recreation park	Not creditable	
Local linear park	N/A	19
Sub-total	***N/A***	***122***
TOTAL	**N/A**	**N/A**

9.4 Review of Emerging Policy

Research into open space policy of other States in Australia provided some additional perspective on the considerations of open space provision for the DCOP. State level policy documents were examined published by New South Wales45, Victoria67 and Western Australia89. These policies provided guidance and frameworks for local governments and practitioners about the provision of open space networks. In summary, consistent themes included:

- A shift away from providing a specific quantum of land for open space, in the face of declining land supply and increasing density.
- Indication that quantitative provision may work against opportunity for multiple use and innovative solutions.
- Recommendations and policy that aims to provide an appropriate amount of open space to cater for a range of community uses.
- Policy that facilitates delivery of a network of open space types (pocket, neighbourhood, community, district, municipal and regional parks) that provide for a range of uses, functions and differing levels of amenity. The open space network should provide a diverse range of spaces that vary in size and function and responds to community needs.
- Consider accessibility based on quality of footpaths and presence of barriers in addition to distribution of parks spatially.
- In some cases, advocating for co-locating schools with public open space, enabling joint use and shared maintenance.

Policies reviewed do provide guidance on other quantitative elements of open space, such as accessibility catchments and park size, as identified below at Table 9-3.

Table 9-3 State Policy Quantitative Characteristics

State	Accessibility Catchment	Park Size
Western Australia	Small Open Space: 300m Local Open Space: 400m Neighbourhood Open Space: 800m District Open Space: 2km Regional Open Space: one or more geographical/social regions.	Small Open Space: <0.4ha Local Open Space: 0.4-1ha Neighbourhood Open Space: 1-5ha District Open Space: 5ha-15+ha Regional Open Space: 20ha +

[4] *Open Space for Recreation Guide*: Government Architect NSW. Draft for Discussion.2018

[5] *Greener Places,* Government Architect NSW. Draft for Discussion

[6] *Metropolitan Open Space Network Portal*, Victorian Planning Authority

[7] *Creating liveable open space-case studies,* July 2013, Dept of Transport, Planning, and Local Infrastructure

[8] *Liveable Neighbourhoods,* Draft 2015, Department of Planning WA Planning Commission

[9] *Classification Framework for public open space*, 2012, Department of Sport and Recreation

State	Accessibility Catchment	Park Size
	Likely to attract users from outside any one LGA	
New South Wales	Distance from dwellings: Local open space (high density area): 200m; Local open space: 400m; District open space: 2km Regional open space: 5-10km	Local open space (high density area): as small as 0.15ha, where no more efficient provision available, or opportunities for re use of small spaces arises. Local open space: 0.3ha min; District open space: 2-5ha Regional open space: >5ha
Victoria	Local network Pocket: 200m-400m Neighbourhood: 400m Community: 800m District:1200m Regional network Municipal: 0-5km Metropolitan: Up to 15km	Local network Pocket: <0.2ha Neighbourhood: 0.2-1ha Community: 1-5ha District:5-15ha Regional network Municipal:15-50ha Metropolitan:>50ha

This review identifies that across various policy documents, park sizes vary within a range that is generally comparable for different park types, and with which the park sizes used in Guideline 12 are broadly consistent. An emphasis on the importance of open space provision that is tailored to the specific community is relevant and validates the consultative process undertaken to develop the benchmarks proposed.

9.5 Consolidation of Existing Information

The research process included consideration of park and open space locations previously allocated in the draft ICOP, as well as locations identified in context plans and Infrastructure Master Plans in development approvals. This review process allowed an identification of park and open space locations that should be considered already allocated by developers and EDQ development assessment team, when developing DCOP network maps.

Although a review of park types, quantities and sizes in IMPs was undertaken, this was not based on a formal database of approvals, such as a formal GIS, and the assessment may have had some margin of error.

It is also noted that while existing parks and open space may exist near the Priority Development Area, these have not been considered as able to service the demand for parks and open space imposed by development within the Priority Development Area.

9.6 Review and Comparison of Adopted Demographics

Initial investigation, prior to engagement with stakeholders involved preliminary comparison of current infrastructure to be provided under the ICOP with that required by the projected population for 2066, as determined by the SGS Demographic analysis.

Table 9-4 below summarises this comparison. It should be noted that EDQ Guideline 12 was used to make these comparisons. The process of recommending park quantities, areas and locations was the result of a PDA specific benchmarking process identifying specific options for this PDA.

Table 9-4 Demographic projection requirements10

Park type	ICOP		Projected requirement	
	Land area (ha)	Qty	Land area (ha)	Qty
District recreation	110	11	72-145	9.6 -14.5
District sport	103	8	109-174	7-15
Major sport park	110	4	73-145	6
Major Recreation Park (Regional Park and garden)	105	5	72.5-145	7
Major linear	94	5	72-159	-
Local linear	74	29	29-116	-

This initial measure indicated that:

- For the projected 145,000 people living in the Greater Flagstone PDA, the existing ICOP may have undersupplied marginally in quantity of sport and recreational parks
- District sport parks had been undersupplied in area
- Linear parks accounted for approximately 28% of total open space under the ICOP, however exceeded the minimum requirement sought by Guideline 12.

9.7 Stakeholder Engagement

A key requirement of the DCOP process was collaborative engagement between EDQ and other key stakeholders. For Parks and Open Space network, key stakeholders included Logan City Council and development industry participants. The purpose of this engagement was to consider the needs of other parties involved in delivery of the network. In addition to ad-hoc discussions, two key workshops between EDQ and Logan City Council were undertaken as outlined below

[10] These are requirements projected to be required based on the SGS demographic analysis. Recommendations proposed for the DCOP were derived from these projections, as well as by forming a considered view based on discussions with stakeholders and emerging policy.

- Workshop 1, 30 January 2020: A workshop to introduce findings of initial investigation of projected demand for parks and open space and comparison with the network previously anticipated.
- Workshop 2, 12 March 2020: A workshop to present recommended network changes, based on feedback from participants of Workshop 1. Feedback received included:
  - Park embellishments can play a role in significant cost burden to Council, including through expensive maintenance. Additionally, they can contribute to considerable charges credits to developers. Feedback sought the consideration of limits to embellishment to minimise risk of such costs,
  - Agreement that sports park provision should be increased,
  - Highlighting that demand for open space in the PDA should be met within the PDA,
  - Co-location of parks and community facilities, such as schools could be considered, with caution. DSS for each type of infrastructure would need to be met, and recreation parks may be more suitable than sports parks,
  - The minimum size of Neighbourhood Recreation parks should be considered for revision, from 0.5ha to 1ha. This may provide for improved efficiency and value,
  - Local recreation parks were encouraged not to be eligible for credits. This was noted, and the current ICOP does exclude these from being creditable, and
  - Linear parks were noted as being a product of topography and constraints, and therefore reconsideration of how they are assessed and credited was suggested. A rate of provision may be inappropriate, and reconsideration of how they are credited is required, to avoid potentially substantial credits for land that may not otherwise be developable.

Ongoing engagement on the outcomes of the analysis has occurred to ensure the DCOP provisions as presented in this IPBR report are consistent with the intent of the PDA and aligned with stakeholder requirements.

9.8 Innovation by Design

Innovation by design as previous defined includes approaches using proven, currently available technologies and/or construction methods to achieve innovative outcomes. These innovations currently exist within the Australian context of urban development and can be readily implemented within the Greater Flagstone PDA.

Design Innovations enable new development and infrastructure in each PDA to showcase already tested innovations that are progressing to business as usual in other locations. These innovations require the development industry’s desire to showcase leading design innovations as part of new urban development. Refer to Section 9.13 for innovation case studies.

9.8.1 General Observations

Engagement with stakeholders indicated an aspiration for innovation in design across all park types and noted that the co-location, or close proximity, of parks and community facilities is acceptable when agreements regarding the management of facilities is reached. It is also noted that:

- Sharing of public open space and school facilities was identified as an emerging trend in policy,
- Stakeholders' desire to ensure that if public open space and community facilities were to share space, that appropriate facilities and area for both users is accommodated is compatible with emerging trends to provide open space in qualitative rather than quantitative ways. By carefully considering how close proximity to co-location benefits each interest, and imposes some limitations, it is necessary to take a qualitative and tailored approach, and
- Close proximity and/or co-location can inherently leverage active travel infrastructure and quality of transport routes.

9.8.2 Innovation Case Studies

The below provides a list of Design Innovations that currently exist within Australian urban communities. These innovations provide examples of locations that have implemented these innovations in place of BAU infrastructure and provide developers, landowners and local governments with on the ground outcomes that they can duplicate in the local context of Greater Flagstone.

Developers are encouraged to implement one or more of the Design Innovations in consultation with EDQ and local government and help progress these innovations to business as usual.

9.8.3 Urban Water Infrastructure

'Water Squares' such as the one in Benthamian, Rotterdam, have established a new benchmark for innovation in open space design. During heavy rainfall events these squares fill up in a controlled manner, acting as water storage by collecting runoff, and preventing flooding in surrounding streets. Water then drains away into surrounding permeable surfaces or the nearby river, while during dry periods they act as a multi-purpose recreational space. The success of Rotterdam's Water Square is largely the result of the high degree of public consultation during the design phase. The outcome resulting in an attractive and innovative solution for water in a built-up urban environment.

Image sourced: Publicspace.org

Figure 9-1 Example of urban water infrastructure

Other examples of efficient water infrastructure are green roofs and multifunctional water storage carparks. They help to regulate and disperse the intensified water cycle process that is the product of highly urbanised environments. In Australia this process is referred to as, Total Water Cycle Management (TWCM) and is being implemented in areas such as Moreton Bay.

Key considerations

As the square transforms into a temporary water tank during rainfall events, appropriate safety barriers and structures need to be installed in the urban space. Information on the dual function and potential risks associated with the space during rainfall events also needs to be part of the interpretation of the space and its signage.

Implementation recommendations

High: TWCM comes in various forms from urban spaces, open spaces and streetscapes. Options for these solutions require significant engagement with local government as the ultimate owner and manager of the asset. State government subsidies, capital incentives and urban capacity limitations have proven effective in achieving adoption of water sensitive infrastructure.

Ownership and operation

As part of the public realm, they are owned and managed by local governments. The Benthamian Square was a government funded project, which is managed by the local council. Opportunities exist to incorporate TWCM within urban spaces and streetscape construction by developers, however this requires asset design beyond BAU and the acceptance of all parties.

Procurement complexity

High: Installation may form part of a TWCM solution for a location or site that is constructed by a developer. Operation and ongoing maintenance would remain with local government. Subject to local government policy position and budget allocation.

Further information

- Orion Lagoon, Springfield Central: https://www.brisbanekids.com.au/orion-lagoon-robelle-domain-parklands/
- Square, Rotterdam: https://www.publicspace.org/works/-/project/h034-water-square-in-benthemplein
- Green Roof Initiative, Rotterdam: https://www.resilientrotterdam.nl/en/initiatives/green-roof-harvests-1
- TWCM, Moreton Bay: https://www.moretonbay.qld.gov.au/files/assets/public/services/publications/planning-strategies/twcm-strategy.pdf

9.8.4 Co-location of Open Space

Co-located open space that integrates schools, community facilities and or infrastructure such as wetlands/flood storage provide dual use and maximise land assets. Through co-location, or proximity, frequency of park use is increased and a reduction in land consumption is achieved. Proximity and/or co-location of open space to community facilities and services, can increase the frequency of active transport and enhance the lifestyle of the local community.

Key considerations

This approach requires acceptable agreements between local government, state government and service authorities for the management of open space assets and a shift in policy to accept shared uses and at times encumbered land (e.g. land subject to inundation). Sharing of public open space and school facilities is an emerging trend in Queensland and PDA stakeholders are keen to ensure that if open space and community facilities co-locate appropriate area for each user is accommodated. Acknowledging the focus is on providing quality open space and user experience, rather than a quantity of land. Due to the proximity or overlapping of open space requirements, co-location benefits for each interest must be protected via a tailored approach.

Image sourced: Central Road Drysdale Developer Contributions

Figure 9-2 Landscape Masterplan

Implementation recommendations

High: Opportunities for co-location and shared use facilities should be implemented across all PDA as part of an integrated planning approach. The social, environmental and economic benefits to co-located open space and facilities is widely acknowledged as a sustainable approach to urban development and growth area planning and is used broadly in other Australian states.

Ownership and operation

Public open space, infrastructure and community facilities are owned by a combination of local and state governments and service authorities. Land and developer contributions are required to ensure the provision of adequate open space based on population projections. Ownership and ongoing operational costs will remain with government.

Procurement complexity

Low: Public open space is required to support a growing community within a PDA. Opportunities to co-locate open space and facilities including infrastructure, provide numerous community benefits. Land and financial contributions will be required from developers through the DCOP.

Further information

- Central Road Drysdale Draft Developer Contributions Plan, Drysdale, Victoria: https://www.geelongaustralia.com.au/common/public/documents/amendments/8d71f19e754e98

9.8.5 Adventure Playgrounds

These facilities increase the time children spend in unstructured play outdoors and in nature. It is founded on the understanding that unstructured play outdoors - nature play - is fundamental to a full and healthy childhood.

Through co-location, or proximity, frequency of park use is increased due to the ease of use and access to these facilities.

There is a strong awareness of the benefits of children's contact with nature and it is ever growing. These benefits include:

- Developing strong connections with nature.
- Engaging and enchanting children in outdoor play for longer periods of time.
- Improving overall wellbeing.
- Developing physical literacy.
- Keeping children physically and mentally active.
- Increasing resilience.
- Building risk assessment awareness.
- Growing social and emotional capacities.
- Enabling problem solving skills to develop.

Key considerations

Many organisations are embracing the idea of developing nature play spaces within their setting. This could be in a local park, school grounds, church grounds, early childhood centre or a kindergarten, sports club or community centre.

Appropriate planning helps create cohesive and connected communities that support children's outdoor free play and independent mobility and contribute to the physical and psychological health of neighbourhoods. Good design enables safe movement through and between areas and provides varied spaces to gather, walk and play in.

Implementation recommendations

High: Opportunities for creation of Adventure Playgrounds should be implemented across all PDA as part of an integrated planning approach for other communities' outdoor facilities. The social, and environmental benefits to implementing these facilities is widely acknowledged as a sustainable approach to urban development and growth area planning

Ownership and operation

Developer contributions can be collected in areas immediately surrounding facilities to contribute to capital costs, however nexus should be clearly defined given ability of activity to draw users from a district/Sub-Regional community. Ownership remains with local government along with ongoing operational costs.

Procurement complexity

Low: Installation may form part of a district or Sub-Regional level park within a PDA subject to local government catchment requirements for recreational facilities. Construction and installation may be required by a developer or through the DCOP as part of district park facilities.

Further information

- https://www.natureplayqld.org.au/
- Example of successful implementation and development: https://www.natureplayqld.org.au/places/underwood-park

9.8.6 Smart Sports Precincts

These facilities optimise ease of use and interaction of users, ensuring that community engagement and use is increased over typical sports fields. Through co-location, or proximity, frequency of other communities' facilities use is increased

Components that differentiate Smart Sports Fields to typical Sports Fields are LED lighting combined with booking and locking systems:

- LED Lighting - Carseldine Village has installed leading edge LED lighting technologies in its parks, public areas, roads, sports fields and courts, including 14 light towers. The choice of highly efficient LED lighting will provide the local sporting clubs with substantially lower electricity costs, better lighting, and longer life luminaires.
- Smart remote lighting control - Carseldine Village has integrated eSwitch technology into The Green. eSwitch, developed by an entrepreneurial start-up business in Southeast Queensland and is quickly becoming a market leader in remote sports lighting control systems, enabling sports clubs and associations to securely, safely and sustainably control their sports field lights via their smart phones.

- Integrated booking, lighting and smart remote locks - The Green also uses the BrightSport booking app, developed by eSwitch in partnership with the Queensland Government. This system benefits the sporting clubs, facility managers and users by making the facilities more accessible, convenient to book and enables better utilization and asset management. EDQ facilitated end-to-end digital hiring system that's revolutionary. Combining smart locks, which uses Bluetooth technology, allows people to make end to end bookings through the BrightSport App. This means a user can Book, Pay and Play.

Key considerations

Many organisations are embracing the idea implementing smart technologies into sporting fields. It should also be considered that the expansion of these technologies to other services and the co-location of other community facilities within the surrounding precinct, this could be in a local park, school grounds, church grounds, early childhood centre or a kindergarten, sports club or community centre.

Appropriate planning helps create cohesive and connected communities that support children's outdoor free play and independent mobility and contribute to the physical and psychological health of neighbourhoods. Good design enables safe movement through and between areas and provides varied spaces to gather, walk and play in.

Implementation recommendations

High: Opportunities for creation of Smart Sports Precincts should be implemented across all PDA as part of an integrated planning approach into other community outdoor facilities. The social, environmental and health benefits to implementing these facilities is widely acknowledged as a sustainable approach to urban development and growth area planning

Ownership and operation

Developer contributions can be collected in areas immediately surrounding facilities to contribute to capital costs, however nexus should be clearly defined given ability of activity to draw users from a district/Sub-Regional community. Ownership remains with local government along with ongoing operational costs.

Procurement complexity

Medium: Installation may form part of a district or Sub-Regional level sport fields within a PDA subject to local government catchment requirements for recreational facilities. Construction and installation may be required by a developer or through the DCOP as part of district park facilities.

Further information

- EDQ has recently delivered the following at Carseldine Village 'The Green Sports precinct' https://www.carseldinevillage.com.au/village-information/the-green/

9.9 Sequencing Strategy (Interim and Ultimate)

Indicative sequencing of open space has been determined having regard to:

- Population projections and the timing of when population benchmarks are likely to be reached
- A balanced delivery of park typologies and uses in line with the DSS

- This ratio of delivery is often organically achieved and controlled through the context planning approval process and the construction delivery phasing determined through conditional development approvals
- The projected areas of population density and establishing what catchments within the open space network will be most utilised
- The surrounding road network, acknowledging that access to the site will need to be provided before parks can be operational
- Areas with topography restrictions and access constraints may trigger earlier, indirect park location sequencing.

9.10 Sequencing and Geographical Analysis

Open space provisions have been forecasted for each timeline horizon, based on the forecasted population requirements. This is intended to ensure the park infrastructure is always delivered to meet the current population requirements, as a minimum.

Parks and open space are types of infrastructure that generally reflect development of land, and therefore demand, in close sequence. Applicants provide Open Space Master Plans, with agreed rates of park provision for their development, and after that, Plans of Development that reflect these.

When acting upon approvals, the design and embellishment of a park is agreed by compliance assessment, and delivery is typically required to occur as lots are developed so that open space is provided to meet expected demand. In this way, locations and numbers of parks are confirmed by approvals, and design is confirmed post-approval. This particularly works in large self-contained developments.

Under more fragmented ownership, additional coordination by assessment managers will be required to ensure conditions of approval requiring delivery of trunk parks considers demand. Co-ordination is also required to ensure that open space supply occurring in other developments is also considered to ensure the overall open space infrastructure is delivered in compliance with the timeline horizon requirements, for the Greater Flagstone PDA.

9.11 Network Analysis and Changes

As a result of all the background research, stakeholder engagements, benchmarking and testing, able 35 provides the adopted network for parks and open space, specific to the Greater Flagstone PDA. Figure 9-3 provides mapping of adopted parks and open space.

Table 9-5 Adopted Parks under DCOP

Park type	DCOP		Difference compared to ICOP11	
	Qty	Area (ha)	Qty	Area (ha)
District/major recreation parks s				
District recreation	11	56	No change	-54
City park/town square	7	2	-1	N/A
Regional recreation	5	50	No change	-55
Sub total	***23***	***108***	***-1***	***-109***
Sport parks				
District sport park	9	91	+1	-34
Regional sport park	4	60	No change	-50
Sub-total	13	151	+1	-114
Major linear park	5	73	N/A	N/A
Sub-total	***5***	***73***	***N/A***	***N/A***
Local parks				
Neighbourhood recreation park	143	103	N/A	N/A
Local linear park	N/A	0-73	N/A	N/A
Sub-total	***N/A***	***176***		
TOTAL	**N/A**	**514.5**	**-4**	**-127.5**

9.11.1 Policy Changes

Key departures from EDQ Guideline 12 DSS include:

- Consideration of accessibility rather than a population as a driver for park quantities
- Accessibility of each park type was mapped across the PDA to derive numbers of park, considering benchmarking against other Local Government Areas and emerging policy

Park size was derived by considering the parks and areas anticipated in endorsed IMPs as well as considering benchmarking against other Local Government Areas and emerging policy.

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[11] Difference highlights the proposed change relative to the draft ICOP. For example, 1 additional regional recreation park is proposed under the DCOP.

9.11.2 Design Changes

The following principles would contribute to high quality and holistic open space outcomes for the PDA. Elements could be implemented regardless of the ultimate quantities and areas achievable in practice.

- Build a greater network connection of open space. Consideration of how parks fit within a greater network will increase pedestrian and environmental movements and increase efficiencies in maintenance and asset protection. This should also include Nature Play Spaces within the network of parks. Consider proximity of parks with schools. The efficiencies of children being able to visit parks during and outside of school hours, whether for sport or recreation reduces travel time, risks to children on streets and promotes a healthy, active lifestyle. The nearby association between schools and parks can contribute to passive surveillance and safety,
- Utilise park spaces for natural permeation. Parks and landscape are the biggest asset our urban environment has for controlling water scouring waterways, by absorption of water flows. This also provide passive irrigation of parks,
- Limiting embellishments for creditable parks. Codifying limits would ensure EDQ and Council are receiving a fair value of open space amenities and facilities for the credit amounts and minimising the maintenance burden. Codification should seek that quantity and quality of park embellishments should be commensurate with the overall size of the park, and
- Parks to follow natural features in the landscape. Identifying natural creek lines, valleys, ridges or conservation areas that may accommodate recreational parks adjacent could increase the greater value of the park space and of habitat and environment. Reduced fragmentation may benefit maintenance costs.

9.12 Adopted Parks and Open Space Network

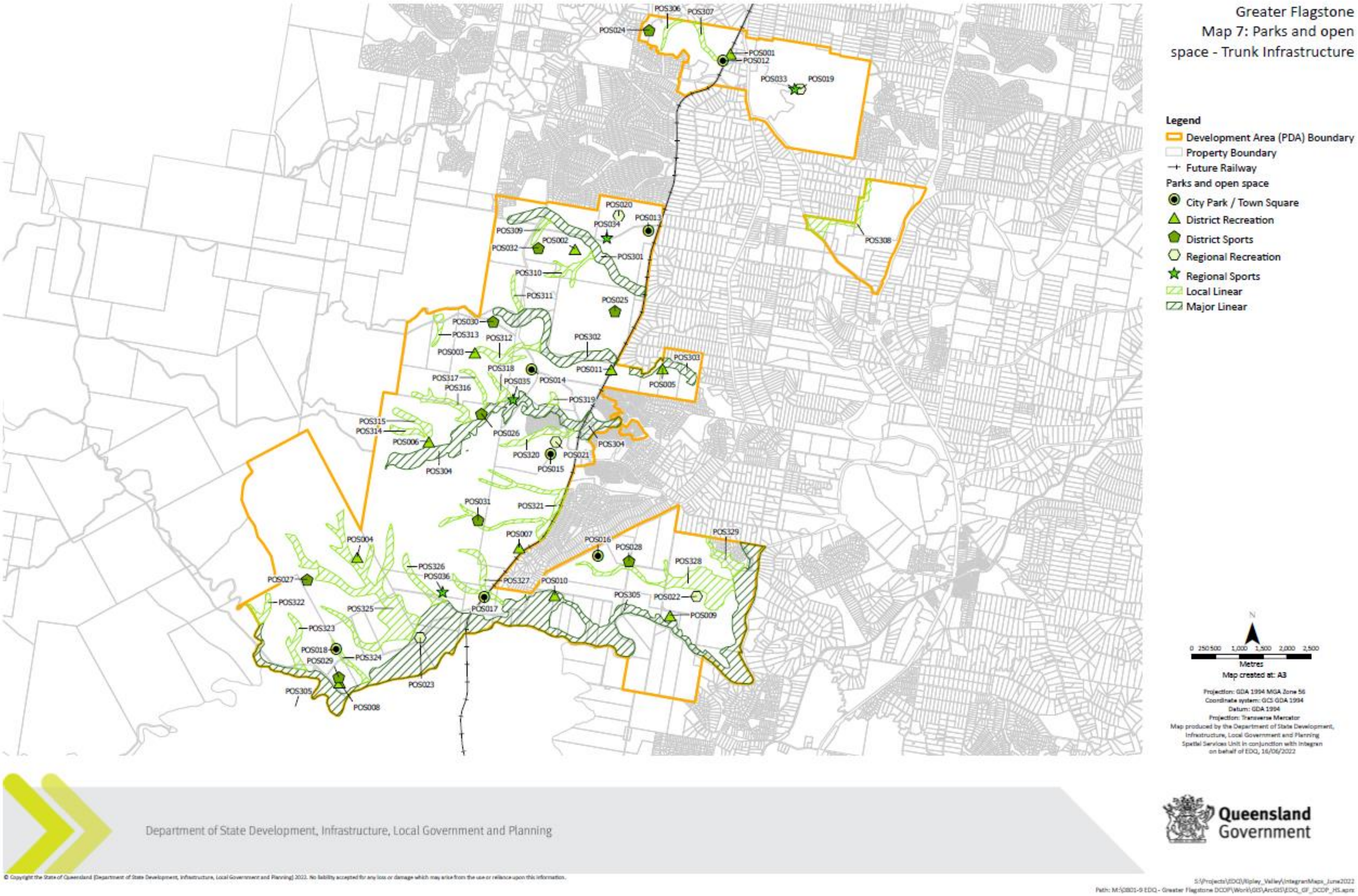


Figure 9-3 Greater Flagstone PDA Adopted Parks and Open Space Network

9.13 Opinion of Cost

Rider Levett Bucknall (RLB) were engaged to develop an opinion of the cost of parks and open space infrastructure to service the Greater Flagstone PDA. The quantities of parks and open space infrastructure were derived from the updated network plan developed as part of this study. Municipal costs for Greater Flagstone PDA were then extracted from the RLB estimates and inserted into the Financial Offset Model per planning horizon, the summaries of which can be found within the Schedule of Works containing within the body of this Infrastructure Planning Background Report (IPBR).

10 Community Facilities

10.1 Introduction

A key basis for the development of the Development Charges and Offset Plan (DCOP) was a demographic study outlined in Chapter 1. The study found:

- Greater Flagstone would be fully developed by 2066, with 54,000 dwellings and 145,000 people.
- This was in increase in population from the 120,000 people and 50,000 anticipated in the Greater Flagstone Urban Development Area Development Scheme.

This chapter outlines the research and consultation undertaken to review the Infrastructure Charges and Offset Plan (ICOP, June 2020) Greater Flagstone Priority Development Area (PDA) (hereafter referred to as the ICOP) with respect to State Community Facilities and compares that with the anticipated demands imposed by the new future population projections described above. This process involved:

- Consideration of the demand imposed by revised population projections, estimated using the Desired Standards of Service (DSS) in Economic Development Queensland's (EDQ) Community Facilities PDA Guideline No. 11 (referred to hereafter as Guideline 11)
- Consideration of stakeholder needs, including feedback from state and local government as well as the development industry
- Consideration of emerging policy trends for community facilities.

This chapter provides:

- A review of the amended population growth figures against Guideline 11 to identify impacts on the delivery of Community Facilities in the PDA
- Preliminary review of Guideline 11 standards through a comparative benchmarking assessment to identify which standards remain valid and which may warrant updating in the new DCOP
- Consideration of workshop and consultation feedback on current shortcomings and areas for improvement for this network
- Development of recommendations, following this PDA specific assessment, with respect to Guideline 11 benchmarks that remain valid and those that may benefit from updating
- Provision of advice on a revised Community Facilities network, including sequence, innovation and cost
- Consideration of emerging policy trends.

10.2 Reference Standards

Initially, the proposed facilities within the ICOP were reviewed against the DSS outlined within section 8.9.2. The first review utilised the original population projection which was defined within the Greater Flagstone Urban Development Area Development Scheme the (Development Scheme) dated October 2011.

This review outlined there is a deficit in many of the State Community Facilities required for the projected population as defined in the Development Scheme. As Table 10-1 shows there is a deficit of fire and emergency services of approximately 4 facilities across the PDA. There is also a significant requirement to increase the number of proposed schools (primary and high schools) by approximately 14 additional facilities.

Table 10-1 Projected Delta Between Existing and Required Facilities

State Community Facilities	QTY
District Police Station	- 3.8
Fire Services	- 3.8
Ambulance Station	- 3.8
Health Centre	- 3.8
Health Precinct	+ 0.4
State High School	- 4.25
State Primary School	- 8.67
TOTAL	**- 27.72**

This deficit was presented to required agencies through the workshopping exercise to ascertain if these numbers are reflective of the requirements for each of the service operators within the PDA and provided further context of the quantum of facilities required to service the PDA. The result of these workshops is provided in the subsequent sections.

10.3 Desired Standards of Service

Rates of provision for community facilities within the ICOP were reviewed for both for State and Local Government facilities. The Desired Standards of Service (DSS) in EDQ's Community Facilities PDA Guideline No. 11 (Guideline 11) and Logan City Council's DSS within the Local Government Infrastructure Plan (LGIP) were used as references for benchmarking facility requirements for the projected population of the PDA. Both guidelines were utilised as each provided rates of provision for different types of facilities i.e. Emergency services (State) and Community Centre (Local Facility).

Community facilities differ from the provision of parks and open space due to the split between State provided facilities and Local Government facilities. DSS for both State and Local Government (Logan City Council) is outlined in Table 10-2 and Table 10-3 below. The main differences between State and Local facilities are that State facilities provide for larger community facilities which serve a large population on a large site. Local facilities are finer grain facilities which have a range of hierarchy from Local (lower order) to Metro (higher order).

Table 10-2 EDQ DSS – Guideline 11 for State Facilities

Facilities	Hierarchy of Provision	No. of Facilities (pop. Triggers)	Indicative site/ facility area
Ambulance	District – depends on a range of factors including current and projected population, planned future development, hazard and risk assessment, road network, incident profile for area.	1:25,000 Consider response time profile, case load per day, proximity to existing ambulance stations and health services.	Site: 3,000m2
Fire & Rescue	Depends on response time and incident history, proximity to existing facilities and population forecasts.	Over 25,000 people	Site: 3,000-4,000m2 (auxiliary station) 3,000-6,000m2 (permanent station) 10,000-20,000sqm (permanent with specialist facilities)
Health Care Centre	Community Health Centre	1:20,000 – 30,000	GFA: 2,000 – 4,000m2 Site: up to 1.6ha
	Community Care Hub	1:30,000 – 100,000	GFA: 4,000 – 8,000m2 Site: 1.6 – 3.2ha
	Community Care Precinct	1:100,000 – 300,000	GFA: 8,000 – 10,000m2 Site: 3.2 – 4ha (including parking)
Hospital – Public	Based on local planning and need analysis	Likely to serve a catchment of over 100,000 people	10-15ha depending on level of service
Police	Main road location preferred by ingress and egress must offer left & right turns Security important Best location in town centre/shopping centre	1:20,000 – 30,000	Police Station Site: 4,000-5,000m2 GFA varies according to local needs – shopfronts, rented space, stations

Facilities	Hierarchy of Provision	No. of Facilities (pop. Triggers)	Indicative site/ facility area
Primary School - State		1:3,000 dwellings	6.5ha -7ha GFA: 5,500m2 for 625 p-7 students[12]
Secondary School - State		1:8,000 dwellings	12ha GFA: 16,870m2 for 1,500 students

Source: Community Facilities PDA Guideline No. 11, EDQ

Table 10-3 Logan City Council DSS for Local Facilities

Community Infrastructure Type	Hierarchy	Rate of Provision (Facility: Population)	Accessibility	Minimum Land Area / GFA
Community / Civic Facilities				
General Community Space (provided in greenfield areas only)	Local	1:10,000	2km	1,000m2 / 400m2
Community Centre	District	1:50,000	5km	3,000m2 / 900m2
Convention/Exhibition Centre	Metro	1:250,000 (1 city-wide)	LGA (15km)	40,000m2 / 15,000m2
Arts and Cultural Facilities				
Library	District	1:40,000	5km	3,000m2 / 1,500m2
	Metro	1:100,000	LGA (15km)	7,500m2 / 4,000m2
Art Gallery or Dedicated Art Space	District	1:50,000	5km	2,000m2 / 600m2
	Metro	1:250,000	LGA (15km)	4,000m2 / 1,200m2
Performing arts facility or space	District	1:50,000	5-7km	3,000m2 / 1,000m2

[12] Department of Education advice

Community Infrastructure Type	Hierarchy	Rate of Provision (Facility: Population)	Accessibility	Minimum Land Area / GFA
	Metro	1:250,000 (1 city wide)	LGA (15km)	40,000m2 / 15,000m2
Sport and Recreation Facilities				
Indoor Sports Facility	District	1:50,000	5km	10,000m2 / 5,000m2
	Major District	1:150,000	15km	15,000m2 / 7,500m2
Aquatic Centre	District	1:50,000	5km	10,000m2 land
	Major District	1:150,000	15km	15,000m2 land
Leisure Centre (combined indoor sports facility and aquatic centre)	District	1:50,000	5km	15,000m2 land
	Major District	1:150,000	15km	25,000m2 land

Source: Logan City Council, LGIP Community Facilities

10.4 Consolidation of Existing Information

Facilities proposed within the ICOP and contained within Logan Community Infrastructure Strategy were then reviewed against any existing or approved context maps. Discrepancies have been outlined and displayed in the diagram contained in Section 9.14. Local Government community facilities are displayed within this diagram to provide greater context of the service delivery of facilities within the PDA.

10.5 Other Observations

10.5.1 Rates of Provision

- Rates of provision of lesser importance for types of community facility types (i.e. provision is based on more qualitative measures and/ or response timeframes for ambulance, police and fire and rescue).
- Lesser rate of provision being applied for health, ambulance, fire and police in Greater Flagstone. In some cases, this is due to existing facilities located outside of the PDA but servicing the PDA population.

10.5.2 Site Location Criteria

- Updates required to site location criteria in some cases. For example, DoE's 'Site Selection Minimum Criteria' policy document (now endorsed) should be reviewed to determine potential updates required to EDQ DSS.13.
- Once site location criteria are further developed, it should be used in initial site selection processes (e.g. whole of PDA sieving mapping exercise using GIS analysis) to determine land suitability for certain community facility types. This could be done prior to development of an ICOP (i.e. for new PDAs).

10.5.3 Site Standards

- Minimum site area requirements may not reflect contemporary models of delivery, or the classification of facilities used by relevant agency. The classification of health facilities used by EDQ and QH currently do not align.
- Further guidance from agencies would be beneficial around when a reduced site allocation and colocation opportunities may be considered. There is a concern that acceptance of lesser site areas can establish a precedent that other developers will seek to follow.

10.5.4 Timing of Provision

- Timing of provision is important to ensure facilities are provided in line with population growth.
- The experience of QAS, as expressed by QAS at the State Agency workshops, is that it has been difficult to secure sites that can be delivered within the required timeframe. Consequently, QAS has needed to purchase its own sites to service Greater Flagstone PDA and not utilise the ICOP allocated site.

10.6 Stakeholder Engagement

Several workshops were held to ensure key agencies and Logan City Council were able to provide feedback to the ICOP, the updated demographics and any shortfalls or oversupply for each facility type.

The phases of engagement are outlined as follow:

- **Review Phase –** Within this phase, an overview was provided of the DSS based on Guideline 11 for State facilities and the Local Government Infrastructure Strategy for local facilities (which has been provided in the previous sections of this report). This initial review phase involved several meetings with EDQ and CHaPs representatives leading up to a workshop held on 30 January 2020 with State Agency representatives. During this phase of work, each department was given the opportunity to comment on the original ICOP allocations and the analysis undertaken to compare these allocations with Guideline 11 DSS rate of provision for state facilities.

[13] DoE (2020) *New School Site Selection Minimum Standards*, Queensland Government.

- **Analysis Phase –** Once each respective agency was given the chance to comment on the review of the DSS rate of provision, mapping was produced displaying the facilities outlined in the ICOP compared against any approvals that included allocations for State facilities. Further a review was undertaken of the adopted DCOP demographic data and the DSS applied to the updated population projections. These figures are outlined in Section 10.8 above. Additional meetings were held separately with Community Hubs and Partnerships (CHaPs), EDQ and various State Agencies as required over February to further understand their requirements. The feedback obtained from this round of engagement is outlined in Table 10-4 below.
- **Preliminary Recommendations -** After feedback was obtained, recommendations were proposed and then subsequently reviewed by each department at a 2-hour workshop held on 24 March 2020.

Table 10-4 Feedback by Each Agency

	Queensland Health (Metro South Health) • 2020-Private health only • 2023- Shared Social Services centre (co-location desirable, 2-4ha site maximum but depends on if co-located) • 2030- Community Health Centre (like Gundu Pa / North Lakes but with additional day procedure spaces and related private and NGO services; 4ha site) • 2036 and beyond-Hospital (2036-200 beds, 2066-400 beds; possible co-location with QAS; site area requirements TBC). • Queensland Health (Children's Health Queensland) – possible partnership opportunities to deliver children's health services from 2020

	Emergency Services & Ambulance
	• QAS have recently purchased land at 1973 Chambers Flat Road, Munruben to provide service for the Greater Flagstone region as allocated site did not meet requirements.
	• Ultimate resourcing – the allocated 6,000m2 site will fall short to accommodate the service requirements; a larger site or 2 separate sites should be considered. It is preferred to have the PDA serviced from a single location and large enough to accommodate the ultimate resourcing. The preferred location is the suburb of Flagstone.
	• The below options have been derived:
	  o Single location (stage 1 would be required by 2026-27):
	    ▪ The location described as STATE-AM001 (along New Beith Road) on the publicly notified ICOP is suitable. This is QAS's most preferred.

	▪ Developer's preference is for an alternative location around the east-west Homestead Drive. This site is also suitable from QAS's perspective (but not most preferred) o Two locations (stage 1 of second station would be required by 2031-32): ▪ Where a single location is not feasible – an initial station can be located at the northern part of the PDA and a second to the Southeast (mid distance between Flagstone and the existing Jimboomba station). Where two stations would be required – second station to the south-east should be delivered in 2031-32 FY.
	Fire Services • 2 x stations required for Flagstone (2 x street frontages, minimum 40m, 6,000m2 for each site) • Timing of land release for PDA site depends on funding, not in capital program in short-medium term. May be brought forward, pending analysis of service area. • QFES open to shared sites.
	Police • 1 x district police station (2 x street frontages, minimum 40m, 1ha site area) • 2 x smaller stations (3,000m2 site area each) • Further planning needed to determine need for stations outside the PDA, timing of land release within PDA, as social factors still developing. • QPS open to shared sites with other appropriate services.
	Education - Department of Education (DoE) • Primary Schools o Current allocated School sites to be delivered by 2031 - 8 o Additional school sites required by 2041– 5 o Future school sites required by 2066– 3 • Secondary Schools o Current allocated school sites to be delivered by 2031- 8 o Additional school sites required by 2041 – 3 o Future school sites required by 2066 – 1.
	Neighbourhood Centres - Department of Communities, Disability Services and Seniors (DCDSS) • Short term (2024/25) 1x neighbourhood centres (site area of 2,500m2) • Long term (25 years) 1x neighbourhood centres (site area of 2,500m2).

	Local Government – Logan City Council (LCC)
	Local Government – Logan City Council (LCC) • Council requested that the facilities identified in LCC's Community Infrastructure Strategy be reflected in the DCOP. • Council is open to discussing opportunities for co-locating Council provided community centres with neighbourhood centres provided by the DCDSS. • Council requested that the Greenbank State School be identified on the mapping as it is the current catchment schools for part of the Greater Flagstone PDA.

Source: Stakeholder Workshop 2019-20

10.7 Innovation by Design

Innovation by design, includes approaches using proven, currently available technologies and/or construction methods to achieve innovative outcomes. These innovations currently exist within the Australian context of urban development and can be readily implemented within the Greater Flagstone PDA.

Design innovations enable new development and infrastructure in each PDA to showcase already tested innovations that are progressing to business as usual in other locations. These innovations require the development industry's desire to showcase leading design innovations as part of new urban development.

10.7.1 Best practices

Research into best practices for Innovation by Design outcomes has outlined the following principles:

Fit for Purpose

- Type of service delivery and function are of critical importance
- Land location, size and other key attributes are to be considered early for land suitability

Land Efficiencies

- Land allocation is to be undertaken early acknowledging high demand and competition for sites
- Alternative designs and models of delivery should be considered including integrated facilities (discussed further at point 4) and vertical models for facilities such as schools and hospitals.

Timely Provision

- Provision of facilities to align with population growth and demand
- Undertake needs assessment planning early as to accommodate planning and development lead time.

Continuum of Integrated Service Delivery (see Figure 10-1 below)

- The integrated service delivery model recognises the benefits and efficiencies (from both the customer and the service delivery perspectives) to be gained from integrated rather than separated service delivery

- Integrated service delivery can range from a ‘co-location’ model through to an ‘integration’ model as depicted in Figure 10-1
- It involves:
  - Multiple service agencies providing coordinated support services
  - Services are delivered through shared facilities and community hubs (not stand-alone facilities).

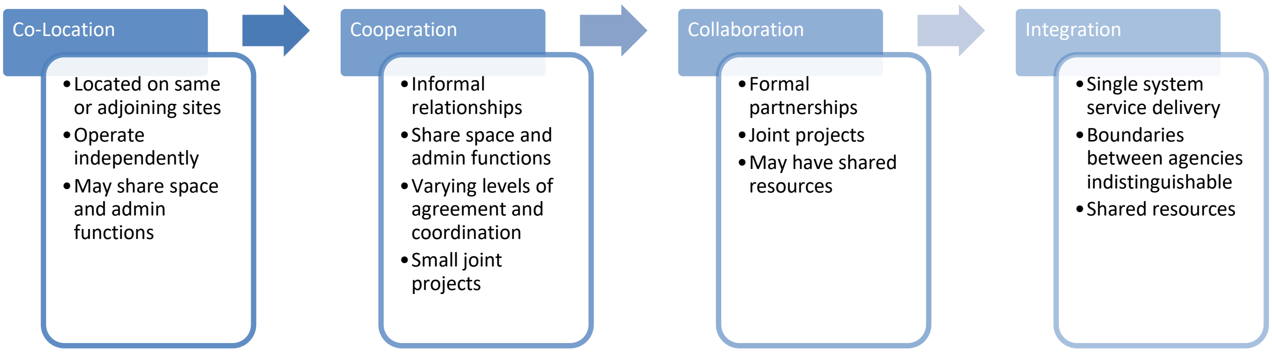


Figure 10-1 Integrated Service Delivery

Source: Urbis, 2020

10.7.2 Guiding Principles

Considerations relating to the built form of community facilities:

Co-Location – more than one facility on the same or adjoining sites

- State high schools and primary schools
- State schools with general community facilities (e.g. community centres)
- States schools with sporting fields and open space
- Health facilities and ambulance stations
- Ambulance with a range of other community facility types (not just health and emergency services)
- Police stations with fire and rescue stations
- Community facilities within retail precincts (Yarrabilba Hive example).

Shared Use – multiple agencies or groups using a single facility

- Community use of school facilities
- School use of community facilities (incl performance spaces, sporting grounds, parks)
- Shared car parking (e.g. schools and sporting fields).

Community Hubs – a collection of facilities clustered together on the same or adjoining sites as a focal point of programs or activities around a common focus or

- an arts and entertainment precinct or education and technology precinct Schools located near higher education and vocational education facilities would be an example of this.

10.7.3 Case Studies

The below provides a list of Design Innovations that currently exist within Australian urban communities. These innovations provide examples of locations that have implemented these innovations in place of BAU infrastructure and provide developers, landowners and local governments with on the ground outcomes that they can duplicate in the local context of Greater Flagstone.

Developers are encouraged to implement one or more of the Design Innovations in consultation with EDQ and local government and help progress these innovations to business as usual.

Co-locating of community facilities

Integrated community facilities play a critical role in supporting healthy communities, enhancing wellbeing, building networks and providing a resource for training, employment and personal development. Activities supported by shared facilities are wide ranging and can consist of more than one facility on the same or adjoining sites. These facilities can include neighbourhood houses, community centres, youth groups, public meeting spaces, performance spaces, emergency services, community health services, libraries, schools and recreational facilities. Services are delivered through Shared use (multiple agencies or groups using a single facility), Community hubs (a collection of facilities on the same or adjoining sites around a common focus of programs or activities, e.g. arts or education precincts) or Co-location on a single site to share external facilities such as carparking, access arrangements and infrastructure.

Image sourced: Cox Architecture

Figure 10-2 Victorian Cricket and Community Centre

Key considerations

The function and form of service delivery are of vital importance to co-location as land size and location are key attributes in the integrated planning process. Land allocation for government services such as schools, pre-school and Maternal and Child Health need to be undertaken early to ensure early access for a growing community, when site competition is paramount.

Alternative designs and delivery models should be considered that respond to population growth and demand. Needs assessment planning that incorporates surrounding facilities to a PDA must take place early to accommodate opportunities for co-location with existing and future facilities.

Governing shared community facilities and integrated services can be challenging often requiring different management strategies from those traditionally used. Successful management and coordination of these complex arrangements requires good governance, and clearly defined documentation, as multiple service agencies can provide coordinated support services when the governance system is appropriate.

Implementation recommendations

High: Opportunities for co-location and shared use facilities should be implemented across all PDA in association with current needs assessment for adjoining and adjacent suburbs. Easy access to shared and/or co-located facilities reduces land consumption, construction costs, asset management, resource allocation and vehicle trip generation. It encourages walkability, social networks, supports mental health and wellbeing and retail/commercial services, where facilities are grouped with neighbourhood or activity centres. Upgrades to existing facilities that may be adjoining a PDA also provides land and resource efficiency while connecting new and established communities and networks across suburbs.

Ownership and operation

Community hubs, libraries, recreational centres, health services, schools and emergency services are all provided and owned by a combination of local and state government authorities. Developer contributions can be collected to contribute to the provision of these services' capital costs based on population projections. However, nexus should be clearly defined given some large integrated facilities will provide services that draw users from a district or regional community. Ownership will remain with government along with ongoing operational costs.

Procurement complexity

Low: Community facilities are required to support a growing community within a PDA. Opportunities to co-locate or share facilities provide numerous land and construction cost savings, as well as significant community benefits in the form of social connections, community interactions and local employment. Financial contributions may be required by a developer through the DCOP. Approximate capital cost for Yarrabilba Hive was $3.6million.

Further information

- Yarrabilba Hive, Queensland: https://www.statedevelopment.qld.gov.au/projects/chaps/facilitating-projects
- Victorian Cricket and Community Centre, Melbourne: https://www.coxarchitecture.com.au/project/victorian-cricket-and-community-centre/

10.8 Review and Comparison of Adopted Demographics

To summarise, the previous sections have outlined a review of State and Local DSS with the population forecasted in the Development Scheme. This review outlined there is a deficit in the provision of State Facilities namely emergency services (ambulatory and police) and State Schools (primary and high schools).

Following on from this, a review of approved Context Maps and existing facilities was conducted to provide accuracy in the adopted mapping. This has been shown in Section 10.12. Local facilities are also displayed to show greater context of service delivery of community facilities within the PDA.

SGS Economics and Planning reviewed the demographics of Greater Flagstone PDA which included updated developer dwellings forecasts. Figure 10-3 illustrates the original population projection compared to the adopted DCOP demographic analysis.

	Development Scheme October, 2011	DCOP Demographic Analysis
	Greater Flagstone PDA Population 120,000	Greater Flagstone PDA Population 145,000
	Total Dwellings 50,000	Total Dwellings 54,000
	Average Person per Household 2.4	Average Person per Household 2.7

Figure 10-3 Comparison of Recent Population Projections with Original Assumptions

The adopted demographic figures were reviewed against EDQ Guideline 11 DSS and the impacts have been summarised in Figure 10-4 below. The analysis shows the increase in population projections results in an additional shortfall of facilities for the Greater Flagstone PDA. Primary and Secondary Schools are in further shortfall due to the increase of total number dwellings in the PDA. As noted earlier, a shortfall in some facility types existed under the ICOP, therefore, the shortfall indicated in Figure 10-4 below is not solely a result of the increase in population forecasts.

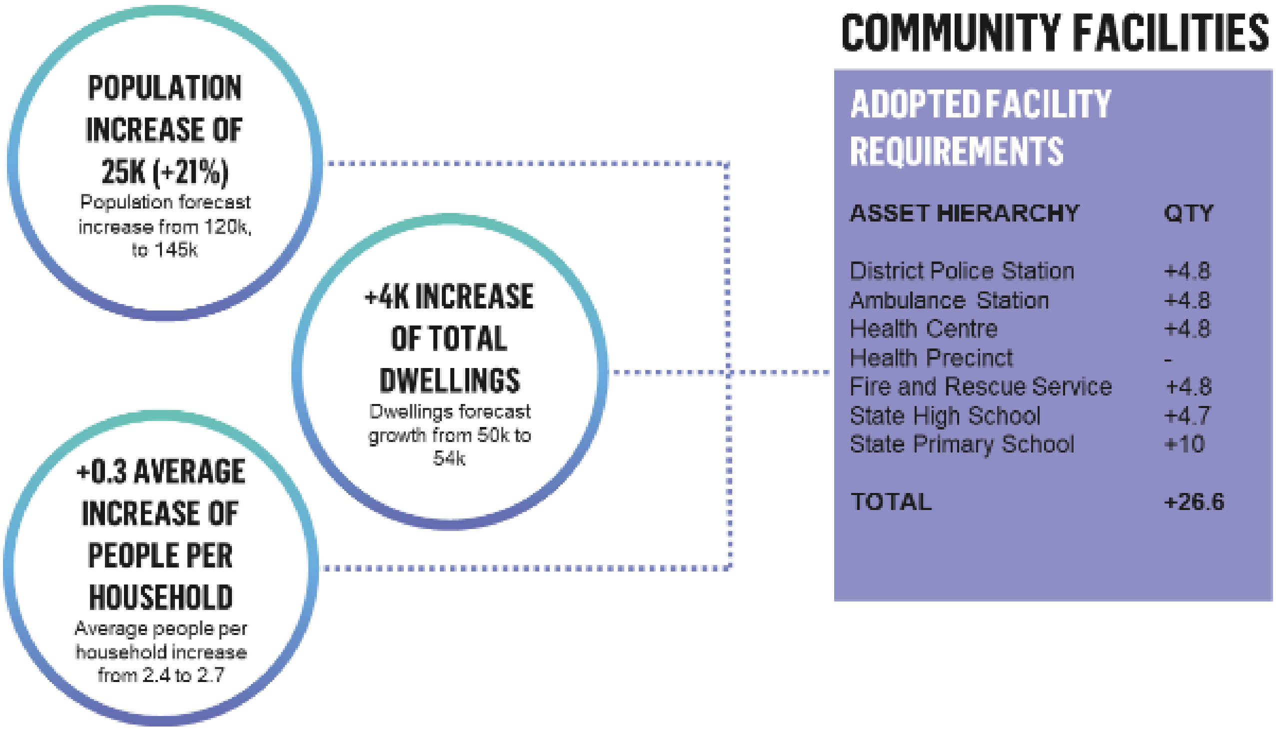


Figure 10-4 Adopted Greater Flagstone Demographic Analysis
Source: SGS, Jan 2020 & EDQ, May 2015

10.9 Sequencing Strategy (Interim and Ultimate)

Indicative sequencing for community facilities has been determined having to:

- Population projections and the timing for when population benchmarks are likely to be reached (NB: this is only relevant where the recommended provision is consistent with the DSS rate of provision)
- Feedback from State Agencies regarding when the need for a facility is likely to occur
- The surrounding road network, acknowledging that access to the site will need to be provided before a facility can commence operation.

In some instances, sequencing has not been assigned to community facilities. This has occurred where:

- The PDA planning horizon (2066) is substantially longer than the responsible State Agency's planning horizon, which in some instances does not extend beyond a 10-year timeframe, and as a result, the State Agency was unable to provide an indication of timing
- The relevant DSS rate of provision was not adopted for the community facility based on the State Agency advice.

Where the DSS rate of provision for a facility is not adopted for the PDA, the State Agency feedback is considered the most authoritative source of information in relation to infrastructure sequencing.

In instances where the State Agency indicated a sequencing that does not align to the sequencing years being used by EDQ (i.e. 2036, 2031, 2036, 2041 etc.), the sequencing has been brought forward to the nearest EDQ timeframe. For example, if the State Agency indicated a facility is required by 2038, for the purpose of the DCOP the sequencing is indicated as 2036. This approach was used to avoid lags in infrastructure provision if a later timeframe is adopted.

10.10 Sequencing and Geographical Analysis

Research and experience relating the delivery model of community facilities has outlined facilities usually come online as the population grows. Due to this model, population growth may arrive at a 'critical' point before the facility comes online, as such there is a lag in delivery and population.

As each agency reviews their own networks, population projections and service delivery may not match the delivery program of the state agency. Agencies are then required to negotiate separately with developers and acquire additional land to push forward service delivery. These sites which are provided to agencies can be unsuitable by size, typography or accessibility.

For facilities which have not been allocated, further investigations will be required as a part of the DCOP.

Schools are an exception to this timing; these are allocated based on the roll out of trunk infrastructure such as road networks. Additionally, workshops held with EDQ and stakeholders identified shortfalls in school provision independent of DSS and Guideline 12 requirements. Information on factors such as future catchments, population growth and topography were used to inform potential additional school locations for the DCOP. These are identified in in Section 10.12.

Identification of timing is primarily based on assumed road sequencing. It is acknowledged that in practice during the early phases of development a slower rate of population growth typically occurs which accelerates in the later life of a new community. Accordingly, school provision and timing can similarly align with this ramp up in line with future population. Such an approach represents a prudent balance and there may be future opportunities to accelerate delivery of schools over the longer term. The delivery of schools in the early years of the new communities should ultimately align with areas of greatest need, and service a wider area as population density across the PDA increases.

10.11 Network Analysis and Timeframes

Through the investigation of spatial data and feedback received from the key agencies, the adopted network has been consolidated in Table 10-5 below.

Table 10-5 Adopted Network

	Queensland Health (West Moreton Health) • 2023 – Consider opportunities with LCC for co-location with local community facilities. Currently assumed no land allocation is required. • 2030 – ICOP allocated health centre at HE001 (3.2ha). Consider opportunities with LCC for co-location with local community facilities. • 2036 – Expand ICOP allocation at HE002 OR AM001 to accommodate 400 bed hospital. Note that an ambulance station could also be accommodated within the hospital. Discussion about site area required.

	Emergency Services & Ambulance
	• 2020 - 1973 Chambers Flat Road, Munruben (this facility was purchased outside of the DCOP process)
	• 20206/27 – Options for considerations, which are yet to be resolved are: for investigation
	  o Expansion of ICOP allocated AM001 site to 1ha at New Beith Road
	  o New allocation of 1ha in size around east-west Homestead Drive
	  o Additional ambulance station could be co-located with hospital site (either at HE002 or AM001).

	Fire Services • Existing allocation (ID FR001) (0.6ha) • Additional station to service the south (given FR001 is in the north and location of Jimboomba Fire Station). Consider if co-location with AM001 is suitable / feasible (will be subject to site selected for hospital). This timing for when this facility will be required has not yet been determined.
	Police • ICOP allocation PO001 (0.6ha) potentially expanded to 1ha. The timing for when this facility will be required has not yet been determined. • Potential to co-locate with ICOP allocation for a fire and rescue station at FR001 if additional 3,000sqm can be accommodated. This timing for when this facility will be required has not yet been determined. • Potential for an additional smaller station to service the south. Location within a district centre (such as Flinders landholding) could be considered, subject to timing. This timing for when this facility will be required has not yet been determined.

	NB: There is a need to consider if the above requirements (as stated at point 2 and 3 above) could be accommodated through GFA rather than land allocation.
	Education - Department of Education (DoE) • 8 Primary schools and 1 high school to be delivered by 2031; • 5 Primary schools and 3 high schools to be delivered by 2041; • 5 Primary schools and 3 high schools to be delivered by 2066
	Neighbourhood Centres - Department of Communities, Disability Services and Seniors (DCDSS) • Potential to co-locate with LCC's community centre RS414 (Flagstone) as indicated in LCC's Community Infrastructure Strategy • Potential to co-locate with LCC's community centre RS515 (New Beith) as indicated in LCC's Community Infrastructure Strategy
	Local Government – Logan City Council • The community facilities as identified in the LCC Community Infrastructure Strategy (as opposed to the local facilities shown in the ICOP) are to be identified in the DCOP

Source: Stakeholder Workshop 2019/20, Urbis 2020

Table 10-6 Community Facilities Sequencing

Year	Facility	Agency
	New ambulance station, 1973 Chambers Flat Rd	Queensland Ambulance Service
2026	AMB001	Queensland Ambulance Service
	PS007	Department of Education primary school
	HCC001	Queensland Health
2031	PS001	Department of Education primary school
	PS002	Department of Education primary school
	PS003	Department of Education primary school
	PS004	Department of Education primary school
	PS005	Department of Education primary school
	PS006	Department of Education primary school
	PS008	Department of Education primary school

[14] Reference from LCC's Community Infrastructure Strategy.

[15] As above.

Year	Facility	Agency
	SS001	Department of Education high school
	HE002	Queensland Health
2041	PS009	Department of Education primary school
	PS010	Department of Education primary school (*location subject to investigation)
	PS011	Department of Education primary school
	PS012	Department of Education primary school
	PS013	Department of Education primary school
	SS002	Department of Education high school (*location subject to investigation)
	SS003	Department of Education high school
	SS004	Department of Education high school
2066	AMB002	Queensland Ambulance Service
	PS014	Department of Education primary school
	PS015	Department of Education primary school
	PS016	Department of Education primary school
	PS017	Department of Education primary school
	PS018	Department of Education primary school
	SS005	Department of Education high school
	SS006	Department of Education high school
TBC	SS007	Department of Education high school
	FR001 & FR002	Queensland Fire and Emergency Service
	PO001	Queensland Police Service
	1 x Additional police station	Queensland Police Service
	1 x Additional police station (co-locate with FR001, subject to investigation)	Queensland Police Service
	Neighbourhood centre 1	Co-locate with RS4 (LCC), Subject to investigation

Source: Urbis Pty Ltd

10.12 Adopted Community Facilitates Network

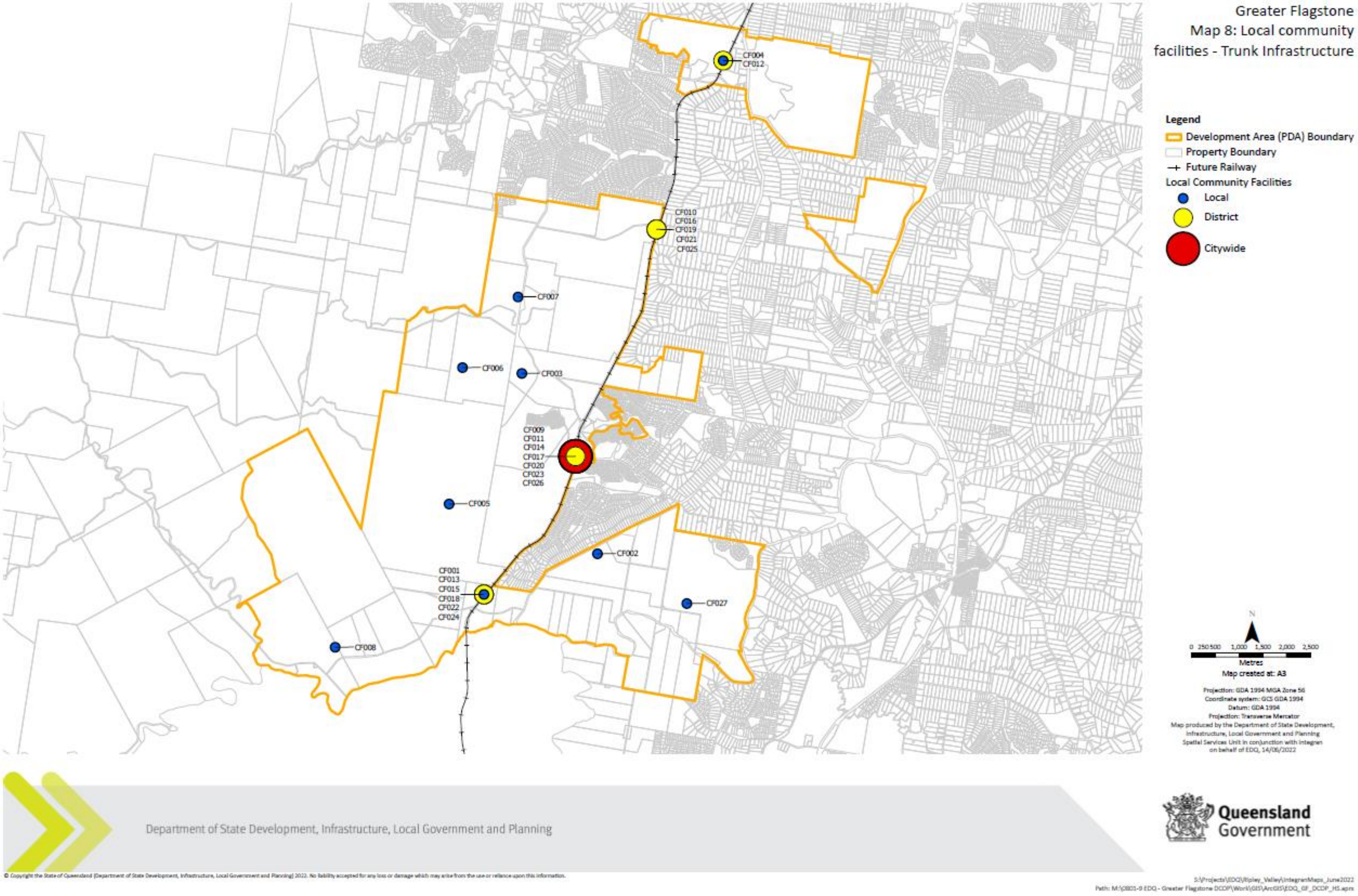


Figure 10-5 Greater Flagstone PDA Adopted Local Community Facilities

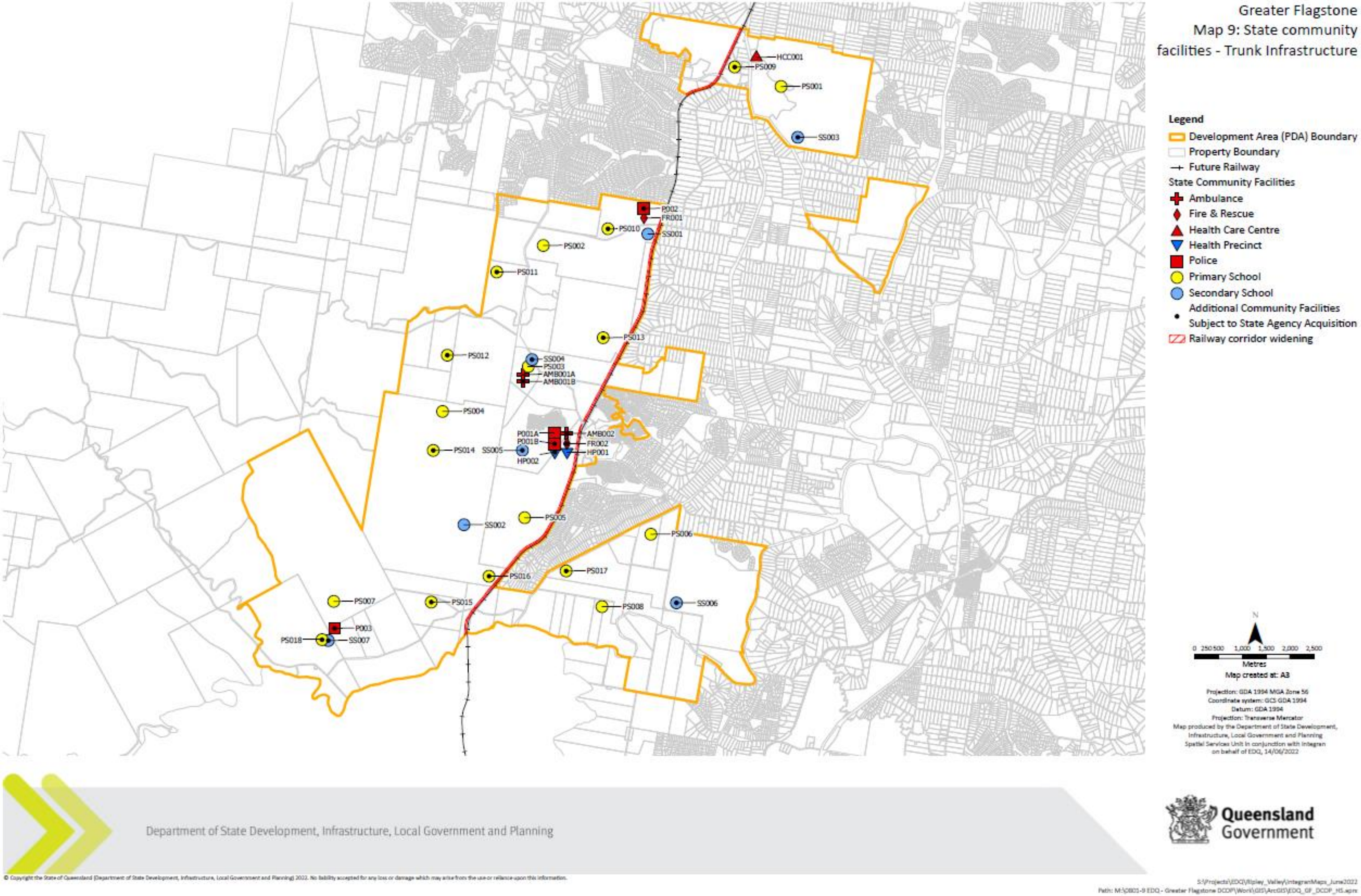


Figure 10-6 Greater Flagstone PDA Adopted State Community Facilities

10.13 Opinion of Cost

Rider Levett Bucknall (RLB) were engaged to develop an opinion of the cost of community facilities infrastructure to service the Greater Flagstone PDA. The quantities of community facilities infrastructure were derived from the updated network plan developed as part of this study. Municipal costs for Greater Flagstone PDA were then extracted from the RLB estimates and inserted into the Financial Offset Model per planning horizon, the summaries of which can be found within the Schedule of Works containing within the body of this Infrastructure Planning Background Report (IPBR).

11 Design and Aspirational Innovation

11.1 Introduction

There are two streams of thought that addresses current innovation practises – by design and emerging innovations – by aspiration. These terms are defined as follows:

Innovation by design: approaches using proven, currently available technologies and/or construction methods to achieve innovative outcomes (e.g. provision for charging stations of electric cars, like the Tesla models, incorporated into street, carparking and building infrastructure).

Innovation by aspiration: approaches using conceptual or cutting-edge technologies and/or construction methods to achieve innovative outcomes (e.g. preparing for autonomous vehicles by installing conduit or similar in road infrastructure).

Based on these two definitions the innovations within the document are grouped under Design Innovation with the expectation that these innovations will be implemented at some point through the development of the PDA, and Aspirational Innovation to be explored and tested in association with EDQ support in the form of test beds. The innovations discussed and outlined provide a variety of solutions and samples as Use cases with actual existing examples, where available.

11.2 Methodology

As the innovations discussed in this document are both currently existing within our urban environment and soon to exist, the prioritising of innovations for the PDA is based on a triple bottom line approach to achieving sustainability by considering the social (people), environmental (place) and economic (price) benefits of each innovation. By using the triple bottom line approach, the Implementation Rating for each innovation can be rated as High, Moderate or Low. This rating when combined with Procurement ratings of High, Moderate or Low provides a basic performance criterion from which to judge each innovation. Such that where an Implementation Rating is High or Moderate for sustainability and Procurement is Moderate or Low for cost, that innovation should be implemented within the PDA, with the expectation that costs will continue to reduce over time as innovations transition to Business as Usual (BAU).

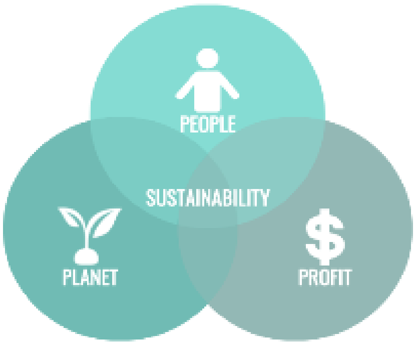


Figure 11-1 Triple Bottom Line (image sourced from Red Lab Experience 2019)

The consideration of the triple bottom line approach to innovations in infrastructure must have regard to the context in which they are being in applied. Specifically, the Greenfields growth areas of Southeast Queensland and the urban expansion of south-west Brisbane. The ability to achieve sustainability in infrastructure in Greenfield areas is maximised because of the general rural/farming nature of the land and the opportunity to remediate and restore the often-degraded natural systems as part of its conversion to urban and creation of open spaces and protection of habitats. The target of Shaping SEQ - Southeast Queensland Regional Plan 2017 of 70%

developable area and 30% for non-developable will include environmental corridors, open space, transport networks, sports, education and health facilities to ensure a sustainable community can be supported.

However, the edge or fringe nature of growth area development, that forms the development front extending from suburban areas, means that historically services generally follow the new community's occupation. The provision of services, whether they be transport, health, educational or commercial all relies on population targets or a critical mass of people to sustain cost effective service provision. Consequently, early occupants of growth areas, the community demographic (predominately young families and couples), can often feel isolated and disconnected due to distance to local services and support networks, and often become reliant and habitual on inefficient and unsustainable means of private transport due to the scheduling of public transport (PT) implementation.

Consequently, the innovations outlined below that support active transport and transport options beyond BAU and/or form part of a broader transport network system rate High on sustainability under Implementation Rating as they support both people (through health and wellbeing) and the planet (through reduced carbon emissions, in accordance with Queensland Climate Transition Strategy) at a minimal additional price. Similarly, the provision of co-located community services, educational and health facilities, open space and stormwater infrastructure also rate High on sustainability. Due to their intrinsic value to support people (mothers and children's health, education, social networks and mental health) the planet (reduced building footprint, reduced heat island effect, increased permeability and increased greening,) and price (reduced land and construction costs, increased amenity and value creation).

Beyond the triple bottom line approach to sustainability, the fourth consideration for implementation is governance. Within the context of growth area planning the local government areas that will ultimately govern these newly developed suburbs will also manage and maintain most of the required and constructed infrastructure.

Consequently, the approach to rating Procurement includes the consideration of local councils' approach to infrastructure maintenance, budget and resource allocation. Management and ongoing maintenance of infrastructure are significant consumers of local government resources and the establishment of new or alterative infrastructure solutions require significant input from the future owner of this infrastructure. Where the innovations discussed below incorporate minor changes or additions to BAU infrastructure then additional costs will be minimal and are rated as Low or Moderate.

However, where these innovations require changes to planning policy, management policy, budget and resource allocations these innovations are rated High as they are likely to be perceived as complex or costly to local councils and will require ongoing collaboration, education and state government support to achieve a BAU approach. Examples of this are innovations that require significant populations or critical mass of users to see benefits, such as electronic data collection that requires a broad network of installation to receive quantifiable data that is useful, increased complexity in maintenance regimes, or increased perceived risks for staff, users or governance.

The Procurement rating also considers the nature of nexus for core infrastructure delivery, as innovations in infrastructure while desirable, may be considered beyond the basic needs of the residential community. The development industry in their provision of required infrastructure will deliver those clearly defined and benchmarked infrastructure requirements. However, innovations that incur additional costs without a clear line to nexus, financial benefits or value add, are likely to struggle to achieve implementation and therefore have also been rated as High, due to their legitimacy as core infrastructure.

11.3 An Implementation Framework – Incentives

The DCOP provides the actual mechanism through which infrastructure is delivered as part of new urban development. This is based on the need's assessment for the projected population, across health services, open space, community and sports facilities etc. and minimum standard requirements for utilities and infrastructure (sewer, stormwater, road widening, intersection capacity, etc.) to support the future community. These infrastructure requirements are based on the nexus between the population (numbers of people) and the required service (generated need) to ensure development can proceed and therefore are generally supplied at a basic level of service and cost.

The DCOP provides a practical framework and well-defined approach to land requirements, construction costs, staged delivery and the implementation of assets to be transferred to local government or service authorities once works are complete, based on BAU practises that are well established, known and implementation ready. This detailed and cost focused nature of the DCOP without augmentation by an innovation mechanism provides limited opportunities for innovations to be explored as their costs, maintenance, ownership or policy position are yet to be resolved or clearly defined.

To enable and facilitate innovation and evolve infrastructure delivery beyond BAU, Design Innovations need to be reinforced through the DCOP and supported by planning policy so that implementation of these innovations can be mainstreamed. Through the DCOP and the state government planning framework in association with education and agreement with local government, innovations need to be mandated into policy to enable their transition to BAU. Through consistent planning policy and implementation mechanisms, a level playing field is created for the development industry regardless of location or council area. This requires the development of standardised costs and construction that enables those innovations to be implemented in an efficient and effective manner, such that they are automatically factored into developer costs as part of any future project. The DCOP provides the framework for a top-down policy approach and a bottom up showcasing of innovations to progress to construction ready infrastructure, supporting widespread implementation over time.

Similarly, as Aspirational Innovations evolve over time through test beds and research and development, they will become Design Innovations that are implemented in a confined or locational manner, unless they are adopted and endorsed holistically by state governments (e.g., Adaptive Signalling for traffic lights) and rolled out across the state, accordingly. However, as this top-down approach is yet to be created opportunities for implementation of Design Innovations and ultimately Aspirational Innovations remain at the discretion of the development industry, subject to their estates marketing approach and their desire to create a point of difference.

This Chapter provides EDQ and developers with examples of use cases that they can review and investigate as potential implementable innovations within current or future estates in the PDA. In this regard developers are encouraged to implement one or more of the Design Innovations, or the Aspirational Innovations when they become implementable, in consultation with EDQ and the applicable local council.

Opportunities for joint ventures, state government grants, collaborative test beds, state government land development, investment funding and development concessions (reduced car parking rates, increased residential densities and/or Floor Space Ratios) could all be explored with local government and developers as part of facilitating actual innovation within the PDA.

Alternatively, EDQ in association with the local council may actively select and require specific innovations within the PDA, that will create the greatest benefit for the broader future community and achieve the desired triple bottom line approach to development. Through innovation by example, EDQ will set the tone and raise the bar for development within the PDA, to achieve sustainable communities.

11.4 Innovation Proposal Assessment

Sustainability provides a guiding principle to the pursuit of innovation and incentivises the delivery of infrastructure which is optimised across multiple criteria, capturing the interests or challenges of present and future stakeholders, minimising externalised costs and maximising intangible social and environmental benefits.

This approach recognises the synergistic advantages which are realised when taking a truly integrated approach, where the outcome/benefits achieved can be more than the sum of its parts if each function/challenge were to be considered and addressed individually. This is particularly important in maximising the positive impact or Return on Investment to EDQ, local government and the community from the Development Charges offset.

11.4.1 Innovation Project Selection and Evaluation Criteria

Innovation project proposals must demonstrate a high degree of sustainability and target best practice across the following sustainability themes. Reporting against all criteria is mandatory, unless it can be demonstrated that the criteria is not material to the project proposal (including secondary interactions with related development designs/assets).

11.4.2 Infrastructure Sustainability Themes

- Governance (Integrating Sustainability into Leadership & Management, Knowledge Sharing)
- Sustainable Procurement (Supply Chain and Supplier Assessment)
- Resilience (Resilience Strategy, Natural Hazard and Climate Risks)
- Economic Business Case (Valuing Externalities, Equity, Financial Sustainability)
- Economic Benefits (Benefits Mapping, Post Project Evaluation)
- Energy & Carbon (Energy Efficiency, Renewable Energy, Offsetting)
- Green Infrastructure
- Environmental Impacts (Water/Air Quality, Noise, Vibration, Light Pollution)
- Resource Efficiency (Resource Recovery, Adaptability, Material Life cycle, Sustainability Labelling)
- Water (Water efficiency, Appropriate use of Water Sources)
- Ecology (Ecological Assessment and Risk Management, Ecological Monitoring)
- Stakeholder Engagement (Strategy and Implementation)
- Heritage (Assessment and Monitoring
- Workforce Sustainability (Workforce Planning, Workforce Culture and Wellbeing, Jobs and Skills).

Further guidance on infrastructure sustainability reporting may be taken from recognised industry peak bodies, government and non-government policy and guidance documents and the United Nations Sustainable Development Goals (SDGs).

Third party verification/assurance and obtaining independent infrastructure sustainability ratings is strongly encouraged. Innovation proposal acceptance will give preference to projects for which infrastructure sustainability ratings are sought, particularly on proposals representing larger capital expenditure, high complexity, higher risk elements or involving multiple stakeholders/developers.

11.4.3 Innovation Project Inspiration

EDQ currently focuses on innovation around four themes, which will necessarily shift over time and be revised in subsequent revisions to the DCOP:

- Clean energy
- Sustainability and planning innovation
- Transport and mobility
- Digital

As of June 2020, EDQ is believes the following are to be considered as innovation projects:

- Disruptive infrastructure planning
- Smarter building materials (lower carbon, lower waste)
- Circular economy
- Blue-green infrastructure
- Water Sensitive Urban Design
- Sustainability rating schemes
- EV charging provisions
- Shared mobility
- Waste to energy
- Renewable energy (residential/industrial)
- District energy generation / storage
- Virtual power stations
- Internet of things, digital communications
- Innovation education partnerships

Further guidance may be taken from the following resources

- PDA Guideline No. 14 – Environmental Values and Sustainable Resource Use (2015)
- PDA Practice Note. 04 – Integrating Sustainable Principles into Residential Subdivisions (2014)
- Overarching Site Strategies (OSSs) or Infrastructure Master Plans (IMPs) approved for each master development approval which detail environmental and sustainability goals.

11.4.4 Government Policy Imperatives

Innovation proposals which facilitate the advancement of non-mandatory State Government or Federal Government policy goals are encouraged. Examples:

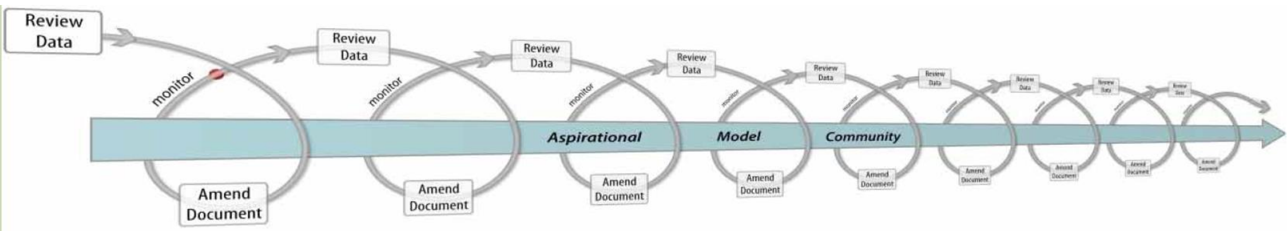
- Advancing Queensland's Priorities - Reducing Queensland's contribution to climate change - 'A 30% reduction in 2005 net greenhouse gas emissions by 2030'.
- Queensland Climate Transition Strategy - Action 2.3 - 'Integrate zero net emissions goals into state infrastructure planning'

- COAG - Phasing out exports of waste plastic, paper, glass and tyres - Response strategy to implement the August 2019 agreement of the Council of Australian Governments.

11.4.5 Innovation Project Eligibility Criteria

To be eligible for the Innovation development charge offset the proposed infrastructure project/proponent must meet the following criteria:

- **Project Benefits** - The proposed infrastructure innovation must generate, facilitate or accelerate economic, social and environmental benefit.
- **Project Forms** - Projects will likely take the form of transport infrastructure works, communication technology, water supply, sewerage transport/treatment, stormwater infrastructure, energy technology, or innovation in the design of open space assets. However, other proposals will be considered provided they meet the eligibility criteria, including other categories of infrastructure, precinct/catchment planning instruments, proposals for non-mandatory environmental protection/rehabilitation or construction management proposals.
- **Demonstration of Need** - There is demonstrated need for the infrastructure innovation proposal to enhance the development outcome and facilitate the achievement of the economic and sustainable development goals for the PDA, or to address a present or future barrier to the achievement of these goals (i.e. resource shortages, climate change etc.).
- **Improvement on BAU** - The Innovation proposal must represent a material and quantifiable improvement over BAU (proof of “additionality”), with the definition of BAU to be necessarily revised over time and evaluated at the time of assessment, following industry and technology trends.
- **Eligible infrastructure –** Incorporation of recycled or innovative construction materials or methods which represents an Australian, State or PDA first adoption, or which is a known innovation which is currently under-utilized, and the proposal advances the development of the material/method for broader adoption.
  Examples: water mining from sewer infrastructure to supply non-potable water to open space or community assets. Grid-connected battery storage, quarry pumped hydro or floating solar which provide electricity network services that reduce overall infrastructure costs and electricity bills.
- **Ineligible infrastructure –** Incorporation of recently developed technology such as LED post lighting for roads and sports parks which represents Business and Usual or is approaching BAU within the State/PDA.



- **Verification/Assurance –** Proposal benefit representations are to be independently verified unless otherwise agreed by EDQ. EDQ further reserves the right to request independent verification where necessary. Projects are encouraged to seek independent sustainability ratings. Where the implementation of a rating is an innovation (rating scheme is novel or at present underutilised), this may be lodged as a standalone innovation proposal.

- **Technical Evidence** - Projects are supported by robust technical evidence that the proposal meets relevant standards, and that present and future risks are mitigated. The degree of evidence required is proportional to the extent of prior adoption of the design/technology, the significance departures from standards and assessment of risk. For example, should designs or specifications differ from Australian Standards the proposal must be supported by evidence to the satisfaction of EDQ and relevant stakeholders, such as independent field/laboratory testing and a performance-based specification, with appropriate certification by a suitably qualified person.
- **Development Integration and Asset Handover** - Proposals must integrate with the development such that the implementation does not compromise the ability to satisfy conditions approval and other relevant approvals or standards, unless agreed by EDQ or other relevant authority. Non-compliance with conditions/standards arising as a result of the proposal must be identified prior to implementation and specifically addressed such that the proposal holistically enhances the development outcome.
- **Financial Viability and Maintenance** - The project is financially sound, including demonstrated value-for-money and a plan for the viability of the project (such as local government capacity to manage, operate and maintain the infrastructure following construction). Depending on the nature of the proposal, whole of life cost evaluation, return on investment or consideration for a modified maintenance period may be required.
- **Project Proponent Capacity** - The proponent has the capability to deliver the project including appropriate staff, expertise and capacity to manage the project. Required to demonstrate the financial capability to deliver the project.
- **Innovation Adoption Strategy** - Projects incorporate elements which facilitate industry adoption, including mechanisms for ongoing measurement/capture of data, industry education and capacity building opportunities. Preference will be given to proposals which produce an Innovation Adoption Strategy that details how the innovation will be incorporated into the subject development and strategies for maximising the potential for broader industry adoption. This Innovation Adoption Strategy plan is to incorporate the following: -
    - Open-Source data capture and sharing approach (insofar as allowable by copyright and IP) to maximise opportunities for wider innovation adoption.
    - Strategies to facilitate standardisation of successful innovations across PDAs, and to promote and encourage innovations for wider adoption.
    - Partnerships with educational institutions or industry peak bodies to leverage case study production are strongly encouraged.
- **Innovative Planning Proposals** - Innovations may focus on the drafting or implementation of infrastructure planning solutions which seek to break down the siloed approach historically driven by fragmented land ownership, such that “artificial” cadastral development boundaries do not drive the delivery of costly, inefficient and suboptimal infrastructure designs and rather result in a best for community outcome which minimises long term costs.

- **Eligible planning proposals** - Includes the creation of a multi-stakeholder precinct frameworks (where otherwise not required by Development Approvals) such as catchment approaches to total water cycle management, precinct urban heat island or climate resilience/adaptation plans, precinct earthworks plan that eliminate the requirement for cut-fill balance within limited parcels, or plans that create integrated open space and environmental protection outcomes
- **Planning solutions** may address the "growing pains" of Greenfield development, such as development of decentralised of strategies to facilitate the delivery of otherwise "out of sequence" development. Examples include the adoption of decentralised technology for provision of water or energy supply which is determined to be required based on a network analysis that demonstrates that the existing network and service model is constraining development and the achievement of economic, social and environmental goals.
- **Development Application** Approvals and Change Applications - It is noted that innovation proposals may necessitate the alteration of ancillary development infrastructure for the proposal to be adequately integrated. Innovation proposals must be submitted either prior to the approval of the relevant development application, i.e. Material Change of Use, Realignment of a Lot or Operational Works, or a change to approval must be obtained to facilitate the approval of the proposal.

11.4.6 Innovation Project Identification

Innovations are constantly evolving to respond to emerging changes in our urban environment, declining resources and increasing community expectations. The need to build resilient suburbs and cities that can accommodate climate change, natural hazards, transport modernisations and evolving social norms, require flexible approaches to urban infrastructure delivery.

However, the means in which urban infrastructure is delivered is defined by catchment analysis and associated unit cost, to enable infrastructure costs to be transferred to the ultimate purchaser of the land, the future resident. The provision of basic services and facilities that enable urban, particularly residential, development to occur are well established and can be easily quantified. To change these known costs through innovations in infrastructure, beyond BAU, requires clearly defined state planning policy, along with adopted and consistent implementation at the local government level. To enable innovations to transition to BAU and achieve sustainable outcomes that create liveable communities.

EDQ is leading by example as they focus their efforts on innovations in infrastructure through the DCOP that will achieve sustainable communities. While many of the innovations within this report could be applied the methodology focuses on sustainable outcomes that are contextual to place, given the Greenfields nature of the PDA, and the opportunity to minimise additional costs to current BAU infrastructure.

To achieve sustainability within the PDA Design Innovations that are rated as High or Moderate under Implementation Recommendation and Moderate or Low under Procurement should be pursued through discussions with both local government and the development industry to ensure that practical implementation and ongoing maintenance is achievable within the PDA. For innovations to progress to BAU infrastructure they must be endorsed by the ultimate asset owner, generally local government, through a bottom-up test bed approach, to enact change and champion sustainability within these emerging communities.

Aspirational Innovations will continue to evolve over the development life of the PDA until they become Design Innovations that are implemented in urban environments. Just as Design Innovations will mainstream into urban developments as BAU infrastructure or become superseded by Aspirational Innovations (e.g. AV removing the need for public car parking) as they mainstream.

Regardless of the timing a holistic view to innovations in infrastructure delivery is required within the PDA, which should incorporate a top-down state government planning approach, supported by a bottom-up local government practical implementation program. This provides clear and defined direction to the development industry on achieving sustainable urban development within SEQ.

Potential Sustainability and Innovation offset projects will be identified:

- through the submission of a proposal using the preliminary information form on EDQ's website,
- through identification of a target project by EDQ in conjunction with local governments and/or proponents and via direct contact by a proponent with EDQ; or
- In identifying potential Innovation Offset projects, EDQ or local governments may identify strategic infrastructure sustainability and innovation priorities through regional/infrastructure planning documents. Local governments are also encouraged to engage with development proponents and other relevant organisations as part of this process. Further information may be requested during the assessment process.

11.5 Good Ideas – Yet to be Tangible

Aspirational innovation as previously defined are approaches using conceptual or cutting-edge technologies and/or construction methods to achieve innovative outcomes. These innovations conceptualise current thinking into tangible technologies or infrastructure that pre-empt future development. Avoiding the need to retrofit or replace expensive and complex infrastructure in the future when these innovations become reality.

Aspirational Innovation is the ultimate approach to future proofing new and emerging communities in SEQ growth areas. Providing cost efficiency in current infrastructure and maximising returns for service authorities, infrastructure managers, local councils and ultimately striving for sustainability and housing affordability for the future community.

However Aspirational Innovations are still undergoing tests and refinement on their path to implementation and consequently presently unresolved matters related to government policy, legislative requirements, risk, governance, ownership and cost implications must be addressed. As these innovations evolve over time clarity and resolution of these matters will follow and mechanisms that will facilitate their broad scale implantation will rolled out through appropriate

11.5.1 Illustrative Examples

The following provides a list of Aspirational Innovations that are currently emerging across Australian urban communities. These innovations provide several examples that can be considered, explored and implemented by future and existing developers, landowners and local government, developing land within the Ripley Valley PDA.

Provided as a snapshot of future innovations, in the form of Use cases, this list is not exhaustive and future innovations will continue to evolve over time. However, this list is provided to inform and lead the development industry in its implementation of innovative solutions through development within the PDAs.

Developers are encouraged to review the Aspirational Innovations listed below in consultation with EDQ and local governments to future proof current infrastructure delivery, as Aspirational Innovations seek to move to Design Innovations. Opportunities exist to form part of a broader government approach to showcase innovations through joint ventures, test beds, case studies, grants, developer incentives and funding mechanisms as part of facilitating actual innovation within these growing communities.

11.5.1.1 Autonomous vehicles

Image sourced: Sedg.org

Figure 11-2 Artist's impression

Autonomous Vehicles (AVs) have the potential to completely disrupt the way people use and consume transport. Moving away from ownership to usership models (akin to buying CDs to paying a monthly fee for music streaming), changing the need for parking at private residences or requiring the construction of drop off bays at commercial premises, as the need for static parking is removed. AVs could fundamentally change the way in which people go about their lives.

While these vehicles are 2 to 8 years away from commercial (freight or taxis) and up to 20 years away for private use, they have the potential to facilitate travel without human input and in doing so would free individuals to use their time traveling to do other activities. This may see the AVs built in the form of mini gyms, meeting or conference rooms, hotels, and many other potential uses. There has been significant talk about the need for AV only traffic lanes to be constructed to allow the operation of these vehicles, but this is considered by most to be unnecessary.

Key considerations

Buildings and transport hubs should be designed with this innovation in mind. Buildings without flexibility in their design to accommodate these foreseen changes would be costly and inefficient, for example car parking structures being designed to enable enclosure and adequate floor to ceiling heights to be converted for commercial or housing uses. However, the road network and infrastructure requirements are unknown or not yet standardised, with complimentary operational infrastructure expected to be built as needed, as legal matters related to road use and licencing of AVs need to be addressed through government regulation.

Implementation recommendations

Low: AV require sophisticated technologies that can provide diagnostic and predictive tools to understand and interpret human behaviour of other drivers. Such technology will increase the bandwidth demand on the internet and global location data.

Ownership and operation

Currently, AV business models can involve ownership by individuals, businesses and organisations.

Procurement complexity

Moderate: As infrastructure requirements are yet to be defined costs associated with AVs are unknown. However, as they will be using the existing local street and road network retrofitting of streets and roads will fall to the owners of this infrastructure, local and state governments. Mechanisms for cost recovery are likely to come through broadscale fees such as licensing and rates.

Further information

- Local Queensland examples EZ10 Driverless shuttle Ipswich: https://www.ipswichsmartcity.com.au/projects/

- Cooperative and Automated Vehicle Initiative – CAVI: https://www.tmr.qld.gov.au/About-us/News-and-media/News-and-media-frequently-asked-questions/Cooperative-and-Automated-Vehicle-Initiative-CAVI

11.5.1.2 Mobility as a service (MaaS)

Mobility as a Service (MaaS) is a new system which looks to integrate all modes of transport and provide multi-phased options for a traveller's journey. Here, the customer can choose their preferred option (based on timing, connections, and cost), arrange and pay for it through a single interface or app. One potential avenue of MaaS is the subscription model, where a traveller would buy a subscription to mobility services (combination of micro-mobility, public transport, parking, ridesharing) for a price that suits their needs. Currently the implementation of MaaS in Australia is low, with some trials taking place around the country. Apps such as UbiGo and Whim in Europe have seen commercial success.

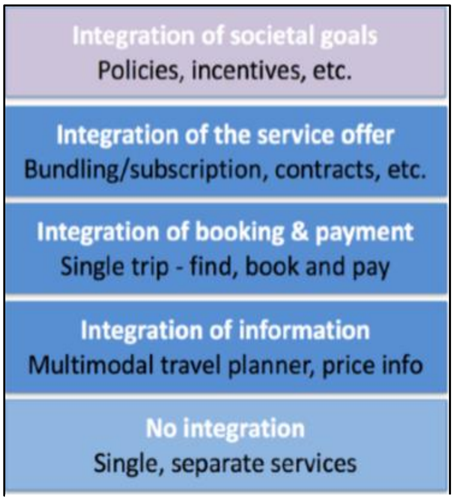


Image sourced: Sarasini, S. (2017)

Figure 11-4 Example of mobility as a service framework

Key considerations

Various factors must be considered before the implementation of a MaaS system such as who the target market is, how payments will be processed and how the public sector will incentivise the services.

Implementation recommendations

High: The opportunity to provide an interactive approach to transport service delivery provides both variety in transport modes and convenience at the users' fingertips as choice and cost can be determined by the user. In a Greenfields situation access to transport may be limited in the short term so any alternative transport options that can help to connect and support the community while PT is being established provides a sustainable outcome and should be pursued.

Ownership and operation

Will require integration across transport services in relation to payments. Existing ownership and operation models for the various forms of transport would remain the same.

Procurement complexity

Low: Given trials are currently underway in Australia and all transport modes are currently available, systems related to the processing of payments and the accepted use of the app would incur some cost as part of MaaS implementation. However, the opportunity to increase demand for services would ultimately offset that cost.

Further information

- Sarasini, S. "A topical approach to mobility as a service: A proposed tool for understanding requirements and effects" (2017)

11.5.1.3 Automated Public Transport

Automated busses are also experiencing trials across Australia. Adelaide's 'Olli" bus trial, which is a driverless shuttle bus that runs along a fixed route, poses a possible solution to the first mile/last mile issue that PT has difficulty enabling due to catchment-based transport planning. Automation of public transport would result in considerable financial benefits to its respective operators' state governments and transport authorities as it eliminates the cost of driver training and labour issues.

Figure 11-5 Example of automated public transport

Image sourced: Transport.nsw.qld.gov.au

Key considerations

Given that this technology is in its early stages, care must be taken to properly implement and operate it within the existing public transport network. Safety measures and risk mitigation must be thoroughly employed.

Implementation recommendations

High: Continued development and testing are ongoing within current trials, before this technology can be completely mainstreamed as part of all PT systems. However, this approach to driverless vehicles within controlled PT environments, namely vehicles on rails or acting as a shuttle (only two-point destinations), is highly desirable and cost effective for PT operators.

Ownership and operation

PT ownership and operations would not change, only the technology within the vehicle or the type of vehicle used to enable it to operate autonomously (LIDAR, GPS technology and emergency brakes).

Procurement complexity

High: Current trials consist of a combination of partners including a motor company, an automation company, an AI company with IoT technology and local and state governments. The South Australian Government previously invested $2.8 million in driverless shuttle buses trials at the Adelaide airport in 2017.

Further information

- Adelaide Olli bus: https://www.zdnet.com/article/south-australia-kicks-off-six-month-driverless-shuttle-trial/
- Sydney Metro: https://www.transport.nsw.gov.au/sydney-metro

11.5.1.4 Demand Responsive Transport/Ride Share

Demand Responsive Transport (DRT) is a shared transport service that offers flexibility for trips where PT such as buses and trains are not available. It is most effective in the first and last mile of a journey, connecting people to more rapid transit or local attractors.

DRT typically operates as an area wide service, connecting customers from nearby suburbs to a destination and/or attraction. It is intended to replace short private vehicle trips. The service operates with the customer notifying the operator of their desire to travel to a specific destination. The customer will then proceed to a predetermined location to minimise delay along the route for other customers onboard. The customer may be expected to walk a distance from their home (not more than 400 m) to the pickup location. This is determined by an algorithm optimising the journey, which has 'preferred' virtual stops along the route from which pick up and drop off would typically take place.

A DRT service could also be supplied specifically to a residential development, as a complementary service offering. This is an emerging use, which has the potential to offset the need for a second vehicle at each household.

Key considerations

DRT is considered relevant for trips where public transport, such as a bus service, is not considered financially viable, due to low passenger demand, industrial or rural areas. DRT services can be designed for any location. Setup generally involves vehicles, commonly small minibuses, and a booking system for customers to book a transport service.

Implementation recommendations

High: Subject to staging of developments. Where access to PT (train or trunk bus route) is not within 1km. DRT should be implemented to ensure PT use habits are established from early occupation until PT implementation replaces or supports ongoing use of DRT. Reduces community isolation at development front.

Ownership and operation

DRTs pilots may be fully or partially funded by developers and transit authorities for specific estates with limited access to PT.

Procurement complexity

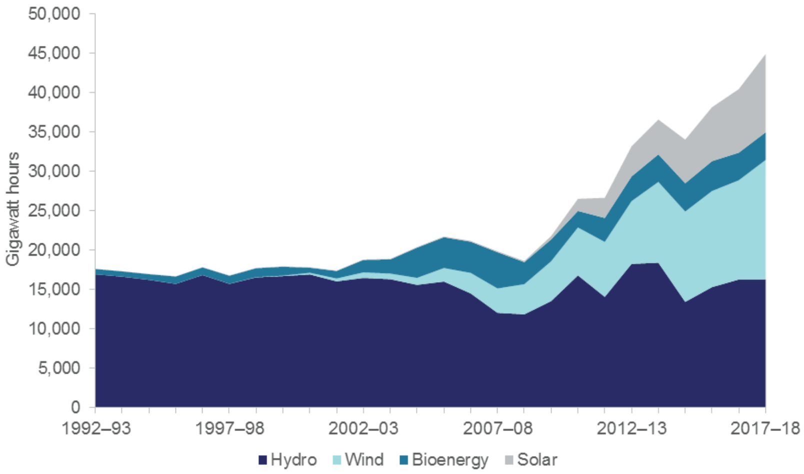
Moderate: Subject to area covered by service, significant cost investment is required given Queensland Government Translink is subsiding transport fares. A shared approach between developers, local and state government would reduce costs and provide a reliable data source to support future PT decisions and investments in growing communities.

Further information

- TfNSW the Ponds and Northern Beaches: https://transportnsw.info/travel-info/ways-to-get-around/on-demand/ponds-on-demand-service
- https://transportnsw.info/travel-info/ways-to-get-around/on-demand/northern-beaches
- Kan-go, Toowoomba: https://translink.com.au/travel-with-us/taxi-and-community-transport/kan-go

11.5.1.5 Renewable Energy

According to the Australian Government's Renewable Energy Agency (ARENA), renewable energy is produced using natural resources that are constantly replaced and never run out. Renewable energy types include common technologies like solar, wind power and hydropower. Energy harnessing technologies include geothermal energy, bioenergy and ocean energy. Grid strengthening technologies include battery storage and smart technology, which predicts when and where electricity is required Businesses can manage their energy costs better and Australia can move towards a low emissions economy by enhanced technological development and innovation.



Renewable energy sources accounted for 6% of Australian energy consumption in 2017-2018, comprising mainly biomass, hydro and wind energy. Renewable energy has diversified significantly as wind and solar capacity came online, generation has doubled over the past decade.

Figure 11-6: Australian electricity generation renewable sources

(Source: Department of the Environment and Energy (2019) Australian Energy Statistics)

An excellent example of bioenergy is demonstrated by the Logan City Biosolids Gasification Project. The biosolids gasification facility processes sewage sludge by dewatering it in a centrifuge, drying it in a paddle dryer, and treating it with high temperatures in a gasifier to produce biogas. Recovered energy in the biogas is used to power the drying and heating processes.

The gasification facility is energy neutral, with 70 per cent of the energy in biosolids recovered and reused, and the remaining energy requirements met by an onsite solar array. The gasification facility reduces the volume of biosolids by 90 per cent and produces a 'biochar' containing carbon, phosphorus and potassium

In another project, Water Corporation will provide biogas to technology company Hazer Group as feedstock for the Australian-first commercial demonstration project. The operation will produce 100 tonnes of fuel-grade hydrogen and 380 tonnes of graphite each year. The project capitalises on the waste product of biogas – mainly composed of methane and carbon dioxide – that is released during the wastewater treatment process as biosolids breaks down.

There is also the opportunity in the PDA to utilise Smart Grid technology to enable improved communication between parties involved with energy to support new and increased renewable technologies and enhance supply and demand reliability, information, response and efficiency, from both the supplier and consumer aspect. It does this through implementing information and communication technologies into the electric power system to enhance data available.

Key considerations

Developers and local government can play an active role in reducing energy demand and supporting the growth of distributed renewable energy sources in electricity networks. Accordingly, the Office of Clean Energy will assist all new and refurbished master planned communities, large - scale commercial developments and government infrastructure services to develop Clean Energy Plans. These plans will encompass demand side management, energy conservation and renewable energy options aimed at speeding up the deployment of clean energy technologies in major population growth hot spots. This initiative will align with the Queensland Government's Green Door and Cleaner, Greener Buildings initiatives (The Queensland Renewable Energy Plan (June 2009)). The Ripley Valley PDA will therefore be in an ideal position to harness the benefits of these initiatives. The unique environmental conditions of the Ripley Valley PDA should be well understood to determine which renewable energy sources are most like to yield efficient results.

While the technology that underpins this is readily available, the reasoning why this innovation is not included as by design, is due to the change in business model necessary to facilitate it. It is not the current 'business as usual' model and the traditional cost/benefit assessment when it comes to systems like this doesn't include the benefits that this can realised, such as environmental, community perspective and quantification of data quality increase.

- Origin Energy's Smart Grid: https://www.originenergy.com.au/blog/what-makes-a-smart-grid-so-smart/
- US Department of Energy Smart Grids: https://www.smartgrid.gov/the_smart_grid/smart_grid.html

Implementation recommendations

Moderate: Key considerations with the new Ripley Valley PDA can include focussing on the following four key interventions (www.energycommunity.org):

- Solar Water Heaters/Solar Power Heat Pumps
- Energy Efficient Lighting
- Energy Efficient Buildings
- Transport (Modal shift from private to public)

Victoria's Renewable Energy Action Plan focusses on supporting sector growth, empowering communities and consumers and modernising their energy system. For the Ripley Valley PDA, the relevant sector will be to empower and engage households and businesses. Industrial developments can be constructed with a targeted focus on renewable energy as well as the performance of daily operations. The transportation sector can also embark on innovative and sustainable choices to modernise their vehicles and decrease the carbon emissions.

Ownership and operation

Some initiatives will be led by public sector involvement while others will be completely managed by the individual. Solar power and energy efficient lighting can be the responsibility of the landowners while the transport shift is shared between public organs of state and the individual. Large scale renewable energy projects will mostly be managed by state jurisdictions.

Procurement complexity

Medium to High: In instances where privately owned initiatives are developed, the procurement will be simpler than large-scale state projects. According to The Queensland Renewable Energy Plan (June 2009) a regulatory reform package was to be delivered aimed at simplifying the business, regulatory and planning environment in Queensland for renewable energy projects. A Renewable Energy Regulatory Taskforce were to examine existing legislation and provide options to remove or reduce impediments and streamline planning processes for renewable energy projects. For example, the project was to examine the best mechanisms for facilitating access to land for renewable energy, which may have included acquisitions, land designations or declaration of State Development Areas.

Further information

- Logan City Biosolids Gasification Project:
- https://arena.gov.au/projects/logan-city-biosolids-gasification-project/Veolia Biogas recovery:
- https://www.veolia.com/anz/our-services/our-services/energy-services/waste-energy/biogas/biogas-wastewater-treatment-plants Biogas opportunities for Australia: https://www.energynetworks.com.au/resources/reports/biogas-opportunities-for-australia-enea-consulting/Water Corporation: https://watersource.awa.asn.au/technology/innovation/water-corporation-fuelling-an-australian-first-hydrogen-project/

11.5.1.6 Heat Island Effect and Street Greening

The term "heat island" describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with 1 million people or more can be 1–3°C warmer than its surroundings. In the evening, the difference can be as high as 12°C. Heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and water pollution. A green street is a stormwater management approach that incorporates vegetation (perennials, shrubs, trees), soil, and engineered systems (e.g., permeable pavements) to slow, filter, and cleanse stormwater runoff from impervious surfaces (e.g., streets, sidewalks).

Given the long history of hot weather in Australia and particularly this PDA, the increasing frequency and severity of extreme heat events will only amplify the Urban Heat Island Effect However, there are some simple and effective nature-based solutions for cooling our cities that deliver heaps of other benefits besides.

Key considerations

There are a few cooling strategies that could be utilised in the PDA such as:

- increasing tree and vegetation cover (increased tree and vegetation cover lowers surface and air temperatures by providing shade and cooling through evapotranspiration),
- installing green roofs (growing a vegetative layer on a rooftop reduces temperatures)
- cool, mainly reflective roofs (with materials or coatings that reflect sunlight and heat away)
- using cool pavements either reflective or permeable (cooler due to reflecting more solar energy and enhancing water evaporation
- Utilizing smart growth practices (range of development and conservation strategies).

Efforts can either be voluntary or policy driven. Voluntary efforts include demonstration projects, incentives, urban forestry programs, weatherization, outreach and education programs. Policy efforts include procurement, resolutions, tree and landscape ordinances, comprehensive plans and design guidelines, zoning codes, green building programs and standards, building codes, and air quality requirements.

An example of Street Greening can be seen with Sydney streets being transformed with more plant life making it more pleasant and safer for residents, workers and visitors to move around the local area, under 2 City of Sydney improvement programs. Standard footpath improvements under the greening Sydney plan are improved, with new garden beds, trees and shrubs to soften and enhance the appearance of streets and public places. More than $75 million have been committed to the footpath renewal and public domain landscaping programs over the next 10 years.

Implementation recommendations

Moderate: It is recommended to support both voluntary efforts as well as policy efforts to promote street greening and decrease the heat island effect. In Australia several projects are underway including the following:

- Nature in Cities program (strategically planting trees and other vegetation in built-up areas),
- Our Park, Our Place (working on Noongar country with four of Perth's lowest-canopy council areas to regenerate some local parks),
- Adelaide Green Cities project (engage local communities in practical demonstrations about how plants can help create a carbon neutral city),
- Cooling the Schools project (working with schools and their communities to add plants to public parks and playgrounds across Sydney, prioritised by their vulnerability to the Urban Heat Island Effect),
- For Penrith City Council, the following policy and planning controls were identified:
    - Planning controls for new developments specifying requirements such as reflective surfaces, porous pavements, WSUD, open/green space,
    - Procurement of cool products – e.g. reflective roofing, porous pavement, sustainable building products,
    - Target setting – e.g. % of canopy cover, open space, heat reduction, reflective roof surfaces,
    - Tree and landscape rules and standards,
    - Stormwater project design,
    - Comprehensive plans and design guidelines, and
    - Green building standards.

Ownership and operation

Voluntary efforts to be owned and operated by individuals and policy efforts to be driven by the public sector. The Yarra City Council developed the Embedding Green Infrastructure Best Practice Toolkit. It also provides a resource manual to help the implementation of green infrastructure become streamlined, cost effective, and business as usual. The Self-assessment Tool uses the Best Practice Framework to set out three stages (Organisation culture and structure, Internal systems and Delivery) and twelve aspects for evaluation by Councils to determine current strengths and weakness. The traffic-light assessment helps to identify key areas requiring further development to truly embed green infrastructure into Council operations as business-as-usual.

Procurement complexity

Medium to High: Procurement of voluntary efforts can be quite simple whereas procurement related to the policy efforts can be more complex and time-consuming. It is recommended that the council and state development schemes and codes be expanded to include guidelines and how to gradually transform built-up areas towards heat reduction and a greener environment. As time passes by these measures can be refined to become more stringent and include monitoring KPI's and the like.

Further information

- Greening Australia – Tackling Heat Island Effect: https://www.greeningaustralia.org.au/how-can-nature-help-tackle-the-urban-heat-island-effect
- City of Sydney Greening Sydney Plan: https://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0009/135882/GreeningSydneyPlan.pdfhttps://www.cityofsydney.nsw.gov.au/vision/better-infrastructure/streets-and-public-places/completed-works/greening-our-streets
- Urban Heat Island effect: https://watersource.awa.asn.au/environment/built-environment/losing-our-cool-how-water-can-help-combat-urban-heat/
- City of Yarra Green Infrastructure Best Practice Toolkit: https://www.yarracity.vic.gov.au/about-us/sustainability-initiatives/embedding-green-infrastructure-toolkit
- Cooperative Research Centre for Water Sensitive Cities – Ideas for Fisherman's Bend: https://watersensitivecities.org.au/wp-content/uploads/2016/04/Ideas-for-FishermansBend-REPORT.pdf
- Yarra Council Toolkit – practical options: http://www.wdc.govt.nz/PlansPoliciesandBylaws/Plans/State-of-the-Environment/Pages/Blue-Green-Network-Strategy.aspx
- Heat Island Effect – Penrith City Council: Cooling the City:
- https://www.yoursaypenrith.com.au/25909/widgets/192402/documents/151999
- US EPA – Heat Islands: https://www.epa.gov/heatislands
- CoolSeal Pavement: https://guardtop.com/coolseal/
- https://www.charlessturt.sa.gov.au/environment/climate-change/coolseal

11.5.1.7 Wastewater Treatment & Reuse Systems

Wastewater is treated at local treatment plants to supply class A recycled water back to homes.

Figure 11-7 Precinct-scale water recycling
(Source: Southeast Water & Villawood Properties)

https://southeastwater.com.au/residential/upgrades-and-projects/projects/aquarevo/)

Localised wastewater treatment provides an alternate source of water for irrigation, cold water washing machines and toilet flushing. The pressure sewer system enhances cost-effectiveness of precinct scale wastewater recycling.

Key considerations

Water quality management – network(s) need to be sized for fireflows; however, water demand can be much lower. The lower water demand can mean that there is less water moving through the system at slower rates, leading to water age becoming an issue. However, if recycled water is increasingly treated and utilised, water turnover in pipes will be faster, eliminating any water age issues.

The potential for cross connections into drinking water systems need to be carefully managed.

Implementation recommendations

Medium: This solution can save up to 35% reliance on mains drinking water. Local treatment closes the loop, minimising impact of the development on broader water infrastructure, while avoiding the need for waste-water to be transferred substantial distances

Intelligent pressurised sewers enhance the cost-effectiveness of this solution by eliminating water ingress during wet weather and reducing peak dry-weather loads and discharge of wastewater to the environment is reduced.

Ownership and operation

Utility/local authority. Maintenance of the system to ensure it meets health requirements is ongoing. In the Aquarevo development, South-East Water monitor and maintain the systems, using smart technology to control flows and detect issues

Procurement complexity

Medium to **High** Current costs associated with these systems essentially double network maintenance costs – 2 x pipe networks for conveying the same volume of water. This cost is continually improving though, with rapid advancing technology advances.

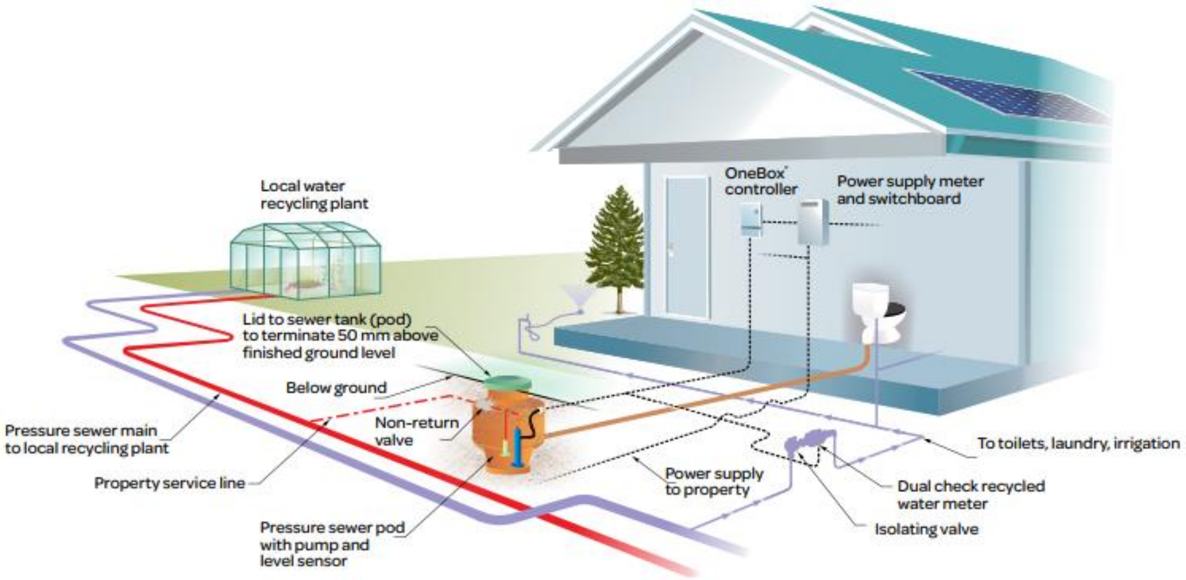


Figure 11-8 Pressure sewer systems
(Source: Southeast Water & Villawood Properties)

https://southeastwater.com.au/residential/upgrades-and-projects/projects/aquarevo/

11.5.1.8 Household Greywater Reuse Systems

Greywater is treated at a household scale for reuse at either the household or neighbourhood scale using the latest filtration technology. An example is the Hydraloop filtration systems, used in the Netherlands.

Key Considerations

Creation of self-sustaining homes can reduce water requirements for a home, development or precinct by up to 85%, increasing drought resilience, sustainability and adaptability. These systems have been installed and are currently being scaled-up in several European countries.

Benefits include:

- Improved water efficiency as new household scale greywater filtration systems can enable reuse of up to 85% of household water
- Reduction in system water losses from storage evaporation & long-distance pipe networks
- Mains water supplementation only required during peak use periods

- Smart water quality monitoring systems can track the household filtration system function and water quality, automatically transferring to mains water if there is a system malfunction
- Implements circular economy principles within local precincts

Implementation recommendations

Medium: The potential for cross connections into drinking water systems need to be carefully managed.

Ownership and operation

Ownership is generally at the household level, with cost of system repairs borne by the householder, unless different business models are considered at either the precinct or Sub-Regional scale.

Current utility business models would need to be redesigned, as mains water use would be significantly reduced.

Procurement complexity

Medium: Household systems are $3-4k for installation, plus ongoing maintenance, which is currently in the range of $200 per year.

Figure 11-9 Household greywater reuse
(Source: C.Thrupp, WaterInnov8)

11.5.1.9 Sustainable Neighbourhoods, with ability to Store and Share Water and Energy

Neighbourhood micro-grids for energy and/or water, usually consisting of household solar or water reuse/generation systems, with infrastructure to connect multiple homes in a local area and/or infrastructure to capture excess energy and peak water for later use in the neighbourhood.

Some examples include:

- Solshare - Village Solar Sharing Project https://me-solshare.com/
- Sustainable neighbourhood with hydropanels for water supply, hydraloop reuse & tank storage

Key Considerations

Sustainable homes and neighbourhoods are increasingly being sought after by climate conscious homeowners, with a range of different designs and scales currently being developed around the world. Creating these sustainable neighbourhoods can combine a range of new technology for energy, water and waste management. Trials are still exploring the scales at which such neighbourhoods are most cost effective.

Energy micro-grids are being developed in many countries around the world, with some of the more advanced approaches enabling new business models for local residents to earn an income from their local infrastructure. Water micro-grids are in early-stage development, usually combined with solar panels for electricity supply and incorporating various household air-water converters and/or water reuse technology.

Implementation recommendations

Medium to high: More sustainable homes and neighbourhoods will minimise the overall water and energy requirements for a development and region.

Ownership and operation

Utilities/ local authorities: new business models will need to be considered for utilities, Councils and landholders. Software-as-a-service platforms now exist to enable effective coordination, monitoring and management of numerous smaller systems.

Procurement complexity

Managing multiple individual systems across each household requires additional coordination and can be more expensive to maintain at larger scales

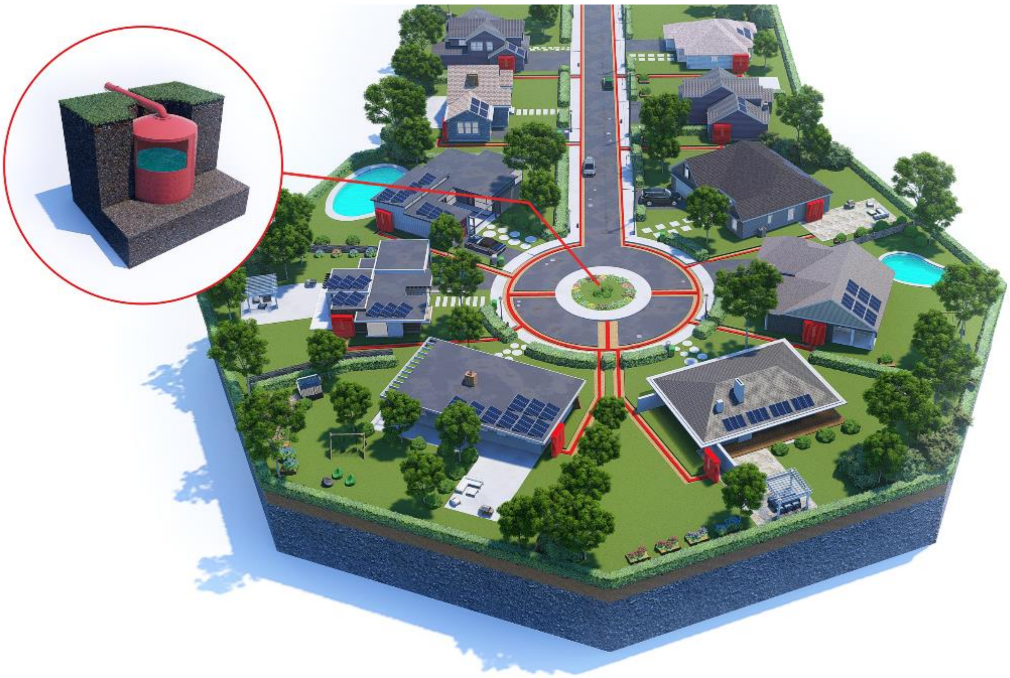


Figure 11-10 Neighbourhood water sharing
(Source: C. Thrupp, WaterInnov8)

11.5.1.10 Integrated Water Servicing – Smart Systems to Manage the Water Cycle

Intelligent utilisation of multiple water resources (e.g. drinking water, recycled water, stormwater) to provide increased water security and reduce environmental impacts. An example is the Aquarevo, Rainwater Tank Smart Monitoring System

Key Considerations

The traditional approach to water management in urban developments is a linear one. Clean water is produced, imported and used (i.e. made dirty) and is then removed, treated to some degree, and disposed. A key limitation of this approach is that all water is treated to a drinking water standard at a high cost, as there is no ability to provide a lower quality water for non-drinking uses.

An integrated water servicing strategy allows the introduction of additional water resources, with the ability to utilise each for different purposes (and potentially even at different times), based on demand, availability, and quality.

Examples include local capture of rainwater for non-drinking, but close contact uses (e.g. supplying laundry, hot water systems), recycled wastewater for non-drinking, low contact uses (e.g. toilet flushing, lawn/garden watering) and drinking water for other domestic purposes. Drinking water can also be plumbed to rainwater tanks to provide a top-up during periods of low rainfall and rainwater tanks can be equipped with smart sensors to drain before a storm; thereby reducing the peak stormwater load during the event.

For community green space, stormwater can be harvested locally and provided as an irrigation water source, backed up by recycled wastewater for irrigation during dry periods.

Typically, harvested rainwater would still require treatment on-site as there is a risk of faecal contamination (bird, vermin etc) or direct vermin entry to the tank. This necessitates on-site treatment, including some type of disinfection.

Further information

- https://www.fishermansbend.vic.gov.au/framework

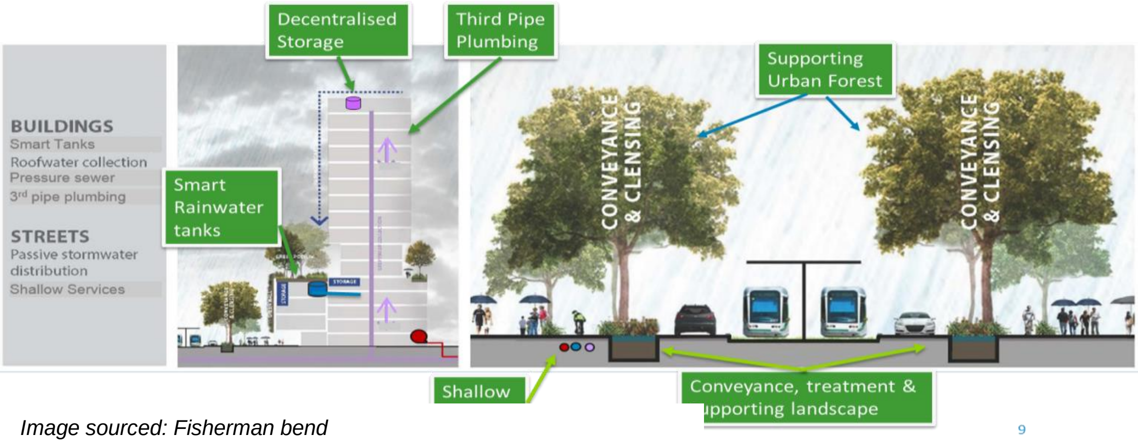


Image sourced: Fisherman bend

Figure 11-11 Example of integrated water supply

Implementation recommendations

Medium. The benefits of integrated water servicing using smart systems include:

- Significant savings in drinking water demand can be achieved
- Stormwater flow reduction (environmental benefit)
- Reduced environmental release of wastewater (and potential benefits of recycled nutrients on irrigated areas)
- Multiple sources of irrigation water to keep community open space green

Ownership and operation

Utility/ local authorities, however onsite treatment and monitoring equipment requires maintenance and Utilities are typically averse to this level of complexity/risk

There is no control or visibility over plumbing works on private property, which could lead to cross-connections or inappropriate water use.

Multiple pipe networks can lead to confusion and any cross-connection of a drinking water supply with another water source can potentially lead to health impacts and/or significant negative reputation impacts

11.5.1.11 Recycled Water Distribution through Stormwater Drainage Network

One of the significant costs in recycled water supply is the cost of distribution and reticulation pipes. An alternative is to use the stormwater drainage system in dry weather when the pipe capacity is unused. The recycled water supply pipe can then be run up the ridge of development with remotely controlled valves to release water into the drain. Water would then run along the drain to the point of demand where it is extracted for use. This maximises the drain's capacity as it is used for dual purposes (stormwater and recycled water) and reduces the cost of recycled water distribution.

Image sourced: Utility Magazine, 2020

Figure 11-12 Illustrative image of water

Key considerations

Key considerations for these examples include topographical constraints, local government appetite, state government support, responsible water authority support, strong customer base and co-location.

Implementation recommendations

Moderate: Opportunity to enhance water recycling and stormwater harvesting resilience, by supplying recycled water into the drainage system to deliver water on demand to the downstream user. Requires a significant downstream irrigation water user(s) as the customer of the scheme. Including regulatory approval and control mechanisms to ensure all recycle water is captured.

Ownership and operation

As the system is an interconnected network it requires centralised management and control. It is logical that the system is operated by local government or the local water authority. However, some assets like extraction pumps and tanks may be privately owned and centrally controlled. Customers would then be able to purchase recycled water directly from the local authority.

Procurement complexity

High: The system could be part of a water security or discharge reduction strategy saving major head works provided by the water authority. The system could also be delivered by the developer in accordance with water authority infrastructure requirements, to be provided to the water authority.

11.5.1.12 Distributed Storage and Smart Systems

Traditional water, sewer and drainage systems are sized for a theoretical worst-case event which occurs rarely. Peak demand for water is 1 in 20 years, design flows for sewer typically are a 1 in 5-year storm event, and peak stormwater for drainage design are a 1 in 100-year flood.

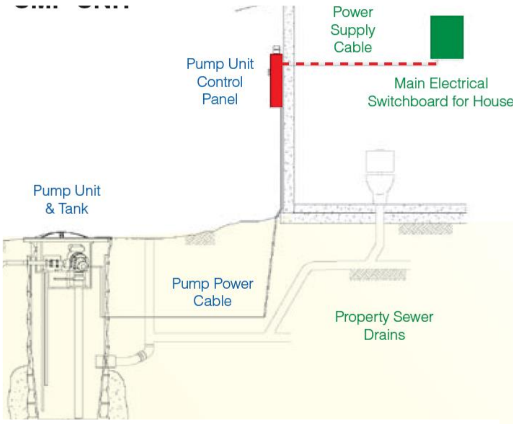


Image sourced: River Shield Southeast Water

Figure 11-13 Example of a distributed storage and smart system

Distributed storages can store these extreme peaks and balance the piped flows in the networks. This is the principal used with retarding basins and water transfer systems, however with a level of conservatism because they are uncontrolled. With an overlay live control on the systems moderating for circumstance, these systems can be worked even harder. For example, providing for future balancing, storage can halve the size of sewage pump stations (from 6* to 3*ADWF), reduce the size of rising mains and impacts on the downstream network, reducing sewage age and odour. In greenfield developments, storage does not need to be built until the catchment is substantially developed and concurrent if the system is monitored for performance. Pressure sewers take this concept to another level. Pump stations poll and wait to share the use of the collection network, so a pipe that services 5 pumps at once, can service 50 pumps overall.

Key considerations

Key considerations for these examples include topographical constraints, local government appetite, state government support, responsible water authority support, strong customer base and co-location.

Implementation recommendations

High: to actively control the operation to the live circumstance. Opportunities within the Flagstone PDA (Flagstone and Beenleigh transfer systems) currently exist to incorporate this IWM sewer solution. Locations that include high cost long transfer pipes will benefit from the use of storage to smooth peak flows rather than build larger pipes for an occasional peak event. To mitigate the risks smart control is proposed

Ownership and operation

The distributed system and smart control would be owned and operated by the responsible water authority.

Procurement complexity

Moderate: The system requirements and management would be defined by the water authority and delivered either by the water authority or a developer, as part of infrastructure works to be provided to the water authority.

Further information

Kansas City, Missouri: https://www.smartcitiesworld.net/special-reports/special-reports/smart-sewers-smart-cities-start-eight-feet-below-the-ground

11.5.1.13 Green Waste Reuse for Energy/Water Generation

Instead of sending green waste to landfill, emerging technology can be used to reuse green waste at a local scale to produce energy and water.

Australian households throw out approximately 2.6 million tonnes of food waste every year, which combines with garden waste to comprise 50% of the total waste from households annually. This organic waste is currently going to landfills, where it is untreated, releasing methane gas to the atmosphere (estimated at 15.3kg methane gas per household per year) (www.metropolitantransferstation.com.au).

An example is the WeDew Sustainable Energy-Water Generator https://www.skysource.org/wedew

Key Considerations

There is new technology available, which is being trialled at differing scales in America and Africa. It uses biomass gasification to create both renewable energy and water for a local neighbourhood. The system is designed at a shipping container scale, capable of creating 25kWh of energy and 2000L of potable water every 24 hours (at a production cost of $0.02 USD per litre).

Implementation recommendations

- Effective reuse of organic material, reduction in volume of waste to landfills and decrease in methane production from landfills
- Cost effective means of producing energy and water
- Smart monitoring systems track the system operation and notify if there is a system malfunction
- Use of circular economy principles to create sustainable neighbourhoods
- Increased drought resilience and sustainability in local communities

Ownership and operation

Current utility business models would need to be redesigned to accommodate the way that waste, water and energy is being managed at this local scale, as well as ensuring coordination across neighbourhoods

Effective neighbourhood scales would need to be trialled to optimise system efficiency and coordination.

11.5.1.14 Biogas Generation from Wastewater for Energy

Urban wastewater is becoming recognised less as a waste product and more as a potential resource. Not only can biosolids be utilised beneficially on farms but wastewater sludge can be broken down to produce biogas, which in turn can be utilised to produce energy. The gas production process is referred to as anaerobic digestion and involves breakdown of organic matter by microorganisms in the absence of oxygen (e.g. in a sealed vessel or reactor). As the organic matter is digested, biogas is produced. The biogas will consist of a relatively high proportion of methane, which is a gas that can be utilised as a fuel for energy production.

An example is the Sydney Water – Malabar Wastewater Treatment Plant

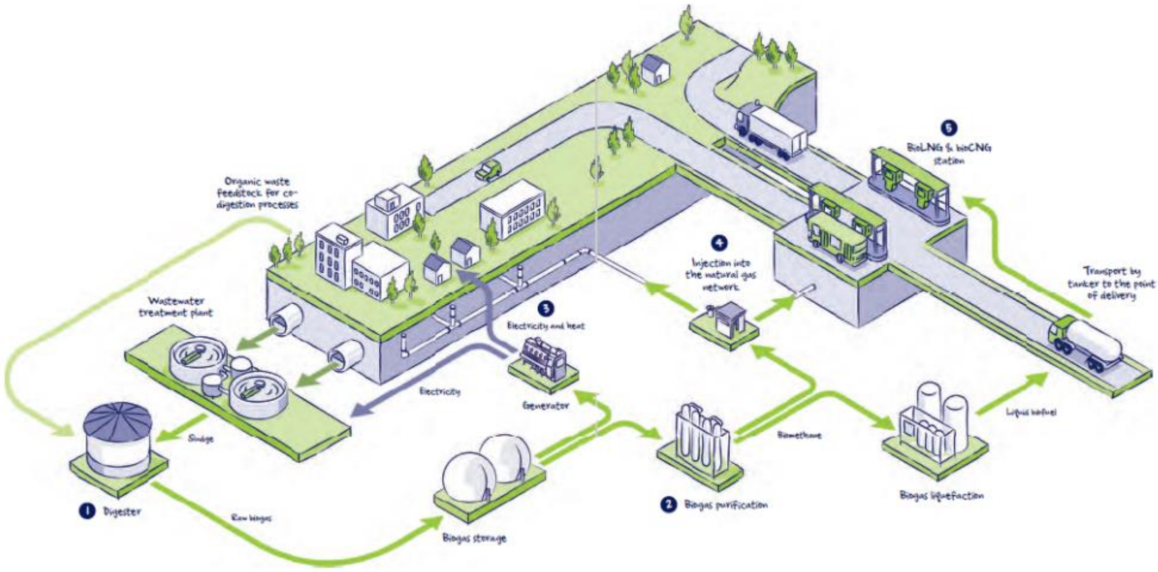


Figure 11-14 Biogas generation loop

(Source: Suez)

https://www.suez.com.au/-/media/suez-au/files/publication-docs/products-and-services/suez_anz_switching_on_biogas_resource.pdf

Key Considerations

Wastewater treatment is an energy intensive process and is becoming increasingly so as environmental regulation increases and pollutant release limits become more stringent. The cost of energy is also increasing, which is often a significant proportion of a wastewater treatment plant's operational cost.

Biogas production and onsite utilisation can help to reduce the overall energy footprint of a wastewater treatment plant. It can be beneficial in both reducing the long-term operational costs of the plant but also play a role in mitigation of energy related climate change impacts.

Where decentralised systems are being proposed, engineering a wastewater treatment plant that is partially or fully self-powered through renewable energy may also increase the appeal when it comes to identifying and securing a long-term Operator.

Implementation recommendations

Medium. The benefits of this type of system include:

- Source of energy to offset cost of operating wastewater treatment plant
- Sewage sludge is a reliable resource for renewable energy production (i.e. not dependant on sun or wind)
- Lower CO2 footprint for the wastewater treatment plant as lower external energy inputs are required (assuming existing energy supply involves fossil fuel consumption)
- Reduces wastewater sludge that needs to be disposed of to landfill
- Potential to accept other wastes for a fee (where beneficial to the digestion process)
- A key challenge is that gas production significantly benefits from external/ imported carbon inputs (e.g. food processing waste).

Ownership and operation

Utility/ local authority due to operations and maintenance requirements – this is a high-tech process requiring ongoing oversight and management.

Procurement complexity

Medium to **high** – While the costs of this approach are still being determined via trial programs, the costs are expected to be relatively high. This is not only for the additional infrastructure at the wastewater treatment plant but also the expertise required in the design, build, operation and maintenance of the infrastructure. Although there are several successful case studies abroad, the technology is not yet widespread in Australia. Yield may also be highly dependent on the external inputs that can be sourced. All these factors mean that it may be difficult to prepare a reliable business case now, but this will improve with time.

Existing projects are predominantly large scale (i.e. city scale); smaller scale projects are relatively rare and may be difficult to justify economically

11.5.1.15 Aquifer Storage & Recovery

Water is stored in underground aquifers during rainfall and flood events or from recycled water for later use, especially during droughts. Examples include:

- Water Corporation in Western Australia https://www.watercorporation.com.au/Our-water/Groundwater/Groundwater-replenishment

- Austin, Texas – Aquifer Storage Program http://austintexas.gov/department/water-forward-drought-supplies .

Key Considerations

Aquifer storage is being increasingly used in dry areas around the world. If designed well, this strategy can capture some of the peak flows, reduce water loss from evaporation in surface water storages and reduce distances from water storage to point of use.

Implementation recommendations

Low to Medium: The aquifer recharge potential in the PDA is not well understood due to limited data. Porosity of aquifers would need to be understood to ensure that water losses through the soil profile were minimised. However, the benefits of these systems include:

- Reduction in peak flows
- Less water loss from evaporation
- Smaller distances for transport of water to point of use
- Less energy required for water supply

Ownership and operation

Utility/ local authority due to careful management of environmental requirements.

Procurement complexity

Medium to High: considerable research would need to be undertaken of the aquifer as well as trials/pilots to understand impacts and manage the process.

11.5.1.16 New Pipe Technology

There are a range of new in-pipe technologies that can ensure that maximum benefit is obtained from pipe infrastructure. These include in-pipe water filtration and energy generation. Examples include:

- In-Pipe Energy Generation https://www.cleantechconcepts.com/2017/02/lucid-energy-has-a-creative-use-for-water-pipes/
- Wastewater biopipe treatment systems https://www.biopipe.co/

Key Considerations

Water and sewer pipes have traditionally been considered for one purpose; however, new technology enables these pipes to have multiple purposes. Where this new technology has been applied in other areas of the world, it has been used for a range of reasons, from reducing the ongoing maintenance costs across the lifecycle of the pipe network, improving water quality, through to supplementation of local energy supply.

Implementation recommendations

Medium - the benefits include:

- Improved water efficiency
- Energy generation
- Improved water quality at water treatment plants and/or overflows to the environment
- Multiple benefit pipes

Ownership and operation

Utility/ local authority

Procurement complexity

Medium to **High** - Depending on technology being implemented, initial cost of pipe installation is likely to be higher than traditional methods. Given the early stage of some of these technologies, ongoing maintenance costs of these pipes are not fully understood yet. However, other countries are implementing these solutions, so data will be rapidly building up to address any gaps in knowledge.

11.5.1.17 Rapid Water Treatment Systems

New technology is enabling faster, high level water treatment, with treatment times down to 30 minutes. This is particularly useful for sewer or combined sewer overflows during a storm event. Examples include:

- Rapid Radicals Technology – Wastewater Treatment, Wisconsin https://www.rapidradicals.com/

Key Considerations

Wastewater treatment plants are unable to cope with peak flows during a storm event, so sewer and combined systems are designed to overflow to the natural environment during storms. This results in untreated wastewater and stormwater flowing into local creeks, rivers and the ocean. The ability to treat water quickly provides the opportunity for high level treatment of this water during storms prior to release into local waterways.

Implementation recommendations

Low: This is early-stage technology just being implemented in the USA, so costs and retrofit design options are still being fully understood. However benefits include:

- Improved water quality being released to creeks, rivers and oceans
- Improved treatment efficiency
- Reduction in human health risks associated with use of recreational waters
- Reduction in back-up of water within pipes during storms

Ownership and operation

Utility/ local authority

Procurement complexity

High: this is early-stage technology and implementation costs are expected to be high.

11.5.1.18 End of Pipe Treatment Systems

Emerging technology is enabling filtration of water at the end of pipe. This will enable better water quality being released into local creeks, rivers and the ocean. Examples include:

- Carbon Fibre Aerogel https://www.ecoworth-tech.com/what-is-cfa

Key Considerations

Untreated stormwater and wastewater overflows are released to the natural environment during storms. This results in a release of pollutants to the environment and deterioration of water quality in local creeks, rivers and the ocean. The ability to screen or treat water prior to release into the natural environment would improve waterway health, reduce plastics in the ocean and improve recreational water quality for swimmers.

Implementation Recommendations

Low to **medium**: This is early-stage technology just being implemented in Singapore, so costs and design options are still being fully understood. Benefits include:

- Improved water quality being released to creeks, rivers and oceans
- Reduction in human health risks associated with use of recreational waters
- Reduction in plastic release to waterways and the ocean

Ownership and operation

Utility/ local authority due to operations and maintenance requirements.

Procurement complexity

High: this is early-stage technology and implementation costs are expected to be high.

11.5.1.19 Smart City/Smart Monitoring Systems

Sensors embedded into stormwater, sewer and other networks to track real-time performance, with data captured in cloud-based software-as-a-service programs to provide graphic dashboards for managers to action. Examples include:

- Stormsensor, USA https://www.stormsensor.io/
- Io Tank, San Francisco https://www.iotank.org/
- Data Technics, Bermingham http://datatecnics.com/

Key Considerations

Traditional monitoring has been undertaken manually at the end of pipe or via in-pipe cameras being used to look at the condition of pipes. This monitoring is usually retrospective, often triggered when there is a leak or release of contaminants to the environment. It can be expensive and is not effectively scalable to entire pipe networks.

New technology allows for sensors to be built into the pipe network to create real-time data on pipe condition, water quality, flow and other key measures. This enables rapid response teams to fix a problem before contamination or water loss occurs. It also enables optimisation of the water network management & maintenance.

Implementation recommendations

Medium to **High** – the benefits include:

- Real time data for improved management of water supply and water quality
- Retrofitting of sensors is possible
- Proactive management of the water network across the asset lifecycle
- Adaptable embedded sensors can be effectively built into all new developments, if considered early in the design phase

Ownership and operation

Utility/ local authority

Procurement complexity

Medium – recommended to be designed for co-installation during installation of infrastructure as it can be capital intensive to install sensors retrospectively.

11.5.1.20 Integrated Flood Detention Systems

Flood detention is commonly provided in urban developments and is often designed to ensure no increase in flooding at the development boundary. In many cases, a site-by-site basis to flood detention, using only site-specific design storms, may result in poor outcomes such as increased flooding due to disparate flood detention systems causing coincidence of flood peaks. Examples include:

- CRC for Water Sensitive Cities – Sponge City Innovation Park, China
- CRC for Water Sensitive Cities – Forest Park Ecological Wetland

Key Considerations

Flood detention is typically provided on a site-by-site basis, with the generally accepted objective of ensuring no worsening of flood peaks at the development boundary, for one set of specific design storm temporal patterns. Such detention is rarely designed regarding the wider catchment context.

A catchment-wide coordinated approach to flood detention is most likely approach to ensure that flood detention is delivered in the most efficient and effective manner.

Note a Sub-Regional approach might entail:

- Having a small number of larger Sub-Regional detention basins sited at catchment outlets,
- A distributed approach where many smaller basins are planned and designed to deliver a clear overall purpose.

A study by Ronalds and Zhang (2019) used a probabilistic Monte Carlo analysis to evaluate various flood detention approaches and assess how flood detention performs in various parts of a catchment. It found that detention can reduce the chance of increased runoff from 99% to less than 8% when a land parcel is in the upper reaches of a catchment. In the lower portion of the same catchment, the same detention has a 72% chance of increasing runoff, compared to a 58% chance without.

Implementation recommendations

Medium – development would require coordination by developers and regulators. Benefits include:

- Beneficial flood management outcomes
- More efficient land use with less land dedicated to flood detention with low effectiveness.

Ownership and operation

Utility/ local authority.

Procurement complexity

Medium to **high** - Costs of these systems will vary depending on catchment hydrology and ultimate development scenarios. Typical costs for on-site underground stormwater detention systems range from \$300 - \$1000/m³. A contribution scheme would need to be established to ensure equitable contributions to Sub-Regional detention basins.

Further information

- Greening Australia – Tackling Heat Island Effect: https://www.greeningaustralia.org.au/how-can-nature-help-tackle-the-urban-heat-island-effect
- City of Sydney Greening Sydney Plan: https://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0009/135882/GreeningSydneyPlan.pdf
- https://www.cityofsydney.nsw.gov.au/vision/better-infrastructure/streets-and-public-places/completed-works/greening-our-streets
- Urban Heat Island effect: https://watersource.awa.asn.au/environment/built-environment/losing-our-cool-how-water-can-help-combat-urban-heat/

- City of Yarra Green Infrastructure Best Practice Toolkit: https://www.yarracity.vic.gov.au/about-us/sustainability-initiatives/embedding-green-infrastructure-toolkit
- Cooperative Research Centre for Water Sensitive Cities – Ideas for Fishermans Bend: https://watersensitivecities.org.au/wp-content/uploads/2016/04/Ideas-for-FishermansBend-REPORT.pdf
- Yarra Council Toolkit – practical options: http://www.wdc.govt.nz/PlansPoliciesandBylaws/Plans/State-of-the-Environment/Pages/Blue-Green-Network-Strategy.aspx
- Heat Island Effect – Penrith City Council: Cooling the City:
- https://www.yoursaypenrith.com.au/25909/widgets/192402/documents/151999
- US EPA – Heat Islands: https://www.epa.gov/heatislands
- CoolSeal Pavement: https://guardtop.com/coolseal/
- https://www.charlessturt.sa.gov.au/environment/climate-change/coolseal

11.5.1.21 Integrated Stormwater Management – Decentralised Stormwater Capture

Householders in a catchment are provided with smart rainwater tanks that can be controlled from a central location so that they act as decentralised storage. Each tank's drain valve is centrally controlled to release water to the central drainage system. When the customer requires water there is a controlled release of water to the drain system to meet the customer needs, who then draws from the downstream drain. This system is like irrigation modernisation where the farmer orders water from the dam and it is delivered via irrigation channels. The Smart Water Victoria trial did this with household tanks, but it could also be applied to upstream community storages or even controlled wetlands.

Key considerations

Key considerations for these examples include topographical constraints, local government appetite, state government support, responsible water authority support, strong customer base and co-location.

Implementation recommendations

Moderate: Opportunity to enhance stormwater harvesting, retardation and nutrient reduction by using upstream storage to deliver water on demand to the downstream users requires a significant downstream irrigation water user(s) as the customer base of the scheme. Using decentralised storage systems and tanks to hold the available water source also requires customer education.

Ownership and operation

Given the system is an interconnected network that requires centralised management and control it is logical it be operated by local government. However, some assets like rainwater tanks may be privately owned and controlled, resulting in customers then having to purchase alternative water from the council.

Procurement complexity

Moderate: Has the potential to form part of an alternative flood mitigation and nutrient reduction strategy saving downstream works and therefore should be provided by the developer as part of required drainage solutions. Alternatively, it may form part of a water supply scheme delivered by the developer with additional costs funded by the alternative water supply. Subject to local government policy position and resource allocations.

Further information

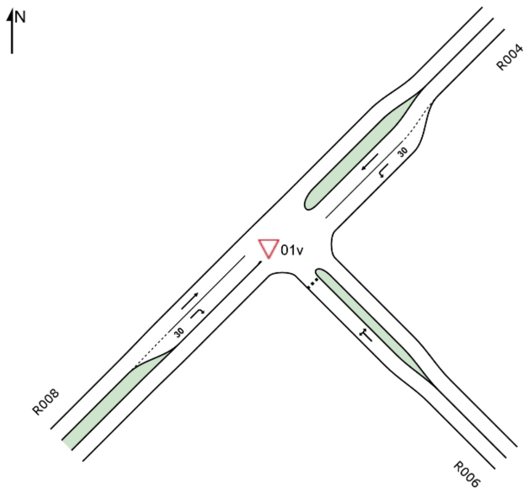
- https://www.stormwater.asn.au/images/Conference_Papers/Stormwater12/McGrath_Jonathan_et_al_-_Non_Refereed_Paper.pdf

Appendix A SIDRA Intersection Layouts

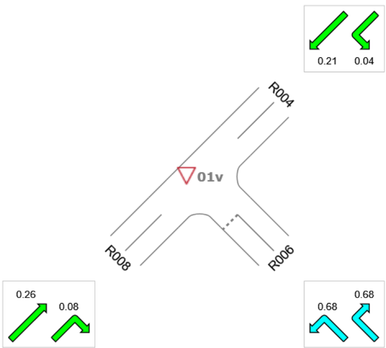
1 Intersection R1001

2031

SITE LAYOUT – R1001 – 2031



DEGREE OF SATURATION AM



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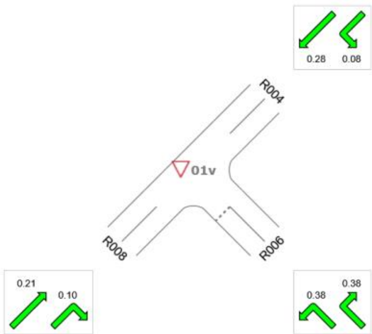

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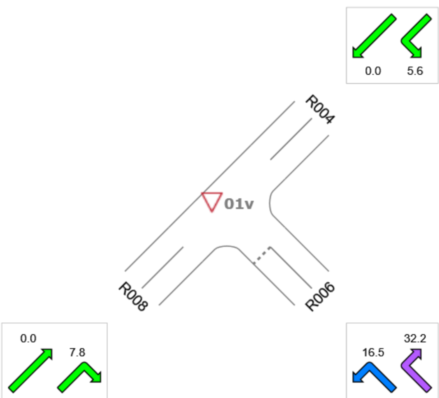

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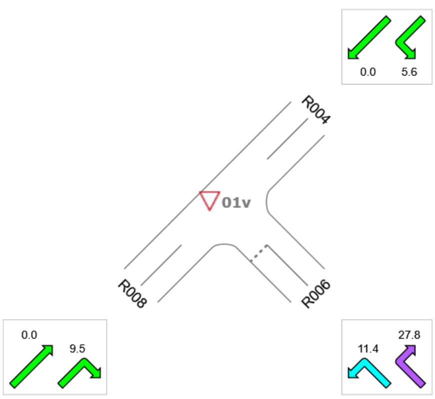


Intersection R1001 – 2031 Cont.

MOVEMENT SUMMARY 2031 AM

Site: 01v [2031 AM]

R1001
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
SouthEast: R006												
4	L2	81	0.0	0.683	16.5	LOS C	4.3	30.5	0.82	1.18	1.66	41.0
6	R2	143	0.7	0.683	32.2	LOS D	4.3	30.5	0.82	1.18	1.66	40.8
Approach		224	0.5	0.683	26.5	LOS D	4.3	30.5	0.82	1.18	1.66	40.9
NorthEast: R004												
7	L2	77	1.4	0.042	5.6	LOS A	0.0	0.0	0.00	0.58	0.00	53.6
8	T1	394	3.5	0.206	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
Approach		471	3.1	0.206	0.9	NA	0.0	0.0	0.00	0.09	0.00	58.8
SouthWest: R008												
2	T1	493	1.9	0.257	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
3	R2	66	0.0	0.077	7.8	LOS A	0.3	2.0	0.49	0.70	0.49	51.4
Approach		559	1.7	0.257	1.0	NA	0.3	2.0	0.06	0.08	0.06	58.8
All Vehicles		1254	2.0	0.683	5.5	NA	4.3	30.5	0.17	0.28	0.32	54.5

MOVEMENT SUMMARY 2031 PM

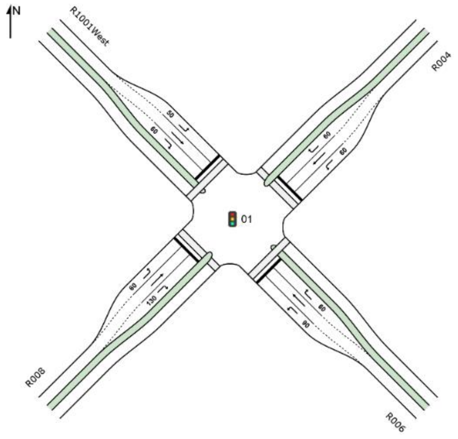
Site: 01v [2031 PM]

R1001
Site Category: (None)
Giveway / Yield (Two-Way)

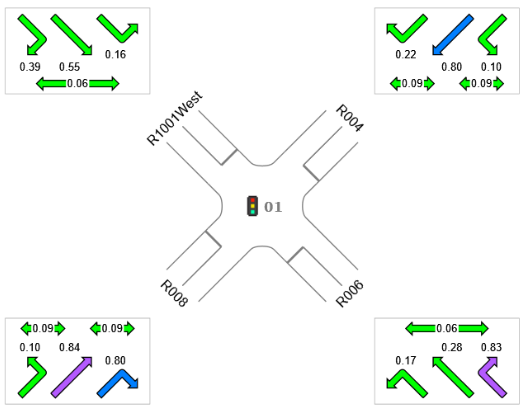
Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
SouthEast: R006												
4	L2	47	0.0	0.378	11.4	LOS B	1.5	10.9	0.79	0.98	1.03	43.9
6	R2	62	1.7	0.378	27.8	LOS D	1.5	10.9	0.79	0.98	1.03	43.7
Approach		109	1.0	0.378	20.7	LOS C	1.5	10.9	0.79	0.98	1.03	43.8
NorthEast: R004												
7	L2	139	0.8	0.075	5.6	LOS A	0.0	0.0	0.00	0.58	0.00	53.6
8	T1	546	1.3	0.283	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
Approach		685	1.2	0.283	1.2	NA	0.0	0.0	0.00	0.12	0.00	58.5
SouthWest: R008												
2	T1	404	2.1	0.212	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
3	R2	64	0.0	0.098	9.5	LOS A	0.4	2.5	0.58	0.81	0.58	50.1
Approach		468	1.8	0.212	1.3	NA	0.4	2.5	0.08	0.11	0.08	58.4
All Vehicles		1263	1.4	0.378	2.9	NA	1.5	10.9	0.10	0.19	0.12	56.8

Intersection R1001-2041

SITE LAYOUT – R1001 - 2041



DEGREE OF SATURATION AM



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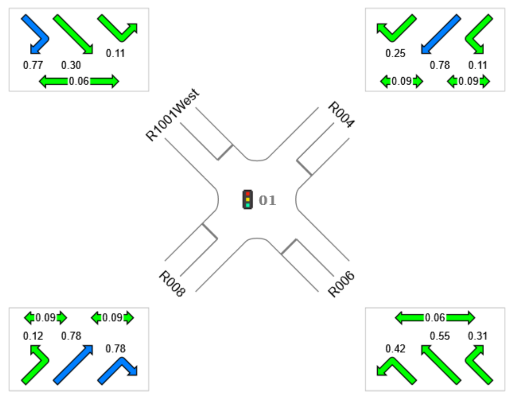
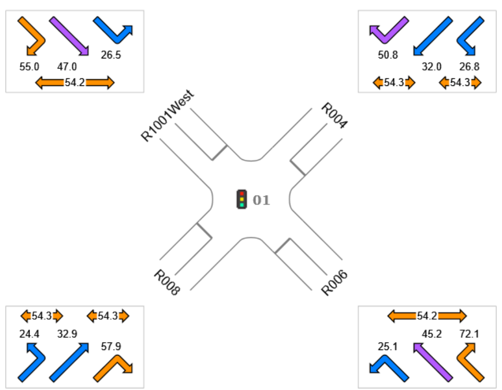


DELAY CONTROL (seconds) AM



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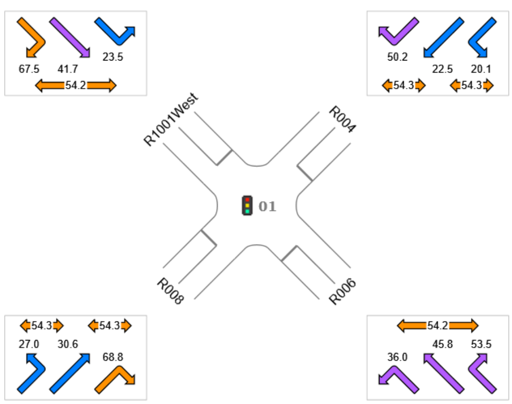


LANE SUMMARY 2041 AM

Site: 01 [2041 AM]

R1001
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R006													
Lane 1	142	2.2	853	0.167	100	25.1	LOS C	4.7	33.7	Short	90	0.0	NA
Lane 2	106	2.0	385	0.276	100	45.2	LOS D	5.3	37.8	Full	500	0.0	0.0
Lane 3	117	0.9	140	0.833	100	72.1	LOS E	7.6	53.9	Short	60	0.0	NA
Approach	365	1.7		0.833		46.0	LOS D	7.6	53.9				
NorthEast: R004													
Lane 1	78	2.7	790	0.099	100	26.8	LOS C	2.7	19.0	Short	60	0.0	NA
Lane 2	609	3.3	763 [1]	0.799	100	32.0	LOS C	30.4	219.1	Full	500	0.0	0.0
Lane 3	75	0.0	340	0.220	100	50.8	LOS D	3.8	26.3	Short	60	0.0	NA
Approach	762	2.9		0.799		33.3	LOS C	30.4	219.1				
NorthWest: R1001West													
Lane 1	126	1.7	795	0.159	100	26.5	LOS C	4.4	31.5	Short	50	0.0	NA
Lane 2	213	2.0	385	0.552	100	47.0	LOS D	11.3	80.7	Full	500	0.0	0.0
Lane 3	80	0.0	208	0.385	100	55.0	LOS E	4.3	30.4	Short	60	0.0	NA
Approach	419	1.5		0.552		42.4	LOS D	11.3	80.7				
SouthWest: R008													
Lane 1	83	0.0	867	0.096	100	24.4	LOS C	2.7	18.6	Short	60	0.0	NA
Lane 2	678	1.9	804 [1]	0.843	100	32.9	LOS C	35.1	249.9	Full	500	0.0	0.0
Lane 3	319	1.3	399	0.800	100	57.9	LOS E	18.9	134.0	Short	130	0.0	NA
Approach	1080	1.6		0.843		39.7	LOS D	35.1	249.9				
Intersection	2626	2.0		0.843		39.1	LOS D	35.1	249.9				

Intersection R1001 – 2041 Cont.

LANE SUMMARY 2041 PM

Site: 01 [2041 PM]

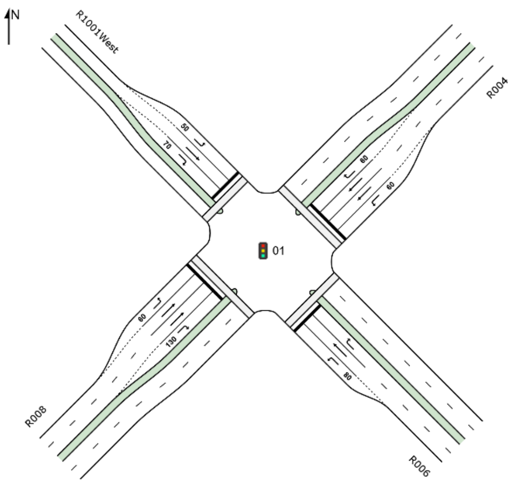
R1001
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

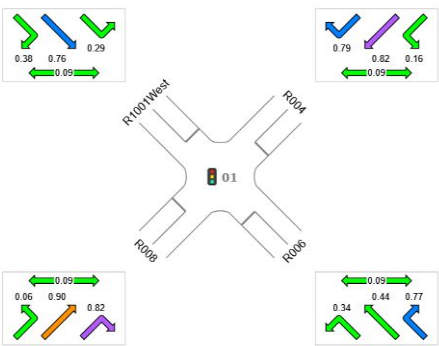
	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R006													
Lane 1	287	0.7	677	0.424	100	36.0	LOS D	12.5	88.4	Short	90	0.0	NA
Lane 2	239	1.3	435	0.549	100	45.8	LOS D	12.5	88.3	Full	500	0.0	0.0
Lane 3	71	1.5	226	0.312	100	53.5	LOS D	3.7	26.3	Short	60	0.0	NA
Approach	597	1.1		0.549		42.0	LOS D	12.5	88.4				
NorthEast: R004													
Lane 1	105	1.0	983	0.107	100	20.1	LOS C	3.0	21.1	Short	60	0.0	NA
Lane 2	741	1.3	946 [1]	0.784	100	22.5	LOS C	32.4	229.2	Full	500	0.0	0.0
Lane 3	88	0.0	356	0.248	100	50.2	LOS D	4.4	31.0	Short	60	0.0	NA
Approach	935	1.1		0.784		24.9	LOS C	32.4	229.2				
NorthWest: R1001West													
Lane 1	95	0.0	867	0.109	100	23.5	LOS C	3.1	21.4	Short	50	0.0	NA
Lane 2	128	1.6	434	0.296	100	41.7	LOS D	6.3	44.5	Full	500	0.0	0.0
Lane 3	102	0.0	133	0.768	100	67.5	LOS E	6.5	45.4	Short	60	0.0	NA
Approach	325	0.6		0.768		44.5	LOS D	6.5	45.4				
SouthWest: R008													
Lane 1	93	0.0	805	0.115	100	27.0	LOS C	3.2	22.2	Short	60	0.0	NA
Lane 2	602	1.9	772 [1]	0.780	100	30.6	LOS C	29.2	207.7	Full	500	0.0	0.0
Lane 3	132	1.6	168	0.782	100	68.8	LOS E	8.2	58.2	Short	130	0.0	NA
Approach	826	1.7		0.782		36.2	LOS D	29.2	207.7				
Intersection	2683	1.2		0.784		34.6	LOS C	32.4	229.2				

Intersection R1001-2066

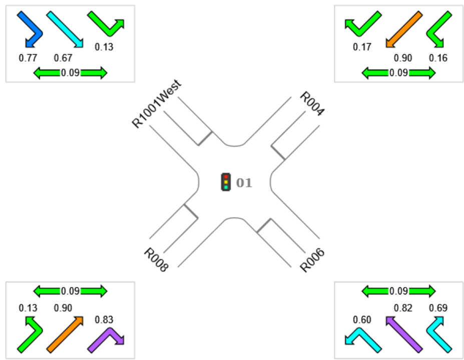
SITE LAYOUT – R1001 – 2066



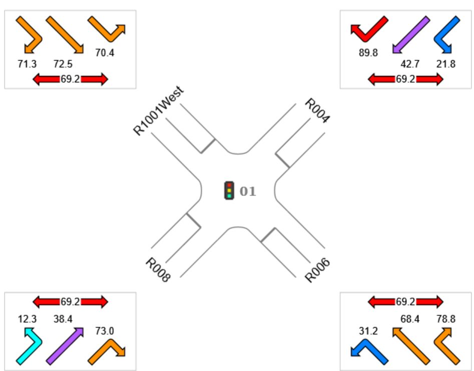
DEGREE OF SATURATION AM



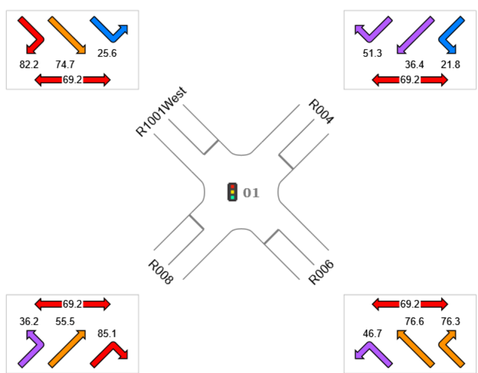
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1001 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 01 [2066 AM]

R1001

Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 150 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R006													
Lane 1	193	4.4	564	0.341	100	31.2	LOS C	7.9	57.4	Short	80	0.0	NA
Lane 2	101	2.1	231	0.438	100	68.4	LOS E	7.0	49.8	Full	500	0.0	0.0
Lane 3	168	1.9	220	0.766	100	78.8	LOS E	12.6	89.7	Full	500	0.0	0.0
Approach	462	3.0		0.766		56.7	LOS E	12.6	89.7				
NorthEast: R004													
Lane 1	165	3.2	1029	0.161	100	21.8	LOS C	5.6	40.4	Short	60	0.0	NA
Lane 2	535	3.7	650[1]	0.824	100	42.4	LOS D	33.5	242.1	Full	500	0.0	0.0
Lane 3	588	3.7	713[1]	0.824	100	43.0	LOS D	37.7	272.4	Full	500	0.0	0.0
Lane 4	68	0.0	87	0.789	100	89.8	LOS F	5.4	38.0	Short	60	0.0	NA
Approach	1357	3.5		0.824		42.5	LOS D	37.7	272.4				
NorthWest: R1001West													
Lane 1	64	0.0	223	0.288	100	70.4	LOS E	4.4	30.5	Short	50	0.0	NA
Lane 2	175	1.8	231[1]	0.756	100	72.5	LOS E	13.0	92.3	Full	500	0.0	0.0
Lane 3	85	0.0	223	0.383	100	71.3	LOS E	5.9	41.0	Short	70	0.0	NA
Approach	324	1.0		0.756		71.8	LOS E	13.0	92.3				
SouthWest: R008													
Lane 1	84	0.0	1325	0.064	100	12.3	LOS B	1.8	12.5	Short	60	0.0	NA
Lane 2	896	2.4	990[1]	0.904	100	38.4	LOS D	60.1	429.3	Full	500	0.0	0.0
Lane 3	806	2.4	892[1]	0.904	100	38.3	LOS D	51.5	367.7	Full	500	0.0	0.0
Lane 4	288	2.2	354	0.816	100	73.0	LOS E	21.5	153.0	Short	130	0.0	NA
Approach	2075	2.2		0.904		42.1	LOS D	60.1	429.3				
Intersection	4218	2.6		0.904		46.1	LOS D	60.1	429.3				

Intersection R1001 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 01 [2066 PM]

R1001

Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 150 seconds (Site User-Given Phase Times)

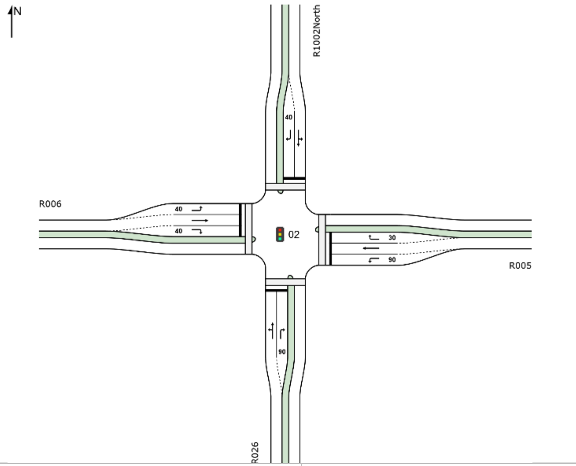
Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R006													
Lane 1	236	1.8	391	0.603	100	46.7	LOS D	13.0	92.7	Short	80	0.0	NA
Lane 2	189	1.1	232	0.816	100	76.6	LOS E	14.5	102.4	Full	500	0.0	0.0
Lane 3	153	1.4	221	0.692	100	76.3	LOS E	11.1	78.7	Full	500	0.0	0.0
Approach	578	1.5		0.816		64.3	LOS E	14.5	102.4				
NorthEast: R004													
Lane 1	167	1.3	1043	0.160	100	21.8	LOS C	5.7	40.2	Short	60	0.0	NA
Lane 2	858	1.7	951 [1]	0.902	100	36.3	LOS D	54.5	386.9	Full	500	0.0	0.0
Lane 3	920	1.7	1019 [1]	0.902	100	36.4	LOS D	60.6	430.3	Full	500	0.0	0.0
Lane 4	80	0.0	483	0.166	100	51.3	LOS D	4.5	31.4	Short	60	0.0	NA
Approach	2025	1.6		0.902		35.7	LOS D	60.6	430.3				
NorthWest: R1001West													
Lane 1	85	0.0	644	0.132	100	25.6	LOS C	3.0	20.8	Short	50	0.0	NA
Lane 2	114	0.0	169	0.673	100	74.7	LOS E	8.4	59.0	Full	500	0.0	0.0
Lane 3	124	0.0	161	0.772	100	82.2	LOS F	9.5	66.5	Short	70	0.0	NA
Approach	323	0.0		0.772		64.6	LOS E	9.5	66.5				
SouthWest: R008													
Lane 1	97	0.0	730	0.133	100	36.2	LOS D	4.4	31.1	Short	60	0.0	NA
Lane 2	616	2.3	683 [1]	0.902	100	55.4	LOS E	45.5	324.5	Full	500	0.0	0.0
Lane 3	627	2.3	695 [1]	0.902	100	55.5	LOS E	46.5	331.5	Full	500	0.0	0.0
Lane 4	141	2.2	171	0.827	100	85.1	LOS F	11.0	78.6	Short	130	0.0	NA
Approach	1481	2.1		0.902		57.0	LOS E	46.5	331.5				
Intersection	4407	1.6		0.902		48.8	LOS D	60.6	430.3				

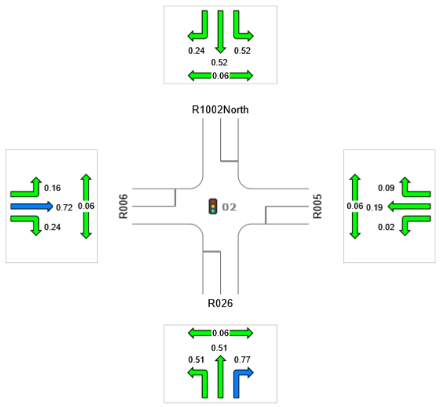
2 Intersection R1002

2041

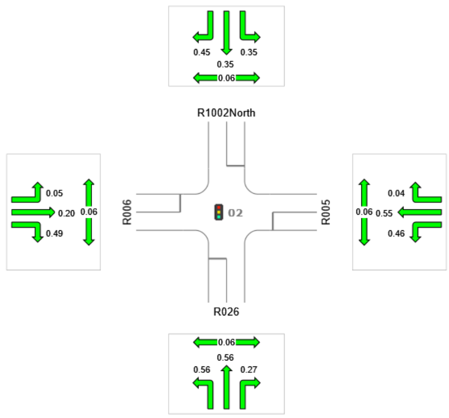
SITE LAYOUT – R1002 – 2041



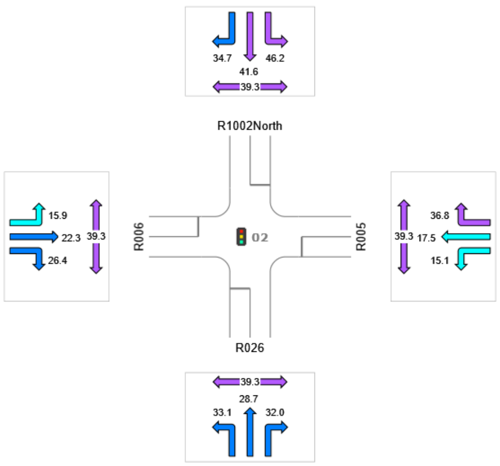
DEGREE OF SATURATION AM



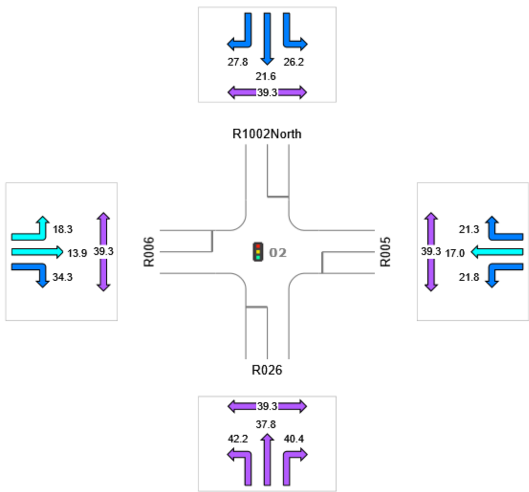
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1002 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 02 [2041 AM]

R1002
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R026													
Lane 1	300	1.4	589	0.509	100	30.5	LOS C	10.9	77.1	Full	500	0.0	0.0
Lane 2	406	1.8	527	0.770	100	32.0	LOS C	13.8	98.3	Short	90	0.0	NA
Approach	706	1.6		0.770		31.4	LOS C	13.8	98.3				
East: R005													
Lane 1	23	4.5	999	0.023	100	15.1	LOS B	0.4	3.3	Short	90	0.0	NA
Lane 2	154	4.1	802	0.192	100	17.5	LOS B	4.2	30.5	Full	500	0.0	0.0
Lane 3	19	5.6	200	0.095	100	36.8	LOS D	0.7	5.1	Short	30	0.0	NA
Approach	196	4.3		0.192		19.1	LOS B	4.2	30.5				
North: R1002North													
Lane 1	122	0.0	236	0.517	100	42.4	LOS D	5.3	36.8	Full	500	0.0	0.0
Lane 2	74	0.0	303	0.244	100	34.7	LOS C	2.7	18.8	Short	40	0.0	NA
Approach	196	0.0		0.517		39.5	LOS D	5.3	36.8				
West: R006													
Lane 1	168	0.6	1027	0.164	100	15.9	LOS B	3.6	25.1	Short	40	0.0	NA
Lane 2	506	1.5	699 [1]	0.724	100	22.3	LOS C	17.6	124.9	Full	500	0.0	0.0
Lane 3	115	1.8	478	0.240	100	26.4	LOS C	3.5	24.8	Short	40	0.0	NA
Approach	789	1.3		0.724		21.6	LOS C	17.6	124.9				
Intersection	1887	1.6		0.770		26.8	LOS C	17.6	124.9				

Intersection R1002 – 2041 Cont.

LANE SUMMARY 2041 PM

Site: 02 [2041 PM]

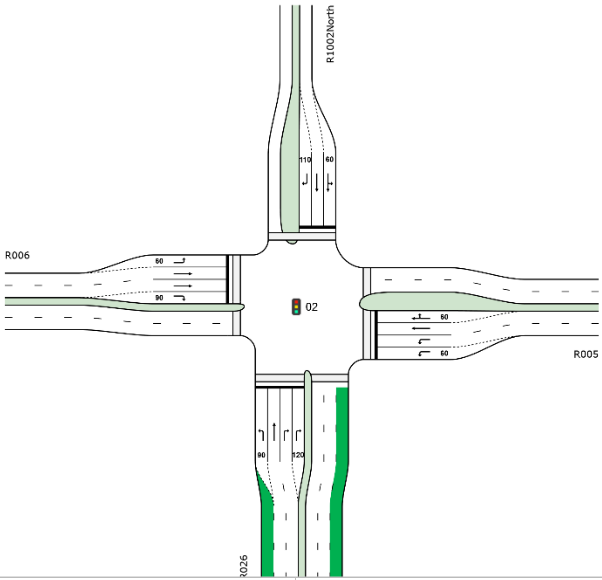
R1002
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

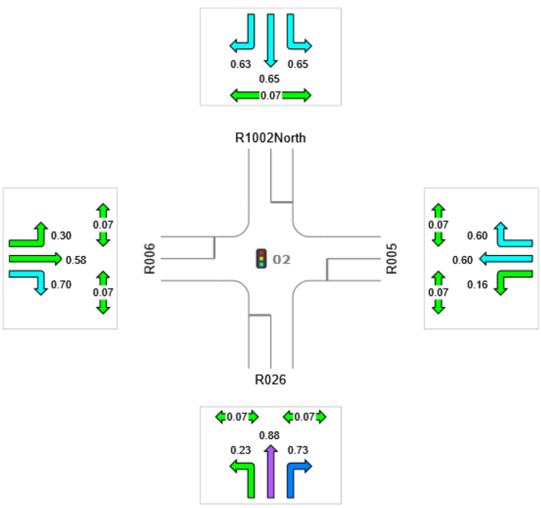
	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R026													
Lane 1	201	0.5	357	0.563	100	40.2	LOS D	8.2	57.9	Full	500	0.0	0.0
Lane 2	67	1.6	253	0.266	100	40.4	LOS D	2.6	18.6	Short	90	0.0	NA
Approach	268	0.8		0.563		40.2	LOS D	8.2	57.9				
East: R005													
Lane 1	413	1.3	900	0.459	100	21.8	LOS C	11.9	84.2	Short	90	0.0	NA
Lane 2	504	1.0	913 [1]	0.552	100	17.0	LOS B	15.2	107.6	Full	500	0.0	0.0
Lane 3	22	0.0	528	0.042	100	21.3	LOS C	0.6	3.9	Short	30	0.0	NA
Approach	939	1.1		0.552		19.2	LOS B	15.2	107.6				
North: R1002North													
Lane 1	255	1.2	726	0.351	100	22.2	LOS C	8.0	56.8	Full	500	0.0	0.0
Lane 2	173	0.6	381	0.453	100	27.8	LOS C	5.5	38.5	Short	40	0.0	NA
Approach	427	1.0		0.453		24.4	LOS C	8.0	56.8				
West: R006													
Lane 1	45	0.0	908	0.050	100	18.3	LOS B	1.0	7.2	Short	40	0.0	NA
Lane 2	189	2.8	936	0.202	100	13.9	LOS B	4.7	33.5	Full	500	0.0	0.0
Lane 3	106	1.0	218	0.488	100	34.3	LOS C	4.0	28.4	Short	40	0.0	NA
Approach	341	1.9		0.488		20.8	LOS C	4.7	33.5				
Intersection	1976	1.2		0.563		23.5	LOS C	15.2	107.6				

Intersection R1002-2066

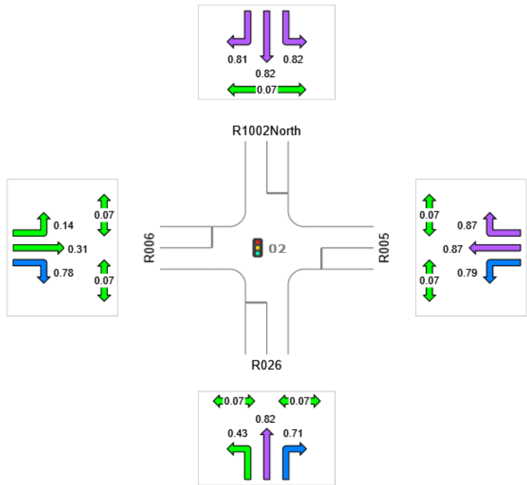
SITE LAYOUT – R1002 – 2066



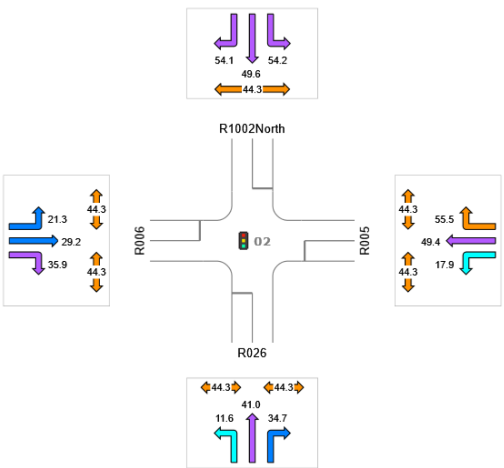
DEGREE OF SATURATION AM



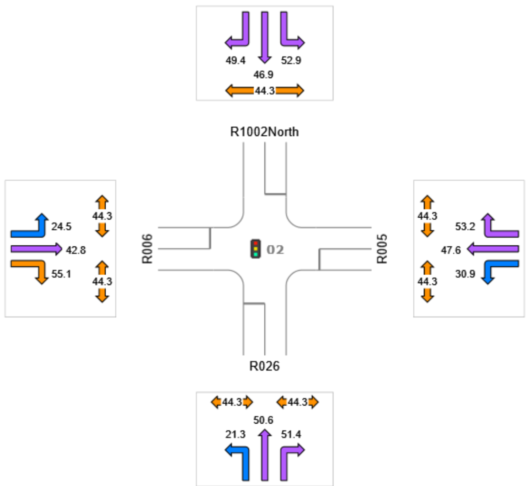
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1002 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 02 [2066 AM]

R1002

Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 100 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R026													
Lane 1	240	0.9	1034	0.232	100	11.6	LOS B	3.0	21.5	Two Seg [10]	500	0.0	0.0
Lane 2	596	2.3	679 [1]	0.878	100	41.0	LOS D	30.5	218.0	Full	500	0.0	0.0
Lane 3	504	3.5	688	0.733	100	34.7	LOS C	21.4	154.1	Full	500	0.0	0.0
Lane 4	504	3.5	688	0.733	100	34.7	LOS C	21.4	154.1	Short	120	0.0	NA
Approach	1844	2.8		0.878		33.7	LOS C	30.5	218.0				
East: R005													
Lane 1	158	5.0	968	0.164	100	17.9	LOS B	3.8	28.0	Short	60	0.0	NA
Lane 2	158	5.0	968	0.164	100	17.9	LOS B	3.8	28.0	Full	500	0.0	0.0
Lane 3	113	5.5	188	0.603	100	49.0	LOS D	5.6	41.1	Full	500	0.0	0.0
Lane 4	91	5.9	151	0.603	100	50.7	LOS D	4.6	33.5	Short	60	0.0	NA
Approach	521	5.3		0.603		30.4	LOS C	5.6	41.1				
North: R1002North													
Lane 1	127	0.4	194	0.653	100	49.7	LOS D	6.3	44.5	Short	60	0.0	NA
Lane 2	127	0.4	194	0.653	100	49.6	LOS D	6.3	44.5	Full	500	0.0	0.0
Lane 3	118	0.0	186	0.635	100	54.1	LOS D	5.9	41.1	Short	110	0.0	NA
Approach	372	0.3		0.653		51.1	LOS D	6.3	44.5				
West: R006													
Lane 1	280	1.1	921	0.304	100	21.3	LOS C	8.0	56.4	Short	60	0.0	NA
Lane 2	376	1.8	651 [1]	0.577	100	29.2	LOS C	15.1	107.1	Full	500	0.0	0.0
Lane 3	378	1.8	655	0.577	100	29.3	LOS C	15.2	108.0	Full	500	0.0	0.0
Lane 4	293	1.4	420	0.697	100	35.9	LOS D	11.7	83.2	Short	90	0.0	NA
Approach	1326	1.6		0.697		29.0	LOS C	15.2	108.0				
Intersection	4063	2.5		0.878		33.4	LOS C	30.5	218.0				

Intersection R1002 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 02 [2066 PM]

R1002

Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 100 seconds (Site User-Given Cycle Time)

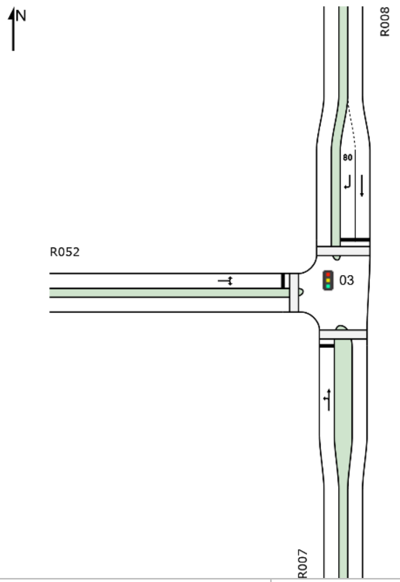
Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R026													
Lane 1	240	0.9	554	0.433	100	21.3	LOS C	5.0	35.4	Two Seg [10]	500	0.0	0.0
Lane 2	254	0.4	311	0.815	100	50.6	LOS D	13.2	92.5	Full	500	0.0	0.0
Lane 3	206	3.8	289	0.713	100	51.4	LOS D	10.1	73.2	Full	500	0.0	0.0
Lane 4	206	3.8	289	0.713	100	51.4	LOS D	10.1	73.2	Short	120	0.0	NA
Approach	906	2.1		0.815		43.2	LOS D	13.2	92.5				
East: R005													
Lane 1	511	2.3	645 [1]	0.792	100	30.9	LOS C	20.2	144.3	Short	60	0.0	NA
Lane 2	511	2.3	645 [1]	0.792	100	30.9	LOS C	20.2	144.3	Full	500	0.0	0.0
Lane 3	361	1.2	416 [1]	0.867	100	47.6	LOS D	19.0	134.2	Full	500	0.0	0.0
Lane 4	360	1.2	416 [1]	0.867	100	47.6	LOS D	19.0	134.2	Short	60	0.0	NA
Approach	1743	1.8		0.867		37.8	LOS D	20.2	144.3				
North: R1002North													
Lane 1	350	1.5	426	0.823	100	48.6	LOS D	17.9	126.9	Short	60	0.0	NA
Lane 2	335	1.6	407 [1]	0.823	100	45.4	LOS D	17.0	120.8	Full	500	0.0	0.0
Lane 3	327	1.0	406	0.807	100	49.4	LOS D	16.6	116.9	Short	110	0.0	NA
Approach	1013	1.4		0.823		47.8	LOS D	17.9	126.9				
West: R006													
Lane 1	107	0.0	780	0.138	100	24.5	LOS C	3.2	22.3	Short	60	0.0	NA
Lane 2	84	3.1	268	0.313	100	42.8	LOS D	3.8	27.2	Full	500	0.0	0.0
Lane 3	84	3.1	268	0.313	100	42.8	LOS D	3.8	27.2	Full	500	0.0	0.0
Lane 4	201	1.0	258	0.779	100	55.1	LOS E	10.3	72.9	Short	90	0.0	NA
Approach	476	1.5		0.779		43.9	LOS D	10.3	72.9				
Intersection	4138	1.7		0.867		42.1	LOS D	20.2	144.3				

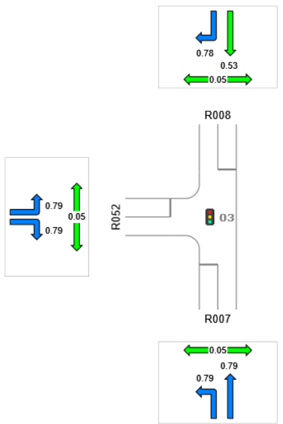
3 Intersection R1003

2041

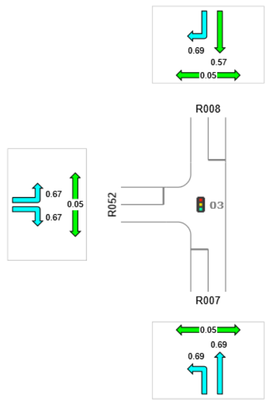
SITE LAYOUT – R1003 – 2041



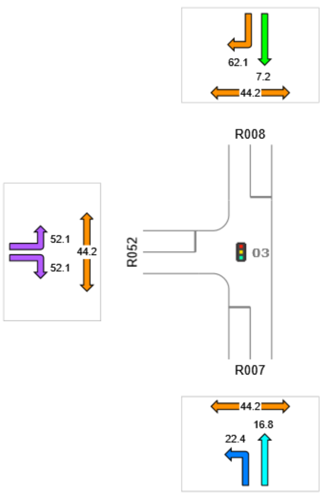
DEGREE OF SATURATION AM



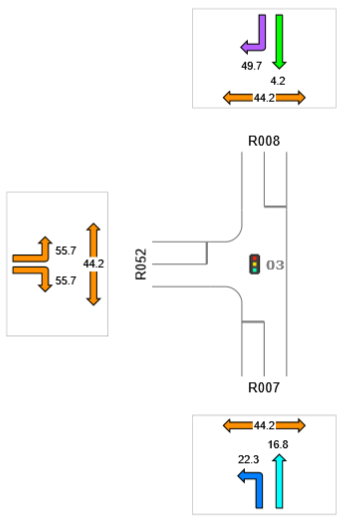
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1003 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 03 [2041 AM]

R1003
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 100 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R007													
Lane 1	898	1.8	1134	0.792	100	17.2	LOS B	33.4	237.3	Full	500	0.0	0.0
Approach	898	1.8		0.792		17.2	LOS B	33.4	237.3				
North: R008													
Lane 1	724	2.8	1360	0.532	100	7.2	LOS A	16.2	116.2	Full	500	0.0	0.0
Lane 2	86	1.2	110	0.781	100	62.1	LOS E	4.7	32.9	Short	80	0.0	NA
Approach	811	2.6		0.781		13.0	LOS B	16.2	116.2				
West: R052													
Lane 1	247	0.9	314	0.788	100	52.1	LOS D	12.6	88.8	Full	500	0.0	0.0
Approach	247	0.9		0.788		52.1	LOS D	12.6	88.8				
Intersection	1956	2.0		0.792		19.9	LOS B	33.4	237.3				

LANE SUMMARY 2041 PM

Site: 03 [2041 PM]

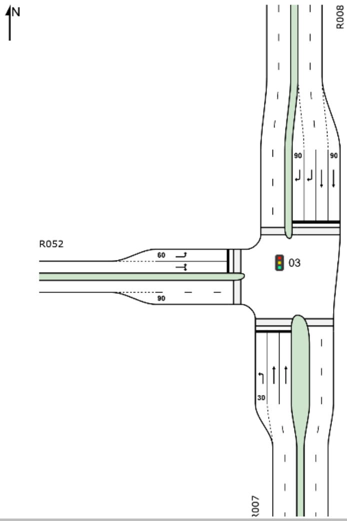
R1003
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 100 seconds (Site User-Given Cycle Time)

Lane Use and Performance

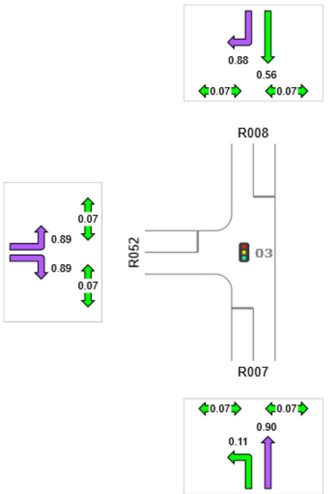
	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R007													
Lane 1	740	1.6	1079	0.686	100	16.9	LOS B	25.5	181.2	Full	500	0.0	0.0
Approach	740	1.6		0.686		16.9	LOS B	25.5	181.2				
North: R008													
Lane 1	864	1.3	1527	0.566	100	4.2	LOS A	15.7	111.3	Full	500	0.0	0.0
Lane 2	218	0.5	315	0.693	100	49.7	LOS D	10.5	73.7	Short	80	0.0	NA
Approach	1082	1.2		0.693		13.4	LOS B	15.7	111.3				
West: R052													
Lane 1	112	0.9	166	0.672	100	55.7	LOS E	5.7	40.0	Full	500	0.0	0.0
Approach	112	0.9		0.672		55.7	LOS E	5.7	40.0				
Intersection	1934	1.3		0.693		17.2	LOS B	25.5	181.2				

Intersection R1003-2066

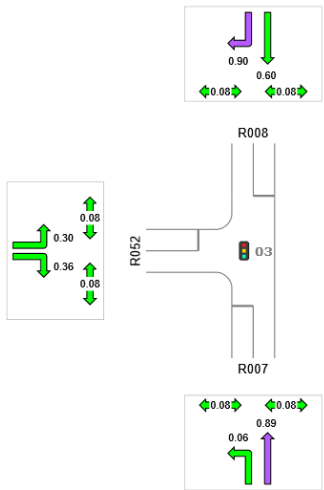
SITE LAYOUT – R1003 – 2066



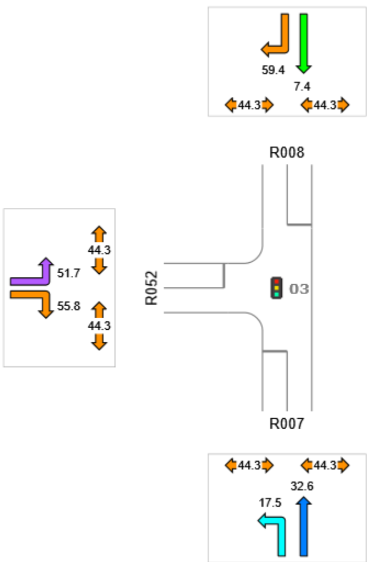
DEGREE OF SATURATION AM



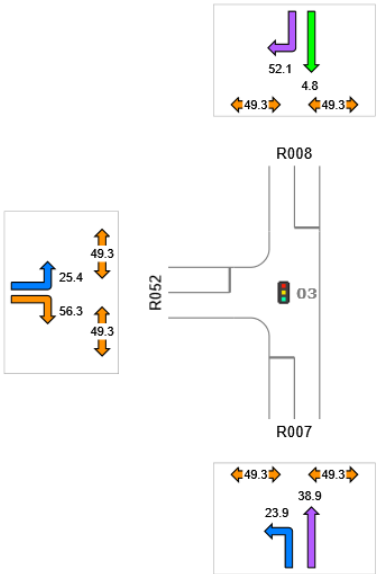
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1003 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 03 [2066 AM]

R1003
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 100 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R007													
Lane 1	115	0.0	1003	0.114	100	17.5	LOS B	2.7	18.9	Short	30	0.0	NA
Lane 2	837	2.5	931 [1]	0.900	100	32.4	LOS C	40.8	291.7	Full	500	0.0	0.0
Lane 3	932	2.5	1036	0.900	100	32.8	LOS C	48.1	343.6	Full	500	0.0	0.0
Approach	1884	2.3		0.900		31.7	LOS C	48.1	343.6				
North: R008													
Lane 1	756	2.9	1359	0.556	100	7.4	LOS A	17.4	124.9	Short	90	0.0	NA
Lane 2	756	2.9	1359	0.556	100	7.4	LOS A	17.4	124.9	Full	500	0.0	0.0
Lane 3	88	2.4	201	0.440	50 [6]	52.4	LOS D	4.2	30.1	Full	500	0.0	0.0
Lane 4	176	2.4	201	0.876	100	62.9	LOS E	9.8	69.8	Short	90	0.0	NA
Approach	1777	2.8		0.876		15.1	LOS B	17.4	124.9				
West: R052													
Lane 1	440	1.2	494 [1]	0.892	100	49.2	LOS D	22.9	162.1	Short	60	0.0	NA
Lane 2	345	0.9	387 [1]	0.892	100	55.8	LOS E	18.9	133.7	Full	500	0.0	0.0
Approach	785	1.1		0.892		52.1	LOS D	22.9	162.1				
Intersection	4446	2.3		0.900		28.7	LOS C	48.1	343.6				

Intersection R1003 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 03 [2066 PM]

R1003
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 110 seconds (Site User-Given Cycle Time)

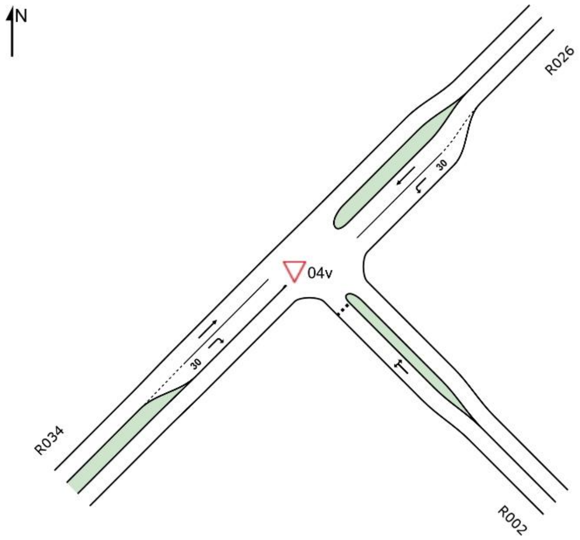
Lane Use and Performance

	Demand Flows		Cap.	Deg.	Lane	Average	Level of	95% Back of Queue		Lane	Lane	Cap.	Prob.
	Total	HV		Satn	Util.	Delay	Service	Veh	Dist	Config	Length	Adj.	Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R007													
Lane 1	52	0.0	827	0.062	100	23.9	LOS C	1.5	10.8	Short	30	0.0	NA
Lane 2	719	1.7	811 [1]	0.886	100	38.8	LOS D	39.4	279.7	Full	500	0.0	0.0
Lane 3	761	1.7	859	0.886	100	39.1	LOS D	42.7	303.0	Full	500	0.0	0.0
Approach	1532	1.6		0.886		38.4	LOS D	42.7	303.0				
North: R008													
Lane 1	911	1.8	1525	0.598	100	4.8	LOS A	19.0	135.0	Short	90	0.0	NA
Lane 2	911	1.8	1525	0.598	100	4.8	LOS A	19.0	135.0	Full	500	0.0	0.0
Lane 3	243	0.9	537	0.452	50 [6]	40.0	LOS D	10.7	75.3	Full	500	0.0	0.0
Lane 4	467	0.9	518 [1]	0.900	100	58.5	LOS E	28.2	198.6	Short	90	0.0	NA
Approach	2532	1.5		0.900		18.1	LOS B	28.2	198.6				
West: R052													
Lane 1	243	2.2	815	0.298	82 [5]	25.4	LOS C	8.3	58.9	Short	60	0.0	NA
Lane 2	67	0.0	186	0.363	100	56.3	LOS E	3.5	24.6	Full	500	0.0	0.0
Approach	311	1.7		0.363		32.1	LOS C	8.3	58.9				
Intersection	4374	1.6		0.900		26.2	LOS C	42.7	303.0				

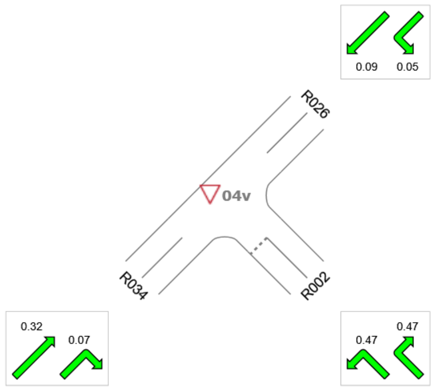
4 Intersection R1004

2041

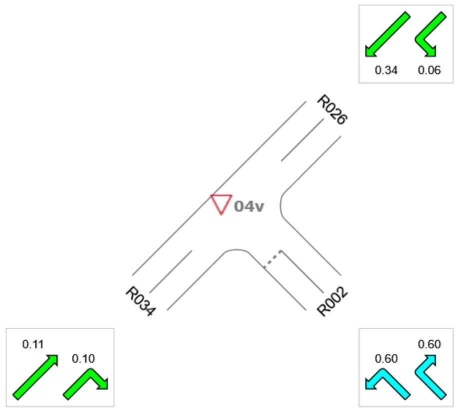
SITE LAYOUT – R1004 – 2041



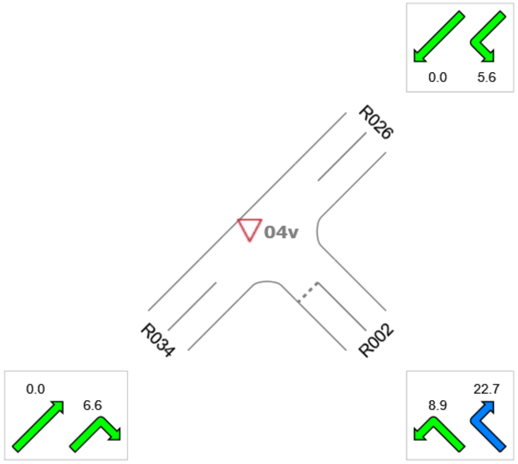
DEGREE OF SATURATION AM



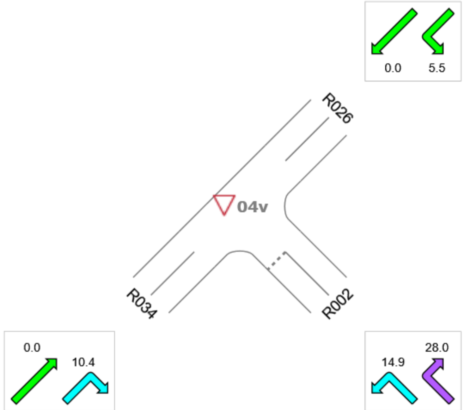
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1004 – 2041 Cont.

MOVEMENT SUMMARY 2041 AM

Site: 04v [2041 AM]

R1004
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: R002												
4	L2	42	0.0	0.471	8.9	LOS A	2.3	16.2	0.66	0.90	0.99	41.6
6	R2	118	0.0	0.471	22.7	LOS C	2.3	16.2	0.66	0.90	0.99	41.5
Approach		160	0.0	0.471	19.0	LOS C	2.3	16.2	0.66	0.90	0.99	41.5
NorthEast: R026												
7	L2	94	2.2	0.051	5.6	LOS A	0.0	0.0	0.00	0.58	0.00	53.5
8	T1	178	1.2	0.092	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
Approach		272	1.6	0.092	1.9	NA	0.0	0.0	0.00	0.20	0.00	57.6
SouthWest: R034												
2	T1	607	1.7	0.318	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
3	R2	74	0.0	0.067	6.6	LOS A	0.3	1.9	0.36	0.62	0.36	48.6
Approach		681	1.5	0.318	0.7	NA	0.3	1.9	0.04	0.07	0.04	58.5
All Vehicles		1113	1.3	0.471	3.7	NA	2.3	16.2	0.12	0.22	0.17	55.0

MOVEMENT SUMMARY 2041 PM

Site: 04v [2041 PM]

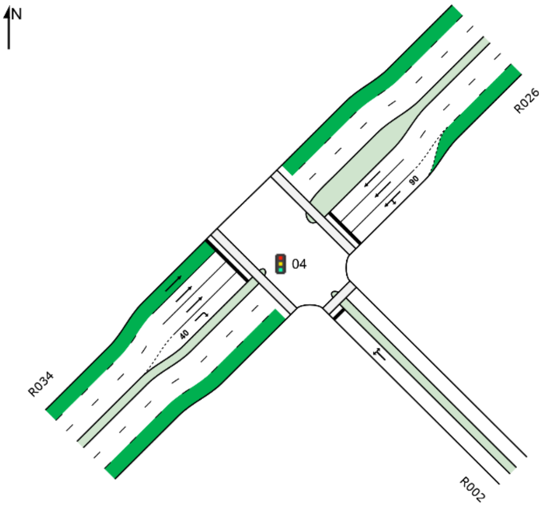
R1004
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

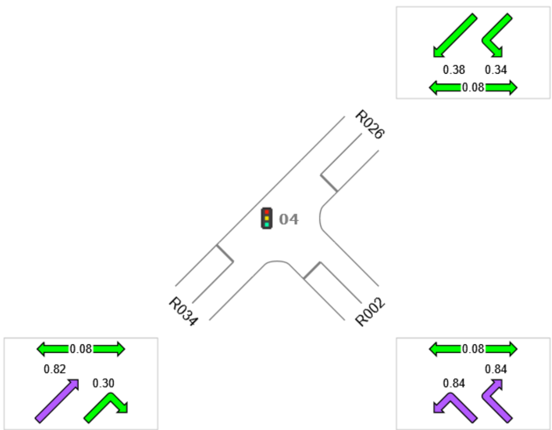
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: R002												
4	L2	100	0.0	0.603	14.9	LOS B	3.2	22.7	0.84	1.13	1.46	40.4
6	R2	104	0.0	0.603	28.0	LOS D	3.2	22.7	0.84	1.13	1.46	40.3
Approach		204	0.0	0.603	21.6	LOS C	3.2	22.7	0.84	1.13	1.46	40.4
NorthEast: R026												
7	L2	108	0.0	0.058	5.5	LOS A	0.0	0.0	0.00	0.58	0.00	53.6
8	T1	651	1.3	0.336	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
Approach		759	1.1	0.336	0.8	NA	0.0	0.0	0.00	0.08	0.00	58.9
SouthWest: R034												
2	T1	212	1.0	0.110	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
3	R2	58	0.0	0.100	10.4	LOS B	0.4	2.5	0.62	0.85	0.62	46.4
Approach		269	0.8	0.110	2.2	NA	0.4	2.5	0.13	0.18	0.13	56.4
All Vehicles		1233	0.9	0.603	4.6	NA	3.2	22.7	0.17	0.28	0.27	54.3

Intersection R1004-2066

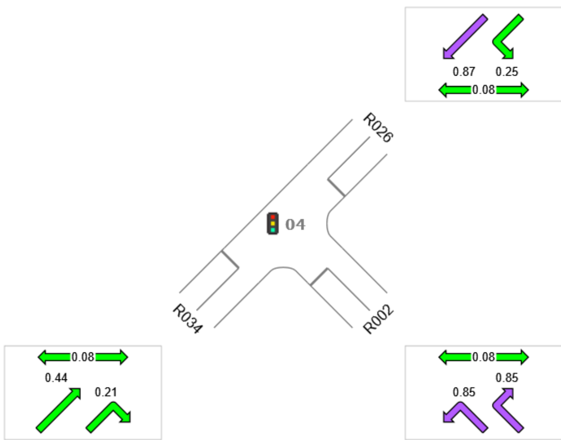
SITE LAYOUT – R1004 – 2066



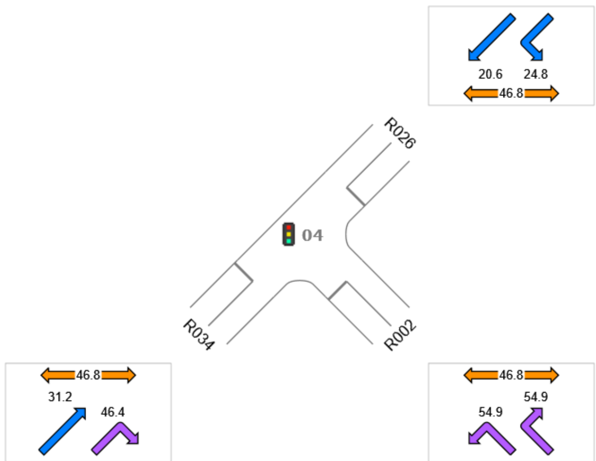
DEGREE OF SATURATION AM



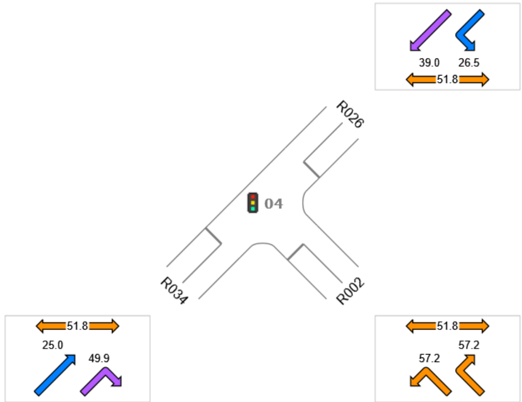
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1004 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 04 [2066 AM]

R1004
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 105 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R002													
Lane 1	309	0.7	370	0.837	100	54.9	LOS D	17.0	119.4	Full	500	0.0	0.0
Approach	309	0.7		0.837		54.9	LOS D	17.0	119.4				
NorthEast: R026													
Lane 1	285	0.7	827	0.345	100	24.8	LOS C	9.5	66.7	Two Seg [10]	500	0.0	0.0
Lane 2	325	2.6	858	0.378	100	20.6	LOS C	11.0	78.5	Full	500	0.0	0.0
Lane 3	325	2.6	858	0.378	100	20.6	LOS C	11.0	78.5	Full	500	0.0	0.0
Approach	935	2.0		0.378		21.9	LOS C	11.0	78.5				
SouthWest: R034													
Lane 1	1	100.0	529	0.002	100	16.8	LOS B	0.0	0.4	Full	500	0.0	0.0
Lane 2	703	3.5	854	0.824	100	31.6	LOS C	33.4	240.9	Full	500	0.0	0.0
Lane 3	625	3.5	759 [1]	0.824	100	30.9	LOS C	28.5	205.4	Full	500	0.0	0.0
Lane 4	101	0.0	336	0.301	100	46.4	LOS D	4.6	31.9	Short	40	0.0	NA
Approach	1431	3.3		0.824		32.3	LOS C	33.4	240.9				
Intersection	2675	2.6		0.837		31.3	LOS C	33.4	240.9				

Intersection R1004 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 04 [2066 PM]

R1004
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 115 seconds (Site Optimum Cycle Time - Minimum Delay)

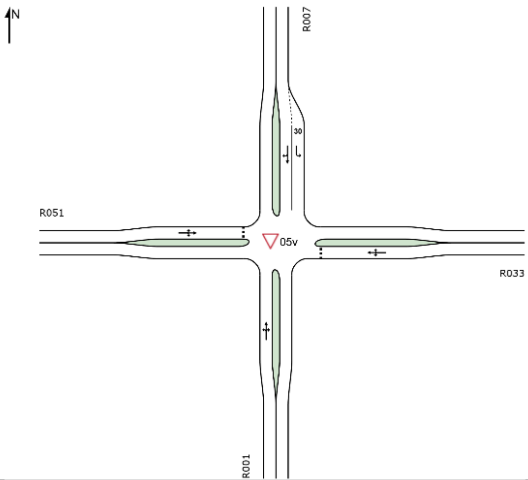
Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R002													
Lane 1	369	0.3	435	0.849	100	57.2	LOS E	22.0	154.4	Full	500	0.0	0.0
Approach	369	0.3		0.849		57.2	LOS E	22.0	154.4				
NorthEast: R026													
Lane 1	199	1.6	798	0.249	100	26.5	LOS C	7.0	49.6	Two Seg [10]	500	0.0	0.0
Lane 2	659	2.3	754 [1]	0.874	100	38.6	LOS D	36.1	257.6	Full	500	0.0	0.0
Lane 3	730	2.3	835	0.874	100	39.2	LOS D	41.5	296.2	Full	500	0.0	0.0
Approach	1587	2.2		0.874		37.4	LOS D	41.5	296.2				
SouthWest: R034													
Lane 1	1	100.0	514	0.002	100	19.3	LOS B	0.0	0.4	Full	500	0.0	0.0
Lane 2	367	2.4	835	0.440	100	25.3	LOS C	14.3	101.9	Full	500	0.0	0.0
Lane 3	335	2.4	761 [1]	0.440	100	24.8	LOS C	12.7	90.9	Full	500	0.0	0.0
Lane 4	68	0.0	323	0.212	100	49.9	LOS D	3.3	23.3	Short	40	0.0	NA
Approach	772	2.3		0.440		27.2	LOS C	14.3	101.9				
Intersection	2728	2.0		0.874		37.2	LOS D	41.5	296.2				

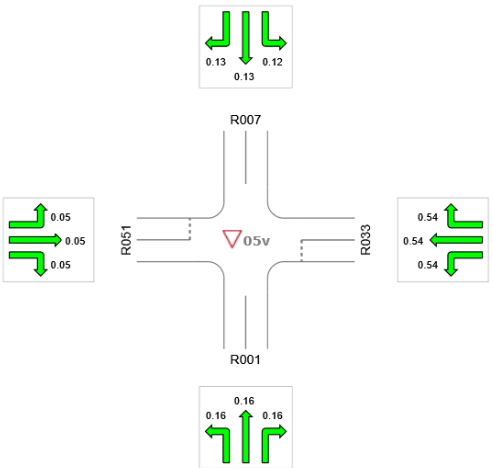
5 Intersection R1005

2031

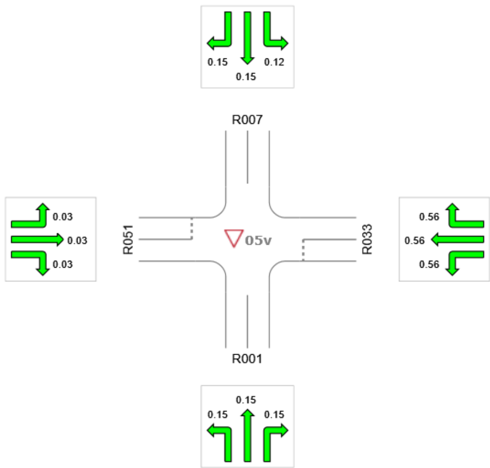
SITE LAYOUT – R1005 – 2031

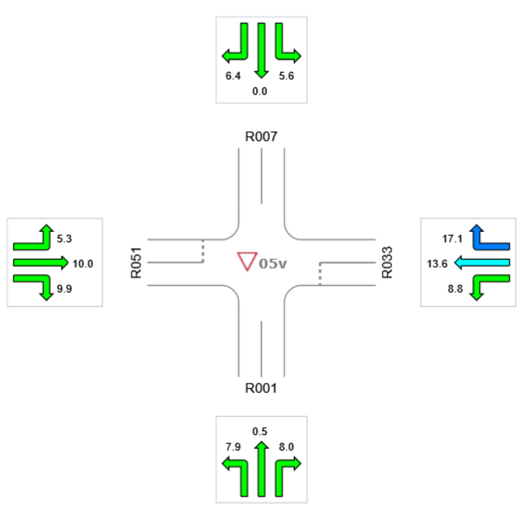
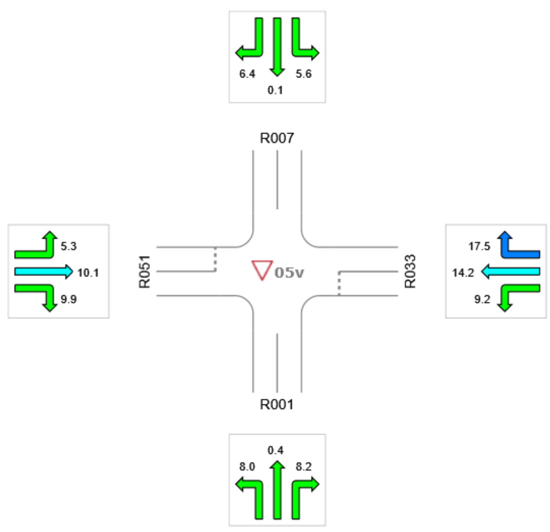


DEGREE OF SATURATION AM



DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM	DELAY CONTROL (seconds) PM
	

Intersection R1005 – 2031 Cont.

MOVEMENT SUMMARY 2031 AM

Site: 05v [2031 AM]

R1005
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
South: R001												
1	L2	5	0.0	0.165	7.9	LOS A	0.4	2.7	0.15	0.08	0.15	52.9
2	T1	249	1.7	0.165	0.5	LOS A	0.4	2.7	0.15	0.08	0.15	58.7
3	R2	28	0.0	0.165	8.0	LOS A	0.4	2.7	0.15	0.08	0.15	52.4
Approach		283	1.5	0.165	1.4	NA	0.4	2.7	0.15	0.08	0.15	57.8
East: R033												
4	L2	32	0.0	0.544	8.8	LOS A	3.4	24.3	0.71	1.01	1.17	43.1
5	T1	6	0.0	0.544	13.6	LOS B	3.4	24.3	0.71	1.01	1.17	40.9
6	R2	209	2.0	0.544	17.1	LOS C	3.4	24.3	0.71	1.01	1.17	42.9
Approach		247	1.7	0.544	15.9	LOS C	3.4	24.3	0.71	1.01	1.17	42.9
North: R007												
7	L2	227	2.3	0.124	5.6	LOS A	0.0	0.0	0.00	0.58	0.00	53.5
8	T1	237	2.7	0.129	0.0	LOS A	0.1	0.4	0.03	0.02	0.03	59.7
9	R2	7	0.0	0.129	6.4	LOS A	0.1	0.4	0.03	0.02	0.03	53.2
Approach		472	2.5	0.129	2.8	NA	0.1	0.4	0.01	0.29	0.01	56.4
West: R051												
10	L2	14	0.0	0.046	5.3	LOS A	0.2	1.2	0.48	0.63	0.48	47.7
11	T1	8	0.0	0.046	10.0	LOS A	0.2	1.2	0.48	0.63	0.48	44.9
12	R2	8	0.0	0.046	9.9	LOS A	0.2	1.2	0.48	0.63	0.48	47.2
Approach		31	0.0	0.046	7.9	LOS A	0.2	1.2	0.48	0.63	0.48	46.8
All Vehicles		1033	1.9	0.544	5.7	NA	3.4	24.3	0.23	0.41	0.34	52.5

Intersection R1005 – 2031 Cont.

MOVEMENT SUMMARY 2031 PM

Site: 05v [2031 PM]

R1005
Site Category: (None)
Giveway / Yield (Two-Way)

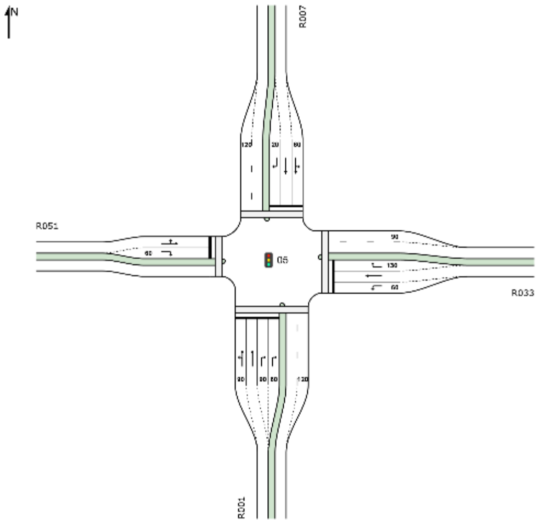
Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: R001												
1	L2	7	0.0	0.153	8.0	LOS A	0.3	2.3	0.13	0.07	0.13	53.0
2	T1	237	1.8	0.153	0.4	LOS A	0.3	2.3	0.13	0.07	0.13	58.7
3	R2	22	0.0	0.153	8.2	LOS A	0.3	2.3	0.13	0.07	0.13	52.4
Approach		266	1.6	0.153	1.3	NA	0.3	2.3	0.13	0.07	0.13	58.0
East: R033												
4	L2	21	0.0	0.559	9.2	LOS A	3.5	24.8	0.74	1.05	1.25	42.8
5	T1	8	0.0	0.559	14.2	LOS B	3.5	24.8	0.74	1.05	1.25	40.5
6	R2	215	1.5	0.559	17.5	LOS C	3.5	24.8	0.74	1.05	1.25	42.6
Approach		244	1.3	0.559	16.7	LOS C	3.5	24.8	0.74	1.05	1.25	42.5
North: R007												
7	L2	229	1.4	0.125	5.6	LOS A	0.0	0.0	0.00	0.58	0.00	53.6
8	T1	268	1.2	0.148	0.1	LOS A	0.1	0.7	0.04	0.03	0.04	59.6
9	R2	13	0.0	0.148	6.4	LOS A	0.1	0.7	0.04	0.03	0.04	53.1
Approach		511	1.2	0.148	2.7	NA	0.1	0.7	0.02	0.27	0.02	56.5
West: R051												
10	L2	8	0.0	0.031	5.3	LOS A	0.1	0.8	0.48	0.62	0.48	47.6
11	T1	6	0.0	0.031	10.1	LOS B	0.1	0.8	0.48	0.62	0.48	44.8
12	R2	5	0.0	0.031	9.9	LOS A	0.1	0.8	0.48	0.62	0.48	47.2
Approach		20	0.0	0.031	8.0	LOS A	0.1	0.8	0.48	0.62	0.48	46.6
All Vehicles		1041	1.3	0.559	5.7	NA	3.5	24.8	0.23	0.41	0.35	52.6

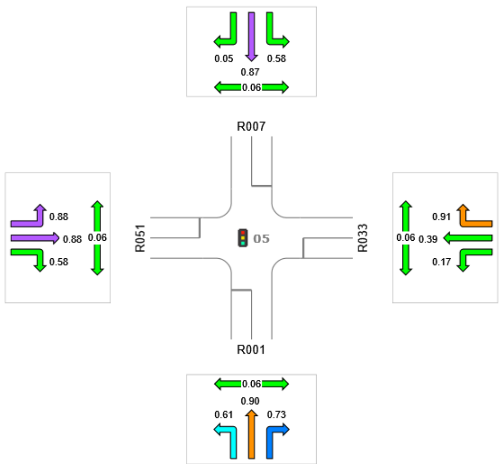
Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Intersection R1005-2041

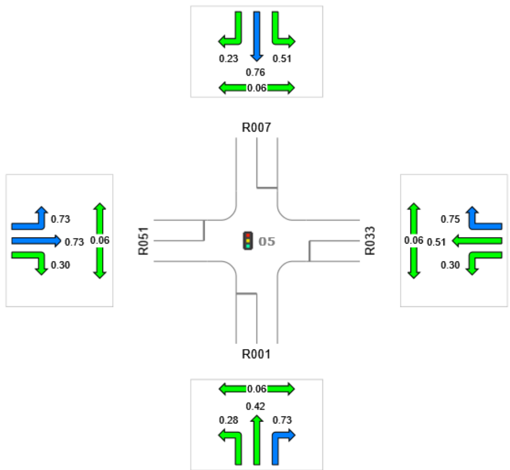
SITE LAYOUT – R1005 – 2041



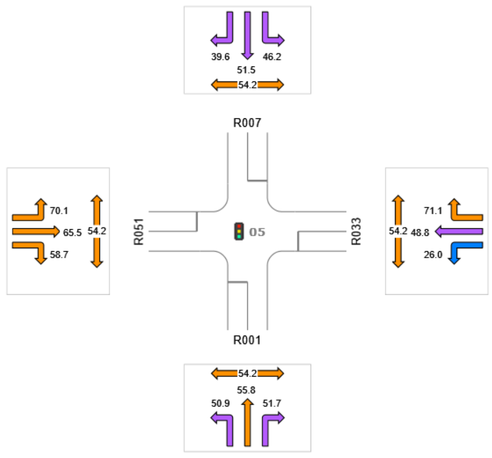
DEGREE OF SATURATION AM

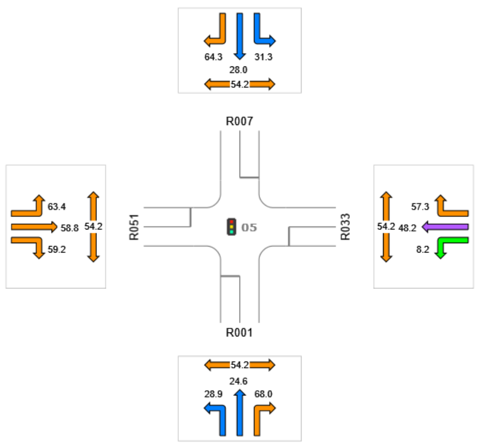


DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM	DELAY CONTROL (seconds) PM





Intersection R1005 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 05 [2041 AM]

R1005
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R001													
Lane 1	261	1.1	430	0.607	67 [6]	46.7	LOS D	13.9	97.8	Short	90	0.0	NA
Lane 2	392	1.4	435	0.901	100	61.1	LOS E	25.8	182.8	Full	500	0.0	0.0
Lane 3	156	1.4	414	0.377	52 [6]	48.3	LOS D	7.8	55.2	Short	90	0.0	NA
Lane 4	293	1.4	400 [1]	0.731	100	53.5	LOS D	16.3	115.5	Short	60	0.0	NA
Approach	1101	1.3		0.901		53.9	LOS D	25.8	182.8				
East: R033													
Lane 1	133	4.0	798	0.166	100	26.0	LOS C	4.6	33.3	Short	60	0.0	NA
Lane 2	126	2.5	320	0.395	100	48.8	LOS D	6.7	47.9	Full	500	0.0	0.0
Lane 3	276	2.3	305	0.906	100	71.1	LOS E	18.5	132.1	Short	130	0.0	NA
Approach	535	2.8		0.906		54.6	LOS D	18.5	132.1				
North: R007													
Lane 1	296	2.2	506	0.584	67 [6]	45.4	LOS D	15.0	107.1	Short	90	0.0	NA
Lane 2	431	2.9	497 [1]	0.867	100	52.5	LOS D	26.5	190.0	Full	500	0.0	0.0
Lane 3	25	4.2	496	0.051	100	39.6	LOS D	1.1	7.8	Short	20	0.0	NA
Approach	752	2.7		0.867		49.3	LOS D	26.5	190.0				
West: R051													
Lane 1	231	1.4	261	0.884	100	66.1	LOS E	15.1	107.1	Full	500	0.0	0.0
Lane 2	143	0.7	246	0.581	100	58.7	LOS E	8.1	57.1	Short	60	0.0	NA
Approach	374	1.1		0.884		63.3	LOS E	15.1	107.1				

Intersection	2761	1.9	0.906	54.0	LOS D	26.5	190.0

Intersection R1005 – 2041 Cont.

LANE SUMMARY 2041 PM

Site: 05 [2041 PM]

R1005
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

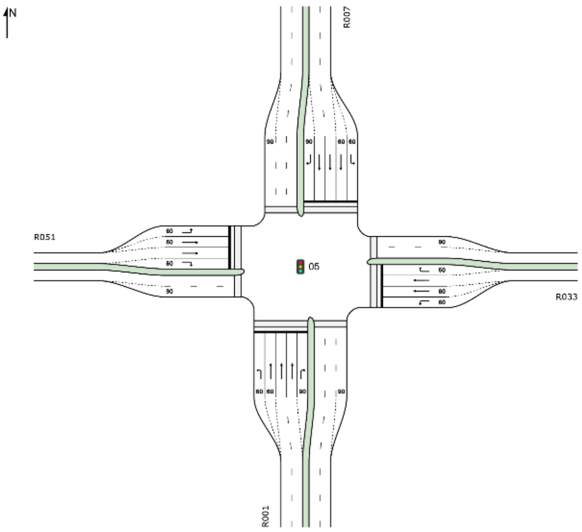
Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R001													
Lane 1	232	0.9	819	0.283	67 [6]	26.1	LOS C	8.6	60.9	Short	90	0.0	NA
Lane 2	351	1.8	835	0.420	100	25.1	LOS C	14.1	99.9	Full	500	0.0	0.0
Lane 3	52	2.8	137	0.378	52 [6]	65.4	LOS E	3.0	21.7	Short	90	0.0	NA
Lane 4	100	2.8	137	0.732	100	69.3	LOS E	6.2	44.5	Short	60	0.0	NA
Approach	734	1.7		0.732		34.3	LOS C	14.1	99.9				
East: R033													
Lane 1	444	1.2	1458	0.305	100	8.2	LOS A	7.0	49.2	Short	60	0.0	NA
Lane 2	182	1.2	355	0.513	100	48.2	LOS D	9.8	68.9	Full	500	0.0	0.0
Lane 3	252	1.3	337	0.746	100	57.3	LOS E	14.6	103.4	Short	130	0.0	NA
Approach	878	1.2		0.746		30.6	LOS C	14.6	103.4				
North: R007													
Lane 1	377	1.4	735 [1]	0.513	67 [6]	29.8	LOS C	15.5	109.9	Short	60	0.0	NA
Lane 2	489	1.1	642 [1]	0.761	100	28.4	LOS C	21.9	154.8	Full	500	0.0	0.0
Lane 3	33	0.0	139	0.234	100	64.3	LOS E	1.9	13.1	Short	20	0.0	NA
Approach	898	1.2		0.761		30.3	LOS C	21.9	154.8				
West: R051													
Lane 1	155	1.4	213	0.726	100	59.5	LOS E	9.3	65.8	Full	500	0.0	0.0
Lane 2	60	0.0	201	0.298	100	59.2	LOS E	3.3	23.4	Short	60	0.0	NA
Approach	215	1.0		0.726		59.4	LOS E	9.3	65.8				

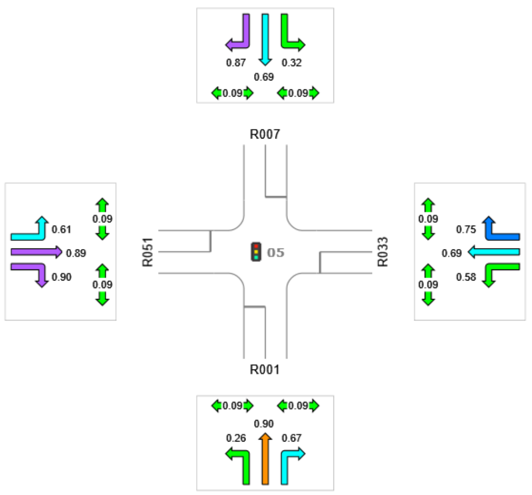
Intersection	2724	1.3	0.761	33.7	LOS C	21.9	154.8

Intersection R1005-2066

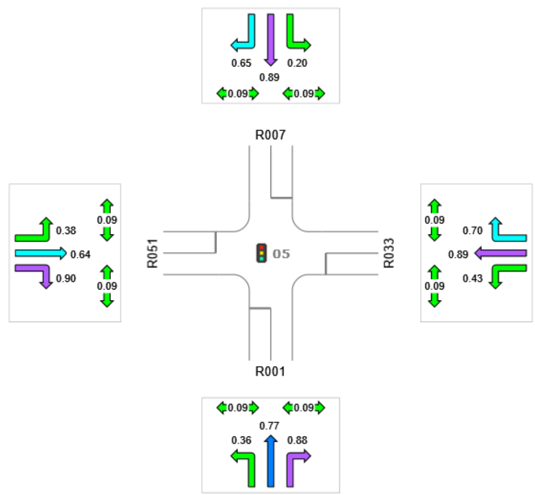
SITE LAYOUT – R1005 – 2066



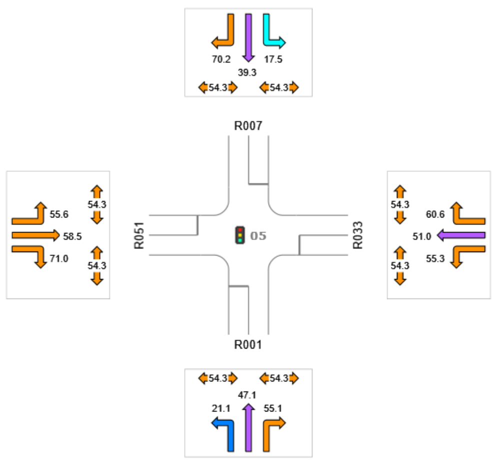
DEGREE OF SATURATION AM



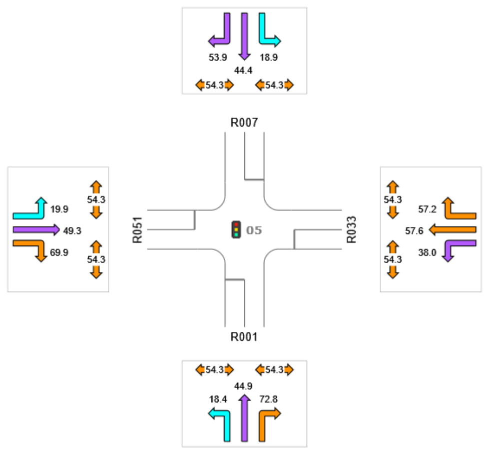
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1005 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 05 [2066 AM - Add'l lane - 80%]

R1005
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R001													
Lane 1	259	1.4	996	0.260	100	21.1	LOS C	8.0	56.4	Short	60	0.0	NA
Lane 2	319	2.3	656	0.486	54 [6]	33.4	LOS C	14.7	104.7	Short	60	0.0	NA
Lane 3	457	2.3	508 [1]	0.901	100	51.6	LOS D	27.9	198.9	Full	500	0.0	0.0
Lane 4	510	2.3	566 [1]	0.901	100	51.7	LOS D	31.7	226.0	Full	500	0.0	0.0
Lane 5	236	1.6	352	0.671	100	55.1	LOS E	13.1	93.0	Short	90	0.0	NA
Approach	1781	2.1		0.901		44.4	LOS D	31.7	226.0				

East: R033													
Lane 1	177	2.6	304	0.582	100	55.3	LOS E	9.8	69.9	Short	60	0.0	NA
Lane 2	126	2.1	321	0.394	57[6]	48.8	LOS D	6.7	47.8	Short	60	0.0	NA
Lane 3	221	2.1	321	0.690	100	52.4	LOS D	12.6	89.6	Full	500	0.0	0.0
Lane 4	205	2.3	274	0.747	100	60.6	LOS E	12.1	86.7	Short	60	0.0	NA
Approach	729	2.3		0.747		54.8	LOS D	12.6	89.6				
North: R007													
Lane 1	261	1.8	810	0.322	100	17.5	LOS B	5.2	37.0	Short	60	0.0	NA
Lane 2	206	3.1	558	0.370	54[6]	36.2	LOS D	9.6	68.7	Short	60	0.0	NA
Lane 3	345	3.1	504[1]	0.686	100	39.6	LOS D	17.5	125.8	Full	500	0.0	0.0
Lane 4	382	3.1	558	0.686	100	40.6	LOS D	19.9	142.8	Full	500	0.0	0.0
Lane 5	226	2.5	259	0.874	100	70.2	LOS E	14.7	105.1	Short	90	0.0	NA
Approach	1421	2.7		0.874		40.2	LOS D	19.9	142.8				
West: R051													
Lane 1	185	3.0	303	0.611	100	55.6	LOS E	10.3	73.9	Short	60	0.0	NA
Lane 2	163	1.7	321	0.508	57[6]	49.9	LOS D	8.9	62.9	Short	60	0.0	NA
Lane 3	272	1.7	306[1]	0.889	100	63.7	LOS E	17.7	125.8	Full	500	0.0	0.0
Lane 4	247	1.5	276	0.897	100	71.0	LOS E	16.4	116.6	Short	60	0.0	NA
Approach	868	1.9		0.897		61.5	LOS E	17.7	125.8				
Intersection	4799	2.3		0.901		47.8	LOS D	31.7	226.0				

Intersection R1005 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 05 [2066 PM - Add'l lane - 80%]

R1005
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

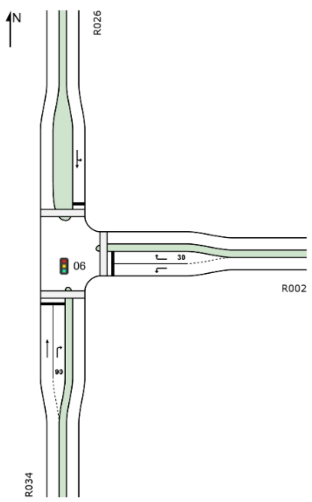
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R001													
Lane 1	283	1.0	784	0.361	100	18.4	LOS B	5.9	41.8	Short	60	0.0	NA
Lane 2	207	1.7	498	0.416	54[6]	39.9	LOS D	10.1	71.7	Short	60	0.0	NA
Lane 3	343	1.7	444[1]	0.772	100	45.9	LOS D	18.9	134.5	Full	500	0.0	0.0
Lane 4	384	1.7	498	0.772	100	46.6	LOS D	21.7	153.8	Full	500	0.0	0.0
Lane 5	173	2.2	198	0.875	100	72.8	LOS E	11.4	81.0	Short	90	0.0	NA
Approach	1391	1.6		0.875		43.0	LOS D	21.7	153.8				
East: R033													
Lane 1	264	1.4	613	0.431	100	38.0	LOS D	12.0	85.1	Short	60	0.0	NA

Lane 2	172	1.3	338	0.507	57[6]	49.0	LOS D	9.2	65.4	Short	60	0.0	NA
Lane 3	282	1.3	318[1]	0.887	100	62.7	LOS E	18.3	129.3	Full	500	0.0	0.0
Lane 4	213	1.3	307	0.695	100	57.2	LOS E	12.2	86.3	Short	60	0.0	NA
Approach	931	1.3		0.887		51.9	LOS D	18.3	129.3				
North: R007													
Lane 1	203	1.9	1039	0.195	100	18.9	LOS B	5.7	40.3	Short	60	0.0	NA
Lane 2	322	1.7	675	0.477	54[6]	32.6	LOS C	14.6	104.0	Short	60	0.0	NA
Lane 3	463	1.7	523[1]	0.886	100	48.3	LOS D	27.3	193.9	Full	500	0.0	0.0
Lane 4	512	1.7	578[1]	0.886	100	48.4	LOS D	30.8	218.4	Full	500	0.0	0.0
Lane 5	239	2.0	366	0.652	100	53.9	LOS D	13.1	93.0	Short	90	0.0	NA
Approach	1738	1.7		0.886		42.8	LOS D	30.8	218.4				
West: R051													
Lane 1	261	2.2	686	0.380	100	19.9	LOS B	6.5	46.5	Short	60	0.0	NA
Lane 2	123	1.7	338	0.363	57[6]	47.6	LOS D	6.4	45.5	Short	60	0.0	NA
Lane 3	215	1.7	338	0.636	100	50.3	LOS D	11.9	84.3	Full	500	0.0	0.0
Lane 4	269	1.1	299[1]	0.899	100	69.9	LOS E	17.8	126.0	Short	60	0.0	NA
Approach	867	1.6		0.899		46.9	LOS D	17.8	126.0				
Intersection	4927	1.6		0.899		45.3	LOS D	30.8	218.4				

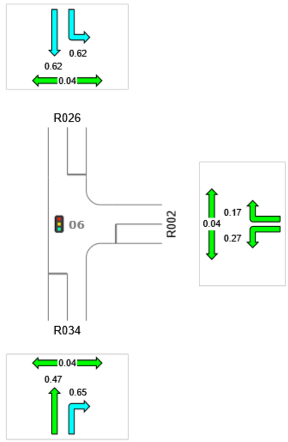
6 Intersection R1006

2041

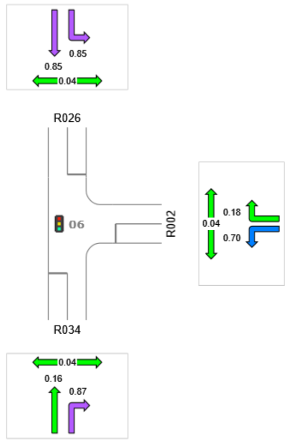
SITE LAYOUT – R1006 – 2041



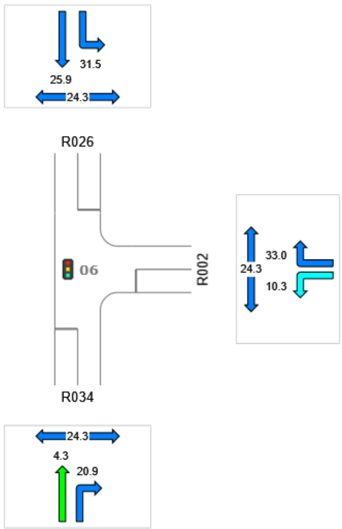
DEGREE OF SATURATION AM



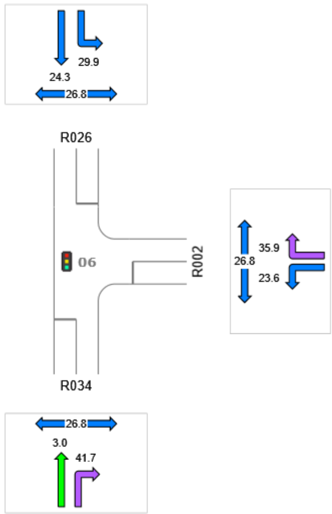
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1006 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 06 [2041 AM]

R1006
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R034													
Lane 1	628	1.7	1350	0.465	100	4.3	LOS A	8.2	58.1	Full	500	0.0	0.0
Lane 2	492	3.0	758	0.649	100	20.9	LOS C	11.7	84.3	Short	90	0.0	NA
Approach	1120	2.3		0.649		11.6	LOS B	11.7	84.3				
East: R002													
Lane 1	301	6.3	1096	0.275	100	10.3	LOS B	4.1	30.1	Full	500	0.0	0.0
Lane 2	32	0.0	186	0.170	100	33.0	LOS C	0.9	6.3	Short	30	0.0	NA

Approach	333	5.7		0.275		12.5	LOS B	4.1	30.1				
North: R026													
Lane 1	220	1.0	353	0.624	100	26.7	LOS C	6.3	44.6	Full	500	0.0	0.0
Approach	220	1.0		0.624		26.7	LOS C	6.3	44.6				
Intersection	1673	2.8		0.649		13.8	LOS B	11.7	84.3				

LANE SUMMARY 2041 PM

Site: 06 [2041 PM]

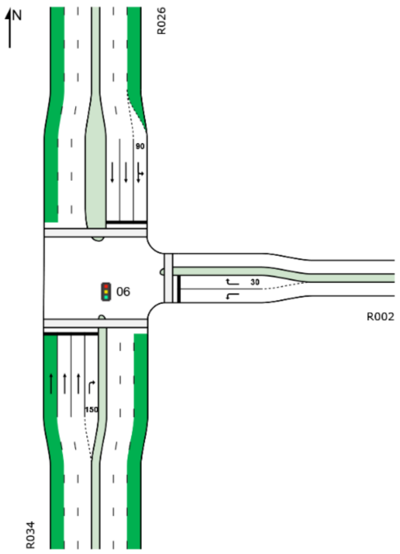
R1006
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 65 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

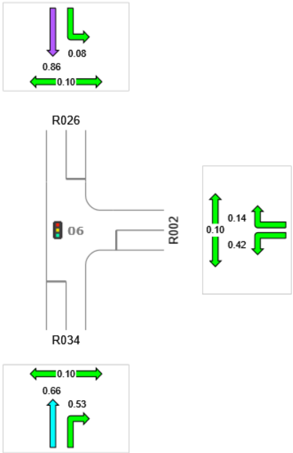
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R034													
Lane 1	222	0.9	1401	0.158	100	3.0	LOS A	2.2	15.4	Full	500	0.0	0.0
Lane 2	312	5.1	358	0.869	100	41.7	LOS D	11.6	85.1	Short	90	0.0	NA
Approach	534	3.4		0.869		25.6	LOS C	11.6	85.1				
East: R002													
Lane 1	476	2.0	675 [1]	0.704	100	23.6	LOS C	13.1	93.6	Full	500	0.0	0.0
Lane 2	32	0.0	171	0.184	100	35.9	LOS D	1.0	6.9	Short	30	0.0	NA
Approach	507	1.9		0.704		24.4	LOS C	13.1	93.6				
North: R026													
Lane 1	703	1.2	832	0.845	100	24.6	LOS C	23.7	167.4	Full	500	0.0	0.0
Approach	703	1.2		0.845		24.6	LOS C	23.7	167.4				
Intersection	1744	2.1		0.869		24.8	LOS C	23.7	167.4				

Intersection R1006-2066

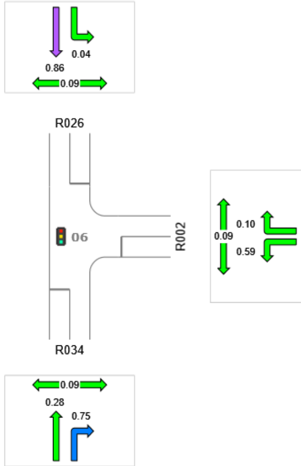
SITE LAYOUT – R1006 – 2066



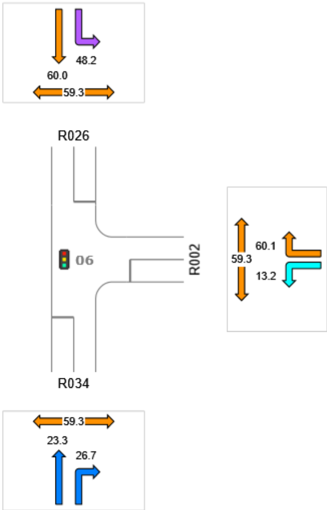
DEGREE OF SATURATION AM



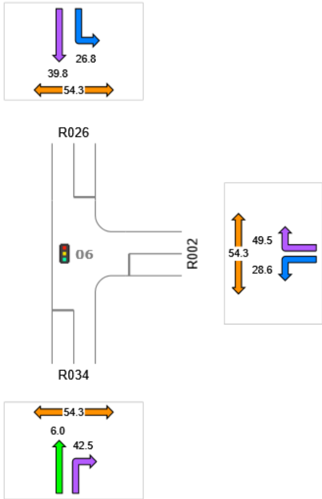
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1006 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 06 [2066 AM]

R1006
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Phase Times)

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R034													
Lane 1	1	100.0	627	0.002	100	14.9	LOS B	0.0	0.4	Full	500	0.0	0.0
Lane 2	668	3.5	1012	0.661	100	23.4	LOS C	30.2	217.5	Full	500	0.0	0.0
Lane 3	668	3.5	1012	0.661	100	23.4	LOS C	30.2	217.5	Full	500	0.0	0.0
Lane 4	514	2.5	969	0.530	100	26.7	LOS C	20.9	149.7	Short	150	0.0	NA
Approach	1852	3.3		0.661		24.3	LOS C	30.2	217.5				
East: R002													

Lane 1	499	5.7	1184 [1]	0.421	100	13.2	LOS B	12.9	94.6	Full	500	0.0	0.0
Lane 2	32	0.0	229	0.138	100	60.1	LOS E	1.8	12.7	Short	30	0.0	NA
Approach	531	5.4		0.421		16.0	LOS B	12.9	94.6				
North: R026													
Lane 1	32	0.0	414	0.076	100	48.2	LOS D	1.6	11.0	Two Seg [10]	500	0.0	0.0
Lane 2	368	2.3	428 [1]	0.859	100	60.0	LOS E	24.7	176.0	Full	500	0.0	0.0
Lane 3	368	2.3	429	0.859	100	60.0	LOS E	24.7	176.3	Full	500	0.0	0.0
Approach	767	2.2		0.859		59.5	LOS E	24.7	176.3				
Intersection	3149	3.4		0.859		31.5	LOS C	30.2	217.5				

Intersection R1006 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 06 [2066 PM]

R1006
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

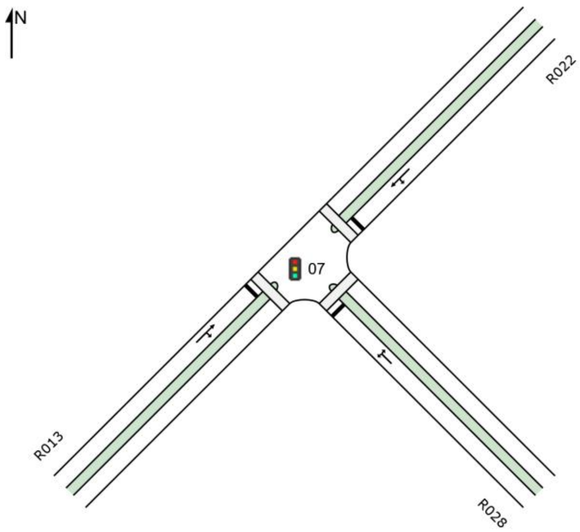
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R034													
Lane 1	1	100.0	857	0.001	100	4.7	LOS A	0.0	0.2	Full	500	0.0	0.0
Lane 2	387	2.2	1394	0.278	100	6.0	LOS A	7.6	54.3	Full	500	0.0	0.0
Lane 3	387	2.2	1394	0.278	100	6.0	LOS A	7.6	54.3	Full	500	0.0	0.0
Lane 4	394	4.8	527	0.747	100	42.5	LOS D	16.9	123.0	Short	150	0.0	NA

Approach	1169	3.2		0.747		18.3	LOS B	16.9	123.0				
East: R002													
Lane 1	487	2.4	823 [1]	0.592	100	28.6	LOS C	20.2	144.4	Full	500	0.0	0.0
Lane 2	32	0.0	325	0.097	100	49.5	LOS D	1.6	10.9	Short	30	0.0	NA
Approach	519	2.2		0.592		29.9	LOS C	20.2	144.4				
North: R026													
Lane 1	32	0.0	789	0.040	100	26.8	LOS C	1.1	7.4	Two Seg [10]	500	0.0	0.0
Lane 2	693	2.3	802 [1]	0.864	100	39.8	LOS D	40.0	285.1	Full	500	0.0	0.0
Lane 3	706	2.3	817	0.864	100	39.9	LOS D	41.0	292.6	Full	500	0.0	0.0
Approach	1431	2.2		0.864		39.5	LOS D	41.0	292.6				
Intersection	3119	2.6		0.864		30.0	LOS C	41.0	292.6				

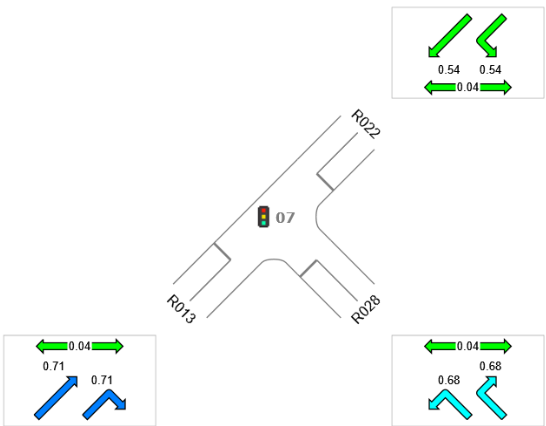
7 Intersection R1007

2041

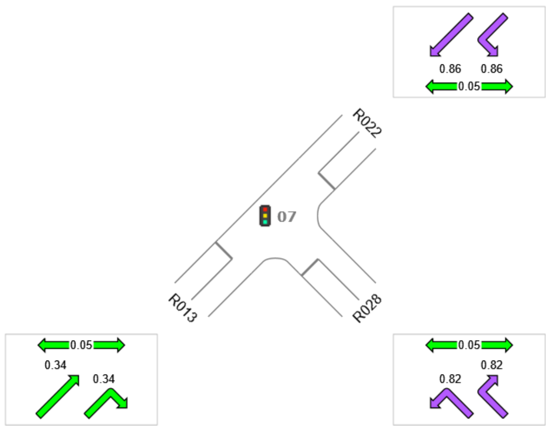
SITE LAYOUT – R1007 – 2041



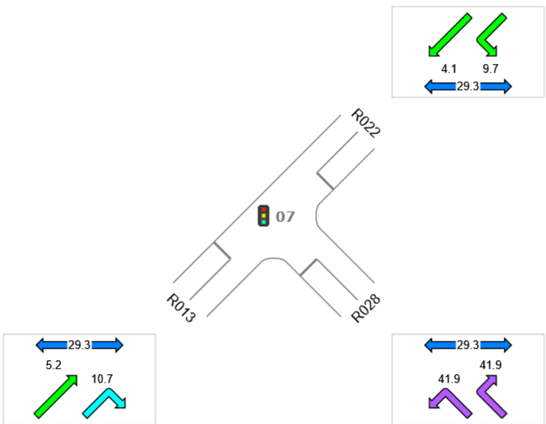
DEGREE OF SATURATION AM



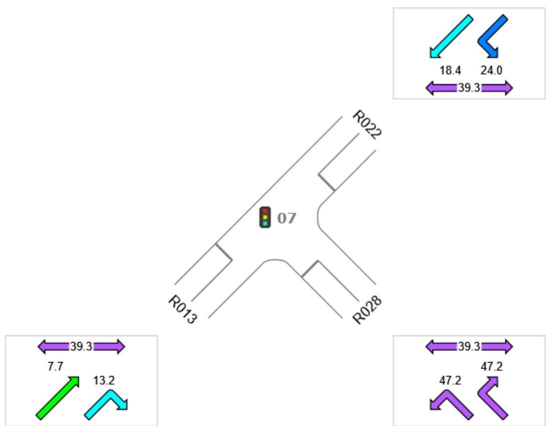
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1007 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 07 [2041 AM]

R1007
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 70 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows		Cap.	Deg.	Lane	Average	Level of	95% Back of Queue		Lane	Lane	Cap.	Prob.
	Total	HV		Satn	Util.	Delay	Service	Veh	Dist	Config	Length	Adj.	Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R028													
Lane 1	106	2.0	157	0.677	100	41.9	LOS D	3.9	27.9	Full	500	0.0	0.0
Approach	106	2.0		0.677		41.9	LOS D	3.9	27.9				
NorthEast: R022													
Lane 1	748	2.7	1390	0.538	100	6.8	LOS A	10.9	78.0	Full	500	0.0	0.0
Approach	748	2.7		0.538		6.8	LOS A	10.9	78.0				
SouthWest: R013													
Lane 1	1001	1.4	1420	0.705	100	5.2	LOS A	18.4	130.1	Full	500	0.0	0.0
Approach	1001	1.4		0.705		5.2	LOS A	18.4	130.1				
Intersection	1856	1.9		0.705		8.0	LOS A	18.4	130.1				

LANE SUMMARY 2041 PM

Site: 07 [2041 PM]

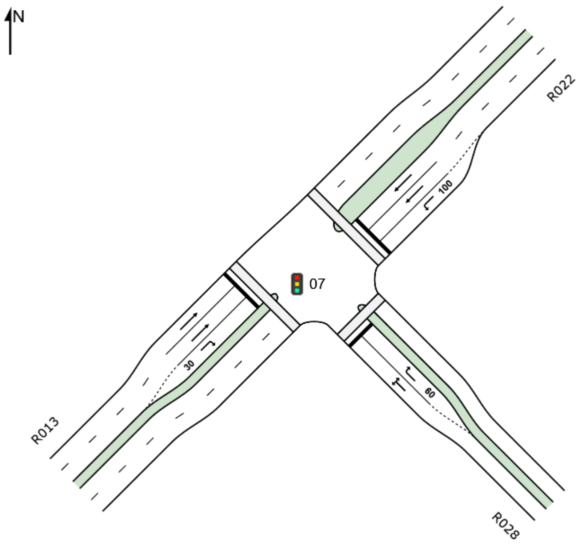
R1007
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

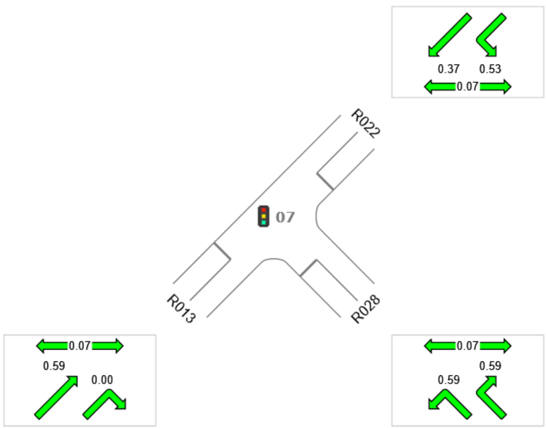
	Demand Flows		Cap.	Deg.	Lane	Average	Level of	95% Back of Queue		Lane	Lane	Cap.	Prob.
	Total	HV		Satn	Util.	Delay	Service	Veh	Dist	Config	Length	Adj.	Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R028													
Lane 1	320	1.3	388	0.824	100	47.2	LOS D	15.0	106.4	Full	500	0.0	0.0
Approach	320	1.3		0.824		47.2	LOS D	15.0	106.4				
NorthEast: R022													
Lane 1	1092	1.1	1263	0.864	100	19.0	LOS B	42.6	301.0	Full	500	0.0	0.0
Approach	1092	1.1		0.864		19.0	LOS B	42.6	301.0				
SouthWest: R013													
Lane 1	422	2.0	1234	0.342	100	7.8	LOS A	8.3	59.4	Full	500	0.0	0.0
Approach	422	2.0		0.342		7.8	LOS A	8.3	59.4				
Intersection	1834	1.3		0.864		21.3	LOS C	42.6	301.0				

Intersection R1007-2066

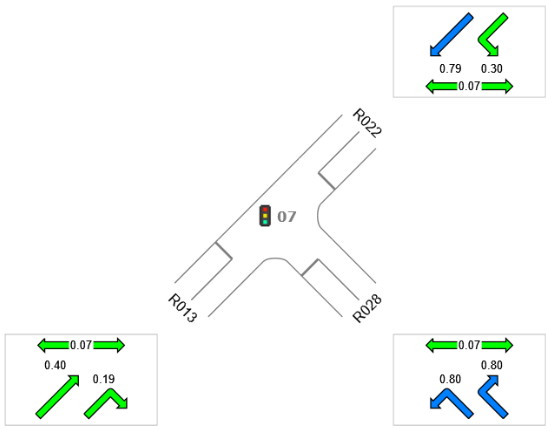
SITE LAYOUT – R1007 – 2066



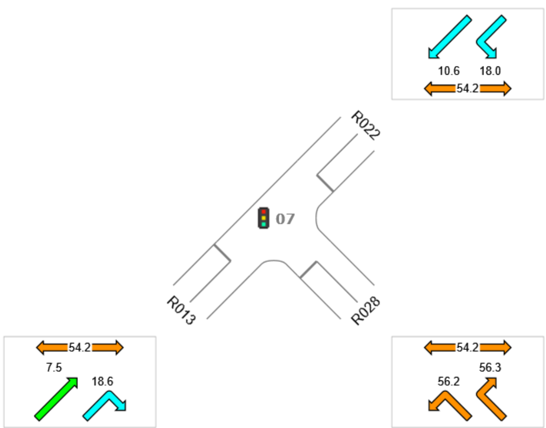
DEGREE OF SATURATION AM



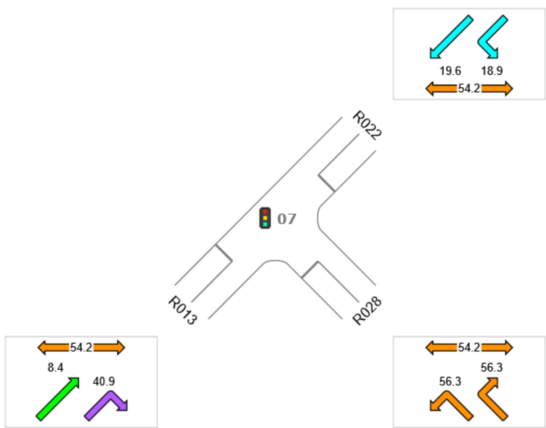
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1007 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 07 [2066 AM]

R1007
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R028													
Lane 1	171	2.1	290	0.592	100	56.2	LOS E	9.5	68.0	Full	500	0.0	0.0
Lane 2	171	2.8	288	0.592	100	56.3	LOS E	9.5	68.1	Short	60	0.0	NA
Approach	342	2.5		0.592		56.3	LOS E	9.5	68.1				
NorthEast: R022													
Lane 1	628	1.8	1176	0.534	100	18.0	LOS B	19.7	140.1	Short	100	0.0	NA
Lane 2	452	3.5	1223	0.370	100	10.6	LOS B	12.2	87.8	Full	500	0.0	0.0
Lane 3	452	3.5	1223	0.370	100	10.6	LOS B	12.2	87.8	Full	500	0.0	0.0
Approach	1533	2.8		0.534		13.6	LOS B	19.7	140.1				
SouthWest: R013													
Lane 1	848	2.1	1427	0.594	100	7.5	LOS A	22.5	159.9	Full	500	0.0	0.0
Lane 2	843	2.1	1419 [1]	0.594	100	7.5	LOS A	22.2	158.3	Full	500	0.0	0.0
Lane 3	1	0.0	249	0.004	100	18.6	LOS B	0.0	0.2	Short	30	0.0	NA
Approach	1693	2.1		0.594		7.5	LOS A	22.5	159.9				
Intersection	3567	2.4		0.594		14.8	LOS B	22.5	159.9				

Intersection R1007 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 07 [2066 PM]

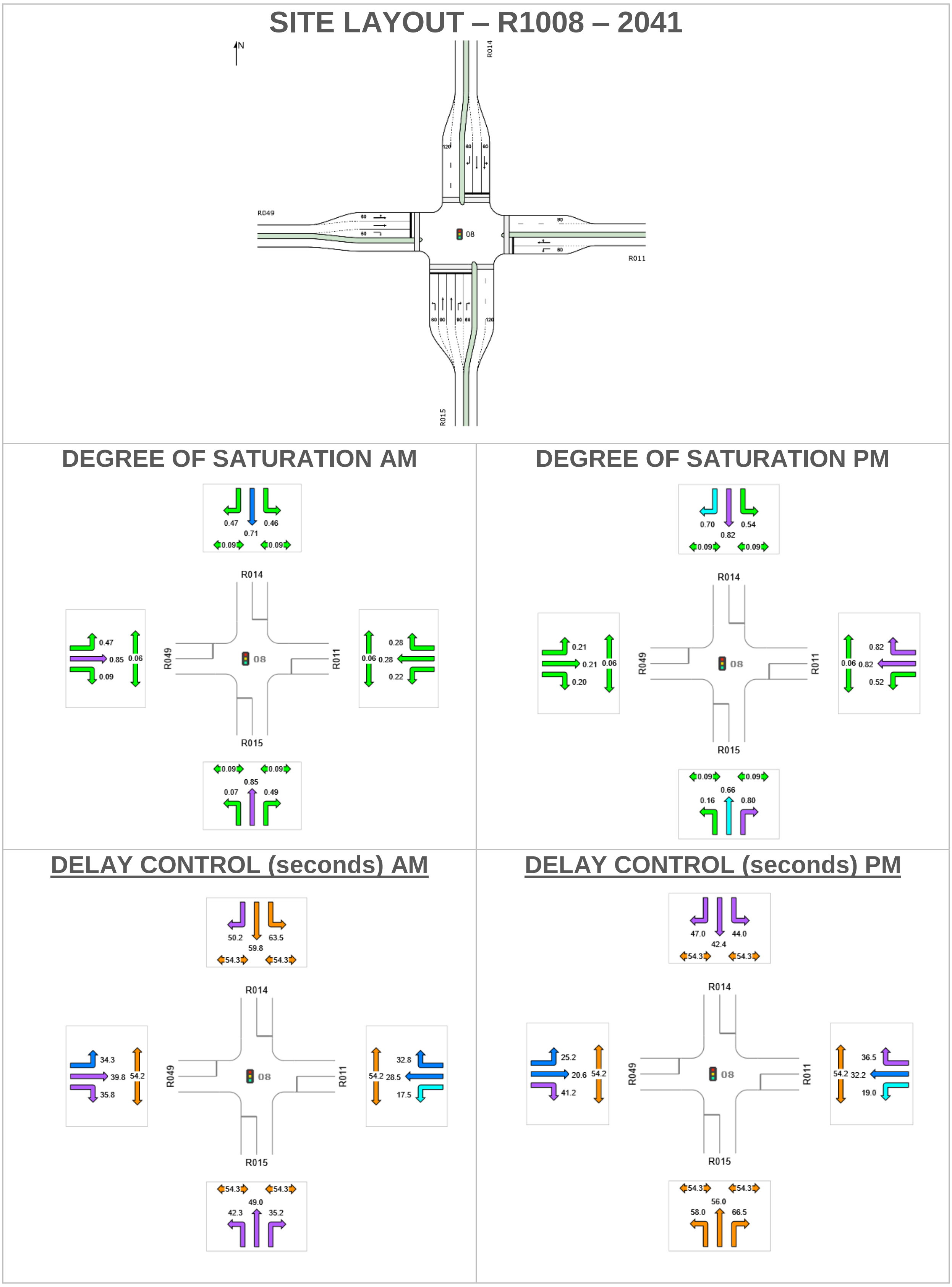
R1007
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R028													
Lane 1	294	1.1	368[1]	0.797	100	56.3	LOS E	17.2	121.4	Full	500	0.0	0.0
Lane 2	294	1.1	368[1]	0.797	100	56.3	LOS E	17.2	121.4	Short	60	0.0	NA
Approach	587	1.1		0.797		56.3	LOS E	17.2	121.4				
NorthEast: R022													
Lane 1	321	2.0	1068	0.301	100	18.9	LOS B	9.3	66.3	Short	100	0.0	NA
Lane 2	789	1.4	996[1]	0.792	100	18.7	LOS B	32.0	226.8	Full	500	0.0	0.0
Lane 3	892	1.4	1127	0.792	100	20.5	LOS C	39.9	282.5	Full	500	0.0	0.0
Approach	2002	1.5		0.792		19.5	LOS B	39.9	282.5				
SouthWest: R013													
Lane 1	527	2.1	1315	0.401	100	8.7	LOS A	13.2	93.8	Full	500	0.0	0.0
Lane 2	390	2.1	973[1]	0.401	100	7.9	LOS A	8.9	63.1	Full	500	0.0	0.0
Lane 3	34	0.0	175	0.193	100	40.9	LOS D	1.6	11.3	Short	30	0.0	NA
Approach	951	2.0		0.401		9.5	LOS A	13.2	93.8				
Intersection	3540	1.6		0.797		22.9	LOS C	39.9	282.5				

8 Intersection R1008

2041



Intersection R1008 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 08 [2041 AM]

R1008
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R015													
Lane 1	35	0.0	464	0.075	100	42.3	LOS D	1.5	10.8	Short	60	0.0	NA
Lane 2	271	1.4	483	0.560	66 [6]	42.5	LOS D	13.9	98.4	Short	90	0.0	NA
Lane 3	407	1.4	477 [1]	0.854	100	53.3	LOS D	25.0	177.2	Full	500	0.0	0.0
Lane 4	169	0.8	692	0.245	50 [6]	33.0	LOS C	6.8	47.6	Short	90	0.0	NA
Lane 5	336	0.8	690 [1]	0.487	100	36.2	LOS D	14.9	105.4	Short	60	0.0	NA
Approach	1218	1.1		0.854		43.1	LOS D	25.0	177.2				
East: R011													
Lane 1	183	1.1	844	0.217	100	17.5	LOS B	4.4	31.4	Short	60	0.0	NA
Lane 2	206	1.0	725	0.284	100	28.6	LOS C	8.3	58.4	Full	500	0.0	0.0
Approach	389	1.1		0.284		23.4	LOS C	8.3	58.4				
North: R014													
Lane 1	81	4.1	174	0.465	66 [6]	58.0	LOS E	4.7	33.9	Short	60	0.0	NA
Lane 2	123	4.1	174	0.708	100	60.9	LOS E	7.5	54.2	Full	500	0.0	0.0
Lane 3	185	2.8	394	0.470	100	50.2	LOS D	9.6	68.6	Short	60	0.0	NA
Approach	389	3.5		0.708		55.2	LOS E	9.6	68.6				
West: R049													
Lane 1	332	1.3	706	0.469	56 [6]	34.2	LOS C	14.5	102.7	Short	60	0.0	NA
Lane 2	482	0.9	570 [1]	0.846	100	40.0	LOS D	25.9	182.7	Full	500	0.0	0.0
Lane 3	32	0.0	334	0.095	100	35.8	LOS D	1.3	9.2	Short	60	0.0	NA
Approach	845	1.0		0.846		37.6	LOS D	25.9	182.7				
Intersection	2842	1.4		0.854		40.4	LOS D	25.9	182.7				

Intersection R1008 – 2041 Cont.

LANE SUMMARY 2041 PM

Site: 08 [2041 PM]

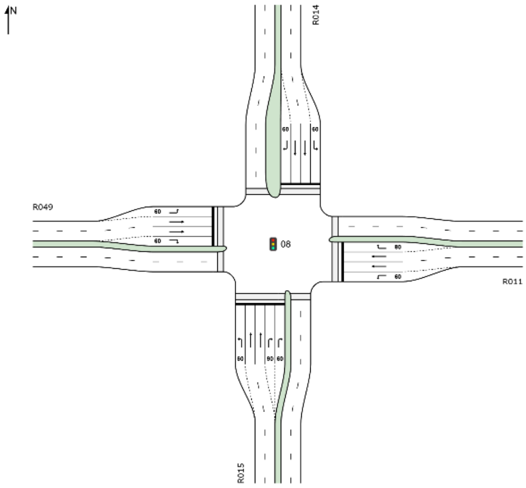
R1008
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

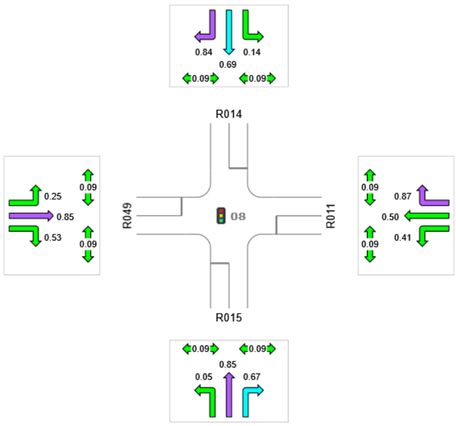
	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R015													
Lane 1	34	0.0	217	0.155	100	58.0	LOS E	1.8	12.7	Short	60	0.0	NA
Lane 2	97	2.2	224	0.431	66 [6]	54.6	LOS D	5.4	38.7	Short	90	0.0	NA
Lane 3	147	2.2	224	0.657	100	57.0	LOS E	8.6	61.4	Full	500	0.0	0.0
Lane 4	74	0.9	184	0.403	50 [6]	62.1	LOS E	4.2	29.9	Short	90	0.0	NA
Lane 5	148	0.9	184	0.801	100	68.7	LOS E	9.3	65.3	Short	60	0.0	NA
Approach	500	1.5		0.801		60.8	LOS E	9.3	65.3				
East: R011													
Lane 1	512	0.6	987 [1]	0.519	100	19.0	LOS B	15.9	112.1	Short	60	0.0	NA
Lane 2	486	0.6	592 [1]	0.822	100	32.2	LOS C	22.8	160.1	Full	500	0.0	0.0
Approach	998	0.6		0.822		25.4	LOS C	22.8	160.1				
North: R014													
Lane 1	304	0.9	564 [1]	0.539	66 [6]	38.5	LOS D	14.9	105.5	Short	60	0.0	NA
Lane 2	373	0.9	455 [1]	0.820	100	45.7	LOS D	20.8	147.0	Full	500	0.0	0.0
Lane 3	317	1.0	453 [1]	0.700	100	47.0	LOS D	16.4	115.8	Short	60	0.0	NA
Approach	994	1.0		0.820		43.9	LOS D	20.8	147.0				
West: R049													
Lane 1	177	1.8	840	0.210	99 [5]	25.2	LOS C	6.1	43.4	Short	60	0.0	NA
Lane 2	188	1.1	887	0.212	100	20.6	LOS C	6.5	46.0	Full	500	0.0	0.0
Lane 3	35	0.0	174	0.199	100	41.2	LOS D	1.6	11.3	Short	60	0.0	NA
Approach	400	1.3		0.212		24.5	LOS C	6.5	46.0				
Intersection	2892	1.0		0.822		37.8	LOS D	22.8	160.1				

Intersection R1008-2066

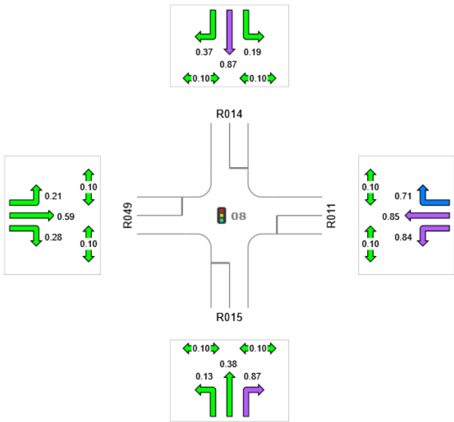
SITE LAYOUT – R1008 – 2066



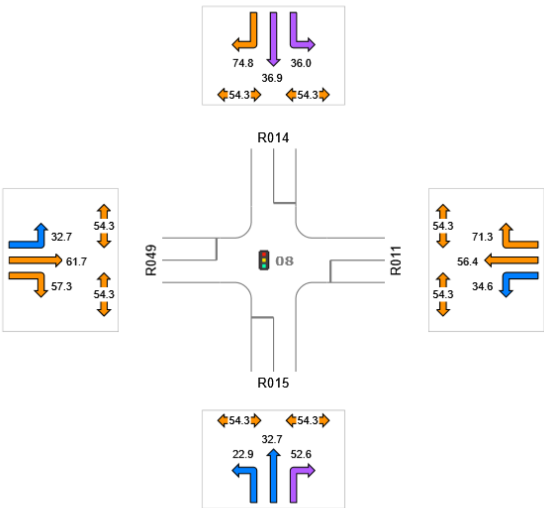
DEGREE OF SATURATION AM



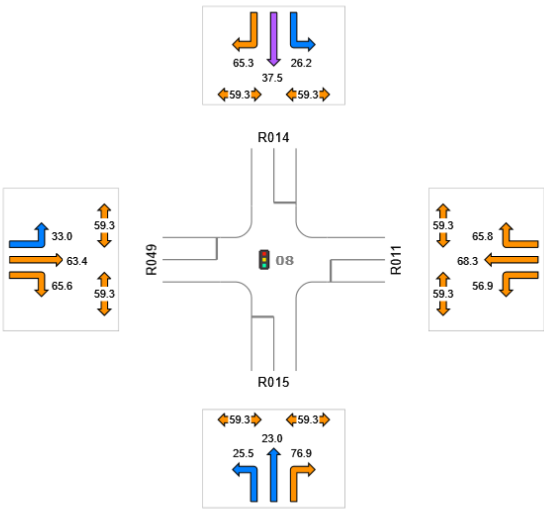
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1008 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 08 [2066 AM]

R1008
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R015													
Lane 1	47	2.2	884	0.054	100	22.9	LOS C	1.4	10.2	Short	60	0.0	NA
Lane 2	762	2.0	894 [1]	0.853	100	33.0	LOS C	40.9	291.0	Full	500	0.0	0.0
Lane 3	652	2.0	765 [1]	0.853	100	32.4	LOS C	33.1	235.5	Full	500	0.0	0.0
Lane 4	267	1.2	399	0.670	100	52.6	LOS D	14.5	102.8	Short	90	0.0	NA
Lane 5	267	1.2	399	0.670	100	52.6	LOS D	14.5	102.8	Short	60	0.0	NA
Approach	1997	1.8		0.853		37.8	LOS D	40.9	291.0				
East: R011													
Lane 1	289	2.5	699	0.414	100	34.6	LOS C	12.3	88.3	Short	60	0.0	NA
Lane 2	112	1.4	225	0.497	100	56.4	LOS E	6.3	45.0	Full	500	0.0	0.0
Lane 3	112	1.4	225	0.497	100	56.4	LOS E	6.3	45.0	Full	500	0.0	0.0
Lane 4	185	1.7	214	0.865	100	71.3	LOS E	12.0	85.3	Short	80	0.0	NA
Approach	699	2.0		0.865		51.3	LOS D	12.3	88.3				
North: R014													
Lane 1	81	1.3	598	0.136	100	36.0	LOS D	3.3	23.5	Short	60	0.0	NA
Lane 2	401	3.5	585 [1]	0.686	100	37.2	LOS D	20.1	144.7	Full	500	0.0	0.0
Lane 3	375	3.5	546 [1]	0.686	100	36.6	LOS D	18.4	132.7	Full	500	0.0	0.0
Lane 4	88	3.6	106	0.837	100	74.8	LOS E	5.8	41.6	Short	60	0.0	NA
Approach	945	3.3		0.837		40.4	LOS D	20.1	144.7				
West: R049													
Lane 1	92	2.3	365	0.251	100	32.7	LOS C	3.5	25.3	Short	60	0.0	NA
Lane 2	233	0.9	275	0.847	100	61.7	LOS E	14.7	103.7	Full	500	0.0	0.0
Lane 3	233	0.9	275	0.847	100	61.7	LOS E	14.7	103.7	Full	500	0.0	0.0
Lane 4	138	0.8	262	0.527	100	57.3	LOS E	7.7	54.1	Short	60	0.0	NA
Approach	695	1.1		0.847		57.0	LOS E	14.7	103.7				
Intersection	4336	2.0		0.865		43.6	LOS D	40.9	291.0				

Intersection R1008 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 08 [2066 PM]

R1008
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

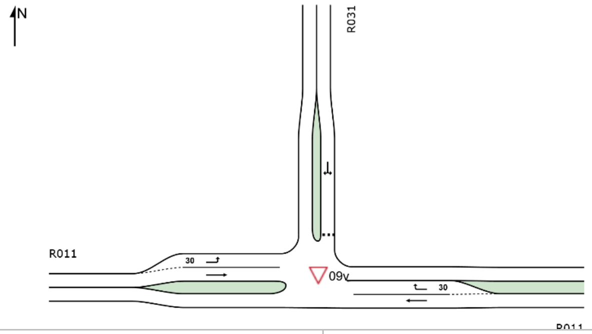
Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R015													
Lane 1	112	0.9	880	0.127	100	25.5	LOS C	3.9	27.2	Short	60	0.0	NA
Lane 2	348	2.1	917	0.380	100	23.0	LOS C	13.9	99.0	Full	500	0.0	0.0
Lane 3	348	2.1	917	0.380	100	23.0	LOS C	13.9	99.0	Full	500	0.0	0.0
Lane 4	172	1.5	198	0.867	100	76.9	LOS E	12.0	85.1	Short	90	0.0	NA
Lane 5	172	1.5	198	0.867	100	76.9	LOS E	12.0	85.1	Short	60	0.0	NA
Approach	1152	1.8		0.867		39.3	LOS D	13.9	99.0				
East: R011													
Lane 1	358	0.9	424 [1]	0.843	100	56.9	LOS E	22.1	156.0	Short	60	0.0	NA
Lane 2	229	0.7	269	0.854	100	68.3	LOS E	15.7	110.4	Full	500	0.0	0.0
Lane 3	229	0.7	269	0.854	100	68.3	LOS E	15.7	110.4	Full	500	0.0	0.0
Lane 4	180	1.2	255	0.706	100	65.8	LOS E	11.4	80.4	Short	80	0.0	NA
Approach	997	0.8		0.854		63.7	LOS E	22.1	156.0				
North: R014													
Lane 1	165	1.3	878	0.188	100	26.2	LOS C	5.9	41.8	Short	60	0.0	NA
Lane 2	695	1.5	797 [1]	0.872	100	37.4	LOS D	40.0	283.3	Full	500	0.0	0.0
Lane 3	748	1.5	858 [1]	0.872	100	37.7	LOS D	44.2	313.0	Full	500	0.0	0.0
Lane 4	73	1.4	198	0.367	100	65.3	LOS E	4.4	31.2	Short	60	0.0	NA
Approach	1681	1.4		0.872		37.6	LOS D	44.2	313.0				
West: R049													
Lane 1	75	2.8	364	0.205	100	33.0	LOS C	2.9	20.8	Short	60	0.0	NA
Lane 2	106	1.0	179	0.592	100	63.4	LOS E	6.7	47.3	Full	500	0.0	0.0
Lane 3	106	1.0	179	0.592	100	63.4	LOS E	6.7	47.3	Full	500	0.0	0.0
Lane 4	47	0.0	171	0.276	100	65.6	LOS E	2.9	20.2	Short	60	0.0	NA
Approach	334	1.3		0.592		56.9	LOS E	6.7	47.3				
Intersection	4163	1.4		0.872		45.9	LOS D	44.2	313.0				

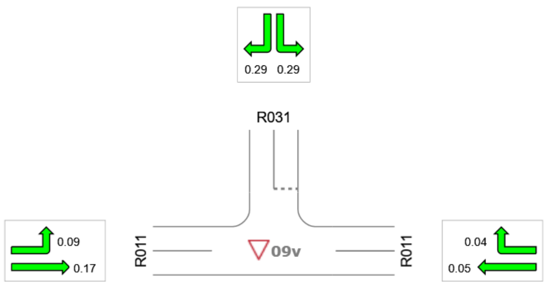
9 Intersection R1009

2031

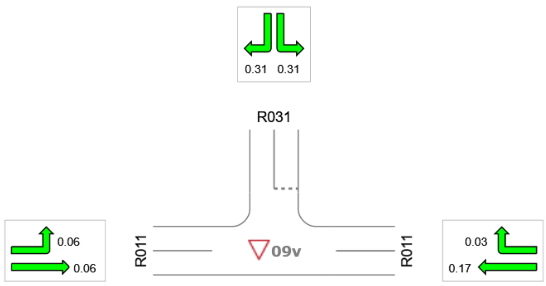
SITE LAYOUT – R1009 – 2031



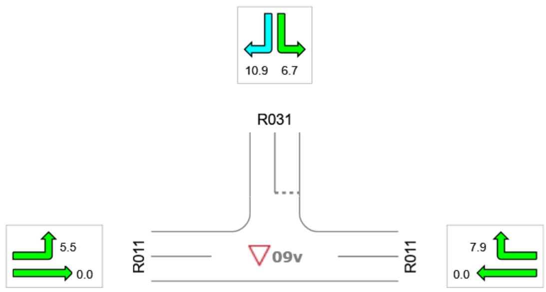
DEGREE OF SATURATION AM



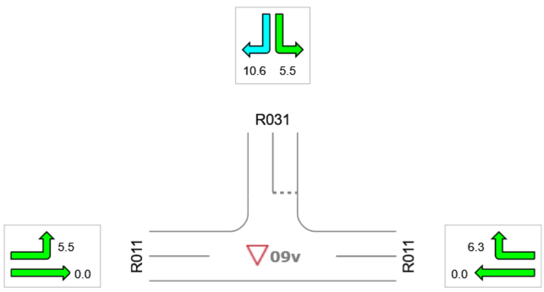
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) AM



Intersection R1009 – 2031 Cont.

MOVEMENT SUMMARY 2031 AM

Site: 09v [2031 AM - FINAL]

R1009
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
East: R011												
5	T1	105	2.0	0.055	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
6	R2	32	0.0	0.038	7.9	LOS A	0.1	1.0	0.49	0.69	0.49	47.9
Approach		137	1.5	0.055	1.8	NA	0.1	1.0	0.11	0.16	0.11	56.7
North: R031												
7	L2	32	0.0	0.288	6.7	LOS A	1.3	8.9	0.60	0.83	0.67	46.3
9	R2	129	0.0	0.288	10.9	LOS B	1.3	8.9	0.60	0.83	0.67	46.2
Approach		161	0.0	0.288	10.1	LOS B	1.3	8.9	0.60	0.83	0.67	46.2
West: R011												
10	L2	175	0.0	0.094	5.5	LOS A	0.0	0.0	0.00	0.58	0.00	53.6
11	T1	339	0.9	0.175	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
Approach		514	0.6	0.175	1.9	NA	0.0	0.0	0.00	0.20	0.00	57.6
All Vehicles		812	0.6	0.288	3.5	NA	1.3	8.9	0.14	0.31	0.15	54.8

MOVEMENT SUMMARY 2031 PM

Site: 09v [2031 PM - FINAL]

R1009
Site Category: (None)
Giveway / Yield (Two-Way)

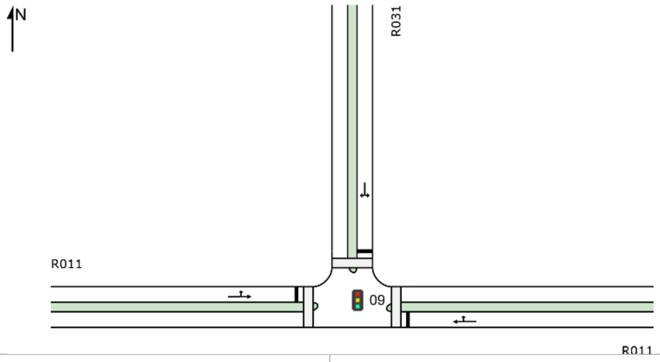
Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
East: R011												
5	T1	329	0.6	0.171	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
6	R2	32	0.0	0.027	6.3	LOS A	0.1	0.7	0.31	0.58	0.31	48.7
Approach		361	0.6	0.171	0.6	NA	0.1	0.7	0.03	0.05	0.03	58.8
North: R031												
7	L2	32	0.0	0.310	5.5	LOS A	1.4	10.1	0.49	0.75	0.56	46.6
9	R2	153	0.0	0.310	10.6	LOS B	1.4	10.1	0.49	0.75	0.56	46.4
Approach		184	0.0	0.310	9.7	LOS A	1.4	10.1	0.49	0.75	0.56	46.4
West: R011												
10	L2	117	0.0	0.063	5.5	LOS A	0.0	0.0	0.00	0.58	0.00	53.6
11	T1	107	1.0	0.055	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0

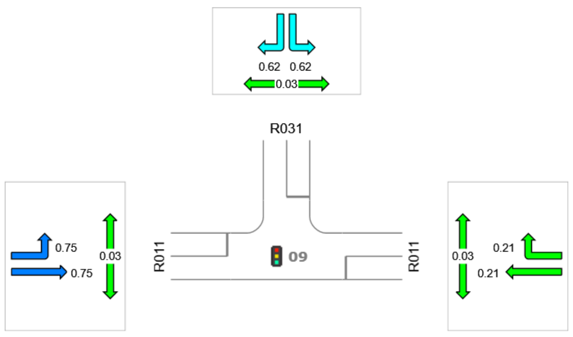
Approach	224	0.5	0.063	2.9	NA	0.0	0.0	0.00	0.30	0.00	56.5
All Vehicles	769	0.4	0.310	3.4	NA	1.4	10.1	0.13	0.29	0.15	54.6

Intersection R1009-2041

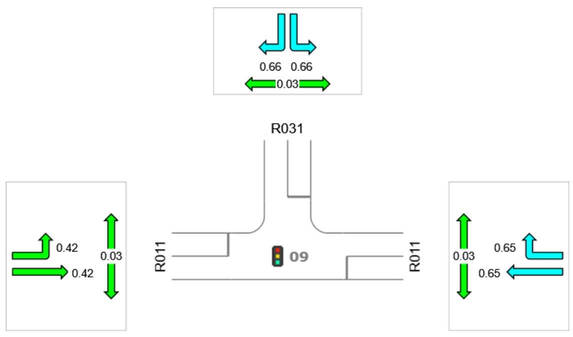
SITE LAYOUT – R1009 – 2041



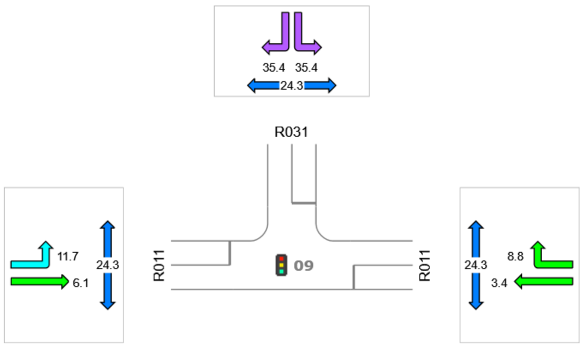
DEGREE OF SATURATION AM



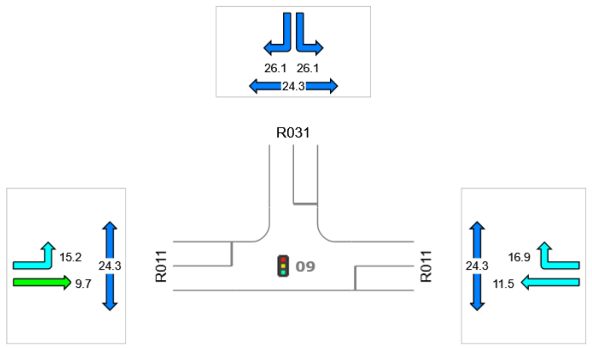
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1009 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 09 [2041 AM - FINAL]

R1009
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
East: R011													
Lane 1	278	1.5	1329	0.209	100	3.4	LOS A	2.8	20.2	Full	500	0.0	0.0
Approach	278	1.5		0.209		3.4	LOS A	2.8	20.2				
North: R031													
Lane 1	114	0.9	184	0.616	100	35.4	LOS D	3.5	24.9	Full	500	0.0	0.0
Approach	114	0.9		0.616		35.4	LOS D	3.5	24.9				
West: R011													
Lane 1	995	0.8	1335	0.745	100	8.0	LOS A	18.4	129.5	Full	500	0.0	0.0
Approach	995	0.8		0.745		8.0	LOS A	18.4	129.5				
Intersection	1386	1.0		0.745		9.3	LOS A	18.4	129.5				

LANE SUMMARY 2041 PM

Site: 09 [2041 PM - FINAL]

R1009
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

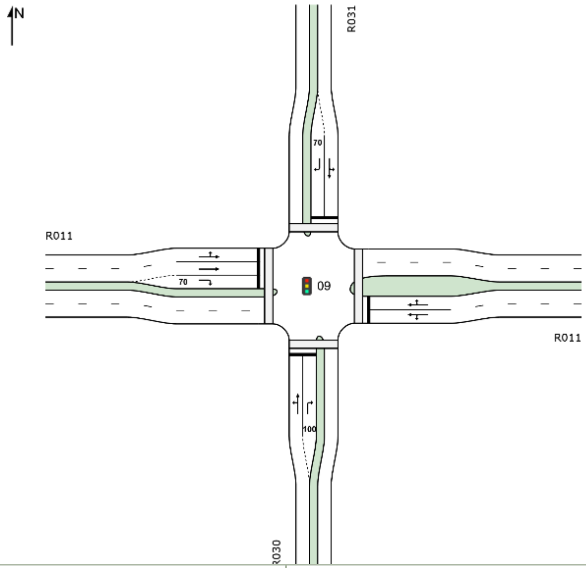
Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
East: R011													
Lane 1	653	0.6	1001	0.652	100	11.5	LOS B	14.1	99.1	Full	500	0.0	0.0
Approach	653	0.6		0.652		11.5	LOS B	14.1	99.1				
North: R031													
Lane 1	345	0.6	524	0.659	100	26.1	LOS C	9.4	65.9	Full	500	0.0	0.0
Approach	345	0.6		0.659		26.1	LOS C	9.4	65.9				

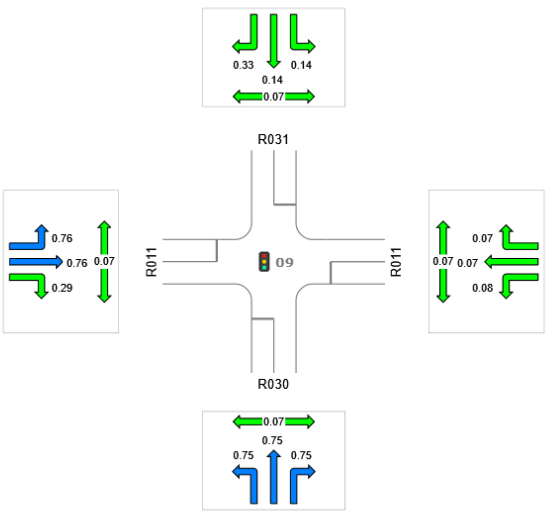
West: R011													
Lane 1	412	1.0	987	0.417	100	11.3	LOS B	7.5	52.8	Full	500	0.0	0.0
Approach	412	1.0		0.417		11.3	LOS B	7.5	52.8				
Intersection	1409	0.7		0.659		15.0	LOS B	14.1	99.1				

Intersection R1009-2066

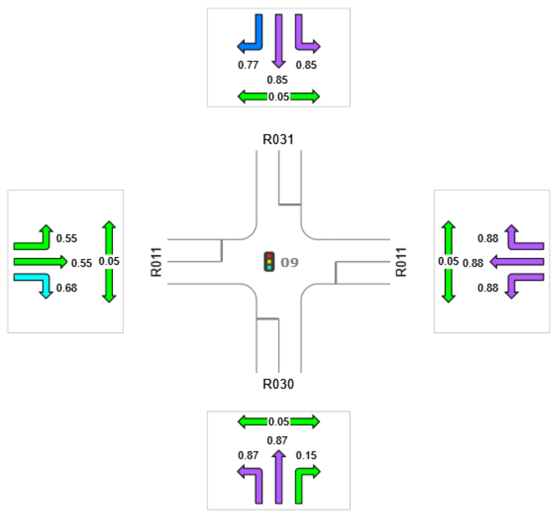
SITE LAYOUT – R1009 – 2066

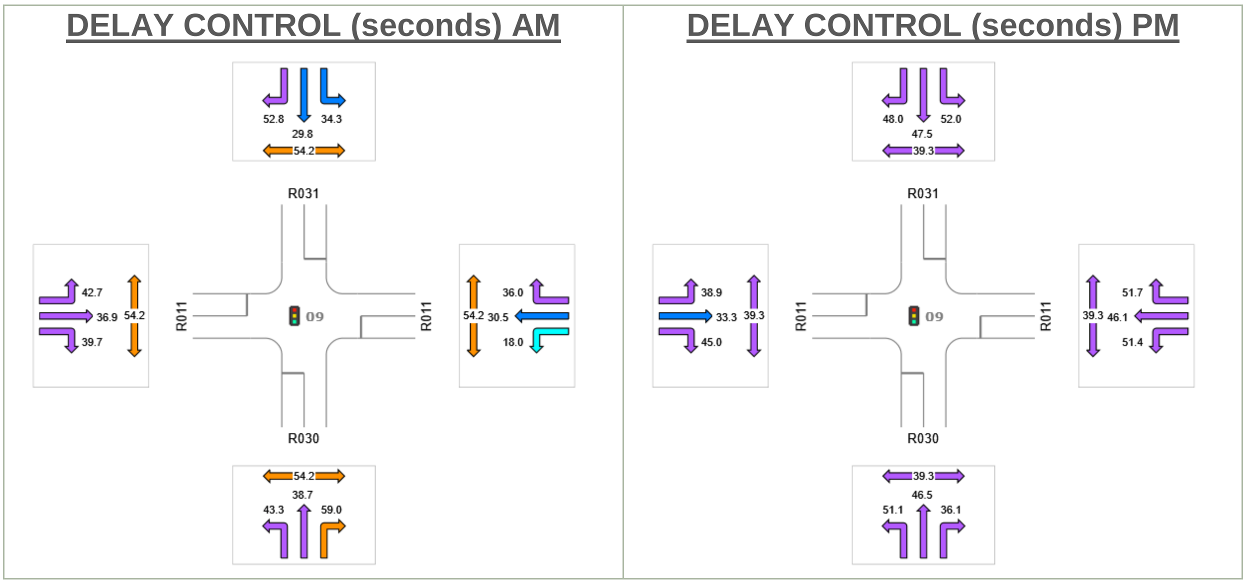


DEGREE OF SATURATION AM



DEGREE OF SATURATION PM





Intersection R1009 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 09 [2066 AM - FINAL]

R1009
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R030													
Lane 1	468	1.6	626	0.749	100	41.2	LOS D	24.6	174.2	Full	500	0.0	0.0
Lane 2	229	1.4	307	0.749	100	59.0	LOS E	13.5	95.5	Short	100	0.0	NA
Approach	698	1.5		0.749		47.1	LOS D	24.6	174.2				
East: R011													
Lane 1	86	1.2	1043	0.083	100	18.0	LOS B	2.2	15.9	Full	500	0.0	0.0
Lane 2	35	21.2	518	0.067	81[5]	30.7	LOS C	1.4	11.6	Full	500	0.0	0.0
Approach	121	7.0		0.083		21.6	LOS C	2.2	15.9				
North: R031													
Lane 1	91	2.3	640	0.141	100	29.8	LOS C	3.7	26.2	Full	500	0.0	0.0
Lane 2	101	2.1	305	0.331	100	52.8	LOS D	5.3	37.8	Short	70	0.0	NA
Approach	192	2.2		0.331		42.0	LOS D	5.3	37.8				
West: R011													
Lane 1	501	1.0	659	0.760	100	40.3	LOS D	25.8	182.5	Full	500	0.0	0.0
Lane 2	463	0.9	610[1]	0.760	100	36.7	LOS D	23.5	166.0	Full	500	0.0	0.0
Lane 3	117	0.9	407	0.287	100	39.7	LOS D	5.2	36.9	Short	70	0.0	NA
Approach	1081	1.0		0.760		38.7	LOS D	25.8	182.5				
Intersection	2092	1.6		0.760		40.8	LOS D	25.8	182.5				

Intersection R1009 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 09 [2066 PM - FINAL]

R1009
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site Practical Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

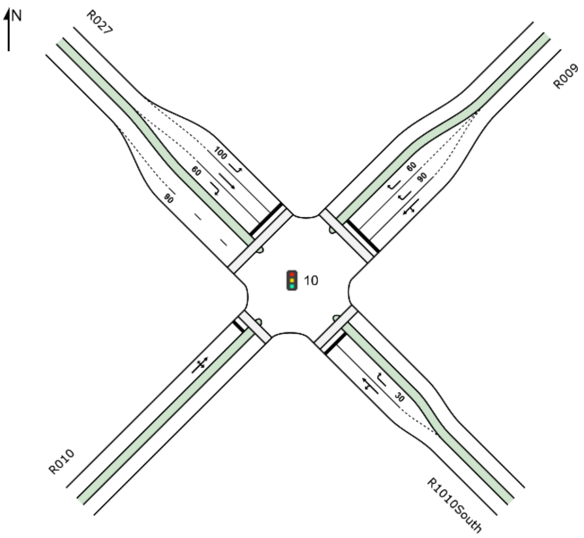
Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R030													
Lane 1	343	1.2	393	0.873	100	50.0	LOS D	17.0	120.5	Full	500	0.0	0.0
Lane 2	58	1.8	387	0.150	100	36.1	LOS D	2.1	14.9	Short	100	0.0	NA
Approach	401	1.3		0.873		48.0	LOS D	17.0	120.5				
East: R011													
Lane 1	384	1.1	437	0.878	100	49.7	LOS D	19.1	135.1	Full	500	0.0	0.0
Lane 2	395	0.8	450	0.878	100	46.2	LOS D	19.7	139.1	Full	500	0.0	0.0
Approach	779	0.9		0.878		47.9	LOS D	19.7	139.1				
North: R031													
Lane 1	256	1.2	301	0.850	100	47.5	LOS D	12.5	88.1	Full	500	0.0	0.0
Lane 2	220	1.0	287	0.767	100	48.0	LOS D	10.1	71.3	Short	70	0.0	NA
Approach	476	1.1		0.850		47.7	LOS D	12.5	88.1				
West: R011													
Lane 1	242	1.5	439	0.553	100	36.3	LOS D	9.6	67.8	Full	500	0.0	0.0
Lane 2	249	1.4	451	0.553	100	33.3	LOS C	9.8	69.6	Full	500	0.0	0.0
Lane 3	228	0.9	335	0.682	100	45.0	LOS D	9.2	65.1	Short	70	0.0	NA
Approach	720	1.3		0.682		38.0	LOS D	9.8	69.6				
Intersection	2376	1.2		0.878		44.9	LOS D	19.7	139.1				

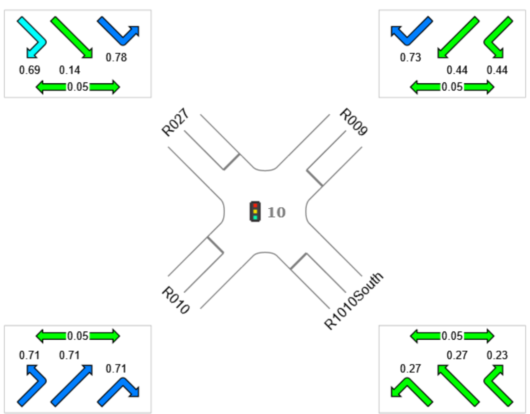
10 Intersection R1010

2031

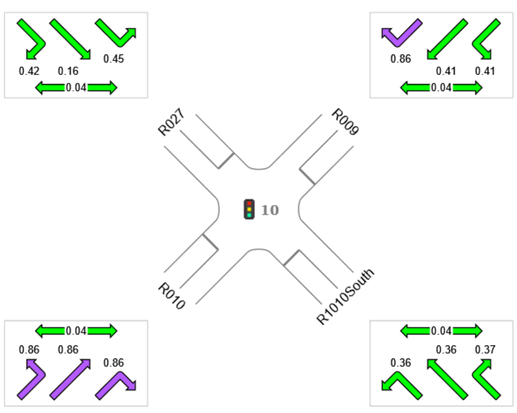
SITE LAYOUT – R1010 – 2031

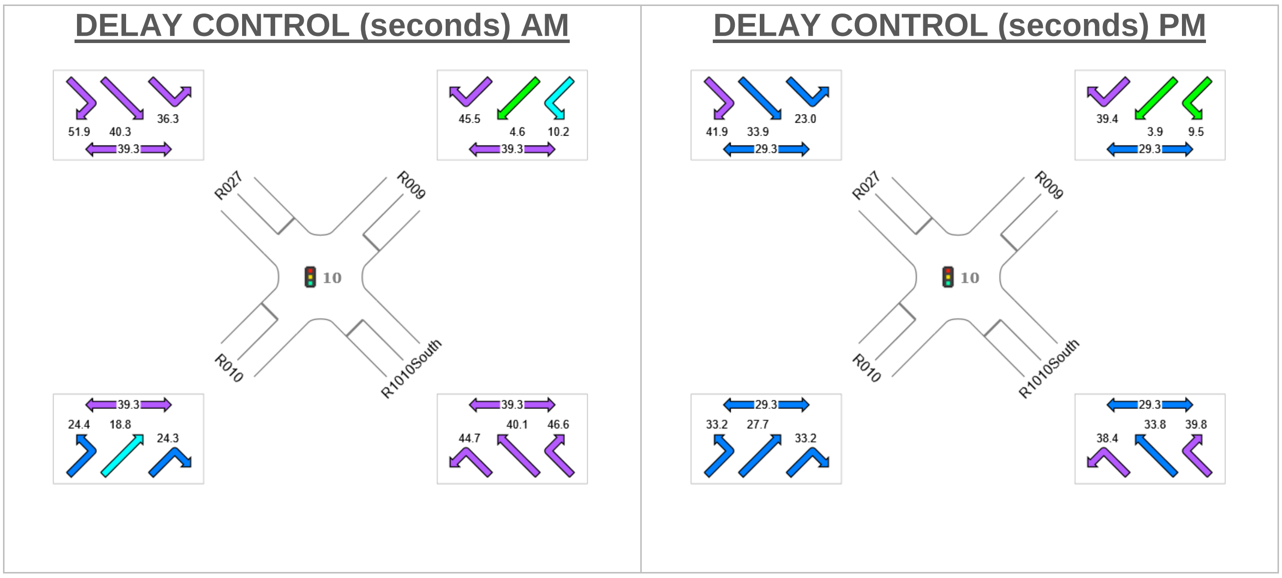


DEGREE OF SATURATION AM



DEGREE OF SATURATION PM





Intersection R1010 – 2031 Cont.

LANE SUMMARY 2031 AM

Site: 10 [2031 AM - FINAL]

R1010
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R1010South													
Lane 1	63	0.0	233	0.272	100	42.4	LOS D	2.6	18.3	Full	500	0.0	0.0
Lane 2	32	10.0	137	0.231	100	46.6	LOS D	1.4	10.3	Short	30	0.0	NA
Approach	95	3.3		0.272		43.8	LOS D	2.6	18.3				
NorthEast: R009													
Lane 1	624	2.4	1423	0.439	100	5.2	LOS A	10.2	73.2	Full	500	0.0	0.0
Lane 2	112	2.2	305	0.368	51 [6]	42.5	LOS D	4.5	32.2	Short	90	0.0	NA
Lane 3	222	2.2	305	0.727	100	47.0	LOS D	9.9	70.5	Short	60	0.0	NA
Approach	958	2.3		0.727		19.2	LOS B	10.2	73.2				
NorthWest: R027													
Lane 1	511	1.6	653	0.782	100	36.3	LOS D	21.3	151.5	Short	100	0.0	NA
Lane 2	34	0.0	238	0.141	100	40.3	LOS D	1.4	9.5	Full	500	0.0	0.0
Lane 3	114	0.9	164	0.693	100	51.9	LOS D	5.3	37.2	Short	60	0.0	NA
Approach	658	1.4		0.782		39.2	LOS D	21.3	151.5				
SouthWest: R010													
Lane 1	627	2.7	879	0.714	100	19.6	LOS B	21.4	153.5	Full	500	0.0	0.0
Approach	627	2.7		0.714		19.6	LOS B	21.4	153.5				
Intersection	2338	2.2		0.782		25.9	LOS C	21.4	153.5				

Intersection R1010 – 2031 Cont.

LANE SUMMARY 2031 PM

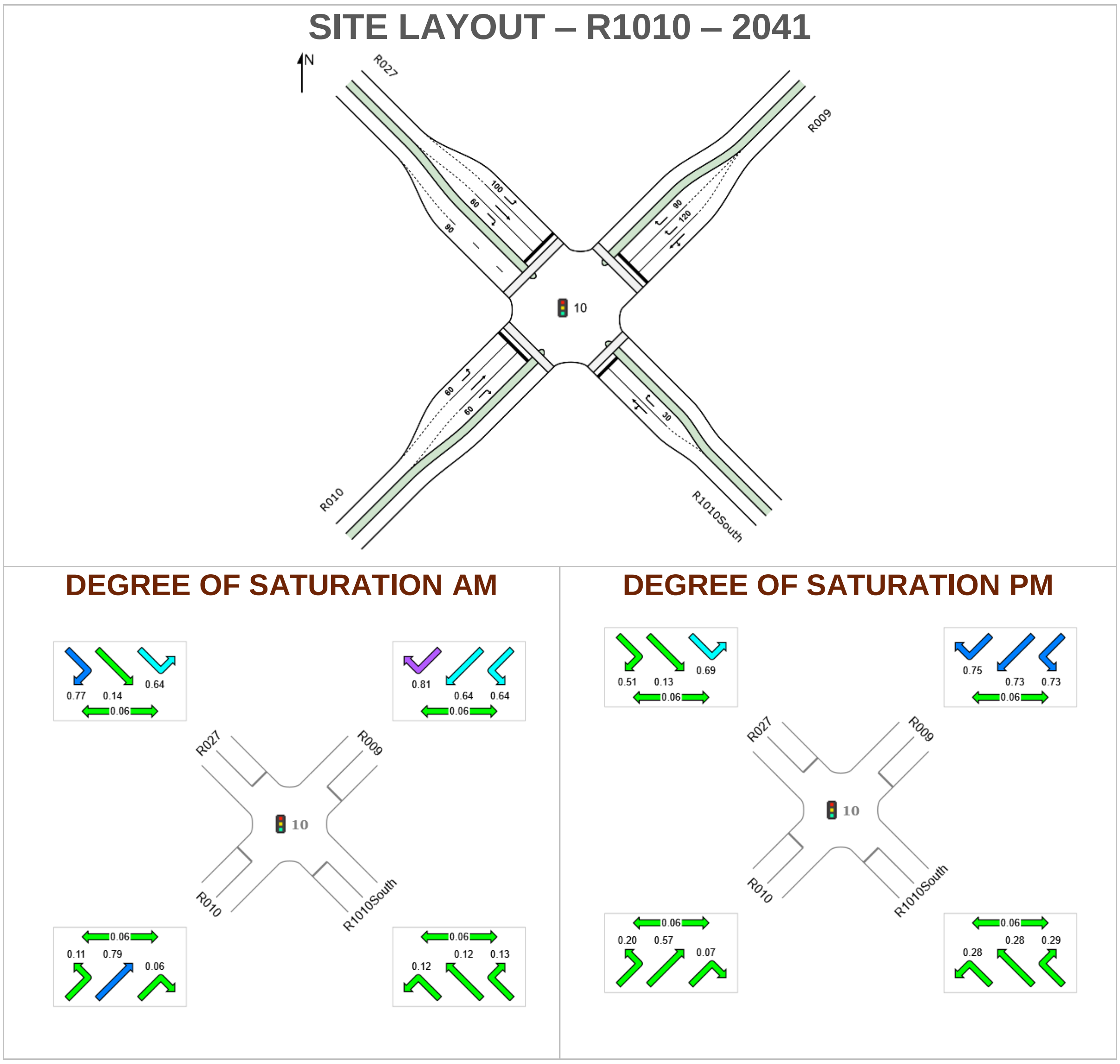
Site: 10 [2031 PM - FINAL]

R1010
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 70 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

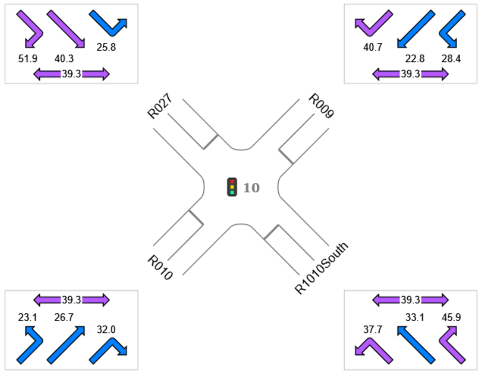
Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R1010South													
Lane 1	69	0.0	191	0.364	100	35.9	LOS D	2.4	16.6	Full	500	0.0	0.0
Lane 2	57	1.9	153	0.372	100	39.8	LOS D	2.0	14.1	Short	30	0.0	NA
Approach	126	0.8		0.372		37.6	LOS D	2.4	16.6				
NorthEast: R009													
Lane 1	574	2.0	1398	0.410	100	4.2	LOS A	7.5	53.6	Full	500	0.0	0.0
Lane 2	160	1.3	368	0.434	51 [6]	33.0	LOS C	5.0	35.1	Short	90	0.0	NA
Lane 3	315	1.3	368	0.857	100	42.7	LOS D	12.3	87.3	Short	60	0.0	NA
Approach	1048	1.7		0.857		20.2	LOS C	12.3	87.3				
NorthWest: R027													
Lane 1	319	2.0	706	0.452	100	23.0	LOS C	8.2	58.4	Short	100	0.0	NA
Lane 2	32	0.0	195	0.162	100	33.9	LOS C	1.0	7.3	Full	500	0.0	0.0
Lane 3	60	1.8	142	0.422	100	41.9	LOS D	2.1	15.1	Short	60	0.0	NA
Approach	411	1.8		0.452		26.6	LOS C	8.2	58.4				
SouthWest: R010													
Lane 1	676	1.6	782	0.864	100	28.8	LOS C	25.4	180.4	Full	500	0.0	0.0
Approach	676	1.6		0.864		28.8	LOS C	25.4	180.4				
Intersection	2261	1.6		0.864		24.9	LOS C	25.4	180.4				

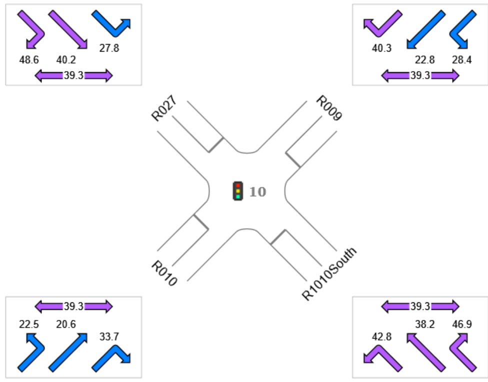
Intersection R1010-2041



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1010 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 10 [2041 AM - FINAL]

R1010
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R1010South													
Lane 1	42	2.5	345	0.122	100	36.6	LOS D	1.6	11.2	Full	500	0.0	0.0
Lane 2	18	11.8	134	0.133	100	45.9	LOS D	0.8	5.8	Short	30	0.0	NA
Approach	60	5.3		0.133		39.4	LOS D	1.6	11.2				
NorthEast: R009													
Lane 1	504	1.9	789	0.639	100	23.3	LOS C	17.7	126.1	Full	500	0.0	0.0
Lane 2	200	1.6	490	0.408	51 [6]	35.2	LOS D	7.3	52.0	Short	120	0.0	NA
Lane 3	395	1.6	490	0.806	100	43.5	LOS D	17.8	126.5	Short	90	0.0	NA
Approach	1099	1.7		0.806		32.7	LOS C	17.8	126.5				
NorthWest: R027													
Lane 1	533	1.4	838	0.636	100	25.8	LOS C	17.9	127.1	Short	100	0.0	NA
Lane 2	32	3.3	233	0.135	100	40.3	LOS D	1.3	9.2	Full	500	0.0	0.0
Lane 3	157	2.0	205	0.767	100	51.9	LOS D	7.4	52.6	Short	60	0.0	NA
Approach	721	1.6		0.767		32.1	LOS C	17.9	127.1				
SouthWest: R010													
Lane 1	85	2.5	750	0.114	100	23.1	LOS C	2.3	16.4	Short	60	0.0	NA
Lane 2	591	2.3	750 [1]	0.787	100	26.7	LOS C	23.4	166.9	Full	500	0.0	0.0
Lane 3	32	0.0	495	0.064	100	32.0	LOS C	1.0	7.2	Short	60	0.0	NA
Approach	707	2.2		0.787		26.5	LOS C	23.4	166.9				

Intersection	2587	1.9	0.806	31.0	LOS C	23.4	166.9

Intersection R1010 – 2041 Cont.

LANE SUMMARY 2041 PM

Site: 10 [2041 PM - FINAL]

R1010
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

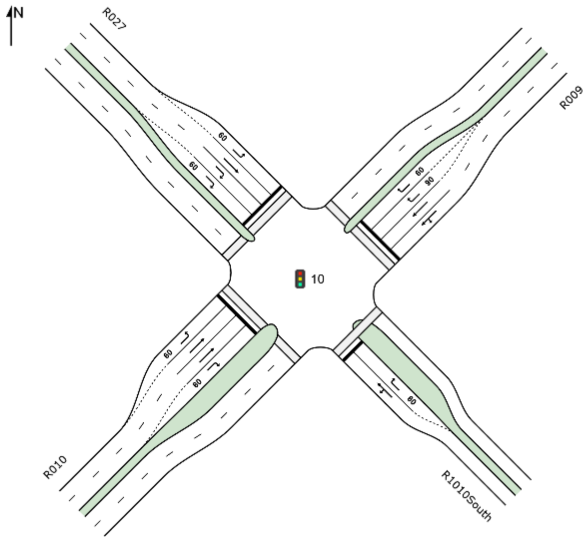
Lane Use and Performance

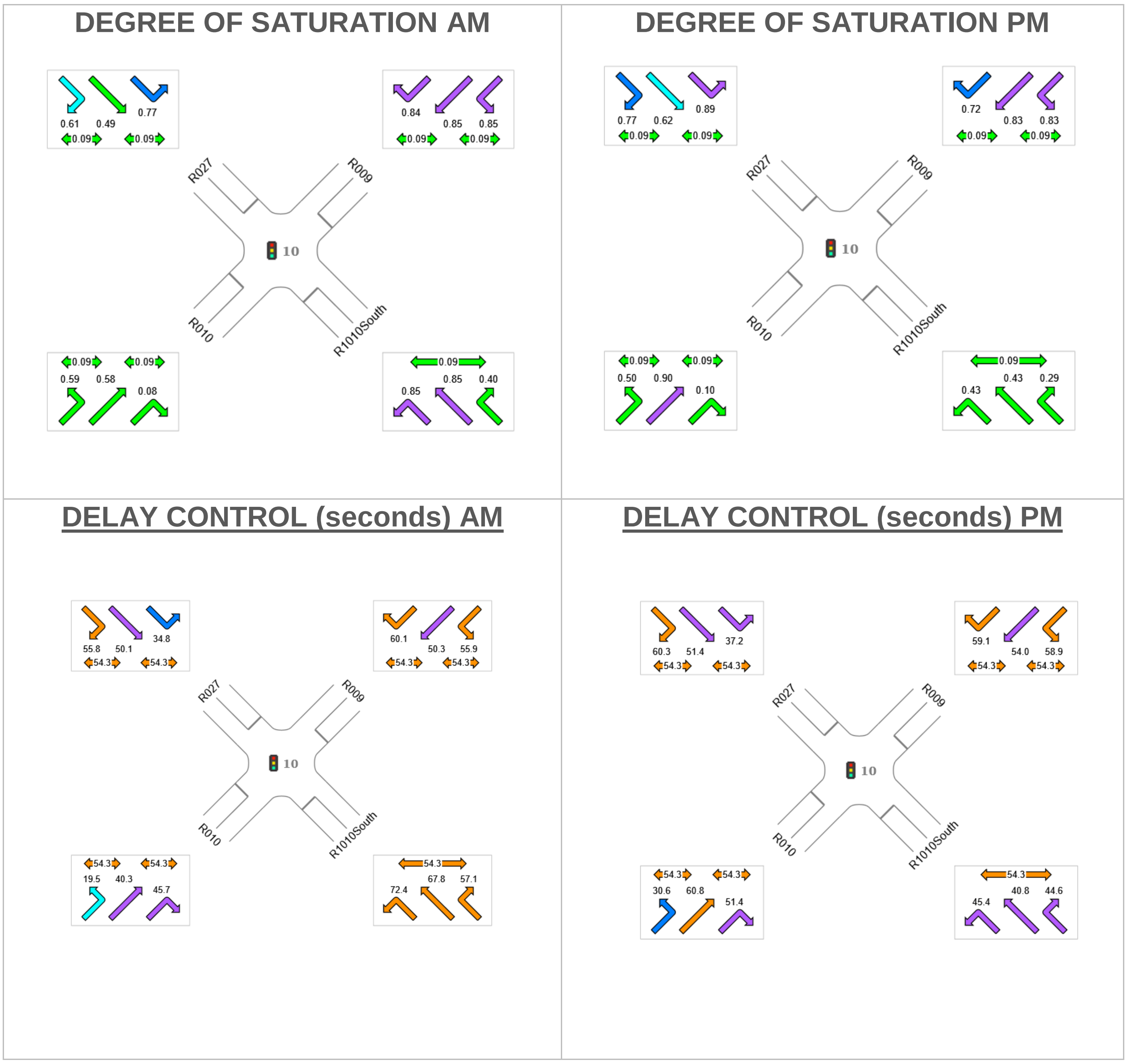
	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R1010South													
Lane 1	74	1.4	261	0.282	100	40.2	LOS D	3.0	21.2	Full	500	0.0	0.0
Lane 2	40	2.6	140	0.286	100	46.9	LOS D	1.7	12.4	Short	30	0.0	NA
Approach	114	1.9		0.286		42.5	LOS D	3.0	21.2				
NorthEast: R009													
Lane 1	612	1.9	833	0.734	100	23.0	LOS C	22.4	159.0	Full	500	0.0	0.0
Lane 2	172	1.0	451	0.381	51 [6]	36.6	LOS D	6.4	45.1	Short	120	0.0	NA
Lane 3	339	1.0	451	0.752	100	42.2	LOS D	14.7	103.7	Short	90	0.0	NA
Approach	1122	1.5		0.752		30.9	LOS C	22.4	159.0				
NorthWest: R027													
Lane 1	551	1.1	798	0.690	100	27.8	LOS C	19.6	138.5	Short	100	0.0	NA
Lane 2	32	0.0	238	0.132	100	40.2	LOS D	1.3	8.9	Full	500	0.0	0.0
Lane 3	94	2.2	183	0.512	100	48.6	LOS D	4.1	29.3	Short	60	0.0	NA
Approach	676	1.2		0.690		31.3	LOS C	19.6	138.5				
SouthWest: R010													
Lane 1	158	2.7	790	0.200	100	22.5	LOS C	4.3	30.6	Short	60	0.0	NA
Lane 2	474	1.1	824 [1]	0.575	100	20.6	LOS C	15.6	110.2	Full	500	0.0	0.0
Lane 3	32	0.0	454	0.070	100	33.7	LOS C	1.1	7.5	Short	60	0.0	NA
Approach	663	1.4		0.575		21.7	LOS C	15.6	110.2				

Intersection	2575	1.4	0.752	29.1	LOS C	22.4	159.0

Intersection R1010-2066

SITE LAYOUT – R1010 – 2066





Intersection R1010 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 10 [2066 AM - FINAL]

R1010
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R1010South													
Lane 1	218	4.8	255	0.853	100	68.5	LOS E	13.6	99.4	Full	500	0.0	0.0
Lane 2	96	3.3	242	0.396	100	57.1	LOS E	5.3	37.9	Short	60	0.0	NA
Approach	314	4.4		0.853		65.0	LOS E	13.6	99.4				
NorthEast: R009													

Lane 1	441	1.9	521	0.847	100	52.0	LOS D	26.5	188.7	Full	500	0.0	0.0
Lane 2	427	1.7	504 [1]	0.847	100	50.3	LOS D	25.6	181.7	Full	500	0.0	0.0
Lane 3	298	1.8	357 [1]	0.835	100	60.1	LOS E	18.0	128.2	Short	90	0.0	NA
Lane 4	298	1.8	357 [1]	0.835	100	60.1	LOS E	18.0	128.2	Short	60	0.0	NA
Approach	1465	1.8		0.847		54.8	LOS D	26.5	188.7				
NorthWest: R027													
Lane 1	529	1.4	684 [1]	0.774	100	34.8	LOS C	24.7	174.9	Short	60	0.0	NA
Lane 2	162	4.5	331	0.489	100	50.1	LOS D	8.7	63.3	Full	500	0.0	0.0
Lane 3	193	3.6	317	0.608	100	55.8	LOS E	10.6	76.6	Full	500	0.0	0.0
Lane 4	193	3.6	317	0.608	100	55.8	LOS E	10.6	76.6	Short	60	0.0	NA
Approach	1077	2.6		0.774		44.6	LOS D	24.7	174.9				
SouthWest: R010													
Lane 1	478	4.2	812	0.589	100	19.5	LOS B	12.4	90.0	Short	60	0.0	NA
Lane 2	298	1.9	515 [1]	0.578	100	40.2	LOS D	15.0	106.6	Full	500	0.0	0.0
Lane 3	305	1.9	527 [1]	0.578	100	40.4	LOS D	15.4	109.6	Full	500	0.0	0.0
Lane 4	32	0.0	402	0.078	100	45.7	LOS D	1.5	10.3	Short	60	0.0	NA
Approach	1112	2.8		0.589		31.5	LOS C	15.4	109.6				
Intersection	3967	2.5		0.853		46.3	LOS D	26.5	188.7				

Intersection R1010 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 10 [2066 PM - FINAL]

R1010
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

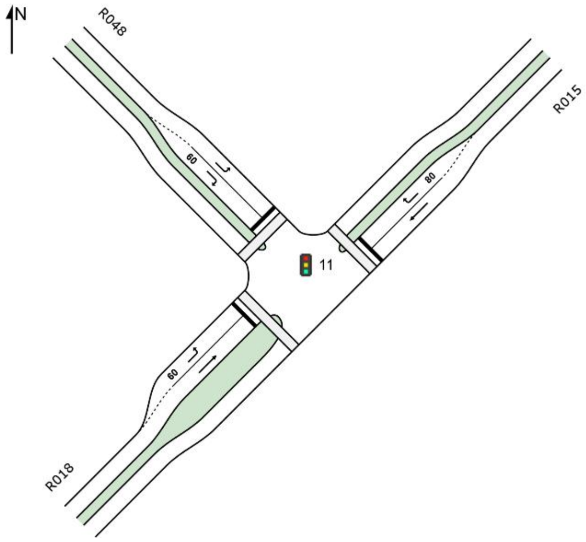
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R1010South													
Lane 1	198	2.7	465	0.425	100	41.6	LOS D	9.8	69.9	Full	500	0.0	0.0
Lane 2	129	1.6	444	0.292	100	44.6	LOS D	6.2	44.0	Short	60	0.0	NA
Approach	327	2.3		0.425		42.8	LOS D	9.8	69.9				
NorthEast: R009													

Lane 1	355	2.1	425	0.835	100	55.2	LOS E	20.8	148.1	Full	500	0.0	0.0
Lane 2	348	1.8	418	0.835	100	54.5	LOS D	21.3	151.1	Full	500	0.0	0.0
Lane 3	221	1.2	307	0.720	100	59.1	LOS E	12.8	90.5	Short	90	0.0	NA
Lane 4	221	1.2	307	0.720	100	59.1	LOS E	12.8	90.5	Short	60	0.0	NA
Approach	1145	1.7		0.835		56.5	LOS E	21.3	151.1				
NorthWest: R027													
Lane 1	542	1.6	609 [1]	0.889	100	37.2	LOS D	20.3	143.9	Short	60	0.0	NA
Lane 2	205	3.6	333	0.616	100	51.4	LOS D	11.3	81.6	Full	500	0.0	0.0
Lane 3	246	2.8	319	0.771	100	60.3	LOS E	14.6	104.6	Full	500	0.0	0.0
Lane 4	246	2.8	319	0.771	100	60.3	LOS E	14.6	104.6	Short	60	0.0	NA
Approach	1239	2.4		0.889		48.7	LOS D	20.3	143.9				
SouthWest: R010													
Lane 1	371	3.1	747 [1]	0.496	100	30.6	LOS C	15.1	108.3	Short	60	0.0	NA
Lane 2	298	1.4	332 [1]	0.896	100	60.5	LOS E	19.0	134.5	Full	500	0.0	0.0
Lane 3	364	1.4	407 [1]	0.896	100	61.0	LOS E	23.8	168.5	Full	500	0.0	0.0
Lane 4	32	0.0	310	0.102	100	51.4	LOS D	1.6	11.0	Short	60	0.0	NA
Approach	1064	2.0		0.896		50.0	LOS D	23.8	168.5				
Intersection	3776	2.0		0.896		50.9	LOS D	23.8	168.5				

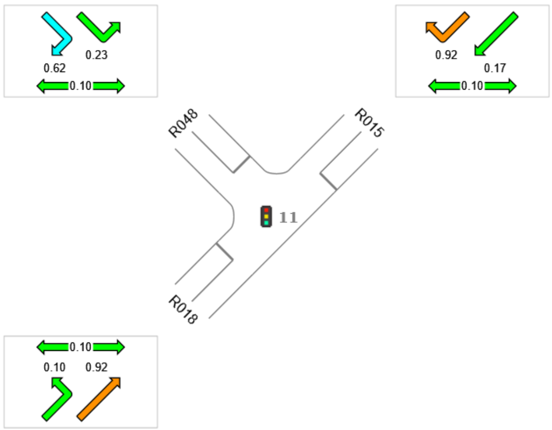
11 Intersection R1011

2041

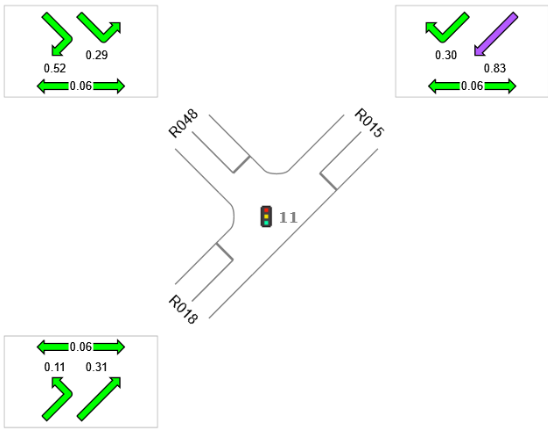
SITE LAYOUT – R1011 – 2041



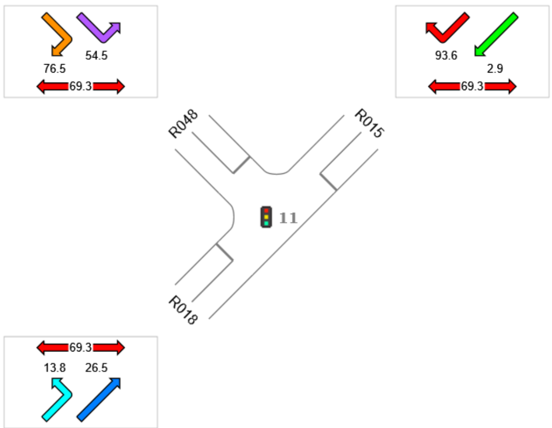
DEGREE OF SATURATION AM



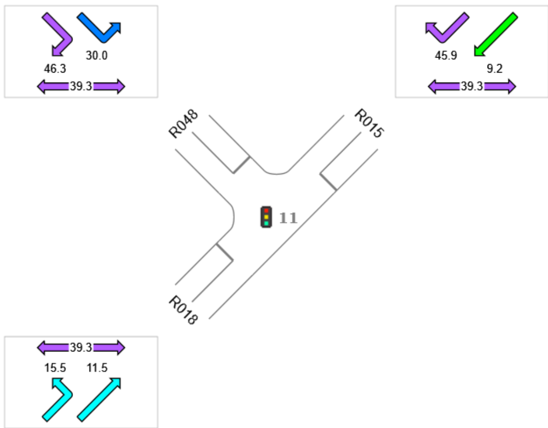
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1011 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 11 [2041 AM -FINAL]

R1011
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 150 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
NorthEast: R015													
Lane 1	261	2.8	1570	0.166	100	2.9	LOS A	3.8	27.6	Full	500	0.0	0.0
Lane 2	157	2.0	171	0.918	100	93.6	LOS F	13.1	93.0	Short	80	0.0	NA
Approach	418	2.5		0.918		37.0	LOS D	13.1	93.0				
NorthWest: R048													
Lane 1	99	2.1	427	0.232	100	54.5	LOS D	5.8	41.6	Full	500	0.0	0.0
Lane 2	114	0.9	184	0.616	100	76.5	LOS E	8.2	58.1	Short	60	0.0	NA
Approach	213	1.5		0.616		66.3	LOS E	8.2	58.1				
SouthWest: R018													
Lane 1	126	0.8	1268	0.100	100	13.8	LOS B	3.0	21.2	Short	60	0.0	NA
Lane 2	1119	0.9	1218 [1]	0.919	100	26.5	LOS C	66.6	470.0	Full	500	0.0	0.0
Approach	1245	0.9		0.919		25.2	LOS C	66.6	470.0				
Intersection	1876	1.3		0.919		32.5	LOS C	66.6	470.0				

LANE SUMMARY 2041 PM

Site: 11 [2041 PM - FINAL]

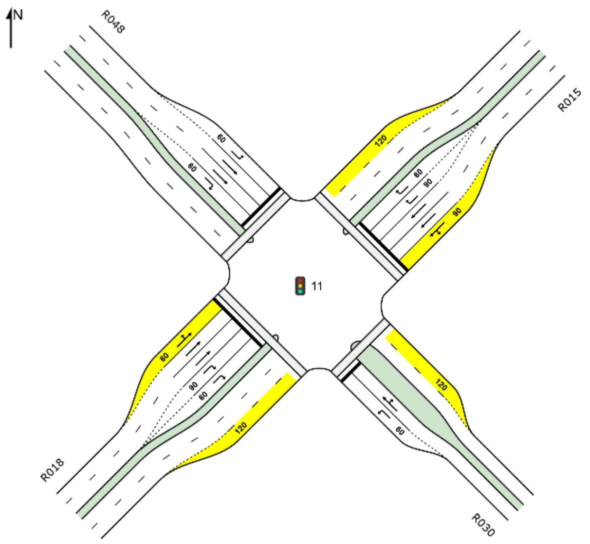
R1011
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

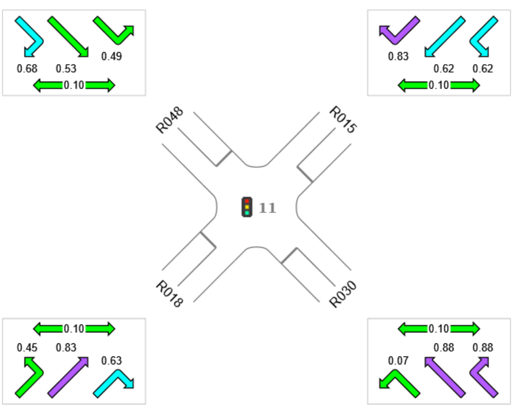
	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
NorthEast: R015													
Lane 1	1155	0.7	1387 [1]	0.833	100	9.2	LOS A	33.2	233.5	Full	500	0.0	0.0
Lane 2	67	3.1	222	0.303	100	45.9	LOS D	2.8	20.2	Short	80	0.0	NA
Approach	1222	0.9		0.833		11.2	LOS B	33.2	233.5				
NorthWest: R048													
Lane 1	164	1.9	570	0.288	100	30.0	LOS C	5.5	39.1	Full	500	0.0	0.0
Lane 2	117	0.9	226	0.518	100	46.3	LOS D	5.0	35.5	Short	60	0.0	NA
Approach	281	1.5		0.518		36.8	LOS D	5.5	39.1				
SouthWest: R018													
Lane 1	108	0.0	1032	0.105	100	15.5	LOS B	2.2	15.5	Short	60	0.0	NA
Lane 2	337	1.3	1075	0.313	100	11.5	LOS B	7.9	55.7	Full	500	0.0	0.0
Approach	445	0.9		0.313		12.5	LOS B	7.9	55.7				
Intersection	1948	1.0		0.833		15.2	LOS B	33.2	233.5				

Intersection R1011-2066

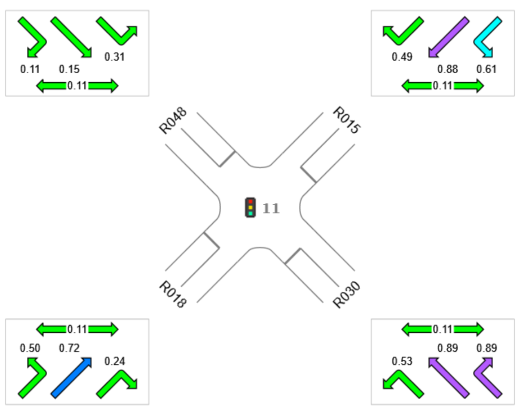
SITE LAYOUT – R1011 – 2066



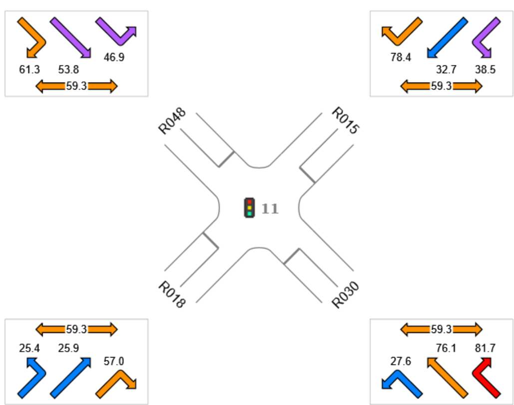
DEGREE OF SATURATION



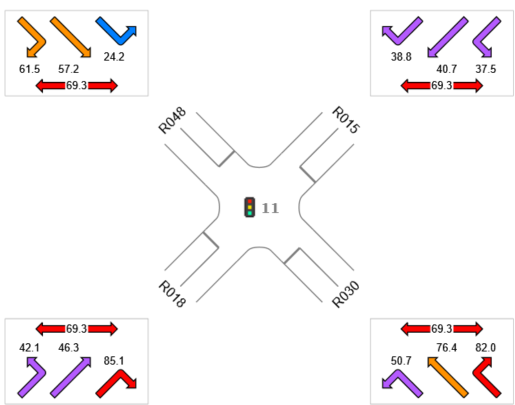
DEGREE OF SATURATION



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1011 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 11 [2066 AM - FINAL]

R1011
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R030													
Lane 1	32	0.0	471	0.067	100	27.6	LOS C	1.0	7.0	Short	60	0.0	NA
Lane 2	103	1.0	117	0.879	100	77.8	LOS E	7.3	51.9	Full	500	0.0	0.0
Approach	135	0.8		0.879		66.0	LOS E	7.3	51.9				
NorthEast: R015													
Lane 1	474	2.8	764	0.621	100	33.3	LOS C	23.6	169.1	Full	500	0.0	0.0
Lane 2	442	3.0	712 [1]	0.621	100	32.4	LOS C	21.6	155.4	Full	500	0.0	0.0
Lane 3	105	3.0	126	0.832	100	78.4	LOS E	7.3	52.3	Short	90	0.0	NA
Lane 4	105	3.0	126	0.832	100	78.4	LOS E	7.3	52.3	Short	60	0.0	NA
Approach	1125	2.9		0.832		41.4	LOS D	23.6	169.1				
NorthWest: R048													
Lane 1	248	1.7	508	0.489	100	46.9	LOS D	13.2	93.6	Short	60	0.0	NA
Lane 2	93	0.8	313	0.296	56 [6]	52.2	LOS D	5.2	36.9	Full	500	0.0	0.0
Lane 3	167	0.8	313	0.534	100	54.7	LOS D	9.9	69.7	Full	500	0.0	0.0
Lane 4	202	1.0	298	0.679	100	61.3	LOS E	12.4	87.6	Short	60	0.0	NA
Approach	711	1.2		0.679		53.5	LOS D	13.2	93.6				
SouthWest: R018													
Lane 1	404	1.9	905 [1]	0.447	54 [6]	20.3	LOS C	15.2	108.3	Short	60	0.0	NA
Lane 2	613	1.8	740 [1]	0.829	100	27.3	LOS C	29.1	206.7	Full	500	0.0	0.0
Lane 3	763	1.8	920 [1]	0.829	100	27.6	LOS C	38.8	275.7	Full	500	0.0	0.0
Lane 4	113	0.6	356	0.319	50 [6]	54.5	LOS D	6.2	43.9	Short	90	0.0	NA
Lane 5	226	0.6	356	0.635	100	58.2	LOS E	13.3	93.9	Short	60	0.0	NA
Approach	2119	1.6		0.829		30.8	LOS C	38.8	275.7				
Intersection	4089	1.9		0.879		38.8	LOS D	38.8	275.7				

Intersection R1011 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 11 [2066 PM - FINAL - 96% demand]

R1011
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 150 seconds (Site Optimum Cycle Time - Minimum Delay)

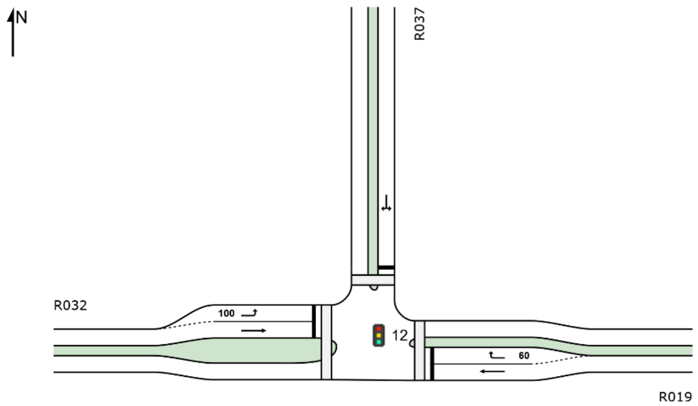
Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R030													
Lane 1	210	1.0	393	0.534	100	50.7	LOS D	9.8	69.2	Short	60	0.0	NA
Lane 2	244	0.8	273 [1]	0.894	100	77.1	LOS E	19.1	134.8	Full	500	0.0	0.0
Approach	454	0.9		0.894		64.9	LOS E	19.1	134.8				
NorthEast: R015													
Lane 1	541	1.2	887	0.609	69 [6]	32.3	LOS C	29.0	205.5	Short	90	0.0	NA
Lane 2	565	1.3	640 [1]	0.882	100	44.1	LOS D	36.0	254.7	Full	500	0.0	0.0
Lane 3	696	1.3	789 [1]	0.882	100	44.2	LOS D	46.8	331.5	Full	500	0.0	0.0
Lane 4	137	1.1	283	0.486	100	38.8	LOS D	5.1	36.3	Short	90	0.0	NA
Lane 5	137	1.1	283	0.486	100	38.8	LOS D	5.1	36.3	Short	60	0.0	NA
Approach	2077	1.3		0.882		40.4	LOS D	46.8	331.5				
NorthWest: R048													
Lane 1	204	2.5	657	0.311	100	24.2	LOS C	6.5	46.4	Short	60	0.0	NA
Lane 2	34	1.3	322	0.105	73 [6]	56.9	LOS E	2.1	14.9	Full	500	0.0	0.0
Lane 3	47	1.3	322	0.145	100	57.4	LOS E	2.9	20.7	Full	500	0.0	0.0
Lane 4	32	3.1	303	0.107	100	61.5	LOS E	2.0	14.4	Short	60	0.0	NA
Approach	317	2.2		0.311		36.4	LOS D	6.5	46.4				
SouthWest: R018													
Lane 1	302	1.1	605	0.500	69 [6]	39.5	LOS D	15.8	112.0	Short	60	0.0	NA
Lane 2	332	1.7	458 [1]	0.724	100	46.6	LOS D	20.2	143.3	Full	500	0.0	0.0
Lane 3	422	1.7	583 [1]	0.724	100	49.3	LOS D	27.2	193.4	Full	500	0.0	0.0
Lane 4	12	0.0	74	0.163	67 [6]	84.7	LOS F	0.9	6.3	Short	90	0.0	NA
Lane 5	18	0.0	74	0.245	100	85.4	LOS F	1.4	9.6	Short	60	0.0	NA
Approach	1086	1.5		0.724		46.8	LOS D	27.2	193.4				
Intersection	3934	1.4		0.894		44.6	LOS D	46.8	331.5				

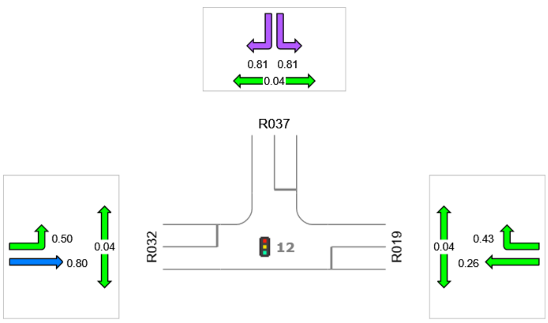
12 Intersection R1012

2066

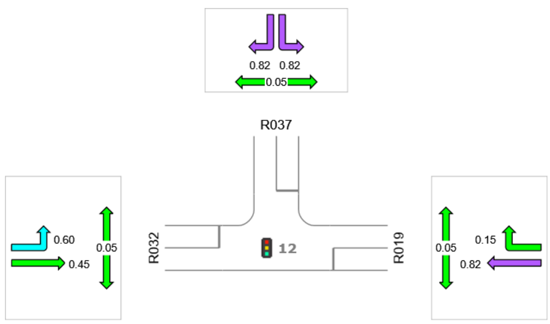
SITE LAYOUT – R1012 – 2066



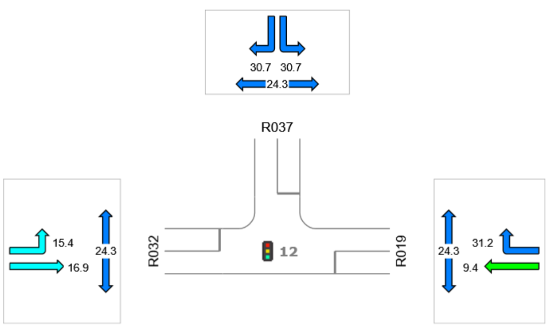
DEGREE OF SATURATION AM



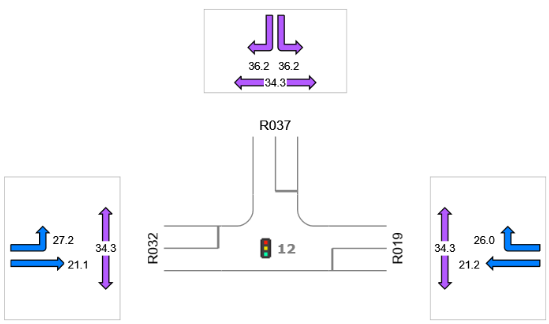
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1012 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 12 [2066 AM - FINAL]

R1012
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
East: R019													
Lane 1	251	4.6	947	0.265	100	9.4	LOS A	4.2	30.9	Full	500	0.0	0.0
Lane 2	68	3.1	160	0.426	100	31.2	LOS C	2.0	14.2	Short	60	0.0	NA
Approach	319	4.3		0.426		14.0	LOS B	4.2	30.9				
North: R037													
Lane 1	446	2.1	549	0.813	100	30.7	LOS C	14.1	100.2	Full	500	0.0	0.0
Approach	446	2.1		0.813		30.7	LOS C	14.1	100.2				
West: R032													
Lane 1	459	0.9	923	0.497	100	15.4	LOS B	9.0	63.8	Short	100	0.0	NA
Lane 2	775	1.1	968	0.800	100	16.9	LOS B	21.3	150.5	Full	500	0.0	0.0
Approach	1234	1.0		0.800		16.4	LOS B	21.3	150.5				
Intersection	1999	1.8		0.813		19.2	LOS B	21.3	150.5				

LANE SUMMARY 2066 PM

Site: 12 [2066 PM - FINAL]

R1012
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 80 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

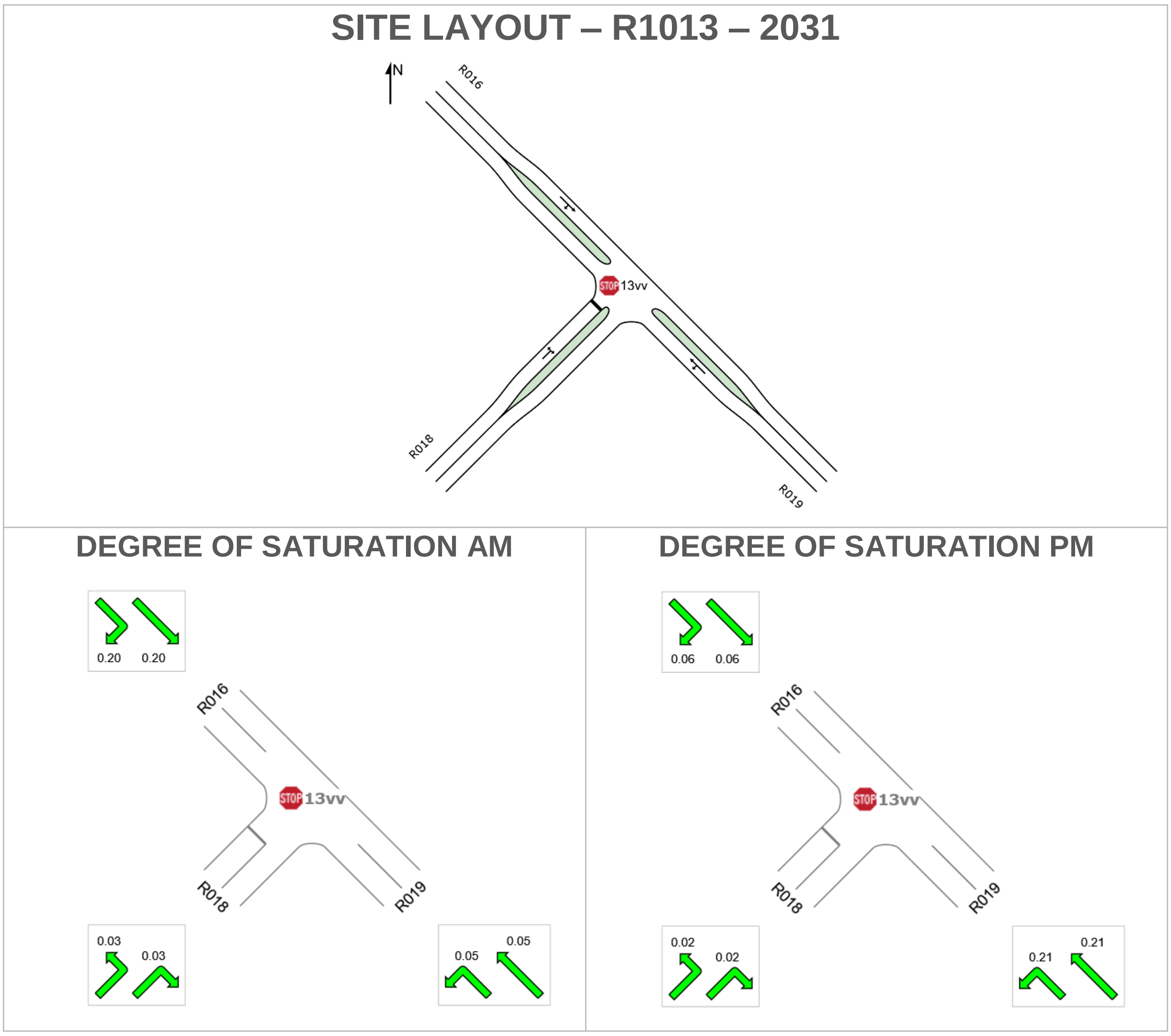
Lane Use and Performance

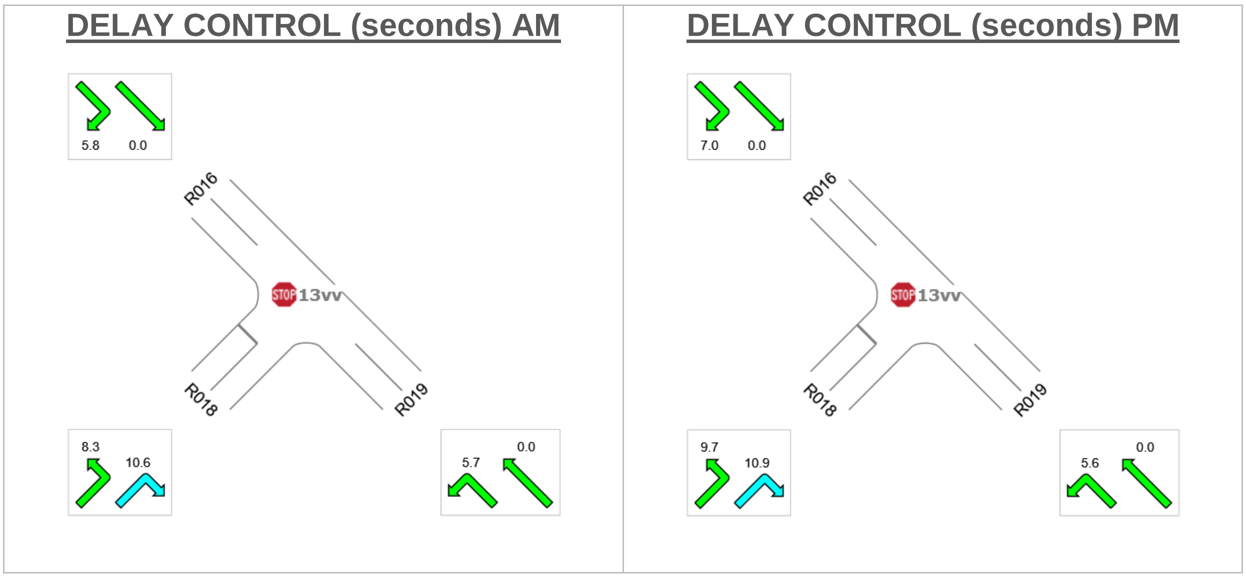
	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
East: R019													
Lane 1	764	0.8	928 [1]	0.824	100	21.2	LOS C	26.8	188.8	Full	500	0.0	0.0
Lane 2	48	2.2	326	0.149	100	26.0	LOS C	1.4	10.0	Short	60	0.0	NA
Approach	813	0.9		0.824		21.5	LOS C	26.8	188.8				
North: R037													
Lane 1	513	1.0	622	0.824	100	36.2	LOS D	20.7	146.3	Full	500	0.0	0.0
Approach	513	1.0		0.824		36.2	LOS D	20.7	146.3				
West: R032													
Lane 1	402	1.3	667	0.603	100	27.2	LOS C	13.0	91.7	Short	100	0.0	NA
Lane 2	314	3.0	693	0.452	100	21.1	LOS C	9.4	67.6	Full	500	0.0	0.0
Approach	716	2.1		0.603		24.5	LOS C	13.0	91.7				

Intersection	2041	1.3	0.824	26.2	LOS C	26.8	188.8

13 Intersection R1013

2031





Intersection R1001 – 2031 Cont.

MOVEMENT SUMMARY 2031 AM

Site: 13vv [2031 AM - FINAL]

R1013
Site Category: (None)
Stop (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: R019												
4	L2	11	10.0	0.051	5.7	LOS A	0.0	0.0	0.00	0.07	0.00	57.3
5	T1	85	4.9	0.051	0.0	LOS A	0.0	0.0	0.00	0.07	0.00	59.4
Approach		96	5.5	0.051	0.6	NA	0.0	0.0	0.00	0.07	0.00	59.2
NorthWest: R016												
11	T1	393	1.1	0.204	0.0	LOS A	0.0	0.1	0.00	0.00	0.00	60.0
12	R2	2	0.0	0.204	5.8	LOS A	0.0	0.1	0.00	0.00	0.00	57.7
Approach		395	1.1	0.204	0.0	NA	0.0	0.1	0.00	0.00	0.00	59.9
SouthWest: R018												
1	L2	1	0.0	0.025	8.3	LOS A	0.1	0.6	0.40	0.91	0.40	50.7
3	R2	16	6.7	0.025	10.6	LOS B	0.1	0.6	0.40	0.91	0.40	49.9
Approach		17	6.3	0.025	10.4	LOS B	0.1	0.6	0.40	0.91	0.40	50.0
All Vehicles		507	2.1	0.204	0.5	NA	0.1	0.6	0.02	0.05	0.02	59.4

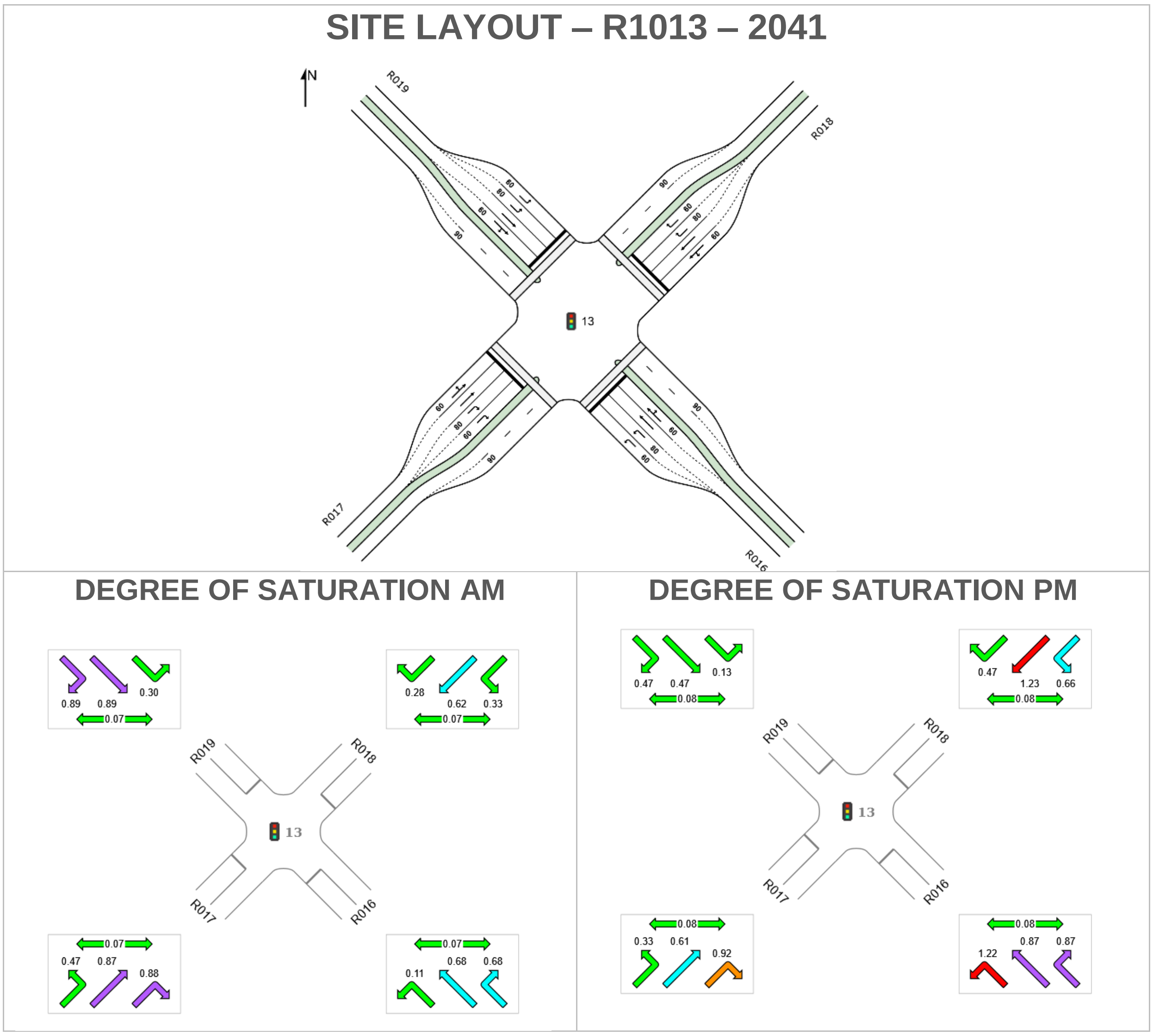
MOVEMENT SUMMARY 2031 PM

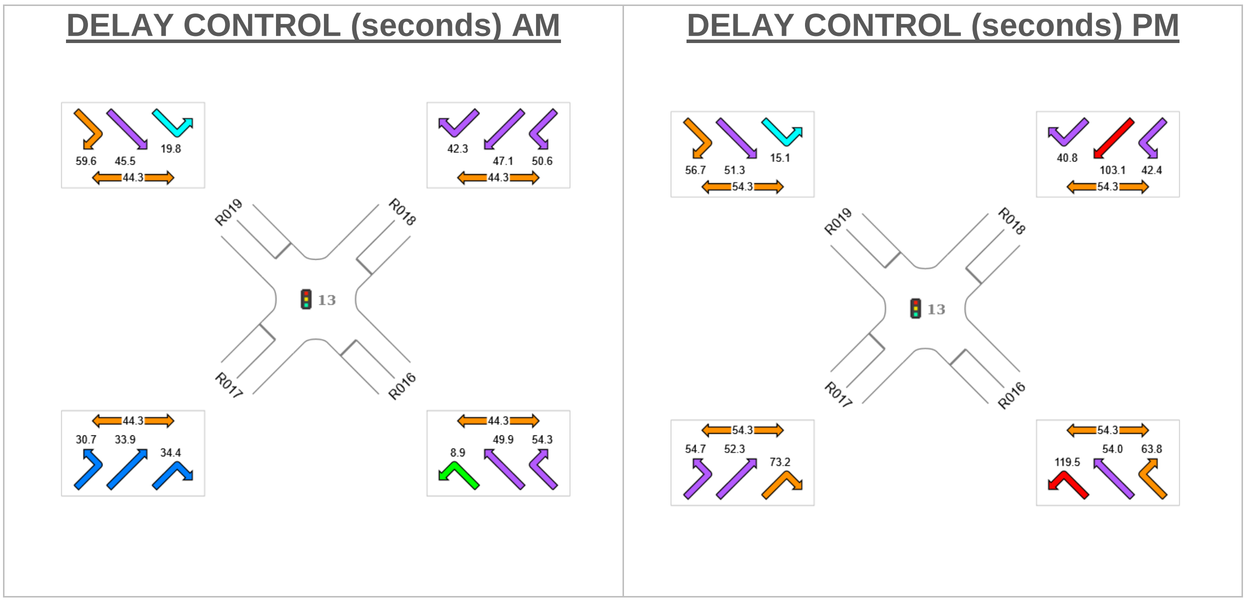
Site: 13vv [2031 PM - FINAL]

R1013
Site Category: (None)
Stop (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
SouthEast: R019												
4	L2	16	0.0	0.210	5.6	LOS A	0.0	0.0	0.00	0.02	0.00	58.1
5	T1	392	0.8	0.210	0.0	LOS A	0.0	0.0	0.00	0.02	0.00	59.7
Approach		407	0.8	0.210	0.2	NA	0.0	0.0	0.00	0.02	0.00	59.7
NorthWest: R016												
11	T1	112	2.8	0.059	0.0	LOS A	0.0	0.1	0.01	0.01	0.01	59.9
12	R2	1	0.0	0.059	7.0	LOS A	0.0	0.1	0.01	0.01	0.01	57.6
Approach		113	2.8	0.059	0.1	NA	0.0	0.1	0.01	0.01	0.01	59.9
SouthWest: R018												
1	L2	1	0.0	0.020	9.7	LOS A	0.1	0.5	0.47	0.91	0.47	50.6
3	R2	12	9.1	0.020	10.9	LOS B	0.1	0.5	0.47	0.91	0.47	49.7
Approach		13	8.3	0.020	10.8	LOS B	0.1	0.5	0.47	0.91	0.47	49.8
All Vehicles		533	1.4	0.210	0.5	NA	0.1	0.5	0.01	0.04	0.01	59.4

Intersection R1013-2041





Intersection R1013 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 13 [2041 AM - FINAL]

R1013
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 100 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R016													
Lane 1	144	7.3	1342	0.107	100	8.9	LOS A	1.8	13.4	Full	500	0.0	0.0
Lane 2	139	6.1	205	0.679	100	50.9	LOS D	6.9	51.1	Short	60	0.0	NA
Approach	283	6.7		0.679		29.5	LOS C	6.9	51.1				
NorthEast: R018													
Lane 1	74	0.3	223	0.332	54 [6]	50.0	LOS D	3.4	24.1	Short	60	0.0	NA
Lane 2	142	2.8	230	0.616	100	47.2	LOS D	6.9	49.3	Full	500	0.0	0.0
Lane 3	55	2.0	366	0.150	53 [6]	41.5	LOS D	2.2	16.0	Short	80	0.0	NA
Lane 4	104	2.0	366	0.284	100	42.7	LOS D	4.4	31.1	Short	60	0.0	NA
Approach	375	2.0		0.616		45.7	LOS D	6.9	49.3				
NorthWest: R019													
Lane 1	141	1.0	922	0.153	50 [6]	18.9	LOS B	3.7	26.0	Short	60	0.0	NA
Lane 2	281	1.0	922	0.305	100	20.3	LOS C	8.0	56.5	Short	80	0.0	NA
Lane 3	222	1.2	464	0.478	54 [6]	35.5	LOS D	9.4	66.6	Full	500	0.0	0.0
Lane 4	267	1.0	302	0.887	100	55.7	LOS E	15.0	105.8	Short	60	0.0	NA
Approach	912	1.0		0.887		34.2	LOS C	15.0	105.8				
SouthWest: R017													
Lane 1	344	0.8	732	0.471	54 [6]	26.0	LOS C	12.7	89.3	Short	60	0.0	NA
Lane 2	518	0.9	593 [1]	0.874	100	38.7	LOS D	25.4	179.3	Full	500	0.0	0.0
Lane 3	375	0.9	849	0.442	50 [6]	25.1	LOS C	12.3	86.9	Short	80	0.0	NA

Lane 4	587	0.9	668 [1]	0.879	100	40.3	LOS D	27.8	195.8	Short	60	0.0	NA
Approach	1824	0.9		0.879		34.0	LOS C	27.8	195.8				
Intersection	3394	1.5		0.887		35.0	LOS C	27.8	195.8				

Intersection R1013 – 2041 Cont.

LANE SUMMARY 2041 PM

Site: 13 [2041 PM - FINAL]

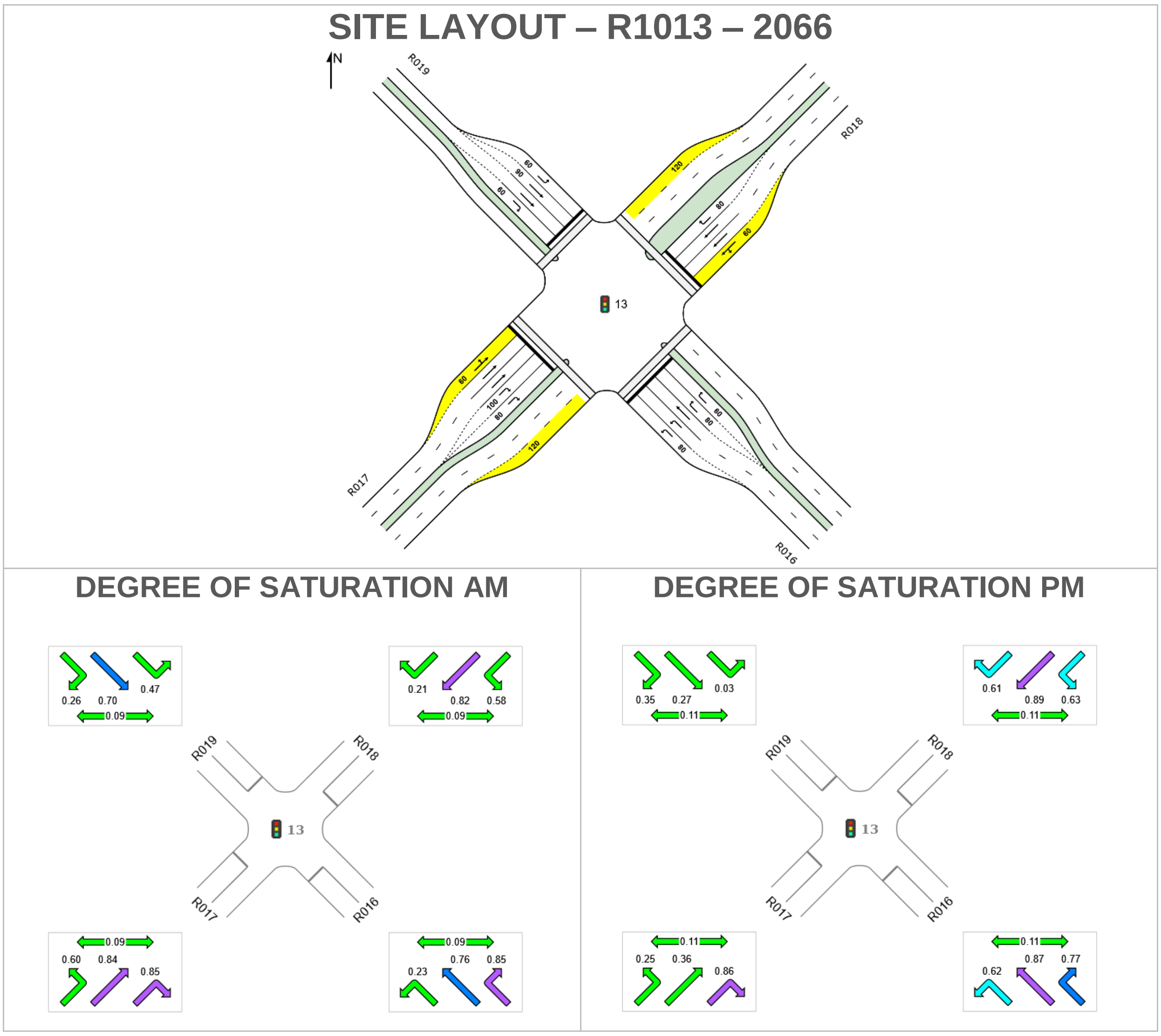
R1013
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

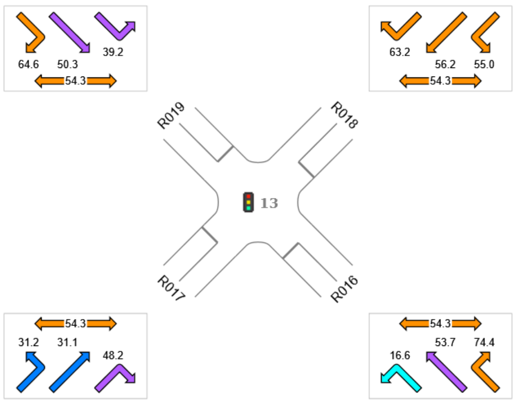
	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R016													
Lane 1	345	0.6	562 [1]	0.613	50 [6]	38.1	LOS D	15.8	111.5	Short	60	0.0	NA
Lane 2	632	0.6	519 [1]	1.218	100	163.9	LOS F	68.8	484.1	Short	80	0.0	NA
Lane 3	190	0.7	404	0.469	54 [6]	46.5	LOS D	9.8	69.3	Full	500	0.0	2.1 [8]
Lane 4	318	0.6	365 [1]	0.870	100	60.2	LOS E	20.0	140.3	Short	60	0.0	NA
Approach	1484	0.6		1.218		97.5	LOS F	68.8	484.1				
NorthEast: R018													
Lane 1	440	0.6	667	0.660	54 [6]	37.3	LOS D	21.4	150.8	Short	60	0.0	NA
Lane 2	437	0.6	356 [1]	1.225	100	165.1	LOS F	48.3	339.6	Full	500	0.0	0.0
Lane 3	142	0.8	569	0.250	53 [6]	38.9	LOS D	6.2	43.8	Short	80	0.0	NA
Lane 4	268	0.8	569	0.471	100	41.7	LOS D	12.7	89.5	Short	60	0.0	NA
Approach	1287	0.7		1.225		81.7	LOS F	48.3	339.6				
NorthWest: R019													
Lane 1	54	1.3	828	0.065	50 [6]	14.9	LOS B	1.0	7.2	Short	60	0.0	NA
Lane 2	107	1.3	828	0.129	100	15.2	LOS B	2.1	14.9	Short	80	0.0	NA
Lane 3	69	2.9	271	0.255	54 [6]	50.2	LOS D	3.7	26.3	Full	500	0.0	0.0
Lane 4	127	1.7	268	0.473	100	54.1	LOS D	7.0	49.6	Short	60	0.0	NA
Approach	357	1.8		0.473		35.7	LOS D	7.0	49.6				
SouthWest: R017													
Lane 1	95	0.9	289	0.329	54 [6]	51.3	LOS D	5.0	35.4	Short	60	0.0	NA
Lane 2	167	1.4	274	0.611	100	53.4	LOS D	9.4	66.8	Full	500	0.0	0.0

Lane 3	89	3.3	181	0.489	53 [6]	62.9	LOS E	5.1	36.8	Short	80	0.0	NA
Lane 4	167	3.3	181	0.921	100	78.6	LOS E	11.4	82.4	Short	60	0.0	NA
Approach	518	2.2		0.921		62.8	LOS E	11.4	82.4				
Intersection	3646	1.0		1.225		81.0	LOS F	68.8	484.1				

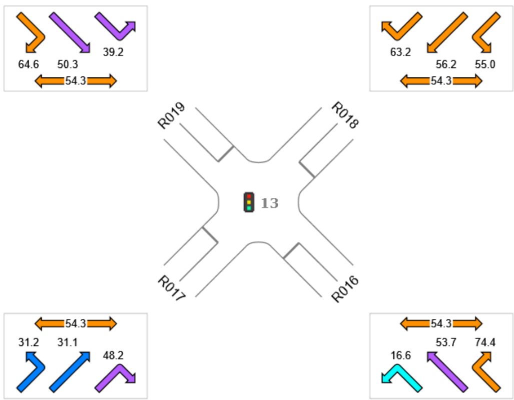
Intersection R1013-2066



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1013 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 13 [2066 AM - FINAL]

R1013

Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R016													
Lane 1	159	6.8	1078	0.148	65 [6]	16.3	LOS B	3.9	29.0	Short	80	0.0	NA
Lane 2	244	6.8	1078	0.226	100	16.9	LOS B	6.4	47.1	Full	500	0.0	0.0
Lane 3	275	5.0	362	0.759	100	53.7	LOS D	16.0	116.6	Full	500	0.0	0.0
Lane 4	103	2.6	122	0.848	100	74.4	LOS E	6.7	48.1	Short	80	0.0	NA
Lane 5	103	2.6	122	0.848	100	74.4	LOS E	6.7	48.1	Short	60	0.0	NA
Approach	884	5.2		0.848		41.6	LOS D	16.0	116.6				
NorthEast: R018													
Lane 1	190	0.9	328	0.580	71 [6]	53.3	LOS D	10.3	73.0	Short	60	0.0	NA

Lane 2	268	3.0	328[1]	0.819	100	56.9	LOS E	16.4	117.5	Full	500	0.0	0.0
Lane 3	274	3.0	335	0.819	100	57.0	LOS E	16.8	120.3	Full	500	0.0	0.0
Lane 4	32	6.7	148	0.214	100	63.2	LOS E	1.8	13.3	Short	80	0.0	NA
Approach	764	2.6		0.819		56.3	LOS E	16.8	120.3				
NorthWest: R019													
Lane 1	283	0.7	600	0.472	100	39.2	LOS D	13.2	92.9	Short	60	0.0	NA
Lane 2	261	1.4	370	0.705	100	50.3	LOS D	14.7	104.0	Short	90	0.0	NA
Lane 3	261	1.4	370	0.705	100	50.3	LOS D	14.7	104.0	Full	500	0.0	0.0
Lane 4	32	0.0	124	0.255	100	64.6	LOS E	1.8	12.9	Short	60	0.0	NA
Approach	837	1.1		0.705		47.1	LOS D	14.7	104.0				
SouthWest: R017													
Lane 1	528	1.5	883	0.598	71[6]	26.0	LOS C	22.7	160.8	Short	60	0.0	NA
Lane 2	512	1.6	606[1]	0.845	100	33.5	LOS C	25.1	178.2	Full	500	0.0	0.0
Lane 3	621	1.6	735[1]	0.845	100	33.5	LOS C	31.8	225.2	Full	500	0.0	0.0
Lane 4	465	2.8	548[1]	0.849	100	48.2	LOS D	26.0	186.4	Short	100	0.0	NA
Lane 5	465	2.8	548[1]	0.849	100	48.2	LOS D	26.0	186.4	Short	80	0.0	NA
Approach	2591	2.0		0.849		37.3	LOS D	31.8	225.2				
Intersection	5076	2.5		0.849		42.5	LOS D	31.8	225.2				

Intersection R1013 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 13 [2066 PM - FINAL - 83%]

R1013

Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 150 seconds (Site User-Given Cycle Time)

Lane Use and Performance

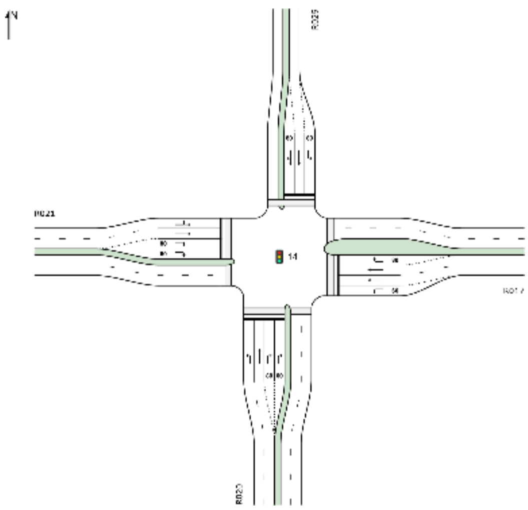
	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R016													
Lane 1	323	2.0	806	0.401	65[6]	35.8	LOS D	15.8	112.7	Short	80	0.0	NA
Lane 2	434	2.0	705[1]	0.615	100	38.2	LOS D	23.0	163.4	Full	500	0.0	0.0
Lane 3	425	1.0	486[1]	0.875	100	65.9	LOS E	32.1	227.0	Full	500	0.0	0.0
Lane 4	57	1.5	73	0.773	100	90.7	LOS F	4.5	32.1	Short	80	0.0	NA
Lane 5	57	1.5	73	0.773	100	90.7	LOS F	4.5	32.1	Short	60	0.0	NA
Approach	1297	1.6		0.875		51.3	LOS D	32.1	227.0				

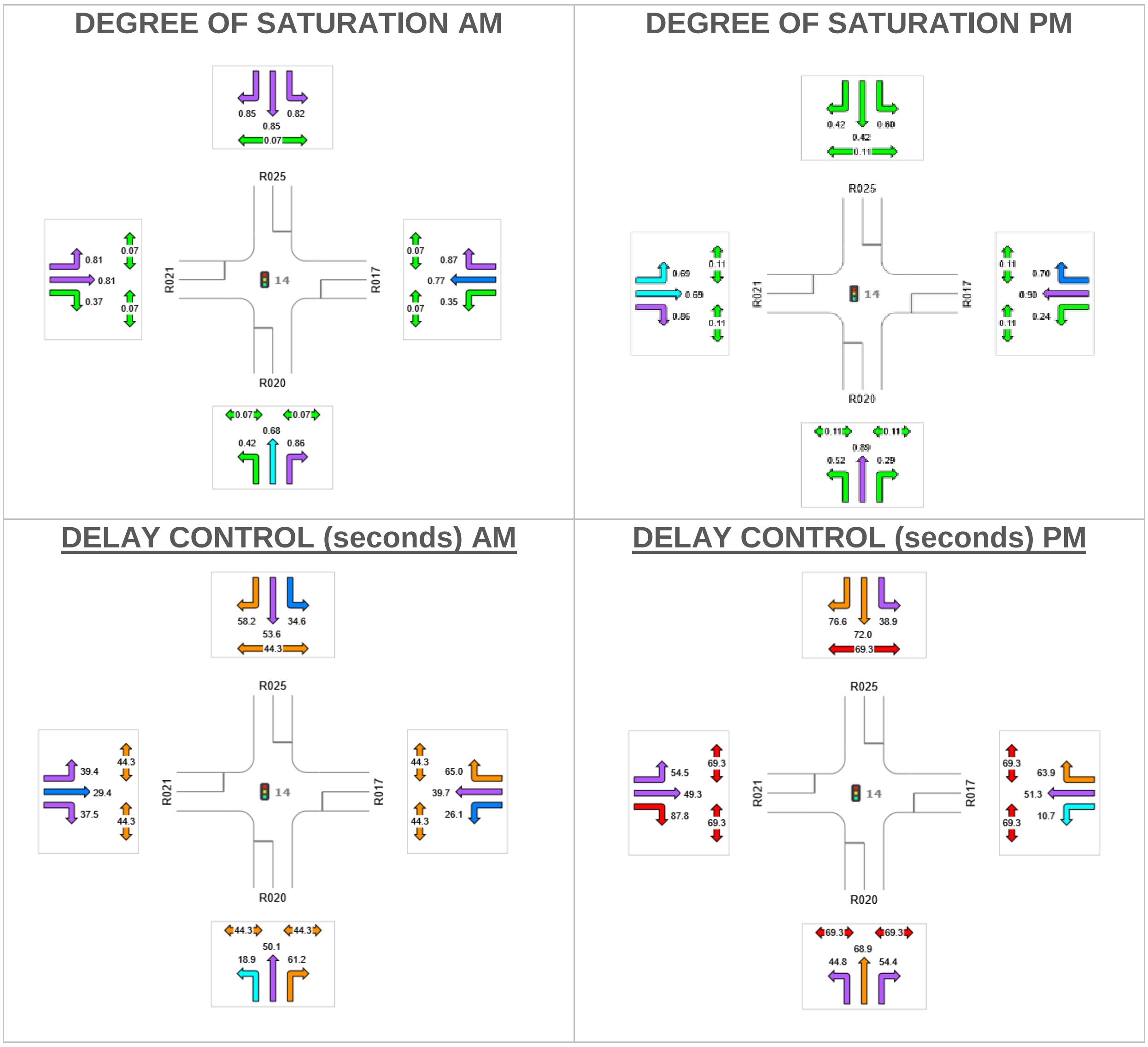
NorthEast: R018													
Lane 1	481	1.4	762	0.631	71 [6]	39.6	LOS D	27.6	195.5	Short	60	0.0	NA
Lane 2	443	1.2	497 [1]	0.891	100	52.3	LOS D	29.7	210.2	Full	500	0.0	0.0
Lane 3	552	1.2	619 [1]	0.891	100	52.1	LOS D	38.4	271.8	Full	500	0.0	0.0
Lane 4	235	0.4	383	0.614	100	64.1	LOS E	15.7	110.3	Short	80	0.0	NA
Approach	1710	1.1		0.891		50.3	LOS D	38.4	271.8				
NorthWest: R019													
Lane 1	26	0.0	879	0.030	100	16.2	LOS B	0.6	4.2	Short	60	0.0	NA
Lane 2	139	3.4	509	0.274	100	46.4	LOS D	8.0	57.6	Short	90	0.0	NA
Lane 3	139	3.4	509	0.274	100	46.4	LOS D	8.0	57.6	Full	500	0.0	0.0
Lane 4	26	0.0	74	0.353	100	85.0	LOS F	2.0	14.0	Short	60	0.0	NA
Approach	331	2.9		0.353		47.1	LOS D	8.0	57.6				
SouthWest: R017													
Lane 1	140	1.4	549	0.255	71 [6]	51.3	LOS D	8.3	58.8	Short	60	0.0	NA
Lane 2	199	1.7	553	0.360	100	24.1	LOS C	7.0	49.8	Full	500	0.0	0.0
Lane 3	199	1.7	553	0.360	100	24.1	LOS C	7.0	49.8	Full	500	0.0	0.0
Lane 4	205	4.7	240	0.855	100	83.0	LOS F	16.1	117.2	Short	100	0.0	NA
Lane 5	205	4.7	240	0.855	100	83.0	LOS F	16.1	117.2	Short	80	0.0	NA
Approach	947	3.0		0.855		53.6	LOS D	16.1	117.2				
Intersection	4285	1.8		0.891		51.1	LOS D	38.4	271.8				

14 Intersection R1014

2066

SITE LAYOUT – R1014 – 2066





Intersection R1014 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 14 [2066 AM - FINAL]

R1014
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 100 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R020													
Lane 1	276	4.2	649	0.425	100	18.9	LOS B	6.6	47.9	Full	500	0.0	0.0
Lane 2	129	3.3	191	0.678	100	50.1	LOS D	6.5	46.9	Full	500	0.0	0.0
Lane 3	157	2.3	183	0.859	100	61.2	LOS E	8.6	61.5	Short	80	0.0	NA
Lane 4	157	2.3	183	0.859	100	61.2	LOS E	8.6	61.5	Short	60	0.0	NA
Approach	719	3.2		0.859		43.0	LOS D	8.6	61.5				

	Total (veh/h)	HV (%)	Cap. (veh/h)	Deg. Satn (v/c)	Lane Util. (%)	Average Delay (sec)	Level of Service	95% Back of Queue Veh	Dist (m)	Lane Config	Lane Length (m)	Cap. Adj. (%)	Prob. Block. (%)
East: R017													
Lane 1	275	2.7	784	0.351	100	26.1	LOS C	9.0	64.1	Short	60	0.0	NA
Lane 2	358	4.3	468 [1]	0.766	100	39.5	LOS D	16.7	121.2	Full	500	0.0	0.0
Lane 3	392	4.3	512	0.766	100	40.0	LOS D	18.6	134.8	Full	500	0.0	0.0
Lane 4	112	1.9	128	0.870	100	65.0	LOS E	6.2	44.3	Short	80	0.0	NA
Approach	1137	3.7		0.870		38.9	LOS D	18.6	134.8				
North: R025													
Lane 1	301	2.4	365	0.825	100	34.6	LOS C	11.3	81.0	Short	80	0.0	NA
Lane 2	213	1.3	251	0.849	100	53.6	LOS D	11.5	81.3	Full	500	0.0	0.0
Lane 3	212	1.1	250	0.849	100	54.3	LOS D	11.4	80.7	Short	80	0.0	NA
Approach	726	1.7		0.849		45.9	LOS D	11.5	81.3				
West: R021													
Lane 1	619	2.2	769	0.805	100	34.9	LOS C	27.8	198.5	Full	500	0.0	0.0
Lane 2	619	2.2	769	0.805	100	23.9	LOS C	18.7	133.4	Full	500	0.0	0.0
Lane 3	177	2.1	476	0.373	100	37.5	LOS D	7.2	51.0	Short	80	0.0	NA
Lane 4	177	2.1	476	0.373	100	37.5	LOS D	7.2	51.0	Short	60	0.0	NA
Approach	1593	2.2		0.805		31.2	LOS C	27.8	198.5				
Intersection	4175	2.7		0.870		37.9	LOS D	27.8	198.5				

Intersection R1014 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 14 [2066 PM - FINAL - 94%]

R1014
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 150 seconds (Site User-Given Cycle Time)

Lane Use and Performance

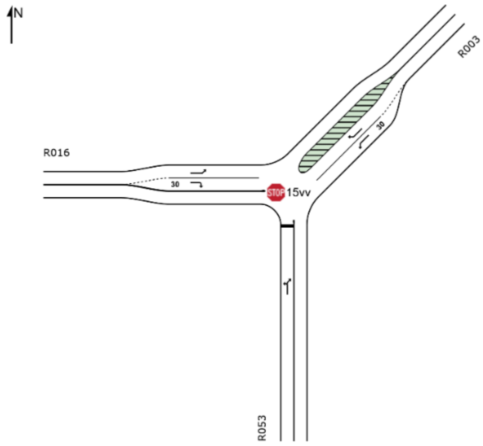
	Demand Flows Total (veh/h)	HV (%)	Cap. (veh/h)	Deg. Satn (v/c)	Lane Util. (%)	Average Delay (sec)	Level of Service	95% Back of Queue Veh	Dist (m)	Lane Config	Lane Length (m)	Cap. Adj. (%)	Prob. Block. (%)
South: R020													
Lane 1	343	1.4	662	0.519	100	44.8	LOS D	19.6	138.6	Full	500	0.0	0.0
Lane 2	378	1.0	426 [1]	0.887	100	68.9	LOS E	29.2	206.0	Full	500	0.0	0.0
Lane 3	127	1.9	440	0.289	100	54.4	LOS D	7.6	53.8	Short	80	0.0	NA
Lane 4	127	1.9	440	0.289	100	54.4	LOS D	7.6	53.8	Short	60	0.0	NA

Approach	976	1.4		0.887		56.6	LOS E	29.2	206.0				
East: R017													
Lane 1	296	1.7	1236	0.239	100	10.7	LOS B	4.2	30.0	Short	60	0.0	NA
Lane 2	561	1.6	625 [1]	0.899	100	51.3	LOS D	38.2	270.9	Full	500	0.0	0.0
Lane 3	579	1.6	644 [1]	0.899	100	51.2	LOS D	39.6	281.1	Full	500	0.0	0.0
Lane 4	283	1.7	404	0.701	100	63.9	LOS E	19.2	136.3	Short	80	0.0	NA
Approach	1719	1.7		0.899		46.3	LOS D	39.6	281.1				
North: R025													
Lane 1	184	1.1	307	0.599	100	38.9	LOS D	8.1	56.9	Short	80	0.0	NA
Lane 2	70	2.2	167	0.422	100	72.0	LOS E	5.0	35.9	Full	500	0.0	0.0
Lane 3	70	2.0	166	0.422	100	72.3	LOS E	5.0	35.7	Short	80	0.0	NA
Approach	325	1.5		0.599		53.3	LOS D	8.1	56.9				
West: R021													
Lane 1	385	3.2	560	0.687	100	49.9	LOS D	24.7	177.3	Full	500	0.0	0.0
Lane 2	335	3.2	488 [1]	0.687	100	48.6	LOS D	20.9	150.2	Full	500	0.0	0.0
Lane 3	126	2.4	146	0.860	100	87.8	LOS F	10.1	71.8	Short	80	0.0	NA
Lane 4	126	2.4	146	0.860	100	87.8	LOS F	10.1	71.8	Short	60	0.0	NA
Approach	972	3.0		0.860		59.3	LOS E	24.7	177.3				
Intersection	3991	1.9		0.899		52.6	LOS D	39.6	281.1				

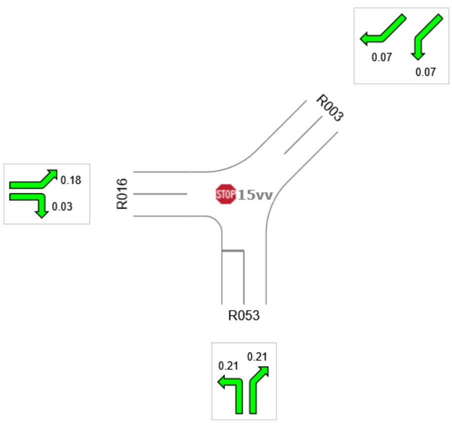
15 Intersection R1015

2031

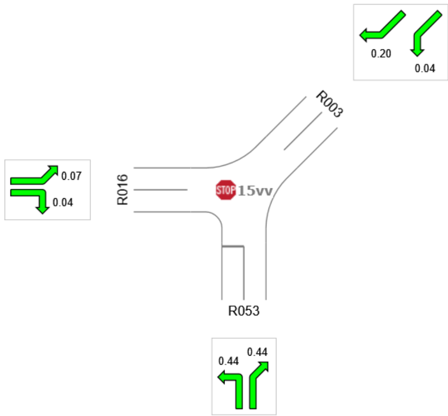
SITE LAYOUT – R1015 – 2031



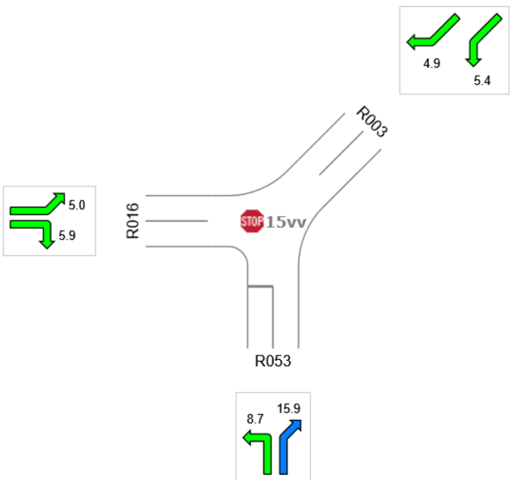
DEGREE OF SATURATION AM



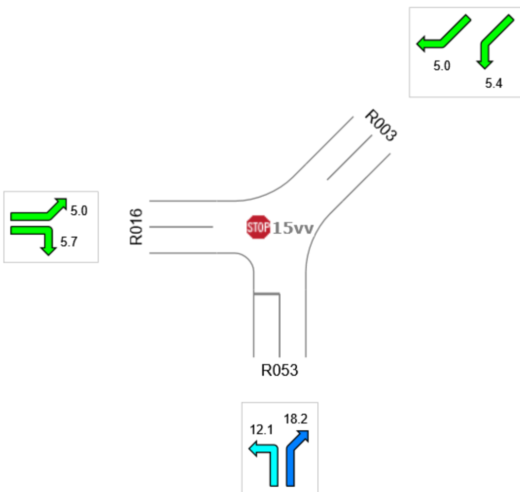
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1015 – 2031 Cont.

MOVEMENT SUMMARY 2031 AM

Site: 15vv [2031 AM - FINAL]

R1015
Site Category: (None)
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: R053												
1	L2	47	2.2	0.211	8.7	LOS A	0.8	5.9	0.40	0.99	0.40	49.1
3a	R1	67	6.3	0.211	15.9	LOS C	0.8	5.9	0.40	0.99	0.40	48.8
Approach		115	4.6	0.211	12.9	LOS B	0.8	5.9	0.40	0.99	0.40	48.9
NorthEast: R003												
24a	L1	140	3.0	0.075	5.4	LOS A	0.0	0.0	0.00	0.59	0.00	53.1
26a	R1	116	3.6	0.068	4.9	LOS A	0.3	2.3	0.14	0.53	0.14	53.5
Approach		256	3.3	0.075	5.2	NA	0.3	2.3	0.06	0.56	0.06	53.3
West: R016												
10a	L1	334	1.3	0.177	5.0	LOS A	0.0	0.0	0.00	0.57	0.00	53.6
12	R2	48	2.2	0.031	5.9	LOS A	0.1	1.0	0.25	0.56	0.25	52.4
Approach		382	1.4	0.177	5.1	NA	0.1	1.0	0.03	0.57	0.03	53.5
All Vehicles		753	2.5	0.211	6.3	NA	0.8	5.9	0.10	0.63	0.10	52.7

MOVEMENT SUMMARY 2031 PM

Site: 15vv [2031 PM - FINAL]

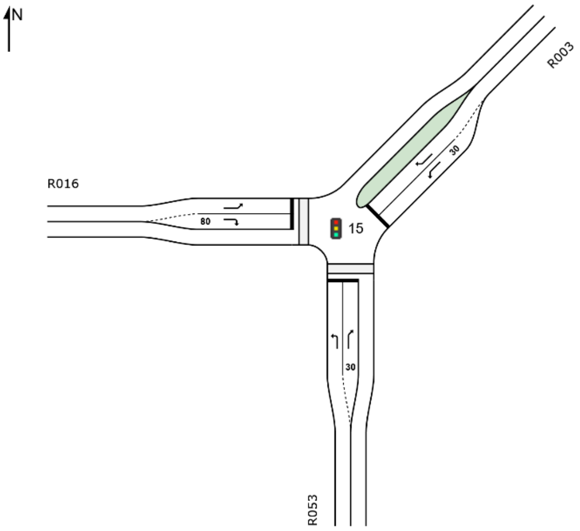
R1015
Site Category: (None)
Stop (Two-Way)

Movement Performance - Vehicles

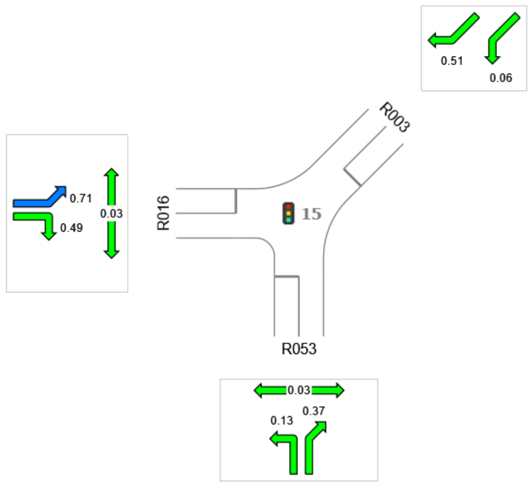
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: R053												
1	L2	53	0.0	0.436	12.1	LOS B	2.4	16.8	0.66	1.12	0.94	47.1
3a	R1	154	2.1	0.436	18.2	LOS C	2.4	16.8	0.66	1.12	0.94	46.9
Approach		206	1.5	0.436	16.7	LOS C	2.4	16.8	0.66	1.12	0.94	46.9
NorthEast: R003												
24a	L1	79	4.0	0.042	5.4	LOS A	0.0	0.0	0.00	0.59	0.00	53.1
26a	R1	338	0.9	0.200	5.0	LOS A	1.1	7.4	0.19	0.53	0.19	53.5
Approach		417	1.5	0.200	5.1	NA	1.1	7.4	0.15	0.54	0.15	53.4
West: R016												
10a	L1	136	2.3	0.073	5.0	LOS A	0.0	0.0	0.00	0.57	0.00	53.6
12	R2	68	0.0	0.041	5.7	LOS A	0.2	1.3	0.18	0.56	0.18	52.6
Approach		204	1.5	0.073	5.2	NA	0.2	1.3	0.06	0.57	0.06	53.3
All Vehicles		827	1.5	0.436	8.0	NA	2.4	16.8	0.26	0.69	0.32	51.6

Intersection R1015-2041

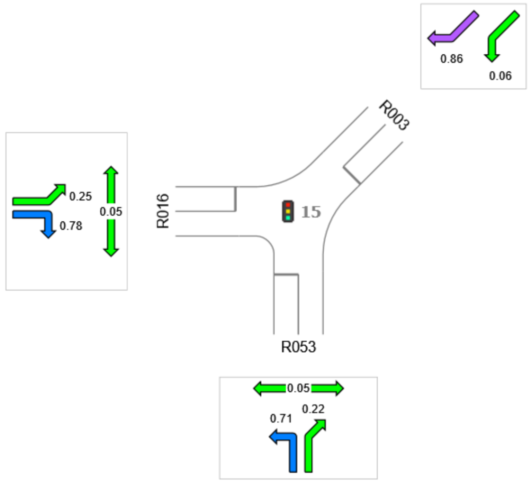
SITE LAYOUT – R1015 – 2041



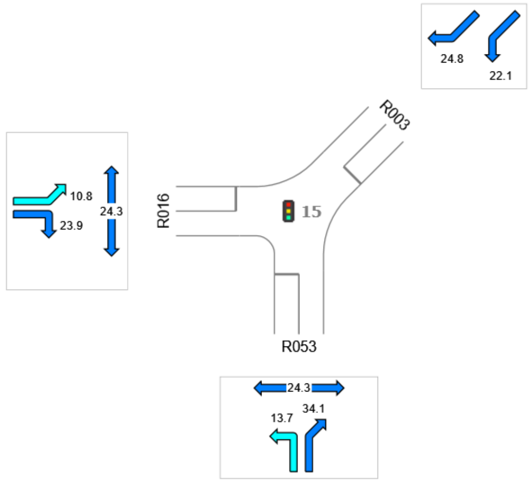
DEGREE OF SATURATION AM



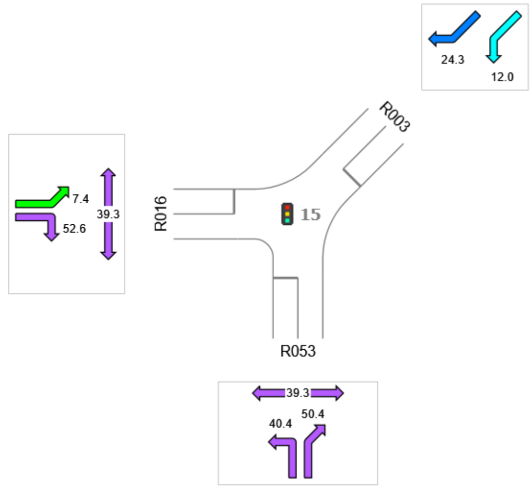
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1015 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 15 [2041 AM - FINAL]

R1015
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R053													
Lane 1	120	2.6	942	0.127	100	13.7	LOS B	1.8	13.0	Full	500	0.0	0.0
Lane 2	68	4.6	185	0.369	100	34.1	LOS C	2.0	14.7	Short	30	0.0	NA
Approach	188	3.4		0.369		21.1	LOS C	2.0	14.7				
NorthEast: R003													
Lane 1	32	3.3	529	0.060	100	22.1	LOS C	0.7	4.9	Short	30	0.0	NA
Lane 2	267	5.1	523	0.511	100	24.8	LOS C	6.8	49.5	Full	500	0.0	0.0
Approach	299	4.9		0.511		24.5	LOS C	6.8	49.5				
West: R016													
Lane 1	942	1.1	1328	0.709	100	10.8	LOS B	16.5	116.5	Full	500	0.0	0.0
Lane 2	285	1.1	583	0.489	100	23.9	LOS C	6.9	49.0	Short	80	0.0	NA
Approach	1227	1.1		0.709		13.8	LOS B	16.5	116.5				
Intersection	1715	2.0		0.709		16.5	LOS B	16.5	116.5				

LANE SUMMARY2041 PM

Site: 15 [2041 PM - FINAL]

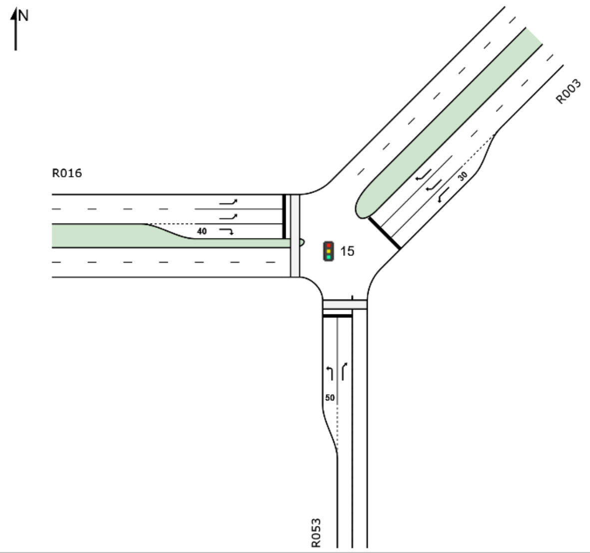
R1015
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site User-Given Cycle Time)

Lane Use and Performance

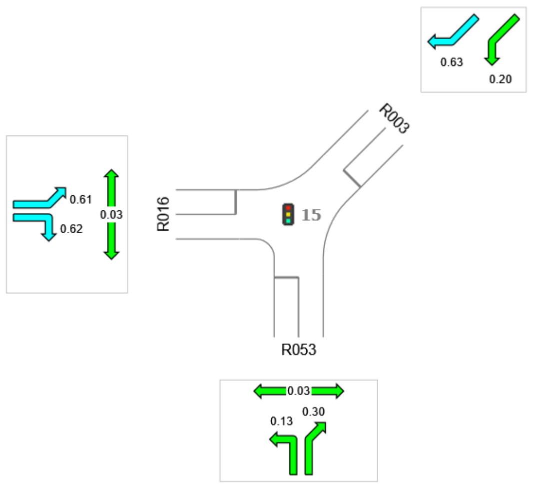
	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R053													
Lane 1	303	0.7	428 [1]	0.708	100	40.4	LOS D	12.6	88.6	Full	500	0.0	0.0
Lane 2	28	0.0	127	0.223	100	50.4	LOS D	1.3	8.8	Short	30	0.0	NA
Approach	332	0.6		0.708		41.2	LOS D	12.6	88.6				
NorthEast: R003													
Lane 1	73	2.9	1166	0.062	100	12.0	LOS B	1.2	8.8	Short	30	0.0	NA
Lane 2	956	0.8	1116 [1]	0.856	100	24.3	LOS C	36.2	255.2	Full	500	0.0	0.0
Approach	1028	0.9		0.856		23.4	LOS C	36.2	255.2				
West: R016													
Lane 1	377	2.8	1500	0.251	100	7.4	LOS A	4.1	29.1	Full	500	0.0	0.0
Lane 2	159	1.3	204	0.778	100	52.6	LOS D	7.5	53.2	Short	80	0.0	NA
Approach	536	2.4		0.778		20.8	LOS C	7.5	53.2				
Intersection	1896	1.3		0.856		25.8	LOS C	36.2	255.2				

Intersection R1015-2066

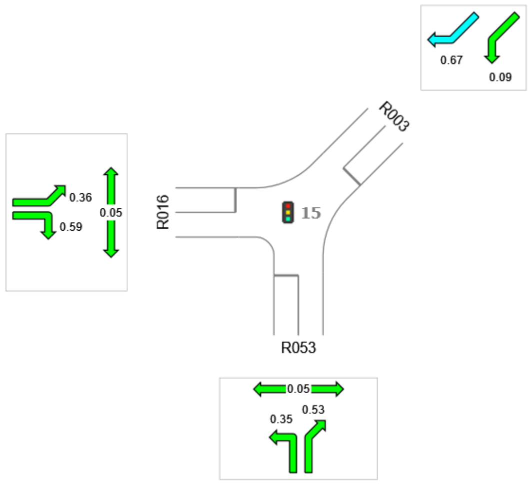
SITE LAYOUT – R1015 – 2066



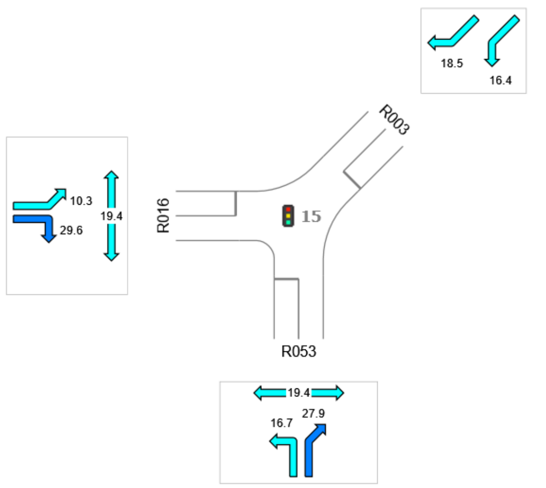
DEGREE OF SATURATION AM



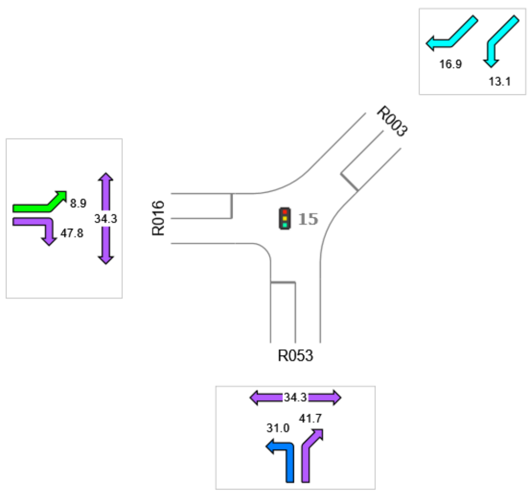
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1015 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 15 [2066 AM - FINAL]

R1015
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 50 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R053													
Lane 1	85	4.9	682	0.125	100	16.7	LOS B	1.4	10.1	Short	50	0.0	NA
Lane 2	67	4.7	222	0.303	100	27.9	LOS C	1.6	11.8	Full	500	0.0	0.0
Approach	153	4.8		0.303		21.6	LOS C	1.6	11.8				
NorthEast: R003													
Lane 1	141	2.2	715	0.197	100	16.4	LOS B	2.4	16.8	Short	30	0.0	NA
Lane 2	423	4.9	672 [1]	0.630	100	18.4	LOS B	8.6	62.5	Full	500	0.0	0.0
Lane 3	442	4.9	703	0.630	100	18.6	LOS B	9.1	66.2	Full	500	0.0	0.0
Approach	1006	4.5		0.630		18.2	LOS B	9.1	66.2				
West: R016													
Lane 1	732	2.3	1205	0.607	100	10.3	LOS B	10.6	75.9	Full	500	0.0	0.0
Lane 2	718	2.3	1182	0.607	100	10.2	LOS B	10.3	73.6	Full	500	0.0	0.0
Lane 3	158	2.0	256	0.616	100	29.6	LOS C	4.0	28.4	Short	40	0.0	NA
Approach	1607	2.2		0.616		12.2	LOS B	10.6	75.9				
Intersection	2766	3.2		0.630		14.9	LOS B	10.6	75.9				

Intersection R1015 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 15 [2066 PM - FINAL]

R1015
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 80 seconds (Site Optimum Cycle Time - Minimum Delay)

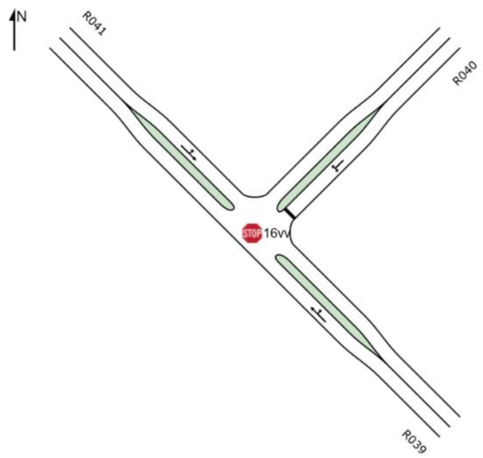
Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R053													
Lane 1	178	1.2	506	0.351	100	31.0	LOS C	5.7	40.1	Short	50	0.0	NA
Lane 2	126	0.8	238	0.532	100	41.7	LOS D	4.9	34.3	Full	500	0.0	0.0
Approach	304	1.0		0.532		35.4	LOS D	5.7	40.1				
NorthEast: R003													
Lane 1	93	3.4	1074	0.086	100	13.1	LOS B	1.6	11.5	Short	30	0.0	NA
Lane 2	677	1.6	1004 [1]	0.675	100	16.6	LOS B	17.5	124.0	Full	500	0.0	0.0
Lane 3	733	1.6	1087	0.675	100	17.2	LOS B	19.8	140.8	Full	500	0.0	0.0
Approach	1503	1.8		0.675		16.7	LOS B	19.8	140.8				
West: R016													
Lane 1	487	3.6	1352	0.360	100	8.9	LOS A	7.0	50.4	Full	500	0.0	0.0
Lane 2	487	3.6	1352	0.360	100	8.9	LOS A	7.0	50.4	Full	500	0.0	0.0
Lane 3	80	3.9	135	0.591	100	47.8	LOS D	3.3	23.9	Short	40	0.0	NA
Approach	1054	3.6		0.591		11.9	LOS B	7.0	50.4				
Intersection	2861	2.4		0.675		16.9	LOS B	19.8	140.8				

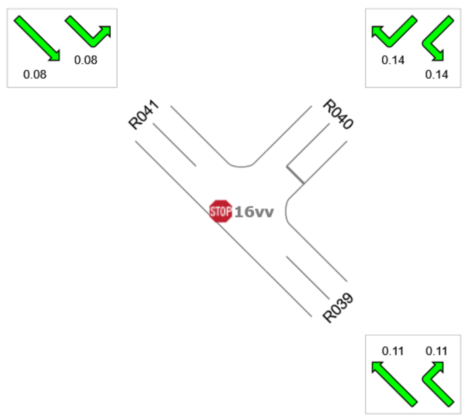
16 Intersection R1016

2041

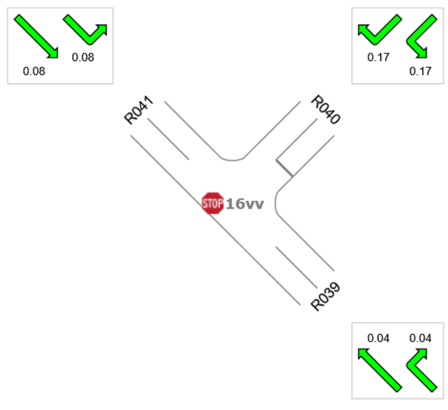
SITE LAYOUT – R1016 – 2041



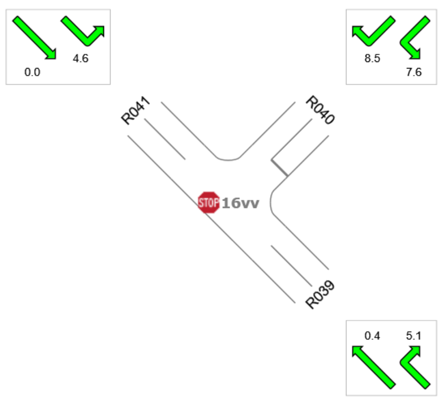
DEGREE OF SATURATION AM



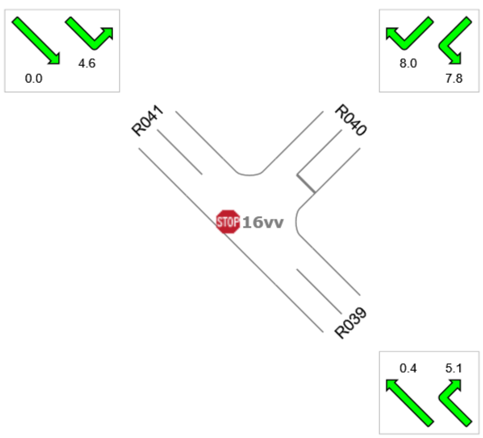
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1016 – 2041 Cont.

MOVEMENT SUMMARY 2041 AM

Site: 16vv [2041 AM - FINAL]

R1016
Site Category: (None)
Stop (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
SouthEast: R039												
2	T1	74	0.0	0.113	0.4	LOS A	0.5	3.8	0.26	0.33	0.26	47.5
3	R2	116	0.9	0.113	5.1	LOS A	0.5	3.8	0.26	0.33	0.26	46.6
Approach		189	0.6	0.113	3.3	NA	0.5	3.8	0.26	0.33	0.26	47.0
NorthEast: R040												
4	L2	24	0.0	0.138	7.6	LOS A	0.5	3.5	0.21	0.93	0.21	44.7
6	R2	105	1.0	0.138	8.5	LOS A	0.5	3.5	0.21	0.93	0.21	44.3
Approach		129	0.8	0.138	8.3	LOS A	0.5	3.5	0.21	0.93	0.21	44.4
NorthWest: R041												
7	L2	112	0.9	0.081	4.6	LOS A	0.0	0.0	0.00	0.40	0.00	47.3
8	T1	39	2.7	0.081	0.0	LOS A	0.0	0.0	0.00	0.40	0.00	47.8
Approach		151	1.4	0.081	3.4	NA	0.0	0.0	0.00	0.40	0.00	47.4
All Vehicles		469	0.9	0.138	4.7	NA	0.5	3.8	0.16	0.52	0.16	46.4

Intersection R1016 – 2041 Cont.

MOVEMENT SUMMARY 2041 PM

Site: 16vv [2041 PM - FINAL]

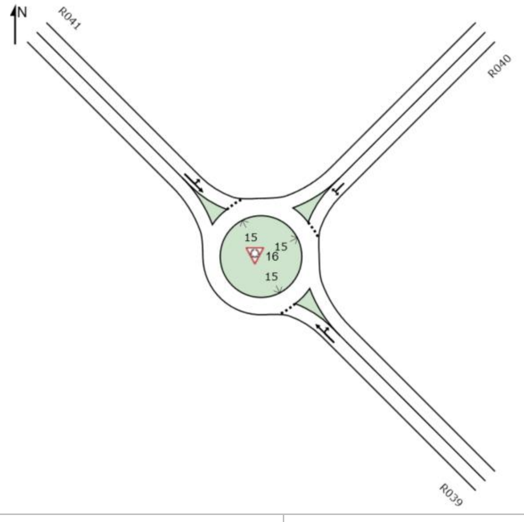
R1016
Site Category: (None)
Stop (Two-Way)

Movement Performance - Vehicles

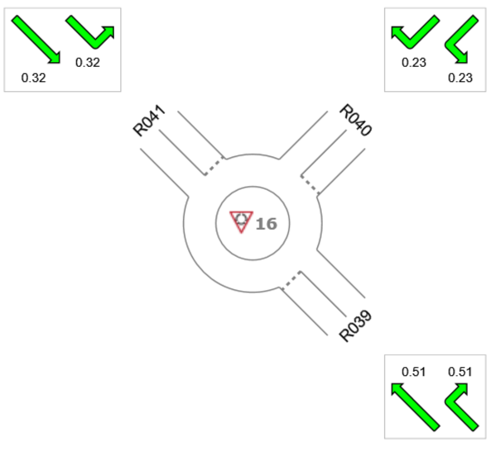
Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
SouthEast: R039												
2	T1	35	0.0	0.044	0.4	LOS A	0.2	1.4	0.24	0.29	0.24	47.8
3	R2	39	2.7	0.044	5.1	LOS A	0.2	1.4	0.24	0.29	0.24	46.9
Approach		74	1.4	0.044	2.9	NA	0.2	1.4	0.24	0.29	0.24	47.3
NorthEast: R040												
4	L2	107	1.0	0.173	7.8	LOS A	0.7	4.9	0.20	0.91	0.20	45.0
6	R2	89	1.2	0.173	8.0	LOS A	0.7	4.9	0.20	0.91	0.20	44.6
Approach		197	1.1	0.173	7.9	LOS A	0.7	4.9	0.20	0.91	0.20	44.8
NorthWest: R041												
7	L2	88	0.0	0.084	4.6	LOS A	0.0	0.0	0.00	0.30	0.00	47.9
8	T1	72	0.0	0.084	0.0	LOS A	0.0	0.0	0.00	0.30	0.00	48.3
Approach		160	0.0	0.084	2.5	NA	0.0	0.0	0.00	0.30	0.00	48.1
All Vehicles		431	0.7	0.173	5.0	NA	0.7	4.9	0.13	0.57	0.13	46.4

Intersection R1016-2066

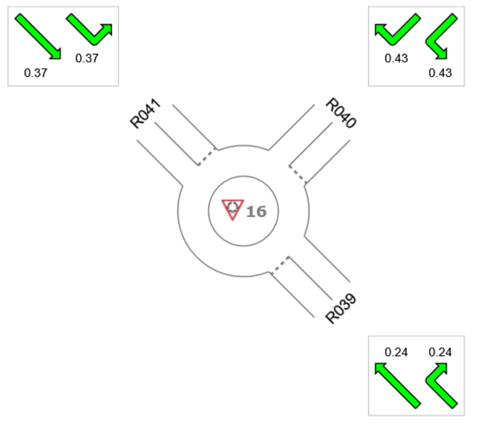
SITE LAYOUT – R1016 – 2066



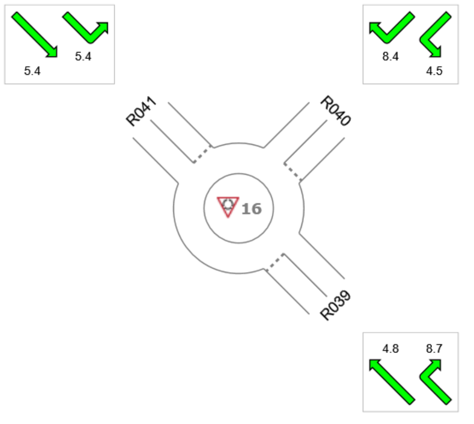
DEGREE OF SATURATION AM



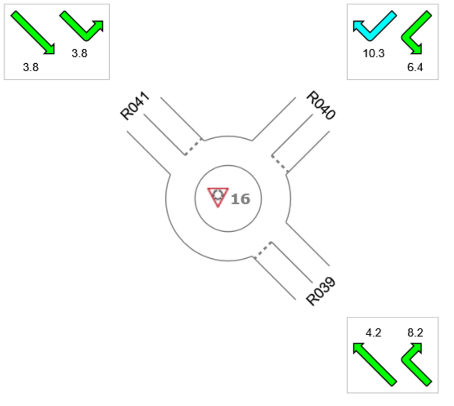
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1016 – 2066 Cont.

MOVEMENT SUMMARY 2066 AM

Site: 16 [2066 AM - FINAL]

R1016
Site Category: (None)
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
SouthEast: R039												
2	T1	324	1.3	0.514	4.8	LOS A	4.6	32.7	0.58	0.59	0.58	46.0
3	R2	245	1.3	0.514	8.7	LOS A	4.6	32.7	0.58	0.59	0.58	46.0
Approach		569	1.3	0.514	6.5	LOS A	4.6	32.7	0.58	0.59	0.58	46.0
NorthEast: R040												
4	L2	74	2.9	0.226	4.5	LOS A	1.5	10.8	0.46	0.60	0.46	45.1
6	R2	159	0.7	0.226	8.4	LOS A	1.5	10.8	0.46	0.60	0.46	45.8
Approach		233	1.4	0.226	7.1	LOS A	1.5	10.8	0.46	0.60	0.46	45.6
NorthWest: R041												
7	L2	140	0.8	0.325	5.4	LOS A	2.3	16.5	0.59	0.60	0.59	46.0
8	T1	161	3.3	0.325	5.4	LOS A	2.3	16.5	0.59	0.60	0.59	46.8
Approach		301	2.1	0.325	5.4	LOS A	2.3	16.5	0.59	0.60	0.59	46.4
All Vehicles		1103	1.5	0.514	6.3	LOS A	4.6	32.7	0.56	0.59	0.56	46.0

Intersection R1016 – 2066 Cont.

MOVEMENT SUMMARY 2066 PM

Site: 16 [2066 PM - FINAL]

R1016
Site Category: (None)
Roundabout

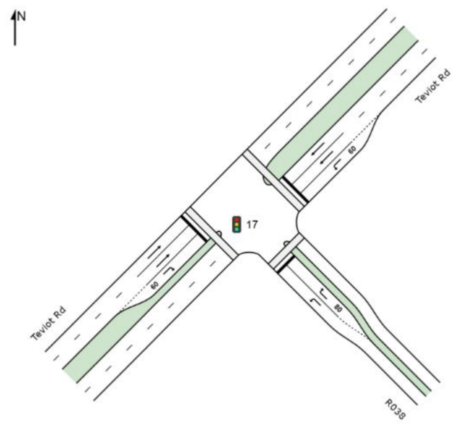
Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
SouthEast: R039												
2	T1	173	2.4	0.239	4.2	LOS A	1.7	12.0	0.44	0.53	0.44	46.5
3	R2	83	1.3	0.239	8.2	LOS A	1.7	12.0	0.44	0.53	0.44	46.5
Approach		256	2.1	0.239	5.5	LOS A	1.7	12.0	0.44	0.53	0.44	46.5
NorthEast: R040												
4	L2	238	0.9	0.432	6.4	LOS A	3.2	22.4	0.69	0.72	0.69	44.9
6	R2	139	0.8	0.432	10.3	LOS B	3.2	22.4	0.69	0.72	0.69	45.6
Approach		377	0.8	0.432	7.8	LOS A	3.2	22.4	0.69	0.72	0.69	45.1
NorthWest: R041												
7	L2	138	0.8	0.370	3.8	LOS A	3.0	20.9	0.37	0.43	0.37	46.6
8	T1	323	1.0	0.370	3.8	LOS A	3.0	20.9	0.37	0.43	0.37	47.4
Approach		461	0.9	0.370	3.8	LOS A	3.0	20.9	0.37	0.43	0.37	47.1
All Vehicles		1094	1.2	0.432	5.6	LOS A	3.2	22.4	0.49	0.55	0.49	46.3

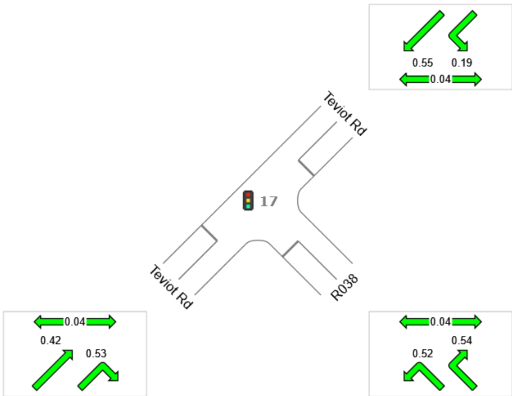
17 Intersection R1017

2066

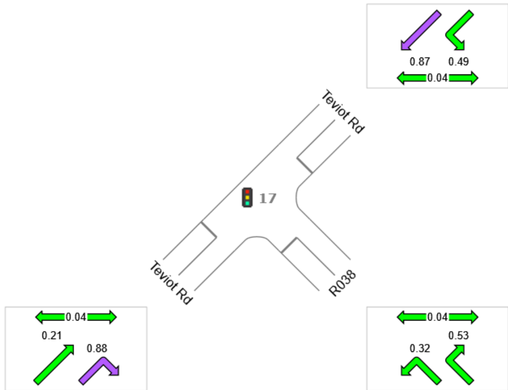
SITE LAYOUT – R1017 – 2066



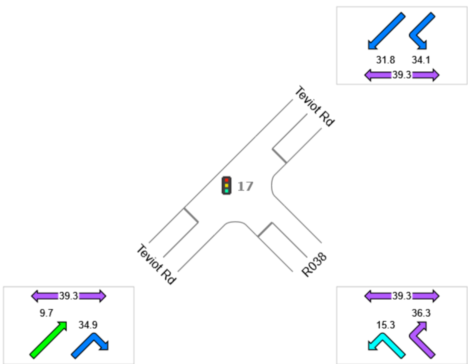
DEGREE OF SATURATION AM



DEGREE OF SATURATION PM



<u>DELAY CONTROL (seconds) AM</u>



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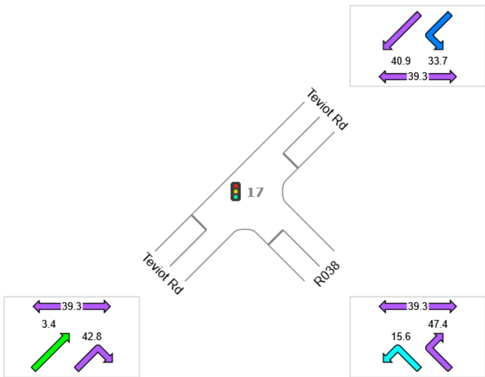


Intersection R1017 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 17 [2066 AM - FINAL]

R1017
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R038													
Lane 1	592	0.7	1129	0.524	100	15.3	LOS B	14.7	103.8	Full	500	0.0	0.0
Lane 2	254	1.7	469	0.541	100	36.3	LOS D	9.8	69.6	Short	80	0.0	NA
Approach	845	1.0		0.541		21.6	LOS C	14.7	103.8				
NorthEast: Teviot Rd													
Lane 1	86	6.1	455	0.190	100	34.1	LOS C	3.0	22.1	Short	60	0.0	NA
Lane 2	261	8.5	472	0.553	100	31.8	LOS C	10.1	76.0	Full	500	0.0	0.0
Lane 3	261	8.5	472	0.553	100	31.8	LOS C	10.1	76.0	Full	500	0.0	0.0
Approach	608	8.1		0.553		32.1	LOS C	10.1	76.0				
SouthWest: Teviot Rd													
Lane 1	488	2.6	1172	0.417	100	9.7	LOS A	11.1	79.2	Full	500	0.0	0.0
Lane 2	488	2.6	1172	0.417	100	9.7	LOS A	11.1	79.2	Full	500	0.0	0.0
Lane 3	283	1.5	531	0.533	100	34.9	LOS C	10.6	75.1	Short	60	0.0	NA
Approach	1260	2.3		0.533		15.4	LOS B	11.1	79.2				
Intersection	2714	3.2		0.553		21.1	LOS C	14.7	103.8				

Intersection R1017 – 2066 Cont.

LANE SUMMARY 2066 PM

Site: 17 [2066 PM - FINAL]

R1017
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site User-Given Cycle Time)

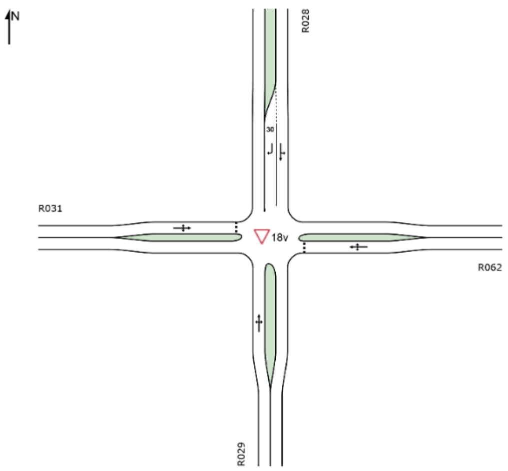
Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R038													
Lane 1	336	1.3	1043	0.322	100	15.6	LOS B	7.7	54.8	Full	500	0.0	0.0
Lane 2	107	2.9	202	0.531	100	47.4	LOS D	4.7	33.7	Short	80	0.0	NA
Approach	443	1.7		0.531		23.3	LOS C	7.7	54.8				
NorthEast: Teviot Rd													
Lane 1	268	1.2	553	0.486	100	33.7	LOS C	9.8	69.1	Short	60	0.0	NA
Lane 2	446	1.9	512 [1]	0.871	100	40.7	LOS D	21.1	150.1	Full	500	0.0	0.0
Lane 3	503	1.9	578	0.871	100	41.1	LOS D	24.4	173.5	Full	500	0.0	0.0
Approach	1218	1.7		0.871		39.3	LOS D	24.4	173.5				
SouthWest: Teviot Rd													
Lane 1	305	5.5	1422	0.214	100	3.4	LOS A	3.8	28.1	Full	500	0.0	0.0
Lane 2	305	5.5	1422	0.214	100	3.4	LOS A	3.8	28.1	Full	500	0.0	0.0
Lane 3	515	0.6	583 [1]	0.883	100	42.8	LOS D	23.7	166.7	Short	60	0.0	NA
Approach	1124	3.3		0.883		21.4	LOS C	23.7	166.7				
Intersection	2785	2.3		0.883		29.5	LOS C	24.4	173.5				

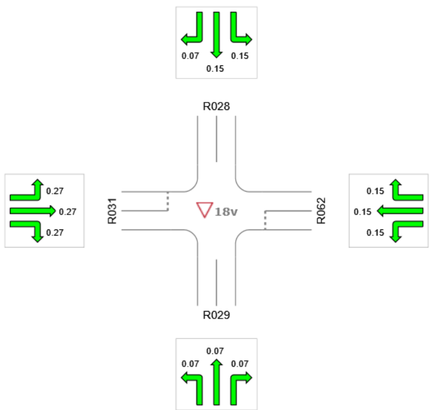
18 Intersection R1018

2031

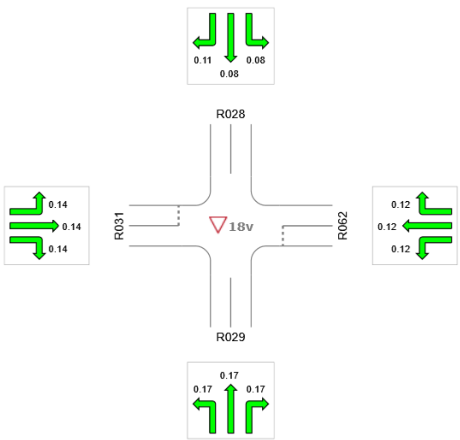
SITE LAYOUT – R1018 – 2031



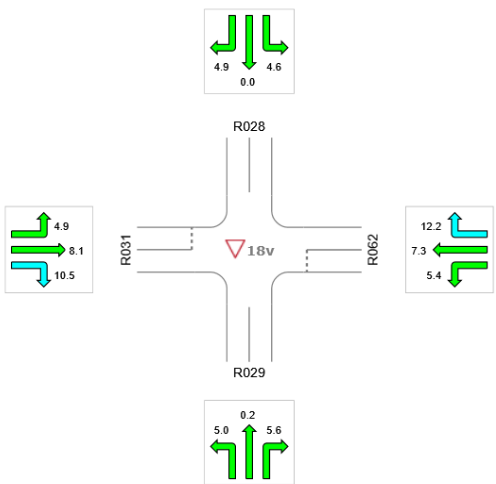
DEGREE OF SATURATION AM



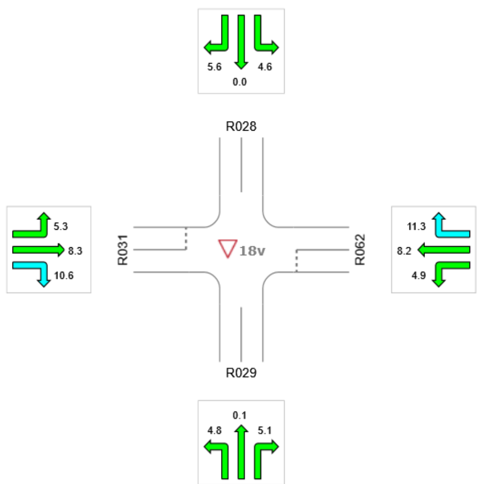
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1018 – 2031 Cont.

MOVEMENT SUMMARY 2031 AM

Site: 18v [2031 AM - FINAL]

R1018
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
South: R029												
1	L2	23	0.0	0.068	5.0	LOS A	0.1	0.9	0.12	0.15	0.12	48.3
2	T1	88	3.6	0.068	0.2	LOS A	0.1	0.9	0.12	0.15	0.12	48.8
3	R2	13	0.0	0.068	5.6	LOS A	0.1	0.9	0.12	0.15	0.12	47.8
Approach		124	2.5	0.068	1.6	NA	0.1	0.9	0.12	0.15	0.12	48.6
East: R062												
4	L2	29	0.0	0.153	5.4	LOS A	0.6	4.1	0.53	0.71	0.53	44.1
5	T1	16	0.0	0.153	7.3	LOS A	0.6	4.1	0.53	0.71	0.53	44.3
6	R2	43	2.4	0.153	12.2	LOS B	0.6	4.1	0.53	0.71	0.53	43.9
Approach		88	1.2	0.153	9.1	LOS A	0.6	4.1	0.53	0.71	0.53	44.0
North: R028												
7	L2	40	2.6	0.153	4.6	LOS A	0.0	0.0	0.00	0.07	0.00	49.0
8	T1	251	1.7	0.153	0.0	LOS A	0.0	0.0	0.00	0.07	0.00	49.6
9	R2	106	0.0	0.065	4.9	LOS A	0.3	2.1	0.22	0.53	0.22	45.7
Approach		397	1.3	0.153	1.8	NA	0.3	2.1	0.06	0.20	0.06	48.4
West: R031												
10	L2	161	0.0	0.272	4.9	LOS A	1.2	8.5	0.26	0.56	0.26	45.4
11	T1	24	0.0	0.272	8.1	LOS A	1.2	8.5	0.26	0.56	0.26	45.6
12	R2	66	1.6	0.272	10.5	LOS B	1.2	8.5	0.26	0.56	0.26	45.0
Approach		252	0.4	0.272	6.7	LOS A	1.2	8.5	0.26	0.56	0.26	45.3
All Vehicles		861	1.2	0.272	3.9	NA	1.2	8.5	0.17	0.35	0.17	47.0

Intersection R1018 – 2031 Cont.

MOVEMENT SUMMARY 2031 PM

Site: 18v [2031 PM - FINAL]

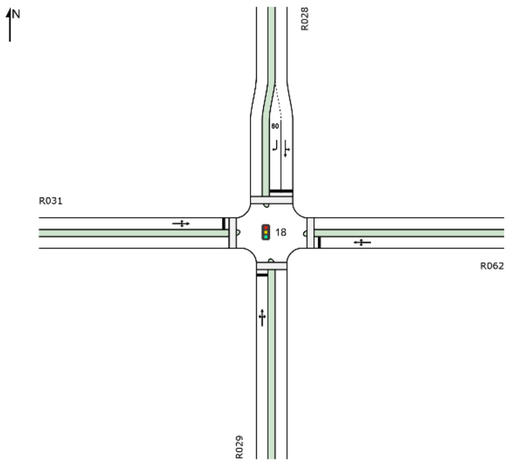
R1018
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

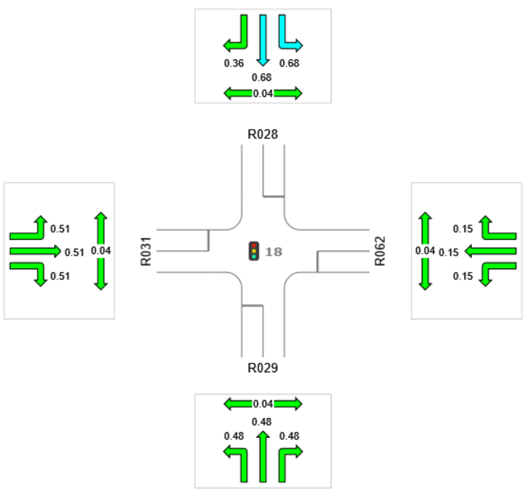
Mov ID	Turn	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
South: R029												
1	L2	60	0.0	0.169	4.8	LOS A	0.3	2.0	0.08	0.15	0.08	48.4
2	T1	226	1.4	0.169	0.1	LOS A	0.3	2.0	0.08	0.15	0.08	48.9
3	R2	29	0.0	0.169	5.1	LOS A	0.3	2.0	0.08	0.15	0.08	48.0
Approach		316	1.0	0.169	1.4	NA	0.3	2.0	0.08	0.15	0.08	48.7
East: R062												
4	L2	15	0.0	0.118	4.9	LOS A	0.4	3.1	0.44	0.67	0.44	44.1
5	T1	19	0.0	0.118	8.2	LOS A	0.4	3.1	0.44	0.67	0.44	44.3
6	R2	33	0.0	0.118	11.3	LOS B	0.4	3.1	0.44	0.67	0.44	43.9
Approach		66	0.0	0.118	9.0	LOS A	0.4	3.1	0.44	0.67	0.44	44.1
North: R028												
7	L2	42	0.0	0.078	4.6	LOS A	0.0	0.0	0.00	0.16	0.00	48.6
8	T1	104	3.0	0.078	0.0	LOS A	0.0	0.0	0.00	0.16	0.00	49.1
9	R2	145	0.0	0.105	5.6	LOS A	0.5	3.4	0.39	0.59	0.39	45.4
Approach		292	1.1	0.105	3.4	NA	0.5	3.4	0.19	0.37	0.19	47.1
West: R031												
10	L2	100	0.0	0.144	5.3	LOS A	0.6	4.1	0.39	0.60	0.39	45.5
11	T1	13	0.0	0.144	8.3	LOS A	0.6	4.1	0.39	0.60	0.39	45.7
12	R2	23	0.0	0.144	10.6	LOS B	0.6	4.1	0.39	0.60	0.39	45.1
Approach		136	0.0	0.144	6.5	LOS A	0.6	4.1	0.39	0.60	0.39	45.4
All Vehicles		809	0.8	0.169	3.6	NA	0.6	4.1	0.20	0.35	0.20	47.2

Intersection R1015-2041

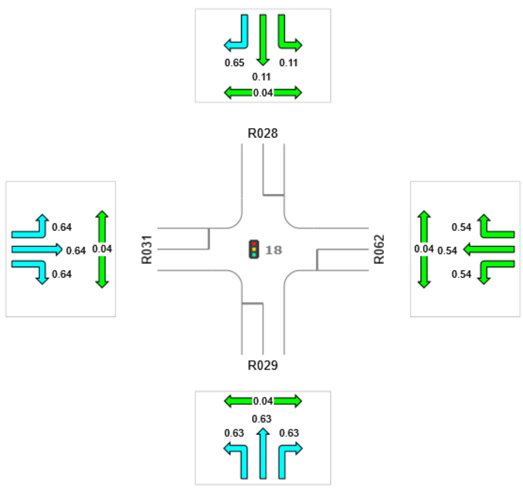
SITE LAYOUT – R1018 – 2041



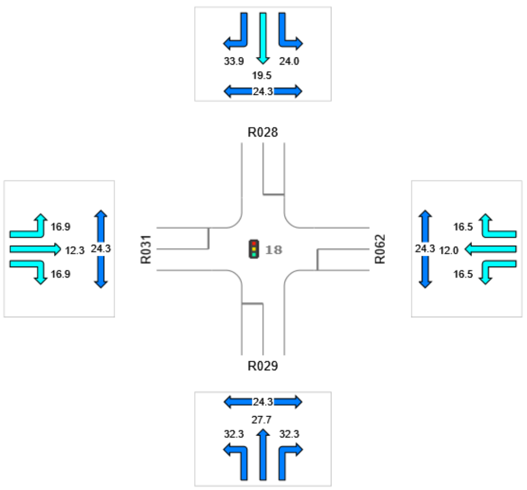
DEGREE OF SATURATION AM



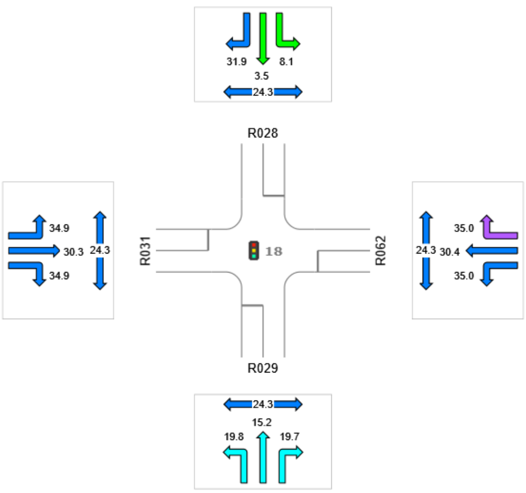
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1018 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 18 [2041 AM - FINAL]

R1018
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R029													
Lane 1	117	1.8	242	0.482	100	28.8	LOS C	3.4	24.1	Full	500	0.0	0.0
Approach	117	1.8		0.482		28.8	LOS C	3.4	24.1				
East: R062													
Lane 1	87	1.2	582	0.150	100	15.0	LOS B	1.6	11.5	Full	500	0.0	0.0
Approach	87	1.2		0.150		15.0	LOS B	1.6	11.5				
North: R028													
Lane 1	432	1.7	638	0.676	100	20.1	LOS C	11.3	80.6	Full	500	0.0	0.0
Lane 2	65	1.6	184	0.355	100	33.9	LOS C	1.9	13.7	Short	60	0.0	NA
Approach	497	1.7		0.676		21.9	LOS C	11.3	80.6				
West: R031													
Lane 1	394	0.8	766	0.514	100	16.4	LOS B	8.2	58.1	Full	500	0.0	0.0
Approach	394	0.8		0.514		16.4	LOS B	8.2	58.1				
Intersection	1095	1.3		0.676		20.1	LOS C	11.3	80.6				

Intersection R1018 – 2041 Cont.

LANE SUMMARY 2041 PM

Site: 18 [2041 PM - FINAL]

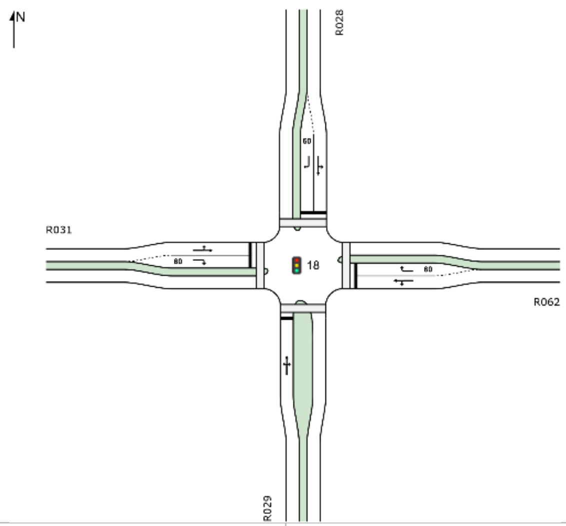
R1018
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

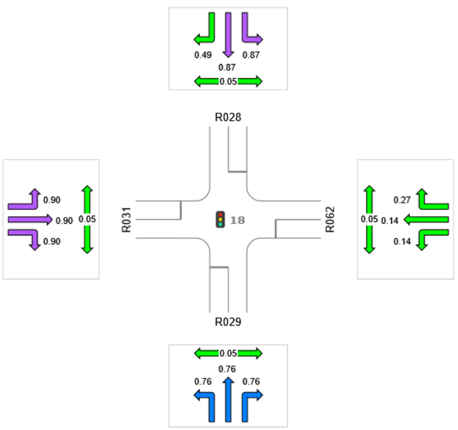
	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R029													
Lane 1	498	0.8	789	0.631	100	16.7	LOS B	11.8	82.9	Full	500	0.0	0.0
Approach	498	0.8		0.631		16.7	LOS B	11.8	82.9				
East: R062													
Lane 1	91	1.2	168	0.540	100	33.2	LOS C	2.8	19.6	Full	500	0.0	0.0
Approach	91	1.2		0.540		33.2	LOS C	2.8	19.6				
North: R028													
Lane 1	142	2.2	1292	0.110	100	5.0	LOS A	1.4	10.1	Full	500	0.0	0.0
Lane 2	200	1.1	307	0.651	100	31.9	LOS C	5.9	41.8	Short	60	0.0	NA
Approach	342	1.5		0.651		20.7	LOS C	5.9	41.8				
West: R031													
Lane 1	126	0.8	197	0.643	100	33.9	LOS C	3.9	27.6	Full	500	0.0	0.0
Approach	126	0.8		0.643		33.9	LOS C	3.9	27.6				
Intersection	1057	1.1		0.651		21.5	LOS C	11.8	82.9				

Intersection R1018-2066

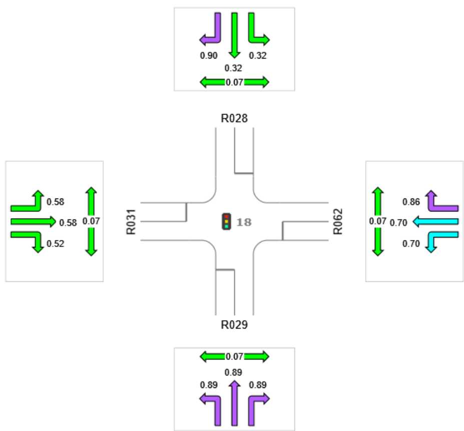
SITE LAYOUT – R1018 – 2066



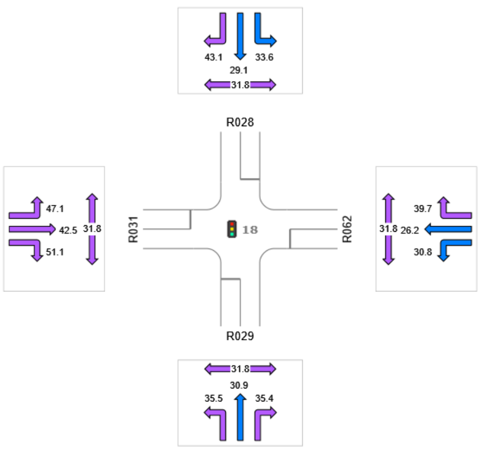
DEGREE OF SATURATION AM



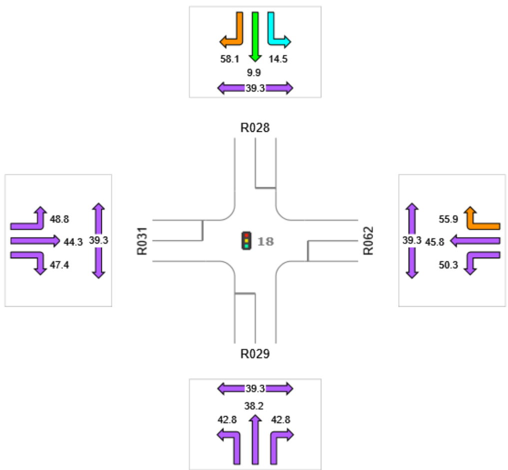
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1018 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 18 [2066 AM - FINAL]

R1018
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 75 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R029													
Lane 1	361	2.9	477	0.757	100	31.9	LOS C	13.2	94.9	Full	500	0.0	0.0
Approach	361	2.9		0.757		31.9	LOS C	13.2	94.9				
East: R062													
Lane 1	56	0.0	412	0.136	100	27.1	LOS C	1.7	11.8	Full	500	0.0	0.0
Lane 2	53	2.0	195	0.269	100	39.7	LOS D	1.9	13.3	Short	60	0.0	NA
Approach	108	1.0		0.269		33.2	LOS C	1.9	13.3				
North: R028													
Lane 1	693	1.7	795 [1]	0.871	100	30.3	LOS C	27.2	193.0	Full	500	0.0	0.0
Lane 2	72	2.9	146	0.492	100	43.1	LOS D	2.7	19.5	Short	60	0.0	NA
Approach	764	1.8		0.871		31.5	LOS C	27.2	193.0				
West: R031													
Lane 1	359	1.2	401	0.896	100	45.2	LOS D	15.7	111.2	Full	500	0.0	0.0
Lane 2	177	0.6	197	0.897	100	51.1	LOS D	7.8	54.6	Short	60	0.0	NA
Approach	536	1.0		0.897		47.2	LOS D	15.7	111.2				
Intersection	1769	1.7		0.897		36.4	LOS D	27.2	193.0				

LANE SUMMARY 2066 PM

Site: 18 [2066 PM - FINAL]

R1018
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site Optimum Cycle Time - Minimum Delay)

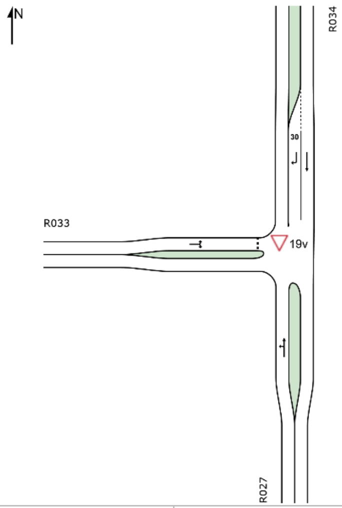
Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R029													
Lane 1	666	0.9	748	0.891	100	39.6	LOS D	32.8	231.4	Full	500	0.0	0.0
Approach	666	0.9		0.891		39.6	LOS D	32.8	231.4				
East: R062													
Lane 1	135	0.8	193	0.696	100	46.0	LOS D	6.2	43.6	Full	500	0.0	0.0
Lane 2	177	1.2	205	0.864	100	55.9	LOS E	8.8	62.5	Short	60	0.0	NA
Approach	312	1.0		0.864		51.6	LOS D	8.8	62.5				
North: R028													
Lane 1	355	2.1	1126	0.315	100	10.5	LOS B	7.8	55.4	Full	500	0.0	0.0
Lane 2	201	1.6	224	0.896	100	58.1	LOS E	10.4	73.5	Short	60	0.0	NA
Approach	556	1.9		0.896		27.7	LOS C	10.4	73.5				
West: R031													
Lane 1	109	1.0	188	0.583	100	47.2	LOS D	4.9	34.5	Full	500	0.0	0.0
Lane 2	106	2.0	203	0.522	100	47.4	LOS D	4.6	33.0	Short	60	0.0	NA
Approach	216	1.5		0.583		47.3	LOS D	4.9	34.5				
Intersection	1749	1.3		0.896		38.9	LOS D	32.8	231.4				

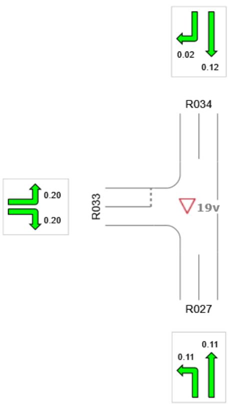
19 Intersection R1019

2031

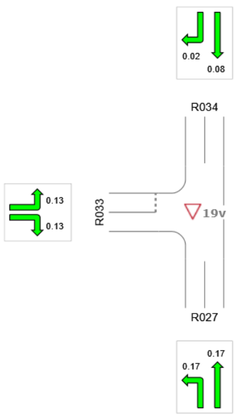
SITE LAYOUT – R1019 – 2031



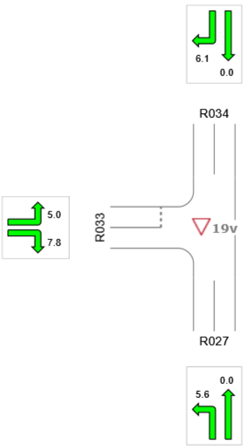
DEGREE OF SATURATION AM



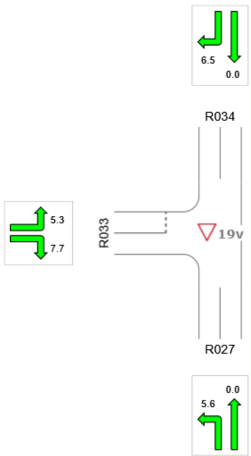
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1019 – 2031 Cont.

MOVEMENT SUMMARY 2031 AM

Site: 19v [2031 AM - FINAL]

R1019
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
South: R027												
1	L2	79	1.3	0.111	5.6	LOS A	0.0	0.0	0.00	0.22	0.00	56.4
2	T1	131	1.6	0.111	0.0	LOS A	0.0	0.0	0.00	0.22	0.00	58.0
Approach		209	1.5	0.111	2.1	NA	0.0	0.0	0.00	0.22	0.00	57.4
North: R034												
8	T1	236	1.3	0.123	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
9	R2	32	0.0	0.021	6.1	LOS A	0.1	0.6	0.31	0.56	0.31	48.7
Approach		267	1.2	0.123	0.7	NA	0.1	0.6	0.04	0.07	0.04	58.4
West: R033												
10	L2	32	0.0	0.195	5.0	LOS A	0.8	5.7	0.43	0.67	0.43	48.1
12	R2	123	0.9	0.195	7.8	LOS A	0.8	5.7	0.43	0.67	0.43	47.6
Approach		155	0.7	0.195	7.3	LOS A	0.8	5.7	0.43	0.67	0.43	47.7
All Vehicles		632	1.2	0.195	2.8	NA	0.8	5.7	0.12	0.27	0.12	55.0

Intersection R1019 – 2031 Cont.

MOVEMENT SUMMARY 2031 PM

Site: 19v [2031 PM - FINAL]

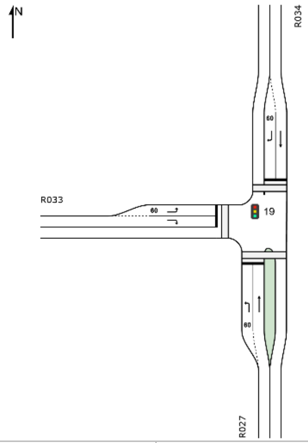
R1019
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

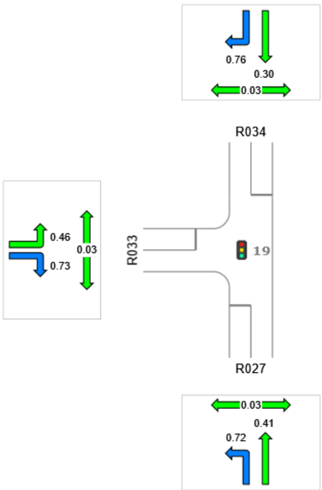
Mov ID	Turn	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
South: R027												
1	L2	111	1.0	0.168	5.6	LOS A	0.0	0.0	0.00	0.21	0.00	56.6
2	T1	209	1.0	0.168	0.0	LOS A	0.0	0.0	0.00	0.21	0.00	58.1
Approach		320	1.0	0.168	1.9	NA	0.0	0.0	0.00	0.21	0.00	57.6
North: R034												
8	T1	144	1.5	0.075	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
9	R2	32	0.0	0.024	6.5	LOS A	0.1	0.7	0.39	0.59	0.39	48.5
Approach		176	1.2	0.075	1.2	NA	0.1	0.7	0.07	0.11	0.07	57.6
West: R033												
10	L2	32	0.0	0.133	5.3	LOS A	0.5	3.7	0.44	0.66	0.44	48.2
12	R2	77	1.4	0.133	7.7	LOS A	0.5	3.7	0.44	0.66	0.44	47.7
Approach		108	1.0	0.133	7.0	LOS A	0.5	3.7	0.44	0.66	0.44	47.9
All Vehicles		604	1.0	0.168	2.6	NA	0.5	3.7	0.10	0.26	0.10	55.5

Intersection R1019-2041

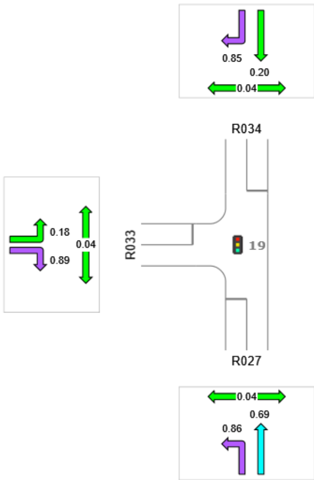
SITE LAYOUT – R1019 – 2041



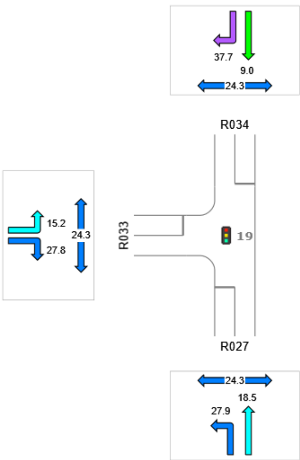
DEGREE OF SATURATION AM



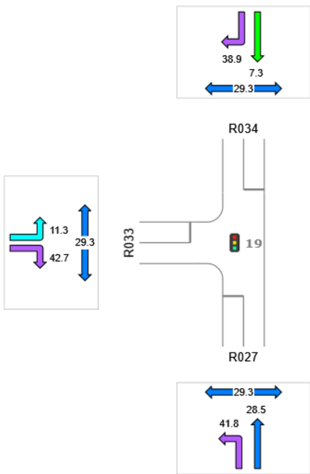
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1019 – 2041 Cont.

LANE SUMMARY 2041 AM

Site: 19 [2041 AM - FINAL]

R1019
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	398	1.9	550	0.724	100	27.9	LOS C	11.3	80.3	Short	60	0.0	NA
Lane 2	235	3.6	572	0.411	100	18.5	LOS B	5.6	40.6	Full	500	0.0	0.0
Approach	633	2.5		0.724		24.5	LOS C	11.3	80.3				
North: R034													
Lane 1	295	3.6	985	0.299	100	9.0	LOS A	5.0	35.8	Full	500	0.0	0.0
Lane 2	158	5.3	209	0.756	100	37.6	LOS D	5.1	37.3	Short	60	0.0	NA
Approach	453	4.2		0.756		19.0	LOS B	5.1	37.3				
West: R033													
Lane 1	422	2.0	916	0.461	100	15.2	LOS B	8.1	57.8	Short	60	0.0	NA
Lane 2	379	1.4	521	0.727	100	27.8	LOS C	10.9	77.2	Full	500	0.0	0.0
Approach	801	1.7		0.727		21.2	LOS C	10.9	77.2				
Intersection	1886	2.6		0.756		21.7	LOS C	11.3	80.3				

Intersection R1019 – 2041 Cont.

LANE SUMMARY 2041 PM

Site: 19 [2041 PM - FINAL]

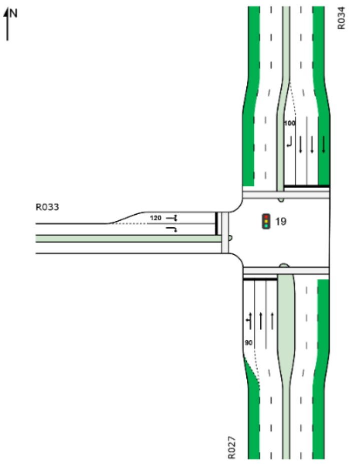
R1019
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 70 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

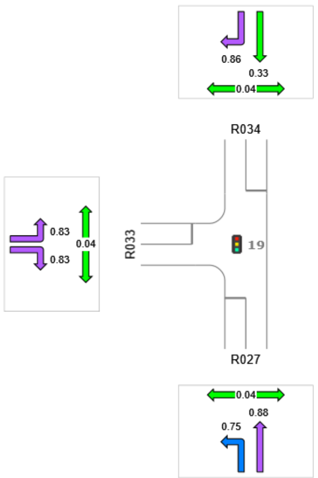
	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	362	1.2	421	0.860	100	41.8	LOS D	14.2	100.2	Short	60	0.0	NA
Lane 2	302	3.5	436	0.693	100	28.5	LOS C	10.0	72.4	Full	500	0.0	0.0
Approach	664	2.2		0.860		35.7	LOS D	14.2	100.2				
North: R034													
Lane 1	222	2.4	1125	0.197	100	7.3	LOS A	3.5	25.2	Full	500	0.0	0.0
Lane 2	423	1.5	499	0.848	100	38.9	LOS D	16.2	114.5	Short	60	0.0	NA
Approach	645	1.8		0.848		28.0	LOS C	16.2	114.5				
West: R033													
Lane 1	193	3.3	1089	0.177	100	11.3	LOS B	2.9	21.1	Short	60	0.0	NA
Lane 2	396	1.3	447	0.886	100	42.7	LOS D	16.1	113.9	Full	500	0.0	0.0
Approach	588	2.0		0.886		32.4	LOS C	16.1	113.9				
Intersection	1898	2.0		0.886		32.1	LOS C	16.2	114.5				

Intersection R1019-2066

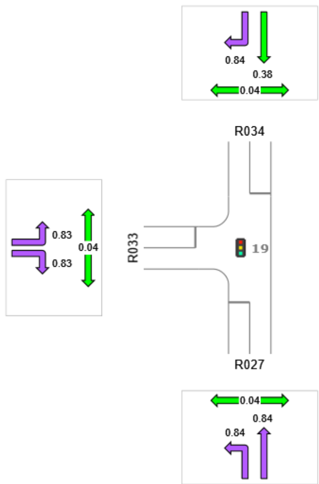
SITE LAYOUT – R1019 – 2066



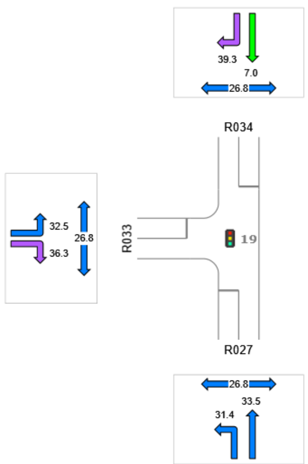
DEGREE OF SATURATION AM



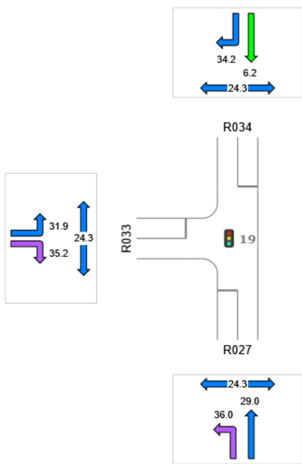
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) PM



Intersection R1019 – 2066 Cont.

LANE SUMMARY 2066 AM

Site: 19 [2066 AM - FINAL]

R1019
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 65 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	378	2.2	506	0.746	100	31.4	LOS C	11.9	85.1	Two Seg [10]	500	0.0	0.0
Lane 2	459	4.5	525	0.876	100	33.5	LOS C	17.1	124.4	Full	500	0.0	0.0
Lane 3	459	4.5	525	0.876	100	33.5	LOS C	17.1	124.4	Full	500	0.0	0.0
Approach	1297	3.8		0.876		32.9	LOS C	17.1	124.4				
North: R034													
Lane 1	1	100.0	709	0.001	100	5.5	LOS A	0.0	0.2	Full	500	0.0	0.0
Lane 2	382	4.1	1139	0.335	100	7.0	LOS A	6.1	43.9	Full	500	0.0	0.0
Lane 3	382	4.1	1139	0.335	100	7.0	LOS A	6.1	43.9	Full	500	0.0	0.0
Lane 4	359	2.9	420	0.855	100	39.3	LOS D	13.1	93.9	Short	100	0.0	NA
Approach	1123	3.8		0.855		17.3	LOS B	13.1	93.9				
West: R033													
Lane 1	503	2.0	603	0.835	100	32.5	LOS C	17.4	123.8	Short	120	0.0	NA
Lane 2	331	1.5	396	0.835	100	37.4	LOS D	11.8	83.4	Full	500	0.0	0.0
Approach	834	1.8		0.835		34.4	LOS C	17.4	123.8				
Intersection	3254	3.3		0.876		27.9	LOS C	17.4	124.4				

LANE SUMMARY 2066 PM

Site: 19 [2066 PM - FINAL]

R1019
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

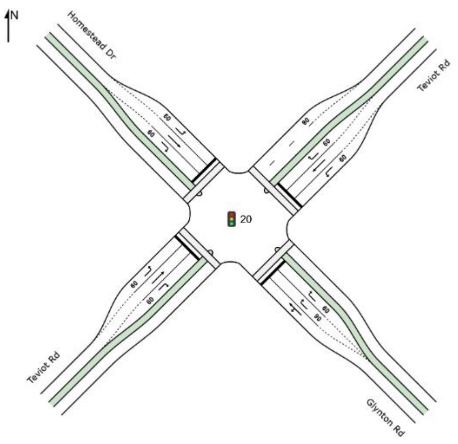
Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	361	1.5	429	0.842	100	36.0	LOS D	12.0	85.1	Two Seg 10	500	0.0	0.0
Lane 2	364	3.6	445	0.819	100	29.0	LOS C	11.8	84.8	Full	500	0.0	0.0
Lane 3	364	3.6	445	0.819	100	29.0	LOS C	11.8	84.8	Full	500	0.0	0.0
Approach	1089	2.9		0.842		31.3	LOS C	12.0	85.1				
North: R034													
Lane 1	1	100.0	729	0.001	100	4.7	LOS A	0.0	0.2	Full	500	0.0	0.0
Lane 2	447	3.1	1179	0.379	100	6.2	LOS A	6.6	47.2	Full	500	0.0	0.0
Lane 3	447	3.1	1179	0.379	100	6.2	LOS A	6.6	47.2	Full	500	0.0	0.0
Lane 4	438	1.4	521	0.841	100	34.2	LOS C	14.4	102.2	Short	100	0.0	NA
Approach	1334	2.6		0.841		15.4	LOS B	14.4	102.2				
West: R033													
Lane 1	451	2.0	543	0.831	100	31.9	LOS C	14.6	103.9	Short	120	0.0	NA
Lane 2	280	1.7	336	0.831	100	36.3	LOS D	9.3	66.0	Full	500	0.0	0.0
Approach	731	1.9		0.831		33.6	LOS C	14.6	103.9				
Intersection	3154	2.5		0.842		25.1	LOS C	14.6	103.9				

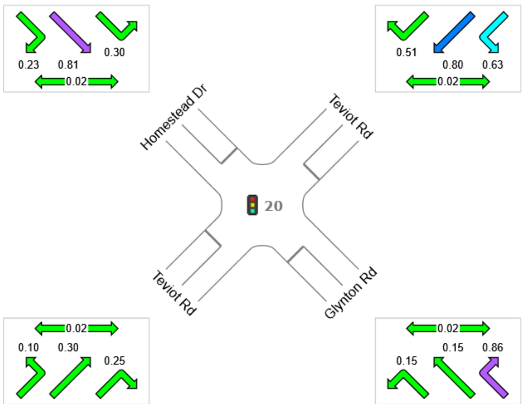
20 Intersection R1020

2031

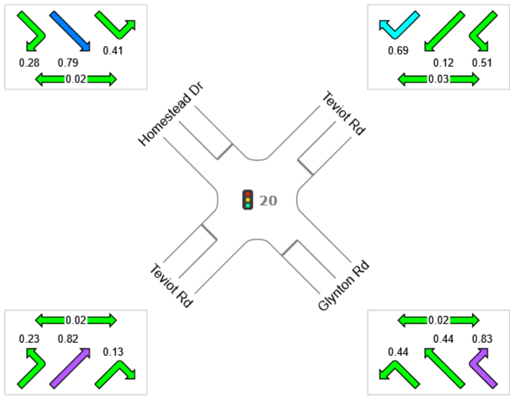
SITE LAYOUT – R1020– 2031



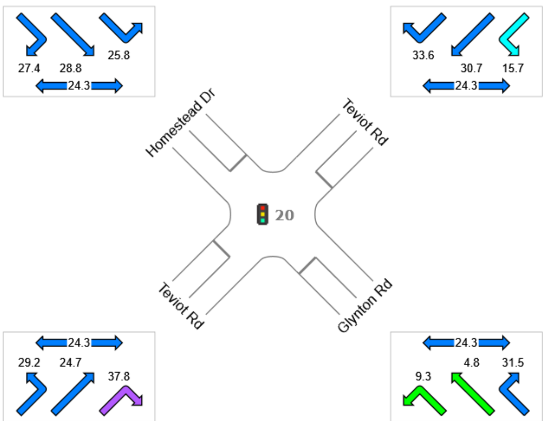
DEGREE OF SATURATION AM



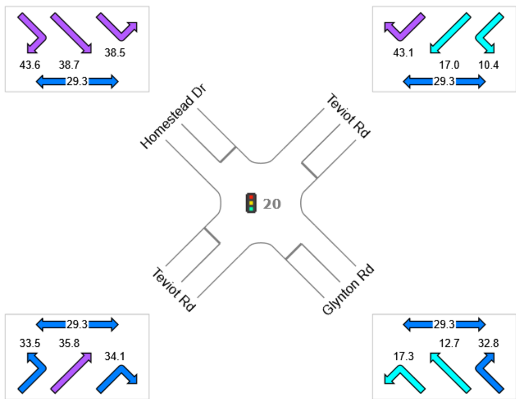
DEGREE OF SATURATION PM



DELAY CONTROL (seconds) AM



DELAY CONTROL (seconds) AM



LANE SUMMARY

Site: 20 [2031 AM - FINAL]

R1020
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: Glynton Rd													
Lane 1	184	3.4	1198	0.154	100	5.6	LOS A	2.2	15.7	Full	500	0.0	0.0
Lane 2	224	3.8	512	0.438	51 [6]	24.1	LOS C	5.5	40.1	Short	90	0.0	NA
Lane 3	443	3.8	512	0.865	100	35.2	LOS D	15.2	109.8	Short	60	0.0	NA
Approach	852	3.7		0.865		25.9	LOS C	15.2	109.8				
NorthEast: Teviot Rd													
Lane 1	624	4.0	993	0.629	100	15.7	LOS B	12.7	92.1	Short	60	0.0	NA
Lane 2	257	1.6	322	0.799	100	30.7	LOS C	8.3	58.8	Full	500	0.0	0.0
Lane 3	114	0.9	221	0.514	100	33.6	LOS C	3.3	23.5	Short	60	0.0	NA
Approach	995	3.1		0.799		21.6	LOS C	12.7	92.1				
NorthWest: Homestead Dr													
Lane 1	138	0.8	462	0.299	100	25.8	LOS C	3.4	23.8	Short	60	0.0	NA
Lane 2	391	1.3	483	0.808	100	28.8	LOS C	12.4	87.5	Full	500	0.0	0.0
Lane 3	73	1.4	315	0.230	100	27.4	LOS C	1.8	13.0	Short	60	0.0	NA
Approach	601	1.2		0.808		28.0	LOS C	12.4	87.5				
SouthWest: Teviot Rd													
Lane 1	32	0.0	310	0.102	100	29.2	LOS C	0.8	5.7	Short	60	0.0	NA
Lane 2	97	0.0	325	0.298	100	24.7	LOS C	2.6	18.2	Full	500	0.0	0.0
Lane 3	32	0.0	127	0.249	100	37.8	LOS D	1.0	6.8	Short	60	0.0	NA
Approach	160	0.0		0.298		28.2	LOS C	2.6	18.2				
Intersection	2607	2.7		0.865		24.9	LOS C	15.2	109.8				

LANE SUMMARY

Site: 20 [2031 PM - FINAL]

R1020
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 70 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: Glynton Rd													
Lane 1	416	1.0	937	0.444	100	13.1	LOS B	9.3	66.0	Full	500	0.0	0.0
Lane 2	218	2.8	520	0.418	51 [6]	26.9	LOS C	6.2	44.2	Short	90	0.0	NA
Lane 3	430	2.8	520	0.826	100	35.7	LOS D	15.8	113.5	Short	60	0.0	NA
Approach	1063	2.1		0.826		25.1	LOS C	15.8	113.5				
NorthEast: Teviot Rd													
Lane 1	667	3.0	1299	0.514	100	10.4	LOS B	10.2	73.6	Short	60	0.0	NA
Lane 2	79	0.0	669	0.118	100	17.0	LOS B	1.9	13.0	Full	500	0.0	0.0
Lane 3	111	0.0	159	0.694	100	43.1	LOS D	4.1	28.6	Short	60	0.0	NA
Approach	857	2.3		0.694		15.2	LOS B	10.2	73.6				
NorthWest: Homestead Dr													
Lane 1	87	0.0	212	0.412	100	38.5	LOS D	3.0	20.7	Short	60	0.0	NA
Lane 2	172	3.1	219	0.785	100	38.7	LOS D	6.4	46.3	Full	500	0.0	0.0
Lane 3	32	0.0	113	0.279	100	43.6	LOS D	1.1	8.0	Short	60	0.0	NA
Approach	291	1.8		0.785		39.2	LOS D	6.4	46.3				
SouthWest: Teviot Rd													
Lane 1	73	1.4	315	0.230	100	33.5	LOS C	2.2	15.7	Short	60	0.0	NA
Lane 2	272	1.2	332	0.819	100	35.8	LOS D	10.2	72.2	Full	500	0.0	0.0
Lane 3	32	0.0	243	0.130	100	34.1	LOS C	1.0	6.8	Short	60	0.0	NA
Approach	376	1.1		0.819		35.2	LOS D	10.2	72.2				
Intersection	2586	2.0		0.826		24.9	LOS C	15.8	113.5				

LANE SUMMARY

Site: 20 [2041 AM - FINAL DoS 0.935]

R1020
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 150 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %

SouthEast: Glynton Rd													
Lane 1	359	5.6	1262	0.284	100	10.8	LOS B	10.3	75.7	Full	500	0.0	0.0
Lane 2	186	3.5	387	0.482	52 [6]	60.4	LOS E	12.0	86.5	Short	90	0.0	NA
Lane 3	301	3.5	322 [1]	0.935	100	85.3	LOS F	24.8	178.8	Short	60	0.0	NA
Approach	846	4.4		0.935		48.2	LOS D	24.8	178.8				
NorthEast: Teviot Rd													
Lane 1	547	2.3	709 [1]	0.772	100	33.9	LOS C	28.1	200.6	Short	60	0.0	NA
Lane 2	233	1.8	475	0.489	100	51.9	LOS D	14.5	103.3	Full	500	0.0	0.0
Lane 3	208	1.0	230 [1]	0.904	100	88.8	LOS F	17.1	120.4	Short	60	0.0	NA
Approach	988	1.9		0.904		49.7	LOS D	28.1	200.6				
NorthWest: Homestead Dr													
Lane 1	318	1.0	662 [1]	0.481	52 [6]	36.8	LOS D	16.0	113.2	Short	60	0.0	NA
Lane 2	547	1.7	594 [1]	0.920	100	57.4	LOS E	39.1	277.9	Full	500	0.0	0.0
Lane 3	63	1.7	353	0.179	100	42.4	LOS D	3.2	22.9	Short	60	0.0	NA
Approach	928	1.5		0.920		49.3	LOS D	39.1	277.9				
SouthWest: Teviot Rd													
Lane 1	73	0.3	152	0.480	52 [6]	76.0	LOS E	5.3	37.2	Short	60	0.0	NA
Lane 2	143	0.6	155	0.918	100	88.6	LOS F	11.8	83.3	Full	500	0.0	0.0
Lane 3	32	0.0	53	0.598	100	91.3	LOS F	2.5	17.5	Short	60	0.0	NA
Approach	247	0.4		0.918		85.2	LOS F	11.8	83.3				
Intersection	3011	2.3		0.935		52.1	LOS D	39.1	277.9				

LANE SUMMARY

Site: 20 [2041 PM - FINAL]

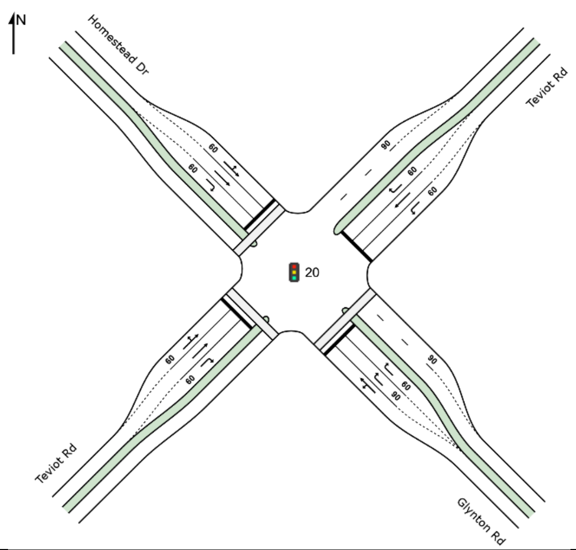
R1020
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: Glynton Rd													
Lane 1	691	1.2	928 [1]	0.744	100	18.8	LOS B	26.9	190.0	Full	500	0.0	0.0
Lane 2	199	1.6	444	0.448	52 [6]	46.5	LOS D	10.0	70.7	Short	90	0.0	NA
Lane 3	341	1.6	392 [1]	0.869	100	60.3	LOS E	21.2	150.2	Short	60	0.0	NA
Approach	1231	1.4		0.869		34.8	LOS C	26.9	190.0				
NorthEast: Teviot Rd													
Lane 1	455	2.3	1142	0.398	100	17.4	LOS B	13.0	93.1	Short	60	0.0	NA
Lane 2	163	0.6	647	0.252	100	31.1	LOS C	6.9	48.5	Full	500	0.0	0.0
Lane 3	227	0.9	261	0.870	100	69.6	LOS E	14.7	103.8	Short	60	0.0	NA
Approach	845	1.6		0.870		34.1	LOS C	14.7	103.8				
NorthWest: Homestead Dr													
Lane 1	228	1.5	509	0.448	52 [6]	43.7	LOS D	11.1	78.6	Short	60	0.0	NA
Lane 2	378	3.6	441 [1]	0.857	100	52.2	LOS D	22.5	162.5	Full	500	0.0	0.0
Lane 3	32	0.0	71	0.444	100	71.5	LOS E	2.0	13.8	Short	60	0.0	NA
Approach	638	2.6		0.857		50.1	LOS D	22.5	162.5				

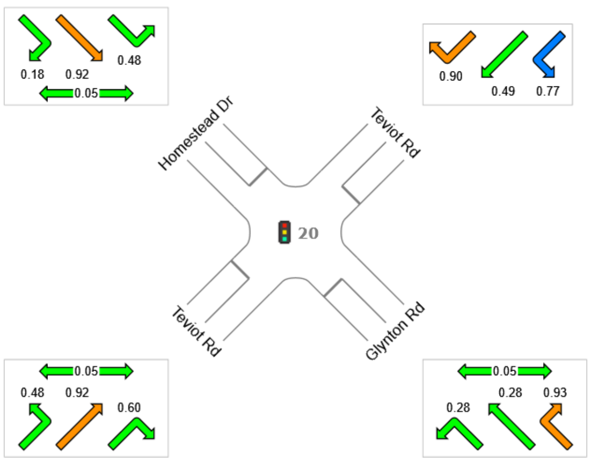
SouthWest: Teviot Rd													
Lane 1	116	1.3	265	0.439	52 [6]	55.6	LOS E	6.4	45.1	Short	60	0.0	NA
Lane 2	230	1.2	274	0.839	100	61.2	LOS E	14.4	102.1	Full	500	0.0	0.0
Lane 3	32	0.0	132	0.240	100	63.6	LOS E	1.8	12.7	Short	60	0.0	NA
Approach	378	1.1		0.839		59.7	LOS E	14.4	102.1				
Intersection	3092	1.7		0.870		40.8	LOS D	26.9	190.0				

SITE LAYOUT – R1020– 2041



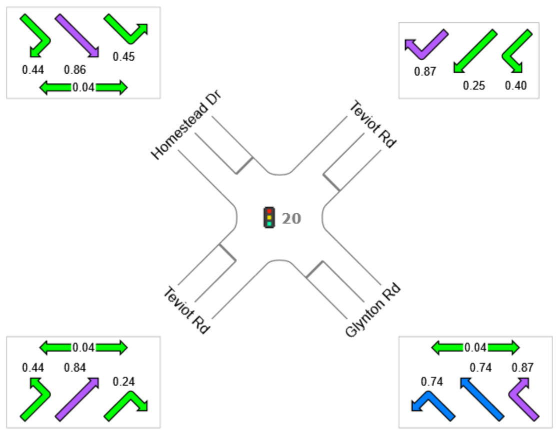
DEGREE OF SATURATION

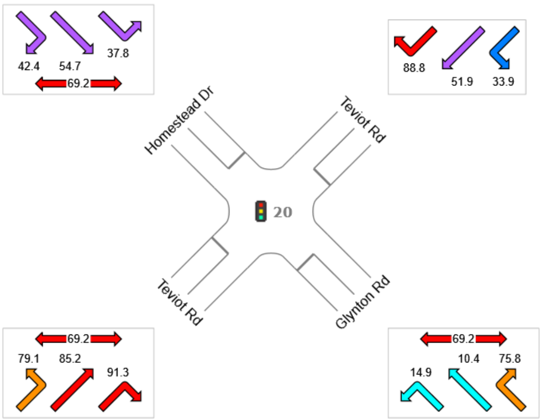
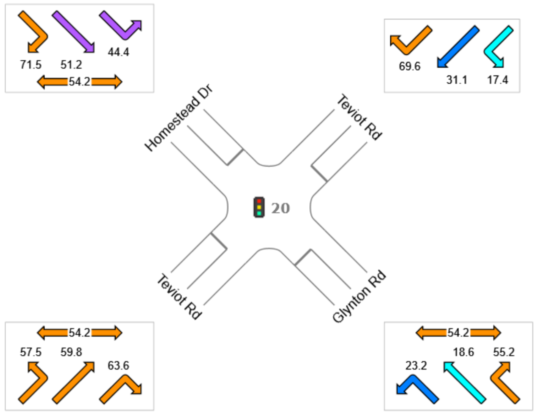
2041 – AM



DEGREE OF SATURATION

2041 – PM



DELAY (CONTROL)	DELAY (CONTROL)
2041– AM	2041– PM
	

LANE SUMMARY

Site: 20 [2066 AM - needs further analysis]

R1020
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: Glynton Rd													
Lane 1	203	8.0	649	0.313	71[6]	30.5	LOS C	8.5	63.8	Short	60	0.0	NA
Lane 2	286	8.1	649	0.442	100	32.1	LOS C	12.8	96.1	Full	500	0.0	0.0
Lane 3	286	8.1	649	0.442	100	32.1	LOS C	12.8	96.1	Full	500	0.0	0.0
Lane 4	349	3.5	399[1]	0.876	100	58.2	LOS E	21.3	153.6	Short	90	0.0	NA
Lane 5	349	3.5	399[1]	0.876	100	58.2	LOS E	21.3	153.6	Short	60	0.0	NA
Approach	1474	5.9		0.876		44.2	LOS D	21.3	153.6				
NorthEast: Teviot Rd													

Lane 1	676	3.4	745 [1]	0.907	100	51.5	LOS D	41.9	301.8	Short	60	0.0	NA
Lane 2	81	2.0	225	0.358	100	54.1	LOS D	4.5	31.8	Full	500	0.0	0.0
Lane 3	81	2.0	225	0.358	100	54.1	LOS D	4.5	31.8	Full	500	0.0	0.0
Lane 4	98	1.6	107	0.919	100	80.8	LOS F	6.7	47.8	Short	90	0.0	NA
Lane 5	98	1.6	107	0.919	100	80.8	LOS F	6.7	47.8	Short	60	0.0	NA
Approach	1034	2.9		0.919		57.5	LOS E	41.9	301.8				
NorthWest: Homestead Dr													
Lane 1	374	0.8	846	0.442	100	29.0	LOS C	14.7	103.6	Short	60	0.0	NA
Lane 2	370	2.5	573 [1]	0.646	71 [6]	34.9	LOS C	17.3	124.0	Short	120	0.0	NA
Lane 3	573	2.5	629 [1]	0.912	100	54.6	LOS D	36.9	264.0	Full	500	0.0	0.0
Lane 4	577	2.5	633 [1]	0.912	100	54.7	LOS D	37.2	266.3	Full	500	0.0	0.0
Lane 5	58	1.8	504	0.115	100	40.4	LOS D	2.5	17.9	Short	60	0.0	NA
Approach	1952	2.2		0.912		45.6	LOS D	37.2	266.3				
SouthWest: Teviot Rd													
Lane 1	101	0.4	223	0.451	100	56.4	LOS E	5.7	39.8	Full	500	0.0	0.0
Lane 2	102	0.6	227	0.451	100	54.8	LOS D	5.8	40.5	Full	500	0.0	0.0
Lane 3	47	2.2	107	0.444	100	68.3	LOS E	2.9	20.4	Short	60	0.0	NA
Approach	251	0.8		0.451		58.0	LOS E	5.8	40.5				
Intersection	4709	3.4		0.919		48.4	LOS D	41.9	301.8				

LANE SUMMARY

Site: 20 [2066 PM - needs further analysis]

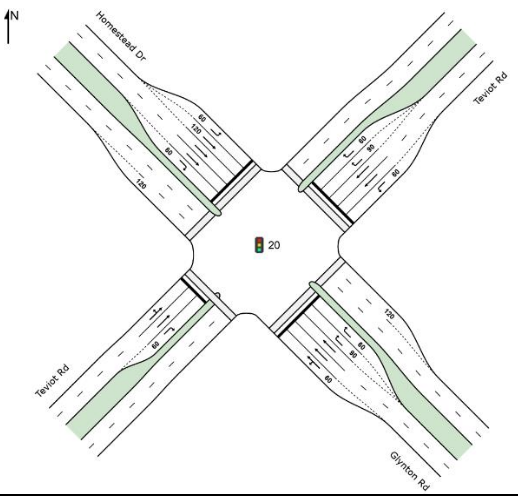
R1020
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 140 seconds (Site User-Given Cycle Time)

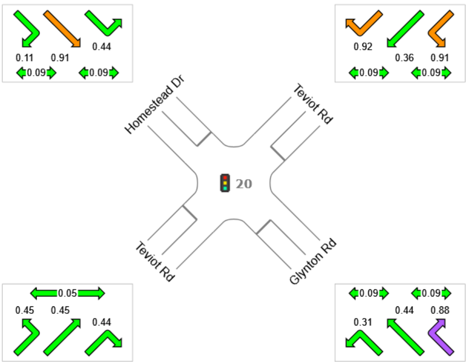
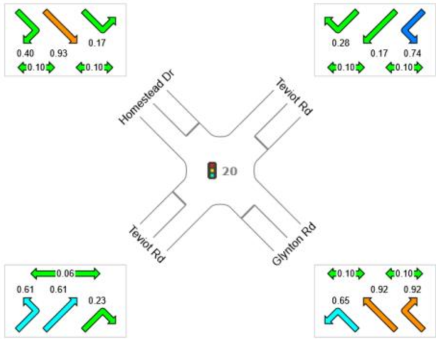
Lane Use and Performance

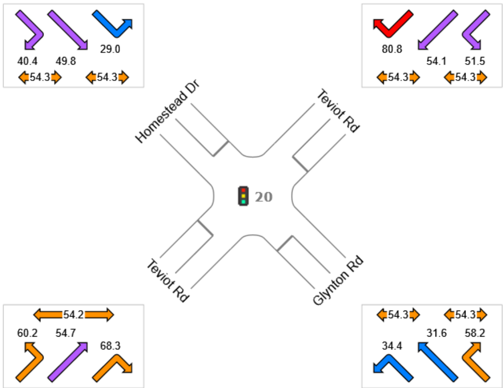
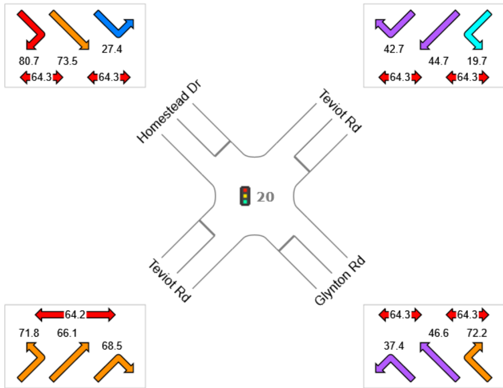
	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: Glynton Rd													
Lane 1	547	1.6	838	0.653	71 [6]	33.2	LOS C	28.9	205.1	Short	60	0.0	NA
Lane 2	486	1.7	528 [1]	0.922	100	53.4	LOS D	31.9	226.5	Full	500	0.0	0.0
Lane 3	592	1.7	642 [1]	0.922	100	52.8	LOS D	40.2	285.3	Full	500	0.0	0.0
Lane 4	352	2.4	381 [1]	0.923	100	72.2	LOS E	25.9	185.1	Short	90	0.0	NA

Lane 5	352	2.4	381 [1]	0.923	100	72.2	LOS E	25.9	185.1	Short	60	0.0	NA
Approach	2329	1.9		0.923		54.2	LOS D	40.2	285.3				
NorthEast: Teviot Rd													
Lane 1	695	2.9	939 [1]	0.740	100	19.7	LOS B	21.6	155.0	Short	60	0.0	NA
Lane 2	82	0.6	472	0.173	100	44.7	LOS D	4.4	30.8	Full	500	0.0	0.0
Lane 3	82	0.6	472	0.173	100	44.7	LOS D	4.4	30.8	Full	500	0.0	0.0
Lane 4	173	0.9	606	0.285	100	42.7	LOS D	8.6	61.0	Short	90	0.0	NA
Lane 5	173	0.9	606	0.285	100	42.7	LOS D	8.6	61.0	Short	60	0.0	NA
Approach	1203	2.0		0.740		29.7	LOS C	21.6	155.0				
NorthWest: Homestead Dr													
Lane 1	154	1.4	880	0.175	100	27.4	LOS C	5.8	41.4	Short	60	0.0	NA
Lane 2	234	5.0	355	0.660	71 [6]	57.8	LOS E	14.9	108.6	Short	120	0.0	NA
Lane 3	340	5.0	364	0.933	100	79.1	LOS E	26.9	196.4	Full	500	0.0	0.0
Lane 4	327	5.0	351 [1]	0.933	100	78.9	LOS E	25.8	188.1	Full	500	0.0	0.0
Lane 5	32	0.0	80	0.397	100	80.7	LOS F	2.2	15.7	Short	60	0.0	NA
Approach	1086	4.4		0.933		67.2	LOS E	26.9	196.4				
SouthWest: Teviot Rd													
Lane 1	122	1.6	201	0.607	100	69.5	LOS E	8.2	58.2	Full	500	0.0	0.0
Lane 2	125	1.8	207	0.607	100	66.1	LOS E	8.4	59.9	Full	500	0.0	0.0
Lane 3	44	2.4	196	0.226	100	68.5	LOS E	2.8	20.2	Short	60	0.0	NA
Approach	292	1.8		0.607		67.9	LOS E	8.4	59.9				
Intersection	4911	2.5		0.933		51.9	LOS D	40.2	285.3				

SITE LAYOUT – R1020– 2066



DEGREE OF SATURATION	DEGREE OF SATURATION
2066 – AM	2066 – PM
	

DELAY (CONTROL)	DELAY (CONTROL)
2066– AM	2066– PM
	

MOVEMENT SUMMARY

Site: 21v [2031 AM - Conversion]

R1021
Site Category: -
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: R1021 South												
1	L2	1	0.0	0.083	5.0	LOS A	0.3	2.1	0.68	0.83	0.68	43.4
2	T1	3	0.0	0.083	14.0	LOS B	0.3	2.1	0.68	0.83	0.68	41.2
3	R2	20	5.3	0.083	16.2	LOS C	0.3	2.1	0.68	0.83	0.68	43.3

Approach		24	4.3	0.083	15.4	LOS C	0.3	2.1	0.68	0.83	0.68	43.0
NorthEast: R010												
4	L2	37	0.0	0.020	5.5	LOS A	0.0	0.0	0.00	0.58	0.00	53.6
5	T1	121	0.0	0.062	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
6	R2	109	0.0	0.092	7.1	LOS A	0.4	2.8	0.47	0.66	0.47	48.5
Approach		267	0.0	0.092	3.7	NA	0.4	2.8	0.19	0.35	0.19	53.9
NorthWest: R029												
7	L2	375	0.0	0.408	7.3	LOS A	2.3	15.8	0.52	0.76	0.63	48.6
8	T1	16	0.0	0.076	13.4	LOS B	0.3	1.9	0.72	0.86	0.72	41.8
9	R2	8	0.0	0.076	15.7	LOS C	0.3	1.9	0.72	0.86	0.72	43.7
Approach		399	0.0	0.408	7.7	LOS A	2.3	15.8	0.53	0.76	0.64	48.2
SouthWest: R012												
10	L2	63	50.0	0.343	7.0	LOS A	1.6	12.2	0.23	0.19	0.23	51.3
11	T1	343	0.0	0.343	0.5	LOS A	1.6	12.2	0.23	0.19	0.23	57.7
12	R2	121	26.1	0.343	6.9	LOS A	1.6	12.2	0.23	0.19	0.23	51.1
Approach		527	12.0	0.343	2.8	NA	1.6	12.2	0.23	0.19	0.23	55.2
All Vehicles		1218	5.3	0.408	4.8	NA	2.3	15.8	0.33	0.43	0.36	52.1

MOVEMENT SUMMARY

Site: 21v [2031 PM - Conversion]

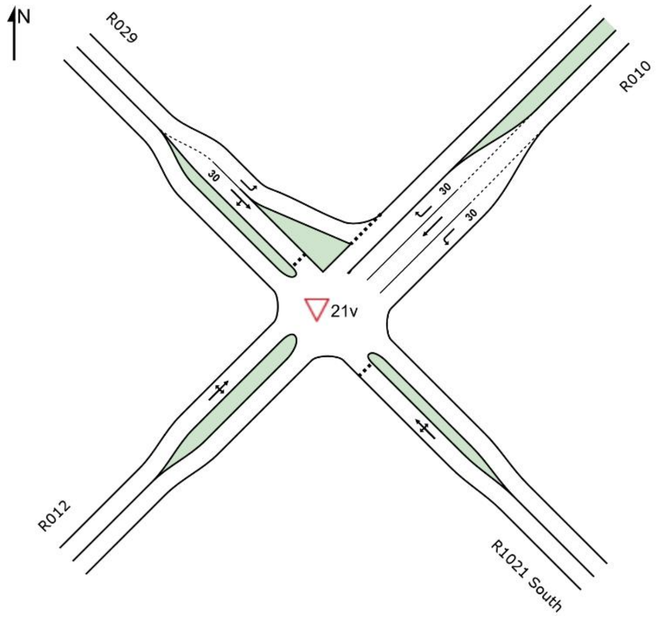
R1021
Site Category: -
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
SouthEast: R1021 South												
1	L2	4	0.0	0.215	6.7	LOS A	0.8	5.4	0.79	0.90	0.84	41.3
2	T1	14	0.0	0.215	19.3	LOS C	0.8	5.4	0.79	0.90	0.84	39.3
3	R2	34	0.0	0.215	21.6	LOS C	0.8	5.4	0.79	0.90	0.84	41.3
Approach		52	0.0	0.215	19.8	LOS C	0.8	5.4	0.79	0.90	0.84	40.7
NorthEast: R010												
4	L2	18	0.0	0.010	5.5	LOS A	0.0	0.0	0.00	0.58	0.00	53.6
5	T1	333	0.0	0.172	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
6	R2	344	0.0	0.229	6.3	LOS A	1.2	8.3	0.35	0.59	0.35	48.8
Approach		695	0.0	0.229	3.3	NA	1.2	8.3	0.17	0.31	0.17	53.7
NorthWest: R029												
7	L2	131	0.0	0.113	5.1	LOS A	0.4	3.0	0.26	0.51	0.26	49.6
8	T1	3	0.0	0.023	16.6	LOS C	0.1	0.5	0.78	0.87	0.78	39.9
9	R2	2	0.0	0.023	20.9	LOS C	0.1	0.5	0.78	0.87	0.78	41.6
Approach		136	0.0	0.113	5.7	LOS A	0.4	3.0	0.28	0.53	0.28	49.2
SouthWest: R012												
10	L2	63	50.0	0.256	8.3	LOS A	1.5	12.0	0.46	0.34	0.46	49.4
11	T1	122	0.0	0.256	2.1	LOS A	1.5	12.0	0.46	0.34	0.46	55.4
12	R2	121	26.1	0.256	8.4	LOS A	1.5	12.0	0.46	0.34	0.46	49.3

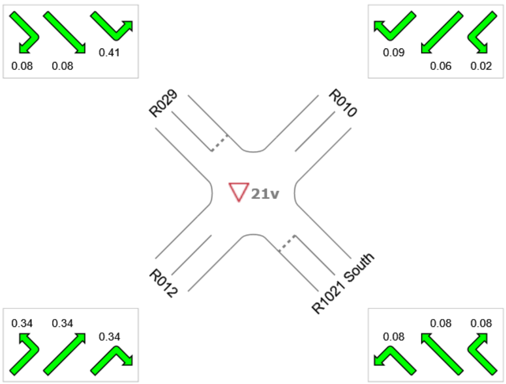
Approach	306	20.6	0.256	5.8	NA	1.5	12.0	0.46	0.34	0.46	51.6
All Vehicles	1188	5.3	0.256	4.9	NA	1.5	12.0	0.29	0.37	0.29	51.9

SITE LAYOUT – R1021– 2031



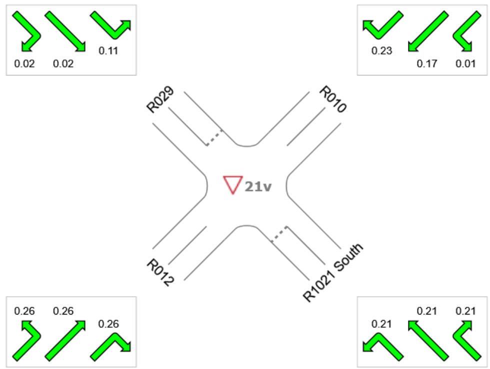
DEGREE OF SATURATION

2031 – AM



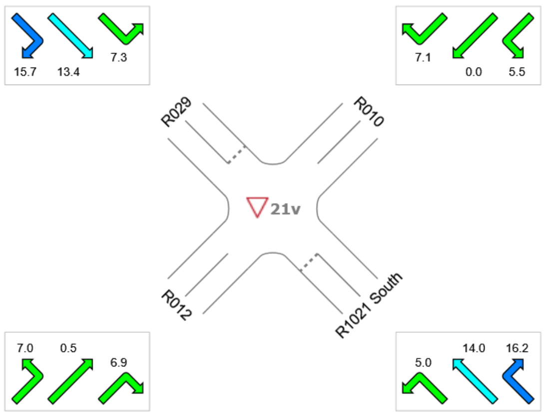
DEGREE OF SATURATION

2031 – PM



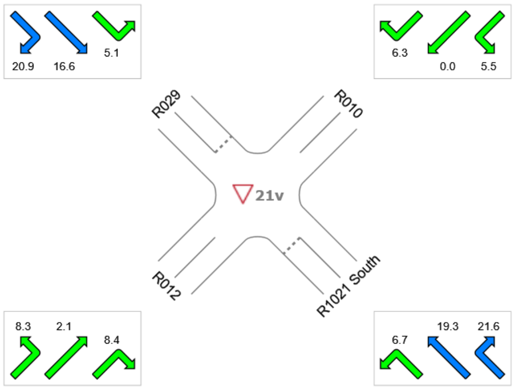
DELAY (CONTROL)

2031– AM



DELAY (CONTROL)

2031– PM



LANE SUMMARY

Site: 21 [2041 AM - FINAL]

R1021
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 80 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R1021 South													
Lane 1	63	6.3	227	0.278	100	38.0	LOS D	2.3	17.3	Full	500	0.0	0.0
Lane 2	32	3.6	136	0.232	100	44.8	LOS D	1.2	9.0	Short	30	0.0	NA
Approach	95	5.4		0.278		40.3	LOS D	2.3	17.3				
NorthEast: R010													
Lane 1	343	1.5	862	0.398	100	16.6	LOS B	8.9	63.4	Full	500	0.0	0.0
Lane 2	55	1.9	137	0.398	100	46.5	LOS D	2.2	15.6	Short	30	0.0	NA
Approach	398	1.6		0.398		20.7	LOS C	8.9	63.4				
NorthWest: R029													
Lane 1	184	1.7	262	0.704	100	40.9	LOS D	7.4	52.6	Full	500	0.0	0.0
Lane 2	32	0.0	139	0.227	100	44.7	LOS D	1.2	8.7	Short	30	0.0	NA
Approach	216	1.5		0.704		41.4	LOS D	7.4	52.6				
SouthWest: R012													
Lane 1	625	1.0	870	0.719	100	19.5	LOS B	19.8	140.1	Full	500	0.0	0.0
Lane 2	62	0.0	139	0.446	100	46.6	LOS D	2.5	17.5	Short	30	0.0	NA
Approach	687	0.9		0.719		22.0	LOS C	19.8	140.1				
Intersection	1396	1.5		0.719		25.9	LOS C	19.8	140.1				

LANE SUMMARY

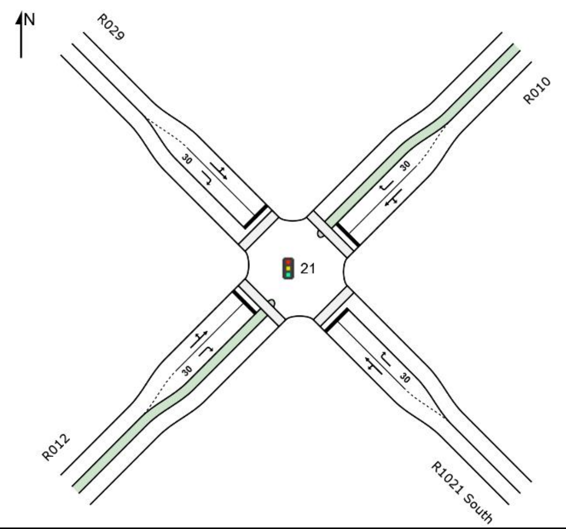
Site: 21 [2041 PM - FINAL]

R1021
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 80 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

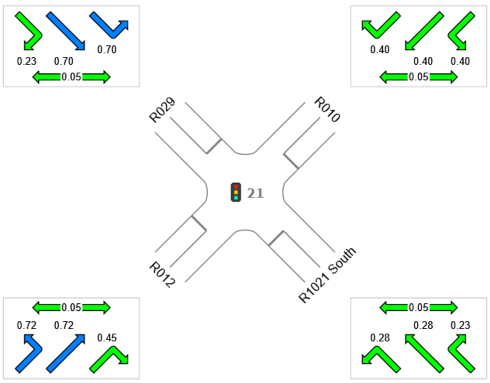
	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R1021 South													
Lane 1	106	1.0	236	0.450	100	38.3	LOS D	4.0	28.3	Full	500	0.0	0.0
Lane 2	46	2.3	137	0.338	100	45.3	LOS D	1.8	13.2	Short	30	0.0	NA
Approach	153	1.4		0.450		40.4	LOS D	4.0	28.3				
NorthEast: R010													
Lane 1	627	0.9	846	0.742	100	21.1	LOS C	20.8	146.4	Full	500	0.0	0.0
Lane 2	109	1.0	161	0.678	100	47.5	LOS D	4.5	32.1	Short	30	0.0	NA
Approach	737	0.9		0.742		25.0	LOS C	20.8	146.4				
NorthWest: R029													
Lane 1	92	1.1	268	0.342	100	37.2	LOS D	3.3	23.6	Full	500	0.0	0.0
Lane 2	32	0.0	139	0.227	100	44.7	LOS D	1.2	8.7	Short	30	0.0	NA
Approach	123	0.9		0.342		39.1	LOS D	3.3	23.6				
SouthWest: R012													
Lane 1	336	0.9	844	0.398	100	17.0	LOS B	8.9	62.9	Full	500	0.0	0.0
Lane 2	32	0.0	163	0.194	100	44.1	LOS D	1.2	8.5	Short	30	0.0	NA
Approach	367	0.9		0.398		19.3	LOS B	8.9	62.9				
Intersection	1380	0.9		0.742		26.4	LOS C	20.8	146.4				

SITE LAYOUT – R1021– 2041



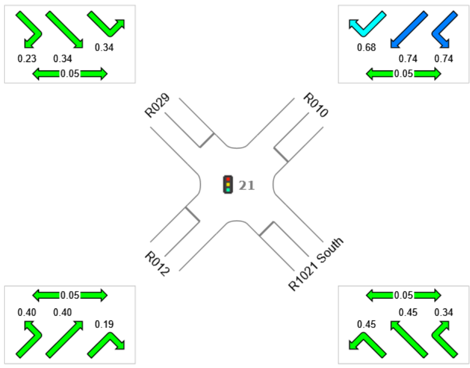
DEGREE OF SATURATION

2041 – AM



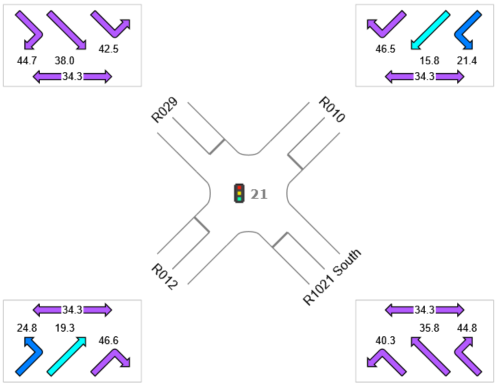
DEGREE OF SATURATION

2041 – PM



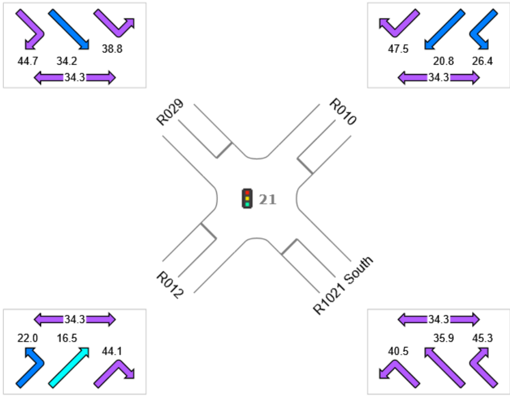
DELAY (CONTROL)

2041– AM



DELAY (CONTROL)

2041– PM



LANE SUMMARY

Site: 21 [2066 AM - FINAL]

R1021
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 80 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R1021South													
Lane 1	56	3.8	327	0.171	100	31.7	LOS C	1.9	13.6	Full	500	0.0	0.0
Lane 2	33	3.2	136	0.240	100	44.8	LOS D	1.3	9.3	Short	60	0.0	NA
Approach	88	3.6		0.240		36.5	LOS D	1.9	13.6				
NorthEast: R010													
Lane 1	318	2.2	717	0.444	100	20.8	LOS C	9.3	66.6	Full	500	0.0	0.0
Lane 2	320	2.1	721	0.444	100	20.3	LOS C	9.4	67.3	Full	500	0.0	0.0
Lane 3	137	3.8	158	0.865	100	53.3	LOS D	6.2	44.8	Short	60	0.0	NA
Approach	776	2.4		0.865		26.3	LOS C	9.4	67.3				
NorthWest: R029													
Lane 1	327	1.9	398 [1]	0.822	100	41.0	LOS D	13.7	97.6	Full	500	0.0	0.0
Lane 2	18	0.0	139	0.128	100	44.1	LOS D	0.7	4.8	Short	30	0.0	NA
Approach	345	1.8		0.822		41.1	LOS D	13.7	97.6				
SouthWest: R012													
Lane 1	608	1.2	723	0.841	100	30.9	LOS C	24.6	173.7	Full	500	0.0	0.0
Lane 2	586	1.3	697 [1]	0.841	100	30.4	LOS C	23.5	166.3	Full	500	0.0	0.0
Lane 3	32	0.0	163	0.194	100	44.2	LOS D	1.2	8.5	Short	30	0.0	NA
Approach	1225	1.2		0.841		31.0	LOS C	24.6	173.7				
Intersection	2435	1.8		0.865		31.2	LOS C	24.6	173.7				

LANE SUMMARY

Site: 21 [2066 PM - FINAL]

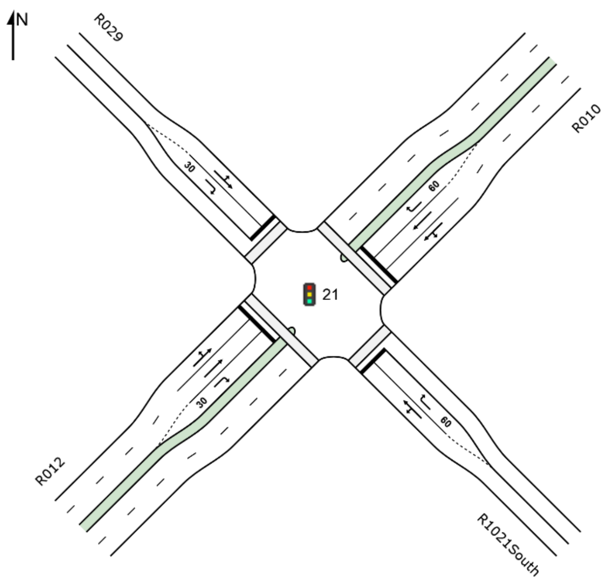
R1021
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 80 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
SouthEast: R1021South													
Lane 1	100	1.1	286	0.349	100	35.4	LOS D	3.6	25.7	Full	500	0.0	0.0
Lane 2	32	3.3	136	0.232	100	44.8	LOS D	1.2	9.0	Short	30	0.0	NA
Approach	132	1.6		0.349		37.7	LOS D	3.6	25.7				

NorthEast: R010													
Lane 1	605	1.2	772	0.784	100	25.3	LOS C	22.0	155.4	Full	500	0.0	0.0
Lane 2	538	1.0	686 [1]	0.784	100	24.6	LOS C	18.9	133.8	Full	500	0.0	0.0
Lane 3	219	1.0	438	0.500	100	34.7	LOS C	7.6	53.5	Short	60	0.0	NA
Approach	1362	1.1		0.784		26.5	LOS C	22.0	155.4				
NorthWest: R029													
Lane 1	198	2.7	440	0.450	100	20.3	LOS C	4.8	34.1	Full	500	0.0	0.0
Lane 2	33	0.0	139	0.234	100	44.7	LOS D	1.3	9.0	Short	30	0.0	NA
Approach	231	2.3		0.450		23.8	LOS C	4.8	34.1				
SouthWest: R012													
Lane 1	310	1.5	460	0.674	100	34.0	LOS C	11.3	80.0	Full	500	0.0	0.0
Lane 2	297	1.6	441 [1]	0.674	100	30.9	LOS C	10.9	77.2	Full	500	0.0	0.0
Lane 3	20	0.0	139	0.144	100	45.1	LOS D	0.8	5.4	Short	30	0.0	NA
Approach	627	1.5		0.674		32.9	LOS C	11.3	80.0				
Intersection	2352	1.3		0.784		28.6	LOS C	22.0	155.4				

SITE LAYOUT – R1021– 2066

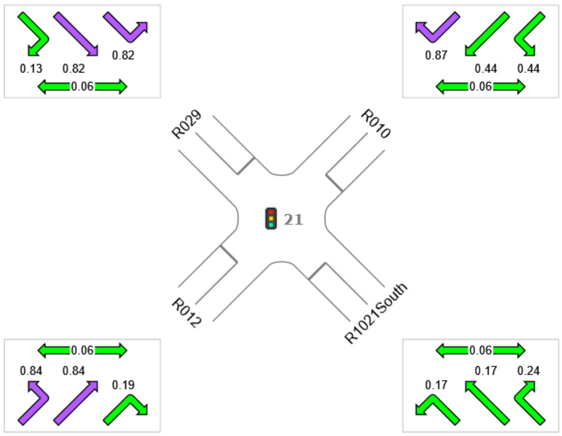


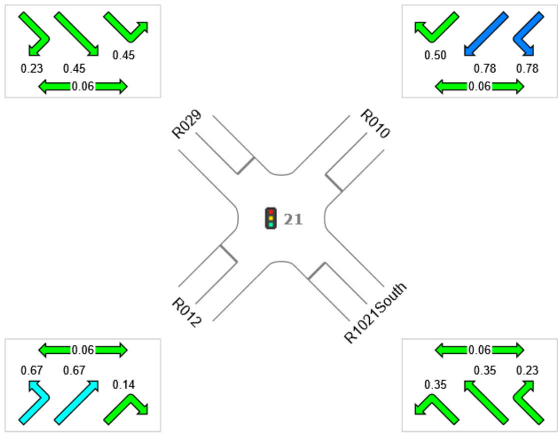
DEGREE OF SATURATION

2066 – AM

DEGREE OF SATURATION

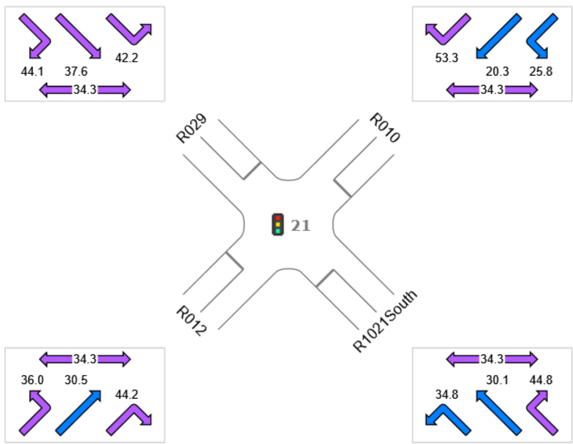
2066 – PM





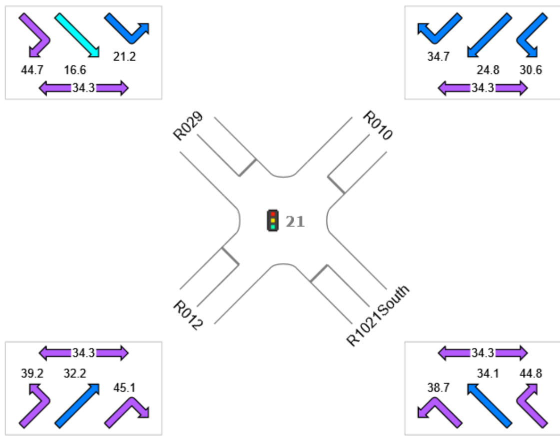
DELAY (CONTROL)

2066– AM



DELAY (CONTROL)

2066– PM



MOVEMENT SUMMARY

Site: 22v [2031 AM - FINAL]

R1022
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
SouthEast: R041												
1	L2	54	0.0	0.065	4.7	LOS A	0.2	1.7	0.14	0.53	0.14	49.4
3	R2	28	0.0	0.065	6.0	LOS A	0.2	1.7	0.14	0.53	0.14	49.0
Approach		82	0.0	0.065	5.2	LOS A	0.2	1.7	0.14	0.53	0.14	49.3
NorthEast: Teviot Rd												
4	L2	1	0.0	0.031	4.6	LOS A	0.0	0.0	0.00	0.01	0.00	49.4
5	T1	58	5.5	0.031	0.0	LOS A	0.0	0.0	0.00	0.01	0.00	49.9
Approach		59	5.4	0.031	0.1	NA	0.0	0.0	0.00	0.01	0.00	49.9
SouthWest: Teviot Rd												
11	T1	263	1.2	0.154	0.0	LOS A	0.2	1.4	0.04	0.05	0.04	54.3
12	R2	28	3.7	0.154	4.8	LOS A	0.2	1.4	0.04	0.05	0.04	52.0
Approach		292	1.4	0.154	0.5	NA	0.2	1.4	0.04	0.05	0.04	54.1
All Vehicles		433	1.7	0.154	1.3	NA	0.2	1.7	0.05	0.14	0.05	52.5

MOVEMENT SUMMARY

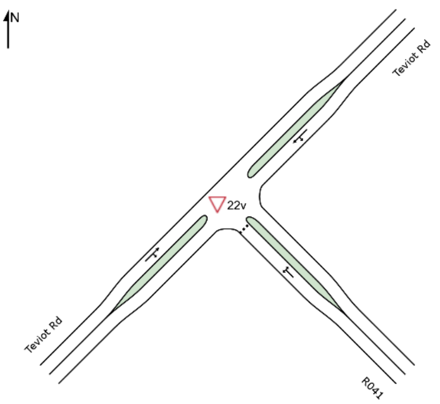
Site: 22v [2031 PM - FINAL]

R1022
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
SouthEast: R041												
1	L2	23	0.0	0.019	5.4	LOS A	0.1	0.5	0.34	0.54	0.34	48.9
3	R2	1	0.0	0.019	6.2	LOS A	0.1	0.5	0.34	0.54	0.34	48.5
Approach		24	0.0	0.019	5.5	LOS A	0.1	0.5	0.34	0.54	0.34	48.9
NorthEast: Teviot Rd												
4	L2	1	0.0	0.144	4.6	LOS A	0.0	0.0	0.00	0.00	0.00	49.5
5	T1	277	1.1	0.144	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	50.0
Approach		278	1.1	0.144	0.0	NA	0.0	0.0	0.00	0.00	0.00	50.0
SouthWest: Teviot Rd												
11	T1	79	2.7	0.083	0.6	LOS A	0.4	2.5	0.30	0.25	0.30	52.3
12	R2	58	0.0	0.083	5.5	LOS A	0.4	2.5	0.30	0.25	0.30	50.3
Approach		137	1.5	0.083	2.7	NA	0.4	2.5	0.30	0.25	0.30	51.5
All Vehicles		439	1.2	0.144	1.2	NA	0.4	2.5	0.11	0.11	0.11	50.4

SITE LAYOUT – R1022– 2031

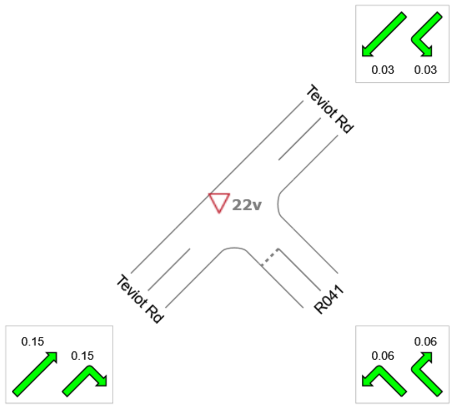


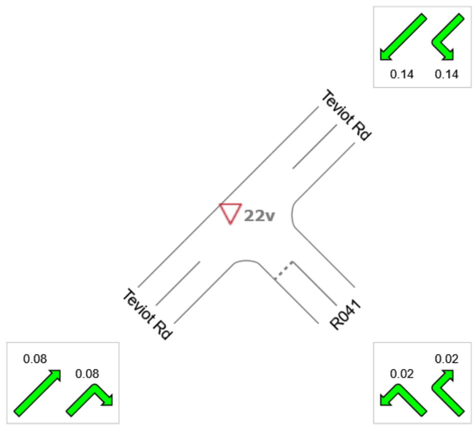
DEGREE OF SATURATION

2031 – AM

DEGREE OF SATURATION

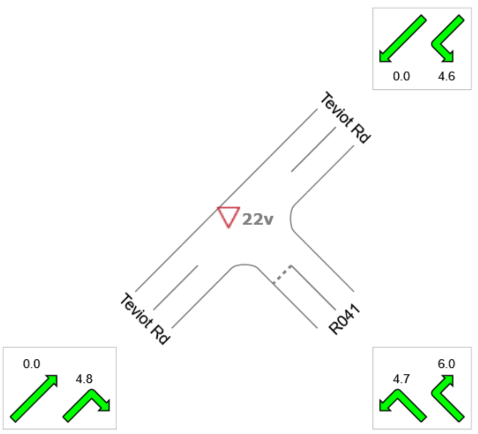
2031 – PM





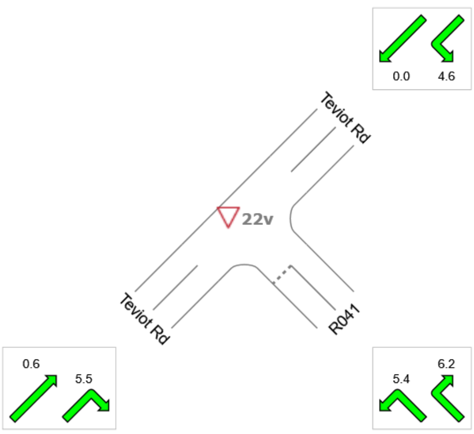
DELAY (CONTROL)

2031– AM



DELAY (CONTROL)

2031– PM



LANE SUMMARY

Site: 22 [2041 AM - FINAL]

R1022
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R041													
Lane 1	151	0.7	770	0.195	100	16.6	LOS B	2.8	19.9	Short	60	0.0	NA
Lane 2	514	1.8	764	0.673	100	20.3	LOS C	12.5	88.9	Full	500	0.0	0.0
Approach	664	1.6		0.673		19.5	LOS B	12.5	88.9				
NorthEast: Teviot Rd													

Lane 1	126	2.5	243	0.519	100	32.5	LOS C	3.7	26.4	Short	30	0.0	NA
Lane 2	153	7.6	248	0.616	100	28.7	LOS C	4.6	34.1	Full	500	0.0	0.0
Approach	279	5.3		0.616		30.4	LOS C	4.6	34.1				
SouthWest: Teviot Rd													
Lane 1	436	1.4	741	0.588	100	16.2	LOS B	10.4	73.5	Full	500	0.0	0.0
Lane 2	171	1.2	276	0.618	100	32.4	LOS C	5.0	35.7	Short	50	0.0	NA
Approach	606	1.4		0.618		20.7	LOS C	10.4	73.5				
Intersection	1549	2.2		0.673		21.9	LOS C	12.5	88.9				

LANE SUMMARY

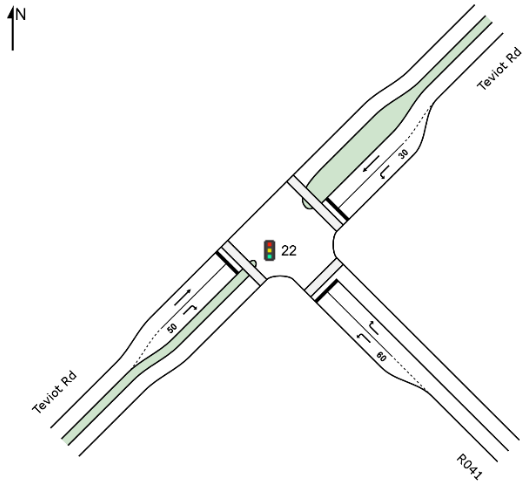
Site: 22 [2041 AM - FINAL]

R1022
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site User-Given Cycle Time)

Lane Use and Performance

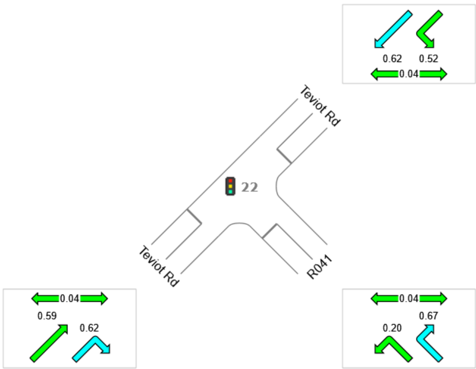
	Demand Flows		Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	Total	HV						Veh	Dist				
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R041													
Lane 1	151	0.7	770	0.195	100	16.6	LOS B	2.8	19.9	Short	60	0.0	NA
Lane 2	514	1.8	764	0.673	100	20.3	LOS C	12.5	88.9	Full	500	0.0	0.0
Approach	664	1.6		0.673		19.5	LOS B	12.5	88.9				
NorthEast: Teviot Rd													
Lane 1	126	2.5	243	0.519	100	32.5	LOS C	3.7	26.4	Short	30	0.0	NA
Lane 2	153	7.6	248	0.616	100	28.7	LOS C	4.6	34.1	Full	500	0.0	0.0
Approach	279	5.3		0.616		30.4	LOS C	4.6	34.1				
SouthWest: Teviot Rd													
Lane 1	436	1.4	741	0.588	100	16.2	LOS B	10.4	73.5	Full	500	0.0	0.0
Lane 2	171	1.2	276	0.618	100	32.4	LOS C	5.0	35.7	Short	50	0.0	NA
Approach	606	1.4		0.618		20.7	LOS C	10.4	73.5				
Intersection	1549	2.2		0.673		21.9	LOS C	12.5	88.9				

SITE LAYOUT – R1022– 2041



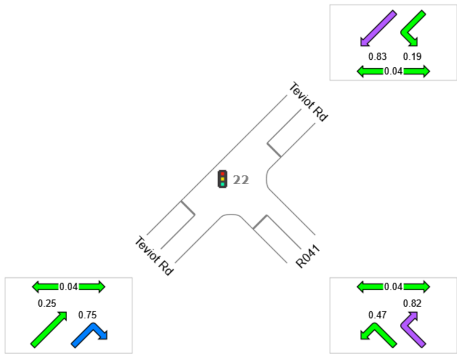
DEGREE OF SATURATION

2041 – AM



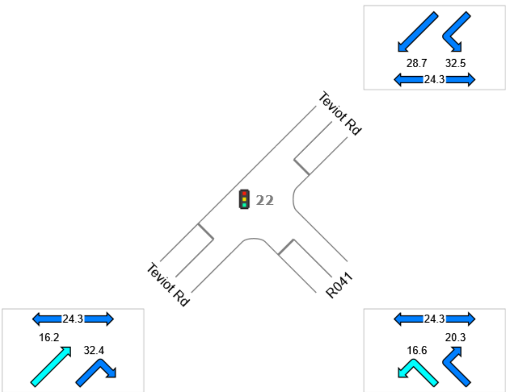
DEGREE OF SATURATION

2041 – PM



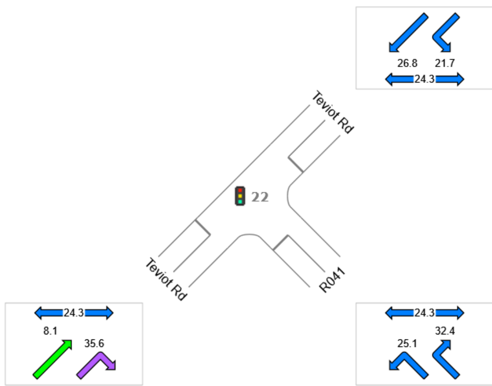
DELAY (CONTROL)

2041– AM



DELAY (CONTROL)

2041– PM



LANE SUMMARY

Site: 22 [2066 AM - FINAL]

R1022
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R041													
Lane 1	552	1.6	643	0.858	100	32.1	LOS C	18.4	130.9	Full	500	0.0	0.0
Lane 2	552	1.6	643	0.858	100	32.1	LOS C	18.4	130.9	Short	100	0.0	NA
Approach	1103	1.6		0.858		32.1	LOS C	18.4	130.9				
NorthEast: Teviot Rd													
Lane 1	201	3.7	302	0.667	100	32.2	LOS C	6.0	43.4	Short	100	0.0	NA
Lane 2	263	8.8	307	0.856	100	33.8	LOS C	9.0	67.9	Full	500	0.0	0.0
Lane 3	263	8.8	307	0.856	100	33.8	LOS C	9.0	67.9	Full	500	0.0	0.0
Approach	727	7.4		0.856		33.4	LOS C	9.0	67.9				
SouthWest: Teviot Rd													
Lane 1	507	2.6	863	0.588	100	13.5	LOS B	11.3	80.7	Full	500	0.0	0.0
Lane 2	507	2.6	863	0.588	100	13.5	LOS B	11.3	80.7	Full	500	0.0	0.0
Lane 3	269	1.2	338	0.798	100	34.8	LOS C	8.7	61.3	Short	70	0.0	NA
Approach	1284	2.3		0.798		17.9	LOS B	11.3	80.7				
Intersection	3115	3.2		0.858		26.6	LOS C	18.4	130.9				

LANE SUMMARY

Site: 22 [2066 PM - FINAL]

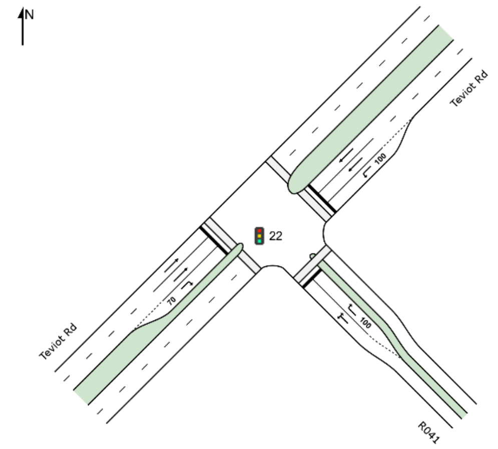
R1022
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 70 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
SouthEast: R041													
Lane 1	399	1.6	472	0.844	100	38.3	LOS D	15.2	107.6	Full	500	0.0	0.0
Lane 2	396	2.4	470	0.844	100	38.3	LOS D	15.1	107.8	Short	100	0.0	NA
Approach	795	2.0		0.844		38.3	LOS D	15.2	107.8				
NorthEast: Teviot Rd													
Lane 1	436	1.4	630	0.691	100	26.8	LOS C	13.3	94.2	Short	100	0.0	NA
Lane 2	528	1.8	661	0.799	100	26.4	LOS C	18.2	129.1	Full	500	0.0	0.0
Lane 3	528	1.8	661	0.799	100	26.4	LOS C	18.2	129.1	Full	500	0.0	0.0
Approach	1492	1.7		0.799		26.5	LOS C	18.2	129.1				
SouthWest: Teviot Rd													

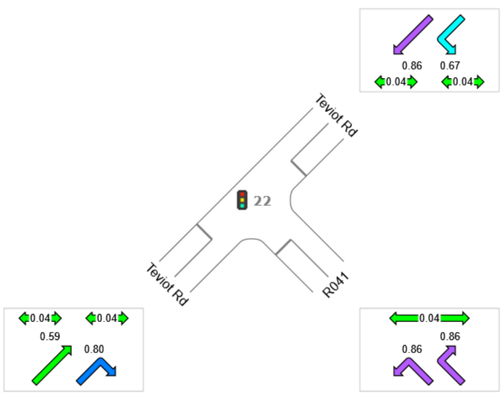
Lane 1	300	5.6	1075	0.279	100	8.2	LOS A	5.2	38.2	Full	500	0.0	0.0
Lane 2	300	5.6	1075	0.279	100	8.2	LOS A	5.2	38.2	Full	500	0.0	0.0
Lane 3	222	1.4	263	0.846	100	43.4	LOS D	8.7	61.4	Short	70	0.0	NA
Approach	822	4.5		0.846		17.7	LOS B	8.7	61.4				
Intersection	3108	2.5		0.846		27.2	LOS C	18.2	129.1				

SITE LAYOUT – R1022– 2066



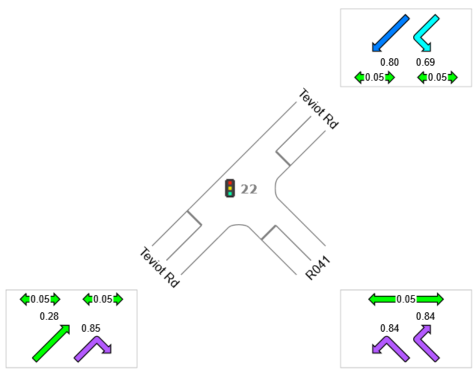
DEGREE OF SATURATION

2066 – AM



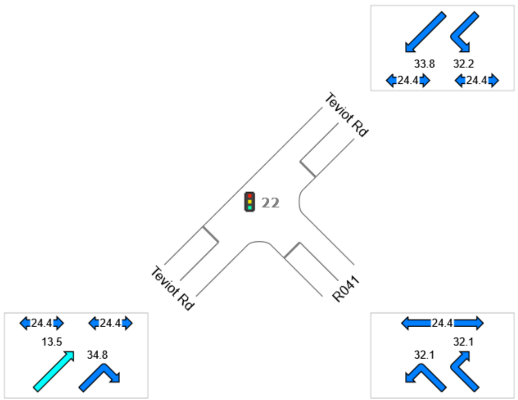
DEGREE OF SATURATION

2066– PM



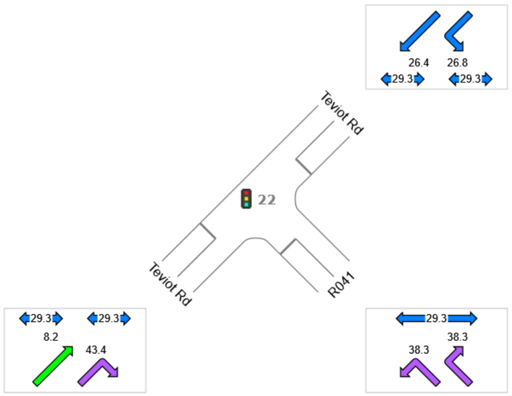
DELAY (CONTROL)

2066– AM



DELAY (CONTROL)

2066– PM



MOVEMENT SUMMARY

▽ Site: 23v [2031 AM - FINAL]

R1023
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
East: R061												
5	T1	75	1.4	0.028	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	54.3
6	R2	272	13.2	0.196	6.5	LOS A	1.0	7.6	0.36	0.59	0.36	48.6
Approach		346	10.6	0.196	5.1	NA	1.0	7.6	0.28	0.47	0.28	49.4
North: R047												
7	L2	767	5.5	0.685	7.5	LOS A	8.7	63.7	0.52	0.67	0.68	48.3
9	R2	34	6.3	0.066	9.6	LOS A	0.2	1.8	0.56	0.75	0.56	46.0
Approach		801	5.5	0.685	7.6	LOS A	8.7	63.7	0.53	0.68	0.68	48.2
West: R046												
10	L2	52	4.1	0.108	5.6	LOS A	0.0	0.0	0.00	0.15	0.00	56.9
11	T1	153	1.4	0.108	0.0	LOS A	0.0	0.0	0.00	0.15	0.00	58.7
Approach		204	2.1	0.108	1.4	NA	0.0	0.0	0.00	0.15	0.00	58.2
All Vehicles		1352	6.3	0.685	6.0	NA	8.7	63.7	0.38	0.54	0.47	49.8

MOVEMENT SUMMARY

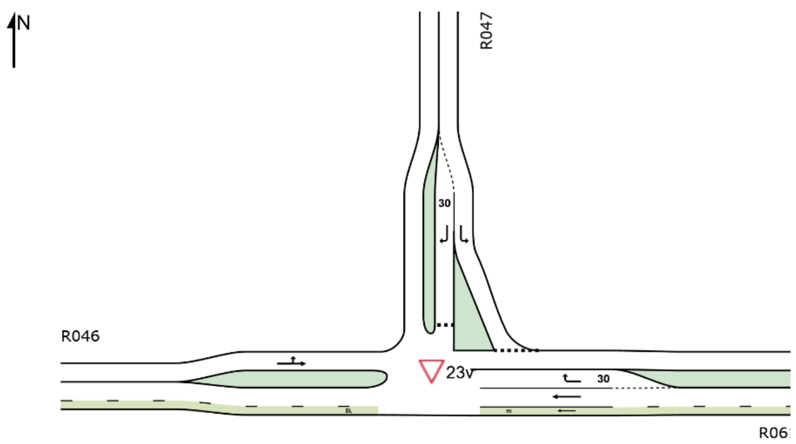
▽ Site: 23v [2031 PM - FINAL]

R1023
Site Category: (None)
Giveway / Yield (Two-Way)

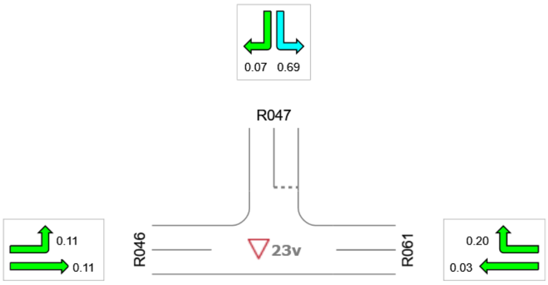
Movement Performance - Vehicles

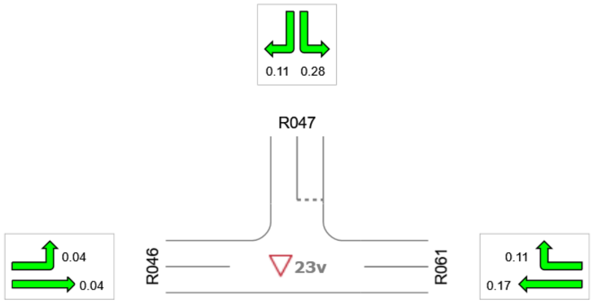
Mov ID	Turn	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
East: R061												
5	T1	343	1.5	0.168	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	58.7
6	R2	176	16.2	0.113	5.9	LOS A	0.5	4.4	0.18	0.55	0.18	49.0
Approach		519	6.5	0.168	2.0	NA	0.5	4.4	0.06	0.19	0.06	54.7
North: R047												
7	L2	343	8.3	0.277	4.8	LOS A	1.3	9.5	0.14	0.47	0.14	49.7
9	R2	54	2.0	0.109	10.1	LOS B	0.4	2.9	0.58	0.80	0.58	45.8
Approach		397	7.4	0.277	5.5	LOS A	1.3	9.5	0.20	0.52	0.20	49.2
West: R046												
10	L2	32	11.1	0.037	5.7	LOS A	0.0	0.0	0.00	0.28	0.00	55.6
11	T1	36	2.9	0.037	0.0	LOS A	0.0	0.0	0.00	0.28	0.00	57.6
Approach		67	6.8	0.037	2.7	NA	0.0	0.0	0.00	0.28	0.00	56.7
All Vehicles		983	6.9	0.277	3.5	NA	1.3	9.5	0.11	0.33	0.11	52.4

SITE LAYOUT – R1023– 2031

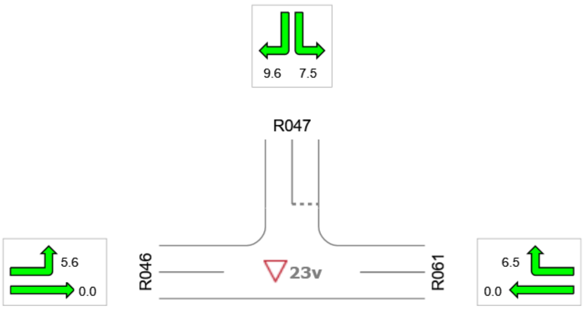


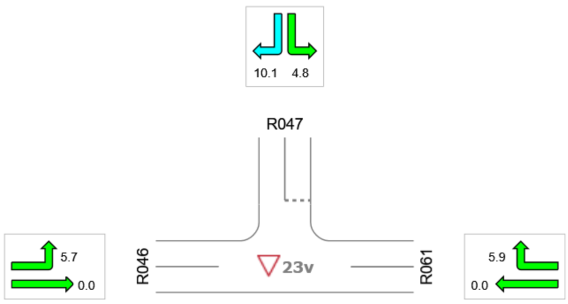
DEGREE OF SATURATION	DEGREE OF SATURATION
2031 – AM	2031– PM





DELAY (CONTROL)	DELAY (CONTROL)
2031– AM	2031– PM





LANE SUMMARY

Site: 23 [2041 AM - FINAL]

R1023
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
East: R061													
Lane 1 (BL)	26	0.0	4337	0.006	100	2.8	LOS A	0.2	0.6	Full	500	0.0	0.0
Lane 2	222	4.7	1324	0.168	100	3.3	LOS A	2.2	16.0	Full	500	0.0	0.0

Lane 3	179	7.6	294	0.610	100	32.5	LOS C	5.2	39.0	Short	40	0.0	NA
Approach	427	5.7		0.610		15.5	LOS B	5.2	39.0				
North: R047													
Lane 1	311	6.1	653	0.476	100	20.7	LOS C	7.1	52.6	Short	60	0.0	NA
Lane 2	32	22.7	160	0.198	100	33.7	LOS C	0.9	7.7	Full	500	0.0	0.0
Approach	342	7.6		0.476		21.9	LOS C	7.1	52.6				
West: R046													
Lane 1	486	2.4	791	0.615	100	20.0	LOS B	11.2	80.0	Short	80	0.0	NA
Lane 2	516	2.4	832	0.620	100	14.4	LOS B	11.9	85.0	Full	500	0.0	0.0
Approach	1002	2.4		0.620		17.1	LOS B	11.9	85.0				
Intersection	1772	4.2		0.620		17.6	LOS B	11.9	85.0				

LANE SUMMARY

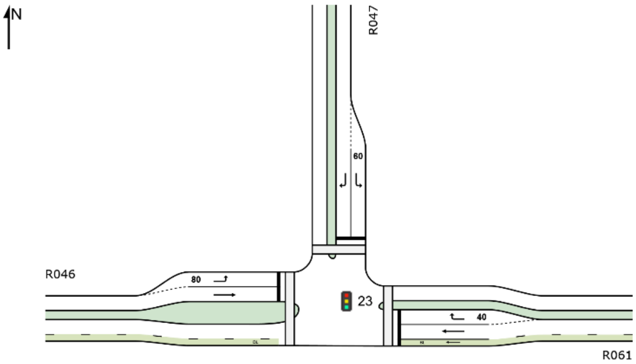
Site: 23 [2041 PM - FINAL]

R1023
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site User-Given Cycle Time)

Lane Use and Performance

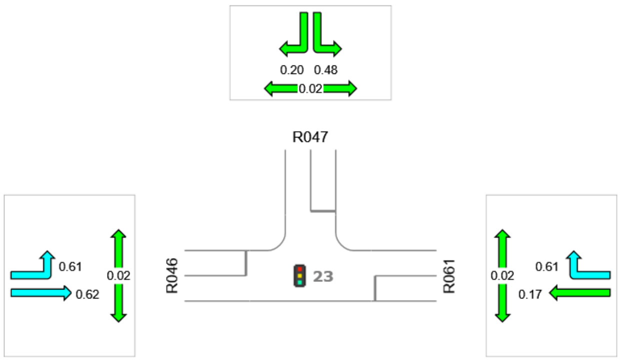
	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
East: R061													
Lane 1 (BL)	26	0.0	4027	0.007	100	3.8	LOS A	0.3	0.7	Full	500	0.0	0.0
Lane 2	835	2.0	1059 [1]	0.788	100	10.0	LOS A	17.3	123.2	Full	500	0.0	0.0
Lane 3	211	2.5	578	0.364	100	23.0	LOS C	4.9	34.9	Short	40	0.0	NA
Approach	1072	2.1		0.788		12.4	LOS B	17.3	123.2				
North: R047													
Lane 1	241	5.2	1014	0.238	100	11.6	LOS B	3.5	25.9	Short	60	0.0	NA
Lane 2	193	2.2	274	0.702	100	33.7	LOS C	5.9	42.2	Full	500	0.0	0.0
Approach	434	3.9		0.702		21.4	LOS C	5.9	42.2				
West: R046													
Lane 1	121	7.0	413	0.293	100	26.8	LOS C	3.0	22.4	Short	80	0.0	NA
Lane 2	161	1.3	451	0.357	100	21.4	LOS C	4.1	28.9	Full	500	0.0	0.0
Approach	282	3.7		0.357		23.7	LOS C	4.1	28.9				
Intersection	1787	2.8		0.788		16.4	LOS B	17.3	123.2				

SITE LAYOUT – R1023– 2041



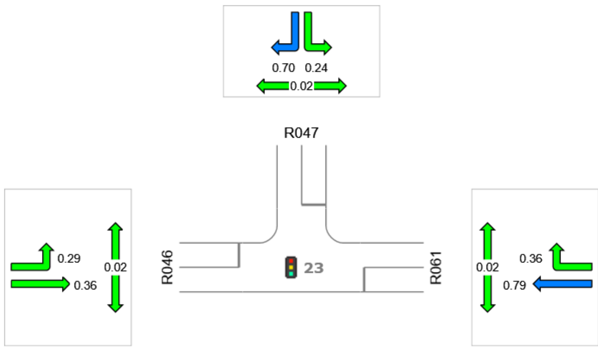
DEGREE OF SATURATION

2041 – AM



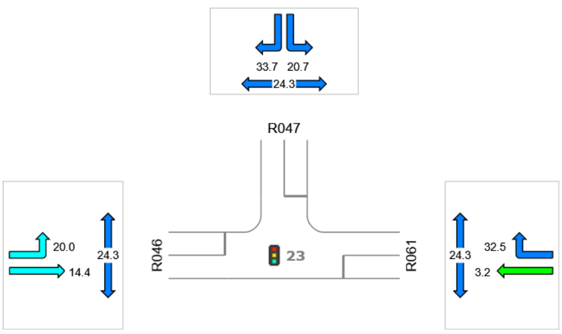
DEGREE OF SATURATION

2041– PM



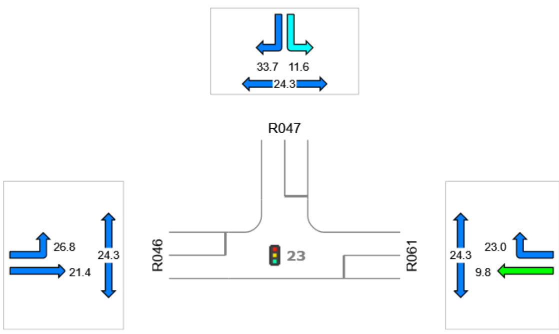
DELAY (CONTROL)

2041– AM



DELAY (CONTROL)

2041– PM



LANE SUMMARY

Site: 23 [2066 AM - FINAL]

R1023
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
East: R061													
Lane 1 (BL)	32	0.0	4337	0.007	100	2.8	LOS A	0.3	0.7	Full	500	0.0	0.0
Lane 2	163	5.3	1319	0.123	49 [6]	3.2	LOS A	1.5	11.3	Short	60	0.0	NA
Lane 3	331	5.3	1319	0.251	100	3.5	LOS A	3.5	25.7	Full	500	0.0	0.0
Lane 4	214	8.4	321	0.665	100	32.4	LOS C	6.3	47.4	Short	60	0.0	NA
Approach	739	6.0		0.665		11.8	LOS B	6.3	47.4				
North: R047													
Lane 1	342	2.8	698	0.490	100	20.0	LOS C	7.8	55.7	Short	60	0.0	NA
Lane 2	37	28.6	154	0.239	100	34.0	LOS C	1.1	9.4	Full	500	0.0	0.0
Approach	379	5.3		0.490		21.4	LOS C	7.8	55.7				
West: R046													
Lane 1	534	3.2	757	0.705	100	22.2	LOS C	13.5	97.4	Short	60	0.0	NA
Lane 2	271	2.6	799	0.340	49 [6]	13.0	LOS B	5.5	39.1	Full	500	0.0	0.0
Lane 3	553	2.6	799	0.692	100	16.1	LOS B	13.7	97.9	Short	60	0.0	NA
Approach	1358	2.8		0.705		17.8	LOS B	13.7	97.9				
Intersection	2476	4.1		0.705		16.6	LOS B	13.7	97.9				

LANE SUMMARY

Site: 23 [2066 PM - FINAL]

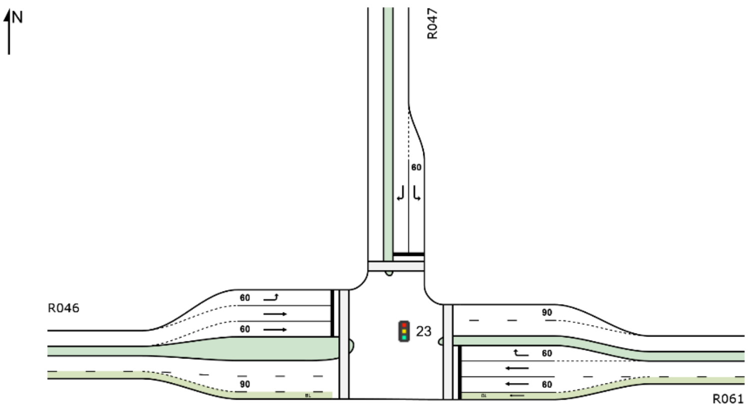
R1023
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
East: R061													
Lane 1 (BL)	32	0.0	2960	0.011	100	12.7	LOS B	0.7	1.9	Full	500	0.0	0.0
Lane 2	356	1.9	920	0.387	49 [6]	16.1	LOS B	10.0	70.9	Short	60	0.0	NA
Lane 3	542	1.9	687 [1]	0.788	100	21.8	LOS C	18.8	134.0	Full	500	0.0	0.0
Lane 4	347	2.1	407	0.854	100	49.9	LOS D	16.8	120.1	Short	60	0.0	NA
Approach	1277	1.9		0.854		27.6	LOS C	18.8	134.0				
North: R047													
Lane 1	262	6.0	1207	0.217	100	10.4	LOS B	4.3	31.5	Short	60	0.0	NA
Lane 2	527	2.4	589 [1]	0.896	100	43.9	LOS D	25.1	179.3	Full	500	0.0	0.0

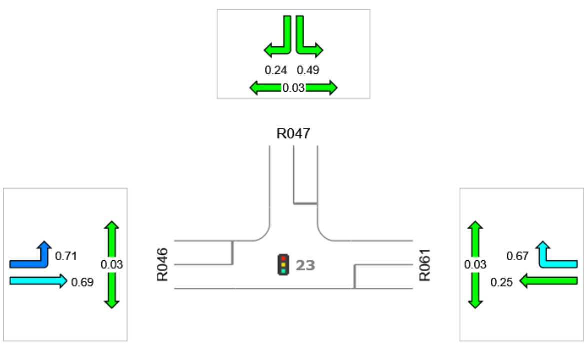
Approach	789	3.6		0.896		32.8	LOS C	25.1	179.3				
West: R046													
Lane 1	129	9.8	328	0.395	100	41.1	LOS D	5.1	38.9	Short	60	0.0	NA
Lane 2	153	2.9	361	0.424	49 [6]	35.5	LOS D	6.1	43.6	Full	500	0.0	0.0
Lane 3	312	2.9	361	0.863	100	46.7	LOS D	15.3	110.0	Short	60	0.0	NA
Approach	595	4.4		0.863		42.6	LOS D	15.3	110.0				
Intersection	2661	3.0		0.896		32.5	LOS C	25.1	179.3				

SITE LAYOUT – R1023– 2066



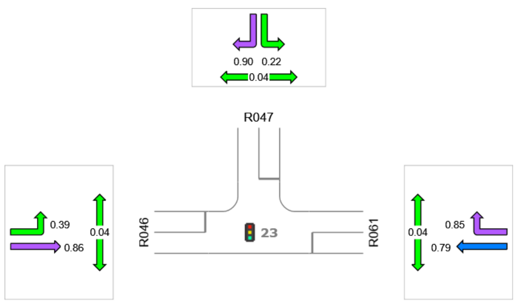
DEGREE OF SATURATION

2066 – AM



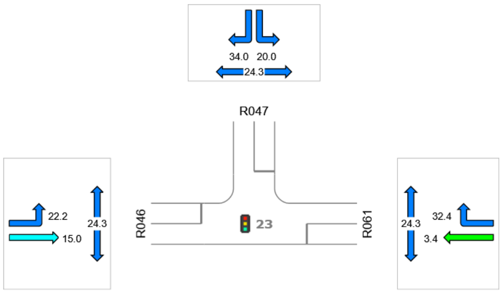
DEGREE OF SATURATION

2066– PM



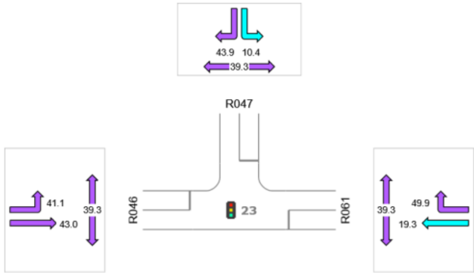
DELAY (CONTROL)

2066– AM



DELAY (CONTROL)

2066– PM



LANE SUMMARY

Site: 24 [2031 AM - FINAL]

R1024
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 100 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
East: R1024East													
Lane 1 (BL)	21	0.0	5081	0.004	100	1.7	LOS A	0.2	0.5	Full	500	0.0	0.0
Lane 2	153	7.6	1524	0.100	100	1.9	LOS A	1.4	10.6	Full	500	0.0	0.0
Lane 3	153	7.6	1524	0.100	100	1.9	LOS A	1.4	10.6	Full	500	0.0	0.0
Lane 4	33	3.2	109	0.300	100	57.5	LOS E	1.6	11.8	Short	60	0.0	NA
Approach	360	6.7		0.300		6.9	LOS A	1.6	11.8				
North: R1024North													
Lane 1	65	3.2	144	0.452	100	54.8	LOS D	3.2	23.2	Full	500	0.0	0.0
Approach	65	3.2		0.452		54.8	LOS D	3.2	23.2				
West: R1024West													
Lane 1	746	2.5	1334	0.559	100	8.6	LOS A	17.7	126.3	Full	500	0.0	0.0
Lane 2	750	2.7	1341	0.559	100	7.8	LOS A	17.8	127.1	Full	500	0.0	0.0
Approach	1496	2.6		0.559		8.2	LOS A	17.8	127.1				
Intersection	1921	3.4		0.559		9.5	LOS A	17.8	127.1				

LANE SUMMARY

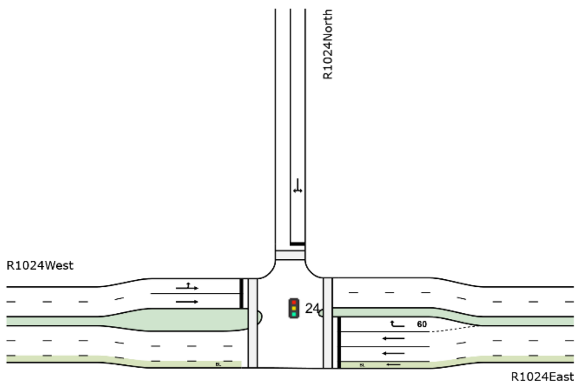
Site: 24 [2031 PM - FINAL]

R1024
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 50 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

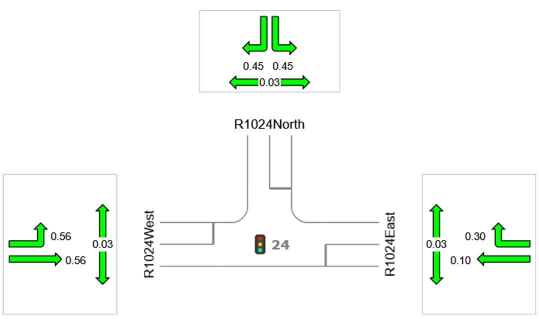
	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
East: R1024East													
Lane 1 (BL)	21	0.0	3717	0.006	100	4.1	LOS A	0.2	0.5	Full	500	0.0	0.0
Lane 2	673	1.8	1156	0.582	100	6.7	LOS A	10.2	72.6	Full	500	0.0	0.0
Lane 3	673	1.8	1156	0.582	100	6.7	LOS A	10.2	72.6	Full	500	0.0	0.0
Lane 4	33	3.2	218	0.150	100	28.3	LOS C	0.8	5.5	Short	60	0.0	NA
Approach	1399	1.8		0.582		7.2	LOS A	10.2	72.6				
North: R1024North													
Lane 1	183	1.1	310	0.590	100	26.5	LOS C	4.4	31.4	Full	500	0.0	0.0
Approach	183	1.1		0.590		26.5	LOS C	4.4	31.4				
West: R1024West													
Lane 1	195	4.7	675	0.288	100	13.6	LOS B	3.5	25.3	Full	500	0.0	0.0
Lane 2	196	5.0	680	0.288	100	12.6	LOS B	3.5	25.6	Full	500	0.0	0.0
Approach	391	4.9		0.288		13.1	LOS B	3.5	25.6				
Intersection	1973	2.3		0.590		10.1	LOS B	10.2	72.6				

SITE LAYOUT – R1024– 2031



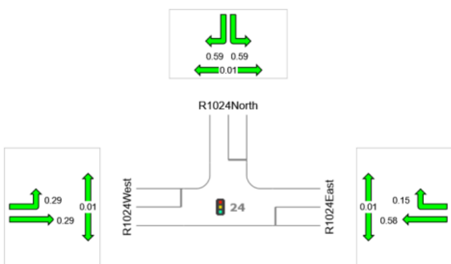
DEGREE OF SATURATION

2031 – AM

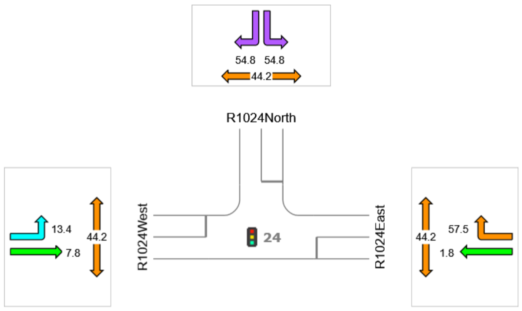


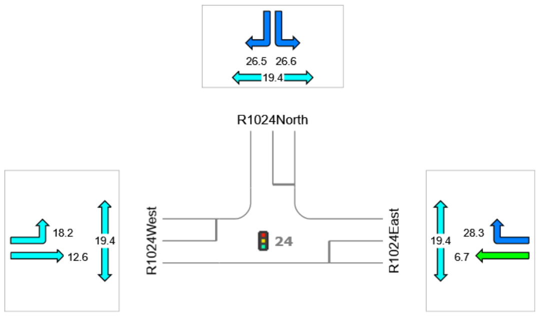
DEGREE OF SATURATION

2031– PM



DELAY (CONTROL)	DELAY (CONTROL)
2031– AM	2031– PM





LANE SUMMARY

Site: 24 [2041 AM - FINAL]

R1024
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R035													
Lane 1	98	3.2	149	0.658	100	50.4	LOS D	4.5	32.6	Full	500	0.0	0.0
Approach	98	3.2		0.658		50.4	LOS D	4.5	32.6				
East: R1024East													
Lane 1 (BL)	26	0.0	4062	0.006	100	5.5	LOS A	0.4	1.0	Full	500	0.0	0.0
Lane 2	302	7.7	1211	0.250	100	7.4	LOS A	5.4	40.2	Full	500	0.0	0.0
Lane 3	303	8.3	1213	0.250	100	6.8	LOS A	5.4	40.5	Full	500	0.0	0.0
Lane 4	33	3.2	121	0.270	100	51.6	LOS D	1.5	10.5	Short	60	0.0	NA
Approach	664	7.4		0.270		9.2	LOS A	5.4	40.5				
North: R1024North													
Lane 1	70	3.1	173	0.406	100	45.8	LOS D	3.1	22.0	Short	60	0.0	NA
Lane 2	47	2.0	115	0.406	100	52.3	LOS D	2.1	15.2	Full	500	0.0	0.0
Approach	117	2.7		0.406		48.4	LOS D	3.1	22.0				
West: R1024West													
Lane 1	954	2.1	1241	0.768	100	13.2	LOS B	28.8	205.3	Full	500	0.0	0.0
Lane 2	943	2.2	1227 [1]	0.768	100	11.2	LOS B	27.7	198.0	Full	500	0.0	0.0
Lane 3	33	3.2	121	0.270	100	51.6	LOS D	1.5	10.5	Short	60	0.0	NA

Approach	1929	2.2	0.768	12.9	LOS B	28.8	205.3
Intersection	2808	3.5	0.768	14.8	LOS B	28.8	205.3

LANE SUMMARY

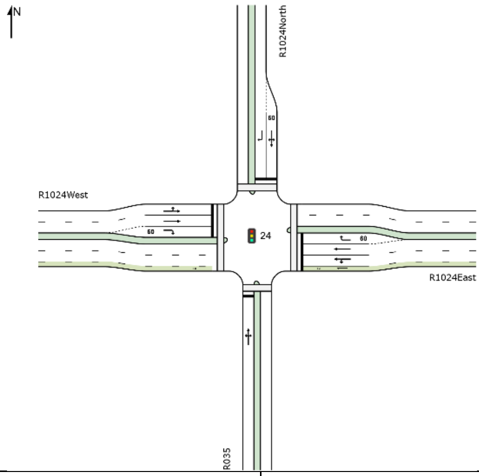
Site: 24 [2041 PM - FINAL]

R1024
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 120 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

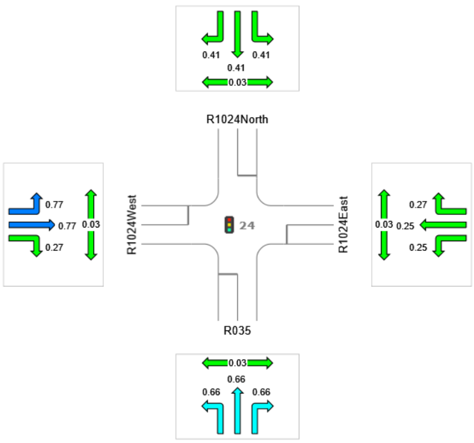
	Demand Flows		Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	Total	HV						Veh	Dist				
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R035													
Lane 1	98	3.2	153	0.641	100	58.2	LOS E	5.6	40.3	Full	500	0.0	0.0
Approach	98	3.2		0.641		58.2	LOS E	5.6	40.3				
East: R1024East													
Lane 1 (BL)	26	0.0	2891	0.009	100	17.5	LOS B	0.8	2.1	Full	500	0.0	0.0
Lane 2	791	1.5	900	0.879	100	38.4	LOS D	45.9	325.5	Full	500	0.0	0.0
Lane 3	768	1.4	874 [1]	0.879	100	38.1	LOS D	44.3	313.8	Full	500	0.0	0.0
Lane 4	33	3.2	91	0.359	100	69.2	LOS E	2.0	14.3	Short	60	0.0	NA
Approach	1618	1.4		0.879		38.5	LOS D	45.9	325.5				
North: R1024North													
Lane 1	104	2.5	152	0.684	100	57.6	LOS E	6.0	42.9	Short	60	0.0	NA
Lane 2	321	1.2	469	0.684	100	49.6	LOS D	15.5	109.7	Full	500	0.0	0.0
Approach	425	1.5		0.684		51.5	LOS D	15.5	109.7				
West: R1024West													
Lane 1	428	4.7	879	0.487	100	23.8	LOS C	16.9	122.9	Full	500	0.0	0.0
Lane 2	405	4.9	833 [1]	0.487	100	23.1	LOS C	15.9	116.1	Full	500	0.0	0.0
Lane 3	33	3.2	91	0.359	100	69.2	LOS E	2.0	14.3	Short	60	0.0	NA
Approach	865	4.7		0.487		25.2	LOS C	16.9	122.9				
Intersection	3006	2.5		0.879		37.2	LOS D	45.9	325.5				

SITE LAYOUT – R1024– 2041



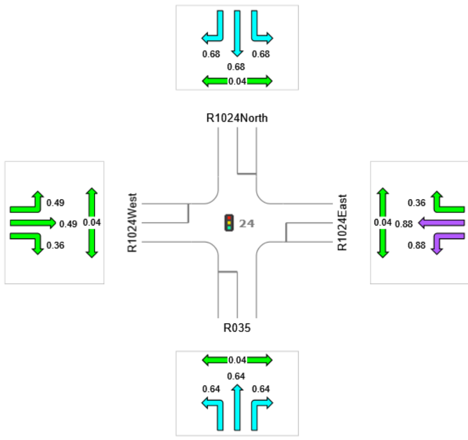
DEGREE OF SATURATION

2041 – AM



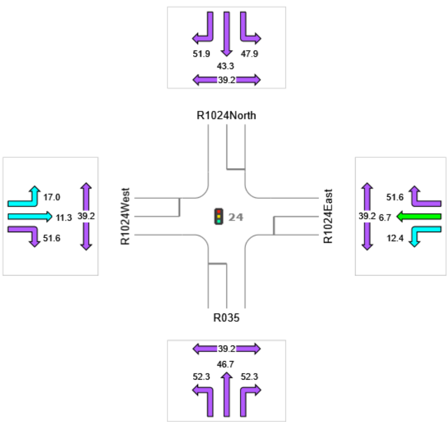
DEGREE OF SATURATION

2041– PM



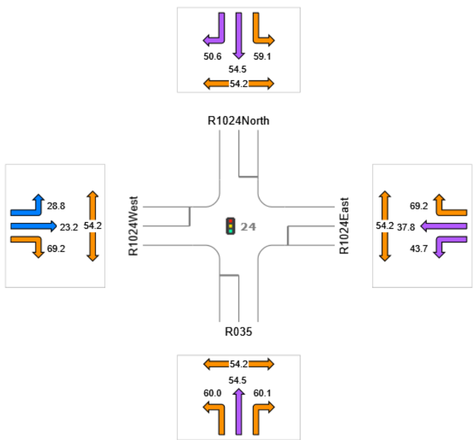
DELAY (CONTROL)

2041– AM



DELAY (CONTROL)

2041– PM



LANE SUMMARY

Site: 24 [2066 AM - FINAL]

R1024
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 140 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R035													
Lane 1	44	31.0	576	0.077	100	35.4	LOS D	1.9	16.8	Short	60	0.0	NA
Lane 2	32	26.7	190	0.166	100	61.5	LOS E	2.0	17.1	Full	500	0.0	0.0
Lane 3	32	66.7	86	0.367	100	77.7	LOS E	2.2	24.2	Short	60	0.0	NA
Approach	107	40.2		0.367		55.5	LOS E	2.2	24.2				
East: R1024East													
Lane 1 (BL)	32	0.0	3319	0.010	100	15.5	LOS B	1.0	2.6	Full	500	0.0	0.0
Lane 2	226	25.6	841	0.269	100	24.5	LOS C	8.2	70.3	Short	60	0.0	NA
Lane 3	506	9.1	986	0.513	100	22.0	LOS C	21.7	164.0	Full	500	0.0	0.0
Lane 4	480	9.1	935 [1]	0.513	100	21.6	LOS C	20.2	152.5	Full	500	0.0	0.0
Lane 5	32	10.0	74	0.425	100	81.3	LOS F	2.3	17.2	Short	60	0.0	NA
Approach	1276	11.8		0.513		23.6	LOS C	21.7	164.0				
North: R1024North													
Lane 1	113	3.7	225	0.501	100	64.7	LOS E	7.4	53.3	Short	60	0.0	NA
Lane 2	25	0.0	153	0.165	100	68.5	LOS E	1.6	11.4	Full	500	0.0	0.0
Lane 3	25	0.0	153	0.165	100	68.5	LOS E	1.6	11.4	Short	60	0.0	NA
Approach	163	2.6		0.501		65.9	LOS E	7.4	53.3				

West: R1024West													
Lane 1	412	1.8	1310	0.314	100	13.3	LOS B	10.1	71.7	Short	60	0.0	NA
Lane 2	871	3.2	1031 [1]	0.845	100	12.0	LOS B	31.3	224.9	Full	500	0.0	0.0
Lane 3	974	3.2	1153 [1]	0.845	100	12.3	LOS B	37.9	272.7	Full	500	0.0	0.0
Lane 4	207	4.1	400	0.519	100	57.5	LOS E	12.5	90.7	Short	60	0.0	NA
Approach	2464	3.0		0.845		16.1	LOS B	37.9	272.7				
Intersection	4011	6.8		0.845		21.6	LOS C	37.9	272.7				

LANE SUMMARY

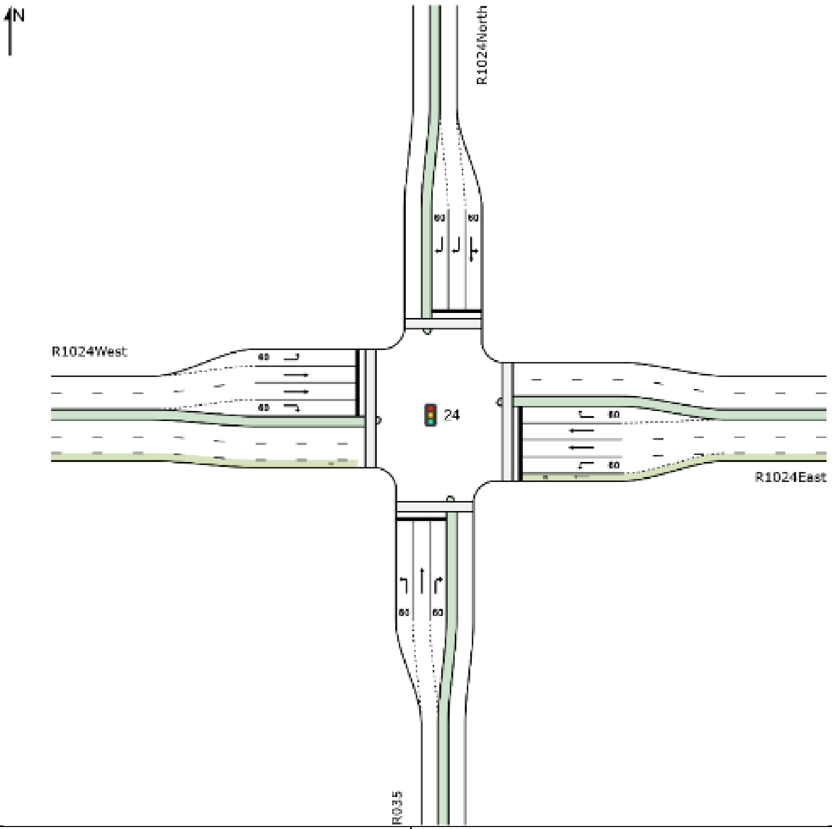
Site: 24 [2066 PM - FINAL]

R1024
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 150 seconds (Site User-Given Cycle Time)

Lane Use and Performance

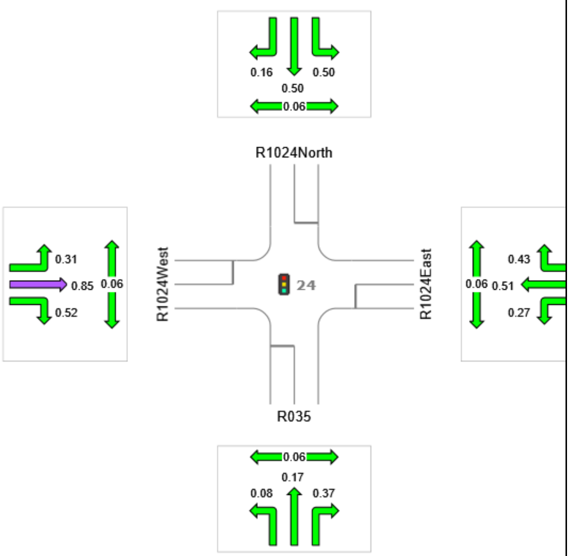
	Demand Flows		Cap.	Deg.	Lane	Average	Level of	95% Back of Queue		Lane	Lane	Cap.	Prob.
	Total	HV		Satn	Util.	Delay	Service	Veh	Dist	Config	Length	Adj.	Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R035													
Lane 1	273	2.7	325 [1]	0.838	100	74.4	LOS E	20.5	146.6	Short	60	0.0	NA
Lane 2	76	4.2	215	0.352	100	67.4	LOS E	5.2	37.8	Full	500	0.0	0.0
Lane 3	186	21.5	222 [1]	0.841	100	82.1	LOS F	14.6	120.7	Short	60	0.0	NA
Approach	535	9.4		0.841		76.1	LOS E	20.5	146.6				
East: R1024East													
Lane 1 (BL)	32	0.0	3387	0.009	100	15.8	LOS B	1.0	2.7	Full	500	0.0	0.0
Lane 2	32	50.0	995	0.032	100	12.1	LOS B	0.6	6.3	Short	60	0.0	NA
Lane 3	925	2.1	1052	0.880	100	34.7	LOS C	60.8	433.0	Full	500	0.0	0.0
Lane 4	898	2.1	1020 [1]	0.880	100	34.5	LOS C	57.9	412.4	Full	500	0.0	0.0
Lane 5	33	3.2	73	0.449	100	86.8	LOS F	2.5	18.0	Short	60	0.0	NA
Approach	1919	2.9		0.880		34.8	LOS C	60.8	433.0				
North: R1024North													
Lane 1	71	10.4	223	0.317	100	67.4	LOS E	4.8	36.4	Short	60	0.0	NA
Lane 2	196	1.3	258	0.760	100	75.0	LOS E	14.4	102.3	Full	500	0.0	0.0
Lane 3	196	1.3	258	0.760	100	75.0	LOS E	14.4	102.3	Short	60	0.0	NA
Approach	462	2.7		0.760		73.9	LOS E	14.4	102.3				
West: R1024West													
Lane 1	77	1.4	1336	0.057	100	11.6	LOS B	1.5	11.0	Short	60	0.0	NA
Lane 2	583	5.8	962 [1]	0.606	100	23.6	LOS C	27.5	201.9	Full	500	0.0	0.0
Lane 3	588	5.8	970 [1]	0.606	100	23.7	LOS C	27.8	204.4	Full	500	0.0	0.0
Lane 4	38	19.4	65	0.581	100	88.7	LOS F	3.0	24.2	Short	60	0.0	NA
Approach	1286	5.9		0.606		24.8	LOS C	27.8	204.4				
Intersection	4202	4.6		0.880		41.3	LOS D	60.8	433.0				

SITE LAYOUT – R1024– 2066



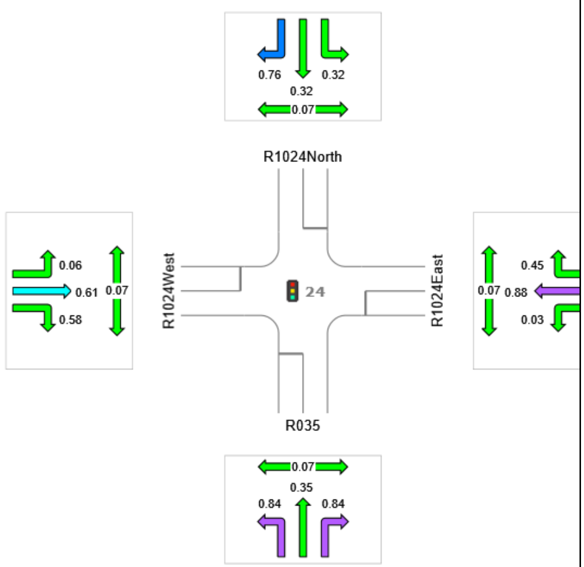
DEGREE OF SATURATION

2066 – AM

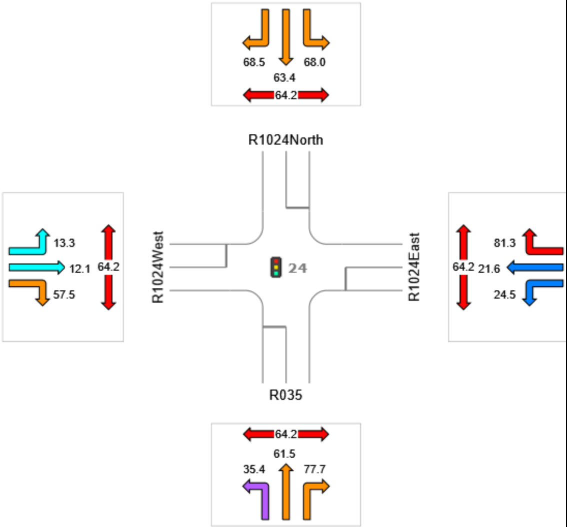


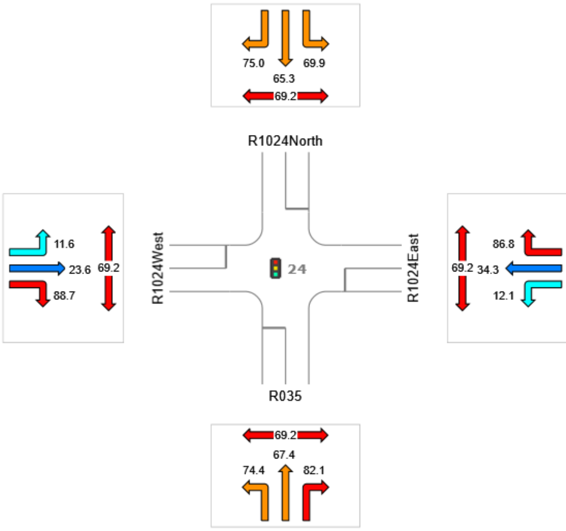
DEGREE OF SATURATION

2066– PM



DELAY (CONTROL)	**DELAY (CONTROL)**
2066– AM	2066– PM





LANE SUMMARY

Site: 25 [2066 AM - FINAL]

R1025
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 100 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R018													
Lane 1	32	3.7	887	0.036	100	19.5	LOS B	0.8	5.7	Short	30	0.0	NA
Lane 2	783	1.9	913 [1]	0.857	100	29.7	LOS C	36.6	260.7	Full	500	0.0	0.0
Lane 3	688	1.9	802 [1]	0.857	100	29.2	LOS C	30.6	217.9	Full	500	0.0	0.0
Lane 4	306	1.0	590	0.519	100	35.6	LOS D	12.3	86.6	Short	90	0.0	NA
Approach	1808	1.8		0.857		30.3	LOS C	36.6	260.7				
East: R054													
Lane 1	91	1.2	939	0.096	100	17.9	LOS B	2.2	15.8	Short	60	0.0	NA
Lane 2	149	1.4	251	0.595	100	45.9	LOS D	7.1	50.6	Full	500	0.0	0.0
Lane 3	32	0.0	84	0.376	100	59.4	LOS E	1.6	11.4	Short	30	0.0	NA
Approach	272	1.2		0.595		38.1	LOS D	7.1	50.6				
North: R015													
Lane 1	32	4.3	666	0.047	100	27.0	LOS C	1.0	7.1	Short	30	0.0	NA
Lane 2	377	2.6	679 [1]	0.555	100	26.6	LOS C	14.4	103.3	Full	500	0.0	0.0
Lane 3	386	2.6	696 [1]	0.555	100	26.8	LOS C	14.9	106.4	Full	500	0.0	0.0
Lane 4	304	2.8	364	0.835	100	53.9	LOS D	16.0	114.3	Short	60	0.0	NA

Approach	1099	2.7		0.835		34.2	LOS C	16.0	114.3				
West: R048													
Lane 1	597	1.2	718	0.831	100	39.1	LOS D	28.8	203.4	Full	500	0.0	0.0
Lane 2	193	0.7	232 [1]	0.831	100	52.4	LOS D	10.2	71.5	Full	500	0.0	0.0
Lane 3	69	0.0	109	0.638	100	58.7	LOS E	3.6	25.4	Short	30	0.0	NA
Approach	859	1.0		0.831		43.7	LOS D	28.8	203.4				
Intersection	4038	1.8		0.857		34.7	LOS C	36.6	260.7				

LANE SUMMARY

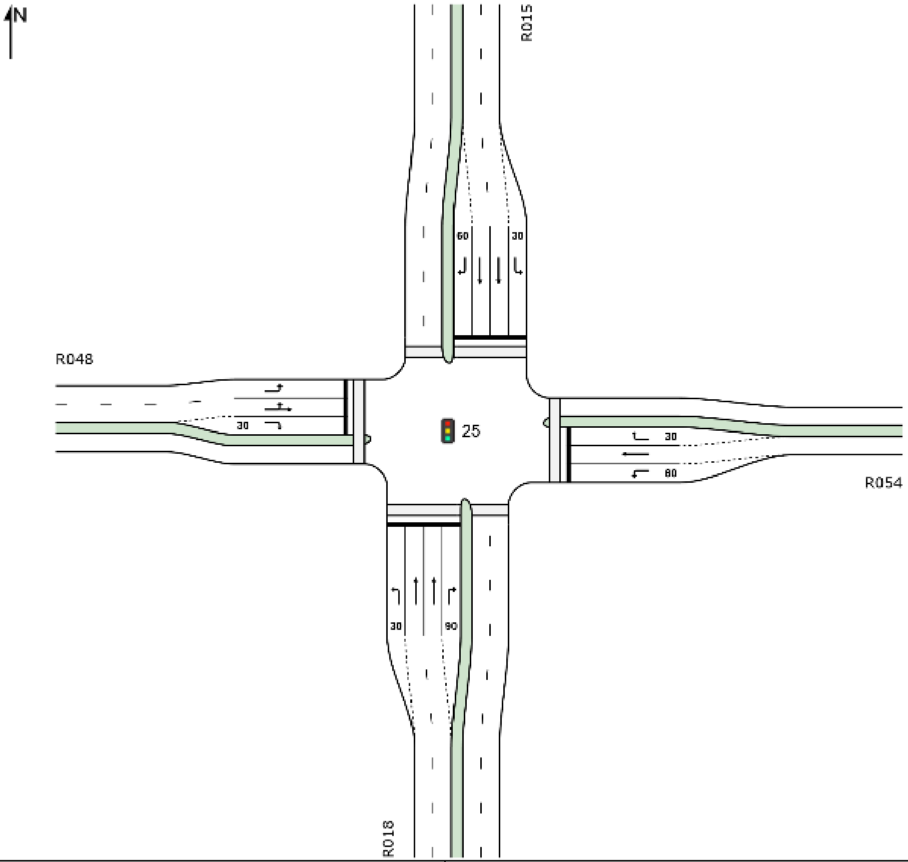
Site: 25 [2066 PM - FINAL]

R1025
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 70 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

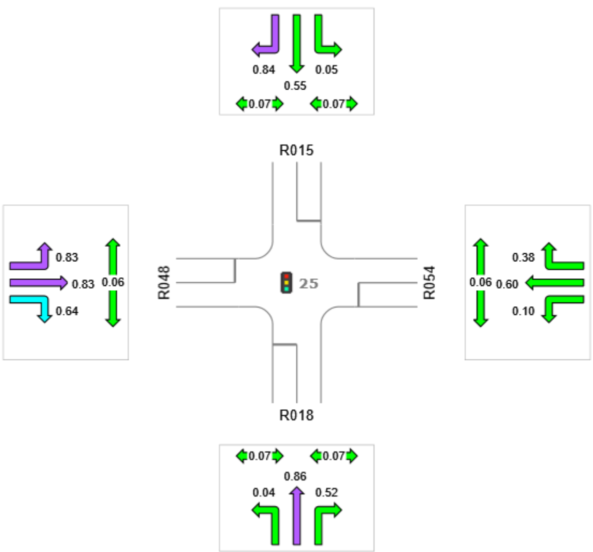
	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R018													
Lane 1	63	0.0	504	0.125	100	26.5	LOS C	1.6	11.5	Short	30	0.0	NA
Lane 2	373	1.6	492 [1]	0.759	100	27.9	LOS C	12.6	89.3	Full	500	0.0	0.0
Lane 3	397	1.6	524	0.759	100	28.1	LOS C	13.5	96.1	Full	500	0.0	0.0
Lane 4	99	1.1	158	0.626	100	42.3	LOS D	3.6	25.4	Short	90	0.0	NA
Approach	933	1.5		0.759		29.4	LOS C	13.5	96.1				
East: R054													
Lane 1	311	1.0	500	0.620	100	29.3	LOS C	9.6	67.5	Short	60	0.0	NA
Lane 2	162	0.6	194	0.835	100	40.0	LOS D	6.3	44.4	Full	500	0.0	0.0
Lane 3	32	0.0	113	0.279	100	42.6	LOS D	1.1	8.0	Short	30	0.0	NA
Approach	504	0.8		0.835		33.6	LOS C	9.6	67.5				
North: R015													
Lane 1	32	0.0	1035	0.031	100	12.9	LOS B	0.5	3.3	Short	30	0.0	NA
Lane 2	724	1.4	1049 [1]	0.690	100	11.8	LOS B	17.5	124.3	Full	500	0.0	0.0
Lane 3	743	1.4	1076	0.690	100	12.0	LOS B	18.3	129.7	Full	500	0.0	0.0
Lane 4	611	0.9	686	0.891	100	39.2	LOS D	24.7	173.9	Short	120	0.0	NA
Approach	2108	1.2		0.891		19.8	LOS B	24.7	173.9				
West: R048													
Lane 1	312	1.7	1022	0.305	46 [5]	13.5	LOS B	5.7	40.3	Full	500	0.0	0.0
Lane 2	127	1.7	193	0.660	100	35.9	LOS D	4.6	32.6	Full	500	0.0	0.0
Lane 3	32	0.0	92	0.343	100	44.2	LOS D	1.2	8.2	Short	30	0.0	NA
Approach	471	1.6		0.660		21.6	LOS C	5.7	40.3				
Intersection	4016	1.3		0.891		24.0	LOS C	24.7	173.9				

SITE LAYOUT – R1025– 2066



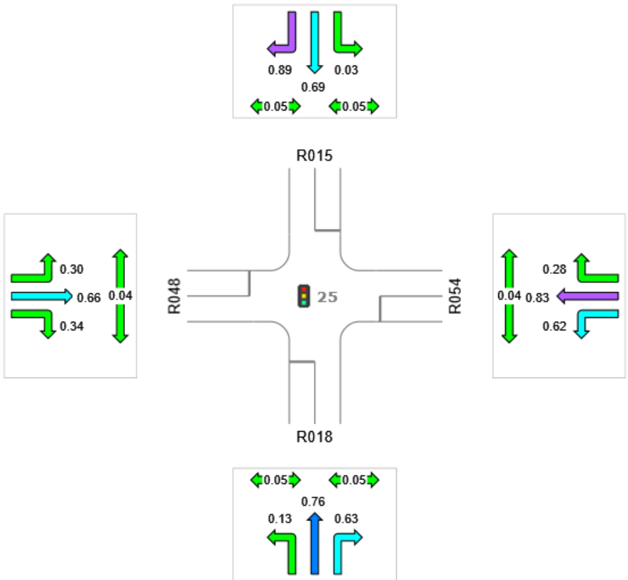
DEGREE OF SATURATION

2066 – AM



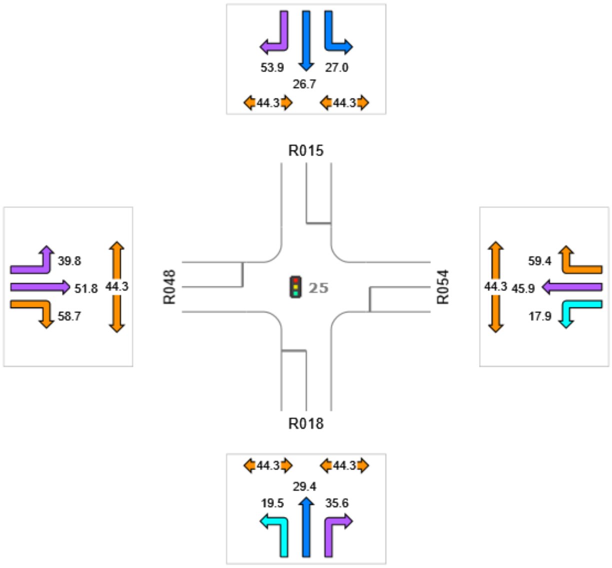
DEGREE OF SATURATION

2066– PM



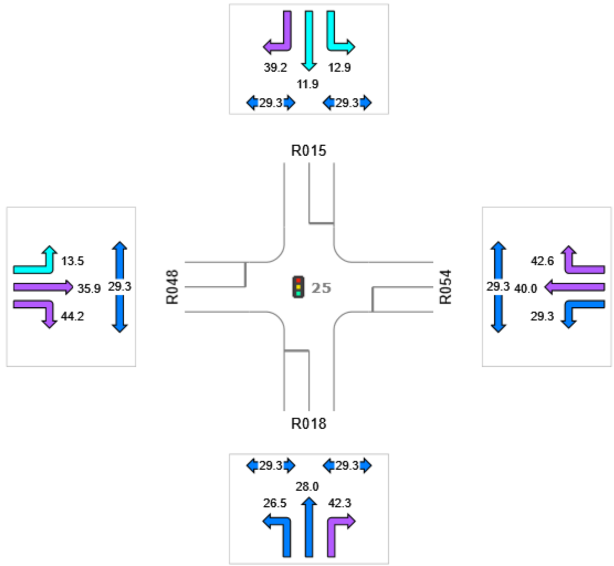
DELAY (CONTROL)

2066– AM



DELAY (CONTROL)

2066– PM



LANE SUMMARY

Site: 26 [2066 AM - FINAL]

R1026
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows		Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	Total	HV						Veh	Dist				
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%

East: R036													
Lane 1	86	1.2	821	0.105	100	15.9	LOS B	1.5	10.6	Short	30	0.0	NA
Lane 2	666	0.8	766[1]	0.870	100	29.9	LOS C	21.7	152.7	Full	500	0.0	0.0
Approach	753	0.8		0.870		28.3	LOS C	21.7	152.7				
NorthWest: R030													
Lane 1	443	1.7	1323	0.335	100	8.8	LOS A	5.1	36.0	Full	500	0.0	0.0
Lane 2	177	1.8	306	0.579	100	31.0	LOS C	5.1	36.1	Short	160	0.0	NA
Approach	620	1.7		0.579		15.1	LOS B	5.1	36.1				
SouthWest: R054													
Lane 1	545	1.4	610[1]	0.893	100	35.2	LOS D	19.1	135.0	Full	500	0.0	0.0
Lane 2	101	1.0	190	0.532	100	34.8	LOS C	3.1	21.6	Short	30	0.0	NA
Approach	646	1.3		0.893		35.1	LOS D	19.1	135.0				
Intersection	2019	1.3		0.893		26.4	LOS C	21.7	152.7				

LANE SUMMARY

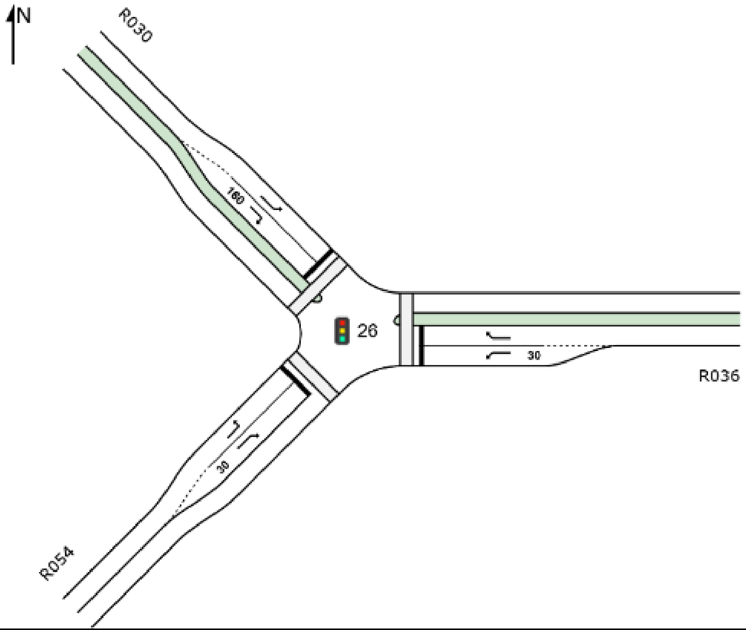
Site: 26 [2066 PM - FINAL]

R1026
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 80 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

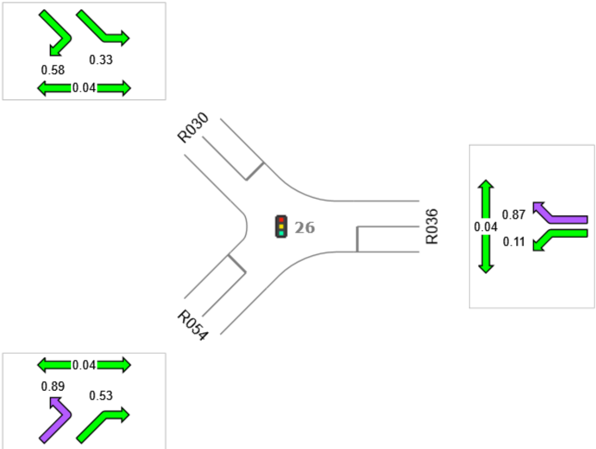
	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
East: R036													
Lane 1	95	1.1	593	0.160	100	26.5	LOS C	2.7	19.0	Short	30	0.0	NA
Lane 2	456	1.2	531[1]	0.858	100	40.0	LOS D	19.1	134.8	Full	500	0.0	0.0
Approach	551	1.1		0.858		37.7	LOS D	19.1	134.8				
NorthWest: R030													
Lane 1	593	0.7	1427	0.415	100	8.8	LOS A	8.3	58.4	Full	500	0.0	0.0
Lane 2	555	1.1	668	0.831	100	35.4	LOS D	22.4	158.4	Short	160	0.0	NA
Approach	1147	0.9		0.831		21.7	LOS C	22.4	158.4				
SouthWest: R054													
Lane 1	193	1.1	990	0.194	100	14.8	LOS B	3.9	27.2	Full	500	0.0	0.0
Lane 2	54	2.0	189	0.285	100	42.7	LOS D	2.1	14.6	Short	30	0.0	NA
Approach	246	1.3		0.285		20.9	LOS C	3.9	27.2				
Intersection	1944	1.0		0.858		26.1	LOS C	22.4	158.4				

SITE LAYOUT – R1026– 2066



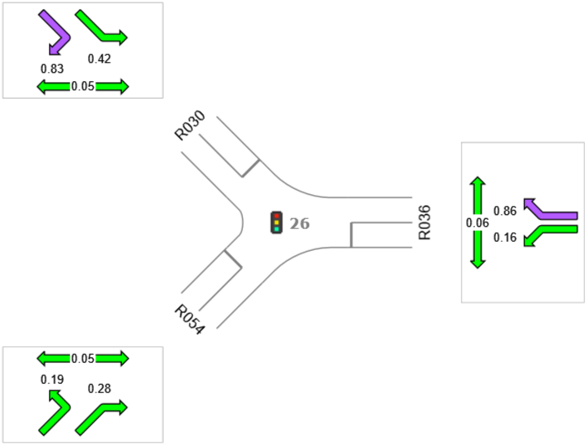
DEGREE OF SATURATION

2066 – AM



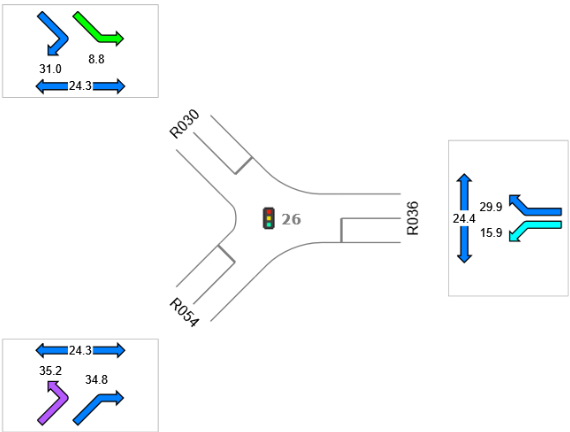
DEGREE OF SATURATION

2066– PM



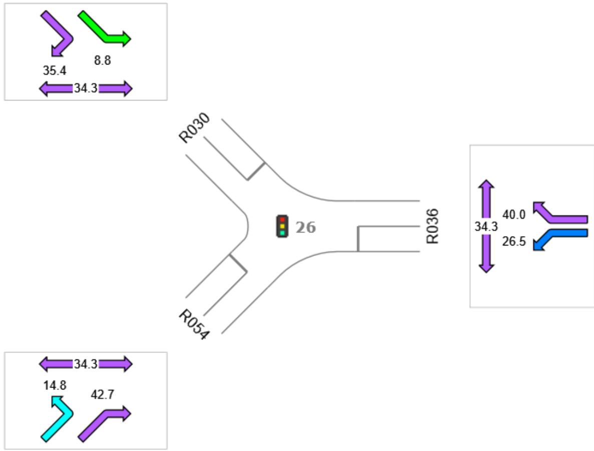
DELAY (CONTROL)

2066– AM



DELAY (CONTROL)

2066– PM



MOVEMENT SUMMARY

Site: 27v [2041 AM - FINAL]

R1027
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
South: R063												
1	L2	32	0.0	0.095	4.6	LOS A	0.5	3.5	0.70	0.51	0.70	47.0
3a	R1	32	3.3	0.095	19.4	LOS C	0.5	3.5	0.70	0.51	0.70	46.6
Approach		63	1.7	0.095	12.0	LOS B	0.5	3.5	0.70	0.51	0.70	46.8
NorthEast: R012												
24a	L1	62	1.7	0.342	5.6	LOS A	1.5	10.9	0.21	0.62	0.22	52.0
26a	R1	259	1.2	0.342	7.2	LOS A	1.5	10.9	0.21	0.62	0.22	52.4
Approach		321	1.3	0.342	6.9	LOS A	1.5	10.9	0.21	0.62	0.22	52.3
West: R011												
10a	L1	631	0.8	0.332	5.4	LOS A	0.0	0.0	0.00	0.59	0.00	53.2
12	R2	32	0.0	0.017	5.4	LOS A	0.0	0.0	0.00	0.60	0.00	53.1

Approach		662	0.8	0.332	5.4	NA	0.0	0.0	0.00	0.59	0.00	53.2
All Vehicles		1046	1.0	0.342	6.2	NA	1.5	10.9	0.11	0.60	0.11	52.5

MOVEMENT SUMMARY

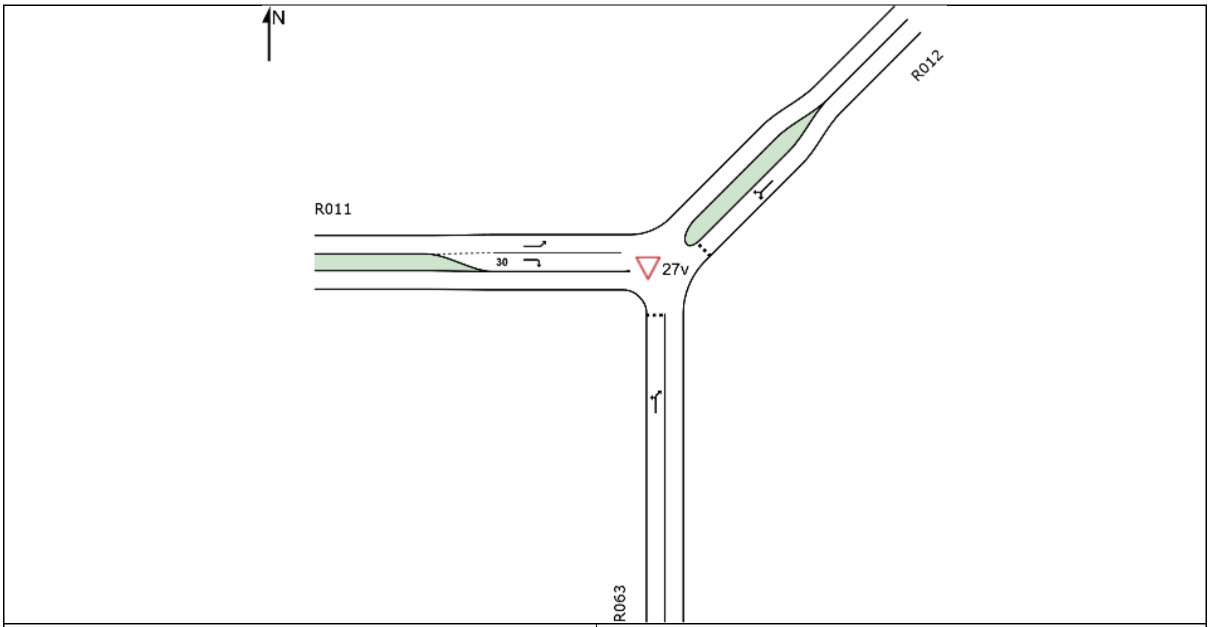
Site: 27v [2041 PM - FINAL]

R1027
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

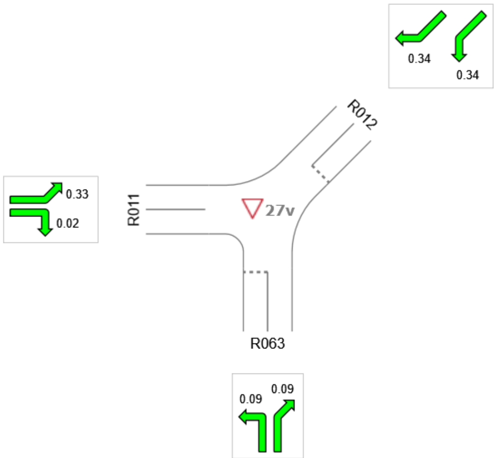
Mov ID	Turn	Demand Flows Total	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
South: R063												
1	L2	32	0.0	0.155	4.6	LOS A	0.7	4.9	0.71	0.61	0.71	47.4
3a	R1	57	1.9	0.155	16.4	LOS C	0.7	4.9	0.71	0.61	0.71	47.1
Approach		88	1.2	0.155	12.1	LOS B	0.7	4.9	0.71	0.61	0.71	47.2
NorthEast: R012												
24a	L1	32	3.3	0.628	6.6	LOS A	6.1	42.9	0.42	0.69	0.55	51.5
26a	R1	626	0.7	0.628	7.6	LOS A	6.1	42.9	0.42	0.69	0.55	51.9
Approach		658	0.8	0.628	7.5	LOS A	6.1	42.9	0.42	0.69	0.55	51.9
West: R011												
10a	L1	278	0.8	0.146	5.3	LOS A	0.0	0.0	0.00	0.59	0.00	53.2
12	R2	32	0.0	0.017	5.4	LOS A	0.0	0.0	0.00	0.60	0.00	53.1
Approach		309	0.7	0.146	5.4	NA	0.0	0.0	0.00	0.59	0.00	53.2
All Vehicles		1056	0.8	0.628	7.3	NA	6.1	42.9	0.32	0.65	0.40	51.8

SITE LAYOUT – R1027– 2041



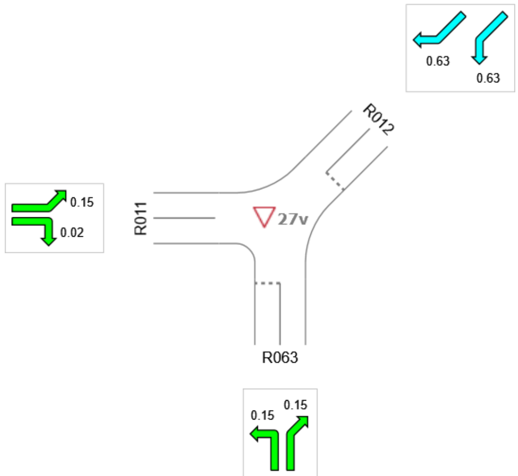
DEGREE OF SATURATION

2041 – AM



DEGREE OF SATURATION

2041– PM

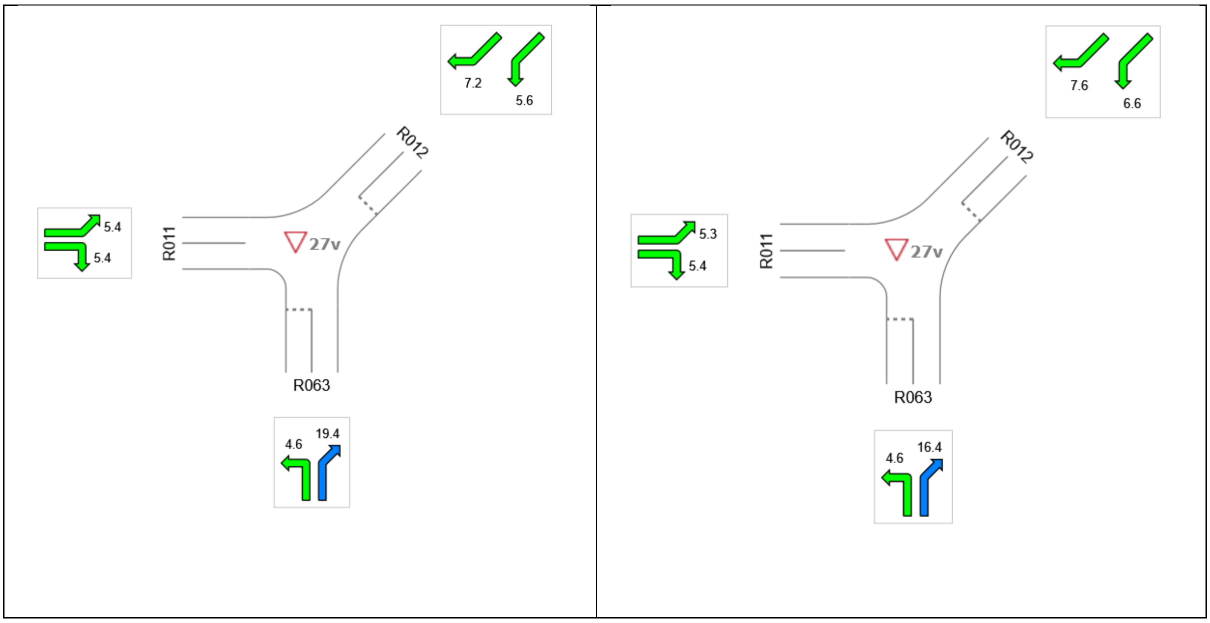


DELAY (CONTROL)

2041– AM

DELAY (CONTROL)

2041– PM



LANE SUMMARY

Site: 27 [2066 AM - FINAL]

R1027
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 70 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R063													
Lane 1	32	0.0	1088	0.029	100	11.0	LOS B	0.4	3.1	Short	30	0.0	NA
Lane 2	516	1.6	627 [1]	0.823	100	32.4	LOS C	18.3	129.8	Full	500	0.0	0.0
Approach	547	1.5		0.823		31.2	LOS C	18.3	129.8				
NorthEast: R012													
Lane 1	304	1.7	459	0.663	100	32.0	LOS C	9.8	69.7	Short	120	0.0	NA
Lane 2	179	2.1	458	0.392	100	29.1	LOS C	5.3	37.5	Full	500	0.0	0.0
Lane 3	179	2.1	458	0.392	100	29.1	LOS C	5.3	37.5	Full	500	0.0	0.0
Approach	663	1.9		0.663		30.4	LOS C	9.8	69.7				
West: R011													
Lane 1	365	1.2	461	0.793	100	35.6	LOS D	13.1	92.4	Full	500	0.0	0.0
Lane 2	352	1.2	444 [1]	0.793	100	35.5	LOS D	12.5	88.6	Full	500	0.0	0.0
Lane 3	32	0.0	292	0.108	100	33.7	LOS C	1.0	6.7	Short	30	0.0	NA
Approach	748	1.1		0.793		35.5	LOS D	13.1	92.4				
Intersection	1959	1.5		0.823		32.6	LOS C	18.3	129.8				

LANE SUMMARY

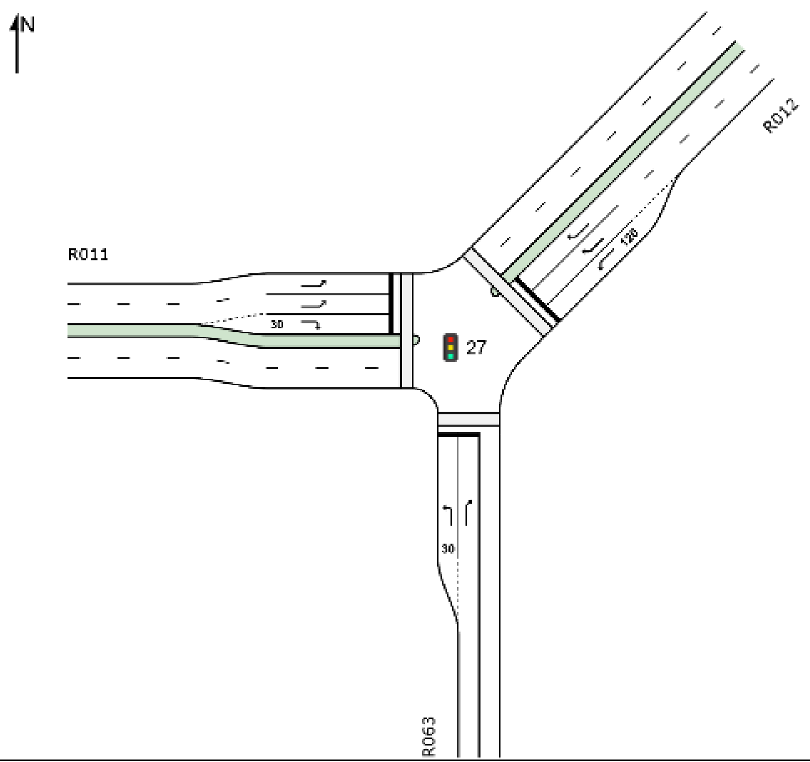
Site: 27 [2066 PM - FINAL]

R1027
Site Category: (None)
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

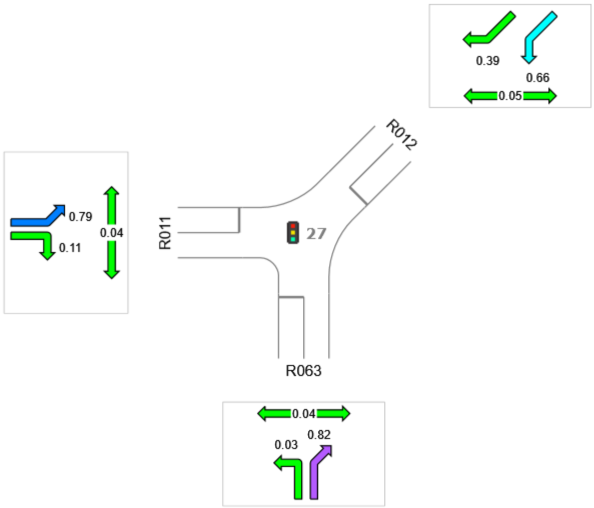
	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R063													
Lane 1	32	0.0	805	0.039	100	15.1	LOS B	0.5	3.7	Short	30	0.0	NA
Lane 2	279	1.5	344 [1]	0.810	100	35.1	LOS D	9.0	64.1	Full	500	0.0	0.0
Approach	311	1.4		0.810		33.0	LOS C	9.0	64.1				
NorthEast: R012													
Lane 1	546	1.3	694	0.787	100	26.8	LOS C	16.0	113.3	Short	120	0.0	NA
Lane 2	315	1.0	696	0.452	100	20.4	LOS C	7.1	50.4	Full	500	0.0	0.0
Lane 3	315	1.0	696	0.452	100	20.4	LOS C	7.1	50.4	Full	500	0.0	0.0
Approach	1176	1.2		0.787		23.3	LOS C	16.0	113.3				
West: R011													
Lane 1	182	1.4	694	0.262	100	19.1	LOS B	3.8	26.9	Full	500	0.0	0.0
Lane 2	182	1.4	694	0.262	100	19.1	LOS B	3.8	26.9	Full	500	0.0	0.0
Lane 3	32	0.0	279	0.113	100	30.3	LOS C	0.8	5.8	Short	30	0.0	NA
Approach	396	1.3		0.262		20.0	LOS B	3.8	26.9				
Intersection	1882	1.2		0.810		24.2	LOS C	16.0	113.3				

SITE LAYOUT – R1027– 2066



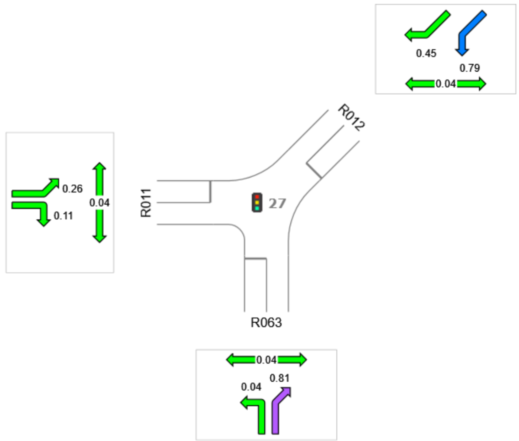
DEGREE OF SATURATION

2066 – AM



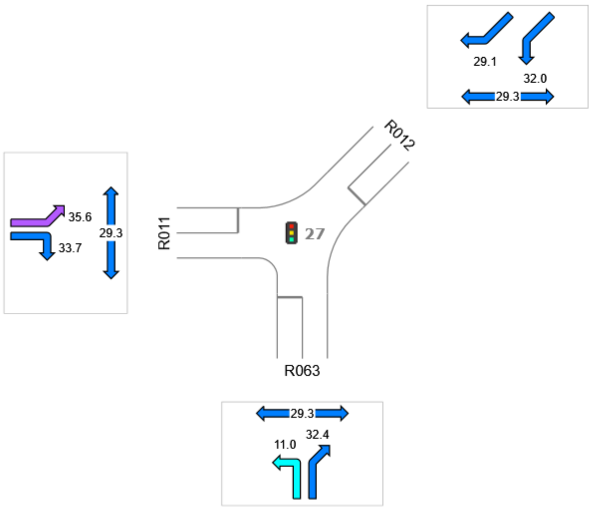
DEGREE OF SATURATION

2066– PM



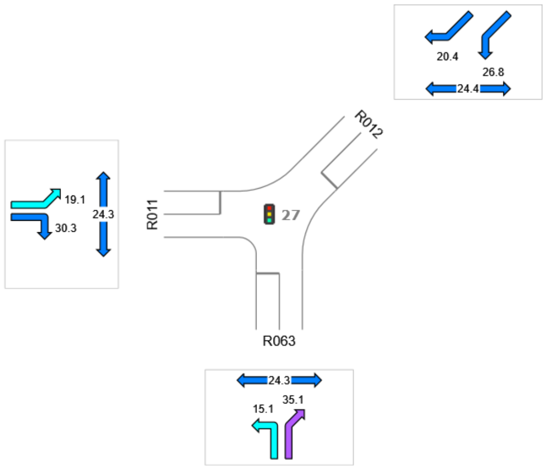
DELAY (CONTROL)

2066– AM



DELAY (CONTROL)

2066– PM



LANE SUMMARY

Site: 28 [2031 AM - FINAL same as 2041]

R1028
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows		Cap.	Deg.	Lane	Average	Level of	95% Back of Queue		Lane	Lane	Cap.	Prob.
	Total	HV		Satn	Util.	Delay	Service	Veh	Dist	Config	Length	Adj.	Block.

	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	87	3.6	724	0.121	100	12.0	LOS B	0.9	6.3	Short	60	0.0	NA
Lane 2	235	1.8	578	0.406	100	18.5	LOS B	5.6	39.9	Full	500	0.0	0.0
Lane 3	80	2.6	182	0.439	100	35.2	LOS D	2.4	17.1	Short	30	0.0	NA
Approach	402	2.4		0.439		20.4	LOS C	5.6	39.9				
East: R1028East													
Lane 1	151	1.4	257	0.586	100	21.5	LOS C	2.9	20.9	Full	500	0.0	0.0
Approach	151	1.4		0.586		21.5	LOS C	2.9	20.9				
North: R027													
Lane 1	476	1.3	578	0.823	100	26.8	LOS C	15.0	106.5	Full	500	0.0	0.0
Lane 2	32	0.0	186	0.170	100	34.0	LOS C	0.9	6.3	Short	30	0.0	NA
Approach	507	1.2		0.823		27.2	LOS C	15.0	106.5				
West: R062													
Lane 1	63	0.0	249	0.253	100	28.9	LOS C	1.8	12.3	Full	500	0.0	0.0
Lane 2	127	2.5	182	0.698	100	36.4	LOS D	4.1	29.0	Short	50	0.0	NA
Approach	191	1.7		0.698		33.9	LOS C	4.1	29.0				
Intersection	1251	1.7		0.823		25.4	LOS C	15.0	106.5				

LANE SUMMARY

Site: 28 [2031 PM - FINAL same as 2041]

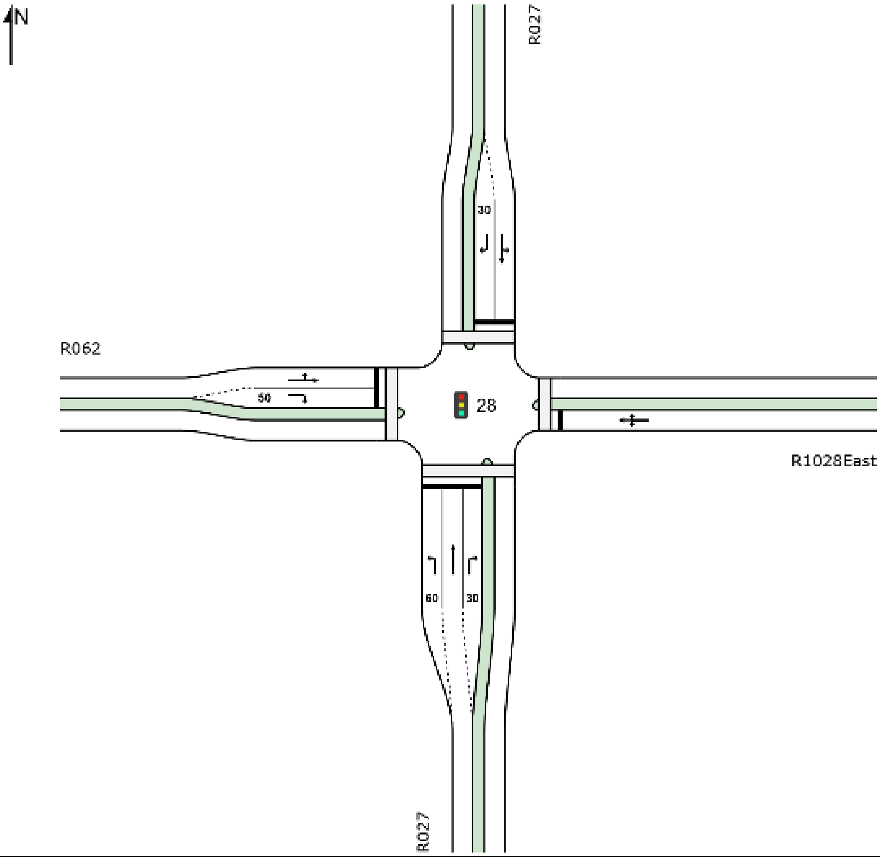
R1028
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows		Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	Total	HV						Veh	Dist				
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	124	1.7	734	0.169	100	12.2	LOS B	1.3	9.1	Short	60	0.0	NA
Lane 2	415	1.0	527 [1]	0.787	100	24.3	LOS C	12.3	86.8	Full	500	0.0	0.0
Lane 3	79	1.3	184	0.429	100	35.1	LOS D	2.4	16.7	Short	30	0.0	NA
Approach	618	1.2		0.787		23.2	LOS C	12.3	86.8				
East: R1028East													
Lane 1	135	0.8	248	0.544	100	21.5	LOS C	2.6	18.0	Full	500	0.0	0.0
Approach	135	0.8		0.544		21.5	LOS C	2.6	18.0				
North: R027													
Lane 1	275	1.5	576	0.477	100	19.5	LOS B	6.7	47.7	Full	500	0.0	0.0
Lane 2	32	0.0	186	0.170	100	34.0	LOS C	0.9	6.3	Short	30	0.0	NA
Approach	306	1.4		0.477		21.0	LOS C	6.7	47.7				
West: R062													
Lane 1	63	0.0	249	0.253	100	28.9	LOS C	1.8	12.3	Full	500	0.0	0.0
Lane 2	79	2.7	182	0.433	100	34.2	LOS C	2.4	16.9	Short	50	0.0	NA
Approach	142	1.5		0.433		31.9	LOS C	2.4	16.9				

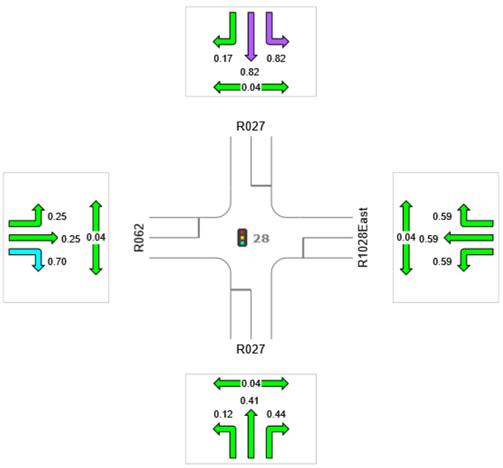
Intersection	1201	1.2	0.787	23.5	LOS C	12.3	86.8

SITE LAYOUT – R1028– 2031



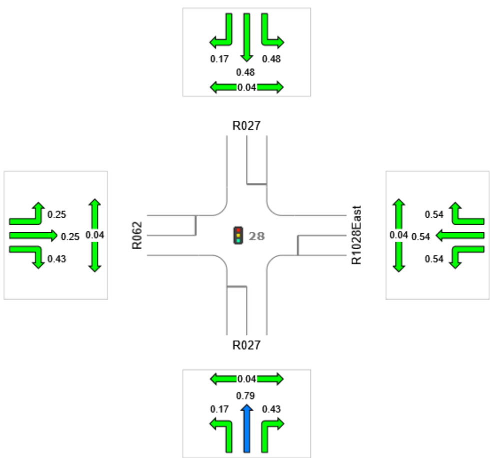
DEGREE OF SATURATION

2031 – AM

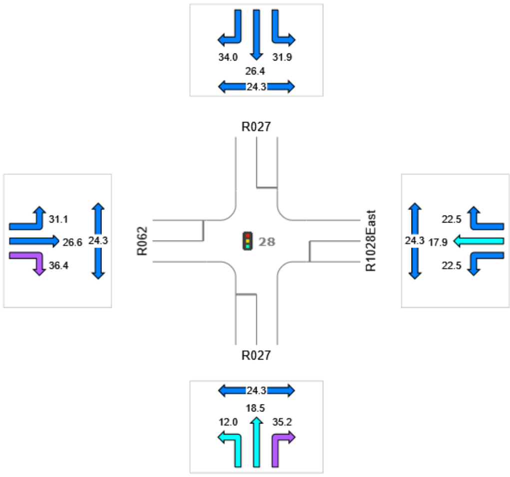


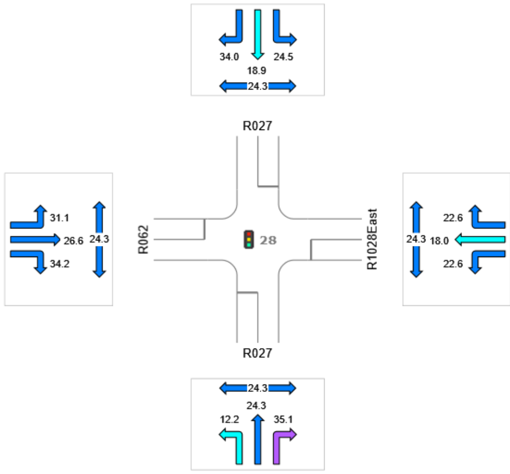
DEGREE OF SATURATION

2031– PM



DELAY (CONTROL)	DELAY (CONTROL)
2031– AM	2031– PM





LANE SUMMARY

Site: 28 [2041 AM - FINAL]

R1028
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 70 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	205	1.5	814	0.252	100	12.5	LOS B	2.3	16.5	Short	60	0.0	NA
Lane 2	421	1.8	599 [1]	0.703	100	22.0	LOS C	12.6	89.8	Full	500	0.0	0.0
Lane 3	65	1.6	184	0.355	100	39.3	LOS D	2.2	15.8	Short	30	0.0	NA
Approach	692	1.7		0.703		20.8	LOS C	12.6	89.8				
East: R1028East													
Lane 1	120	3.8	253	0.474	100	27.0	LOS C	2.8	19.9	Full	500	0.0	0.0
Approach	120	3.8		0.474		27.0	LOS C	2.8	19.9				
North: R027													
Lane 1	571	1.7	659	0.865	100	31.7	LOS C	21.8	154.6	Full	500	0.0	0.0
Lane 2	137	3.8	181	0.757	100	43.4	LOS D	5.1	37.1	Short	30	0.0	NA
Approach	707	2.1		0.865		33.9	LOS C	21.8	154.6				
West: R062													
Lane 1	157	4.7	337	0.465	100	31.4	LOS C	4.9	35.9	Full	500	0.0	0.0
Lane 2	122	2.6	182	0.670	100	40.8	LOS D	4.4	31.7	Short	50	0.0	NA
Approach	279	3.8		0.670		35.5	LOS D	4.9	35.9				
Intersection	1798	2.3		0.865		28.7	LOS C	21.8	154.6				

LANE SUMMARY

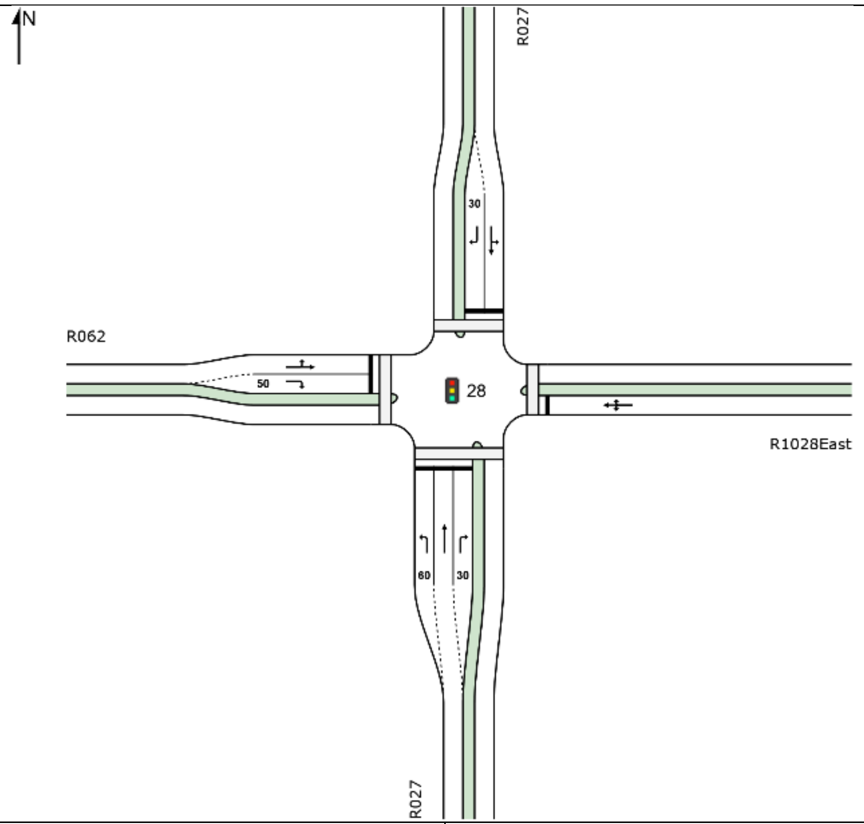
Site: 28 [2041 PM - FINAL]

R1028
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 80 seconds (Site User-Given Cycle Time)

Lane Use and Performance

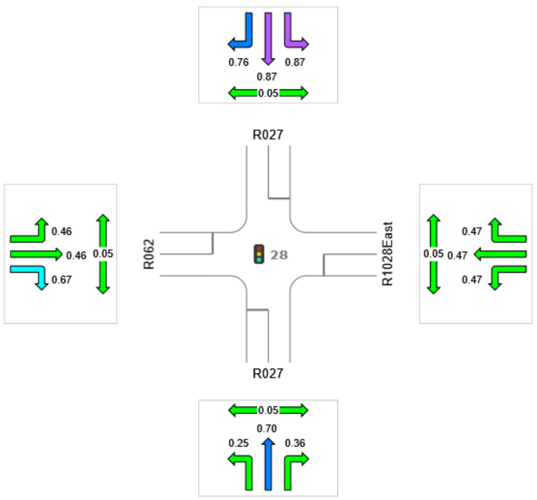
	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	132	1.6	872	0.151	100	12.1	LOS B	1.5	10.8	Short	60	0.0	NA
Lane 2	528	1.4	631 [1]	0.837	100	31.4	LOS C	21.2	150.0	Full	500	0.0	0.0
Lane 3	52	2.0	183	0.282	100	43.4	LOS D	2.0	14.1	Short	30	0.0	NA
Approach	712	1.5		0.837		28.7	LOS C	21.2	150.0				
East: R1028East													
Lane 1	121	1.7	272	0.445	100	30.3	LOS C	3.1	21.8	Full	500	0.0	0.0
Approach	121	1.7		0.445		30.3	LOS C	3.1	21.8				
North: R027													
Lane 1	441	1.9	671	0.657	100	24.2	LOS C	14.6	104.1	Full	500	0.0	0.0
Lane 2	135	3.9	181	0.746	100	47.9	LOS D	5.7	41.1	Short	30	0.0	NA
Approach	576	2.4		0.746		29.7	LOS C	14.6	104.1				
West: R062													
Lane 1	163	2.6	376	0.433	100	34.0	LOS C	5.7	40.7	Full	500	0.0	0.0
Lane 2	191	1.1	230	0.827	100	48.1	LOS D	8.3	58.6	Short	50	0.0	NA
Approach	354	1.8		0.827		41.6	LOS D	8.3	58.6				
Intersection	1762	1.9		0.837		31.7	LOS C	21.2	150.0				

SITE LAYOUT – R1028– 2041



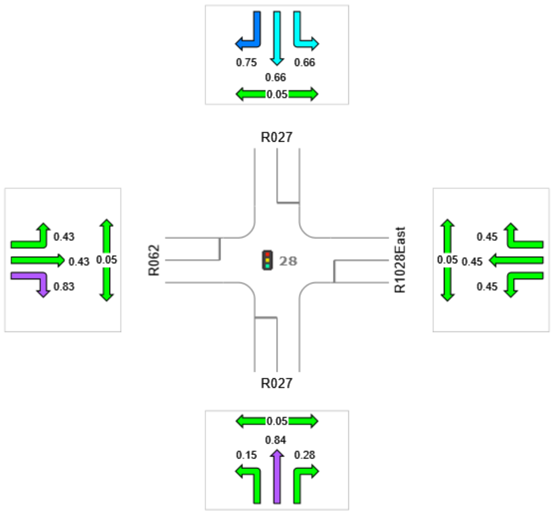
DEGREE OF SATURATION

2041 – AM

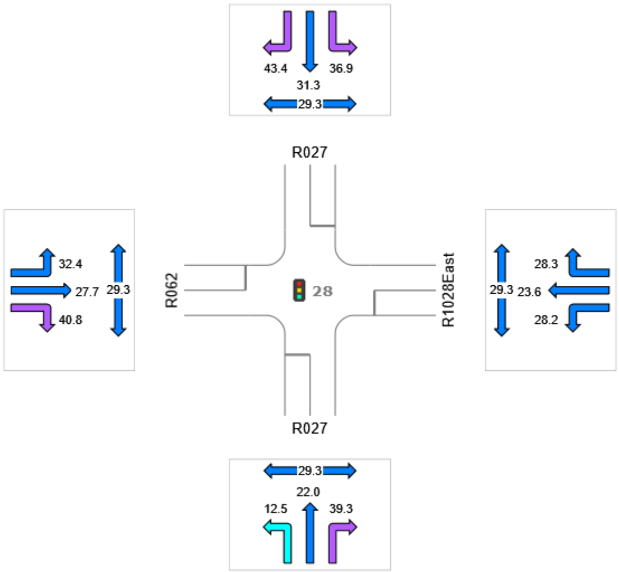


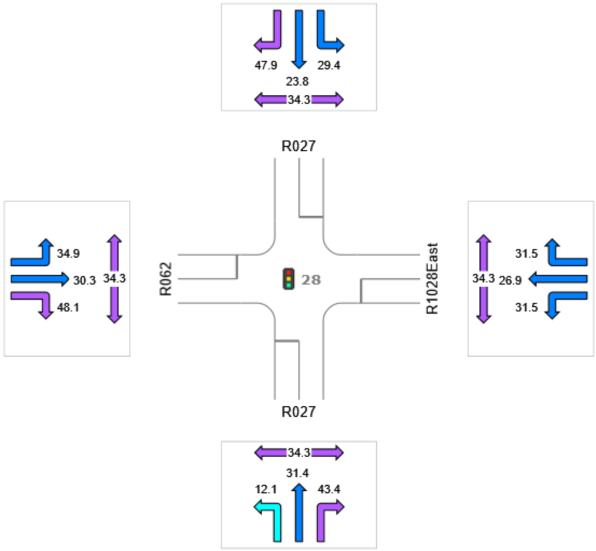
DEGREE OF SATURATION

2041– PM



DELAY (CONTROL)	DELAY (CONTROL)
2041– AM	2041– PM





LANE SUMMARY

Site: 28 [2066 AM - FINAL]

R1028
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 140 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: R027													
Lane 1	148	2.1	941	0.158	100	15.2	LOS B	2.7	19.4	Two Seg 10	500	0.0	0.0
Lane 2	508	3.5	584 1	0.871	100	51.2	LOS D	33.8	243.7	Full	500	0.0	0.0
Lane 3	528	3.5	607 1	0.871	100	51.4	LOS D	35.5	255.6	Full	500	0.0	0.0
Lane 4	76	1.4	289	0.262	100	61.9	LOS E	4.6	32.5	Short	30	0.0	NA

Approach	1261	3.2		0.871		47.7	LOS D	35.5	255.6				
East: R1028East													
Lane 1	123	3.4	313	0.394	100	51.3	LOS D	5.9	42.5	Full	500	0.0	0.0
Approach	123	3.4		0.394		51.3	LOS D	5.9	42.5				
North: R027													
Lane 1	32	3.6	1009	0.031	100	20.2	LOS C	0.9	6.8	Two Seg [10]	500	0.0	0.0
Lane 2	459	2.7	662 [1]	0.692	100	40.6	LOS D	26.3	188.1	Full	500	0.0	0.0
Lane 3	474	2.7	684	0.692	100	41.0	LOS D	27.4	196.4	Full	500	0.0	0.0
Lane 4	246	3.8	284	0.867	100	77.2	LOS E	18.2	131.9	Short	140	0.0	NA
Approach	1211	3.0		0.867		47.7	LOS D	27.4	196.4				
West: R062													
Lane 1	168	6.9	385	0.437	100	54.6	LOS D	10.0	73.9	Full	500	0.0	0.0
Lane 2	84	2.5	287	0.294	100	61.3	LOS E	5.1	36.7	Short	60	0.0	NA
Approach	253	5.4		0.437		56.8	LOS E	10.0	73.9				
Intersection	2847	3.3		0.871		48.7	LOS D	35.5	255.6				

LANE SUMMARY

Site: 28 [2066 PM - FINAL]

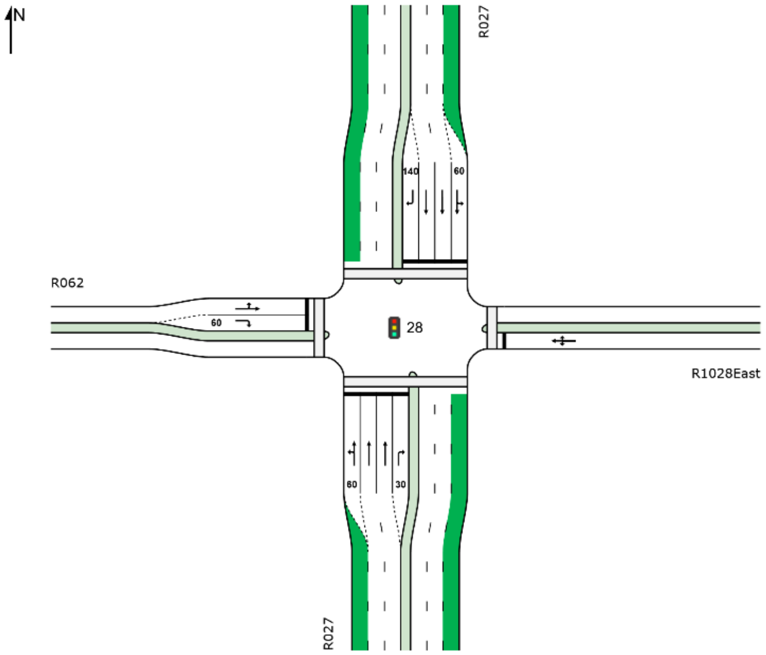
R1028
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	91	2.3	984	0.092	100	13.5	LOS B	1.5	10.8	Two Seg [10]	500	0.0	0.0
Lane 2	425	2.4	674 [1]	0.630	100	34.6	LOS C	21.4	152.7	Full	500	0.0	0.0
Lane 3	409	2.4	649 [1]	0.630	100	34.2	LOS C	20.4	145.5	Full	500	0.0	0.0
Lane 4	55	1.9	211	0.259	100	63.3	LOS E	3.2	23.1	Short	30	0.0	NA
Approach	979	2.4		0.630		34.1	LOS C	21.4	152.7				
East: R1028East													
Lane 1	131	0.8	331	0.394	100	47.3	LOS D	5.5	39.1	Full	500	0.0	0.0
Approach	131	0.8		0.394		47.3	LOS D	5.5	39.1				
North: R027													
Lane 1	32	0.0	1086	0.029	100	17.4	LOS B	0.8	5.7	Two Seg [10]	500	0.0	0.0
Lane 2	510	2.4	702 [1]	0.726	100	36.7	LOS D	27.3	194.8	Full	500	0.0	0.0
Lane 3	526	2.4	724	0.726	100	37.1	LOS D	28.4	203.0	Full	500	0.0	0.0
Lane 4	148	5.7	206	0.721	100	69.0	LOS E	9.6	70.5	Short	140	0.0	NA
Approach	1216	2.8		0.726		40.3	LOS D	28.4	203.0				
West: R062													
Lane 1	265	2.8	444 [1]	0.598	100	50.8	LOS D	14.9	107.0	Full	500	0.0	0.0
Lane 2	137	1.5	297	0.461	100	58.6	LOS E	8.0	56.7	Short	60	0.0	NA

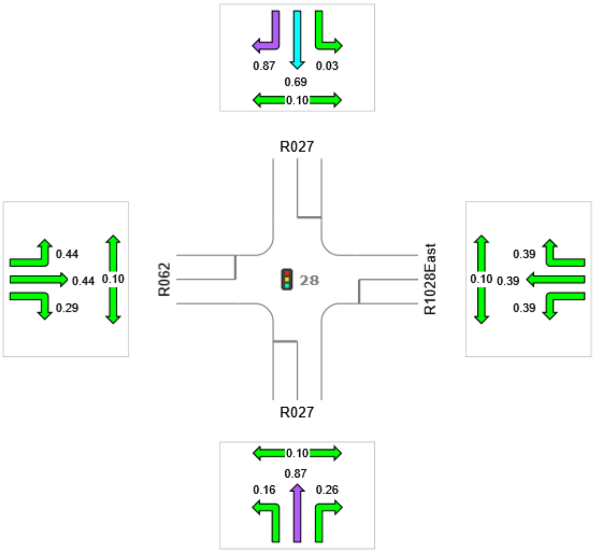
Approach	402	2.4	0.598	53.5	LOS D	14.9	107.0
Intersection	2727	2.5	0.726	40.4	LOS D	28.4	203.0

SITE LAYOUT – R1028– 2066



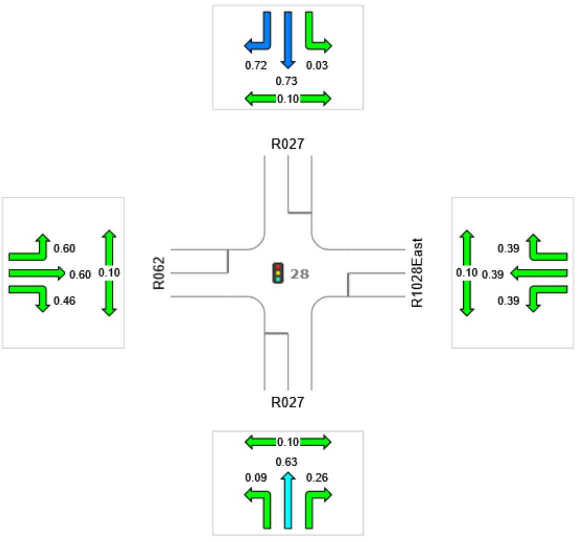
DEGREE OF SATURATION

2066– AM

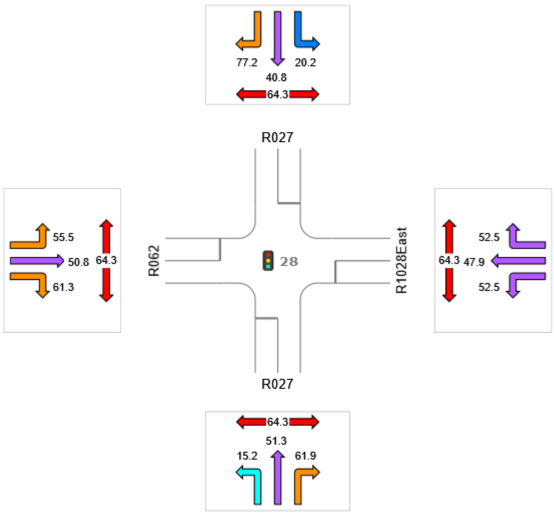


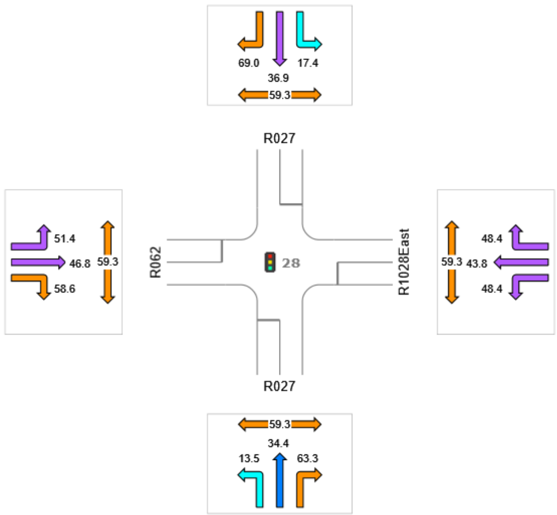
DEGREE OF SATURATION

2066– PM



DELAY (CONTROL)	DELAY (CONTROL)
2066– AM	2066– PM





MOVEMENT SUMMARY

Site: 29v [2031 AM - FINAL]

R1029
Site Category: -
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
South: R027												
2	T1	247	2.1	0.129	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	60.0
3	R2	21	0.0	0.020	7.3	LOS A	0.1	0.6	0.49	0.64	0.49	48.3
Approach		268	2.0	0.129	0.6	NA	0.1	0.6	0.04	0.05	0.04	58.9
East: R1029East												
4	L2	44	0.0	0.132	6.4	LOS A	0.5	3.4	0.57	0.75	0.57	47.1
6	R2	40	0.0	0.132	11.5	LOS B	0.5	3.4	0.57	0.75	0.57	46.7
Approach		84	0.0	0.132	8.8	LOS A	0.5	3.4	0.57	0.75	0.57	46.9
North: R027												
7	L2	34	0.0	0.259	5.6	LOS A	0.0	0.0	0.00	0.04	0.00	58.0
8	T1	466	1.4	0.259	0.0	LOS A	0.0	0.0	0.00	0.04	0.00	59.6
Approach		500	1.3	0.259	0.4	NA	0.0	0.0	0.00	0.04	0.00	59.5
All Vehicles		853	1.4	0.259	1.3	NA	0.5	3.4	0.07	0.11	0.07	57.7

LANE SUMMARY

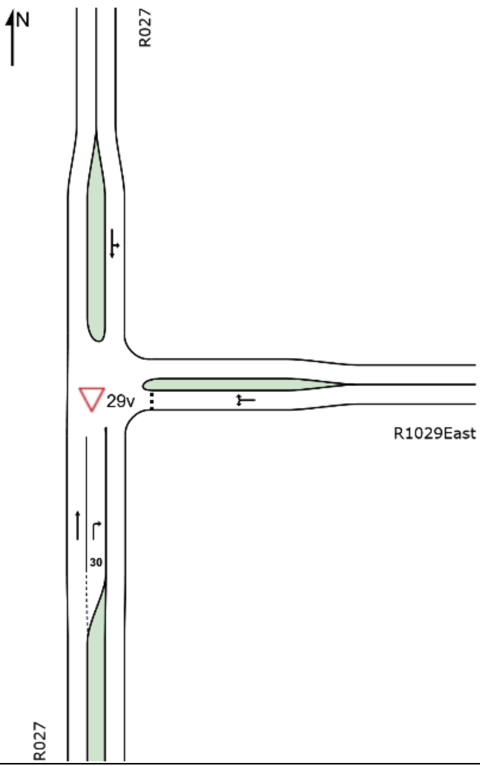
Site: 29v [2031 PM - FINAL]

R1029
Site Category: -
Giveway / Yield (Two-Way)

Lane Use and Performance

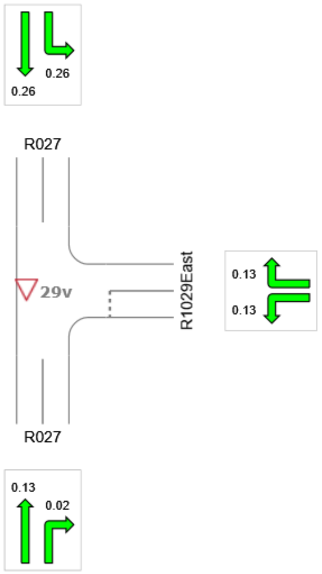
	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	433	1.0	1923	0.225	100	0.0	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	40	0.0	1370	0.029	100	6.4	LOS A	0.1	0.9	Short	30	0.0	NA
Approach	473	0.9		0.225		0.6	NA	0.1	0.9				
East: R1029East													
Lane 1	44	0.0	633	0.070	100	8.6	LOS A	0.3	1.8	Full	500	0.0	0.0
Approach	44	0.0		0.070		8.6	LOS A	0.3	1.8				
North: R027													
Lane 1	291	1.4	1920	0.151	100	0.7	LOS A	0.0	0.0	Full	500	0.0	0.0
Approach	291	1.4		0.151		0.7	NA	0.0	0.0				
Intersection	807	1.0		0.225		1.0	NA	0.3	1.8				

SITE LAYOUT – R1029– 2031



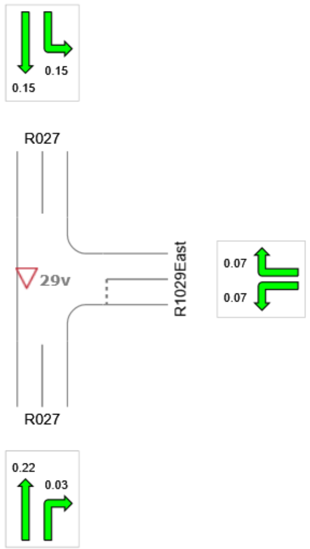
DEGREE OF SATURATION

2031– AM



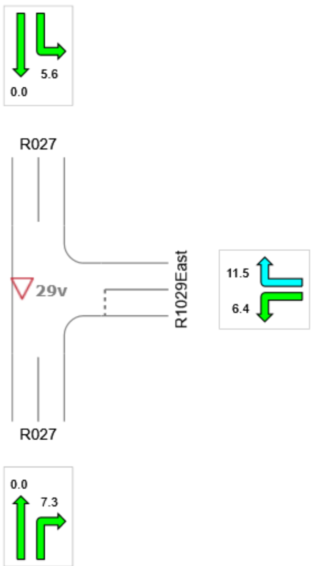
DEGREE OF SATURATION

2031– PM



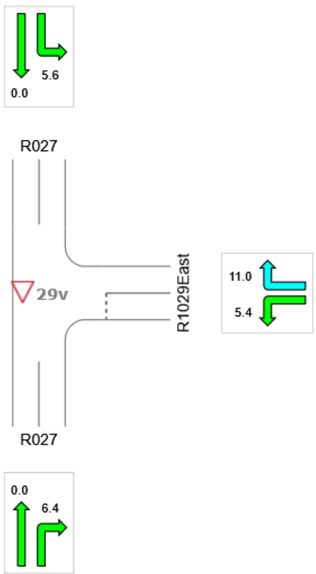
DELAY (CONTROL)

2031– AM



DELAY (CONTROL)

2031– PM



MOVEMENT SUMMARY

Site: 29v [2041 AM - FINAL]

R1029
Site Category: -
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
South: R027												
2	T1	547	2.9	0.288	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
3	R2	15	0.0	0.019	9.0	LOS A	0.1	0.5	0.60	0.73	0.60	47.2
Approach		562	2.8	0.288	0.3	NA	0.1	0.5	0.02	0.02	0.02	59.5
East: R1029East												
4	L2	27	0.0	0.520	15.3	LOS C	2.2	15.4	0.90	1.08	1.30	36.8
6	R2	80	2.6	0.520	35.8	LOS E	2.2	15.4	0.90	1.08	1.30	36.4
Approach		107	2.0	0.520	30.6	LOS D	2.2	15.4	0.90	1.08	1.30	36.5
North: R027												
7	L2	48	4.3	0.386	5.6	LOS A	0.0	0.0	0.00	0.04	0.00	57.7
8	T1	691	2.0	0.386	0.1	LOS A	0.0	0.0	0.00	0.04	0.00	59.5
Approach		739	2.1	0.386	0.4	NA	0.0	0.0	0.00	0.04	0.00	59.4
All Vehicles		1408	2.4	0.520	2.7	NA	2.2	15.4	0.07	0.11	0.11	56.7

MOVEMENT SUMMARY

Site: 29v [2041 PM - FINAL]

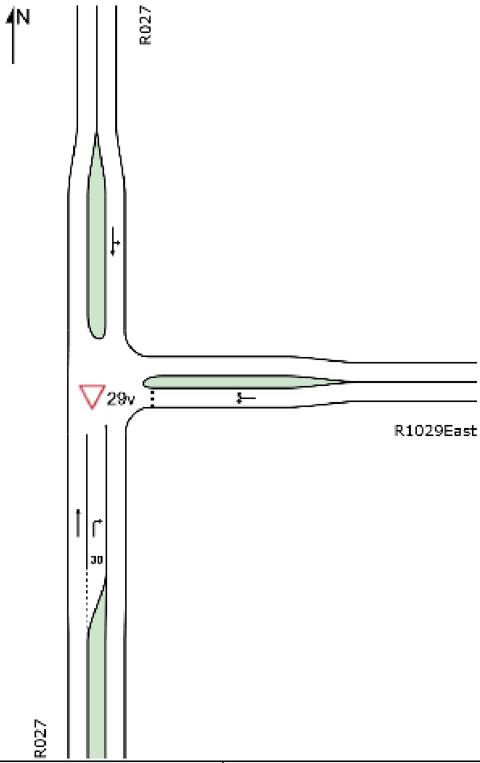
R1029
Site Category: -
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed
		veh/h	%	v/c	sec		veh	m				km/h
South: R027												
2	T1	674	1.7	0.352	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	59.9
3	R2	23	0.0	0.025	8.1	LOS A	0.1	0.7	0.55	0.70	0.55	47.8
Approach		697	1.7	0.352	0.3	NA	0.1	0.7	0.02	0.02	0.02	59.4
East: R1029East												
4	L2	15	0.0	0.260	8.5	LOS A	0.9	6.5	0.84	0.95	0.94	39.6
6	R2	40	5.3	0.260	29.0	LOS D	0.9	6.5	0.84	0.95	0.94	39.2
Approach		55	3.8	0.260	23.5	LOS C	0.9	6.5	0.84	0.95	0.94	39.3
North: R027												
7	L2	72	2.9	0.323	5.6	LOS A	0.0	0.0	0.00	0.07	0.00	57.6

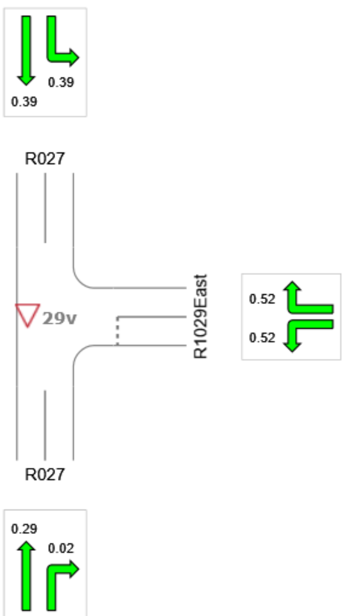
8	T1	546	2.1	0.323	0.0	LOS A	0.0	0.0	0.00	0.07	0.00	59.3
Approach		618	2.2	0.323	0.7	NA	0.0	0.0	0.00	0.07	0.00	59.1
All Vehicles		1369	2.0	0.352	1.4	NA	0.9	6.5	0.04	0.08	0.05	58.1

SITE LAYOUT – R1029– 2041



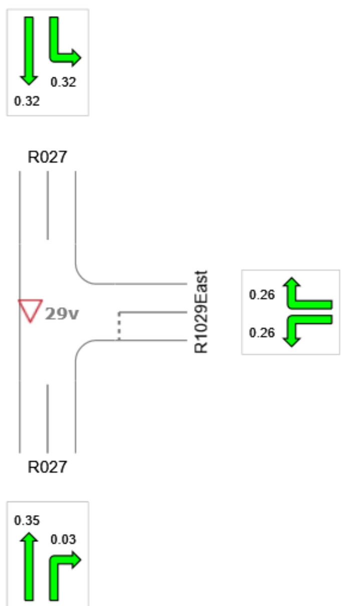
DEGREE OF SATURATION

2041– AM



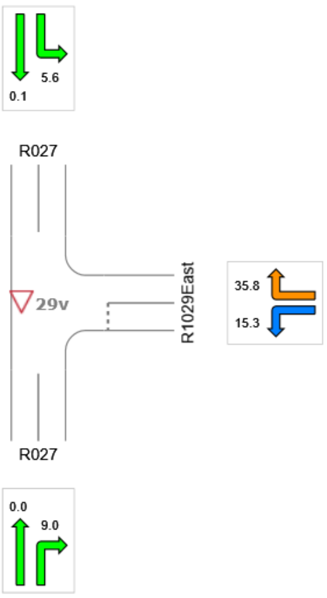
DEGREE OF SATURATION

2041– PM



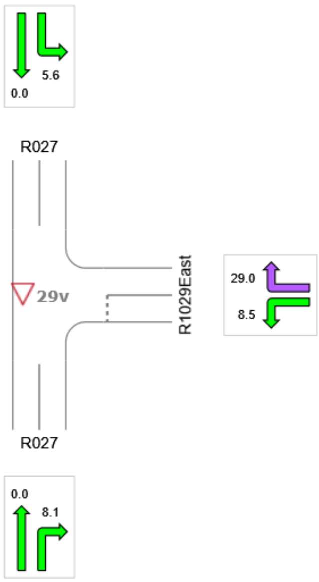
DELAY (CONTROL)

2041– AM



DELAY (CONTROL)

2041– PM



LANE SUMMARY

Site: 29 [2066 AM]

R1029
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 90 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	3	100.0	801	0.004	100	4.9	LOS A	0.0	0.6	Full	500	0.0	0.0
Lane 2	593	4.0	1288	0.461	100	7.2	LOS A	12.1	87.3	Full	500	0.0	0.0
Lane 3	580	4.0	1259 [1]	0.461	100	7.1	LOS A	11.7	84.5	Full	500	0.0	0.0
Lane 4	15	0.0	124	0.119	100	50.6	LOS D	0.6	4.5	Short	30	0.0	NA
Approach	1192	4.2		0.461		7.7	LOS A	12.1	87.3				
East: R1029East													
Lane 1	105	2.0	346	0.304	100	39.2	LOS D	4.1	29.0	Full	500	0.0	0.0
Approach	105	2.0		0.304		39.2	LOS D	4.1	29.0				
North: R027													
Lane 1	47	11.1	945	0.050	100	15.0	LOS B	1.0	7.3	Two Seg [10]	500	0.0	0.0
Lane 2	591	2.9	1029 [1]	0.574	100	14.5	LOS B	17.0	122.0	Full	500	0.0	0.0
Lane 3	599	2.9	1042	0.574	100	14.5	LOS B	17.3	124.3	Full	500	0.0	0.0
Approach	1237	3.2		0.574		14.5	LOS B	17.3	124.3				

Intersection	2534	3.7		0.574	12.3	LOS B	17.3	124.3

LANE SUMMARY

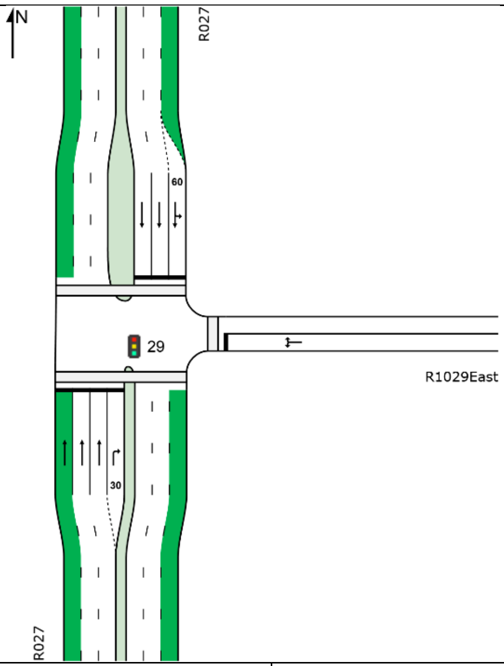
Site: 29 [2066 PM]

R1029
Site Category: -
Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site Optimum Cycle Time - Minimum Delay)

Lane Use and Performance

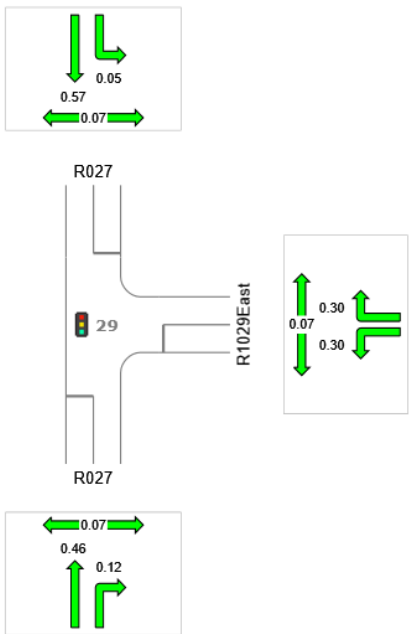
	Demand Flows Total	Demand Flows HV	Cap.	Deg. Satn	Lane Util.	Average Delay	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist	Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	veh/h	%	veh/h	v/c	%	sec			m		m	%	%
South: R027													
Lane 1	3	100.0	882	0.004	100	4.4	LOS A	0.0	0.6	Full	500	0.0	0.0
Lane 2	551	2.5	1431	0.385	100	6.2	LOS A	12.1	86.7	Full	500	0.0	0.0
Lane 3	527	2.5	1369 [1]	0.385	100	6.1	LOS A	11.4	81.5	Full	500	0.0	0.0
Lane 4	25	0.0	86	0.295	100	74.4	LOS E	1.7	11.6	Short	30	0.0	NA
Approach	1106	2.8		0.385		7.7	LOS A	12.1	86.7				
East: R1029East													
Lane 1	55	0.0	300	0.182	100	55.7	LOS E	3.0	21.2	Full	500	0.0	0.0
Approach	55	0.0		0.182		55.7	LOS E	3.0	21.2				
North: R027													
Lane 1	71	4.5	1184	0.060	100	13.5	LOS B	1.6	11.4	Two Seg [10]	500	0.0	0.0
Lane 2	584	2.8	1219 [1]	0.479	100	11.8	LOS B	18.0	129.3	Full	500	0.0	0.0
Lane 3	599	2.8	1252	0.479	100	11.9	LOS B	18.7	134.4	Full	500	0.0	0.0
Approach	1254	2.9		0.479		12.0	LOS B	18.7	134.4				
Intersection	2415	2.8		0.479		11.0	LOS B	18.7	134.4				

SITE LAYOUT – R1029– 2066



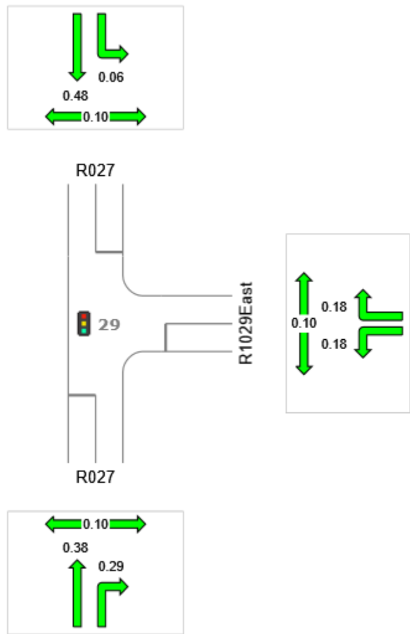
DEGREE OF SATURATION

2066– AM



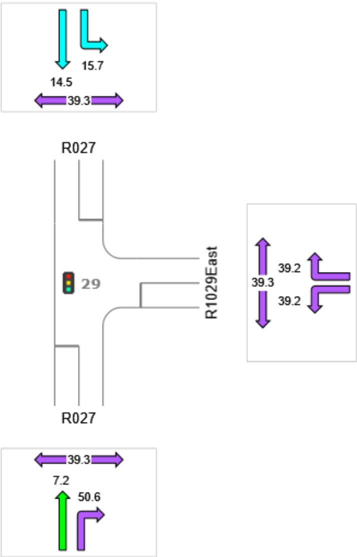
DEGREE OF SATURATION

2066– PM



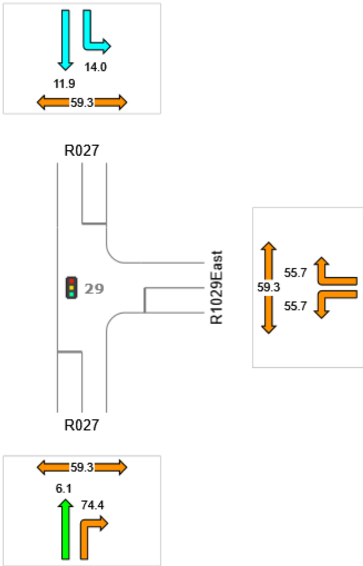
DELAY (CONTROL)

2066– AM



DELAY (CONTROL)

2066– PM



Appendix E Demographic analysis

SGS Economics & Planning

DEMOGRAPHIC ANALYSIS FOR THREE PRIORITY DEVELOPMENT AREAS

FINAL REPORT
FEBRUARY 2020

Prepared for
Economic Development Queensland - DSDMIP

Independent insight.

SGS Economics and Planning Pty Ltd
ACN 007 437 729
www.sgsep.com.au
Offices in Canberra, Hobart, Melbourne, Sydney

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GLOSSARY

CBD	Central Business District
CHaPs	Community Hubs and Partnerships
DoE	Department Education
DSDMIP	Queensland Department of State Development, Infrastructure and Planning
EDQ	Economic Development Queensland
ICC	Ipswich City Council
ICOP	Infrastructure Charging and Offsets Plan
PDA	Priority Development Area
QGSO	Queensland Government Statisticians Office
SA2	Statistical Area 2
SEQ	South East Queensland
ShapingSEQ	ShapingSEQ Regional Plan
TMR	Department of Transport and Main Roads

Version Control

Report Version	Date Provided	File Name
Final Report v3	05/02/2020	*20190482 Demographic Analysis – Final Report 200205.docx*
Final Report v2	15/01/2020	*20190482 Demographic Analysis – Final Report 200115.docx*
Final Report v1	20/12/2019	*20190482 Demographic Analysis – Final Report 201219.docx*
Draft Report	10/12/2019	*20190482 PDA Demographic Analysis – Final Report 101219.docx*

EXECUTIVE SUMMARY

This report provides land use projections for the Greater Flagstone, Yarrabilba and Ripley Valley Priority Development Areas (PDA).

The land use projections have been produced by a method that combines a 'top down' approach with a 'bottom up' approach ensuring that all relevant information is used to produce a robust set of projections.

The key 'top down' data input is the South East Queensland population projections produced by SGS. The 'bottom up' input data, includes Census data, building approvals data, information from developers, transport model land use data as well as State Government and Council population projections.

Each of these datasets has its own strengths and weakness. For example, SGS has applied an annual reduction to the dwelling's yields provided by developers (informed by the SGS South East Queensland population projection model). Effectively, the developers appear slightly optimistic about the number of dwellings they could sell each year. This small reduction means that the SGS expects the various PDAs will be fully built out around 5 years later than previously expected.

Key statistics (rounded to the nearest thousand) for each PDA are:

- Greater Flagstone (2066)
  - Dwellings – 54,000
  - Population – 145,000
  - Employment – 34,000
- Yarrabilba (2066)
  - Dwellings – 19,000
  - Population – 53,000
  - Employment – 13,000
- Ripley Valley (2066)
  - Dwellings – 50,000
  - Population – 135,000
  - Employment – 14,000

1. INTRODUCTION

1.1 Project scope

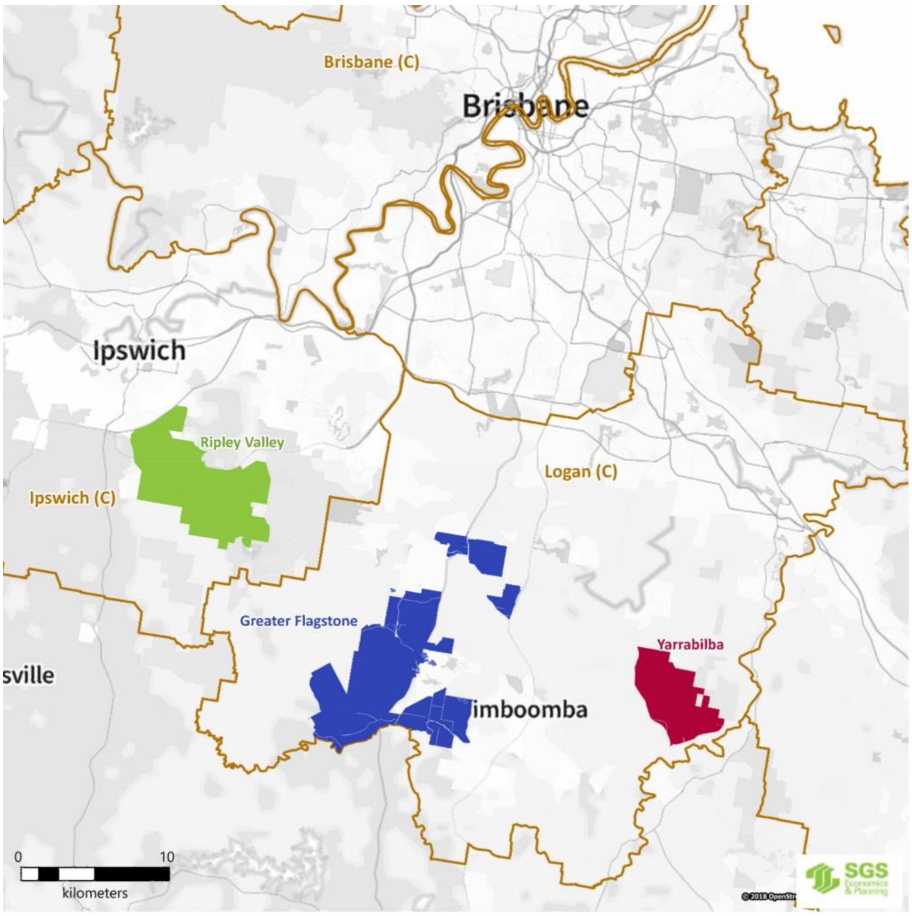
This report provides updated demographic forecasts of dwellings, population and employment for the Greater Flagstone, Yarrabilba and Ripley Valley Priority Development Areas (PDA).

These forecasts are informed by existing population growth assumptions and employment projections produced by Logan City Council (Logan CC), Ipswich City Council, VLC and Jacobs transport modelling as well as Queensland Government Statisticians Office (QGSO) 2018 forecasts, the ShapingSEQ Regional Plan (ShapingSEQ) and individual feedback from developers. SGS has also conducted a review of the most recent data available for each PDA, including the recent ABS building approvals data, to inform the forecasts.

1.2 Study area

The project study area is defined as the three priority development areas (PDAs) of Greater Flagstone, Yarrabilba and Ripley Valley. These are shown on Figure 1 below.

FIGURE 1: MAP OF STUDY AREA



Source: SGS Economics and Planning

1.3 Disclaimer

This report and associated data form a confidential document that has been prepared by SGS Economics & Planning Pty Ltd (SGS). This model has been provided at the request of the Queensland Department of State Development, Infrastructure and Planning (DSDMIP) in relation to Greater Flagstone, Yarrabilba and Ripley Valley Demographic Analysis ('the Project').

The analysis contained in this model has been prepared by SGS based on SGS' own information, as well as information provided by DSDMIP.

No verification of the information provided by DSDMIP or other third parties has been carried out by SGS, and in particular, SGS has not undertaken any review of the information supplied or made available during the course of the engagement. This model does not purport to contain all the information DSDMIP may require in considering the Project.

SGS has based this report on the assumption that the information received or obtained is accurate and, where it is represented by management as such, complete. SGS makes no express or implied representation or warranty as to the accuracy, reliability or completeness of the information provided.

SGS may in its absolute discretion, but without being under any obligation to do so, update or adjust this model, or any inputs that are used within this model.

SGS will not provide any express or implied opinion (and assumes no responsibility) as to whether actual results will be consistent with, or reflect the results of, any of the outputs generated by this model.

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This model is for the sole use of DSDMIP in assisting with the decision-making process relating to the Project. All information contained in this model is strictly confidential and must not be copied, reproduced, distributed, disseminated or used, in whole or in part, for any purpose other than as detailed above without SGS' explicit written permission.

1.4 Report structure

This report is structured as follows:

- Chapter 2 Methodology – outlines the approach used to produce demographic forecasts for each PDA
- Chapter 3 Greater Flagstone – provides a comparison of existing forecasts and SGS' forecasts for this PDA
- Chapter 4 Yarrabilba – provides a comparison of existing forecasts and SGS' forecasts for this PDA
- Chapter 5 Ripley Valley – provides a comparison of existing forecasts and SGS' forecasts for this PDA
- Appendices – includes further detail on each developer area within each of the PDAs

2. METHOD OVERVIEW

This section briefly describes the method used to produce forecasts of dwellings, population and employment for each priority development area (PDA).

These dwelling, population and employment projections are the result of our method that combines a 'top down' approach with a 'bottom up' approach to ensure that all relevant information is used to produce a set of land use projections.

The key 'top down' data input is the South East Queensland (SEQ) population projections produced by SGS. These account for the total demand for future housing and where that housing is likely to take place. These are informed by State Government and Australian Bureau of Statistics (ABS) population projections and relevant data on the economic performance of SEQ.

The 'bottom up' input data includes Census data, building approvals data, information from developers in the PDAs, Council population projections and transport model land use data. Each of these datasets has its own strengths and weaknesses, which have been assessed.

These various data sources are brought together to create a coherent view of the growth in dwellings, population and employment over the next 50 years.

Some of the key aspects and assumptions of our 'top down' approach with a 'bottom up' methodology are summarised below.

2.1 Dwellings

The **ultimate dwelling yield** has been estimated as the total number of potential dwellings in each PDA at full build out. The ultimate dwelling yield is based around the expected dwelling densities and the amount of net developable land. Full build out is assumed to be 2066 for Greater Flagstone, 2056 for Yarrabilba and 2066 for Ripley Valley.

Forecast **dwelling timing** between 2019 and 2031 has been informed by the feedback provided by developers for each developer area, as shown on the map in Figure 1.

In Greater Flagstone and Yarrabilba SGS has applied a 5 per cent reduction to the total dwelling yield in each year to account for the likelihood that not all of the dwellings planned by developers are achieved in that year. This reduction was informed by SGS' SEQ population projection model which assesses potential residential growth across the whole of SEQ. Effectively, this means that developers are slightly optimistic (5 per cent) about the number of dwelling they could sell each year.

In Ripley Valley SGS has used recent dwelling approvals, developer feedback data (where available) and assumptions on the timing of development to estimate total dwellings in this PDA.

2.2 Population

The population projection is based on the applying an average person per household to the dwelling projections.

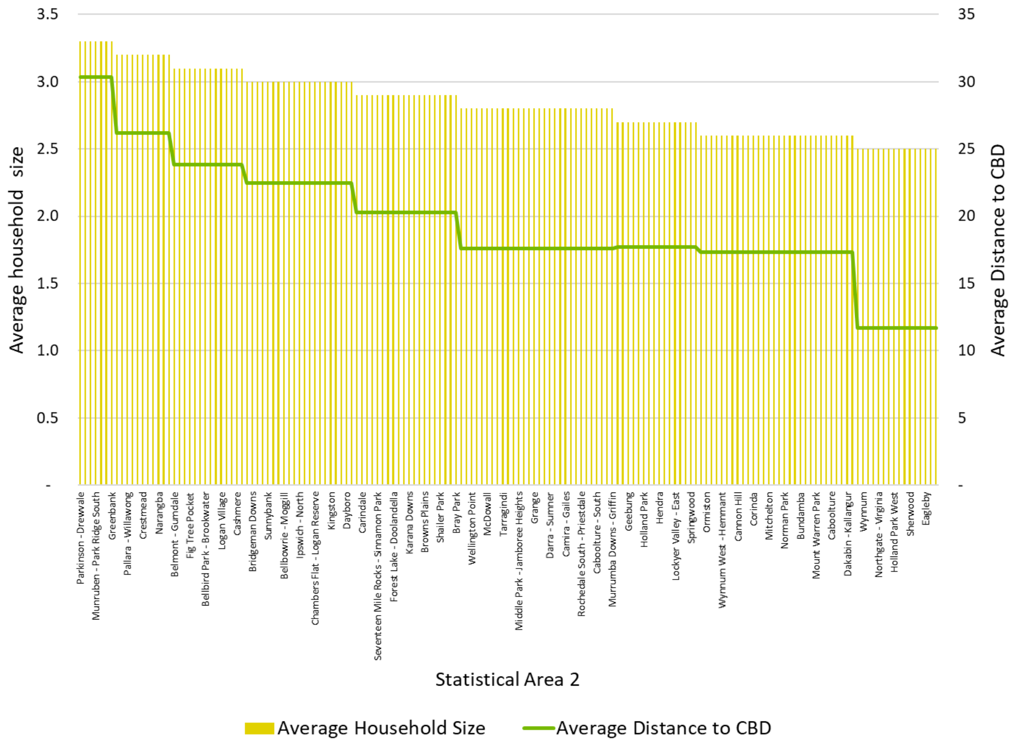
This has been informed by the **dwelling mix** based on Council forecasts of attached and detached dwellings, and the average household size expected in a greenfield area adjusted to account for variations in dwelling mix (e.g. detached houses or medium density).

Figure 2 presents the average distance to Brisbane CBD for each SA2 within each average household size grouping. The purpose of this figure is to illustrate that, in general, as distance to the CBD increases, the average household size increases[1]. Locations like Springfield, Coomera and North Lakes all have average household sizes between 3.0-3.2 persons per household.

For an area like Yarrabilba, Greater Flagstone and Ripley Valley, an average household size of around 3.0 could be expected. This will vary within the PDAs as some areas will have larger or smaller dwellings.

This analysis is supported by the average household size used by VLC and Logan City Council (Greater Flagstone and Yarrabilba) or Jacobs and Ipswich City Council (Ripley Valley). In the long term, the average person per household does decline as the first generation of children born in the PDA, move out of home and their parents remain. Although even in the later years of the analysis the PDA average person per households is still above State average of 2.6.

FIGURE 2: AVERAGE HOUSEHOLD SIZE BY THE AVERAGE DISTANCE TO THE CBD SELECTED SA2



Source: SGS Economic and Planning from ABS Census data 2016

The age profile is derived from the population projection. After a review by SGS, the QGSO projections for share of population in each age group was used to create the age breakdowns.

[1] This figure compares the average household size of the SA2 with the average distance of the SA2 from the CBD, not the actual distance. For example, the average household size of Dakabin-Kallangur SA2 is 2.6 persons per households. Typically, areas with an average household size of 2.6 persons are located 17km from the CBD, which is closer than the actual distance of the SA2 to the CBD. This illustrates that Dakabin-Kallangur SA2 has a lower household size than other SA2s of a similar distance from the CBD.

2.3 Employment

The bulk of the employment which will be located in the PDAs will be population serving. To produce a projection of future employment, a set of job to population ratios have been utilised and applied to the projected population.

Table 1 presents the assumed employment growth for population serving industries which have been used for the PDAs (which are based on the historical averages for greenfield areas). Using these numbers, the rate of employment growth is between 0.6 to 0.7 jobs per new household in Greater Flagstone and Yarrabilba, and 0.3 jobs per new household in Ripley Valley.

TABLE 1: POPULATION SERVING EMPLOYMENT ASSUMPTIONS

Industry	Jobs per 1000 new residents	
	Greater Flagstone & Yarrabilba	Ripley Valley
Construction	20	22
Retail Trade	20	20
Accommodation and Food Services	15	9
Financial and Insurance Services	5	1
Rental, Hiring and Real Estate Services	7	4
Professional, Scientific and Technical Services	25	26
Administrative and Support Services	10	9
Public Administration and Safety	15	12
Education and Training	30	22
Health Care and Social Assistance	75	34
Arts and Recreation Services	9	1
Other Services	3	5
Total Population Serving Employment	**234**	**165**

Source: SGS Economics and Planning, based on ABS Census (1996 – 2016)

3. GREATER FLAGSTONE

This chapter provides a comparison of existing forecasts produced for Greater Flagstone and SGS' forecasts for the PDA.

3.1 Dwellings

Total occupied private dwellings have been forecast for Greater Flagstone, and each of the developer areas within the PDA. The following section compares previous forecasts prepared by Logan CC and VLC, along with our own analysis of developer feedback data and recent development trends in the region.

Comparison of existing forecasts

Table 2 below highlights the variation in dwelling forecasts for the City of Logan between the State Government's ShapingSEQ, QGSO 2018 projections, Council's own figures as well as VLC's Strategic Transport Modelling for the LGA. The values for 2016 vary slightly, whereas the variation increases for projections at 2041 and 2061. Logan CC and the ShapingSEQ forecast similar dwelling numbers in 2041, with 198,000 dwellings. The 2061 forecast varies by 5,545 dwellings between Logan CC and VLC. ShapingSEQ and QGSO do not currently have forecasts specific to the PDA for 2061.

TABLE 2: LOGAN LOCAL GOVERNMENT AREA DWELLING FORECASTS

Projection Source	2016	2041	2061	Growth 2016 – 2061
ShapingSEQ	108,770	198,670	N/A	N/A
QGSO 2018 Projections	108,770	192,533	N/A	N/A
Logan City Council	111,484	198,579	292,498	181,014
VLC Forecasts	110,216	196,593	286,953	176,737

Source: ShapingSEQ, Logan City Council, VLC Transport Modelling, QGSO Forecasts 2018

Feedback was received from each developer in Greater Flagstone on their 'realistic' and 'aspirational' dwelling yields per year to 2031. These are summarized in Table 3 below (Further information available in Appendix 1). Annual dwelling yield is expected to be between 44 and 365 dwellings per year across the developer areas in Greater Flagstone.

This information has been used to inform SGS' dwelling forecasts, specifically the timing and location of dwelling growth to 2031. In some cases, data was provided on the dwelling mix (detached vs attached dwellings), and where relevant this has been used to inform the population projections in the following chapter.

This reduction was informed by SGS SEQ population projection model which assessing potential residential growth across the whole of the SEQ. Effectively, this means that developers were slightly optimistic (5 per cent[2]) about the number of dwellings they could sell each year.

[2] Although this 5 per cent varies from year to year, hence there isn't a constant 5 per cent reduction applied to all developer areas in all year.

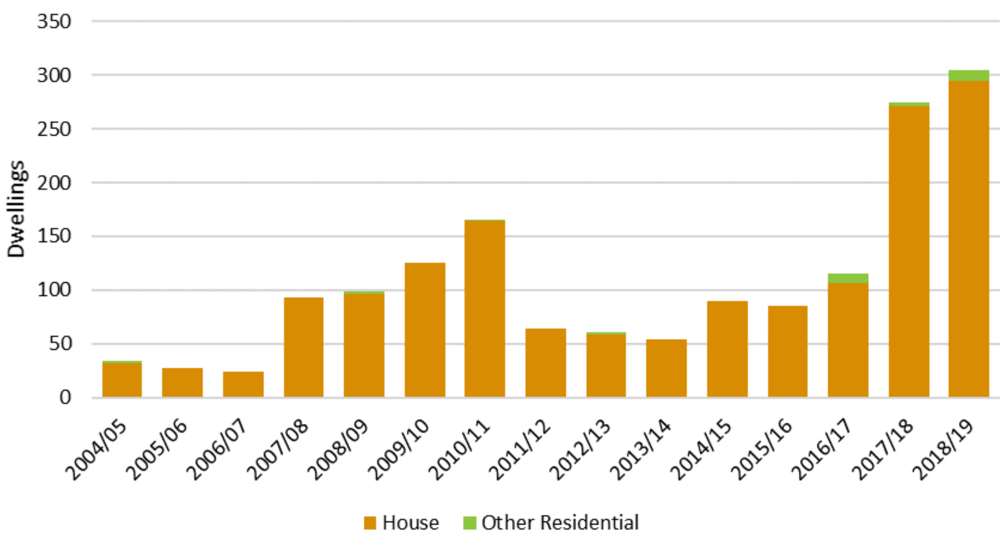
TABLE 3: GREATER FLAGSTONE DEVELOPER – EXPECTED DWELLINGS IN 2031

Developer Area	Realistic 2031 Dwellings	Realistic Dwellings per year	Aspirational 2031 Dwellings	Aspirational Dwellings per year
Celestino	875	67	1,900	146
Mirvac	2,701	265	2,961	291
Peet Flagstone City	4,751	365	6,500	500
Pioneer Fortune	1,399	108	1,749	135
Wilsons New Beith	569	44	946	73
Flinders Land Holdings	3,357	258	4,465	343
Villa Green	1,502	116	1,502	116
Total	**15,154**	**1,223**	**20,023**	**1,604**

Source: Greater Flagstone Developers 2019

The following chart shows recent building approvals for Greenbank SA2, representing Greater Flagstone. It should be noted Greater Flagstone covers approximately one quarter of the Greenbank SA2 and a small component of the Jimboomba SA2. Recent data shows that between 250 to 300 dwellings have been approved per year. Recent development in the Greater Flagstone PDA has been slow, with issues relating to infrastructure provision delaying residential development.

FIGURE 3: RECENT BUILDING APPROVALS GREATER FLAGSTONE (GREENBANK SA2)



Source: ABS Dwellings Approvals 2018/19

SGS forecasts

Table 4 shows the dwelling forecasts for the Greater Flagstone prepared by SGS, compared to those prepared by Logan CC and VLC. SGS forecasts total dwellings in Greater Flagstone PDA to reach 54,000 dwellings at ultimate development in 2066. This is broadly in line with Logan CC and VLC forecasts for 2061. By 2066 it is expected that 19 per cent of dwellings in Logan LGA will be located in Greater Flagstone.

SGS forecasts in 2041 are slightly higher than VLC and Logan CC forecasts due to the different datasets and assumptions used by SGS. As shown in Figure 4, SGS forecasts are slightly above the VLC and Logan CC forecasts up to 2046, due to the use of developer feedback data. Beyond 2046 SGS forecasts are lower than VLC and Logan CC as development is expected to occur at a slower rate, with both reaching 54,000 dwellings by 2066.

These forecasts assume that major infrastructure would have been provided and a number of sub-precincts would have been planned and activated.

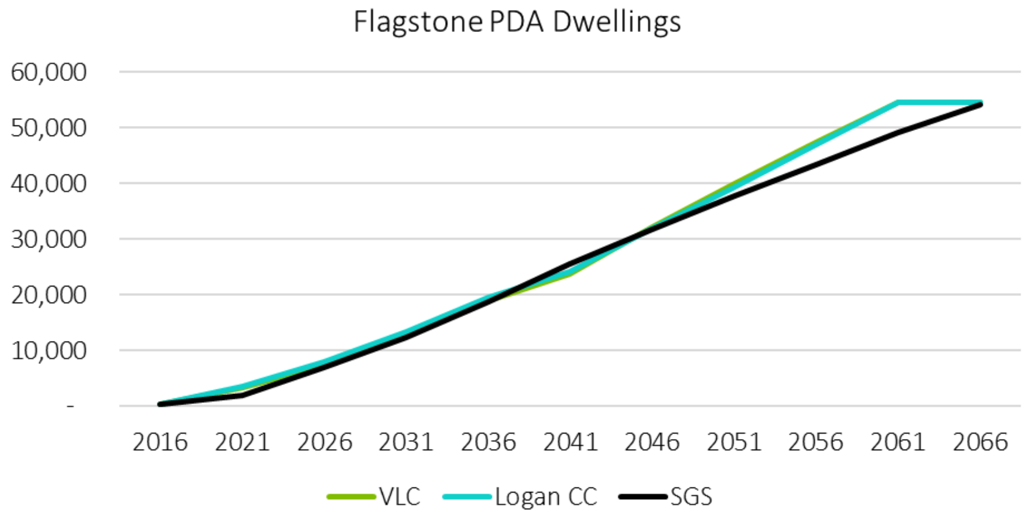
TABLE 4: GREATER FLAGSTONE PDA DWELLING FORECASTS

Projection Source	2016	2041	2066	Growth 2016 – 2066
SGS	236	25,484	54,145	53,910
Logan City Council	272	24,182	54,597*	54,325*
VLC	248	23,683	54,586*	54,338*

Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

* Note These are 2061 estimates

FIGURE 4: GREATER FLAGSTONE PDA DWELLING FORECASTS



Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

Table 5 presents SGS' forecasts of dwellings by developer area within the Greater Flagstone PDA. Areas with the largest forecast dwellings include Peet Flagstone City, Pioneer Fortune, Wilsons New Beith, Flinders Land Holdings, Celestino and Mirvac.

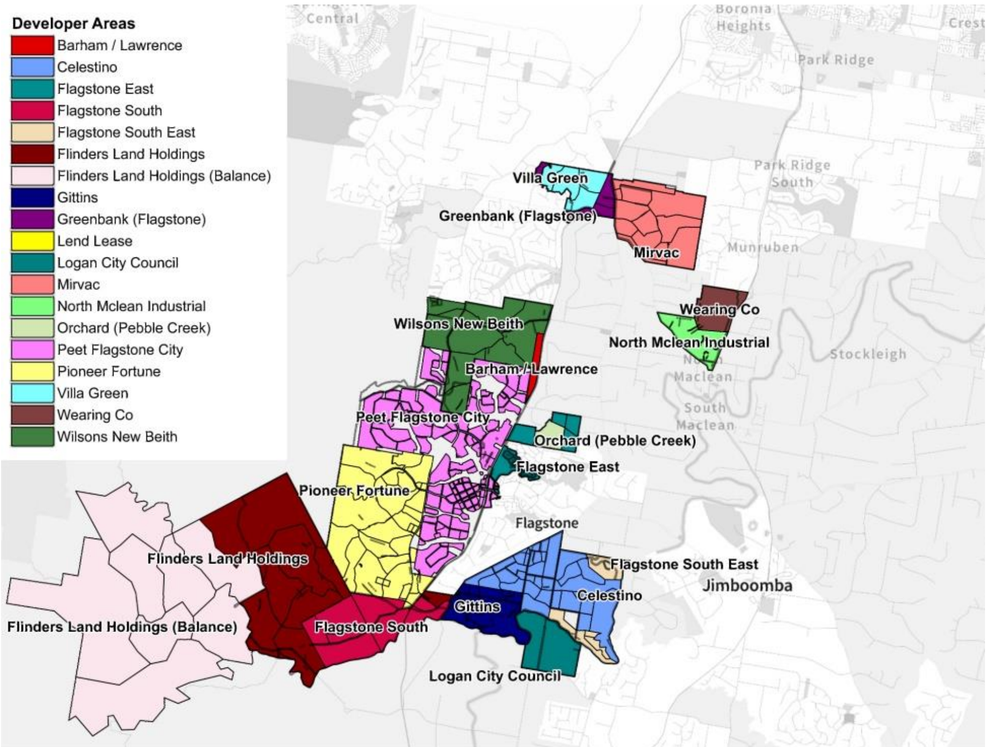
These forecasts have been informed by the developer feedback provided by each of the large developers on their realistic and aspirational dwelling yields to 2031.

TABLE 5: GREATER FLAGSTONE PDA DWELLING FORECASTS BY DEVELOPER AREA

Developer Area	2016	2041	2066	Growth 2016 – 2061
Celestino	-	2,807	6,643	6,643
Mirvac	-	3,018	3,114	3,114
Peet Flagstone City	-	6,581	14,121	14,121
Pioneer Fortune	-	2,920	7,533	7,533
Wilsons New Beith	-	3,219	7,463	7,463
Flinders Land Holdings	-	4,398	7,673	7,673
Villa Green	-	1,411	1,427	1,427
Gittins	-	-	1,861	1,861
Flagstone East	149	481	1,046	897
Flagstone South	8	8	2,377	2,369
Flagstone South East	54	64	301	247
Greenbank (Flagstone)	10	12	13	3
Logan City Council	1	1	1	0
North Mclean Industrial	12	12	13	1
Orchard (Pebble Creek)	-	552	558	558
Wearing Co	1	1	1	0
Barham / Lawrence	-	-	-	-
Total Greater Flagstone PDA	235	25,485	54,145	53,910

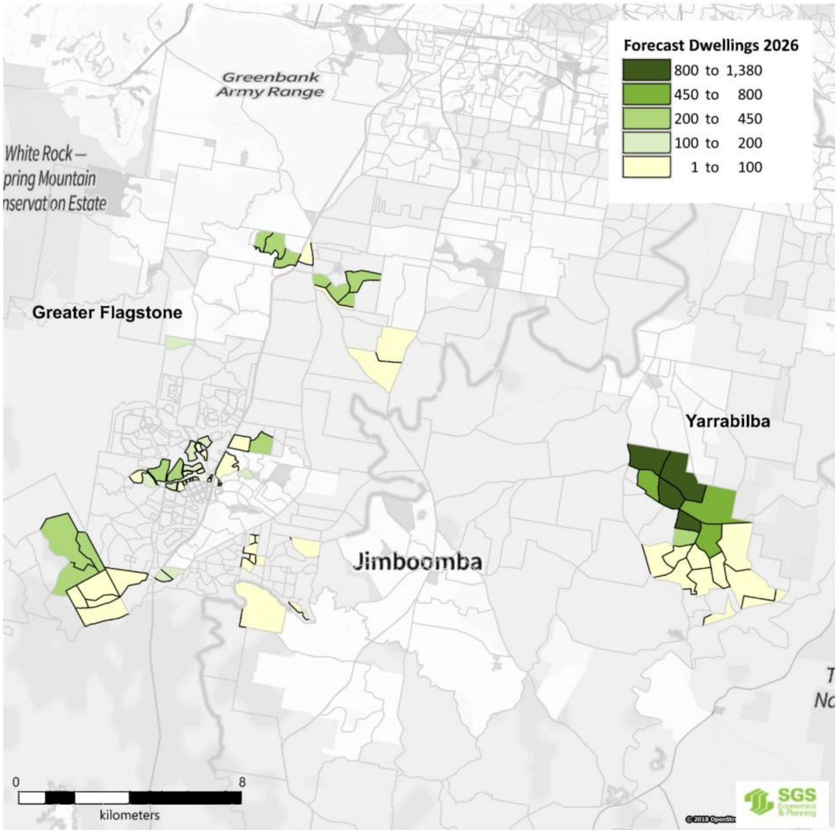
Source: SGS Economics and Planning 2019

FIGURE 5: GREATER FLAGSTONE PDA DEVELOPER AREAS



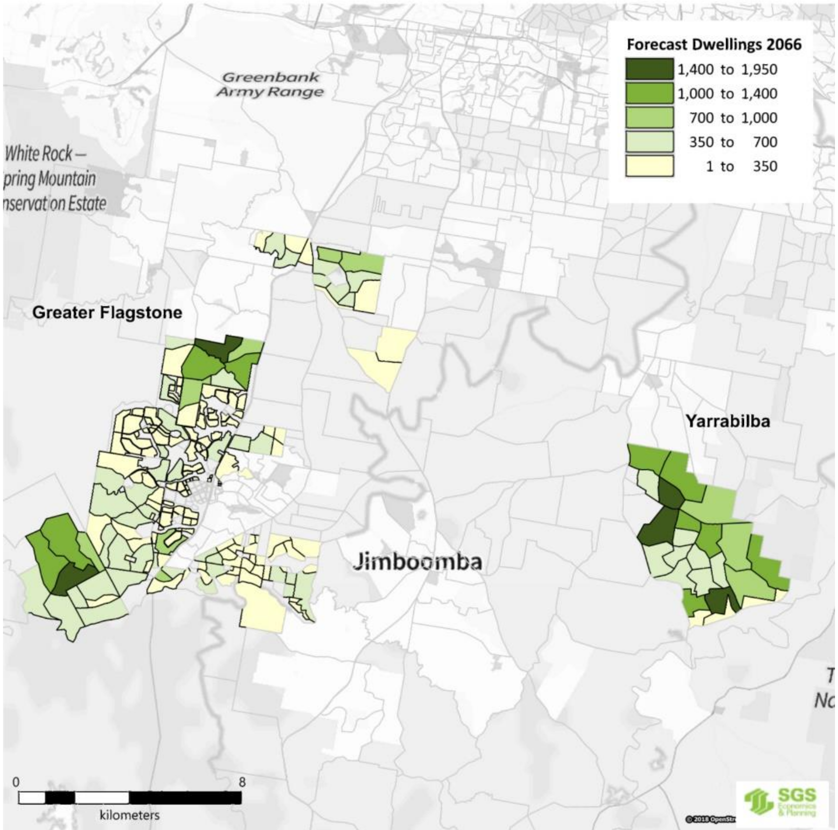
Source: DSDMIP Economic Development Queensland

FIGURE 6: GREATER FLAGSTONE PDA DWELLING FORECASTS 2026



Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

FIGURE 7: GREATER FLAGSTONE PDA DWELLING FORECASTS 2066



Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

3.2 Population

Comparison of existing forecasts

Table 6 below highlights the variation in population forecasts for the City of Logan between ShapingSEQ, QGSO 2018 projections, Council's own figures as well as VLC's Strategic Transport Modelling for the area. While values are similar in 2016, there is considerable variation in forecasts for 2041. Logan CC and VLC have the same values whereas QGSO and ShapingSEQ are projecting more people in the Logan LGA by 2041 (i.e. a faster rate of population growth).

TABLE 6: LOGAN LOCAL GOVERNMENT AREA POPULATION FORECASTS

Projection Source	2016	2041	2061	Growth 2016 – 2061	Average household size 2016	Average household size 2061
Shaping SEQ	313,800	586,000	NA	NA	2.9	NA
QGSO 2018 Projections	313,785	554,327	NA	NA	2.9	NA
Logan City Council	313,846	548,628	782,821	468,975	2.8	2.7
VLC Forecasts	313,846	548,628	782,821	468,975	2.8	2.7

Source: Shaping SEQ, Logan City Council, VLC Transport Modelling, QGSO Forecasts 2018

SGS Forecasts

SGS forecasts of population for Greater Flagstone PDA are shown in Table 7. An estimated 145,000 residents are forecast for the PDA in 2066, based on an average household size of 2.7 persons per household. This aligns with Logan CC and VLC's forecasts of population.

As shown in Figure 8, SGS forecasts of population are slightly above the VLC and Logan CC forecasts up to 2046, in line with our dwelling forecast. Beyond 2046 SGS forecasts are lower than VLC and Logan CC as growth is expected to occur at a slower rate.

SGS forecasts a decline in average household size, from a high of 3.3 in 2016, to 2.9 by 2031 and 2.7 in the longer term beyond 2046. This trend is seen in older growth areas that have already developed.

Average household size tends to be higher in the early development stages as families with children move in to detached dwellings. This is expected to decline in the longer term due to more apartments being built and changing age profiles, with more older people less school aged people.

Greater Flagstone household size is still expected to remain slightly above the QLD average household size of 2.6 persons per household.

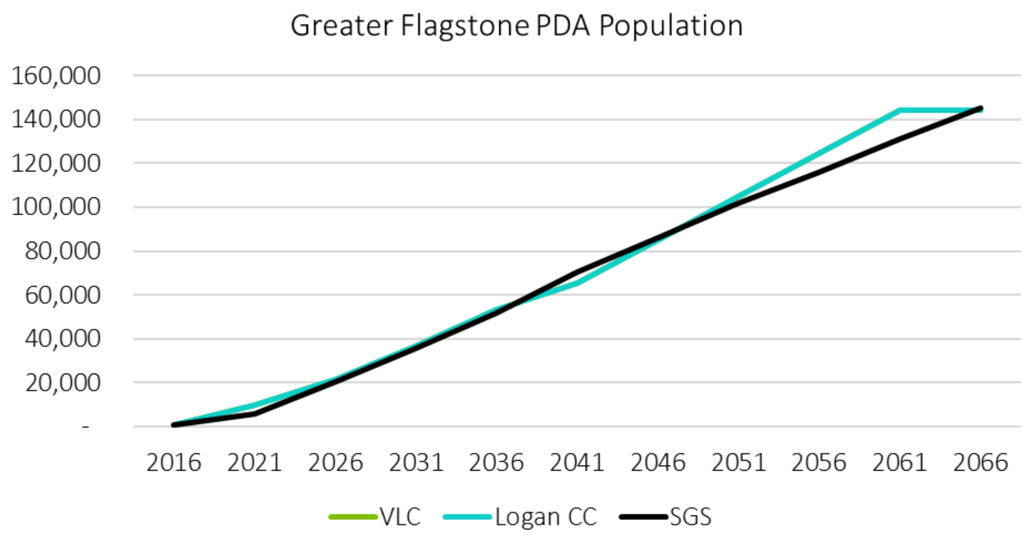
TABLE 7: GREATER FLAGSTONE PDA POPULATION FORECASTS

Projection Source	2016	2041	2066	Growth 2016 – 2066
SGS	775	70,548	144,738	143,963
Avg household size	3.3	2.8	2.7	-0.6
Logan City Council	819	65,394	144,335*	143,516*
Avg household size	3.0	2.7	2.6	-0.4
VLC	816	65,391	144,332*	143,516*
Avg household size	3.3	2.8	2.6	-0.6

Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

* Note These are 2061 estimates

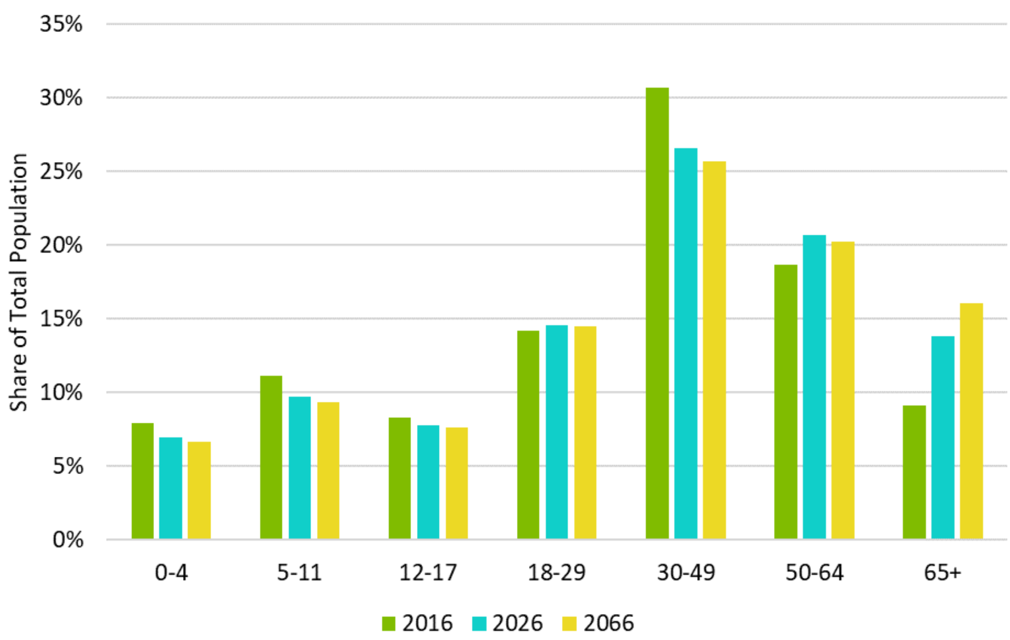
FIGURE 8: GREATER FLAGSTONE PDA POPULATION FORECASTS



Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

Population forecasts by age group have been prepared for Greater Flagstone using the QGSO population by age forecasts for the SA2 in which it is located (Greenbank SA2). It has been assumed that as the PDA develops there will be a changing age profile of residents. The proportion of older age people (50 to 64 and 65+) is forecast to increase in 2036 and 2066 (see Figure 9). This is in line with state-wide trends of an ageing population.

FIGURE 9: GREATER FLAGSTONE PDA POPULATION BY AGE – SHARE OF AGE GROUP

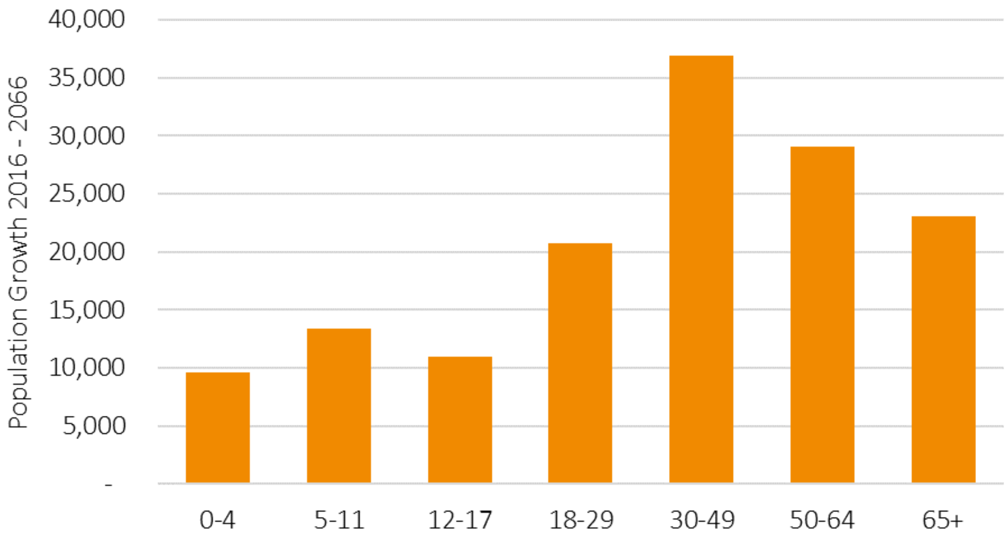


Source: SGS Economics and Planning 2019, QGSO 2018

As shown in Figure 10 below, the number of primary school aged children (5-11 years) living in Greater Flagstone is forecast to increase by 13,400 people to 2066. The number of secondary school aged children (12-17 years) is forecast to increase by 11,000 people to 2066.

The largest amount of population growth is forecast for the 30-49 and 50-64 age group.

FIGURE 10: GREATER FLAGSTONE PDA POPULATION – FORECAST GROWTH BY AGE GROUP



Source: SGS Economics and Planning 2019

There is of course a high degree of uncertainty regarding the future age breakdown of the PDA. This is particularly the case for school aged children. The size of this age group clearly has implications for future school provision. Looking at the existing shares of school aged children for SA2 across Greater Brisbane provides an indication of a possible future range for the PDA (using 2016 ABS Census data).

For children aged 5-11 years, the percentage can be as high as 13 per cent (for example the North Lakes - Mango Hill SA2 is 13.1 per cent). Other SA2 with a similar percentage of children aged 5-11 include the Redbank Plains SA2 (13.5 per cent), Narangba SA2 (13.2%) and Goodna (12.7%). On average, 9.3 per cent of the population across Greater Brisbane were aged 5 to 11 years (in 2016).

Applying this 13 per cent to the PDA projections provides an indication of a future with a very high percentage of primary school aged children. Table 8 compares the baseline forecast of primary school aged children in Greater Flagstone PDA (aged 5 to 11 years), with a high scenario forecast.

TABLE 8: PRIMARY SCHOOL AGED CHILDREN – HIGH SCENARIO, GREATER FLAGSTONE PDA

Population aged 5-11 years	2016	2026	2036	2046	2056	2066	Growth 2016-66
Baseline Forecast	86	1,966	4,829	8,052	10,805	13,536	13,450
Share of total population	11%	10%	9%	9%	9%	9%	
High scenario	86	2,437	6,729	10,357	13,899	17,412	17,326
Share of total population	11%	12%	13%	12%	12%	12%	

Source: SGS Economics and Planning based on ABS Census data 2016

For secondary school children, the current (2016) percentage of the population aged 12-17 years can be as high as 10 per cent (for example the Marsden and Crestmead SA2 are 10.1 per cent). Other SA2 with a similar percentage of children aged 12-17 years include the North Lakes – Mango Hill SA (9.3 per cent), Goodna SA2 (9.2%) and Wakerley (9.2%). On average, 7.6 per cent of the population across Greater Brisbane were aged 12 to 17 years (in 2016).

Applying this 10 per cent to the PDA projections in 2036 provides an indication of a future with a very high percentage of secondary school aged children. Table 9 compares the baseline forecast of secondary school aged children in Greater Flagstone PDA (aged 12 to 17 years), with a high scenario forecast.

TABLE 9: SECONADRY SCHOOL AGED CHILDREN – HIGH SCENARIO, GREATER FLAGSTONE PDA

Population aged 12-17 years	2016	2026	2036	2046	2056	2066	Growth 2016-66
Baseline Forecast	64	1,582	3,940	6,570	8,816	11,044	10,980
Share of total population	8%	8%	8%	8%	8%	8%	
High scenario	64	1,828	5,177	7,768	10,424	13,059	12,995
Share of total population	8%	9%	10%	9%	9%	9%	

Source: SGS Economics and Planning based on ABS Census data 2016

3.3 Employment

Total employment has been forecast for Greater Flagstone, and each of the developer areas within the PDA. SGS has compared previous forecasts prepared by Logan CC and VLC, along with our own analysis of population serving employment trends in new growth areas.

Table 10 compares total employment forecasts for the Logan Local Government Area (LGA) prepared by three sources (Shaping SEQ, Logan CC and VLC transport modelling). All three sources are broadly in line, with employment in Logan LGA forecast to reach 168,000 by 2041 and 272,000 by 2066. VLC forecasts are slightly higher than Logan in 2066 by a small amount.

TABLE 10: LOGAN LOCAL GOVERNMENT AREA EMPLOYMENT FORECASTS

Projection Source	2016	2041	2066	Growth 2016 – 2066
ShapingSEQ	101,980	168,125	N/A	N/A
Logan City Council	103,129	168,313	272,020	168,891
VLC	103,164	168,544	272,251	169,087

Source: ShapingSEQ, Logan City Council, VLC Transport Modelling

Table 9 illustrates SGS' forecasts for total employment in Greater Flagstone PDA to reach 16,900 jobs by 2041, and 34,400 jobs by 2066 (ultimate development). This represents 0.6 additional jobs per additional household in Greater Flagstone.

By 2066 it is expected that 12 per cent of jobs in Logan LGA will be located in Greater Flagstone. The majority of these jobs are expected to be population serving industries including retail, accommodation and food services, health, education and construction.

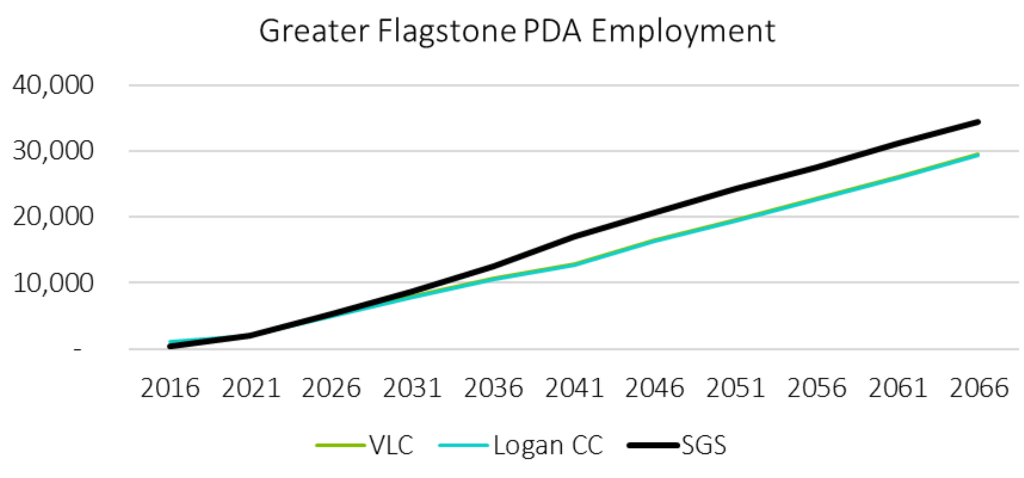
SGS forecasts are slightly higher than VLC and Logan CC forecasts due to the different method used by SGS. SGS employment forecasts are linked to the projected population growth which is also higher than VLC and Logan, as outlined in Section 3.2.

TABLE 11: GREATER FLAGSTONE PDA EMPLOYMENT FORECASTS

Projection Source	2016	2041	2066	Growth 2016 – 2061
SGS	409	16,942	34,387	33,978
Logan City Council	1,044	12,719	29,339	28,295
VLC	409	12,915	29,535	29,126

Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

FIGURE 11: GREATER FLAGSTONE PDA EMPLOYMENT FORECASTS



Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

Table 12 presents SGS' forecasts of total employment by developer area within the Greater Flagstone PDA. Areas with the largest forecast number of jobs include Peet Flagstone City, North Mclean Industrial, Wearing Co, Pioneer Fortune and Wilsons New Beith.

TABLE 12: GREATER FLAGSTONE PDA EMPLOYMENT FORECASTS BY DEVELOPER AREA

Developer Area	2016	2041	2066	Growth 2016 – 2066
Celestino	6	985	1,559	1,554
Mirvac	1	259	674	673
Peet Flagstone City	25	8,407	15,991	15,967
Pioneer Fortune	14	831	2,305	2,291
Wilsons New Beith	37	631	2,136	2,100
Flinders Land Holdings	14	524	1,582	1,568
Villa Green	2	79	70	68
Gittins	2	3	400	398
Flagstone East	27	56	296	269
Flagstone South	6	8	106	101
Flagstone South East	9	12	22	13
Greenbank (Flagstone)	250	1,141	1,013	763
Logan City Council	4	5	4	1
North Mclean Industrial	1	3,970	4,224	4,224
Orchard (Pebble Creek)	12	31	27	16
Wearing Co	0	0	3,976	3,976
Barham / Lawrence	0	1	1	0
Total Greater Flagstone PDA	409	16,942	34,387	33,978

Source: SGS Economics and Planning 2019

4. YARRABILBA

This chapter provides a comparison of existing forecasts produced for Yarrabilba and SGS' forecasts for this PDA.

4.1 Dwellings

Comparison of existing forecasts

As Yarrabilba and Greater Flagstone are both within the Logan LGA, comparison LGA figures for Dwellings, Population and Employment have been outlined above in the Greater Flagstone section.

Feedback was received from Lend Lease, which at the time of writing is assumed to be the only developer in Yarrabilba. Lend Lease provided their realistic and aspirational dwelling yields per year to 2031. These are summarized in Table 13 below (Further information in Appendix 1). Lend Lease expect their annual dwelling yield to be between 380 and 450 dwellings per year in Yarrabilba. This information has been used to inform SGS' dwelling forecasts, specifically the timing and location of dwelling growth to 2031.

SGS has applied a 5 per cent reduction to the total dwelling yield in each year to account for the likelihood that not all of the dwellings planned by developers are sold in that year.

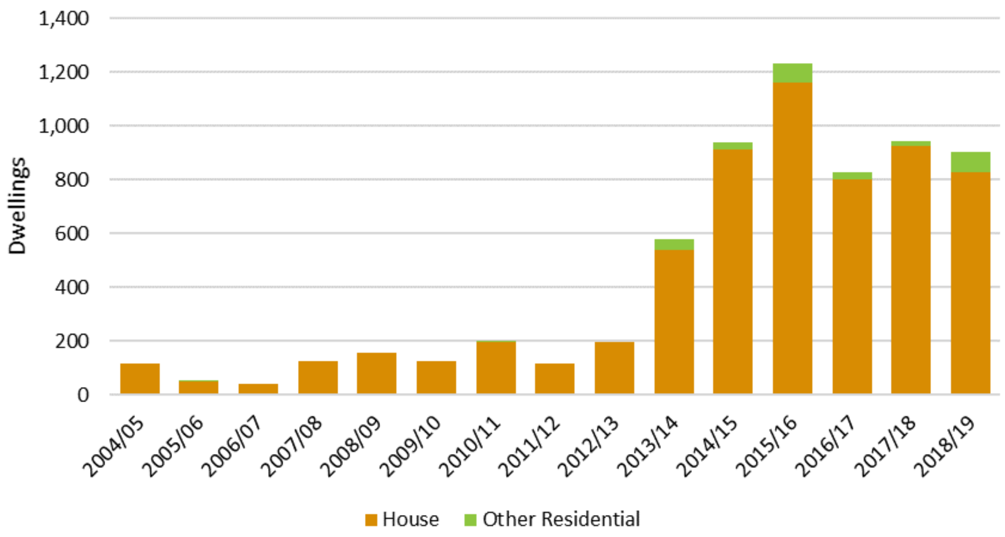
TABLE 13: DEVELOPER FEEDBACK DATA ON EXPECTED DWELLINGS IN 2031 – YARRABILBA

Developer Area	Realistic 2031 Dwellings	Realistic Dwellings per year	Aspirational 2031 Dwellings	Aspirational Dwellings per year
Lend Lease	8,175	394	8,870	452

Source: Lend Lease 2019

The following chart shows recent building approvals for Jimboomba SA2, representing Yarrabilba. It should be noted Yarrabilba covers approximately one quarter of the Jimboomba SA2. Recent data shows that between 800 to 1,000 dwellings have been approved per year in the broader SA2 area.

FIGURE 12: RECENT BUILDING APPROVALS YARRABILBA (JIMBOOMBA SA2)



Source: ABS Dwellings Approvals 2018/19

SGS forecasts

Table 14 shows the dwelling forecasts for the Yarrabilba prepared by SGS, compared to those prepared by Logan CC and VLC. SGS forecasts total dwellings in Yarrabilba PDA to reach 19,000 dwellings at ultimate development in 2066. This is broadly in line with Logan CC and VLC forecasts for 2061. By 2066 it is expected that 7 per cent of dwellings in Logan LGA will be located in Yarrabilba.

SGS forecasts in 2041 are slightly lower than VLC and Logan CC forecasts due to the different datasets and assumptions used by SGS. As shown in Figure 13, SGS forecasts are slightly below the VLC and Logan CC forecasts up to 2051, due to the use of developer feedback data. Beyond 2051 SGS forecasts are in line with VLC and Logan CC with both reaching 19,000 dwellings by 2056.

These forecasts assume that major infrastructure would have been provided and a number of sub-precincts would have been planned and activated.

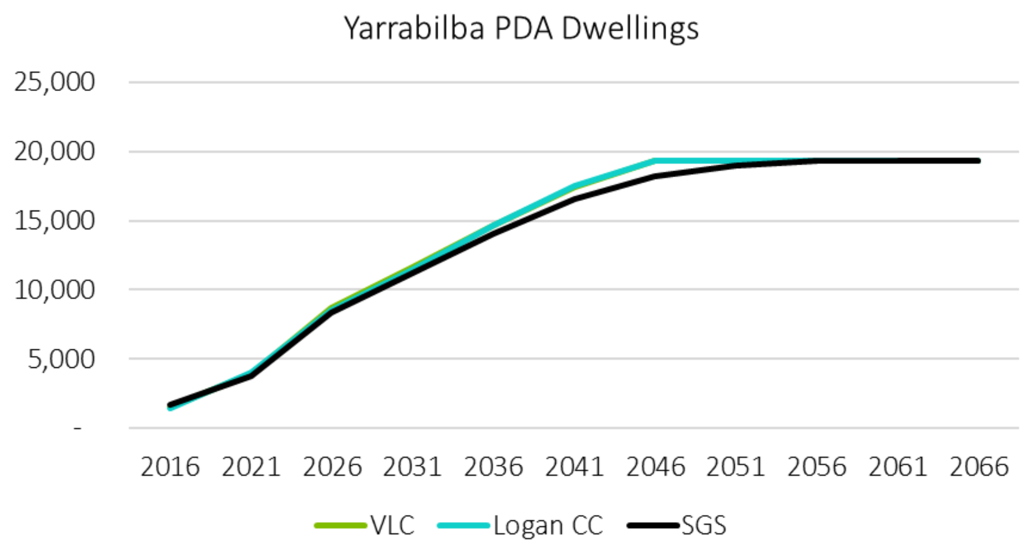
TABLE 14: YARRABILBA PDA DWELLING FORECASTS

Projection Source	2016	2041	2066	Growth 2016 – 2066
SGS	1,652	16,537	19,332	17,680
Logan City Council	1,450	17,492	19,318*	17,868*
VLC	1,525	17,407	19,332*	17,806*

Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

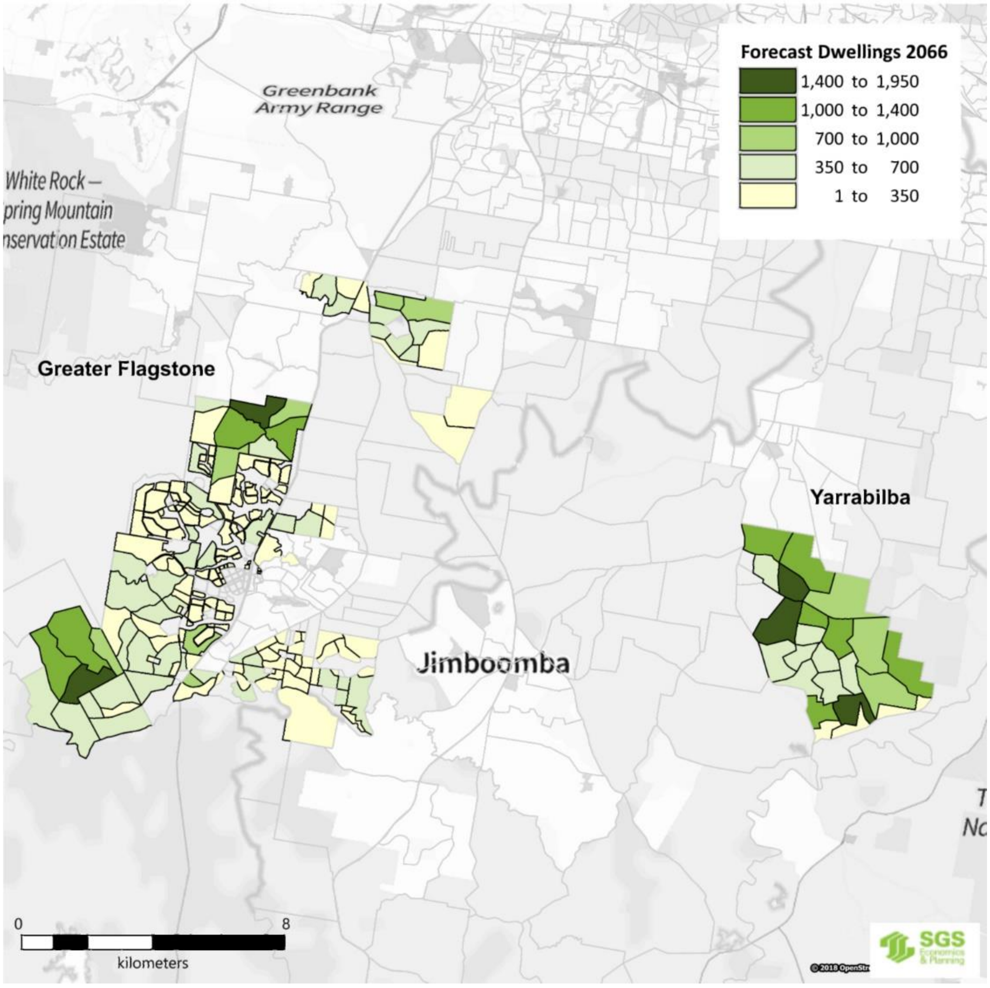
* Note: These are 2061 estimates

FIGURE 13: YARRABILBA PDA DWELLING FORECASTS



Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

FIGURE 14: YARRABILBA PDA DWELLING FORECASTS 2066



Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

4.2 Population

SGS Forecasts

SGS forecasts of population for Yarrabilba PDA are shown in Table 15. An estimated 52,800 residents are forecast for the PDA in 2066, based on an average household size of 2.7 persons per household. This aligns with Logan CC and VLC's forecasts of population.

As shown in Figure 15, SGS forecasts of population are slightly below the VLC and Logan CC forecasts up to 2051, in line with our dwelling forecast. Beyond 2051 SGS forecasts are in line with VLC and Logan CC as the PDA reaches full development.

SGS forecasts a decline in average household size, from 2.9 in 2016, to 2.7 from 2041 onwards. This trend is seen in older growth areas that have already developed. Average household size tends to be higher in the early development stages as families with children move in to detached dwellings. This is expected to decline in the longer term due to more apartments being built and changing age profiles, with more older people and less school aged people.

Yarrabilba's household size is still expected to remain slightly above the QLD average household size of 2.6 persons per household.

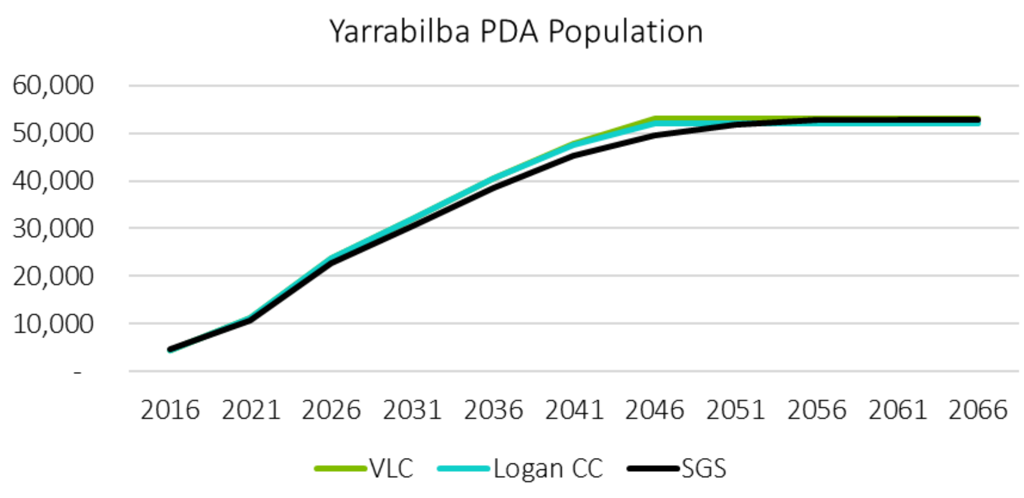
TABLE 15: YARRABILBA PDA POPULATION FORECASTS

Projection Source	2016	2041	2066	Growth 2016 – 2066
SGS	4,809	45,159	52,792	47,983
Avg household size	2.9	2.7	2.7	-0.2
Logan City Council	4,441	47,639	52,099*	47,658*
Avg household size	3.1	2.7	2.7	-0.4
VLC	4,441	47,709	53,086*	47,658*
Avg household size	3.1	2.7	2.7	-0.4

Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

* Note These are 2061 estimates

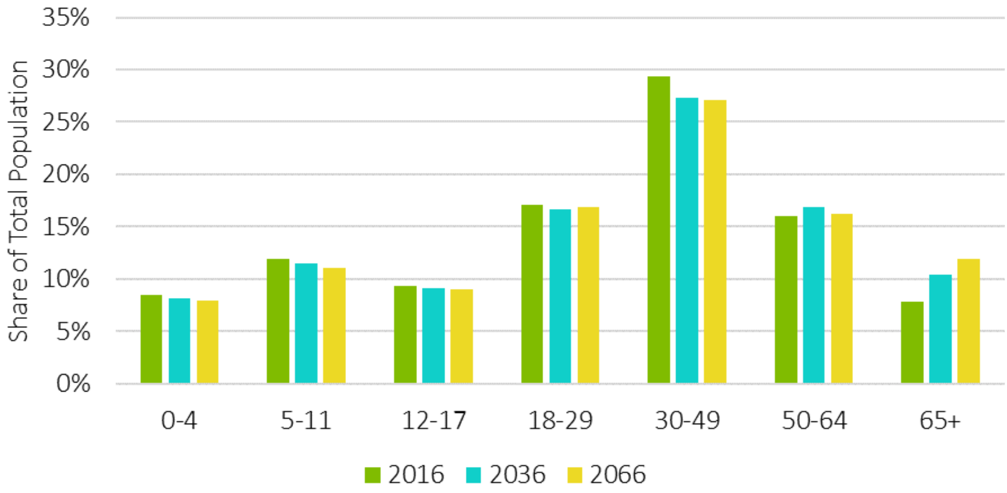
FIGURE 15: YARRABILBA PDA POPULATION FORECASTS



Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

Population forecasts by age group have been prepared for Yarrabilba using the QGSO population by age forecasts for the SA2 in which it is located (Jimboomba SA2). It has been assumed that as the PDA develops there will be a changing age profile of residents. The proportion of older age people (50 to 64 and 65+) is forecast to increase in 2036 and 2066 (see Figure 16). This is in line with state-wide trends of an ageing population.

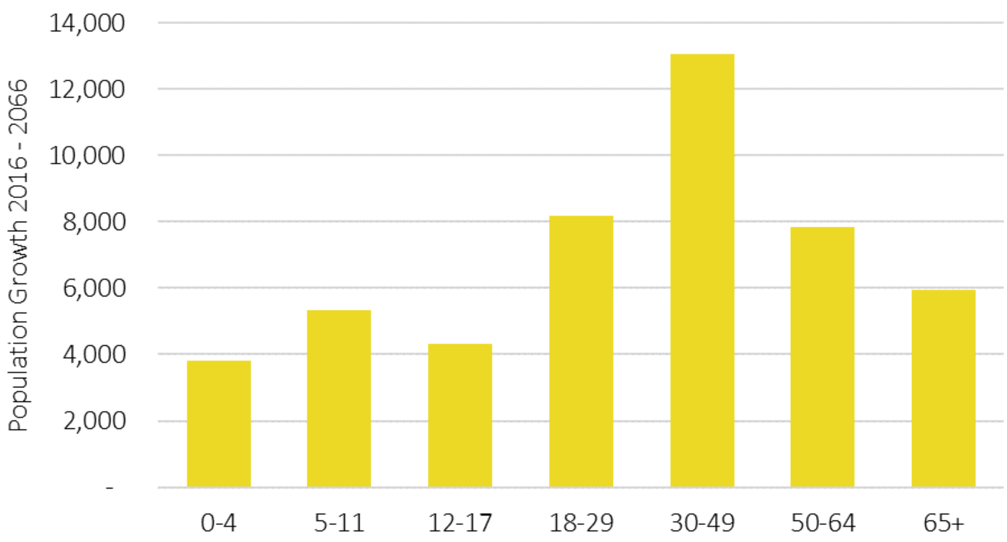
FIGURE 16: YARRABILBA PDA POPULATION BY AGE – SHARE OF AGE GROUP



Source: SGS Economics and Planning 2019, QGSO 2018

As shown in Figure 17, the number of primary school aged children (5-11 years) living in Yarrabilba is forecast to increase by 5,300 people to 2066. The number of secondary school aged children (12-17 years) is forecast to increase by 4,300 people to 2066. The largest amount of population growth is forecast for the 30-49 age group (13,000 additional residents).

FIGURE 17: YARRABILBA PDA POPULATION BY AGE – FORECAST GROWTH BY AGE GROUP



Source: SGS Economics and Planning 2019

There is of course a high degree of uncertainty regarding the future age breakdown of the PDA. This is particularly the case for school aged children. The size of this age group clearly has implications for future school provision. Looking at the existing shares of school aged children for SA2 across Greater Brisbane provides an indication of a possible future range for the PDA (using 2016 ABS Census data).

For children aged 5-11 years, the percentage can be as high as 13 per cent (for example the North Lakes - Mango Hill SA2 is 13.1 per cent). Other SA2 with a similar percentage of children aged 5-11 include the Redbank Plains SA2 (13.5 per cent), Narangba SA2 (13.2%) and Goodna (12.7%). On average, 9.3 per cent of the population across Greater Brisbane were aged 5 to 11 years (in 2016).

Applying this 13 per cent to the PDA projections provides an indication of a future with a very high percentage of primary school aged children. Table 16 compares the baseline forecast of primary school aged children in Yarrabilba PDA (aged 5 to 11 years), with a high scenario forecast.

TABLE 16: PRIMARY SCHOOL AGED CHILDREN – HIGH SCENARIO, YARRABILBA PDA

Population aged 5-11 years	2016	2026	2036	2046	2056	2066	Growth 2016-66
Baseline Forecast	571	2,314	3,758	5,483	5,833	5,833	5,262
Share of total population	12%	11%	11%	11%	11%	11%	
High scenario	571	2,422	4,421	5,955	6,335	6,335	5,764
Share of total population	12%	12%	13%	12%	12%	12%	

Source: SGS Economics and Planning based on ABS Census data 2016

For secondary school children, the current (2016) percentage of the population aged 12-17 years can be as high as 10 per cent (for example the Marsden and Crestmead SA2 are 10.1 per cent). Other SA2 with a similar percentage of children aged 12-17 years include the North Lakes – Mango Hill SA (9.3 per cent), Goodna SA2 (9.2%) and Wakerley (9.2%). On average, 7.6 per cent of the population across Greater Brisbane were aged 12 to 17 years (in 2016).

Applying this 10 per cent to the PDA projections in 2036 provides an indication of a future with a very high percentage of secondary school aged children. Table 17 compares the baseline forecast of secondary school aged children in Yarrabilba PDA (aged 12 to 17 years), with a high scenario forecast.

TABLE 17: SECONADRY SCHOOL AGED CHILDREN – HIGH SCENARIO, YARRABILBA PDA

Population aged 12-17 years	2016	2026	2036	2046	2056	2066	Growth 2016-66
Baseline Forecast	450	1,829	3,047	4,446	4,730	4,730	4,280
Share of total population	9%	9%	9%	9%	9%	9%	
High scenario	450	1,816	3,401	4,466	4,751	4,751	4,301
Share of total population	9%	9%	10%	9%	9%	9%	

Source: SGS Economics and Planning based on ABS Census data 2016

4.3 Employment

Total employment has been forecast for Yarrabilba PDA. SGS has compared previous forecasts prepared by Logan CC and VLC, along with our own analysis of population serving employment trends in new growth areas.

SGS forecasts total employment in Yarrabilba PDA to reach 11,200 jobs by 2041, and 13,000 jobs by 2066 (ultimate development). This represents 0.7 additional jobs per additional household in Yarrabilba.

By 2066 it is expected that 5 per cent of jobs in Logan LGA will be located in Yarrabilba. The majority of these jobs are expected to be population serving industries including retail, accommodation and food services, health, education and construction.

SGS forecasts are slightly lower than VLC and Logan CC forecasts due to the different method used by SGS. SGS employment forecasts are linked to the population growth which is also lower than VLC and Logan CC.

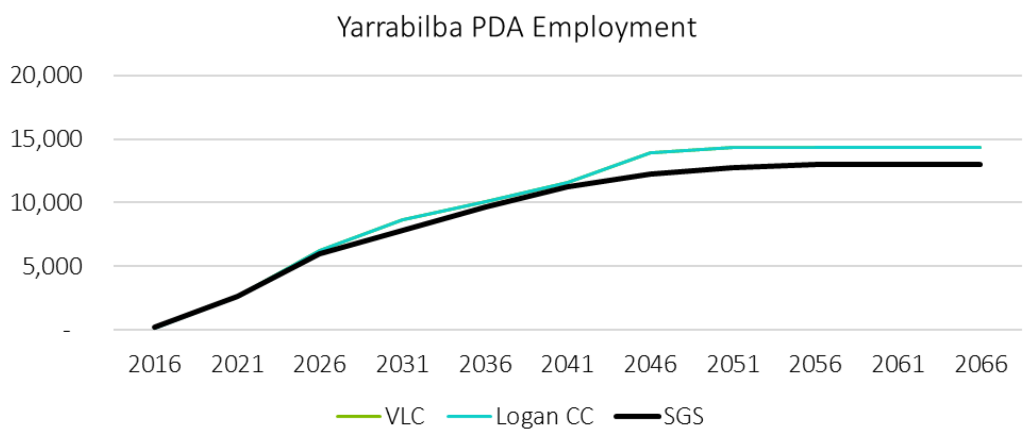
It has been assumed that the majority of Yarrabilba PDA will be developed by Lend Lease, therefore developer area breakdowns are not provided.

TABLE 18: YARRABILBA PDA EMPLOYMENT FORECASTS

Projection Source	2016	2041	2066	Growth 2016 – 2066
SGS	188	11,242	13,028	12,840
Logan City Council	99	11,560	14,373	14,275
VLC	188	11,560	14,373	14,186

Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

FIGURE 18: YARRABILBA PDA EMPLOYMENT FORECASTS



Source: SGS Economics and Planning 2019, Logan City Council, VLC Transport Modelling

5. RIPLEY VALLEY

This chapter provides a comparison of existing forecasts produced for Ripley Valley and SGS' forecasts for this PDA.

5.1 Dwellings

Total occupied private dwellings have been forecast for Ripley Valley, and each of the developer areas within the PDA. The following section compares previous forecasts prepared by Ipswich City Council (ICC) and Jacobs, along with our own analysis of developer feedback data and recent development trends in the region.

Comparison of existing forecasts

Table 19 below highlights the variation in dwelling forecasts for the City of Ipswich between the State Government ShapingSEQ and the Queensland Government Statistician's Office's (QGSO) 2018 projections. Whilst 2016 estimates are in line, the growth forecast for the LGA varies dramatically between the two sources in 2041. The QGSO projections are based on more recently released ABS Census data and suggest a greater level of growth forecast.

TABLE 19: IPSWICH LOCAL GOVERNMENT AREA DWELLING FORECASTS

Projection Source	2016	2041	Growth 2016 – 2041
Shaping SEQ	72,092	183,792	111,700
QGSO 2018 Projections	72,090	218,102	146,012

Source: Shaping SEQ, Ipswich City Council, QGSO Projections 2018

Feedback was received from a number of developers in Ripley Valley on their realistic and aspirational dwelling yields per year to 2031. The realistic dwelling yield figures provided by developers have been revised in consultation with EDQ and are as summarised in Table 20 below. Annual dwelling yield is expected to be between 25 and 259 dwellings per year across the developer areas. This information has been used to inform SGS' dwelling forecasts, specifically the timing and location of dwelling growth to 2031.

Aspirational dwelling figures information was provided by developers in Ripley Valley to provide alternative dwelling forecasts for the developer areas. In an effort to provide a conservative estimate, these figures have not been used to inform SGS' dwelling forecasts.

TABLE 20: RIPLEY VALLEY – EXPECTED DWELLINGS IN 2031

Developer Area	Realistic 2031 Dwellings	Realistic Dwellings per year	Aspirational 2031 Dwellings	Aspirational Dwellings per year
Intrapac	1034	94	1,352	123
Okeland Communities	4419	259	4,495	295
Satterley Property Group	740	56	804	63
South Ripley Developments	262	25	642	58
Stocklands	1,270	127	1,420	129
Totals	**7,725**	**561**	**8,713**	**668**

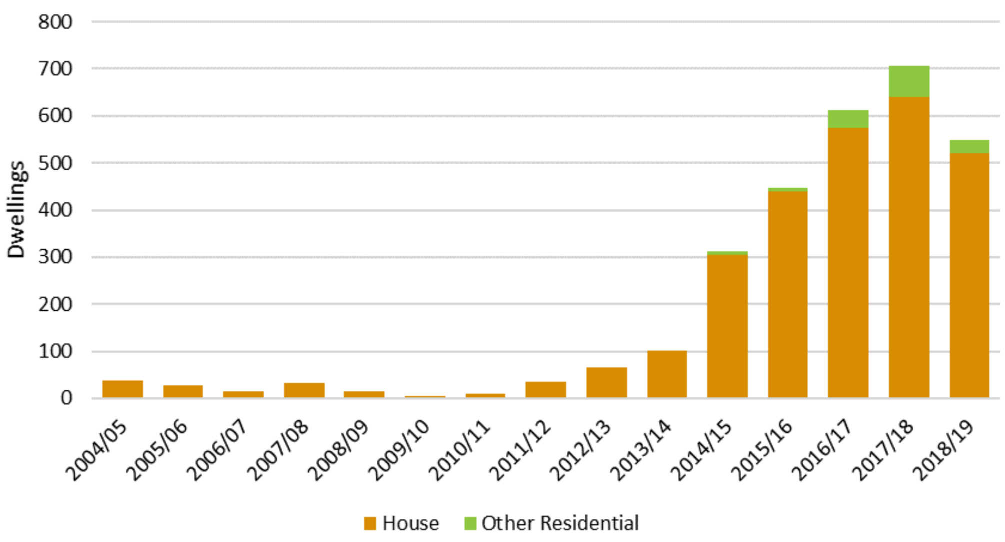
Source: SGS and developer feedback, 2019

The following chart shows recent building approvals for Ripley SA2, representing a slightly larger area than the Ripley Valley PDA. Recent data shows that between 600 to 700 dwellings have been approved per year.

Ripley Valley has an ultimate dwelling yield of about 50,000 dwellings and is located on the western edge of the Brisbane urban extent. Relative to other PDAs in SEQ it is quite well connected to employment, transport and parkland.

This data on recent building approvals has been used to estimate the total number of dwellings in Ripley Valley from 2016 to 2019.

FIGURE 19: RECENT BUILDING APPROVALS – RIPLEY VALLEY (SA2)



Source: ABS Dwellings Approvals 2018/19

Note: 2018/19 is not a full year of data

SGS forecasts

Table 21 shows the dwelling forecasts for the Ripley Valley PDA prepared by SGS, compared to those prepared by ICC and Jacobs. SGS forecasts total dwellings in Ripley Valley PDA to reach 50,000 dwellings at ultimate development in 2051. This is broadly in line with ICC and Jacobs forecasts of ultimate development, however SGS expects this ultimate dwellings estimate to be reached later than 2046.

SGS forecasts in 2046 are lower than Jacobs and ICC forecasts due to the different datasets and assumptions used by SGS. As shown in Figure 20, SGS forecasts are below the Jacobs and

ICC forecasts up to 2046, due to the use of recent dwelling approvals, new lot approvals and developer feedback data.

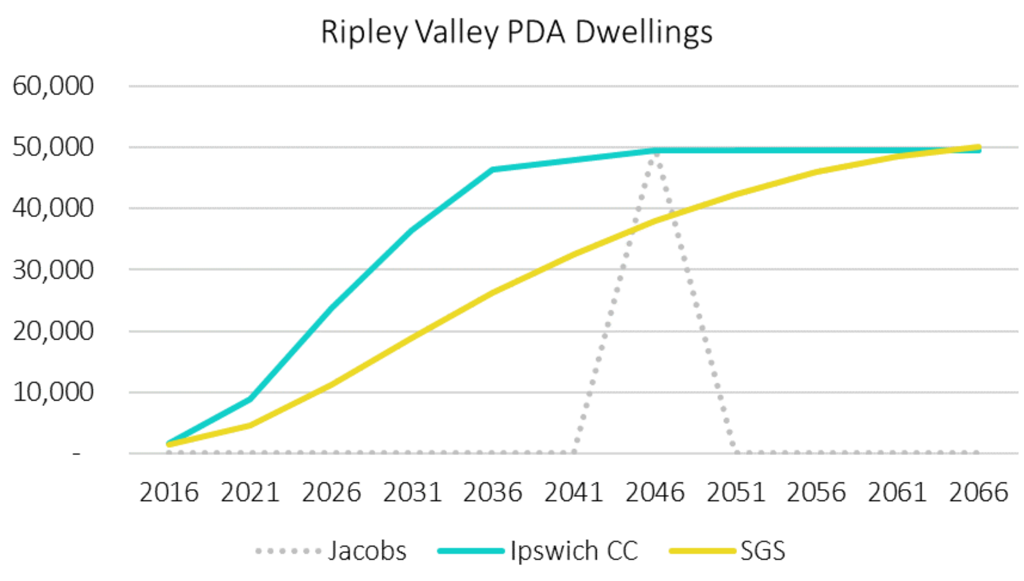
These forecasts assume that major infrastructure would have been provided and a number of sub-precincts would have been planned and activated by 2066.

TABLE 21: RIPLEY VALLEY PDA DWELLING FORECASTS

Projection Source	2016	2046	2066	Growth 2016 – 2061
SGS	1,444	37,971	50,000	48,556
Ipswich City Council	1,555	49,453	49,453	47,898
Jacobs	NA	50,004	NA	NA

Source: SGS Economics and Planning 2019, Ipswich City Council, Jacobs Transport Modelling

FIGURE 20: RIPLEY VALLEY PDA DWELLING FORECASTS



Source: SGS Economics and Planning 2019, Ipswich City Council, VLC Transport Modelling

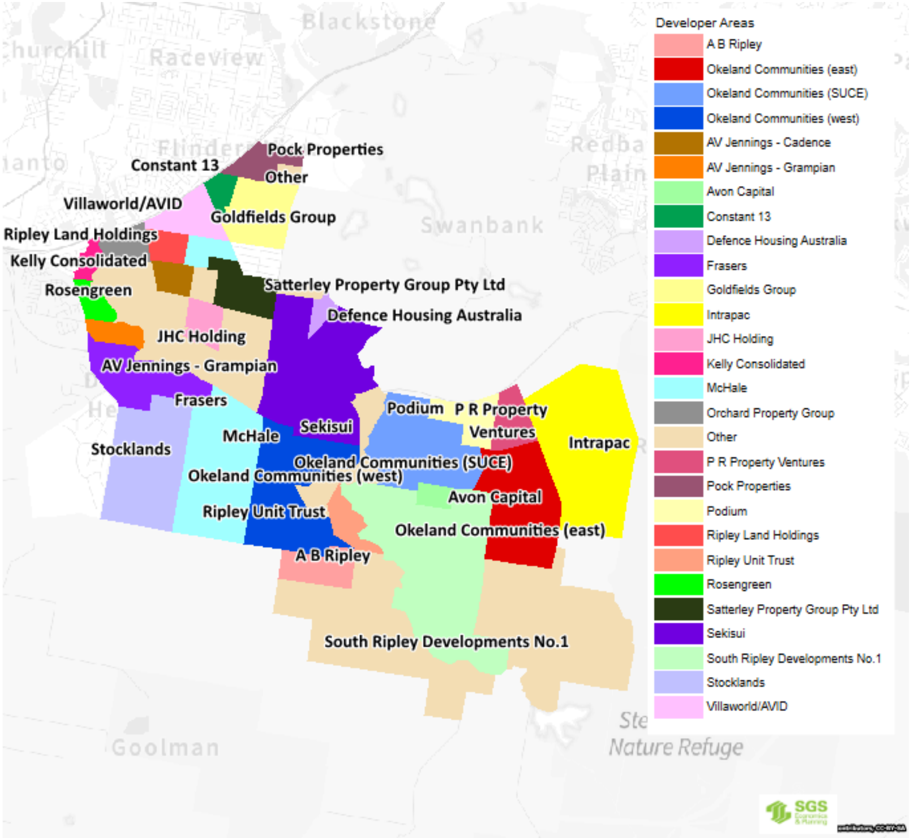
Table 22 presents SGS' forecasts of dwellings by developer area within the Ripley Valley PDA. Areas with the largest forecast dwellings include Okeland Communities, Sekisui, Intrapac, South Ripley Developments, McHale and Stocklands. These forecasts have been informed by the developer feedback provided by a number of developers on their realistic and aspirational dwelling yields to 2031, as well as information provided by EDQ on approved lots.

TABLE 22: RIPLEY VALLEY PDA DWELLING FORECASTS BY DEVELOPER AREA

Developer Area	2016	2046	2066	Growth 2016 – 2061
Intrapac	-	2,289	2,289	2,289
A B Ripley	1	190	190	189
Okeland Communities (east)	1	1,586	1,761	1,760
Okeland Communities (SUCE)	624	2,720	2,720	2,096
Okeland Communities (west)	-	1,585	1,760	1,760
AV Jennings - Cadence	-	303	303	303
AV Jennings - Grampian	1	178	178	177
Avon Capital	1	369	369	368
Pock Properties	1	137	137	136
Constant 13	-	86	86	86
Defence Housing Australia	1	370	370	369
Frasers	1	970	970	969
Goldfields Group	1	1,125	1,125	1,124
Villaworld/AVID	-	600	600	600
JHC Holding	3	316	316	313
Orchard Property Group - Kelly	1	63	63	62
McHale - Monterea	-	543	543	543
McHale - South	1	1,800	2,677	2,676
Other	55	7,442	13,860	13,805
Orchard Property Group - Daleys	-	426	426	426
Podium	1	450	450	449
Ripley Land Holdings	1	437	437	436
Ripley Unit Trust	1	294	294	293
Rosengreen	1	102	102	101
Satterley Property Group Pty Ltd	1	1,050	1,050	1,049
Sekisui	734	8,158	12,012	11,277
South Ripley Developments No.1	12	2,362	2,812	2,800
Stocklands	1	2,020	2,100	2,099
Total	**1,444**	**37,971**	**50,000**	**48,556**

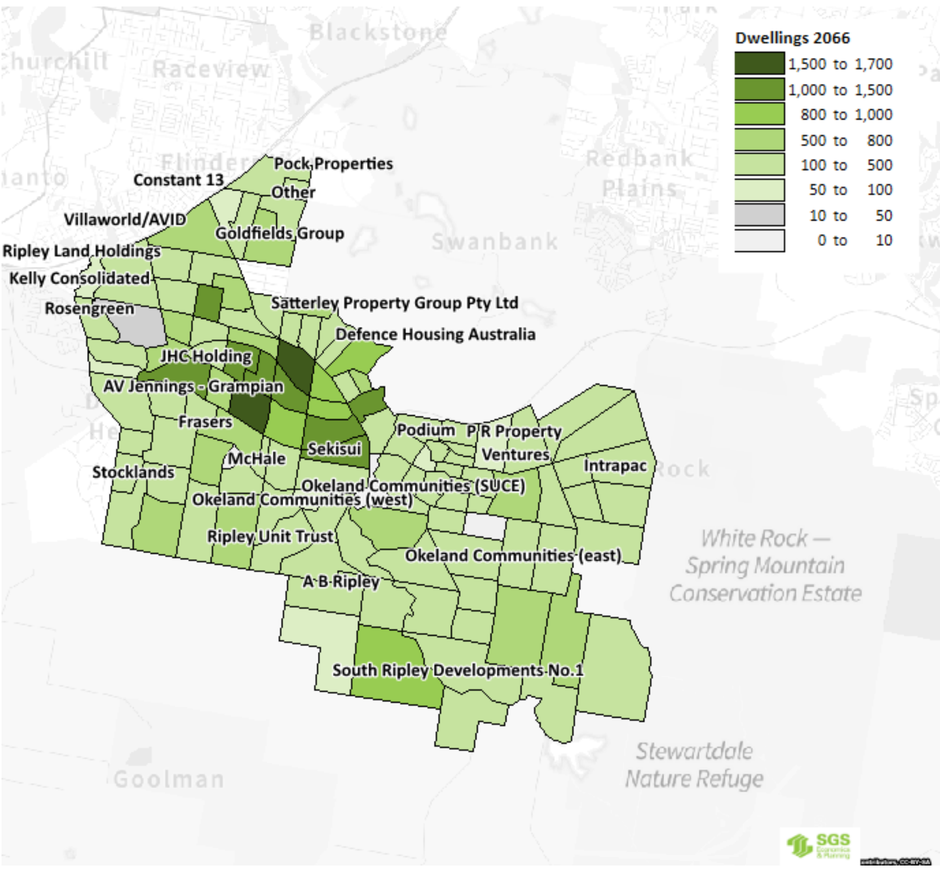
Source: SGS Economics and Planning 2019

FIGURE 21: RIPLEY VALLEY PDA DEVERLOPER AREAS



Source: DSDMIP Economic Development Queensland

FIGURE 22: RIPLEY VALLEY PDA DWELLING FORECASTS 2066



5.2 Population

Comparison of existing forecasts

Table 23 below highlights the variation in population forecasts for the City of Ipswich between the State Government ShapingSEQ and Queensland Government Statistician's Office 2018 projections. While values are similar in 2016, there is considerable variation in forecasts for 2041. QGSO are projecting more people in the Ipswich LGA by 2041 (i.e. a faster rate of population growth).

TABLE 23: IPSWICH LOCAL GOVERNMENT AREA POPULATION FORECASTS

Projection Source	2016	2041	Growth 2016 – 2041	Average household size 2016	Average household size 2041
Shaping SEQ	200,100	520,000	319,900	2.8	2.8
QGSO 2018 Projections	200,123	557,649	357,526	2.8	2.6

Source: Shaping SEQ, Ipswich City Council, Jacobs Transport Modelling, QGSO Forecasts 2018

SGS Forecasts

SGS forecasts of population for Ripley Valley PDA are shown in Table 24. An estimated 135,000 residents are forecast for the PDA in 2066, based on an average household size of 2.7 persons per household. This is slightly higher than ICC and Jacobs forecasts of population as a result of the higher average household size that has been used.

As shown in Figure 23, SGS forecasts of population are below the Jacobs and ICC forecasts up to 2046, in line with our dwelling forecast. Beyond 2046 SGS forecasts are higher than Jacobs and ICC as a result of the higher average household size. The ICC population forecast appears to be based on historical average household size for the PDA area, which reflects a rural residential population (with less people per household) rather than a greenfield development area.

SGS forecasts a decline in average household size, from a high of 2.9 in 2016, to 2.7 by 2066. This trend is seen in older growth areas that have already developed. Average household size tends to be higher in the early development stages as families with children move in to detached dwellings. This is expected to decline in the longer term due to more apartments being built and changing age profiles, with more older people less school aged people.

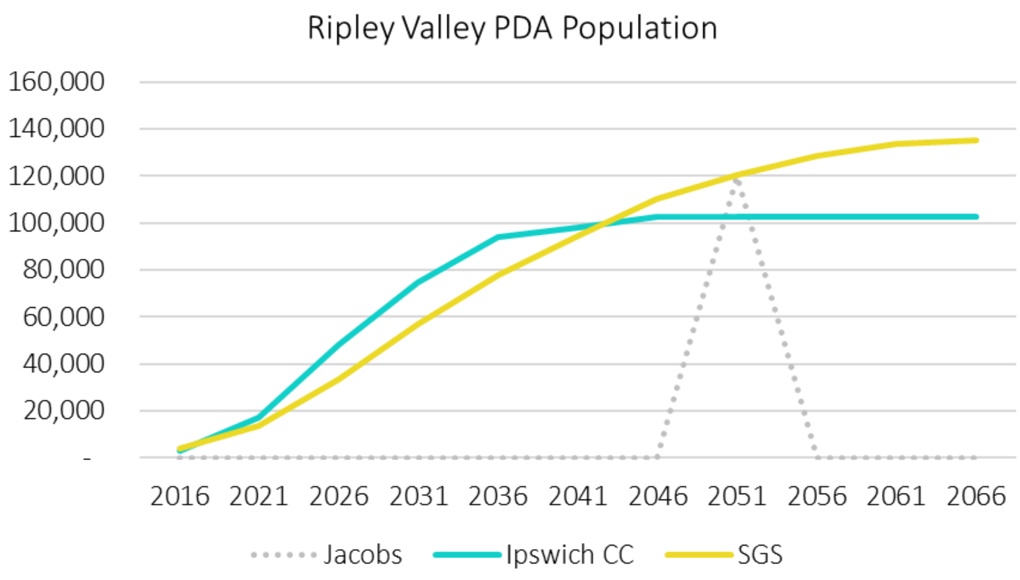
Ripley Valley household size is still expected to remain slightly above the QLD average household size of 2.6 persons per household.

TABLE 24: RIPLEY VALLEY PDA POPULATION FORECASTS

Projection Source	2016	2046	2066	Growth 2016 – 2066
SGS	4,188	110,116	135,001	130,813
Avg household size	2.9	2.9	2.7	
Ipswich City Council	2,857	102,546	102,546	99,689
Avg household size	1.8	2.1	2.1	
Jacobs	NA	120,002	NA	NA
Avg household size	NA	2.4	NA	NA

Source: SGS Economics and Planning 2019, Ipswich City Council, Jacobs Transport Modelling

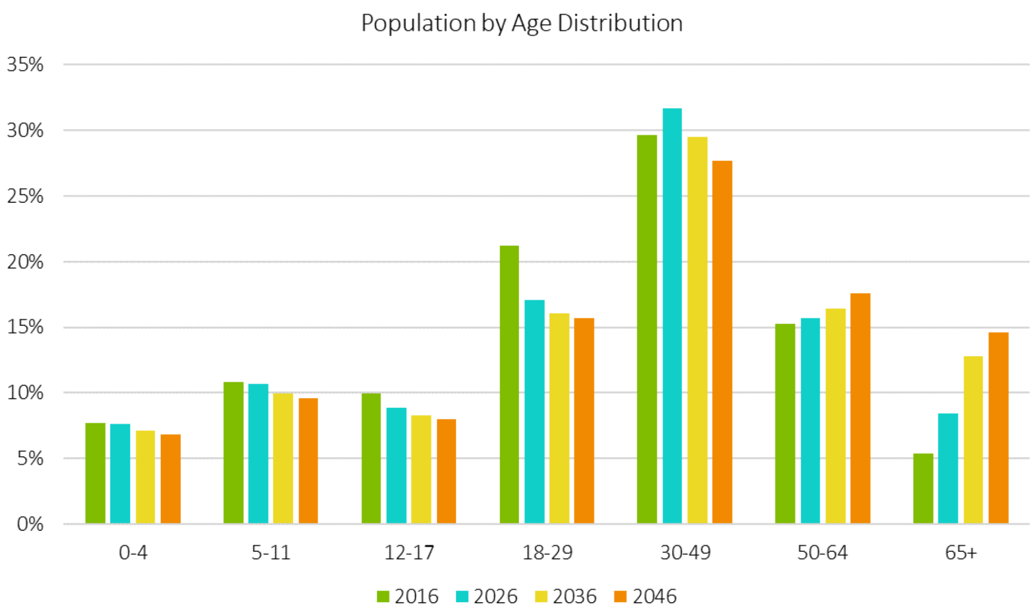
FIGURE 23: RIPLEY VALLEY PDA POPULATION FORECASTS



Source: SGS Economics and Planning 2019, Ipswich City Council, Jacobs Transport Modelling

Population forecasts by age group have been prepared for Ripley Valley using the QGSO population by age forecasts for the SA2 in which it is located (Ripley SA2). It has been assumed that as the PDA develops there will be a changing age profile of residents. The proportion of older age people (50 to 64 and 65+) is forecast to increase in 2036 and 2066 (see Figure 24). This is in line with state-wide trends of an ageing population.

FIGURE 24: RIPLEY VALLEY PDA POPULATION BY AGE – SHARE OF AGE GROUP

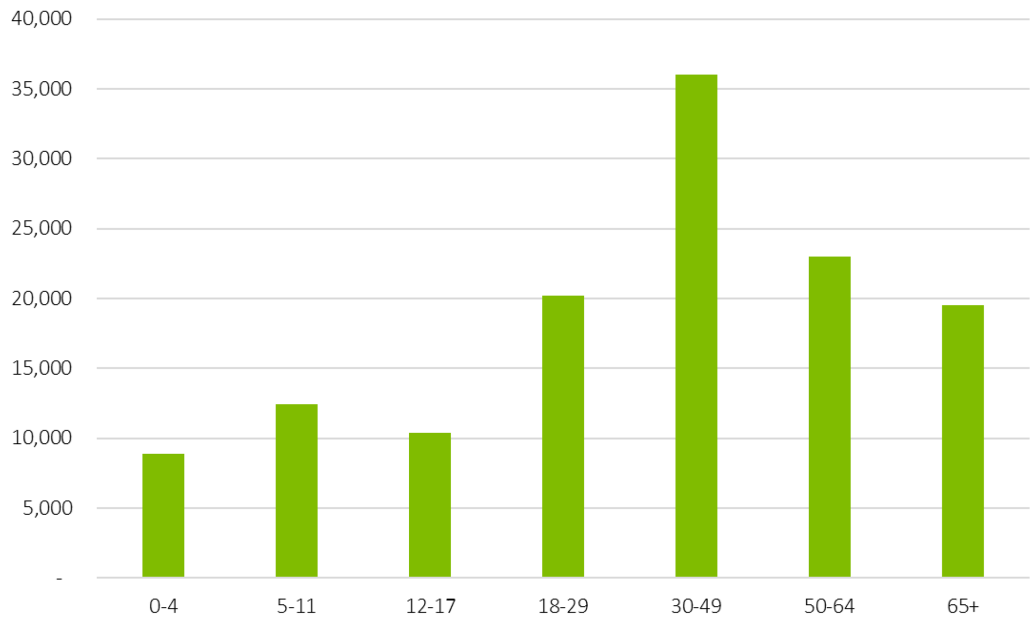


Source: SGS Economics and Planning 2019

As shown in Figure 25 below, the number of primary school aged children (5-11 years) living in Ripley Valley is forecast to increase by 12,400 people to 2066. The number of secondary school aged children (12-17 years) is forecast to increase by 10,400 people to 2066.

The largest amount of population growth is forecast for the 30-49 and 50-64 age group.

FIGURE 25: RIPLEY VALLEY PDA POPULATION BY AGE – FORECAST GROWTH BY AGE GROUP



Source: SGS Economics and Planning 2019

There is of course a high degree of uncertainty regarding the future age breakdown of the PDA. This is particularly the case for school aged children. The size of this age group clearly has implications for future school provision. Looking at the existing shares of school aged children for SA2 across Greater Brisbane provides an indication of a possible future range for the PDA (using 2016 ABS Census data).

For children aged 5-11 years, the percentage can be as high as 13 per cent (for example the North Lakes - Mango Hill SA2 is 13.1 per cent). Other SA2 with a similar percentage of children aged 5-11 include the Redbank Plains SA2 (13.5 per cent), Narangba SA2 (13.2%) and Goodna (12.7%). On average, 9.3 per cent of the population across Greater Brisbane were aged 5 to 11 years (in 2016).

Applying this 13 per cent to the PDA projections provides an indication of a future with a very high percentage of primary school aged children. Table 25 compares the baseline forecast of primary school aged children in Ripley Valley PDA (aged 5 to 11 years), with a high scenario forecast.

TABLE 25: PRIMARY SCHOOL AGED CHILDREN – HIGH SCENARIO, RIPLEY VALLEY PDA

Population aged 5-11 years	2016	2026	2036	2046	2056	2066	Growth 2016-66
Baseline Forecast	453	3,587	7,703	10,536	12,311	12,917	12,464
Share of total population	11%	11%	10%	10%	10%	10%	
High scenario	453	4,023	10,095	13,214	15,440	16,200	15,747
Share of total population	11%	12%	13%	12%	12%	12%	

Source: SGS Economics and Planning based on ABS Census data 2016

For secondary school children, the current (2016) percentage of the population aged 12-17 years can be as high as 10 per cent (for example the Marsden and Crestmead SA2 are 10.1 per cent). Other SA2 with a similar percentage of children aged 12-17 years include the North Lakes – Mango Hill SA (9.3 per cent), Goodna SA2 (9.2%) and Wakerley (9.2%). On average, 7.6 per cent of the population across Greater Brisbane were aged 12 to 17 years (in 2016).

Applying this 10 per cent to the PDA projections in 2036 provides an indication of a future with a very high percentage of secondary school aged children. Table 26 compares the baseline forecast of secondary school aged children in Ripley Valley PDA (aged 12 to 17 years), with a high scenario forecast.

TABLE 26: SECONADRY SCHOOL AGED CHILDREN – HIGH SCENARIO, RIPLEY VALLEY PDA

Population aged 12-17 years	2016	2026	2036	2046	2056	2066	Growth 2016-66
Baseline Forecast	416	2,966	6,414	8,837	10,325	10,834	10,418
Share of total population	10%	9%	8%	8%	8%	8%	
High scenario	416	3,352	7,765	9,910	11,580	12,150	11,734
Share of total population	10%	10%	10%	9%	9%	9%	

Source: SGS Economics and Planning based on ABS Census data 2016

5.3 Employment

SGS forecasts total employment in Ripley Valley PDA to reach 11,700 jobs by 2046, and 14,200 jobs by 2066 (ultimate development). This represents 0.3 additional jobs per additional household in Ripley Valley.

The majority of these jobs are expected to be population serving industries including retail, accommodation and food services, health, education and construction.

SGS forecasts are slightly higher than Jacobs and ICC forecasts due to the different method used by SGS. SGS employment forecasts are linked to the population growth which is also higher than Jacobs and Ipswich.

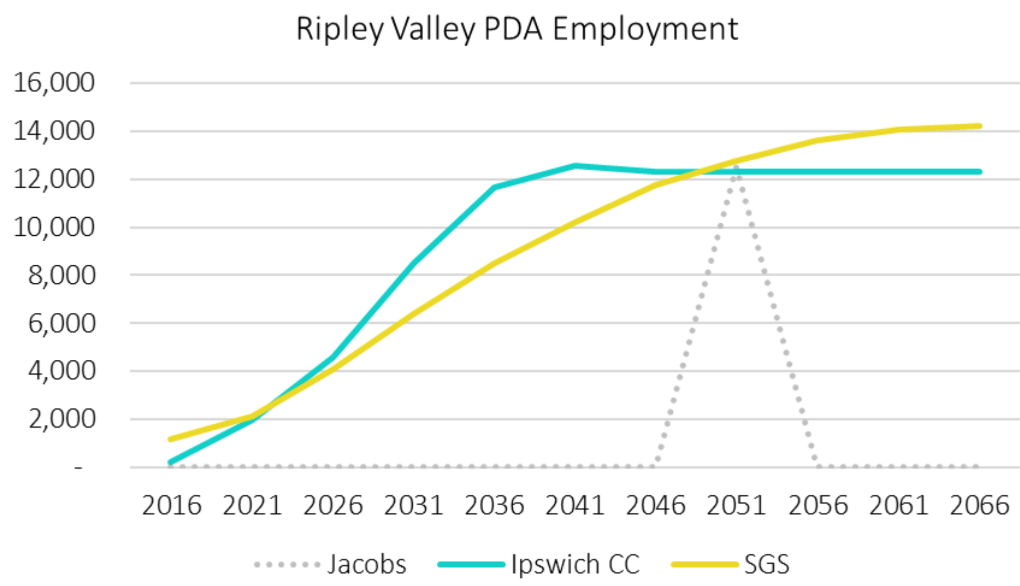
TABLE 27: RIPLEY VALLEY PDA EMPLOYMENT FORECASTS

Projection Source	2016	2046	2066	Growth 2016 – 2061
SGS	1,150	11,743	14,231	13,081
Ipswich City Council	218	12,541	NA	12,323*
Jacobs	NA	12,534	NA	NA

Source: SGS Economics and Planning 2019, Ipswich City Council, Jacobs Transport Modelling

Note: This is growth to 2046

FIGURE 26: RIPLEY VALLEY PDA EMPLOYMENT FORECASTS



Source: SGS Economics and Planning 2019, Ipswich City Council, Jacobs Transport Modelling

Table 28 presents SGS' forecasts of total employment by developer area within the Ripley Valley PDA. Areas with the largest forecast number of jobs include Sekisui and Okeland Communities (SUCE).

TABLE 28: RIPLEY VALLEY PDA EMPLOYMENT FORECASTS BY DEVELOPER AREA

Developer Area	2016	2046	2066	Growth 2016 – 2061
Intrapac	18	188	228	210
A B Ripley	-	-	-	-
Okeland Communities (east)	30	307	372	341
Okeland Communities (SUCE)	109	1,115	1,351	1,242
Okeland Communities (west)	37	381	462	425
AV Jennings - Cadence	4	46	55	51
AV Jennings - Grampian	4	46	55	51
Avon Capital	3	34	41	38
Pock Properties	5	50	60	56
Constant 13	0	0	0	0
Defence Housing Australia	1	14	17	16
Frasers	18	186	226	208
Goldfields Group	23	237	287	264
Villaworld/AVID	4	37	45	41
JHC Holding	7	67	81	74
Orchard Property Group - Kelly	5	50	60	56
McHale - Monterea	12	122	148	136
McHale - South	12	122	148	136
Other	119	1,217	1,475	1,356
Orchard Property Group - Daleys	28	290	351	323
Podium	4	45	55	50
Ripley Land Holdings	0	0	0	0
Ripley Unit Trust	-	-	-	-
Rosengreen	-	-	-	-
Satterley Property Group Pty Ltd	21	216	262	241
Sekisui	577	5,888	7,136	6,559
South Ripley Developments No.1	69	708	857	788
Stocklands	37	377	457	420
Total Ripley Valley	**1,150**	**11,743**	**14,231**	**13,081**

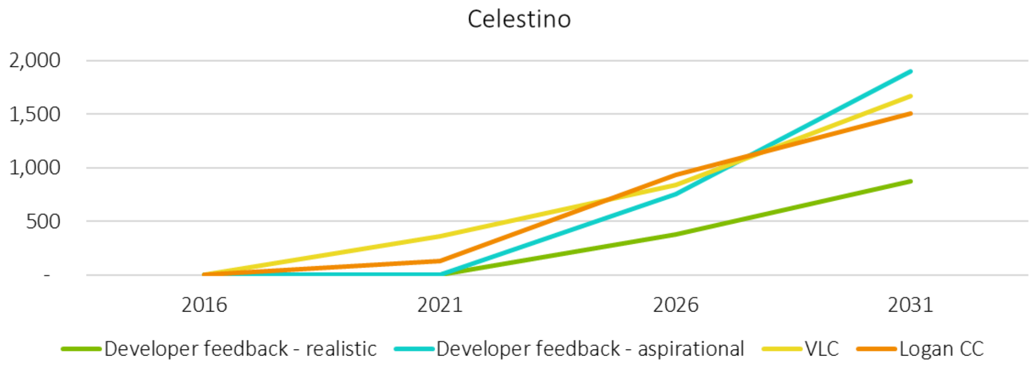
Source: SGS Economics and Planning 2019

APPENDICES

Appendix 1 – Greater Flagstone & Yarrabilba Developer Areas Comparison

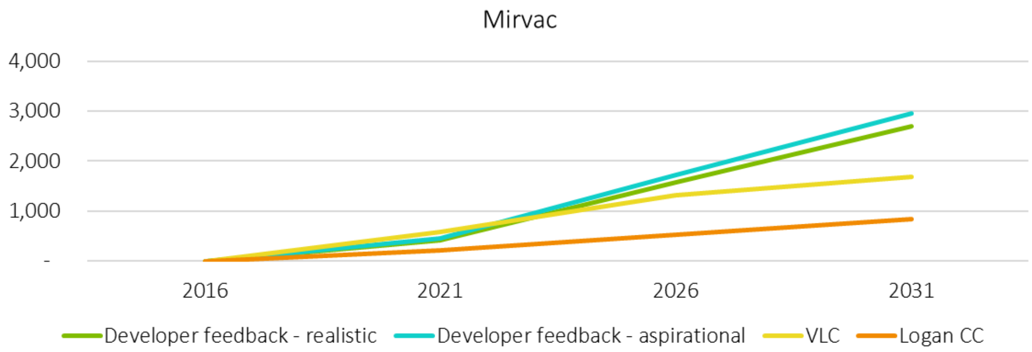
The following charts compare forecasts produced by Logan CC, VLC transport modelling and developer feedback (realistic and aspirational) for each developer area within Greater Flagstone PDA. Across all developer areas the aspirational developer feedback forecast is highest.

FIGURE 27: GREATER FLAGSTONE – CELESTINO DEVELOPER AREA FORECAST



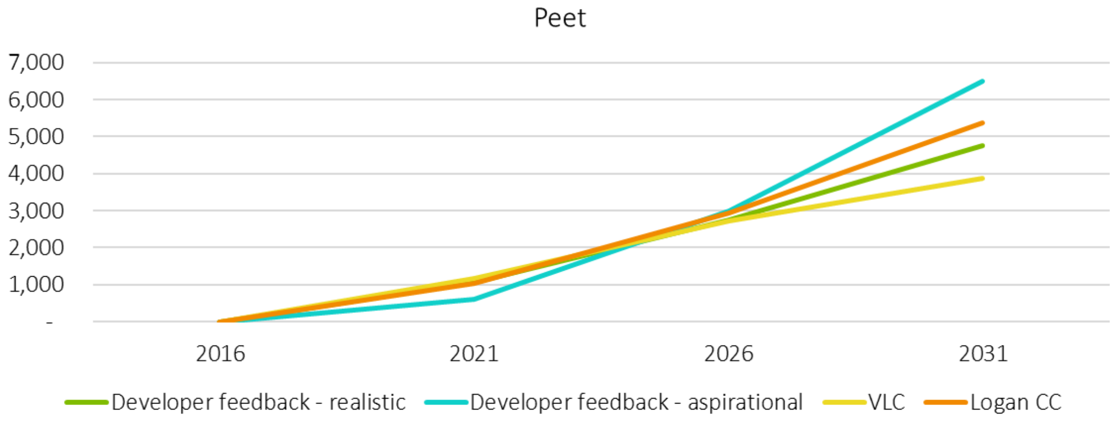
Source: Logan City Council, VLC Transport Modelling, Developer Feedback documentation

FIGURE 28: GREATER FLAGSTONE – MIRVAC DEVELOPER AREA FORECAST



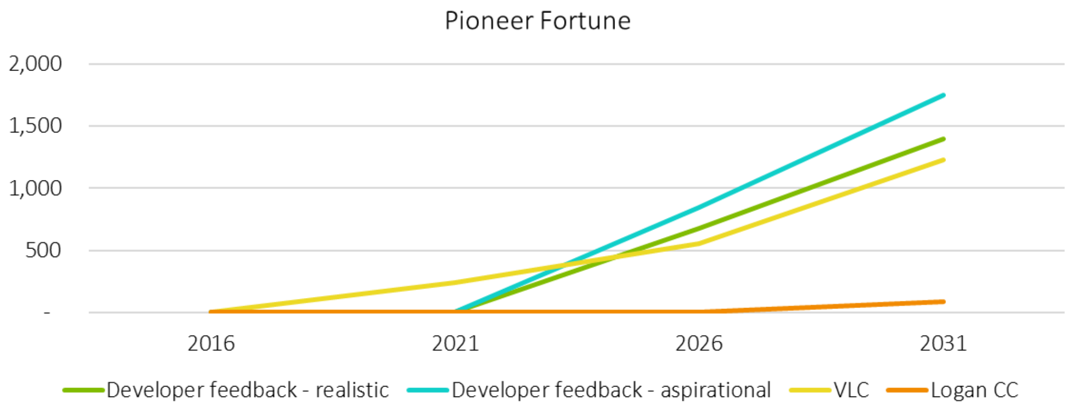
Source: Logan City Council, VLC Transport Modelling, Developer Feedback documentation

FIGURE 29: GREATER FLAGSTONE – PEET DEVELOPER AREA FORECAST



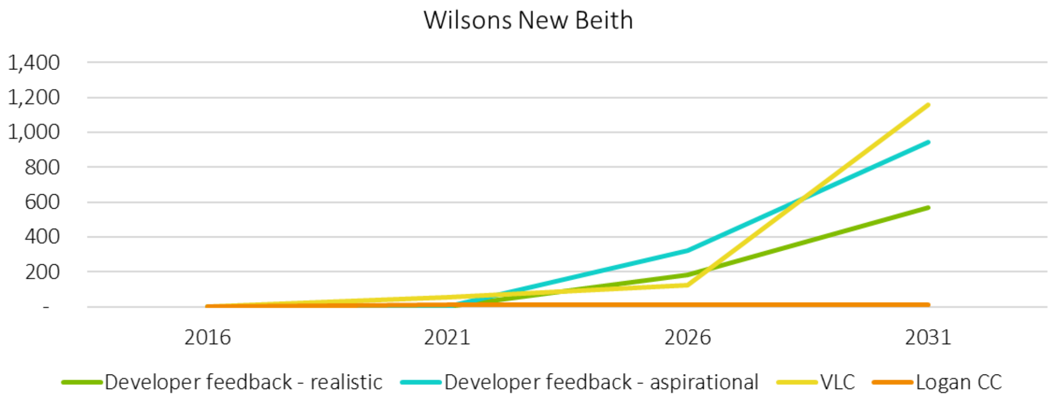
Source: Logan City Council, VLC Transport Modelling, Developer Feedback documentation

FIGURE 30: GREATER FLAGSTONE – PIONEER FORTUNE DEVELOPER AREA FORECAST



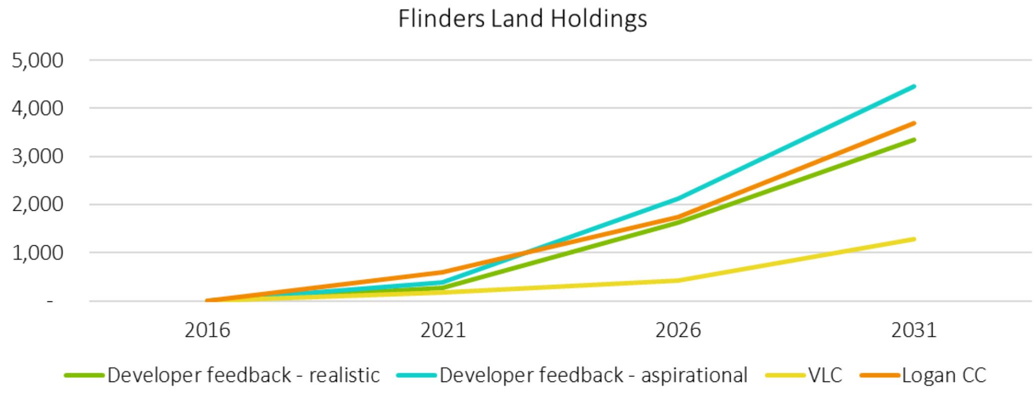
Source: Logan City Council, VLC Transport Modelling, Developer Feedback documentation

FIGURE 31: GREATER FLAGSTONE – WILSONS NEW BEITH DEVELOPER AREA FORECAST



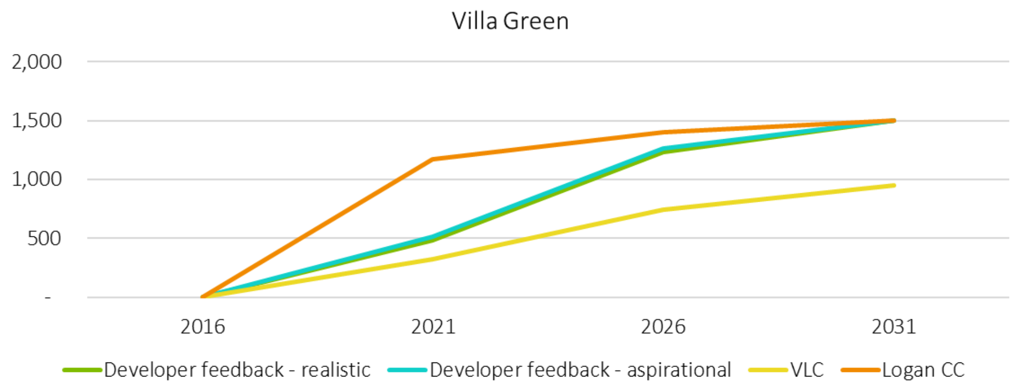
Source: Logan City Council, VLC Transport Modelling, Developer Feedback documentation

FIGURE 32: GREATER FLAGSTONE – FLINDERS LAND HOLDINGS DEVELOPER AREA FORECAST



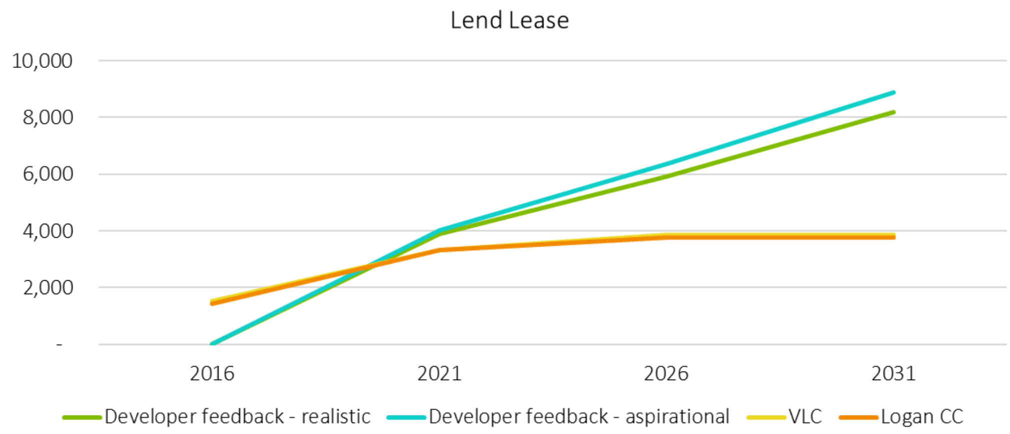
Source: Logan City Council, VLC Transport Modelling, Developer Feedback documentation

FIGURE 33: GREATER FLAGSTONE – VILLA GREEN DEVELOPER AREA FORECAST



Source: Logan City Council, VLC Transport Modelling, Developer Feedback documentation

FIGURE 34: YARRABILBA – LEND LEASE DEVELOPER AREA FORECAST

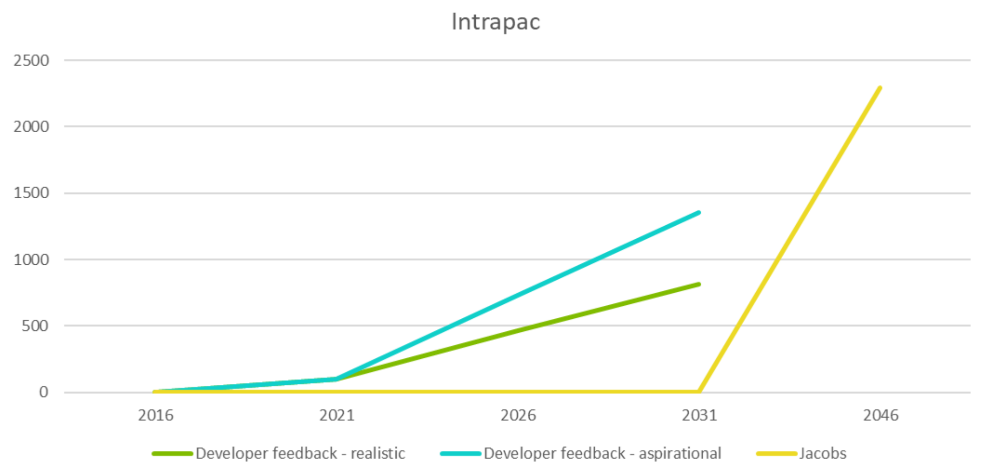


Source: Logan City Council, VLC Transport Modelling, Developer Feedback documentation

Appendix 2 – Ripley Valley Developer Areas Comparison

The following charts compare forecasts produced by Ipswich CC, Jacobs and developer feedback (realistic and aspirational), where available, within Ripley Valley PDA. Dwelling projections by Jacobs are limited to 2046, and dwelling projections by Ipswich are not available for areas owned by Intrapac and Stocklands. Across all developer areas the aspirational developer feedback forecast is highest.

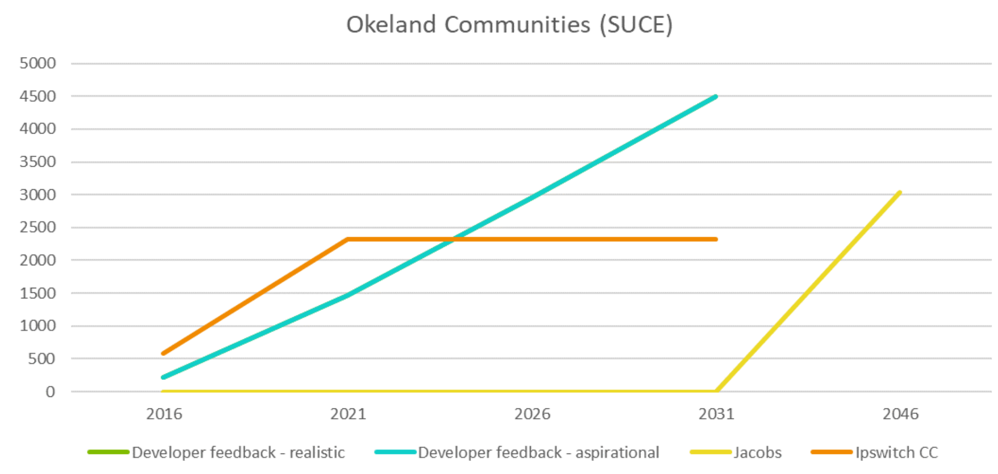
FIGURE 35: RIPLEY VALLEY – INTRAPAC DEVELOPER AREA FORECAST



Source: Jacobs and Developer Feedback documentation

Note: Ipswich City Council dwelling projections for Intrapac developer area were not available

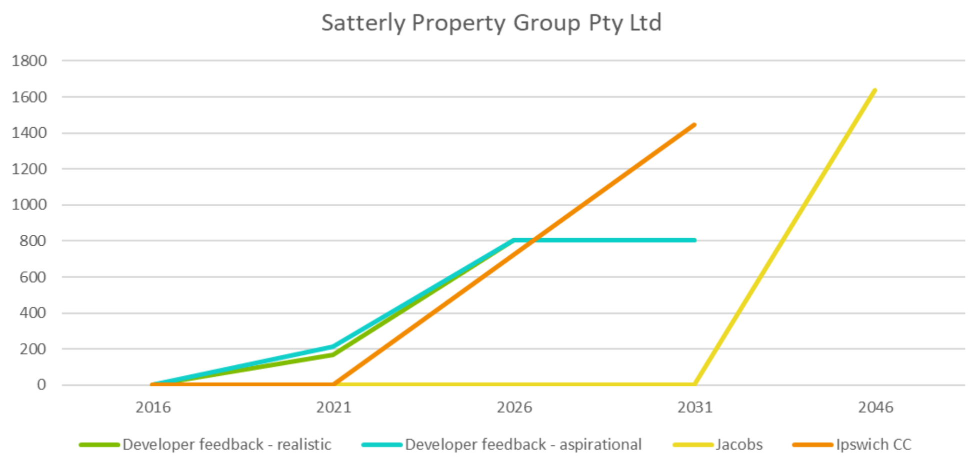
FIGURE 36: RIPLEY VALLEY – OKELAND COMMUNITIES (SUCE) DEVELOPER AREA FORECAST



Source: Ipswich City Council, Jacobs, Developer Feedback documentation

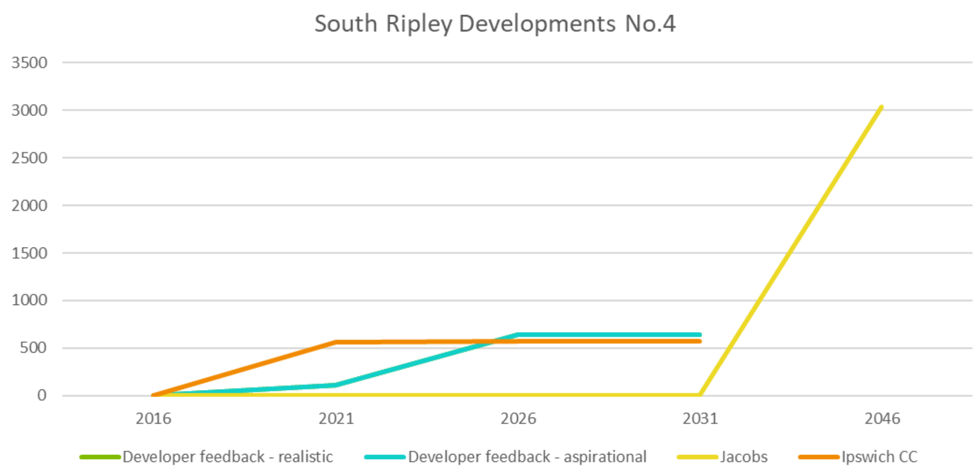
Note: there is no variation between the realistic and aspirational developer feedback dwelling projections

FIGURE 37: RIPLEY VALLEY – SATTERLY PROPERTY GROUP PTY LTD DEVELOPER AREA FORECAST



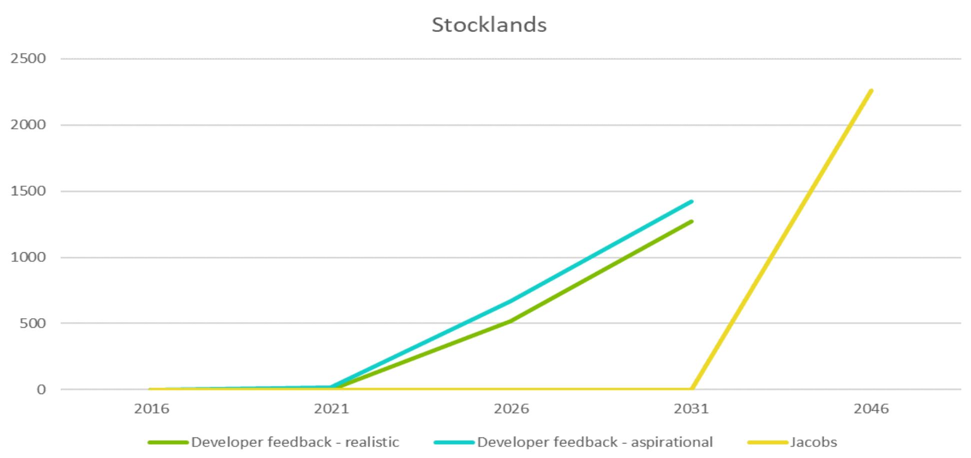
Source: Ipswich City Council, Jacobs, Developer Feedback documentation

FIGURE 38: RIPLEY VALLEY – SOUTH RIPLEY DEVELOPMENTS NO.4 DEVELOPER AREA FORECAST



Source: Ipswich City Council, Jacobs, Developer Feedback documentation
Note: there is no variation between the realistic and aspirational developer feedback dwelling projections

FIGURE 39: RIPLEY VALLEY – STOCKLANDS DEVELOPER AREA FORECAST



Source: Ipswich City Council, Jacobs, Developer Feedback documentation
Note: Ipswich City Council dwelling projections for Stocklands developer area were not available

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