



INNOVATIVE: Journal Of Social Science Research

Volume 3 Nomor 3 Tahun 2023 Page 8459-8468

E-ISSN 2807-4238 and P-ISSN 2807-4246

Website: <https://j-innovative.org/index.php/Innovative>

Performance Study of the Weleri Ring Road Intersection in Central Java

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Abstract

The Weleri ring road intersection is a signalized intersection that connects the Weleri ring road, the district boundary road. Batang – Weleri, the central main highway, and the Weleri toll gate. The purpose of this study was to analyze the performance of the Weleri Ring Road Intersection in terms of capacity, the degree of saturation of delays, and the length of the queue based on the Indonesian Road Capacity Manual (MKJI, 1997), knowing the traffic growth of the Weleri Ring Road Intersection in the next 10 years from the first year. 2022 using the geometric formula method and providing alternative solutions to overcome the degree of saturation, delays and long queues at the Weleri Ring Road Intersection. The procedural framework used in this study starts with identifying the problem followed by collecting primary and secondary data, then processing and analyzing the data and drawing conclusions and suggestions from the results of the analysis. The results of the data analysis obtained the degree of saturation for each approach as follows: the north approach (towards the Weleri ring road) is 0.77, the south approach (to the Weleri toll gate) is 0.65, the east approach (towards Weleri District) of 0.70, and the western approach (towards Batang district) of 0.51. According to the results of geometric calculations, the growth of vehicles during the evening rush hour at the Signalized Four Intersection of the Weleri Ring Road increases annually by 1.34%.

Keyword: *Congestion, capacity, traffic volume, degree of saturation*

Abstrak

Simpang empat jalan lingkaran weleri adalah simpang empat bersinyal yang menghubungkan antara jalan lingkaran weleri, jalan batas Kab. Batang – Weleri, jalan raya utama tengah, dan gerbang tol weleri. Tujuan dari penelitian ini adalah untuk menganalisis kinerja Simpang Empat Jalan Lingkaran Weleri dari segi kapasitas, derajat kejenuhan tundaan, dan panjang antrianya berdasarkan Manual Kapasitas Jalan Indonesia (MKJI, 1997), mengetahui pertumbuhan Lalu lintas Simpang Empat Jalan Lingkaran Weleri 10 tahun mendatang dari tahun awal 2022 dengan metode rumus geometrik serta memberikan alternatif solusi mengatasi derajat kejenuhan, tundaan dan panjang antrian di Simpang Empat Jalan Lingkaran Weleri. Kerangka prosedur yang digunakan dalam penelitian ini dimulai dari identifikasi masalah dilanjutkan dengan pengumpulan data-data primer dan sekunder lalu pengolahan dan analisa data serta pembuatan kesimpulan dan saran dari hasil analisa. Hasil dari analisa data tersebut didapatkan derajat kejenuhan pada masing-masing pendekatan sebagai berikut : pendekatan utara (arah jalan lingkaran weleri) sebesar 0,77, pendekatan selatan (arah gerbang tol weleri) sebesar 0,65, pendekatan timur (arah Kec. Weleri) sebesar 0,70, dan pendekatan barat (arah kab. Batang) sebesar 0,51. Sesuai hasil perhitungan geometrik didapatkan pertumbuhan kendaraan di jam sibuk sore Simpang Empat Bersinyal Jalan Lingkaran Weleri setiap tahunnya meningkat sebesar 1,34%.

Kata Kunci: *Kemacetan, kapasitas, volume lalu lintas, derajat kejenuhan*

INTRODUCTION

Weleri ring road is a road that connects two districts, namely Kendal and Batang districts, Weleri ring road is an alternative road in the west of Kendal Regency with a total road length of 4,600 m and a width of each lane of 7 m (Dewi, Krisdiyanto, & Yasak, 2023; Putri et al., 2021; Tentama et al., 2019). The Weleri Ring Road Intersection is a signalized intersection that connects the Weleri Ring Road and the Kab. Batang-Weleri, the central main highway, and the Weleri toll gate (Ayu et al., 2021; Dewi, Krisdiyanto, Heriyono, et al., 2023; Isnain, 2021). The Weleri Ring Road Signalized Intersection was chosen as the object of research through several considerations, including: 1) Weleri Ring Road is a National Route that connects between cities and national strategic roads. 2) The Weleri Ring Road Intersection of Four connects the Kendal - Batang direction and the Trans Java Toll Gate so that it has a fairly busy travel schedule. 3) The density of traffic on this road often becomes a point of congestion, especially due to the large number of heavy vehicles (axle 6 trucks, axle trucks 8, inter-city buses and so on) that cross the Weleri Ring Road. 4) The mixing of various means of transportation, both motorized with various sizes, and non-motorized such as rickshaws and bicycles (KUSUMAWARDANI et al., 2019; Sholihah & Zaenurrosyid, 2021).

The expected objectives of this research are: 1) To analyze the performance of the Weleri Ring Road Intersection in terms of capacity, degree of saturation delay, and antianya length based on the Indonesian Road Capacity Manual (Naimah et al., 2020; Setiadji et al., 2022). To find out the traffic growth of the Weleri Ring Road Intersection Four in the next 10 years from the beginning of 2022 using the geometric formula method. 3) To provide alternative solutions to overcome the degree of saturation of delays and long queues at the Weleri Ring Road Intersection. The problem limitations of this study are: 1) Observations were made only at the Weleri Ring Road Intersection. 2) The research aims to determine the cycle time of road traffic lights at the intersection. 3) The calculation procedure for performance levels is based on the 1997 Indonesian Highway Capacity Manual (MKJI) (Boomgaard, 2008; Edyanto, 1989).

RESEARCH METHOD

The compilation of data was collected using literature, observation, and interview methods. The data taken is in the form of primary data, namely data directly taken from the field which includes APILL cycle time signals and traffic flow data. While the data were obtained from related agencies and books related to the study literature to expand this research which included LHR data, geometric data, population data, maps of the primary road network.

The research mechanism in the form of research used in conducting the survey is the APILL cycle time signal survey and the length of the queue by manual calculation. The time of the research was carried out for 3 days for each observation location. For conditions at the intersection of the four Weleri Ring Road, 4 observation points were carried out, namely on Monday by conducting a survey at the location to represent working days. While Saturday-Sunday conduct surveys at the location to represent holidays.

RESULTS AND DISCUSSION

Traffic Flow Data

This study retrieves traffic flow data consisting of light vehicles (LV), motorcycles (motorcycles / MC), and heavy vehicles (heavy vehicle / HV). The research was conducted over 3 days, namely Monday 5 December 2022 to represent traffic flow on weekdays and Saturday and Sunday 10-11 December 2022 to represent traffic flow on holidays. The entire calculation is carried out based on the Road Capacity Manual method.

PER SATU JAM														
Waktu	URAIAN	Utara (Arah Kab. Kendal)			Selatan (Arah Gerbang Tol Weleri)			Timur (Arah Kec. Weleri)			Barat (Arah Kab. Batang)			
		LT	ST	RT	LT	ST	RT	LT	ST	RT	LT	ST	RT	
07.00 - 08.00	SEPEDA MOTOR (MC)	241	-	447	-	-	-	-	1.668	1.112	-	870	1.616	-
	KENDARAAN RINGAN (LV)	203	431	381	363	412	194	381	524	48	170	320	362	-
	KENDARAAN BERAT (HV)	52	568	413	209	288	26	77	100	5	90	2	72	-
PER SATU JAM														
08.00 - 09.00	SEPEDA MOTOR (MC)	174	-	323	-	-	-	-	1.471	981	-	768	1.426	-
	KENDARAAN RINGAN (LV)	178	377	333	311	353	166	408	562	51	183	342	388	-
	KENDARAAN BERAT (HV)	39	426	310	230	317	29	58	75	4	67	4	51	-
PER SATU JAM														
12.00 - 13.00	SEPEDA MOTOR (MC)	172	-	210	-	-	-	-	1.079	719	-	563	1.046	-
	KENDARAAN RINGAN (LV)	190	209	235	282	251	228	354	487	44	158	297	336	-
	KENDARAAN BERAT (HV)	41	409	368	306	340	34	61	80	4	71	3	56	-
PER SATU JAM														
13.00 - 14.00	SEPEDA MOTOR (MC)	202	-	219	-	-	-	-	1.275	850	-	665	1.236	-
	KENDARAAN RINGAN (LV)	209	230	258	333	297	270	327	449	41	146	274	311	-
	KENDARAAN BERAT (HV)	38	436	474	366	337	29	70	92	5	84	1	64	-
PER SATU JAM														
16.00 - 17.00	SEPEDA MOTOR (MC)	254	-	472	-	-	-	-	1.766	1.177	-	921	1.711	-
	KENDARAAN RINGAN (LV)	228	485	428	467	529	249	517	711	65	231	434	492	-
	KENDARAAN BERAT (HV)	29	630	805	461	360	17	109	142	8	130	2	99	-
PER SATU JAM														
17.00 - 18.00	SEPEDA MOTOR (MC)	228	-	423	-	-	-	-	1.570	1.046	-	819	1.521	-
	KENDARAAN RINGAN (LV)	216	458	404	441	500	235	436	599	54	195	365	414	-
	KENDARAAN BERAT (HV)	18	814	977	480	400	9	134	176	10	160	3	123	-
PER SATU JAM														
18.00 - 19.00	SEPEDA MOTOR (MC)	161	-	298	-	-	-	-	981	654	-	512	951	-
	KENDARAAN RINGAN (LV)	178	377	333	389	441	208	300	412	37	134	251	285	-
	KENDARAAN BERAT (HV)	10	941	1.030	517	472	5	147	192	10	178	3	131	-

Figure 1. Traffic Flow Survey Data Monday 5 December 2022

PER SATU JAM														
Waktu	URAIAN	Utara (Dari Lingkar Weleri)			Selatan (Dari Gerbang Tol Weleri)			Timur (Dari Kec. Weleri)			Barat (Dari Kab. Batang)			
		LT	ST	RT	LT	ST	RT	LT	ST	RT	LT	ST	RT	
07.00 - 08.00	SEPEDA MOTOR (MC)	275	-	510	-	-	-	-	926	617	-	810	1.505	-
	KENDARAAN RINGAN (LV)	218	463	408	267	303	142	226	311	28	169	318	360	-
	KENDARAAN BERAT (HV)	62	686	499	202	278	25	51	67	4	100	2	80	-
PER SATU JAM														
08.00 - 09.00	SEPEDA MOTOR (MC)	198	-	368	-	-	-	-	1.050	700	-	918	1.706	-
	KENDARAAN RINGAN (LV)	191	405	357	311	353	166	242	333	30	182	340	386	-
	KENDARAAN BERAT (HV)	47	515	374	222	305	28	38	50	3	75	4	58	-
PER SATU JAM														
12.00 - 13.00	SEPEDA MOTOR (MC)	196	-	240	-	-	-	-	679	453	-	594	1.104	-
	KENDARAAN RINGAN (LV)	204	225	252	241	215	196	210	288	26	157	295	334	-
	KENDARAAN BERAT (HV)	49	494	445	295	328	33	40	53	3	80	3	62	-
PER SATU JAM														
13.00 - 14.00	SEPEDA MOTOR (MC)	230	-	249	-	-	-	-	803	535	-	702	1.304	-
	KENDARAAN RINGAN (LV)	225	247	277	285	254	231	194	266	24	145	272	309	-
	KENDARAAN BERAT (HV)	46	526	572	353	325	28	47	61	3	94	2	72	-
PER SATU JAM														
16.00 - 17.00	SEPEDA MOTOR (MC)	290	-	538	-	-	-	-	1.111	741	-	972	1.806	-
	KENDARAAN RINGAN (LV)	245	521	460	400	454	214	274	377	34	206	386	437	-
	KENDARAAN BERAT (HV)	35	760	972	444	347	16	72	95	5	145	3	111	-
PER SATU JAM														
17.00 - 18.00	SEPEDA MOTOR (MC)	259	-	482	-	-	-	-	988	659	-	864	1.605	-
	KENDARAAN RINGAN (LV)	231	492	434	378	429	202	290	399	36	218	408	463	-
	KENDARAAN BERAT (HV)	22	983	1.179	463	386	9	89	117	6	179	3	137	-
PER SATU JAM														
18.00 - 19.00	SEPEDA MOTOR (MC)	183	-	340	-	-	-	-	617	412	-	540	1.003	-
	KENDARAAN RINGAN (LV)	191	405	357	334	378	178	177	244	22	133	250	283	-
	KENDARAAN BERAT (HV)	12	1.136	1.244	499	455	5	98	128	7	199	3	147	-

Figure 2. Traffic Flow Survey Data Saturday 10 December 2022

PER SATU JAM													
WAKTU	URAIAN	Utara (Dari Lingkar Weleri)			Selatan (Dari Gerbang Tol Weleri)			Timur (Dari Kec. Weleri)			Barat (Dari Kab. Batang)		
		LT	ST	RT	LT	ST	RT	LT	ST	RT	LT	ST	RT
07.00 - 08.00	SEPEDA MOTOR (MC)	226	-	420	-	-	-	-	762	508	667	1.239	-
	KENDARAAN RINGAN (LV)	218	463	408	267	303	142	226	311	28	169	318	360
	KENDARAAN BERAT (HV)	59	648	471	191	262	24	48	63	3	95	2	76
PER SATU JAM													
WAKTU	URAIAN	Utara (Arah Kab. Kendal)			Selatan (Arah Gerbang Tol Weleri)			Timur (Arah Kec. Weleri)			Barat (Arah Kab. Batang)		
		LT	ST	RT	LT	ST	RT	LT	ST	RT	LT	ST	RT
08.00 - 09.00	SEPEDA MOTOR (MC)	163	-	303	-	-	-	-	864	576	756	1.404	-
	KENDARAAN RINGAN (LV)	191	405	357	311	353	166	242	333	30	182	340	386
	KENDARAAN BERAT (HV)	44	486	354	210	288	26	36	47	3	71	4	54
PER SATU JAM													
WAKTU	URAIAN	Utara (Arah Kab. Kendal)			Selatan (Arah Gerbang Tol Weleri)			Timur (Arah Kec. Weleri)			Barat (Arah Kab. Batang)		
		LT	ST	RT	LT	ST	RT	LT	ST	RT	LT	ST	RT
12.00 - 13.00	SEPEDA MOTOR (MC)	161	-	197	-	-	-	-	559	373	489	909	-
	KENDARAAN RINGAN (LV)	204	225	252	241	215	196	210	288	26	157	295	334
	KENDARAAN BERAT (HV)	47	467	420	279	310	31	38	50	3	75	3	59
PER SATU JAM													
WAKTU	URAIAN	Utara (Arah Kab. Kendal)			Selatan (Arah Gerbang Tol Weleri)			Timur (Arah Kec. Weleri)			Barat (Arah Kab. Batang)		
		LT	ST	RT	LT	ST	RT	LT	ST	RT	LT	ST	RT
13.00 - 14.00	SEPEDA MOTOR (MC)	189	-	205	-	-	-	-	661	440	578	1.074	-
	KENDARAAN RINGAN (LV)	225	247	277	285	254	231	194	266	24	145	272	309
	KENDARAAN BERAT (HV)	43	497	540	334	307	27	44	58	3	89	2	68
PER SATU JAM													
WAKTU	URAIAN	Utara (Arah Kab. Kendal)			Selatan (Arah Gerbang Tol Weleri)			Timur (Arah Kec. Weleri)			Barat (Arah Kab. Batang)		
		LT	ST	RT	LT	ST	RT	LT	ST	RT	LT	ST	RT
16.00 - 17.00	SEPEDA MOTOR (MC)	239	-	443	-	-	-	-	915	610	801	1.487	-
	KENDARAAN RINGAN (LV)	245	521	460	400	454	214	274	377	34	206	386	437
	KENDARAAN BERAT (HV)	33	718	918	419	328	15	68	90	5	137	2	105
PER SATU JAM													
WAKTU	URAIAN	Utara (Arah Kab. Kendal)			Selatan (Arah Gerbang Tol Weleri)			Timur (Arah Kec. Weleri)			Barat (Arah Kab. Batang)		
		LT	ST	RT	LT	ST	RT	LT	ST	RT	LT	ST	RT
17.00 - 18.00	SEPEDA MOTOR (MC)	213	-	396	-	-	-	-	813	542	712	1.321	-
	KENDARAAN RINGAN (LV)	231	492	434	378	429	202	290	399	36	218	408	463
	KENDARAAN BERAT (HV)	21	928	1.114	438	365	8	85	111	6	169	3	130
PER SATU JAM													
WAKTU	URAIAN	Utara (Arah Kab. Kendal)			Selatan (Arah Gerbang Tol Weleri)			Timur (Arah Kec. Weleri)			Barat (Arah Kab. Batang)		
		LT	ST	RT	LT	ST	RT	LT	ST	RT	LT	ST	RT
18.00 - 19.00	SEPEDA MOTOR (MC)	151	-	280	-	-	-	-	508	339	445	826	-
	KENDARAAN RINGAN (LV)	191	405	357	334	378	178	177	244	22	133	250	283
	KENDARAAN BERAT (HV)	11	1.073	1.175	471	430	5	93	121	7	188	3	139

Figure 3. Traffic Flow Survey Data for Sunday 11 December 2022

According to the survey results, data on the peak traffic flow of the Simpang Empat Weleri Ring Road data was obtained on Monday 5 December 2022 at 16.00 - 17.00. The data is used as the calculation value of the total traffic flow.

KODE PENDEKAT	ARAH	Kendaraan Ringan (LV)			Kendaraan Berat (HV)			Sepeda Motor (MC)			Kendaraan Bermotor		
		emp terlindung :		1,0	emp terlindung :		1,3	emp terlindung :		0,2	total		
		emp terlawan :		1,0	emp terlawan :		1,3	emp terlawan :		0,4	MV		
		kend/jam	smp/jam		kend/jam	smp/jam		kend/jam	smp/jam		kend/jam	smp/jam	
	terlindung	terlawan		terlindung	terlawan		terlindung	terlawan		terlindung	terlawan		
Utara (Dari Lingkar Weleri)	LT	228	228	228	29	38,1	38,1	254	50,9	101,7	512,0	317,3	368,2
	ST	485	485	485	630	818,5	818,5	-	-	-	1.114,9	1.303,8	1.303,8
	RT	428	428	428	805	1.046,9	1.046,9	472	94,5	188,9	1.705,9	1.569,6	1.664,1
	Total	1.142	1.142	1.142	1.464	1.903,5	1.903,5	727	145,3	290,7	3.332,7	3.190,7	3.336,0
Selatan (Dari Gerbang Tol Weleri)	LT	467	467	467	461	598,7	598,7	-	-	-	927,7	1.065,9	1.065,9
	ST	529	529	529	360	468,1	468,1	-	-	-	889,5	997,6	997,6
	RT	249	249	249	17	21,8	21,8	-	-	-	265,9	270,9	270,9
	Total	1.246	1.246	1.246	837	1.088,6	1.088,6	-	-	-	2.083,2	2.334,4	2.334,4
Timur (Dari Kec. Weleri)	LT	517	517	517	109	141,2	141,2	-	-	-	626,0	658,6	658,6
	ST	711	711	711	142	185,0	185,0	1.766	353,2	706,3	2.619,4	1.249,5	1.602,6
	RT	65	65	65	8	10,1	10,1	1.177	235,4	470,9	1.249,6	310,2	545,6
	Total	1.293	1.293	1.293	259	336,3	336,3	2.943	588,6	1.177,2	4.495,0	2.218,3	2.806,8
Barat (Dari Kab. Batang)	LT	231	231	231	130	168,4	168,4	921	184,3	368,5	1.282,2	584,1	768,3
	ST	434	434	434	2	3,0	3,0	1.711	342,2	684,4	2.147,1	779,0	1.121,2
	RT	492	492	492	99	129,3	129,3	-	-	-	591,2	621,0	621,0
	Total	1.157	1.157	1.157	231	300,8	300,8	2.632	526,5	1.052,9	4.020,5	1.984,1	2.510,6

Figure 4. Motorized Traffic Flow (MV) Survey Data

Parameters

Calculating Traffic Flow (Q)

$$Q = Q_{LV} \cdot EMP_{LV} + Q_{HV} \cdot EMP_{HV} + Q_{MC} \cdot EMP_{MC}$$

$$Q_{Amount} = Q_{RT} + Q_{LT} + Q_{ST}$$

Approach symbol

U = North (From the Weleri Circumference)

S = South (From the Weleri Toll Gate)

T = East (From the direction of Weleri District)

B = West (From Batang Regency)

Protected approach

Table 1. Total Traffic Flow

Approach	Total MV Covered
	(pcu/hour)
North	3.190,7
South	2.334,4
East	2.218,3
West	1.984,1

Saturated Current

$$S = S_o \times F_{cs} \times F_{sf} \times F_G \times F_p \times F_{RT} \times F_{LT}$$

$$S_o = 600 \times w_e$$

Table 2. Basic Saturated Current

Approach	We		So Pcu/hour
	(m)		
North	600	7,0	4.200
South	600	6,0	3.600
East	600	6,0	4.600
West	600	7,0	4.200

Fcs

Because the population of Kendal Regency is 1,018,505 people, based on the Fcs table in MKJI 1997, the value for the Fcs is 0,94.

$$FSF = 0,95$$

$$FG = 1$$

$$FP = 1$$

FRT

$$F_{RT} = 1,0 + P_{RT} \times 0,26$$

$$P_{RT} = \frac{Q_{RT}}{Q_{tot}}$$

Table 3. Mark FRT

Approach	Q_{RT}	Q_{TOT}	PRT	FRT
North	1.569,6	3.190,7	0,49	1,13
South	270,9	2.334,4	0,12	1,03
East	310,2	2.218,3	0,14	1,04
West	621,0	1.984,1	0,31	1,08

FLT

$$F_{LT} = 1,0 - P_{LT} \times 0,16$$

$$P_{LT} = \frac{Q_{LT}}{Q_{tot}}$$

Table 4. Mark FLT

Approach	Q_{LT}	Q_{TOT}	PLT	FLT
North	317,3	3.190,7	0,10	0,98
South	1.065,9	2.334,4	0,46	0,93
East	658,6	2.218,3	0,30	0,95
West	584,1	1.984,1	0,29	0,95

Table 5. Saturated Current Rating (S)

Approach	S_o	F_{cs}	F_{sf}	FG	FP	FRT	FLT	S
	(pcu/hour)							(pcu/hour)
North	4.200	0,94	0,95	1	1	1,13	0,98	4.163,00
South	4.200	0,94	0,95	1	1	1,03	0,93	3.581,50
East	3.600	0,94	0,95	1	1	1,04	0,95	3.173,41
West	4.200	0,94	0,95	1	1	1,08	0,95	3.864,78

Calculating Service Level Index

Table 6. Service Level Index

Approach	DS	QL	Delay	ITP
h		(m)	(second)	
U	0,77	352,59	49	E
S	0,65	276,18	30	D
T	0,70	304,42	49	E
B	0,51	220,22	2	A

Calculating traffic growth

$$P_n = P_0 (1+r)^n$$

Table 7. Growth of population with geometric

Num	Year	Total population /Soul	Population growth using geometric	
			Ratio (r)	P 2032
1	2020	1.018.505	1,34%	1.194.949
2	2021	1.032.156		
3	2022	1.045.990		
4	2023	1.060.009		
5	2024	1.074.217		
6	2025	1.088.614		

The growth of vehicles during the afternoon rush hour increases annually by 1.34%. According to the calculation results, the North approach (from the Weleri Circle) has a degree of saturation (DS) of 0.77. So in accordance with MKJI 1997 where for operational analysis and improvement of existing intersections, suggestions are given in. The form of traffic behavior as a function of traffic flow in the standard state of the plan and the form of traffic control must be with the aim of ensuring the degree of saturation does not exceed an acceptable value (usually 0.75). If the DS value is more than 0.75, a review is needed by changing the vehicle flow (Q) and changing the capacity to get a DS value <0.75. In this case the author tries to simulate if the approach width is changed to 7.5 m in order to reduce the degree of saturation.

From the calculation analysis, changing the width of the north approach road (from the Weleri Circle) from the previous 7.0 m to 7.5 m can reduce the degree of saturation,

queue length, and delay values. The comparison results of the calculations are shown in the following Table 8.

Table 8. Geometric conditions of the four circle weleri intersection assuming the addition of approach width

Approach Code	Road Environment Type	Side Barriers	Median (Y/T)	Turn Left Immediately (Y/T)	Vehicle Parking Distance	Approach Width			
						Wa (m)	W Enter (m)	W Go Out (m)	WLTOR (m)
North	COM	R	Y	Y	100	10,50	7,50	7,50	3,00

Table 9. Comparison of Approach Width Adjustment Calculation Results

Approach	Before (Win = 7.0 m)				After (Win = 7.5 m)			
	DS	QL (m)	Delay (second)	ITP	DS	QL (m)	Delay (second)	ITP
North	0,77	352,59	49	E	0,72	320,02	30	D

CONCLUSION

The Weleri Ring Road section is counted as jammed, while the Bts. Batang City – Weleri and Weleri Toll Gate are also relatively quiet. As for the largest vehicle volume, it occurred on Monday, December 5, 2022 on the North approach side (from the Weleri Circle) with a Degree of Saturation (DS) value of 0.77, Queue Length of 352.59 m and Delay of 49 seconds. The total growth of vehicles during the evening rush hour at the Simpang Empat Weleri Ring Road increases annually by 1.34%. Changes in the width of the approach road on the north side (from the Weleri Circle) from previously 7.0 m to 7.5 m can reduce the degree of saturation, queue length, and delay value.

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