P-ISSN : 2598-1277
E-ISSN : 2621-3966

JOURNAL OF GREEN SCIENCE AND TECHNOLOGY

ANALYSIS OF TRAFFIC ACCIDENT-PRONE LOCATIONS (CASE STUDY: KALIURANG ROAD, SLEMAN REGENCY)

Muhammad Farid Halim[1*], Sugianto[1], Rizki Hardimansyah[1]

[1]) Road Transportation System Engineering Study Program, Polytechnic of Road Transportation Safety Tegal.*
Corresponding Author's Email: mfhalim0710@gmail.com
No.HP Corresponding Author: 082268957139

ABSTRACT

Traffic accidents are one of the leading causes of high mortality rates in Indonesia. During the period 2022–2024, Kaliurang Road in Sleman Regency was identified as one of the road segments with a high accident rate, with a total of 359 incidents resulting in 24 fatalities and 451 minor injuries. This study aims to identify accident-prone locations along the Kaliurang Road segment. The methods used include the Equivalent Accident Number (EAN) to weight accident severity levels, as well as the Upper Control Limit (UCL) and Upper Control Boundary (BKA) methods to determine accident-prone locations. The analysis of traffic accident characteristics shows that most incidents occurred in the morning (06:00–12:00), with male drivers being the most frequent offenders and motorcycles being the most commonly involved vehicle type. The most dominant collision type was a crash between the front and side parts of vehicles. Four accident-prone segments were identified: kilometers 7–8, 8–9, 12–13, and 13–14. Recommendations for addressing these accident-prone locations include the installation of rumble strips, rearrangement of community activity spaces or roadside obstruction control, improvement of street lighting, enhancement of road markings and warning signs, and the provision and installation of appropriate traffic signs. This study provides recommendations by identifying accident-prone locations along Kaliurang Road and offering suggestions based on accident characteristics and road conditions to improve traffic safety for road users.

Keyword: *Accident-prone Location, BKA, EAN, Traffic Accident, UCL.*

1. INTRODUCTION

Traffic accidents are one of the biggest causes of death in Indonesia, generally three victims die every hour [1]. The losses caused by traffic accidents themselves are very diverse, ranging from material losses in the form of damage to vehicles and infrastructure to immaterial losses such as injuries and deaths [2]. Traffic accidents also have an impact on increasing poverty due to the cost of treatment, loss of productivity, stress and prolonged suffering [3]. The problem of traffic accidents that continue to occur is a vital issue that needs to be studied, both regarding the causes, consequences, and handling [4]. Accident-prone locations on the road network have an accident frequency or the number of traffic accidents with fatalities or other accident criteria per year greater than the minimum number specified [5].

The causes of accident-prone locations are lack of concentration, high speed, lack of lighting and violation of traffic signs [6]. Traffic accident-prone locations (black spots) are influenced by land use, road geometrics, traffic volume, road capacity, and traffic signs [7]. One of the efforts to help minimize and reduce the accident rate is to identify the factors that cause the high number of traffic accidents. Knowing the accident factors is expected to help handling efforts both specifically and spatially [8]. The identification of traffic accident-prone locations is to determine the locations with the highest accident rates or most at risk. These locations are prioritized for more intensive handling to reduce the number of accidents and improve road user safety [9]. Straight roads often make drivers tend to violate speed limits to go faster and high side obstacles,such as illegal parking activities and street vendors, can disrupt the smooth flow of traffic by narrowing the space for vehicles to move, thus increasing the risk of accidents at accident-prone locations [10].

Kaliurang Road is a place to go to Mount Merapi and in this area there are tours and campuses so that many vehicles pass, enter/exit, and park on the road, as well as many human activities around the road [11]. The road section tends to be straight so that it can make drivers unconsciously speed up their vehicles beyond the regulated speed. Land use conditions on the road are dominated by commercial activities such as markets, shops, and other activities that can increase side obstacles. Based on data from Sleman Police in 2022-2024, traffic accidents that occurred on Kaliurang Road were 359 traffic accidents with 24 fatalities and 451 minor injuries.

The purpose of the accident-prone location analysis research is to identify accident-prone locations and traffic accident characteristics on the Kaliurang Road section as a basis for supporting traffic safety improvements. Locations or areas with the highest weight based on the results of the identification and ranking of accident-prone locations. Recommendations for accident-prone locations are made based on road conditions, including road inventory data, road geometric data, vehicle speed data, side obstacle data, and road condition data.

2. RESEARCH METHODE

2.1 Research Location

The location of this research is Kaliurang Road, Sleman Regency, Yogyakarta Special Region Province. This road is a strategic route that connects Yogyakarta City with Kaliurang tourism area on the southern slope of Mount Merapi: The length of Kaliurang Road is 23 km with the road type is 2 lanes 2 undivided directions (2/2 UD):

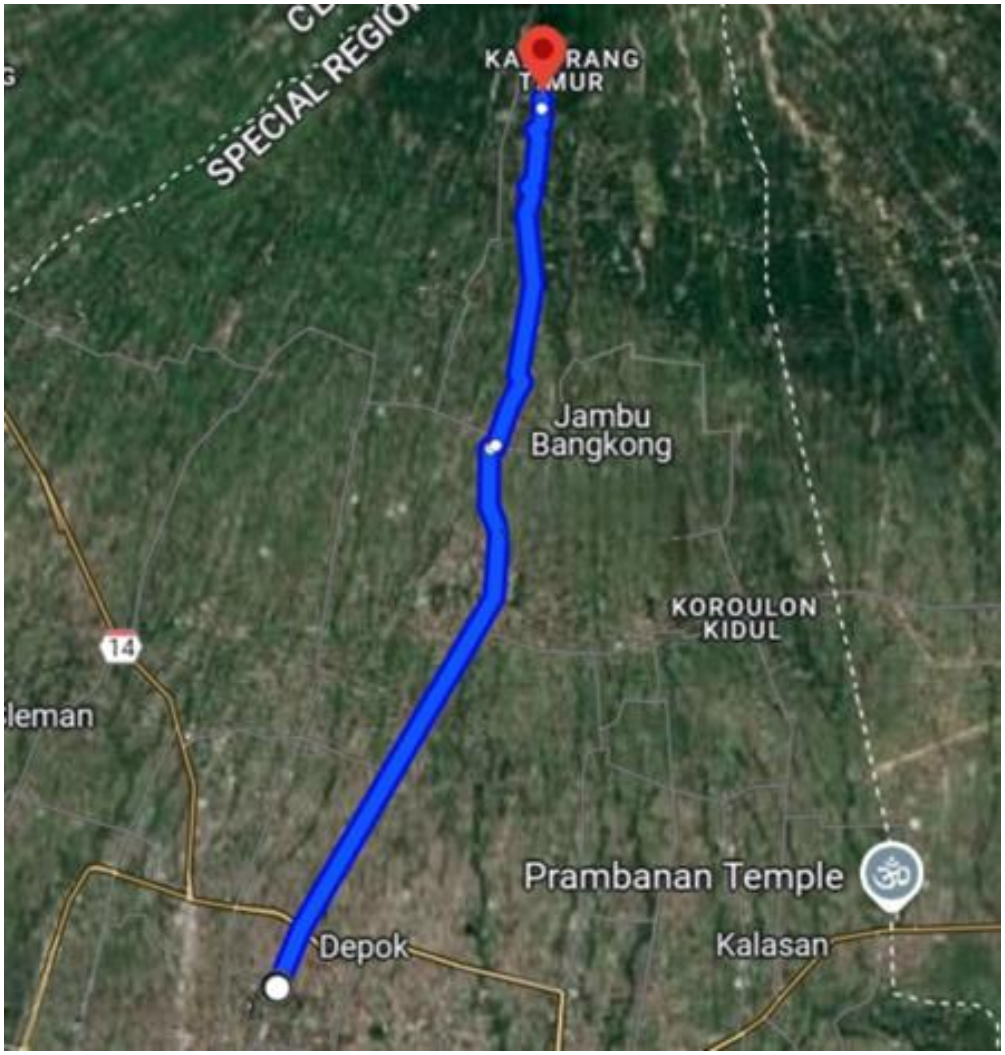

Figure 1. Research Location

P-ISSN : 2598-1277
E-ISSN : 2621-3966

2.2 Research Flowchart

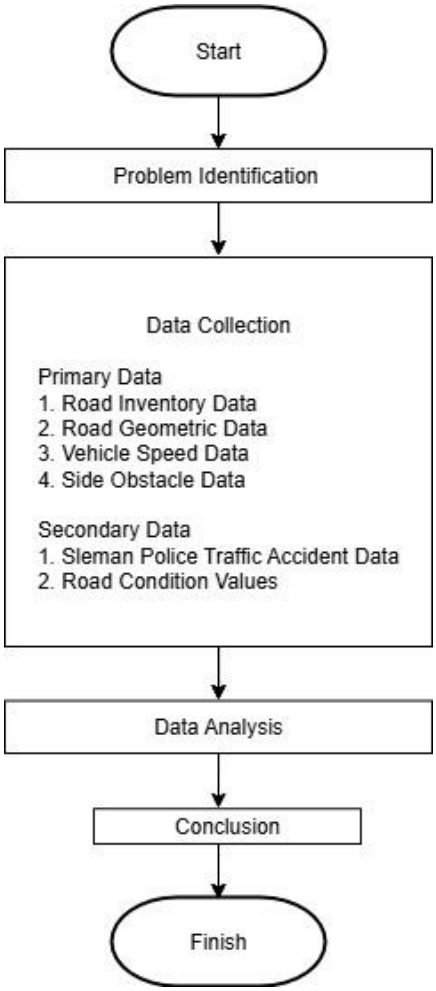

Figure 2. Research Flowchart

Initial information gathering, such as field observations, to obtain an overview of the problems on Kaliurang Road, Sleman Regency. The output from the problem identification and needs assessment is a clear problem statement regarding road conditions, the need for improvements, and the determination of research objectives. Data collection is divided into two categories: primary data, which includes Road Inventory Data, Road Geometric Data, Vehicle Speed Data, and Side Obstacle Data; and secondary data, which consists of existing information such as traffic accident data and road condition data. Data analysis in this study uses the Equivalent Accident Number (EAN) method to weight traffic accident values and the Upper Control Limit (UCL) method to determine accident-prone locations. The conclusion summarizes the main findings of the study and recommendations for improving road safety.

2.3 Data Collection Methods

The data collected in this study consist of primary and secondary data. Primary data collection includes road inventory, roadside friction, and vehicle speed measurements. Secondary data consist of traffic accident records from 2022 to 2024 obtained from the Sleman District Police, as well as road condition assessment data from the Directorate of Highways, Department of Public Works, Housing, and Energy and Mineral Resources of the Special Region of Yogyakarta.

2.4 Data Analysis Methods

1. Characteristics of Accident Prone Locations

   The characteristics of traffic accidents are displayed in percentages based on the time of occurrence, accident rate, victim severity, accident type, location of the accident, and type of vehicle involved. Through this analysis, it is possible to identify accident-prone hours, locations with high accident frequency and vehicles that are often involved.

P-ISSN : 2598-1277
E-ISSN : 2621-3966

2. Identification of Accident Prone Locations

   Identification using Equivalent Accident Number (EAN) is calculated using equation (1).

$$EAN = 12\,MD + 3(LB + LR) + K \quad (1)$$

   Description:

   MD = Death toll (people)

   LB = Number of seriously injured victims (people)

   LR = Number of slightly injured victims (people)

   K = Number of traffic accidents with material losses

3. Determination of Critical Limits of Accident Prone Locations

   This limit value can be calculated using the Upper Control Limit (BKA) and Upper Control Limit (UCL) methods, among others. The upper control limit (BKA) value is determined using equation (2). The upper control limit (UCL) value can be determined using equation (3).

$$BKA = C + 3\sqrt{C} \quad (2)$$

   Description:

   C = Average accident rate EAN

$$UCL = \lambda + \psi \times \sqrt{([(\lambda / m) + ((0.829) / m) + (1 / 2 \times m)\,]\,)} \quad (3)$$

   Description:

   λ = Average accident rate EAN

   ψ = probability factor 2.576

   m = Accident rate of the section under review (EAN)

4. Determination of Accident Prone Locations

   Determination of accident-prone locations is done by ranking based on the number of accidents per kilometer of road that has an Equivalent Accident Number (EAN) weight value exceeding the Upper Control Limit (BKA) and Upper Control Limit (UCL) values.

5. Problem Analysis of Accident Prone Locations

   Conduct observations at the research location to obtain road inventory, vehicle speed, road conditions and side obstacles. The results of this analysis are used to formulate effective handling measures in reducing accidents that often occur.

3. RESULTS AND DISCUSSION

3.1. Traffic Accidents

Between 2022 and 2024, a total of 359 traffic accidents occurred along Kaliurang Road, resulting in 24 fatalities and 451 minor injuries. The data on traffic accident victims on Kaliurang Road are presented in the following table 1.

Table 1. Data of Traffic Accident Victims on Kaliurang Road

Severity Level	Number of Victims
Fatalities	24
Serious Injuries	0
Minor Injuries	451

3.2. Traffic Accident Characteristics

1. Characteristics based on the time of the traffic accident

   The most traffic accidents occurred in the morning, which amounted to 34% or 123 incidents. Furthermore, the second most accidents occurred at night, which amounted to 26% with a total of 91

P-ISSN : 2598-1277
E-ISSN : 2621-3966

incidents. The percentage comparison of the number of accidents based on the time of occurrence is presented in Figure 3.

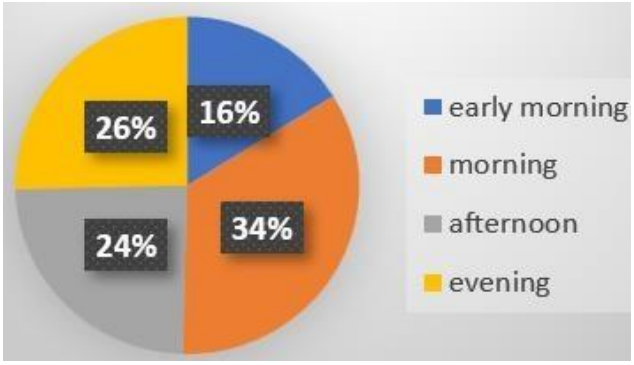

Figure 3. Percentage of Traffic Accident Time

2. Characteristics based on gender
   Most traffic accidents involving men were recorded at 230 incidents or 72%, while women were recorded at 88 incidents or 28%.

   The percentage comparison between males and females in traffic accidents on Kaliurang Road can be seen in Figure 4.

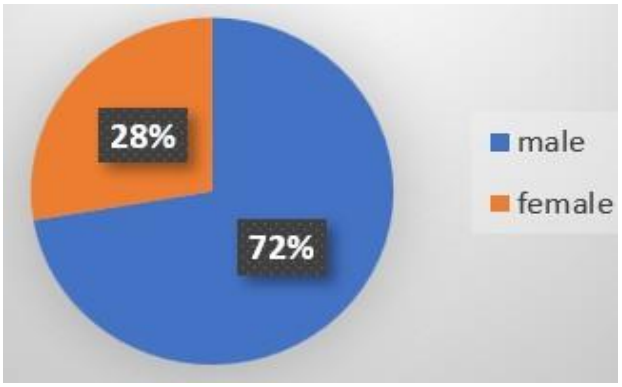

Figure 4. Percentage of Gender of Traffic Accident Perpetrators

3. Characteristics based on vehicle type
   The number of accidents involving motorcycles was recorded as many as 297 incidents or 83%, followed by cars recorded as many as 56 incidents or 16%. The percentage comparison of vehicles involved in traffic accidents on Kaliurang Road can be seen in the following figure.

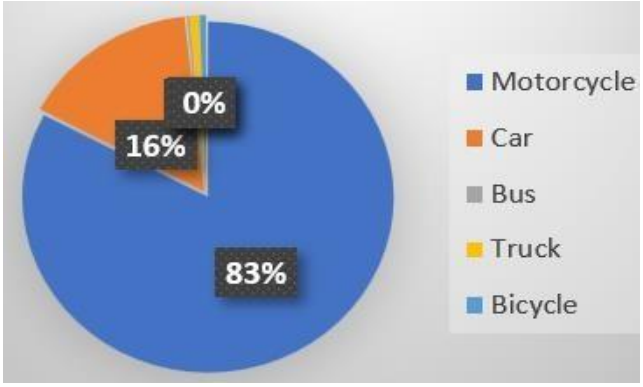

Figure 5. Percentage of Vehicle Type in Traffic Accidents

4. Characteristics based on collision type

P-ISSN : 2598-1277
E-ISSN : 2621-3966

The type of collision that often occurs is front-side collision with 103 traffic accidents. The hit-and-run and side- impact collision types are also frequent collision types on Kaliurang Road with 57 and 52 traffic accidents respectively. The following percentage comparison of traffic accident collision types can be seen in the figure.

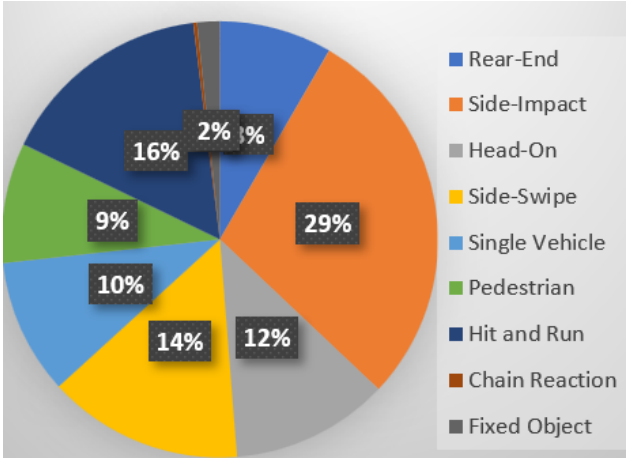

Figure 6. Percentage of Traffic Collision Types

3.3. Determination of Accident Prone Location

The accident rate analysis on Kaliurang Road is divided into 23 segments. The determination of accident-prone locations was calculated using the equivalent accident number (EAN) method. The calculation result of each segment and accident number can be seen in the table below.

Table 2. EAN Value of Kaliurang Road

Segment	Number of events	MD	LB	LR	EAN
0-1	17	1	0	24	84
1-2	11	0	0	16	8
2-3	9	1	0	12	8
3-4	7	0	0	10	30
4-5	23	1	0	24	84
5-6	13	0	0	14	42
6-7	21	1	0	27	93
7-8	25	2	0	31	117
8-9	27	3	0	36	144
9-10	23	0	0	27	81
10-11	18	1	0	23	81
11-12	16	3	0	20	96
12-13	24	3	0	27	117
13-14	30	2	0	36	132
14-15	8	1	0	11	45
15-16	13	1	0	14	54
16-17	19	0	0	25	75
17-18	18	0	0	22	66
18-19	8	0	0	13	39
19-20	10	0	0	15	45
20-21	9	0	0	11	33
21-22	6	2	0	8	48
22-23	4	2	0	5	39
TOTAL	359	24	0	451	1641

The results of the EAN calculation on Kaliurang Road have a value of 1641, then the calculation of the control limit value is carried out to identify locations prone to traffic accidents using the BKA and UCL methods. The calculation results can be seen in the following description:

P-ISSN : 2598-1277
E-ISSN : 2621-3966

$C = \frac{EAN}{Jumlah\ segmen}$
$= \frac{1641}{23}$
$= 71{,}34$

$BKA = C + 3\sqrt{C}$
$= 71{,}34 + 3\sqrt{71{,}34}$
$= 96{,}7$

The above calculation shows that the value of the upper control limit with the BKA method on Jalan Kaliurang is 96.7. For the *upper control limit (UCL)* value with the number of EAN= 1641 in all segments can be seen in the following description:

$\lambda = \frac{1641}{23}$
$= 71{,}34$
$\psi = 2.576$

And the value of m is reviewed for all segments.

Table 3. Determination of Accident Prone Locations

Segment	EAN	UCL	BKA	Category
0-1	84	88.2	96.7	Not Black spot
1-2	8	84.4	96.7	Not Black spot
2-3	8	84.4	96.7	Not Black spot
3-4	30	82.1	96.7	Not Black spot
4-5	84	88.2	96.7	Not Black spot
5-6	42	83.6	96.7	Not Black spot
6-7	93	89.1	96.7	Not Black spot
7-8	117	91.2	96.7	Black spot
8-9	144	93.3	96.7	Black spot
9-10	81	87.9	96.7	Not Black spot
10-11	81	87.9	96.7	Not a Black spot
11-12	96	89.3	96.7	Not Black spot
12-13	117	91.2	96.7	Black spot
13-14	132	92.4	96.7	Black spot
14-15	45	84.0	96.7	Not Black spot
15-16	54	85.1	96.7	Not Black spot
16-17	75	87.3	96.7	Not Black spot
17-18	66	86.4	96.7	Not Black spot
18-19	39	83.3	96.7	Not Black spot
19-20	45	84.0	96.7	Not Black spot
20-21	33	82.5	96.7	Not Black spot
21-22	48	84.4	96.7	Not Black spot
22-23	39	83.3	96.7	Not Black spot

There are 4 segments that include prone locations with EAN values that exceed the BKA and UCL control limit values, namely in the Km 7-8, Km 8-9, Km 12-13 and Km 13-14 segments. The following is a graph of the identification of accident- prone locations listed in Figure.

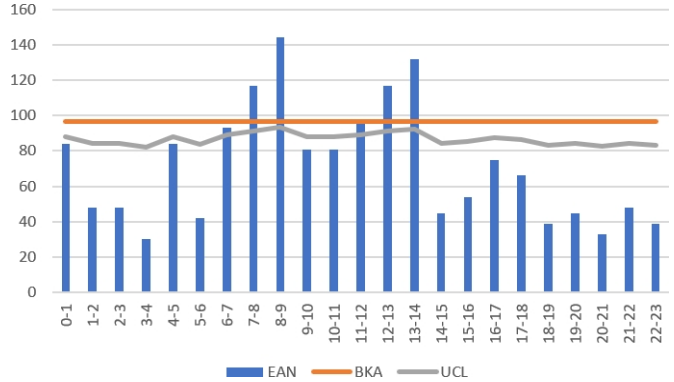

Figure 7. Determination of Accident Prone Location with BKA and UCL

P-ISSN : 2598-1277
E-ISSN : 2621-3966

3.4. Problem Analysis of Accident Prone Location

1. Kaliurang Road Km. 7-8

Table 4. table of problem and recommendations Kaliurang Road Km. 7-8

No	Problem	Recommendation
1	Road damage at STA 7+450 to 7+467 with a severe damage category.	Improvement/reconstruction of road conditions.
2	High side barriers due to activity around Kolombo Market	Removing obstacles by controlling parking and adding parking facilities. Installing speed limit signs to control vehicle speeds in accordance with the characteristics of the surrounding environment. This measure is also expected to increase driver awareness and create safer traffic conditions.
3	There are seven public street lights that are not functioning.	Improvements to public street lighting to increase visibility and reduce hazards for road users at night.
4	Warning sign for a three-way intersection on the right side covered by trees	Repairing signs by trimming tree branches or limbs that obstruct the signs
5	There are no warning signs for the three-way intersection on the left.	Procurement and installation of traffic signs in the form of warning signs for three-way intersections on the left side
6	There are no yield signs for local roads.	The Yield sign gives a clear command for drivers to give way to vehicles that have priority.

2. Jalan Kaliurang Km. 8-9

Table 5. table of problem and recommendations Kaliurang Road Km. 8-9

No	Problem	Recommendation
1	There are eight public street lights that are not functioning.	Improvements to public street lighting to increase visibility and reduce hazards for road users at night.
2	Warning sign for a three-way intersection on the right and left sides covered by a pole	Move the sign to a more open location that is easily visible to road users.
3	Traffic signal warning signs vandalized	Clean graffiti off road signs or replace them so that they are clearly visible to road users.
4	There are no warning signs indicating accident-prone locations.	Procurement and installation of traffic signs in the form of warning signs for accident-prone locations to warn road users to be careful when passing through accident-prone locations.
5	Placement of Three-Sided Right Turn Sign Too Close to Intersection	Improvement of the placement of the Three-Way Intersection Sign on the right side, where the initial distance of the sign to

No	Problem	Recommendation
		the intersection was 19 meters and has been changed to 50 meters.
6	There are no yield signs for local roads.	The Yield sign gives a clear command for drivers to give way to vehicles that have priority.

3. Jalan Kaliurang Km. 12-13

Table 6. table of problem and recommendations Kaliurang Road Km. 12-13

No	Problem	Recommendation
1	There are five public street lights that are not functioning.	Improvements to public street lighting to increase visibility and reduce hazards for road users at night.
2	Warning signs for bridges and signs prohibiting overtaking other vehicles covered by poles	Move the sign to a more open location that is easily visible to road users.
3	There are no warning signs at the intersection.	Procurement and installation of traffic signs and warning signs at intersections to alert road users to the presence of intersections.
4	There are no warning signs for the three-way intersection on the right side.	Procurement and installation of traffic signs in the form of three-sided warning signs on the right side of the road to warn road users of a three-way intersection on the right side of the road.
5	No warning signs for traffic signals	Procurement and installation of traffic signs in the form of warning signs for traffic signal devices to warn road users of the presence of traffic signal locations.
6	There is no speed management system to control vehicle speed, so drivers tend to drive without any monitored speed limits.	Procurement and installation of rumble strips to minimize high speeds at accident-prone locations.
7	Road markings that have faded	Repair road markings by repainting them so that they are visible to road users.

4. Jalan Kaliurang Km. 13-14

Table 7. table of problem and recommendations Kaliurang Road Km. 13-14

No	Problem	Recommendation
1	Traffic signal warning signs vandalized	Clean graffiti off road signs or replace them so that they are clearly visible to road users.
2	There are no warning signs at the intersection.	Procurement and installation of traffic signs and warning signs at intersections to alert road users to the presence of intersections.
3	There are no warning signs for the three-way intersection on the left side.	Procurement and installation of traffic signs in the form of three-sided warning signs on the left side to warn road users of a three-

No	Problem	Recommendation
		way intersection on the right side of the road.
4	There is no speed management system to control vehicle speed, so drivers tend to drive without any monitored speed limits.	Procurement and installation of rumble strips to minimize high speeds at accident-prone locations.

4. CONCLUSIONS AND SUGGESTIONS

During the period of 2022 to 2024, 359 traffic accidents were recorded on Kaliurang Road, with 24 fatalities and 451 minor injuries. The highest incident time was recorded in the morning (06.00-12.00), with male drivers as the most frequent perpetrators, and two-wheeled vehicles as the type of vehicle used.as the most frequent perpetrator, and two-wheeled vehicles as the most frequently involved vehicle type. The dominant accident pattern was a collision between the front and side of the vehicle.

Based on the equivalent accident number (EAN) calculation, the EAN value in this section reached 1,641. By using the UCL and BKA methods to determine there are 4 accident-prone locations on Kaliurang Road, namely at km 7-8, km 8-9, km 12-13 and km 13-14, with the highest accident equivalent number found at km 8-9.

Recommendations for handling accident-prone locations include the addition of rumble strips, rearrangement of residents' activity space or controlling side obstacles, improvement of public street lighting, markings and signs of accident-prone locations to reduce the potential for accidents, procurement and installation of traffic signs.

REFERENCES

[1] Y. Seberkas, "Strategi Penanganan Daerah Rawan Kecelakaan Strategy for Handling Accident-Prone Areas," *Jurnal Litbang*, vol. 20, no. 1, pp. 53–66, 2024, [Online]. Available: http://ejurnal-litbang.patikab.go.id

[2] A. Himawan, "STRATEGI PENANGANAN LOKASI RAWAN KECELAKAAN DI JALAN KALIURANG STA 6+000-16+800 YOGYAKARTA MENGGUNAKAN FIVE PRINCIPLES FOR SUSTAINABLE SAFE TRAFFIC SYSTEM," 2021.

[3] H. Suseno, "Kecelakaan Menghambat Tumbuh dan Berkembang Suatu Bangsa," *Jurnal Indonesia Sosial Sains*, vol. 3, no. 10, pp. 1345–1352, 2022.

[4] Y. Oktopianto, T. Prasetyo, and Y. M. Arief, "Analisis Penanganan Daerah Rawan Kecelakaan Kabupaten Karanganyar," *Borneo Engineering: Jurnal Teknik Sipil*, vol. 5, no. 2, pp. 201–214, 2021.

[5] G. Sugiyanto and A. Fadli, "Identifikasi Lokasi Rawan Kecelakaan Lalu Lintas (Black Spot) di Kabupaten Purbalingga, Jawa Tengah," 2017.

[6] P. H. Jaya, R. Respati, and M. R. Ansyari, "ANALISIS TITIK LOKASI RAWAN KECELAKAN (BLACKSPOT) PADA INFRASTRUKTUR LINTAS SELATAN KALIMANTAN SEBAGAI PENUNJANG MENUJU IKN NUSANTARA," 2023.

[7] R. F. Sutikno, W. P. Nugraheni, R. Arief, and D. Rindyawati, "Kajian Kebutuhan Perlengkapan Jalan Penunjang Sektor Pariwisata Ruas Trowulan-Pacet Kabupaten Mojokerto," *Jurnal Plano Buana*, vol. 5, no. 1, pp. 32–46, 2022.

[8] A. F. Rahman, D. S. Gutama, and A. Shulhan, "ANALISIS DAERAH RAWAN KECELAKAAN DI KABUATEN KEBUMEN DENGAN MENGGUNAKAN METODE ANGKA EKIVALEN KECELAKAAN (AEK) DAN UPPER CONTROL LIMIT (UCL) (STUDI KASUS RUAS JALAN KUTOWINANGUN KM 9 – KM 15)," 2024, [Online]. Available: https://jurnal.ustjogja.ac.id/index.php/renovasi

[9] D. Supriyatno, "Identifikasi Daerah Rawan Kecelakaan Sebagai Dasar Pembuatan Buku Pedoman Teknis Penanganan Kecelakaan (Studi Kasus: Beberapa Ruas Jalan Di Wilayah Kota Surabaya Provinsi Jawa Timur)," vol. 5, no. 1, May 2020.

[10] Herawati, "KARAKTERISTIK DAN PENYEBAB KECELAKAAN LALU LINTAS DI INDONESIATAHUN 2012," 2014.

[11] S. Subagyo, Suryanto, and M. N. Handriansyah, "ANALISA KINERJA LALU LINTAS JALAN KALIURANG (STUDI KASUS: JALAN KALIURANG KM 5,8 – 9,3 , KABUPATEN SLEMAN, DAERAH ISTIMEWA YOGYAKARTA)," *Civil Engineering and Technology Journal*, vol. 6, no. 2, pp. 35–6, 2024, [Online]. Available: https://jurnal.ucy.ac.id/index.php/CivETech/issue/archive