Malaysian Journal of Civil Engineering 27(2):321-335 (2015)

TECHNICAL NOTE

SPATIAL INFORMATION MODEL FOR LOCATION ASSESSMENT OF TEMPORARY LANDFILL SITES (TLS) IN MADIUN CITY

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Abstract: Madiun city has an adequate waste infrastructure with final processing system using controlled landfill system. The data of waste transported to the final landfill in Final Landfill Sites (FLS) Winongo in Madiun reaches approximately 60% of the total existing generated waste. If this number is reviewed from the Millennium Development Goals targets by 70% in 2015, the number is still lacking. One of the influencing factors is the number and location of Temporary Landfill Sites (TLS) which are not in accordance with the requirements. It is important to identify the locations of TLS so they can be used optimally to increase the volume of waste transported to the FLS. The purpose of this study is to assess the TLS location in Madiun, both in terms of technical aspects and public opinion polling as TLS users using geographic information system tools. The analysis technique in this study used quantitative analysis performed to analyze the quantitative data related to the location of TLS and also qualitative analysis as a tool used to analyze a variety of information based on spatial analysis. By examining the feasibility of zoning pattern, it can be seen that the viable deployment zoning model with the dominant influence is a distance factor of TLS to the center of waste generation. It can be viewed from the fact that several TLS locations which are far away from the waste transport route are categorized as feasible and moderate. Based on the analysis, from the 36 TLS locations in Madiun, there are 12 TLS locations which belong to "not feasible" criteria, 12 TLS locations which belong to "moderate" criteria and 12 TLS locations which belong to "feasible" criteria.

Keywords: *Final landfill sites, temporary landfill sites, geographic information system, waste, zoning*

1.0 Introduction

Various issues related to infrastructure services that recently occur lead to increasing level of severe problems, such as issues related to transportation infrastructure service, water supply, waste disposal, etc. One of the important infrastructures which require serious attention is waste infrastructure (Prahasta, 2005; Rohman, 2007). However, the performance of waste management in recent years has decreased as the impact from the changes within government regulation during the reformation era, decentralization, and

economic crisis that occurred in all regions in Indonesia. According to the data from the Directorate of Housing and Settlements Bappenas, the volume of waste in Indonesia in 2012 was approximately 200,000 cubic meters per day (Sanitary, 2012). This increasing number is influenced by some factors such as population growth, rising incomes, public consumption behavior and product handling pattern.

The increasing number of urban solid waste generation of 2-4% per year causes the people who do not get access to waste services and have inadequate land for local waste processing tend to dispose their waste in any place and involve in open burning, hence contribute to the environmental pollution. Percentage of the amount of waste that cannot be transported based on research conducted by the National Socioeconomic Survey (SUSENAS) during three time periods, 2001, 2004 and 2007 did not change much. In 2001 and 2014, the recorded percentages were 78.46% and 79.28% respectively (Anonim, 1999, 2001 & 2006). The condition was slightly increased by the amount of waste that is not transported as much as 58% in 2012 according to data from the Directorate of Housing and Settlements, BAPPENAS (Sanitary, 2012).

Based on the Indonesian Environmental Status Report 2007, from the total waste which is generated daily in Indonesia, the average percentage of waste transported and disposed into FLS was 41.28%, 35.59% was burned, 7.97% was buried, 14, 01%, was carelessly discarded (rivers, canals, roads, etc.), and only 1.15% was properly treated (composted and recycled). The Agenda 21 states that only 40% of urban waste nationally which can be served by public facilities, the rest of the waste was burned or thrown into the river. According to WALHI (2007), such poor waste management will cause environmental pollution, such as the decline in water quality and flood (Yolarita, 2011).

Ineffectiveness of waste management emerges as a chain that is increasingly difficult to be disentangled into operational techniques, institutional, financial, legal protection and participation of the community / stakeholders. Waste management system which is part of the infrastructure management is one of difficult problems since human struggle to eliminate the waste. People do not want to stay close to the location, a phenomenon known as NIMBY (*Not in My Back Yard*). Society always believes the waste management sites will lead to a variety of adverse effects such as traffic, noise, dust, litter, poor environmental, groundwater pollution, and hazardous waste.

This phenomenon will often arise as the consequence on the enactment of a location for waste management activities, although the proposed waste management plans are able to minimize or eliminate most negative impact. Madiun City has an adequate waste infrastructure with final processing system using controlled landfill system. However, the dynamic conditions of the region require more attention in terms of operational management of waste.

The data of waste transported to FLS (Final Landfill Sites) Winongo in Madiun reaches approximately 60% from the existing waste. The number is still less compared to the Millennium Development Goals by 70% in 2015. One of the influence factors is the number and location of polling stations which are not in accordance with the requirements.

The procedures for the procurement and placement of TLS in Madiun use bottom-up approach on a proposal submitted to the community and Sanitation Department Madiun. The condition leads to some different locations of TLS, some TLS locations are able to accommodate sources of waste from a very wide area while the other TLS locations have smaller coverage area of waste source. Appropriate TLS location allows well-accumulation process of waste. Due to these functions, it is important to know the location of the polling station so that it can function optimally in supporting improvement of waste management services to increase the volume of waste transported to the Final Landfill Sites.

The purpose of this study is to assess the TLS locations in Madiun both in terms of technical aspects and public opinion polling as users of TLS using geographic information system tools.

2.0 Literature Review

2.1 Urban Waste Management

Waste is the residue from human daily activities and / or natural processes in the solid form (Anonim, 2008). The meaning of waste management is the activity of arranging or managing waste from lugging, collecting, removing, transporting, and processing it until the end of the storage bins. Waste management system is the process of waste management which includes 5 technical aspects namely operational, institutional, financial, regulatory, and community participation (Kodoatie, 2003 & 2004).

The waste operational techniques according to Government Regulation Number 16 2005 on the Development of Water Supply System Article 14 paragraph 2 is part of the infrastructure and sanitation facilities (Anonim, 2005). Infrastructure and waste facilities include lug process, collection, removal, transportation, processing, and final accommodation conducted in an integrated manner (Article 19, paragraph 1). Waste management is carried out by methods that are environmentally friendly, integrated, taking into account the characteristics of the waste, safety and social conditions of the local community (Article 20, paragraph 2).

Waste management system should be integrated with the management of the entire elements. According to Tchobanoglous (1993), elements of the waste management system generally consists of waste generation, storage and processing at the source, collection, transfer and transport, processing and recovery, as well as the final disposal. Relationships between elements of the waste management system are shown in the Figure 1 below:

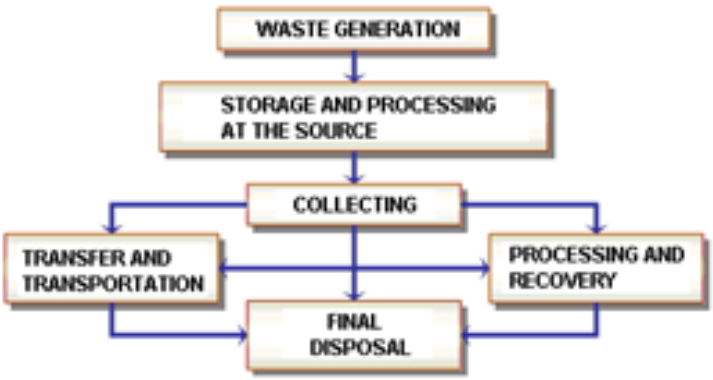

Figure 1: Waste Management System Diagram Elements

2.2 Temporary Landfill Sites (TLS)

According to Anonim (1990 & 1991), the temporary shelter, called as communal lug, is the temporary handling of waste collection activities in a container together, either from a variety of sources as well as public sources. In the Act No. 18 of 2008 on Waste Management Article 1, a temporary shelter is a place before being transported to the garbage recycling, processing, and/or place an integrated processing. TLS position on the elements of the waste management system is the collection of elements, so technical and non-technical aspects of the TLS are closely related to the previous element and the next element namely storage element, removal and transport and waste management.

In the waste management system, TLS is also related with the elements of garbage removal and transportation. The type of TLS will influence the type of transportation equipment, operating systems transport, processing, and recovery element in the waste management system. Reviewing the four patterns of garbage collection (direct individual, indirect individual, direct communal, and indirect communal), direct individual pattern does not require TLS infrastructure as waste collection results are directly discharged to the location of FLS. In the waste management system, TLS is related to the elements of garbage removal and transportation. The type of TLS used

will affect particularly the recognition given to the kind of tools and operating transportation systems. Similarly, in regard to the treatment and recovery elements in the waste management system, not all kinds or types of TLS have a function for waste treatment such as organic waste composting.

The system of waste transfer is a logical consequence from the use of communal collection system using garbage carts. Transfer system is a gathering point between the garbage bins with waste haulers. Waste transfer location is also known as a temporary collection or TLS. In SNI 03-3242-1994 Revision of Procedures Waste Management in Residential, TLS are classified into several types, namely (Anonim, 1994):

1. First type TLS (type I), functioned for transferring waste from waste collectors to waste transportation equipment that is equipped with sorting room, warehouse, container foundation, and land with an area of 10 m^2 to 50 m^2 for waste transfer.
2. Second type TLS (type II), functioned for transferring waste from waste collectors to waste transportation equipment that was equipped with sorting room (10 m^2), organic waste composting (200 m^2), warehouse (50 m^2), the foundation container (60 m^2), and land with an area of 60 m^2 to 200 m^2 for waste transfer.
3. Third type TLS (type III), functioned for transferring waste from garbage collectors to waste transportation equipment that is equipped with sorting room (30 m^2), organic waste composting (800 m^2), warehouse (100 m^2), the foundation container (60 m^2), and land with an area of more than 200 m^2 for waste transfer.

2.3 Determining the Location of Temporary Landfill Sites (TLS)

Several factors in determining the selection of TLS location must consider the needs of land, development financing plan and economically operational, and population density, and the number and prediction of waste generation. Based on the condition and function, waste transfer location or TLS can be divided into two groups, namely:

1. Centralized, serving as the transfer process of centralization and post operational control. In this case, the transfer depot can serve as operational control. It is advisable that every city has at least one unit of the transfer depots, and specifically the big or metropolis cities have one unit for each sub-district.
2. Decentralized, serving as a shelter or temporary waste collection with scattered locations in accordance with the service area. TLS in this case should use the type of container to simplify the process of transporting and maintaining the TLS function as temporary landfill and location of placement.

Determining the location of TLS should consider some conditions (Tchobanoglous, 1993), namely:

1. The proximity distance to the center of waste generation.
2. Accessibility to the transport route to the FLS.
3. The support of the community and the environment.
4. Plan for development financing and the most economical operation.

Furthermore, Tchobanoglous (1993) gives other views regarding the placement of infrastructure facilities TLS that considers several aspects, namely:

1. Type TLS to be used and the services area covered.
2. Consider the environmental health problems and aesthetic value of the means of TLS.
3. The management method that will be used in the TLS means

In assessing the TLS infrastructure, standardized parameter is needed. According to Tchobanoglous (1993), the parameters in the optimization of TLS are:

1. Proportion of balance between the number of population, activity, and waste generation against the available facilities.
2. The ability of each unit of service facilities to accommodate the waste in waste generation.
3. The location of facilities in the region and the distance to the source of waste generation.

2.4 Road

The road is land transportation infrastructure which includes all parts of the road, including complementary buildings and equipment intended for traffic on the ground, above ground, below ground and/or water, as well as on the surface of the water, except railway, road lorries, and the cable way. Road as part of the transportation infrastructure has an important role in the economic, social, cultural, environmental, political, defense and security aspects. Road which is an integrated system of road network connects and binds the whole territory of the Republic of Indonesia. Road network system consists of a primary road network system and a secondary road network system, while public roads by function are grouped into arterial roads, collector roads, local roads, and the environment road.

2.5 Application of Geographic Information Systems in the Assessment of TLS Area in Madiun

Based on GIS capabilities as described above, there are some GIS spatial analysis functions that can be used in the assessment of TLS locations in Madiun which serves as the theme of this research. GIS analysis functions used is buffering, classification, and overlay functions. Buffering and classification function are used to obtain zoning maps of every variable that corresponds to assessment criteria of TLS locations in Madiun.

Overlay function in this study is used to obtain the zoning map of the TLS location in Madiun. The scoring technique is performed through the summation for each component of the zoning map data variables determining the TLS location. Scoring value for each data is grouped into a certain number of classes or categories. The process will produce a zoning map of TLS location and is used as input to the next process, which is an assessment of the existing TLS location and the location of the development plan means TLS in Madiun.

In the assessment of the existing polling locations, the data input in the overlay function of the TLS location zoning map and the existing TLS location map as the result of the position observation of each TLS locations in Madiun. By using the function query (search) on the results of the overlay, it will produce a number of existing TLS locations which are located on each category of TLS locations zoning in Madiun.

3.0 Research Method

3.1 Location and Data

Research location was in Madiun, East Java. The data used in this research served as primary or secondary data. Data collection techniques used in this study was:

1. Primary data collection; associated with the selection of variables and criteria for determining the location of the polling station in the Madiun City. Primary data collection techniques in this study included:

    - Observation; namely the systematic observation.
    - Interviews; how to obtain data or information directly to the face-to-face through verbal communication. Interview techniques used in this study was the snowball-sampling technique (snowball sampling technique).
    - Questionnaire; the sampling technique used in this study was a simple random sampling technique.

2. Secondary data collection; secondary data sources were used in documents format and maps that supported and were obtained from various Government institutions in Madiun (Center Bureau of Statistics, Department of Hygiene and Landscape Gardening Madiun, Regional Development Planning Agency, etc.).

3.2 Analysis Method

This study attempted to get TLS location assessments under the conditions of the recent developments in the study area in Madiun. The factors used in determining the location of TLS were restricted to the road access condition to TLS location, TLS distance to the source of waste/waste generation centers, and the accessibility of the transport route to the FLS.

1) Descriptive Analysis
Analysis technique was used for quantitative analysis, which analyzed the quantitative data relating to the existing TLS conditions. To understand the opinion of the manager of the waste, it was done through the analysis of the scale using a Likert scale.

2) Spatial Analysis
Qualitative analysis is a tool used to analyze a variety of information including other supporting information regarding the TLS location assessment factors as the direction of the TLS location development policy. The analysis used is known as spatial analysis.

3.3 Analysis Techniques

The collection of thematic maps and data as the baseline analysis of the TLS location determination was based on several factors: the spread of settlements, roads network, RUTR of Madiun city, TLS existing location and road condition to TLS. The map was obtained from the phase I model and phase II model. From the thematic map overlay and scoring, the analysis was then performed to produce an optimal TLS location zoning map. The result from the zoning map was overlaid with the existing TLS services thematic maps which produced maps that could be analyzed on the existing TLS location suitability.

4.0 Results and Discussion

There are several factors in determining the TLS location according to the literature, including: the use of TLS location, society, and environmental topography form is not used in this study. Based on the factors that may be applied in Madiun, the variables

used are as follows: 1) TLS distance to the center of waste generation, 2) TLS distance to waste transportation route, and 3) access road to the location of the polling station.

The decision in choosing the criteria for TLS location is determined by the number of classes (range) for each variable. In this research, data collection techniques employ snowball sampling so that the population varies mainly from the social level and the number of range used is 5-levels. Opinions of the survey using snowball sampling technique which are either associated directly or indirectly associated with the waste in Madiun can be seen in Table 1 below.

Table 1: Value Criteria for Determining the Location of TLS in Madiun

Num	VARIABEL	CRITERIA	VALUE	Expected value	QUALITY	VALUE CRITERIA
1	TLS distance to the center of waste generation	a) 0 to 250 meter	1	5	10	10
		b) 250 to 500 meter	5	1	10	50
		c) 500 to 750 meter	4	2	10	40
		d) 750 to 1000 meter	3	3	10	30
		e) > 1000 meter	2	4	10	20
2	TLS Distance to the route of waste transport	a) 0 to 250 meter	2	4	10	20
		b) 250 to 500 meter	5	1	10	50
		c) 500 to 750 meter	4	2	10	40
		d) 750 to 1000 meter	3	3	10	30
		e) > 1000 meter	1	5	10	10
3	The access road to the location of TLS	a) Arterial road >11 m	1	5	10	10
		b) Collector road >9 m	2	4	10	20
		c) Local road >7,5 m	5	1	10	50
		d) Environment road > 6,5 m	4	2	10	40
		e) Paths road < 6,5 m	3	3	10	30

Note : Expected Value *1= Very Expected* *2= Expected* *3= Moderate* *4= Not Expected* *5= Very Not Expected*

4.1 TLS Location Assessment Based on TLS Distance Variable over Waste Generation Center

Referring to Figure 2, the existing TLS locations within the zoning criteria of TLS distance to the central location of waste generation variable can be clearly observed. By using query techniques, it can be seen that most of the existing 32 TLS locations (88.89%) are at a distance of 0-250 m from the center of waste generation, with the criteria of community has expectation value which is undesirable. Two TLS locations have “very expected criteria”, one TLS location with “expected criteria” and one TLS location with “moderate criteria”.

In general, it can be seen that the locations of TLS in Madiun have not reached the category of "expected" location by the respondent in regard to TLS distance to the center of waste generation.

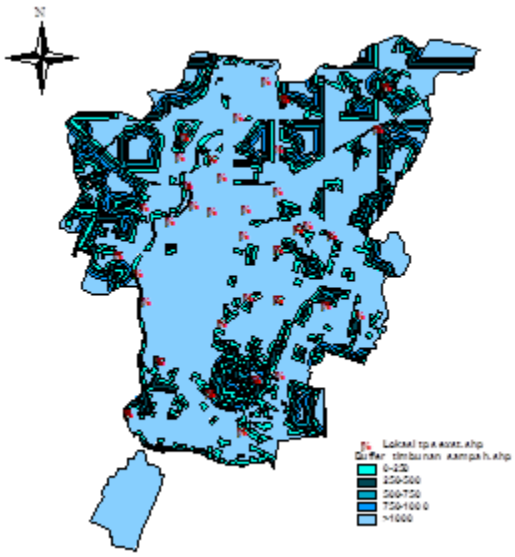

Figure 2: Map Results from the TLS Existing Overlay with zoning variable distance to the Central Waste Generation

4.2 TLS Location Assessment Based on TLS Distance against Waste Transport Route Variable

By overlaying the existing TLS locations and the zoning map of waste transportation route distance variable, the overlay map as shown in Figure 3 is obtained. By using the query techniques, assessment results are obtained to get the description about the suitability of the existing TLS location in terms of the waste transport distance factor.

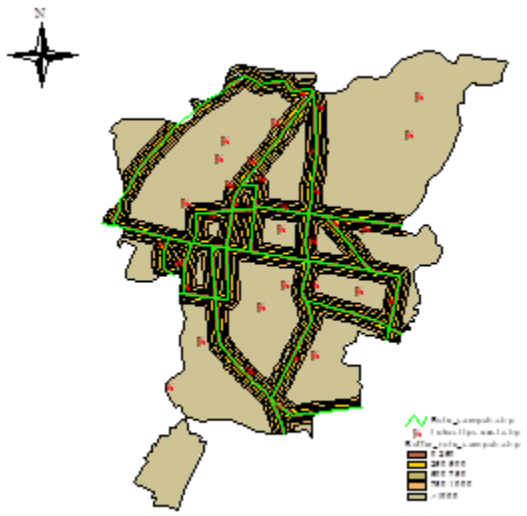

Figure 3: Map Results from Existing TLS Overlay with zoning variable distance on Waste Transport Route

From Figure 3, the locations of the existing TLS inside each zoning criteria of TLS distance to waste transport route variable by using the query techniques can be identified. Search results (query) on TLS locations in Madiun based on the TLS distance to waste transportation route variable shows that the TLS located in Madiun has spread with the highest number (41.67% or 15 locations), greater than 1000 meters with the criteria as "not expected" by respondents.

A total of 16.67% or 6 locations located at a distance of 0 to 250 m from the main road which is used as garbage truck transport pathways, and according to the opinion of the respondents that the distance is an unexpected distance. Meanwhile, there are 8 TLS locations (22.22%) within 250 ms / d 500 m from the garbage truck transport have criterion that are expected by the public, and one other location TLS (2.78%) is 500 ms / d 750 m of the garbage truck transport is a criterion that is expected by respondents. Under these conditions, it can be stated that more than half of TLS locations in Madiun is a location that is not expected by respondents, reflecting on the TLS location distance to waste transportation route aspect.

Meanwhile, there are eight TLS locations (22.22%) within 250 ms / d 500 m from the garbage truck transport which have public criteria of "very expected", and another location of TLS (2.78%) is 500 ms / d 750 m of the garbage truck transport which have criteria of "expected".

4.2 TLS Location Assessment Based on Variables of Road Condition to TLS location

Based on Figure 4, as much as 5.56% or two locations are on arterial roads which are categorized as "not expected" by the respondents, followed by 11.11% or 4 TLS locations are on the collector roads that have the expectation value as "not expected". While as many as 21 or 58.33% are on the local road with the expected value of the respondents are "very expected". And the remaining 25% is on environment road or as many as 9 TLS locations, which has the expectation value "expected". In general, it can be concluded that the existing TLS locations in Madiun is an appropriate location based on the respondents when it is viewed from the aspect of the road condition to the TLS location.

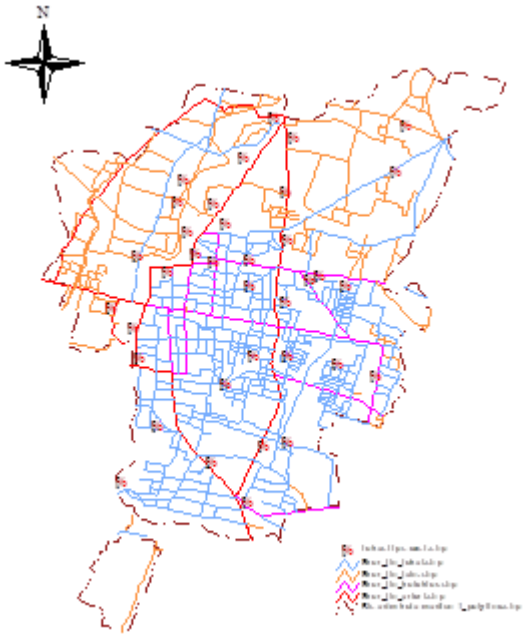

Figure 4: Map Results from the TLS Overlay Zoning with Variable of Road Condition to TLS location

4.3 TLS Location Assessment Based on TLS Location Zoning in Madiun

Assessment to determine the feasibility of TLS locations in Madiun in this study is based on the assessment of the respondents, by doing an overlay on the TLS location map with the TLS location zoning map in Madiun with the results as shown in Figure 5 below.

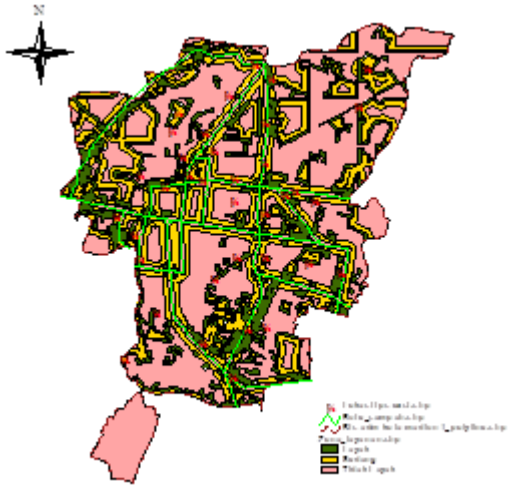

Figure 5: Map Results from the Overlay with Zoning Area of TLS Location in Madiun

Furthermore, from the picture above, query is conducted. The result is as much as one-third (33.33%) or 12 locations TLS in Madiun is the proper zoning to be used as the TLS location. As much as 33.33% or 12 locations belong to "not feasible" location, while the remaining locations belong to the moderate category (33.33% or 12 locations).

Viewed from every district in District Kartoharjo, there are 2 TLS locations that are not feasible while in District Taman there are 4 TLS locations which are not feasible and in District Manguharjo there are 6 TLS locations which are not feasible based on Figure 5. The opposite results occur in each district. The feasible TLS conditions cover 6 TLS locations in District Kartoharjo, 3 TLS locations in District Taman and 3 TLS locations in District Manguharjo.

5.0 Conclusion

By looking at the feasibility of zoning pattern, the feasible zoning can be practically identified. The pattern also shows that the settlement is the dominant factor of TLS distance to the center of waste generation. The evidence is shown by the fact that there are some distant locations from the waste transportation route which belong to the category of feasible and moderate.

Based on the analysis of 36 TLS locations in Madiun, there are 12 TLS locations which are not feasible, 12 TLS which are moderate, and 12 TLS locations which are feasible. Among the 12 TLS sites that are not feasible, there are 11 TLS locations between 0-250m with a value of "not expected", and among them, there are 5 TLS locations adjacent to residential or waste generation centers. Among the 12 TLS sites which are not feasible, there are 9 TLS location within 250 m of the main route of garbage truck transport. Among the 12 sites that are not feasible, there are 2 TLS locations which are precisely located alongside the waste transport route, Jl. Imam Bonjol and Jl. Mayjend. Sungkono. In terms of road condition to TLS location, among 12 TLS locations that are not feasible, there are 2 TLS locations that are located on the collector road and 1 TLS on arterial roads that have a value of "very not expected".

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