APPLICATION OF SMALL BORE SEWER SYSTEM IN KECAMATAN JATINANGOR, KABUPATEN SUMEDANG

PENERAPAN SISTEM SMALL BORE SEWER DI KECAMATAN JATINANGOR, KABUPATEN SUMEDANG

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Abstract : *Small bore sewer systems are designed to handle only the liquid portion of household wastewater, however solid are digested in interceptor tank which will be emptied after five to ten years. This system has been used in many developing and developed countries since it is more economical in terms of investment and easy in maintenance. Smaller diameter pipe used in this system and large quantities of water are not needed for solids transport. Besides, it reduced excavation cost. since the sewer can follow the natural topography more closely than conventional sewer. Small bore sewer system will be applied in Kecamatan Jatinangor. As much 75,51% people in this area already have septic tanks but since soil permeability is low, the ground water level is high and the limited land, it's not possible to make infiltration area. Further analysis was done to compare the condition in planning area with some criteria of small bore sewer. The result is small bore sewer system is suitable used in Kecamatan Jatinangor.*

Keywords *: small bore sewer, septic tanks, infiltration area*

Abstrak *: Riol Ukuran Kecil adalah saluran air buangan yang didesain hanya menerima bagian cair dari limbah rumah tangga sedangkan bagian padatan akan diuraikan di dalam tangki septik yang kemudian akan dikuras setelah 5-10 tahun. Sistem ini telah banyak digunakan di negara berkembang dan negara maju karena lebih ekonomis dari sisi investasi serta mudah dalam pemeliharaan. Sistem ini menggunakan diameter pipa yang lebih kecil dan jumlah air yang banyak tidak diperlukan untuk transpor padatan. Selain itu, pipa dapat dibuat mengikuti topograf lebih baik dari sistem konvensional sehingga mengurangi biaya penggalian. .Konsep small bore sewer ini akan diterapkan di wilayah Kecamatan Jatinangor. Penduduk di wilayah ini 75,51% telah memiliki tangki septik namun kondisi permeabilitas tanah yang rendah, tinggi muka air tanah tinggi dan terbatasnya lahan tidak memungkinkan dibuatnya bidang resapan. Setelah dilakukan analisa lebih dalam dengan membandingkan kondisi di wilayah perencanaan dan kriteria small bore sewer dapat disimpulkan bahwa sistem small bore sewer ini sangat cocok diterapkan di wilayah Jatinangor.*

Kata Kunci *: riol ukuran kecil, tangki septik, bidang resapan*

INTRODUCTION

Small Bore Sewerage is a sewer that conveys only septic tank liquid with no solid. In some countries, small bore sewer also called solid-free sewerage, small diameter gravity sewerage in United States or septic tank effluent drainage in Australia. As these effluents are solid-free the sewer is designed differently from conventional sewerage. On of the differences is this system is not designed for self-cleansing velocity. Compare with conventional sewer, this system is cheaper because it needs small pipe diameter and shallow soil excavation. Further information about small bore sewer and its component will be explain in the next chapter.

The feasibility study of small bore sewers was mentioned in the literature as early as 1935. The first small bore sewer system in Zambia was installed in 1960; in Australia in 1962; in Nigeria in 1964; and in the United States in 1975 (Otis,1985) . Small Bore Sewer sewer has been applied especially in developing countries because the cost of investment, operations and maintenance is cheaper than other systems. The next application will be discussed Bore small sewer in some countries.

In Indonesia, the waste water treatment system has not been quite good compare with developing countries moreover other developed countries. This is caused by many aspects such as institutional aspects, financial, operational, and the role of the community. Services level of waste water in urban settlements through sewerage system just 2,33% and the toilet (private and public facilities) reached a 46.6% whereas in rural areas, the level of service through the local (on-site system) and a private toilet facilities is 49.33% (SUSENAS 2004). Number of cities that have off-site system sewerage and wastewater treatment facilities are 11 cities. From the 11 cities that became a pilot project, Solo city's installation is best used optimally, the customers of waste treatment increased 60% since 2001 to 2008 (Bulletin of Cipta Karya 2009). Meanwhile, sewerage system in other areas still face some problems, so it have't used optimally yet. This indicates the low priority of household waste water management in both the central and region government.

Similar things happened in Jatinangor, West JAva. The lack of commitment to manage household wastewater has caused pollution in Cibeusi and Cikeruh river. According to the Head of Environmental Impact Control Agency (Bapedalda) Jabar, the observation results in June 2006 showed that the pollution was caused by high acid content, phosphate, and fecal coli. Pollution is also caused by household waste ,it reached 75%, while the remaining 25% polluted by company or industrial waste. (Sindo, 2008). Due to this pollution, the quality of public health is declining. In August 2008 there is 13% increasing of diarrhea from the previous month. (Koran Sindo, 12 July 2009).

This condition proved that Palembang city need sewerage system which will overcome household waste problems. The technology that will be used is small bore sewer system. The planning of sewerage system will be focused on one districs, namely Jatinangor because it has dense population. In addition,these districs are the central region of Sumedang city and directly adjacent to the Cikeruh river.

The objective of this research are to analyze how far the technology small bore sewer could be applied and to design sewerage system in Kecamatan Jatinangor, Sumedang using small bore sewer concept.

METHODOLOGY

Lane selection methodology for waste water delivery system can be seen in Figure 2. This work begins with a projections of the populations and urban facility and collection of data needed in planning. Data was collected through field survey or go to the relevant authorities. The data have been obtained and analyzed as a basis for planning wastewater distribution system. Planning waste water delivery system will include service area, the planning period and the location of Waste Water Processing Building (WWPB). The next step is the creation of alternative routes using the consept of small bore sewer. And the methodoly can be seen in **Figure 1**.

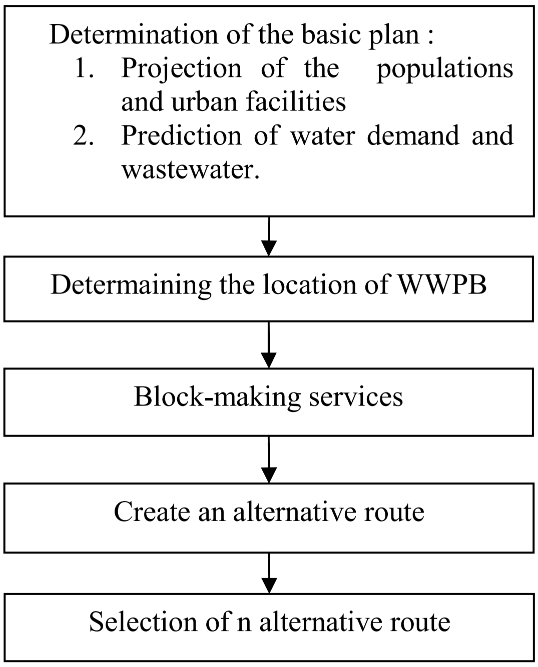


Figure 1. Methodology

DESCRIPTION OF SMALL BORE SEWER SYSTEM

Small bore sewer systems are designed to receive only the liquid portion of household wastewater for off-site treatment and disposal. Grit, grease and other troublesome solids which might cause obstruction in the sewers are separated from the waste flow in interceptor tanks installed upstream of every connection to the sewers; the solids which accumulate in the tanks are removed periodically for safe disposal. Scheme of small bore sewer system shown in **Figure 2** below.

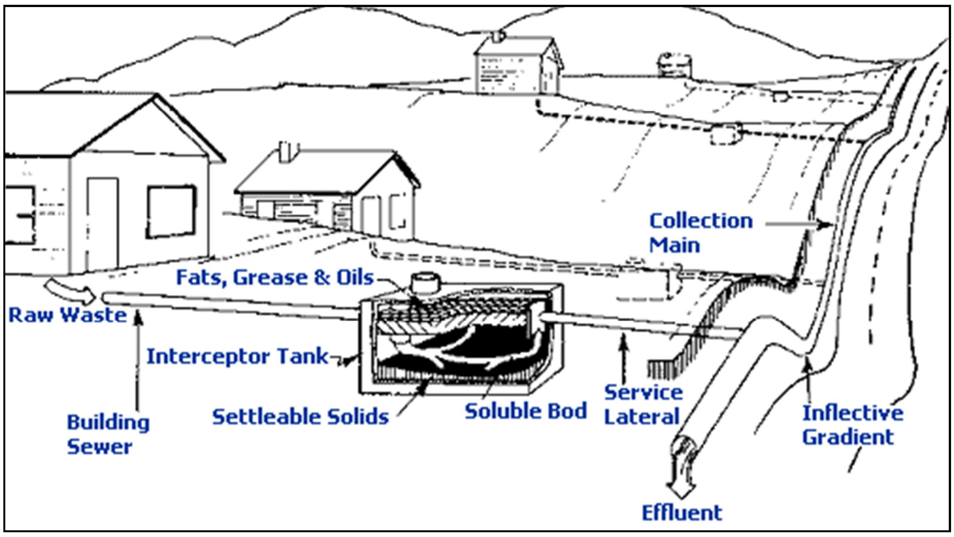


Figure 2 *Small Bore Sewer* shceme

Collecting only settled wastewater in this manner has four principal advantages such as first, reduced water requirements because large quantities of water are not needed for solids transport. Second advantages is reduced excavation cost, since the sewers do not need to be designed to maintain a minimum velocity for self-cleansing, so they may be laid with curveilinier alignment with a variable gradient. Other advantages are reduce material cost and reduced treatment requirements. Peak flows which the small bore sewers must be designed to handle are lower than those experienced with conventional sewers because the interceptor tanks provide some surge storage which attenuates peak flows. Therefore, the sewer and any pumping equipment can be reduced in size. Treatment requirements such as screening, grit removal and primary sedimentation are not needed, since these unit processes are perform in the interceptor tanks.

Small bore sewer is possible apllied in area which has septic tanks facilities and this system can be improved. However, small bore sewer has higher blockage risk than conventional sewerage. This problems caused by smaller pipa diameter, so maintenance activity is a must . It also required skilled personel and high degree operation and maintenance especially if pumping is needed. Besides, septic tanks plays an important role to separate solid. The interceptors must be cleaned regularly. Without regular cleaning, the settleable matter will overflow into the sewer system and cause sewer blockages. The important requirement of this sewer system is that the community is responsible for sewer maintenance, because a public authority will not able to perform frequent sewer cleaning.

Parts of Small Bore Sewer

Small bore sewer systems consist of :

- House connection
  The house connection is made at the inlet to the interceptor tank.
- Interceptor tank
  It is designed to detain the liquid flow for 12 to 24 hours and to remove both floating and settleable soids from the liquid stream. Volume is also provided for storage of the solids, which are periodically removed through an access port.
- Sewer
  Sewers are small bore pipe (minimum diameter of 100 mm) which are trenched into the ground at a depth sufficient to collect the settled wastewater from most connections by

gravity. Unlike conventional sewers, small bore sewers are not necessarily laid on a uniform gradient with straight alignment between manholes or cleanouts. The sewer may have an inflective gradient.

- Cleanout dan Manhole
  Cleanouts and manholes provide access to the sewers for inspection and maintenance. Also, they can be easily concealed to prevent tampering. They function as flushing points during sewer cleaning operations..
- *Vent*
  The sewers must be ventilated to maintain free-flowingconditions.
- Pumping Station
  Lift stations are necessary where elevation differences do not permit gravity flow. Either residential or major lift stations may be used.

Hydraulic Design of Small Bore Sewer

Unlike conventional gravity sewers which are designed for open channel flow, small bore sewers may be installed with sections depressed below the hydraulic grade line. Thus, flow within a small bore sewer may alternate between open channel and pressure flow. The location and outlet elevation of the interceptor tanks together with the local topography will establish the routes and necessary depths of the sewers in most cases.

There are very few data on the magnitude of peak flows in small bore sewers.Usually peak factor 1,2-1,3 or 2 is used, however peak factor in conventional sewerage determined by formula , $fp = 5 / p^{0,2}$ where p = number of people (in thousand).

Generally, small bore sewer design is less difficult than conventional design. This is understand because pipe in small bore sewer carry only the liquid so we can considered it as a full pipe and Manning's equation may be used in this analysis.

$$V_{full} = \frac{1}{n} \times R^{2/3} \times S^{1/2} \qquad \text{..................................(1)}$$

where :
v = velocity of flow, m/s
n = pipe roughness coefficient
R = hydraulic radius, m
S = slope of the hydraulic grade line, m/m

When the full-pipe velocity determined,and the pipe diameter,in mm, selected by the designer, the full-pipe flow can be calculated. This flow must be greater than design flow. If it is not, a larger size pipe must be used or the slope increased. Basically,this calculation use iteration method so that Qfull > Qdesign by changing pipe diameter. The invert of the outlet of any interceptor tank discharging into the sewer along this section must be above the hydraulic grade line in order to avoid backflow into the tank during periods of peak flow. If this is not possible, then a larger pipe diameter must be chosen, or an individual lift station provided, or the sewer elevation at the downstream station lowered;

We can make more simple design calculation by considering that the pipe is not full-pipe. The theoretic diameter is determined by formula :

$$D_{teo} = [4{,}167 \times 10^{-2} \times Qd \times S^{-1/2}]^{3/8} \times 1000 \text{ mm} \qquad \text{................(2)}$$

where :
Qd = design flow (m^3/s)

S = slope of pipe (m/m)

The next step is considered pipe as not full-pipe and used nomograph manning to determined design velocity. The velocity range is between 0,3 and 3 m/s. If it is not, change the slope pipe..

ANALYSIS OF DESIGN AREA

Kecamatan Jatinangor are located in the center of Sumedang and directly adjacent to Cikeruh river.That makes sanitation conditions in this two areas influence Cikeruh river as the water body. Based on Susenas 2000 in Sumedang, 75,51% of the people have their own MCK and septic tanks, 15,87% have joint facilities, and the rest doesn't have MCK. This situation shows that most people in Sumedang, including district have septic tanks and system cubluk (MCK), but the septic tank hasn't been used optimally. It is made without infiltration area due to the limited of the land. In other words, the sanitation facilities in the two districts is not good enough so that the Cikeruh River pollution can not be avoided.

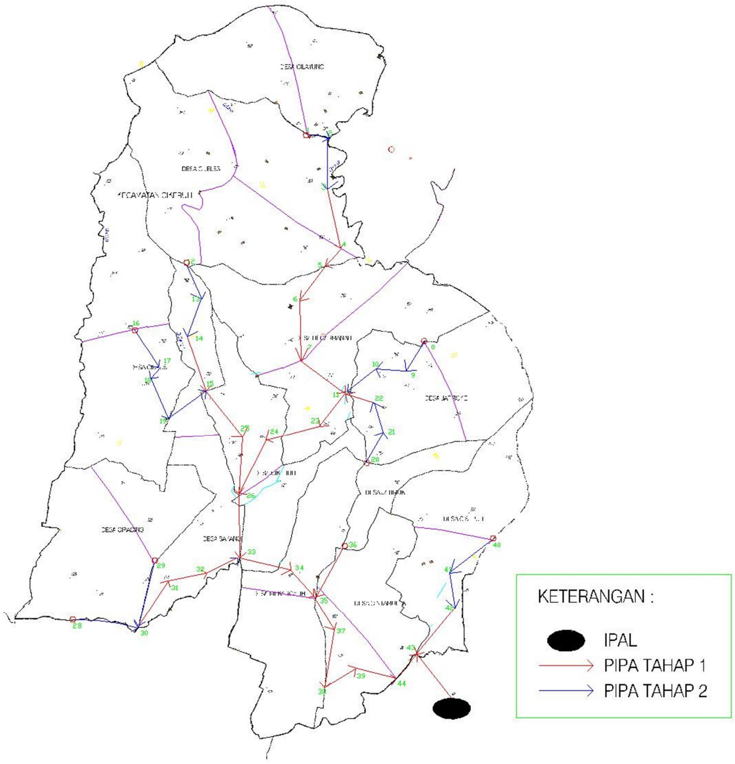
Unavailability areas of land for the septic tank infiltration associated with the function of the region as a government and trade centre. That caused the population density is quite high. In 2007, the population density in Kecamatan Jatinangor is 106 people/ha. At the end of the year 2035 estimated population density in Kecamatan Jatinangor will increased to 143 people/ha. In other words, Kecamatan Jatinangor is a region with medium density, but in this region there are many government offices so that the land for infiltration area remain limited.

Although the infiltration area is built succesfully, it will not well function .This things related to low permeability of the soil in Sumedang, that is about 4.32 L/m^2/day or 0.0003 cm / min. This condition causes the soil is always wet or low infiltration. In addition, there are parts of the Kecamatan Jatinangor that affected by tidal-fall and the depth of ground water is high enough in the range of 0.5 to 6 m.

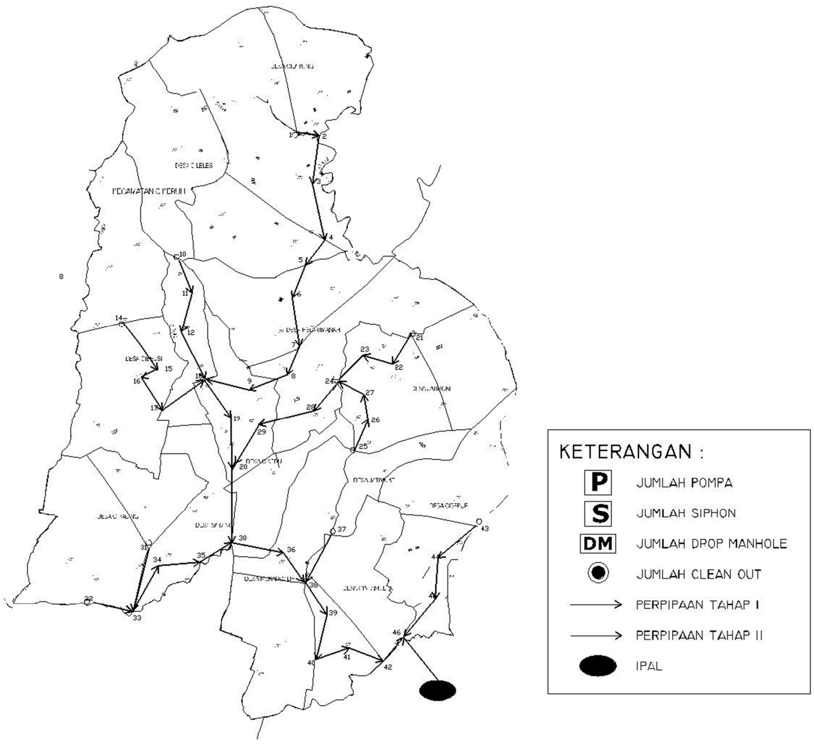
Topography of Sumedang relatively flat with a slope of 0-2,5% in the centre of the city. Kecamatan Jatinangor also have relatively flat topoghraphy in north, and slightly hilly in the west and central part with the highest part reach 14 m above sea level. Then, topography to the south tend to be flat so that the wastewater can be brought to the north or south area. The variation of elevation ranged from 1.2 m to 14 m.

ALTERNATIVE OF PIPELINE ROUTE DISTRBUTION

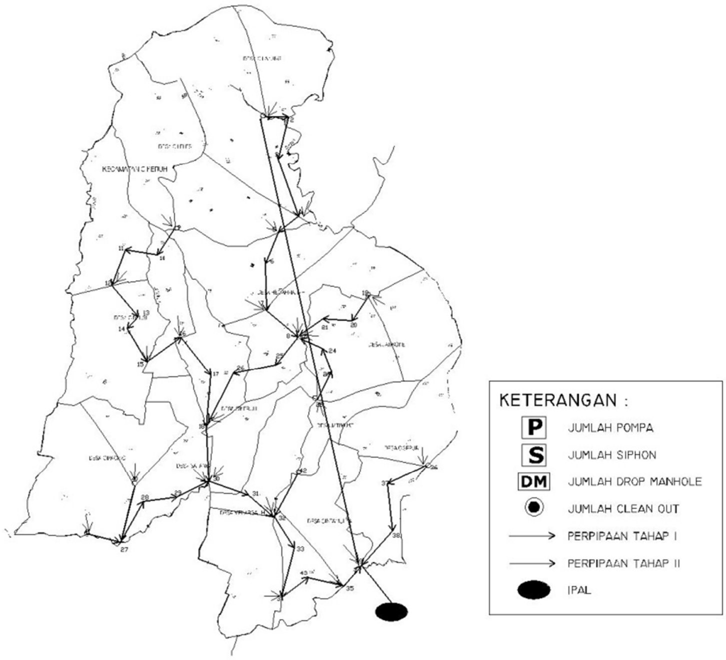
In the planning of waste water delivery system will be proposed three alternative waste water distribution lines as shown in **Figure 3**. Each line is made with consideration of topography, road network, and crossing rivers or railroad tracks. Pipeline route made perpendicular to follow the contour lines so that drainage can be done by gravity. Planned pipeline network in accordance with the existing road or there will be assumed for the road in the future. Waste water delivery is sought through the path as short as possible and the flow of time as short as possible to avoid environmental pollution by waste water is channeled. Pipeline routing also tried to be as little as possible across the river or railroad tracks, to avoid the use of complementary building that could enhance channel development costs. Based on these considerations, it was made 3 type of alternative paths that may be used in the distribution.



ALTERNATIF 1



ALTERNATIF 2



ALTERNATIF 3

Figure 3. Alternative of Pipeline Route

After determined the path of 3 type alternatives that can be used in waste water distribution systems, each numbered line of each segment of pipe and analyzed for comparison. Parameters used in comparing the three alternative route is a total pipe length, flow time, the number of manhole and the number of river crossings.

Parameters the total length of pipe and manhole number associated with the channel of economic aspects. Manhole will be installed every 125 m distance in the pipe. The longer the used of pipe and the greater number of manhole which means the greater the cost needed for the construction of this waste water channel. Flow time parameters associated with the possibility of environmental pollution that may occur. Possible pollution of waste water should be anticipated from the pipe that can be leak occurs. Shorter flow time, the lower the chances of contamination by sewage. Parameters related to crossing the river channel development facilities. The more crossings, the process of planning and development would funnel even more complicated because it requires complementary buildings like siphon. Comparison between the Alternative Line I, the II and III based on these parameters can be seen in **Table 1**.

Tabel 1. The Comparison of Alternative Line 1, 2, and 3

Alternative I	Alternative II	Alternative III
1. The total of pipe lenght 22.462 m. 2. Furthest toward the pipeline 5896.51 m, if the average flow speed is 1 m/s, the flow of time required is 1,64 jam. 3. Number of manhole is 175 4. Number of pumping stations is 3. 5. Number of siphon is 1 6. Number of clean out is 9	1. The total of Pipe length 22.061,06 m. 2. Furthest toward the pipeline 6108 m, if the average flow speed is 1 m/s, the flow of time reguired is 1,7 jam. 3. Number of manhole is 148 4. Number of pumping stations is 2. 5. Number of siphon is 1 6. Number of clean out is 9	1.The total of pipe lenght 22.384,17 m 2.Furthest toward the pipeline 6312 m, if the average flow speed is 1 m/s, the flow of time required is 1,75 jam. 3.Number of manhole is 170. 4.Number of pumping stations is 4 5.Nuber of siphon is 1 6.Number of clean out is 11

SELECTIONS OF THE ALTERNATIVES

Selection of pipeline route alternatives best done by analyzing the three lines of the technical aspects relating to ease of operation and maintenance as well as economic terms. For the technical aspects will be weighting method to determine line operating conditions that enable and easy maintenance. For economic, investment analysis will be done. The path chosen is the path to the value of the smallest investment and operation and maintenance that allows to be done. The analysis will be conducted on technical factors first and then will be the investment analysis.

Each alternative will be evaluated based on technical considerations of using weighting methods. Rate measures of each alternative using the weighting method is as follows:
1. Determining the criteria / parameters important in supporting the system.
2. Comparing the value of interest (CIF: Coefficient of Importance Factor) a criterion to other criteria more important to the value 1, just as important given the value of 0.5 and less important given the value 0.
3. Adding the value of interest.
4. Comparing the parameters for an alternative to the parameters similar to the other alternatives with determining factor values. Alternative that has the best score to worst respectively rated 1.5, 1 and 0.
5. Multiplying each factor on each alternative (obtained from step 4) with the weight value of each factor (in step 3).
6. Summing the total value of the benefits and technical interests for each alternatives.
7. Alternatives that get the greatest value is the best alternative from a technical aspect. Then will be the approximate cost estimate.

The selection of an alternative method using the weighting shown by **table 2**

Table 2 Selection an Alternative Route

Assessment Criteria	Quality	Alternative 1		Alternative 2		Alternative 3	
		Value	Total	Value	Total	Value	Total
Length of pipe	3	0	0	1.5	4.5	1	3
Number of pumping stations	3	1	3	1.5	4.5	1.5	4.5
Number of manhole	3	1	3	1.5	4.5	1.5	4.5
Number of siphom	3	1.5	4.5	1.5	4.5	1.5	4.5
Number of cleanout	3	1.5	4.5	1.5	4.5	1.5	4.5
Flow time	3	1.5	4.5	1	3	0	0
Total			**19.5**		**25.5**		**21**

Based on calculations from the above three alternative path, it can be concluded that the best route is technically an alternative route 2.

APPLICATION ANALYSIS OF SMALL BORE SEWER IN PLANNING AREA

Based on the small bore sewer description and conditions of design areas that have been described previously, it can be inferred some factors that indicate the technical suitability of Small Bore Sewer system (SBS) and condition of design area. The analysis is shown in **Table 3.**

Table 3 Application Analysis of SBS

Condition of Design Area	Criteria of SBS Sytsem
75,51% of the houses already have septic tanks	It would be better and easier if on-site sanitation such as septic tanks are already available
Relatively flat topoghraphy, slope 0-2,5%, elevation range from 1,2 to 14 m	Flatter pipe than conventional system. Therefore, it will reduce excavation cost
Difficulty in making infiltration area because : • Low soil permeability; 0,0003 cm/min • high ground water table; 0,5 to 6 m • High population density. At the end of 2035, estimated population is 143 people/ha • Role of the areas as a government centre and trade centre	Septic tanks effluent distribute to pipeline. Infiltration area is not needed

Besides the planning criteria in accordance with the implementation criteria of SBS. This system also has some advantages because it is far more economical than conventional systems. Small bore sewer must be set deep enough to receive flows from each user and it must have sufficient size and gradient to carry these flows. Therefore, design decisions regarding its location, depth, size and gradient must be carefully made to hold hydraulic losses within the limits of available energy. Where the differences in elevation are insufficient to permit gravity flow, energy must be added to the system by lift pumps.

In operational, small bore sewer has a higher blockage risk than conventional sewergae due to its small diameter, so the maintenance must be done. This system also required a trained operator and adequate technology, particularly if there is a pumping system. The most improtant thing is the role of septic tanks as a solid precipitation area. The interceptors must be cleaned regularly. Without regular cleaning, the settleable matter will overflow into the sewer system and cause sewer blockages. The important requirement of this sewer system is that the community is responsible for sewer maintenance, because a public authority will not able to perform frequent sewer cleaning. The failing septic tanks will caused ground water pollution and public health problems.

The concept of small bore sewer results small diameter pipe ranged from 100 mm to 500 mm and four pump station. The number of pump station can be reduced and also the excavation cost . The selected pipeline in Kecamatan Jatinangor shown on **Figure 4.**

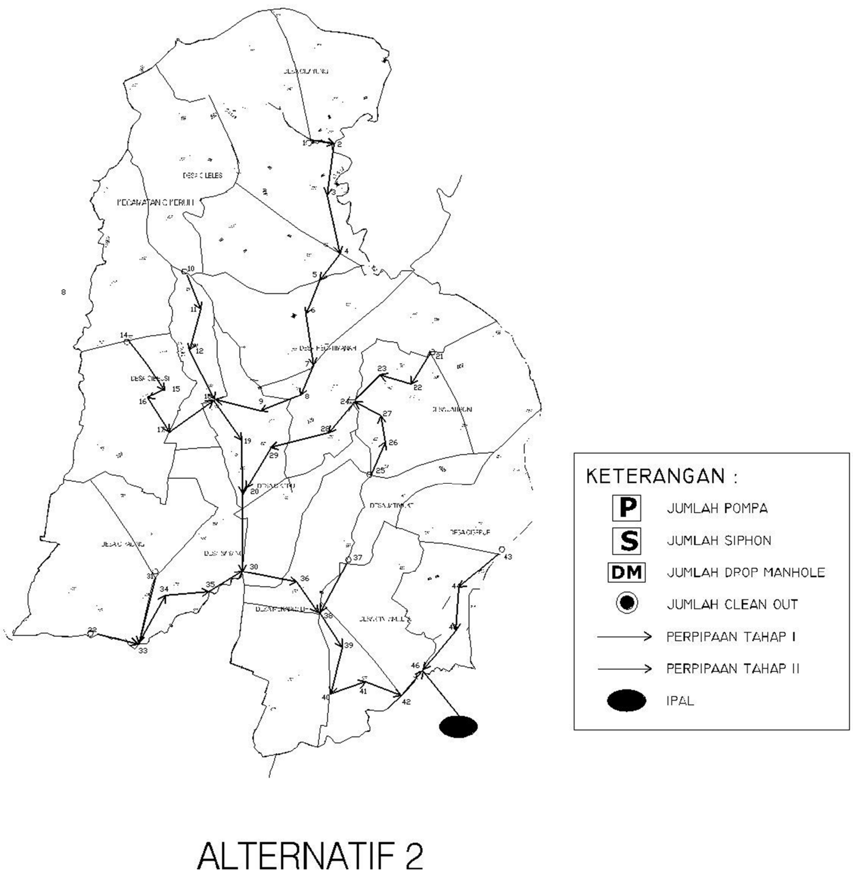


Figure 4 The Selected Pipeline

CONCLUSION

Small bore sewer systems could be implemented effectively in Kecamatan JAtinangor. This system is more economical, because smaller diameter and solid-free pipe need less water for solids transport, reduced excavation cost, easy operation and maintenance. The concept of small bore sewer result diameter pipe range from 100 mm to 500 mm and 4 pump station.

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