# CHAPTER 5

# ASSESSING RESULT AND ANALYZING THE CHOSEN ROUTE

## 5.1 Introduction

This chapter will show the results of implementing the methodology discussed in chapter 4 with the input data in chapter 3. The process in the methodology, as explained in chapter 4, is repeated several times in different settings. In this chapter, all settings, output and the output assessment results will be shown. However, due to the similarity of the output results and to avoid repetition, there will be just one example output assessment explained step-by-step. After describing the assessment process, this chapter will then show the variations of setting and results. Next, the results will be compared and the best result will be determined. Finally, the best route will then be detailed and analyzed for enhancing the optimum output.

## 5.2 Route Assessment

This chapter will use the example data from chapter 4 in the assessment process of the output. This section will start with the setting of the route destination in the following figure.

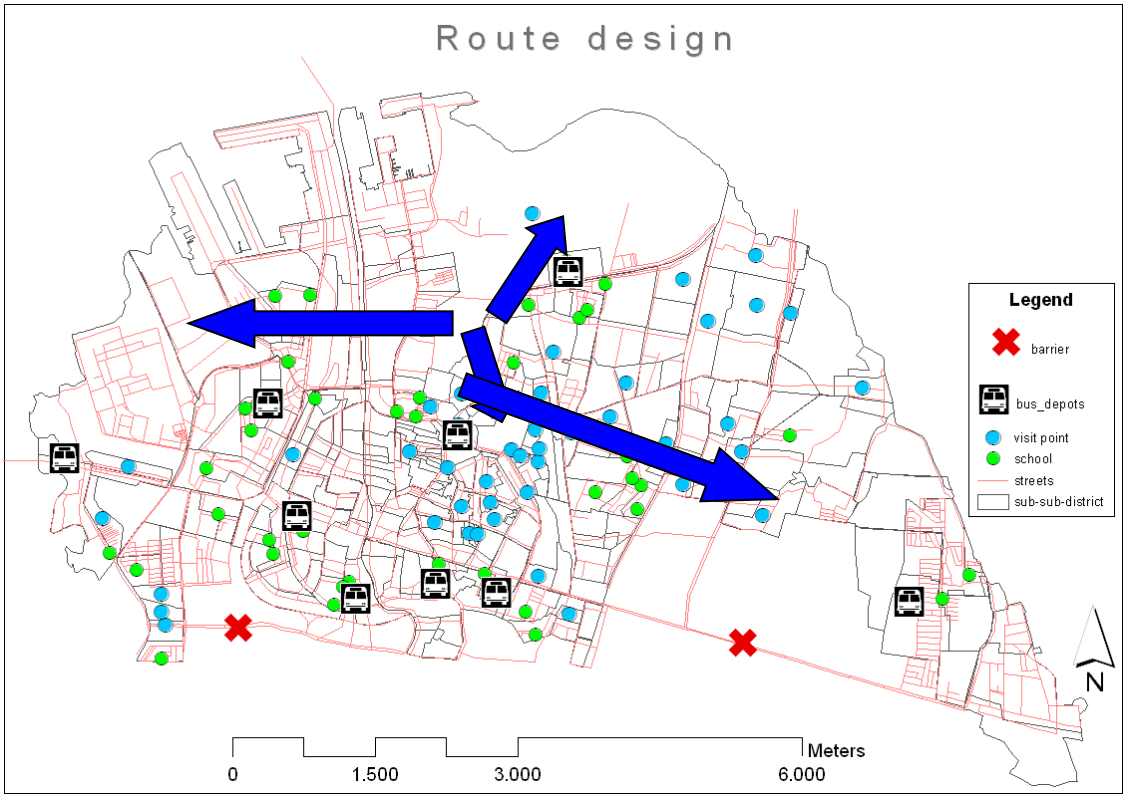



**Figure 5.1** The routes setting (example)

The above figure is taken from a section in chapter 4 pertaining to inspecting the number of routes that are needed to cover all orders. In this chapter, the purpose of the setting is to make a destination of 4 depots in the different directions (north, south, west, and east) by setting orders, depots, and route classes. This example will generate an output like the one shown in figure 5.2 below.

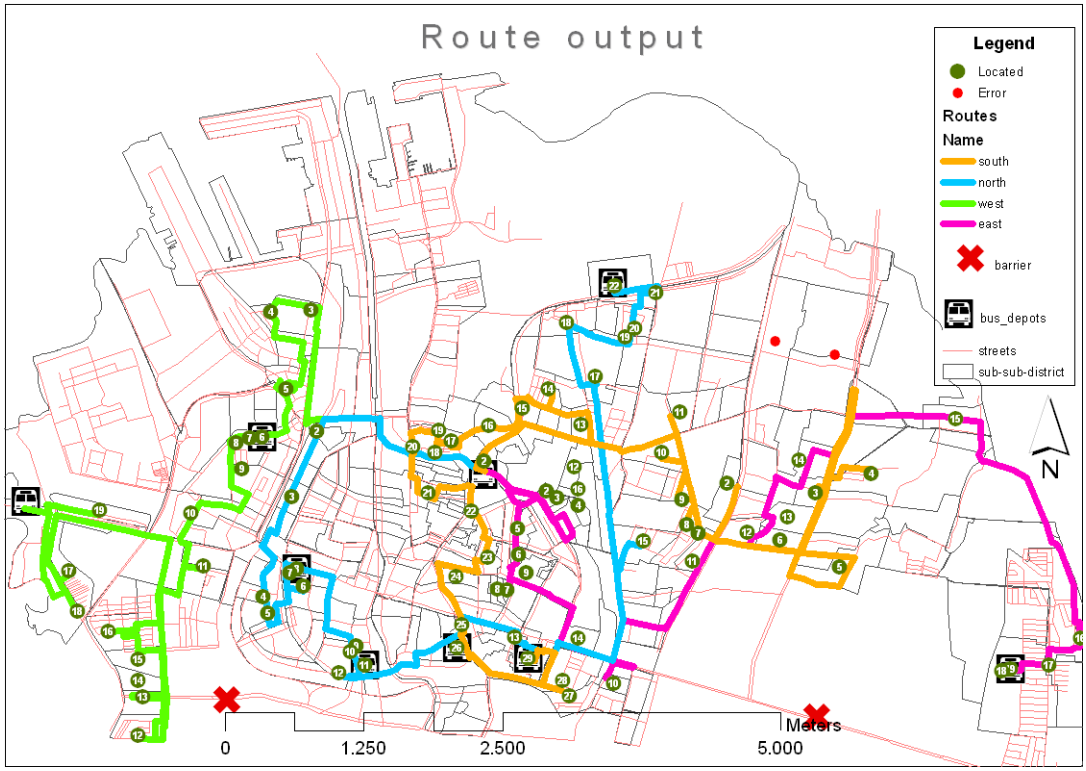



**Figure 5.2** The output (example)

The above output will then be processed and combined with the model in figure 4.34 from section 4.9.1. The four route directions will then be buffered to get each surrounding area, followed by a calculation to determine the needy in that area. Figure 5.3 shows the covered area in the surrounded area of all route directions. The area is shown in graduate color from light grey to black. The darker the color is, the greater the number of needy student who live there. Areas with no color (white) indicate no route coverage. Those areas have distances which exceed 300 meters in any direction of the street which participate in the route.

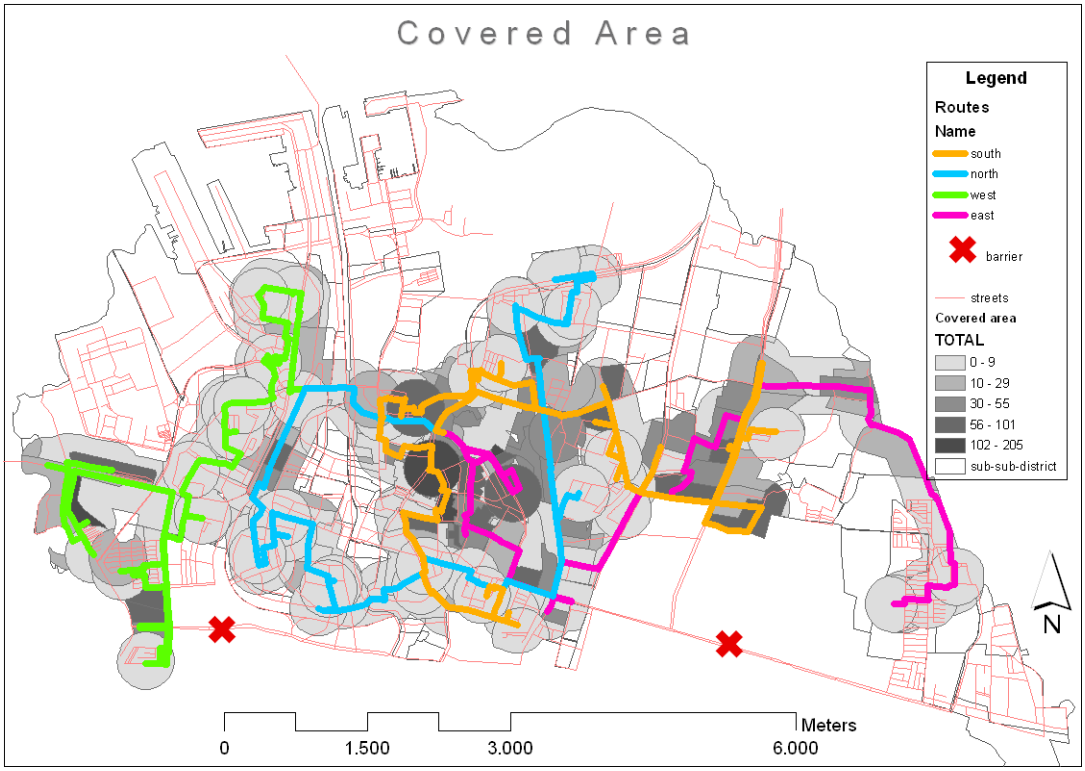



**Figure 5.3** Covered Area of the example routes

After summing up the all needy in the covered area, the result showed that the number of needy in the covered area is 4321 students. Looking back to the refining process of the needy area as explained in section 4.3, it was noted that the total needy number is 5265; this output covers about 83% of needy. Even though many of the remaining students can still access the route by walking a bit further or by riding a bicycle, the 4321 output number will be used to compare with other output results to get the best route.

In the covered area there are some parts that surround 2 or more route directions. The next assessment is to calculate those parts. A model in figure 4.35 will be used to find an area near streets that is passed by 2 or more route directions, and this detailed process has been explained in section 4.9.2. The earlier example output will generate shared areas like that shown in figure 5.4 below.

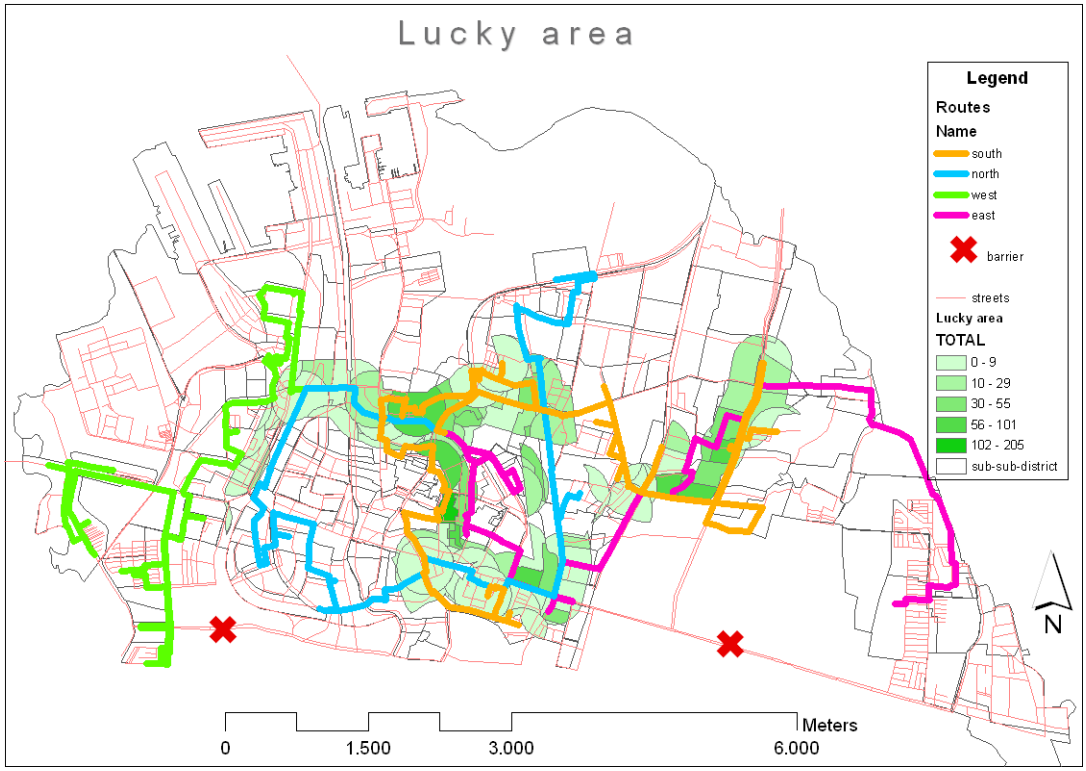



**Figure 5.4.** Shared areas of example output which have access to 2 or more route directions

Figure 5.4 above has surrounded areas with gradation colors from light green to dark green. Again, the darker the color appears is an indication of the greatest numbers of needy. There are few shared areas between west and north route directions in the west part and a medium shared area in the east between south and east route directions. There is a major shared area in the center part which is due to an accumulation of shared areas between east and south, north and south, north and east, and south and north route directions. With the similar calculation used in summing up the covered needy, all the shared areas cover 1840 needy. In summary, this means there is 34% of needy that can choose more than 1 route direction.

The next process is to find shared areas that have access to 3 or more route directions. The process is shown in figure 4.35 and explained in section 4.9.3. If the previous process is to generate a union or common area from all intersection of 2 combined route directions, then this process will make a union from all intersections of 3 route direction combinations. The generated area is a subset of the previous one.

Figure 5.5 shows the result of this process in gradations of red. The total number of students in this area is 549.

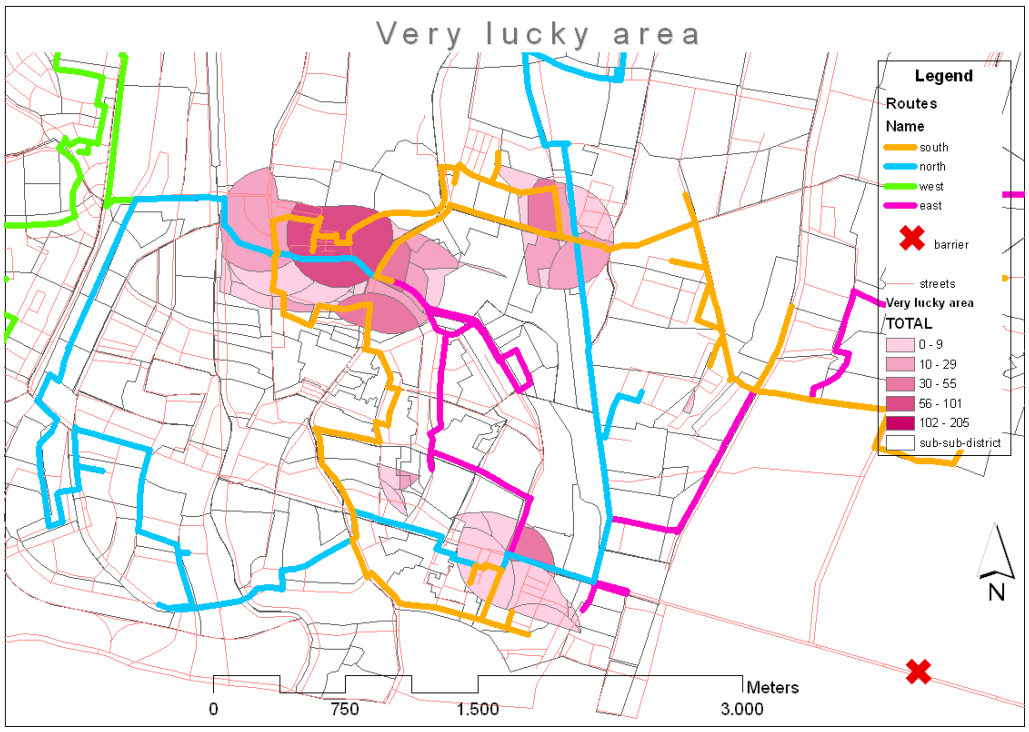



**Figure 5.5**. Shared areas of example output which have access to 3 or more route directions.

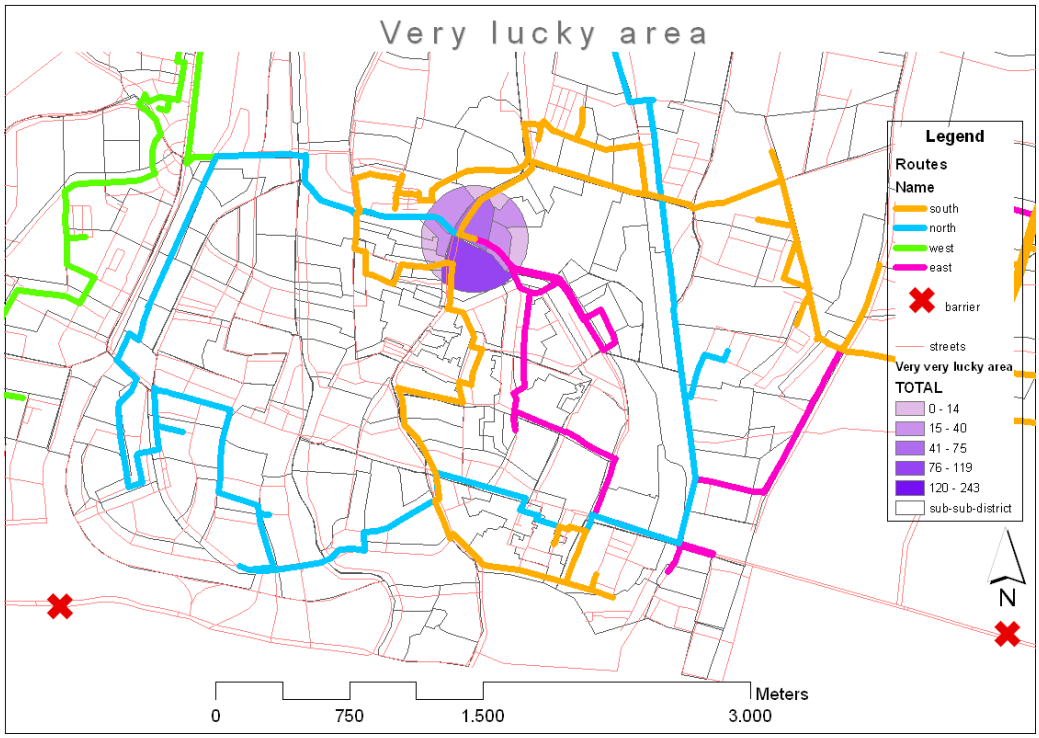



**Figure 5.6**. Shared areas of example output which have access to 4 route directions

Using a similar process, by increasing the number of route directions in the combination, the shared area with 4 route directions can be generated. The process is modeled in figure 4.28. This process will generate a result similar to figure 5.6. The area is small, basically a circle area around the starting depot, and there are 200 needy covered. Because of its rare appearance, except for at the starting depot location, this last shared area will not apply in the others' variation of setting.

The next point to be assessed is the load balance. Each route direction will be separated, then processed using a similar step like that used in the finding the covered area. This time, each route direction will be processed independently. The total covered needy per direction will then be compared with the total capacity of schools in that direction. The process is modeled in figure 4.38 and 4.39. The result of this process is outlined in figure 5.7 below.

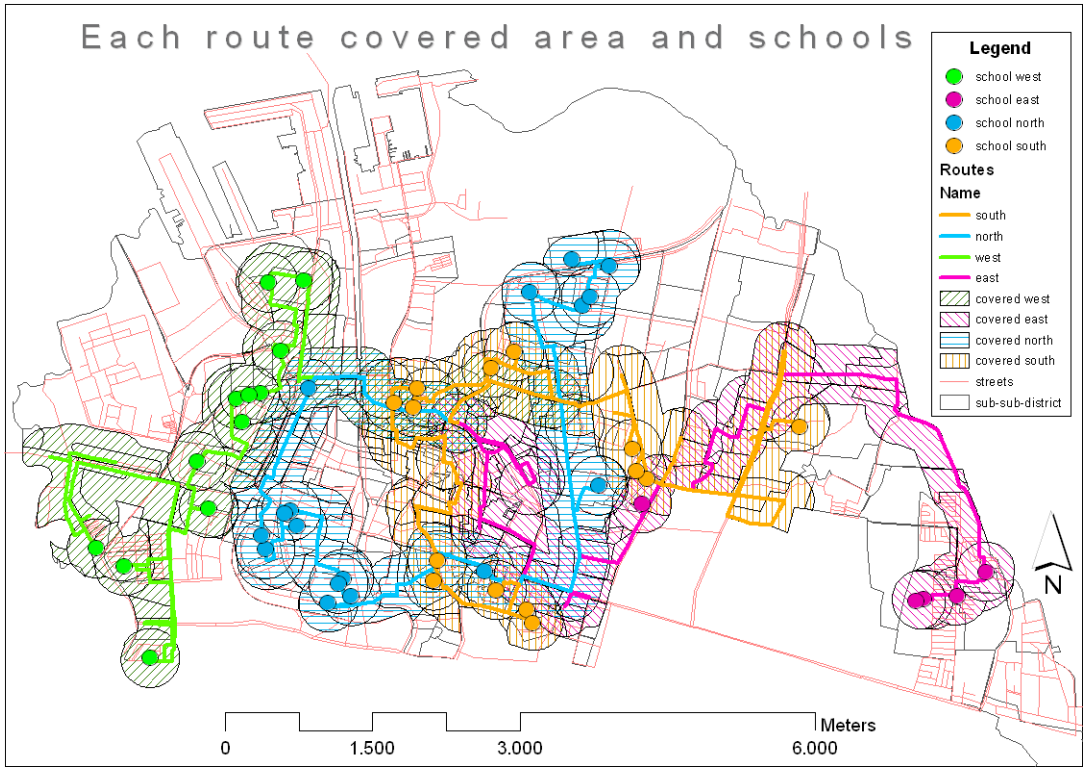



**Figure 5.7.** The 4 route directions including their covered areas and schools

Figure 5.7 shows the 4 route directions as well as their covered areas and schools. This figure shows the routes in different colors: the west route is colored in green, the east route in magenta, the north in cyan, and the south in dark yellow. The schools, symbolized using dots of the same route color, appear similar in numbers across the 4 routes. Moreover, there are routes that cover schools whose location is not its directed area. This is because the VRP engine does not travel across specific separated schools. In other words, it was free to deliver passengers to any school while traveling within the minimum time consumed from the start depot to each destination. This non-assigned school may take the route which will lead to a bad balance which will have a negative impact. Table 5.1 shows the school in each separated area and the total capacities. These totals are then compared with the number of covered needy.

**Table 5.1** Schools separated by routes and capacity

| Name | Route Name | Minutes bus arrived | Needy capacity |
|---|---|---|---|
| SMP Tri Tunggal VII | east | 63 | 97 |
| SMP Romly Tamim | east | 76 | 118 |
| SMP PGRI XI | east | 79 | 150 |
| SMP Terbuka 18 | east | 82 | 152 |
| SMP Negeri 18 | east | 84 | 154 |
| | | **Capacity east** | **671** |
| SMP Gatra | north | 5 | 91 |
| SMP UNESA 1 SURABAYA | north | 10 | 125 |
| SMP Kawung 1 Surabaya | north | 12 | 51 |
| SMP Bina Bangsa | north | 16 | 134 |
| SMP Terbuka 5 | north | 18 | 149 |
| SMP Negeri 5 | north | 20 | 68 |
| SMP Katolik Angelus Custos | north | 24 | 154 |
| SMP GATOTAN 1 SURABAYA | north | 26 | 150 |
| SMP Negeri 2 | north | 29 | 154 |
| SMP Ta'miriyah | north | 31 | 154 |
| SMP Muhammadiyah 1 | north | 37 | 119 |
| SMP Wachid Hasyim I | north | 43 | 99 |
| SMP MUHAMMADIYAH 16 | north | 50 | 30 |
| SMP PGRI VI SBY | north | 53 | 110 |
| MTs Nurul Salam | north | 56 | 13 |
| SMP Cahaya | north | 59 | 134 |
| SMP Negeri 27 | north | 61 | 147 |
| | | **capacity north** | **1882** |
| SMP Taruna Jaya I | south | 23 | 143 |
| SMP Muhammadiyah 15 | south | 31 | 132 |
| SMPK. Pecinta Damai | south | 33 | 148 |
| SMP YP 17 SURABAYA | south | 36 | 93 |
| SMP ISLAM LIL WATHON | south | 44 | 41 |
| SMP ISLAM AL AMAL | south | 47 | 39 |
| SMP ALKHAIRIYAH | south | 51 | 100 |
| SMP AL GHOZALI | south | 54 | 125 |
| SMP AL IRSYAD SURABAYA | south | 56 | 115 |
| SMP Ganesya I Surabaya | south | 64 | 75 |
| SMP Negeri 8 | south | 66 | 136 |
| SMP Triyasa | south | 70 | 148 |
| SMP YPPI 1 | south | 73 | 147 |
| SMP Negeri 41 | south | 76 | 74 |
| | | **capacity south** | **1516** |
| SMP Mujahidin | west | 7 | 109 |
| SMP PGRI 36 | west | 10 | 121 |
| SMP Barunawati | west | 14 | 127 |
| SMP Negeri 7 | west | 18 | 149 |
| SMP K St. Mikael | west | 20 | 125 |
| SMP Al-Ikhlash | west | 22 | 149 |
| SMP Hang Tuah-4 Surabaya | west | 25 | 130 |
| SMP PGRI 5 Surabaya | west | 29 | 146 |
| SMP Kemala Bayangkari 6 | west | 33 | 112 |
| SMP Islam | west | 38 | 72 |
| SMP Muhamadiyah XI | west | 44 | 95 |
| SMP Bina Karya | west | 52 | 76 |
| | | **capacity west** | **1411** |

After summing up the needy in each route destination area, it found that in terms of needs coverage, the west route covers 1130, the east route covers 2163, the north route covers 1377, and the south route covers 2239. The sum of these covered areas is more than the covered area discussed in last section the previous paragraph. As explained earlier, it is due to the fact there are shared areas. Meanwhile, in the west area, there are 12 schools with a total capacity of 1411, in the east 5 schools with 671 capacity, a north area consisting of 17 schools with 1882 capacity, and a south area with a total capacity of 1516. The comparison is as follows: there are 1130 needy for 1411 school seats in the west, 2136 needy for 671 school seats in the east, 1337 needy for 1882 school seats in the north, and finally 2239 needy for 1516 school seats in the south. The west and north areas have a less number of needy, while the east and south area have an excess one. We can conclude from these finding that this proposed route is not as good in terms of the route balance.

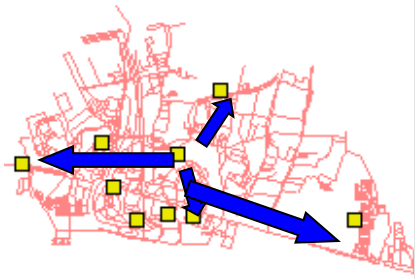
Another important aspect which must be assessed is the time consumed. The time consumed is a total of each direction route's traveling time. This traveling time can be easily found from the output of the VRP process without any additional process applied. The timed consumed has a direct relation to the fuel consumed. In general, longer durations require greater fuel use., and this in turn means an increase in the amount of money which must be spent. But, because the school bus analysis in this research is focused on social rather than commercial objectives, this aspect is placed in the last point, and given less consideration overall in the study, and placed after the other previous points discussed.

## 5.3 Undirected Orders Routes Design

As noted in previous sections, the VRP engine will freely choose which schools will be visited. This first part will not attempt to distribute schools by area but instead will pass these efforts over to the VRP engine to do the optimal distribution. Hopefully, this first part will provide a chance for the VRP engine to get the balance of needy and covered schools determined on its own. Let's call this kind of methodology or part as "undirected orders routes design".

Because the process has been built based on an ArcGis model, the process and calculation, like the previous example, can be done easily. It simply involves re-setting the route design, running the analysis, and continuing with running the models for the assessment process. There are several combinations which have been tried with these undirected orders. The combination entails setting the end depot to each available depot in each direction. Because there is only 1 depot in the north and east areas, these directions are not involved are applicable in this alteration. On the other hand, the other directions, west and south have 3 available depots respectively. Table 5.2 shows this combination of route design, its output layer, its covered area, shared area, and its balance.

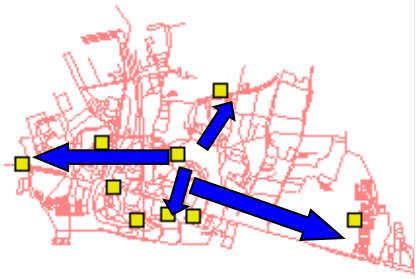
**Table 5.2**. Route design and output analyze of Unsupervised Orders type

| ROUTE DESIGN | OUTPUT |
|---|---|
| **Design 1** | |
|  |  |

| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 6:03-07:00 | 57 min | 1130 | 12 | 1411 |
| East | 5:51-07:00 | 69 min | 2163 | 5 | 671 |
| North | 6:01-07:00 | 59 min | 1377 | 17 | 1882 |
| South | 5:53-07:00 | 67 min | 2239 | 14 | 1516 |
| Total | | 252 min | | 48 | 5480 |

Access 1+: **4321** needy, Access 2+: **1840** needy , Access 3+: **549** needy

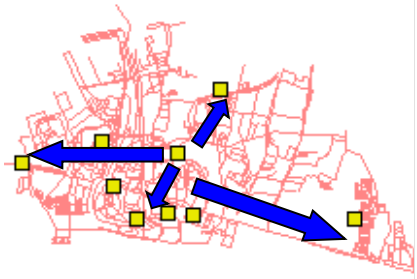
**Design 2**



| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 6:03-07:00 | 57 min | 889 | 12 | 1411 |
| East | 5:55-07:00 | 65 min | 1214 | 9 | 1396 |
| North | 6:00-07:00 | 60 min | 1402 | 16 | 1895 |
| South | 5:48-07:00 | 72 min | 2999 | 11 | 981 |
| Total | | 254 min | | 48 | 5480 |

Access 1+: **4535** needy, Access 2+: **1490** needy , Access 3+: **305** needy

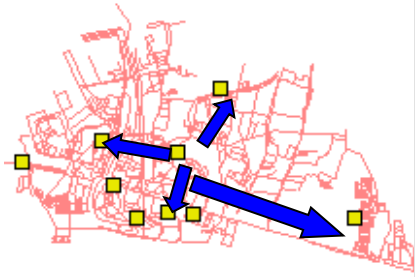
## Design 3



| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 5:56-07:00 | 64 min | 995 | 14 | 1617 |
| East | 5:57-07:00 | 63 min | 1495 | 7 | 788 |
| North | 5:55-07:00 | 65 min | 1998 | 12 | 1237 |
| South | 6:03-07:00 | 57 min | 1695 | 15 | 1838 |
| Total | | 249 min | | 48 | 5480 |

Access 1+: **4529** needy, Access 2+: **1199** needy , Access 3+: **226** needy

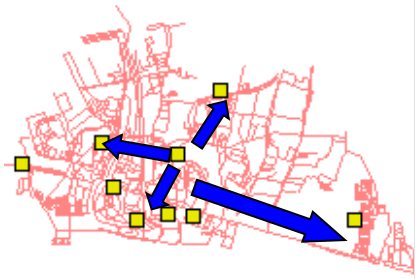
## Design 4



| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 6:01-07:00 | 59 min | 874 | 12 | 1411 |
| East | 5:57-07:00 | 63 min | 1601 | 9 | 1133 |
| North | 5:55-07:00 | 63 min | 1288 | 15 | 1716 |
| South | 6:03-07:00 | 65 min | 2945 | 12 | 1220 |
| Total | | 250 min | | 48 | 5480 |

Access 1+: **4468** needy, Access 2+: **1457** needy , Access 3+: **304** needy

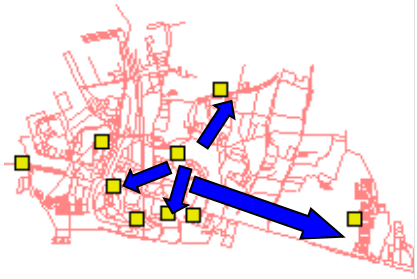
**Design 5**



| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 6:00-07:00 | 60 min | 975 | 12 | 1411 |
| East | 5:55-07:00 | 65 min | 1617 | 8 | 1096 |
| North | 5:54-07:00 | 66 min | 2292 | 12 | 1044 |
| South | 6:01-07:00 | 59 min | 1642 | 16 | 1929 |
| Total | | 250 min | | 48 | 5480 |

Access 1+: **4566** needy, Access 2+: **1503** needy , Access 3+: **227** needy

**Design 6**



| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 5:50-07:00 | 70 min | 862 | 18 | 2212 |
| East | 5:52-07:00 | 68 min | 1875 | 7 | 939 |
| North | 5:49-07:00 | 71 min | 1508 | 14 | 1469 |
| South | 5:52-07:00 | 68 min | 3078 | 9 | 860 |
| Total | | 250 min | | 48 | 5480 |

Access 1+: **4531** needy, Access 2+: **1838** needy, Acess 3+: **405** needy

In the table 5.2 above, numbers typed in red color indicate that there is an imbalance between needy covered and school capacity. Needy areas may be lacking or be excessive. Because in all assessments of the different designs there are two or three rows with a red typed number, it can be said that none of the output from these variation

designs have appropriate results. The VRP engine has failed to make routes that have a balance between the covered needy and the school density of each route destination. However, this failure is not unexpected; the VRP engine in running his duty is parameterized with neither school capacity nor number of needy. It just discovered the optimal time consumed route based on the drive time value in the street layer. The next part will provide a more balanced outcome because some help in the form of added constraints will be applied to the VRP engine.

## 5.4 Directed Orders Routes Design

The problem in the undirected design is that the VRP engine cannot dynamically calculate the needy covered by the route and the school capacity in its routing process. In this section, VRP engine will be provided with some direction to make the route balance better. There are two things that will be added:

**a) Grouped schools.**

Schools will be grouped in 4 areas: west, east, north, and south. With this group, the school number and capacity in each direction are known. This capacity will be written into Route sub-class parameter. These capacities will constrain the number of needy that the bus has been picking up while it traveled the route.

**b) Layer to count the covered needy**

After the capacity in each route has been discovered and written into Route sub-class parameter, the next needed data is the number of needy that can be accumulated while traveling. This is the time value of the street load layer in the section 4.5 added into VRP Classes. This layer is imported as Orders sub-class. The most important setting which needs to be considered while importing this layer is the "PickupQuantities" parameter. This parameter must be set with the field name indicating which number of the needy is saved. In section 4.5, this field is the Cost

field. Another parameter which needs to be set is “ServiceTime”. If set with 0 it indicates that is just a place for travel directions.

The schools spread over the all the study area. There are schools clustered on the north side, south side, west side, east side, and in the center. The school cluster in the center area can be managed and included in one of the route destinations. This center cluster makes a possible variation in the distribution design. The first design of school distribution for 4 areas is like that shown in Figure 5.8 below.

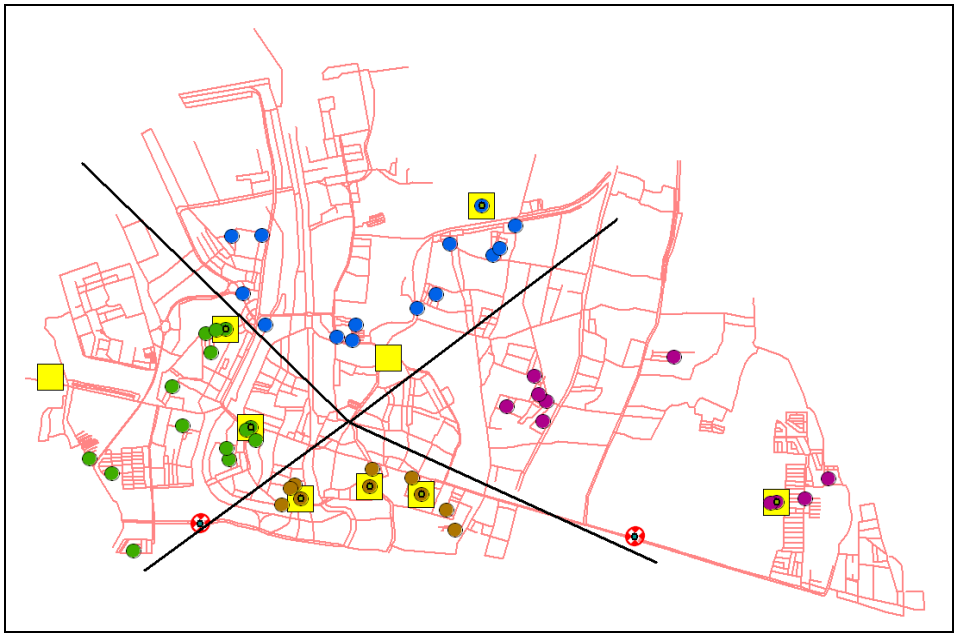
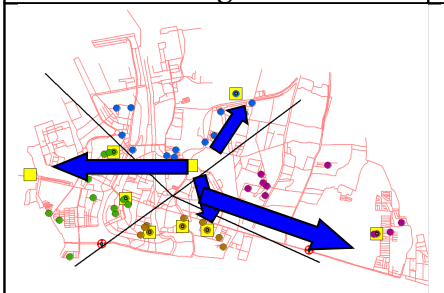


**Figure 5.8** Illustration of the first design of school distribution

The school is distributed and the total capacity in each area is calculated. The number showing school capacity is like that shown in table 4.1. In this first distribution, the west area has 14 schools with capacity and 1581 needy, east has 10 schools with 1286 capacity, north has 14 schools 1302 capacity, and south has 10 with 1311 capacity. With the variation of End Depot like the previous sections, table 5.3 shows the design, output, and the assessment result.

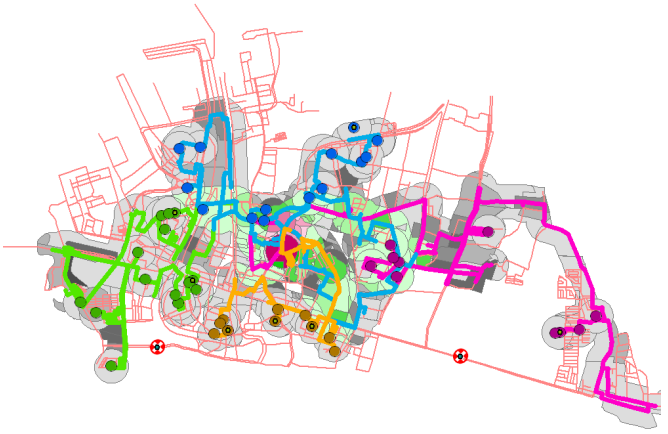
**Table 5.3.** End depot design, output, and the assessment result of Distribution 1

| END DEPOT DESIGN | OUTPUT |
|---|---|
| **Design 1** | |
|  |  |

| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 5:49-07:00 | 71 min | 1045 | 14 | 1581 |
| East | 5:58-07:00 | 62 min | 1484 | 10 | 1286 |
| North | 5:38-07:00 | 82 min | 1641 | 14 | 1302 |
| South | 5:30-07:00 | 90 min | 1499 | 10 | 1311 |
| Total | | 305 min | | 48 | 5480 |

Covered: **4096** needy, Shared 2+: **1119** needy , Shared 3+: **220** needy

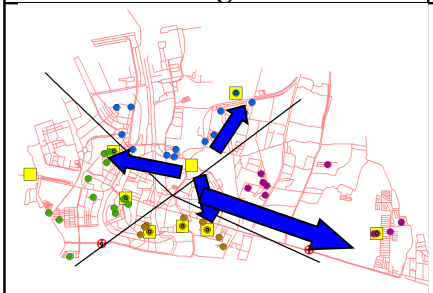
**Design 2**

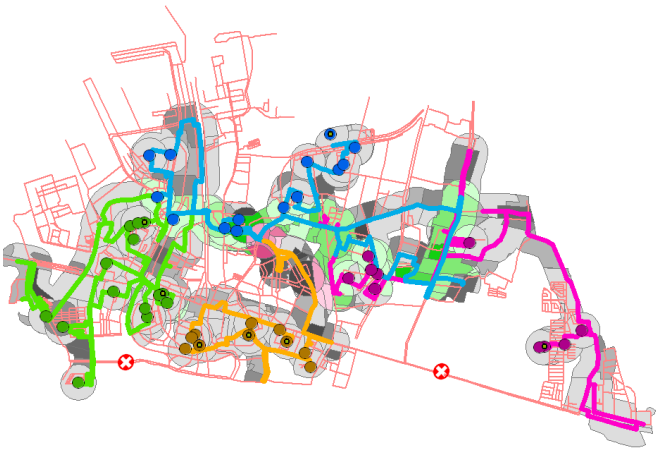


| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 5:44-07:00 | 76 min | 1073 | 14 | 1581 |
| East | 5:45-07:00 | 75 min | 1982 | 10 | 1286 |
| North | 5:33-07:00 | 87 min | 2368 | 14 | 1302 |
| South | 5:30-07:00 | 90 min | 1476 | 10 | 1311 |
| Total | | 328 min | | 48 | 5480 |

Covered: **4428** needy, Shared 2+: **1798** needy , Shared 3+: **370** needy

## Design 3

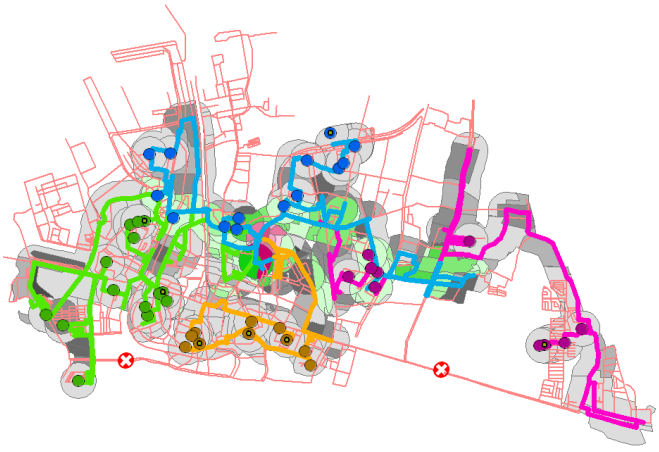




| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 5:44-07:00 | 76 min | 1052 | 14 | 1581 |
| East | 5:57-07:00 | 63 min | 1508 | 10 | 1286 |
| North | 5:37-07:00 | 83 min | 1869 | 14 | 1302 |
| South | 5:30-07:00 | 90 min | 1326 | 10 | 1311 |
| Total | | 312 min | | 48 | 5480 |

Covered: **3985** needy, Shared 2+: **1276** needy , Shared 3+: **264** needy

## Design 4



| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 5:40-07:00 | 80 min | 1348 | 14 | 1581 |
| East | 5:59-07:00 | 61 min | 1511 | 10 | 1286 |
| North | 5:31-07:00 | 89 min | 2035 | 14 | 1302 |
| South | 5:31-07:00 | 89 min | 1415 | 10 | 1311 |
| Total | | 319 min | | 48 | 5480 |

Covered: **4308** needy, Shared 2+: **1500** needy , Shared 3+: **269** needy

Table 5.3 shows that although there still appears a lack or excessive are of covered needy, supervised school areas produce better balance than unsupervised ones. However, as a consequence, the travel time has seen a significant increase and the total covered area, in general, has been decreased. This is because the VRP engine must obey the direction to visit specific schools in each area. In general, this first supervised model produces a pattern: the west route has excessive school capacities than the covered needy in its route; in contrast, the north route has a lack of schools with capacity. Because of this observation, the next distribution design will try to increase the extent of the west area and decrease the extent of the north area. The new design will resemble figure 5.9 below.

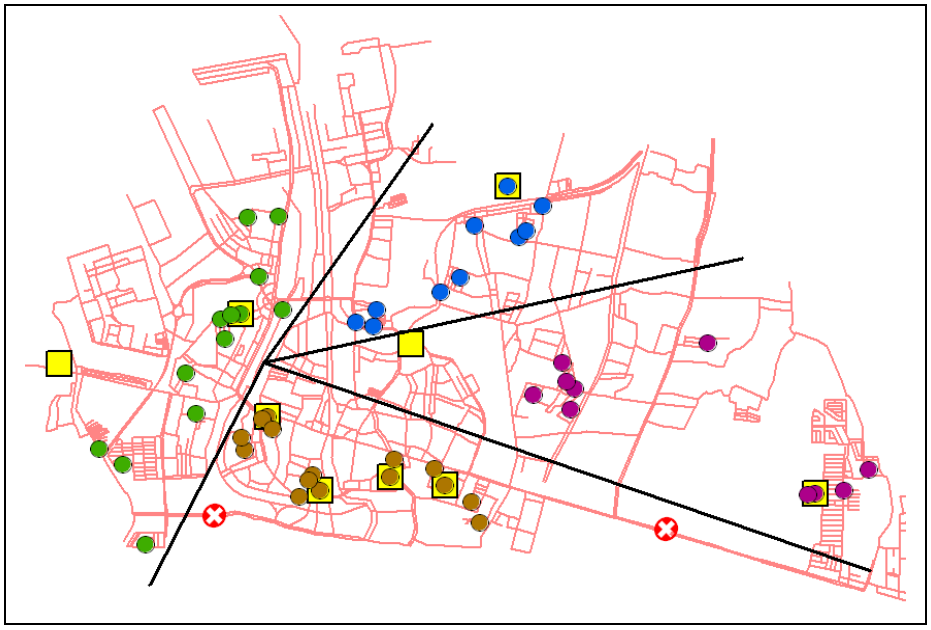


**Figure 5.9**. Illustration of second design of school distribution

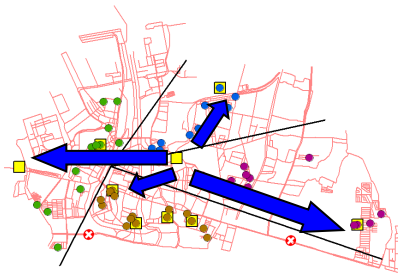
In this second distribution, west will have 13 schools with needy capacity 1502, the east 10 schools with capacity 1286, the north 10 schools with capacity 854, and the south 15 with capacity 1838. This second design also makes some small changes to the distribution of available depots. The west area now just has 2 available depots and the south area has 4 available depots. Following a similar process as with the previous design, output of this school distribution shows in Table 5.4 below.

**Table 5.4.** End depot design, output, and the assessment result of Distribution 2

| END DEPOT DESIGN | OUTPUT |
|---|---|
| **Design 1** | |
|  |  |

| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 5:46-07:00 | 74 min | 1498 | 13 | 1502 |
| East | 6:01-07:00 | 59 min | 1525 | 10 | 1286 |
| North | 6:12-07:00 | 48 min | 907 | 10 | 854 |
| South | 5:48-07:00 | 72 min | 2144 | 15 | 1838 |
| Total | | 253 min | | 48 | 5480 |

Covered : **4252** needy, Shared 2+: **1295** needy , Shared 3+: **281** needy

| | |
|---|---|
| **Design 2** | |
|  |  |

| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 5:44-07:00 | 76 min | 1532 | 13 | 1502 |
| East | 6:05-07:00 | 55 min | 1475 | 10 | 1286 |
| North | 6:00-07:00 | 60 min | 1043 | 10 | 854 |
| South | 5:45-07:00 | 75 min | 2095 | 15 | 1838 |
| Total | | 266 min | | 48 | 5480 |

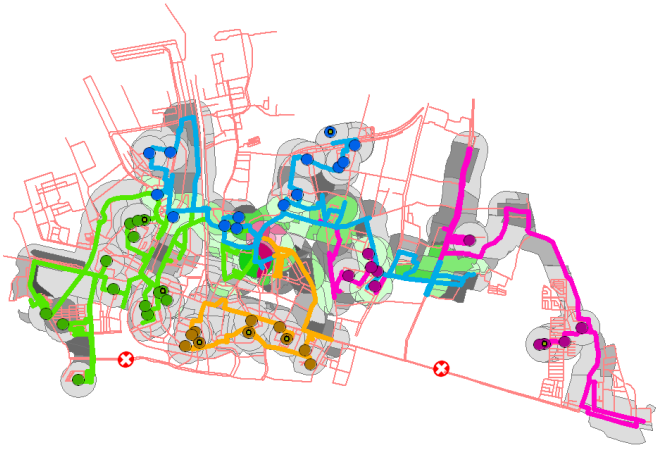
Covered: **4306** needy, Shared 2+: **1304** needy , Shared 3+: **290** needy

## Design 3

| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 5:50-07:00 | 70 min | 1707 | 13 | 1502 |
| East | 6:10-07:00 | 50 min | 1411 | 10 | 1286 |
| North | 6:12-07:00 | 48 min | 950 | 10 | 854 |
| South | 5:59-07:00 | 61 min | 1738 | 15 | 1838 |
| Total | | 229 min | | 48 | 5480 |

Covered: **4079** needy, Shared 2+: **1211** needy , Shared 3+: **267** needy

## Design 4



| Route | Start-Stop | Time | Needy covered | School covered | School capacity |
|---|---|---|---|---|---|
| West | 5:50-07:00 | 70 min | 1713 | 13 | 1502 |
| East | 6:09-07:00 | 51 min | 1373 | 10 | 1286 |
| North | 6:12-07:00 | 48 min | 950 | 10 | 854 |
| South | 6:04-07:00 | 56 min | 1701 | 15 | 1838 |
| Total | | 225 min | | 48 | 5480 |

Covered : **3868** needy, Shared 2+: **1326** needy , Shared 3+: **300** needy

In general, this second design generates better output than the first directed design. Travel time decreases and the needy are comparable with the same number capacity. Some needy covered by each route may be in slight excess than the capacity, but it is not a problem since the routes have sharing areas. Needy in these areas are counted two or three times for different routes. Some covered needy have to be divided among the routes, making the actual covered needy less than the covered in each route.

The first assessment point, the route balanced, is passed by all the end depot designs. The second assessment point is the covered needy. The end depot design 1 can cover 4252, design 2 can cover 4306, design 3 can cover 4079, and design 4 can cover 3868. The output of design 2 has the most widely covered area. The next position is design 1. Therefore, in the second assessment point, the candidate design is design 1 and 2. The next point to examine is the time consumed. Design 1 needs 253 minutes while design 2 needs 266 minutes. The last point, the shared area of design 1, has 1295 needy in that it can choose 2 or more route destinations, while design 2 is 1304. By comparing these points, design 2 is better in covered area and shared area, while design 2 is better in the time consumed output. Considering the objective of the bus school is for helping the needy and not taking a profit, then design 2 is chosen. The next section will detail this chosen route.

If this research is used for another objective, for example for a commercial bus, it is not impossible that the chosen route is different. It needs to be adjusted between potential customer (covered area) and the potential cost (time consumed). The difference of 54 potential passengers may be not worthy spending an additional 13 minutes in the travel time.

## 5.5 The Chosen Route

In the previous section there are several proposed routes that have a good covered balance. The best choice is the design number 2 in the second school distribution design. This section will detail this chosen route to give a better understanding before then continuing with analyzing the route. Figure 5.10 shows these chosen routes.

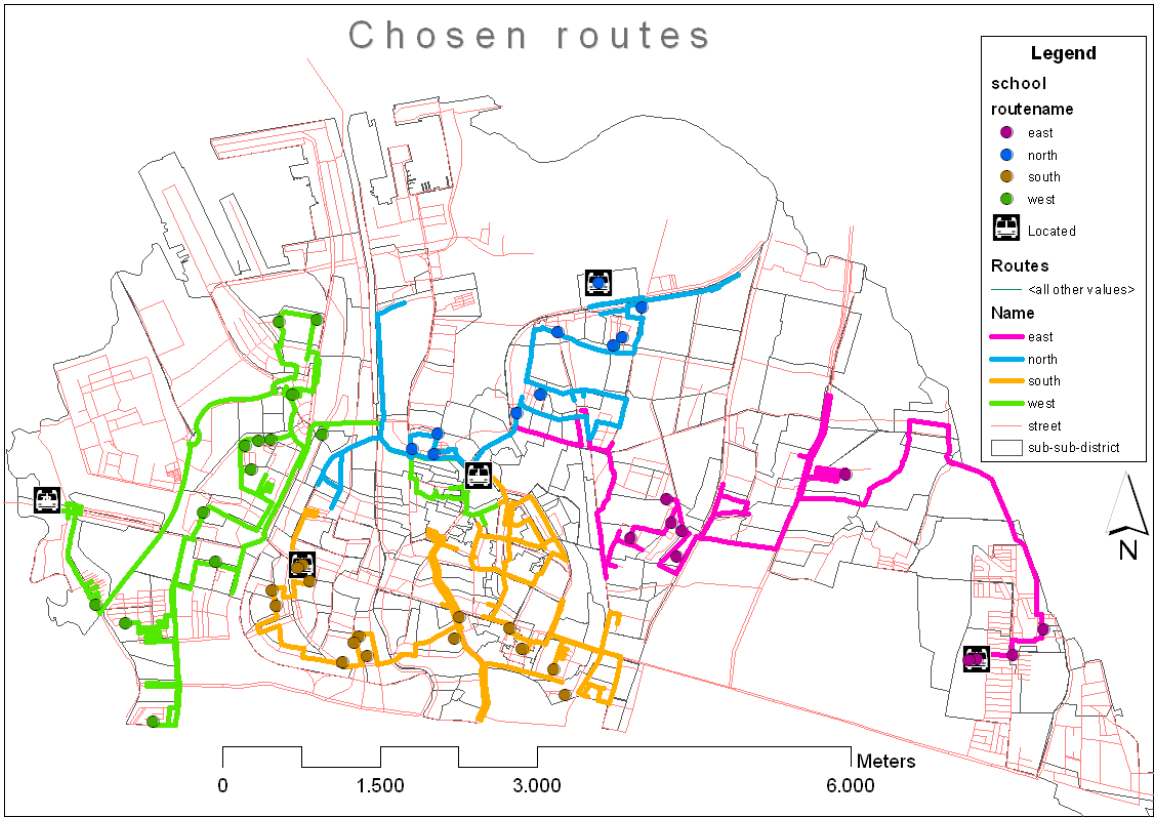
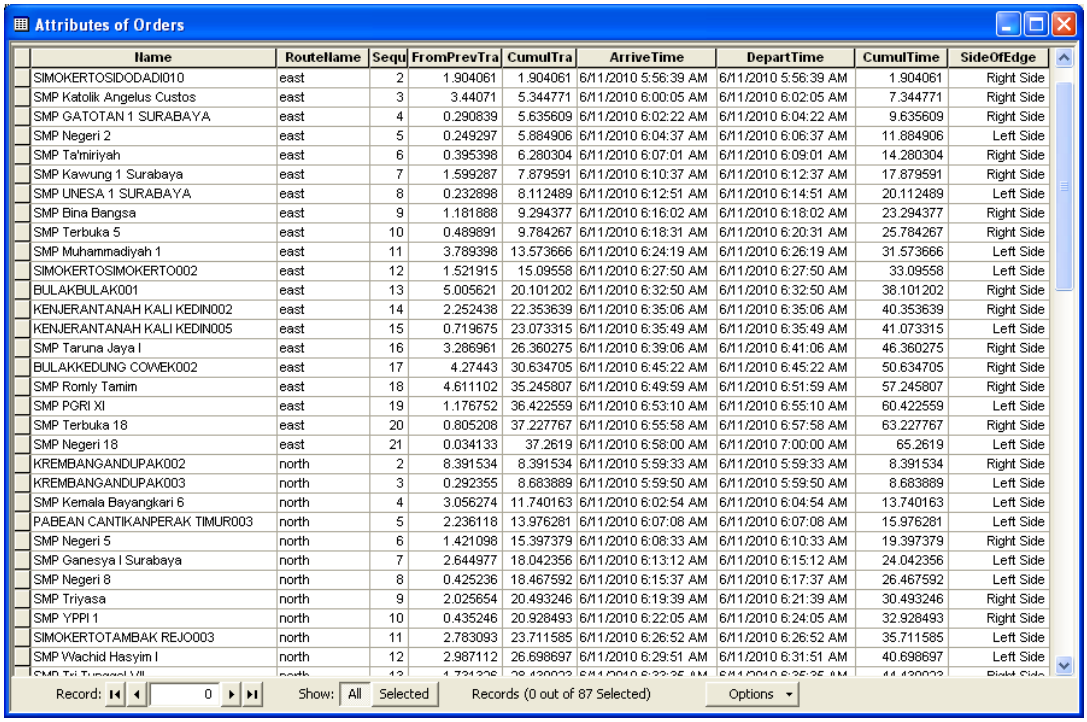



**Figure 5.10** The chosen routes

In tabular view, outputs of routing process are Orders table and Route table. Orders table shows the detailed sequence and time of arrival and departure of the bus in each school of each route destination. In the unsupervised Orders route design, each school will have a certain route name that indicates what route the school is joined, while in the supervised one this name is already set. The next important value of the output table is in the Sequence field, ArriveTime field, and DepartTime field that indicate when the school is visited by the school bus. Another important field is

CommuTime field which indicates the total time of the journey of the bus before stopping at the school. Figure 5.11 shows the output table of the Orders class.



Attributes of Orders

| Name | RouteName | Sequ | FromPrevTra | CumulTra | ArriveTime | DepartTime | CumulTime | SideOfEdge |
|---|---|---|---|---|---|---|---|---|
| SIMOKERTOSIDODADI010 | east | 2 | 1.904061 | 1.904061 | 6/11/2010 5:56:39 AM | 6/11/2010 5:56:39 AM | 1.904061 | Right Side |
| SMP Katolik Angelus Custos | east | 3 | 3.44071 | 5.344771 | 6/11/2010 6:00:05 AM | 6/11/2010 6:02:05 AM | 7.344771 | Right Side |
| SMP GATOTAN 1 SURABAYA | east | 4 | 0.290839 | 5.635609 | 6/11/2010 6:02:22 AM | 6/11/2010 6:04:22 AM | 9.635609 | Right Side |
| SMP Negeri 2 | east | 5 | 0.249297 | 5.884906 | 6/11/2010 6:04:37 AM | 6/11/2010 6:06:37 AM | 11.884906 | Left Side |
| SMP Ta'miriyah | east | 6 | 0.395398 | 6.280304 | 6/11/2010 6:07:01 AM | 6/11/2010 6:09:01 AM | 14.280304 | Right Side |
| SMP Kawung 1 Surabaya | east | 7 | 1.599287 | 7.879591 | 6/11/2010 6:10:37 AM | 6/11/2010 6:12:37 AM | 17.879591 | Right Side |
| SMP UNESA 1 SURABAYA | east | 8 | 0.232898 | 8.112489 | 6/11/2010 6:12:51 AM | 6/11/2010 6:14:51 AM | 20.112489 | Left Side |
| SMP Bina Bangsa | east | 9 | 1.181888 | 9.294377 | 6/11/2010 6:16:02 AM | 6/11/2010 6:18:02 AM | 23.294377 | Right Side |
| SMP Terbuka 5 | east | 10 | 0.489891 | 9.784267 | 6/11/2010 6:18:31 AM | 6/11/2010 6:20:31 AM | 25.784267 | Right Side |
| SMP Muhammadiyah 1 | east | 11 | 3.789398 | 13.573666 | 6/11/2010 6:24:19 AM | 6/11/2010 6:26:19 AM | 31.573666 | Left Side |
| SIMOKERTOSIMOKERTO002 | east | 12 | 1.521915 | 15.09558 | 6/11/2010 6:27:50 AM | 6/11/2010 6:27:50 AM | 33.09558 | Left Side |
| BULAKBULAK001 | east | 13 | 5.005621 | 20.101202 | 6/11/2010 6:32:50 AM | 6/11/2010 6:32:50 AM | 38.101202 | Right Side |
| KENJERANTANAH KALI KEDIN002 | east | 14 | 2.252438 | 22.353639 | 6/11/2010 6:35:06 AM | 6/11/2010 6:35:06 AM | 40.353639 | Right Side |
| KENJERANTANAH KALI KEDIN005 | east | 15 | 0.719675 | 23.073315 | 6/11/2010 6:35:49 AM | 6/11/2010 6:35:49 AM | 41.073315 | Left Side |
| SMP Taruna Jaya I | east | 16 | 3.286961 | 26.360275 | 6/11/2010 6:39:06 AM | 6/11/2010 6:41:06 AM | 46.360275 | Right Side |
| BULAKKEDUNG COWEK002 | east | 17 | 4.27443 | 30.634705 | 6/11/2010 6:45:22 AM | 6/11/2010 6:45:22 AM | 50.634705 | Right Side |
| SMP Romly Tamim | east | 18 | 4.611102 | 35.245807 | 6/11/2010 6:49:59 AM | 6/11/2010 6:51:59 AM | 57.245807 | Right Side |
| SMP PGRI XI | east | 19 | 1.176752 | 36.422559 | 6/11/2010 6:53:10 AM | 6/11/2010 6:55:10 AM | 60.422559 | Left Side |
| SMP Terbuka 18 | east | 20 | 0.805208 | 37.227767 | 6/11/2010 6:55:58 AM | 6/11/2010 6:57:58 AM | 63.227767 | Right Side |
| SMP Negeri 18 | east | 21 | 0.034133 | 37.2619 | 6/11/2010 6:58:00 AM | 6/11/2010 7:00:00 AM | 65.2619 | Left Side |
| KREMBANGANDUPAK002 | north | 2 | 8.391534 | 8.391534 | 6/11/2010 5:59:33 AM | 6/11/2010 5:59:33 AM | 8.391534 | Right Side |
| KREMBANGANDUPAK003 | north | 3 | 0.292355 | 8.683889 | 6/11/2010 5:59:50 AM | 6/11/2010 5:59:50 AM | 8.683889 | Left Side |
| SMP Kemala Bayangkari 6 | north | 4 | 3.056274 | 11.740163 | 6/11/2010 6:02:54 AM | 6/11/2010 6:04:54 AM | 13.740163 | Left Side |
| PABEAN CANTIKANPERAK TIMUR003 | north | 5 | 2.236118 | 13.976281 | 6/11/2010 6:07:08 AM | 6/11/2010 6:07:08 AM | 15.976281 | Left Side |
| SMP Negeri 5 | north | 6 | 1.421098 | 15.397379 | 6/11/2010 6:08:33 AM | 6/11/2010 6:10:33 AM | 19.397379 | Right Side |
| SMP Ganesya I Surabaya | north | 7 | 2.644977 | 18.042356 | 6/11/2010 6:13:12 AM | 6/11/2010 6:15:12 AM | 24.042356 | Left Side |
| SMP Negeri 8 | north | 8 | 0.425236 | 18.467592 | 6/11/2010 6:15:37 AM | 6/11/2010 6:17:37 AM | 26.467592 | Left Side |
| SMP Triyasa | north | 9 | 2.025654 | 20.493246 | 6/11/2010 6:19:39 AM | 6/11/2010 6:21:39 AM | 30.493246 | Right Side |
| SMP YPPI 1 | north | 10 | 0.435246 | 20.928493 | 6/11/2010 6:22:05 AM | 6/11/2010 6:24:05 AM | 32.928493 | Right Side |
| SIMOKERTOTAMBAK REJO003 | north | 11 | 2.783093 | 23.711585 | 6/11/2010 6:26:52 AM | 6/11/2010 6:26:52 AM | 35.711585 | Left Side |
| SMP Wachid Hasyim I | north | 12 | 2.987112 | 26.698697 | 6/11/2010 6:29:51 AM | 6/11/2010 6:31:51 AM | 40.698697 | Left Side |

Record: 0 Show: All Selected Records (0 out of 87 Selected) Options

**Figure 5.11** Result Table of the Orders class

The chosen route is generated based on the distribution area of the schools in Figure 5.9. This distribution made the bus must travel across every school in the area which was in its direction. Buses in the west area need 76 minutes to travel from the center depot to its last direction. The east route requires 55 minutes, North 60 minutes, and South 75 minutes. Table 5.5 shows the schools, the route area, the school capacity and the total capacity of the area, and the detailed minutes when the bus visits them.

**Table 5.5.** Schools visited sequence and time

| No visit | Name | Route Name | Minutes Bus Arrived | Capacity |
|---|---|---|---|---|
| 1 | SMP Wachid Hasyim I | east | 11 | 99 |
| 2 | SMPK. Pecinta Damai | east | 14 | 148 |
| 3 | SMP YP 17 SURABAYA | east | 17 | 93 |
| 4 | SMP Muhammadiyah 15 | east | 20 | 132 |
| 5 | SMP Tri Tunggal VII | east | 23 | 97 |
| 6 | SMP Taruna Jaya I | east | 34 | 143 |
| 7 | SMP Romly Tamim | east | 46 | 118 |
| 8 | SMP PGRI XI | east | 49 | 150 |
| 9 | SMP Negeri 18 | east | 52 | 154 |
| 10 | SMP Terbuka 18 | east | 54 | 152 |
| | | | **Total capacity east** | **1286** |
| 1 | SMP ALKHAIRIYAH | north | 3 | 100 |
| 2 | SMP AL GHOZALI | north | 6 | 125 |
| 3 | SMP AL IRSYAD SURABAYA | north | 8 | 115 |
| 4 | SMP ISLAM AL AMAL | north | 23 | 39 |
| 5 | SMP ISLAM LIL WATHON | north | 30 | 41 |
| 6 | SMP MUHAMMADIYAH 16 | north | 34 | 30 |
| 7 | SMP PGRI VI SBY | north | 38 | 110 |
| 8 | MTs Nurul Salam | north | 40 | 13 |
| 9 | SMP Cahaya | north | 49 | 134 |
| 10 | SMP Negeri 27 | north | 59 | 147 |
| | | | **Total capacity north** | **854** |
| 1 | SMP Muhammadiyah 1 | south | 13 | 119 |
| 2 | SMP Negeri 41 | south | 16 | 74 |
| 3 | SMP YPPI 1 | south | 28 | 147 |
| 4 | SMP Triyasa | south | 30 | 148 |
| 5 | SMP Negeri 8 | south | 36 | 136 |
| 6 | SMP Ganesya I Surabaya | south | 43 | 75 |
| 7 | SMP Katolik Angelus Custos | south | 48 | 154 |
| 8 | SMP GATOTAN 1 SURABAYA | south | 50 | 150 |
| 9 | SMP Negeri 2 | south | 52 | 154 |
| 10 | SMP Ta'miriyah | south | 55 | 154 |
| 11 | SMP Kawung 1 Surabaya | south | 60 | 51 |
| 12 | SMP UNESA 1 SURABAYA | south | 62 | 125 |
| 13 | SMP Bina Bangsa | south | 65 | 134 |
| 14 | SMP Terbuka 5 | south | 67 | 149 |
| 15 | SMP Negeri 5 | south | 72 | 68 |
| | | | **Total capacity south** | **1838** |
| 1 | SMP Gatra | west | 11 | 91 |
| 2 | SMP Negeri 7 | west | 15 | 149 |
| 3 | SMP K St. Mikael | west | 17 | 125 |
| 4 | SMP Al-Ikhlash | west | 20 | 149 |
| 5 | SMP Hang Tuah-4 Surabaya | west | 22 | 130 |
| 6 | SMP PGRI 5 Surabaya | west | 29 | 146 |
| 7 | SMP Islam | west | 35 | 72 |
| 8 | SMP Muhamadiyah XI | west | 42 | 95 |
| 9 | SMP Kemala Bayangkari 6 | west | 47 | 112 |
| 10 | SMP Barunawati | west | 55 | 127 |
| 11 | SMP Mujahidin | west | 59 | 109 |
| 12 | SMP PGRI 36 | west | 62 | 121 |
| 13 | SMP Bina Karya | west | 69 | 76 |
| | | | **Total capacity west** | **1502** |

For better viewing the routes, Table 5.5 will complement with Figure 5.12, 5.13, 5.14, and 5.15 below. These figures show each route unaccompanied by the others. While table 5.5 describes the minutes of the arrived bus, these figures describe the traveling routes.

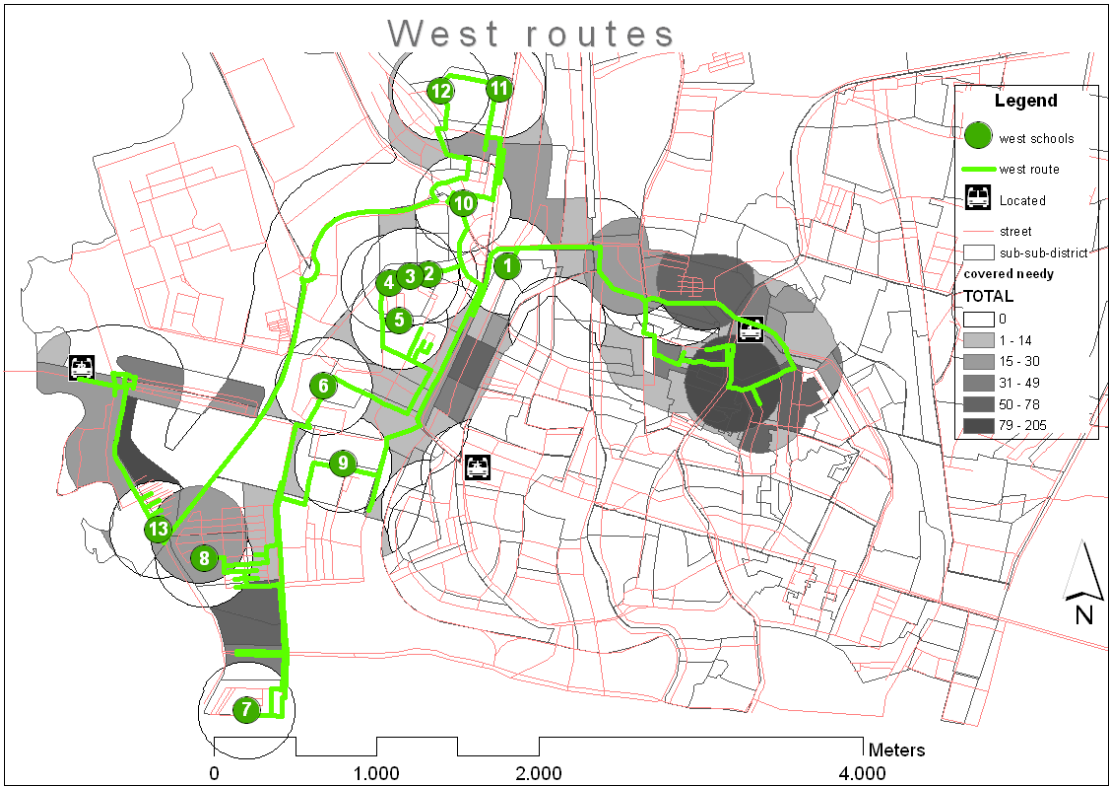



**Figure 5.12** The west route

Figure 5.12 shows that the route begins from the center depot, then it makes a little rotation in its surrounded area to get the needy. Next, it goes to North West and visits the first school in 11 minutes. Because every school bus stopped 2 minutes, at 13 minutes it leaves this school. It turns right, and in two minutes comes to the second school. The second school, third school, fourth school, and fifth school are in a very short distance from one another. Buses will leave the fifth school at 24 minutes, then go south in the next 5 minutes, and finally arrives at the sixth school. Going again to the most south area, the seventh school, it travels in the same way going back to north and makes a little turn left to visit the eighth school. After turning back the previous way, it

is going to the north but takes another street on the right and visits the ninth school. Go along to the north and the most north school in west area visiting the tenth, the eleventh, and the twelfth school. It then head to the south again, and visits the thirteenth school before continuing on to the west depot for a rest.

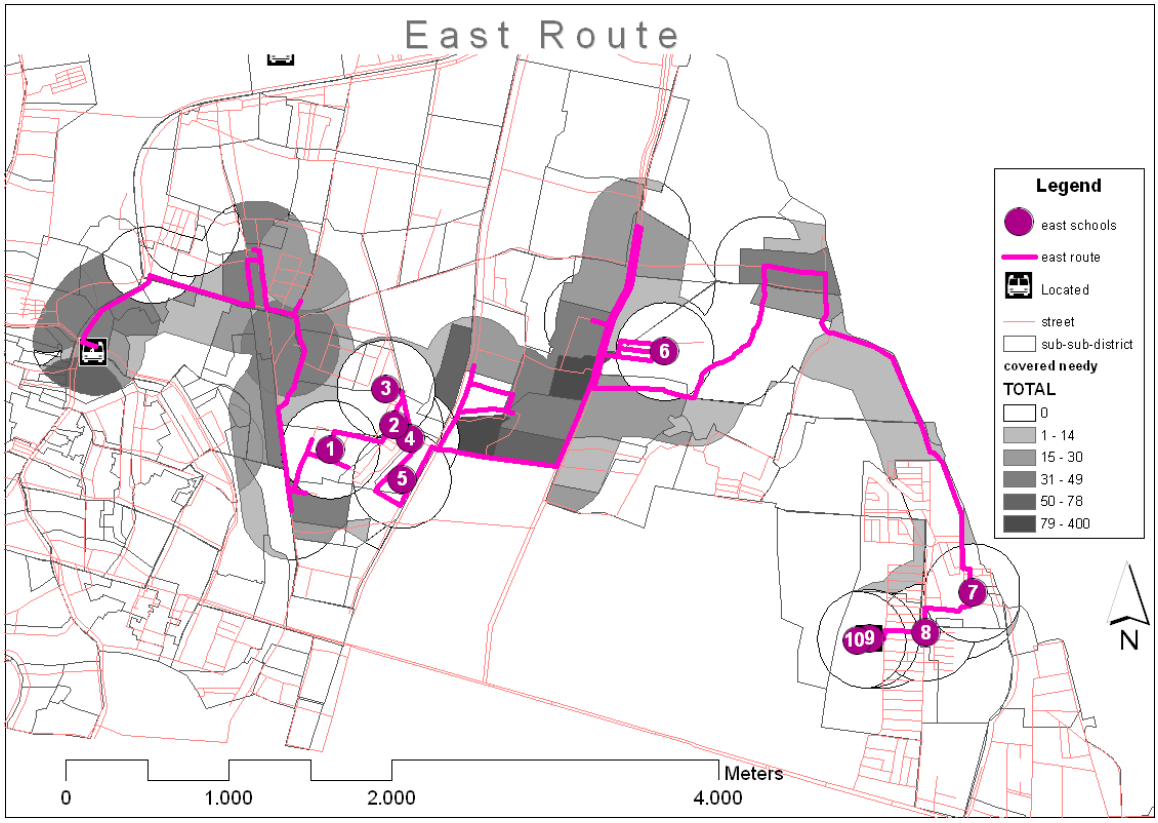



**Figure 5.13** The east route

The west route is complicated, taking a circuitous route back and forth to the north and south. The east route, shown in Figure 5.13 however is much simpler. The Bus is just going to the east. In one third of its journey, it visits the first school up to the fifth school in the contiguous time, because they are a short distance from one another. After the fifth school, in the second third, it visits the sixth school. Finally, it continues going to the South East to visit the seventh to tenth schools and ends its journey.

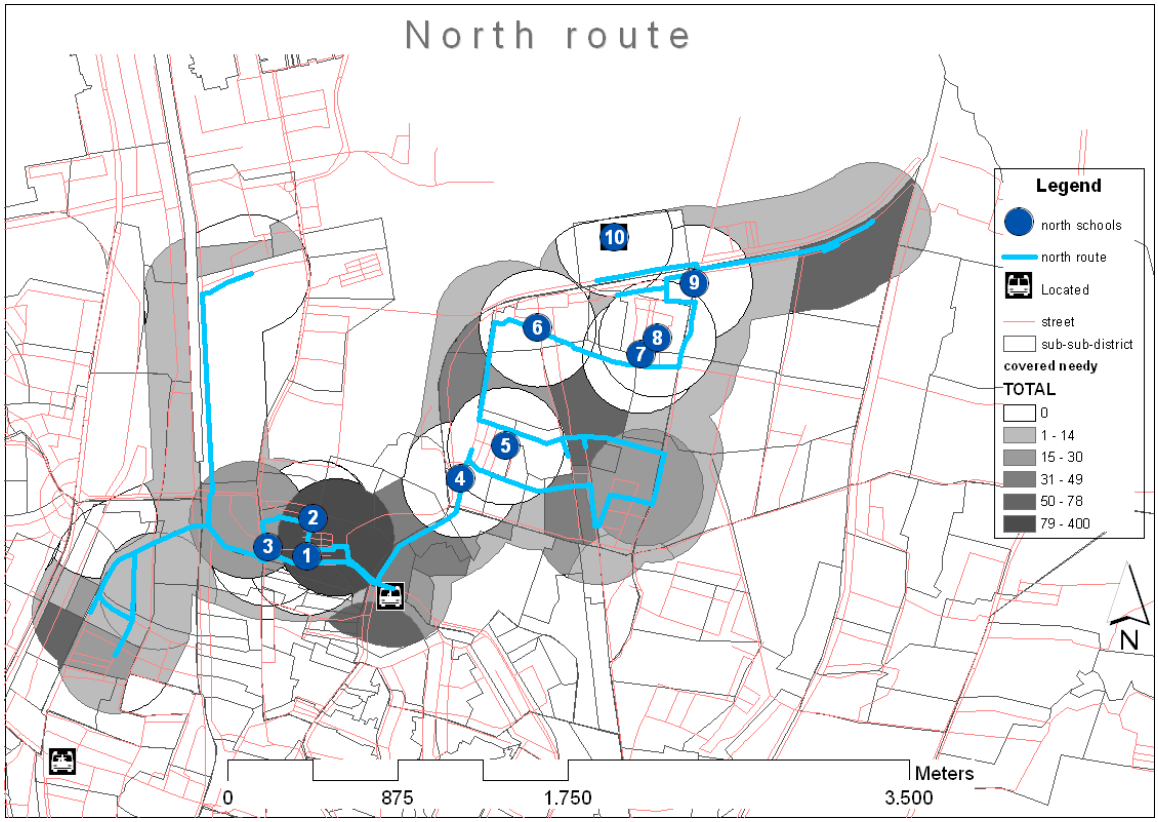



**Figure 5.14** The north route

The north route, Figure 5.14, is pretty simple too. Starting from the center depot, the bus goes to the west to collect passengers. It continues to go back to the east and visit the first, second, and third schools as they lie in a block. Next, in will continue to the north east to visit the fourth school. Then, turning right to collect more passengers, it will eventually turn left again to visit the fifth school. Then, going to north and turning right to visit the sixth, seventh, and eighth schools, it will keep on its journey north to visit the ninth school. After leaving the ninth school, it heads west to collect passengers. When it travels back to the tenth school, it remains to rest there to rest.

The south is the last route is the route and contains the most number of schools and school capacity. The bus will leave the depot and go to the potential needy area in the southern end of the depot. Going around there first and then continuing its travels, the bus will be more of south of both the first school and the second school. It continues to the east to collect passengers again and then back to the west where it visits the third and fourth schools. Continuing its journey to the west, it turns left in a southern

direction to get more passengers, and then back to north to visit the fifth school. The bus will continue to the north for a while to get passengers and once again head back to the south and visit the sixth school. The next part of the route has the bus turning right and going westward. In the middle of its journey west, it visits the seventh to tenth schools. Continuing from there, it goes to the North West and visits the eleventh to fourteenth schools. Finally, before the last school which is the fifth school, it goes to the north for a while to get passengers and then travels back to end its journey. Figure 5.15 shows this route.

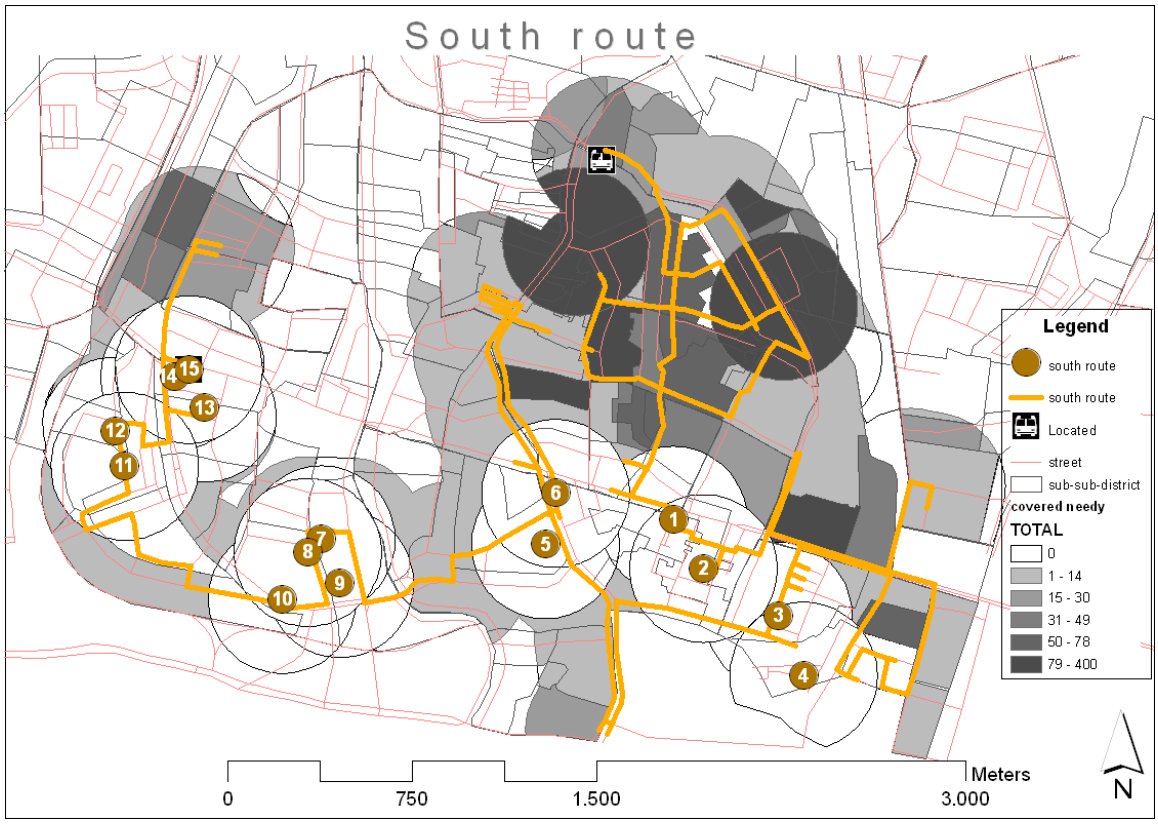
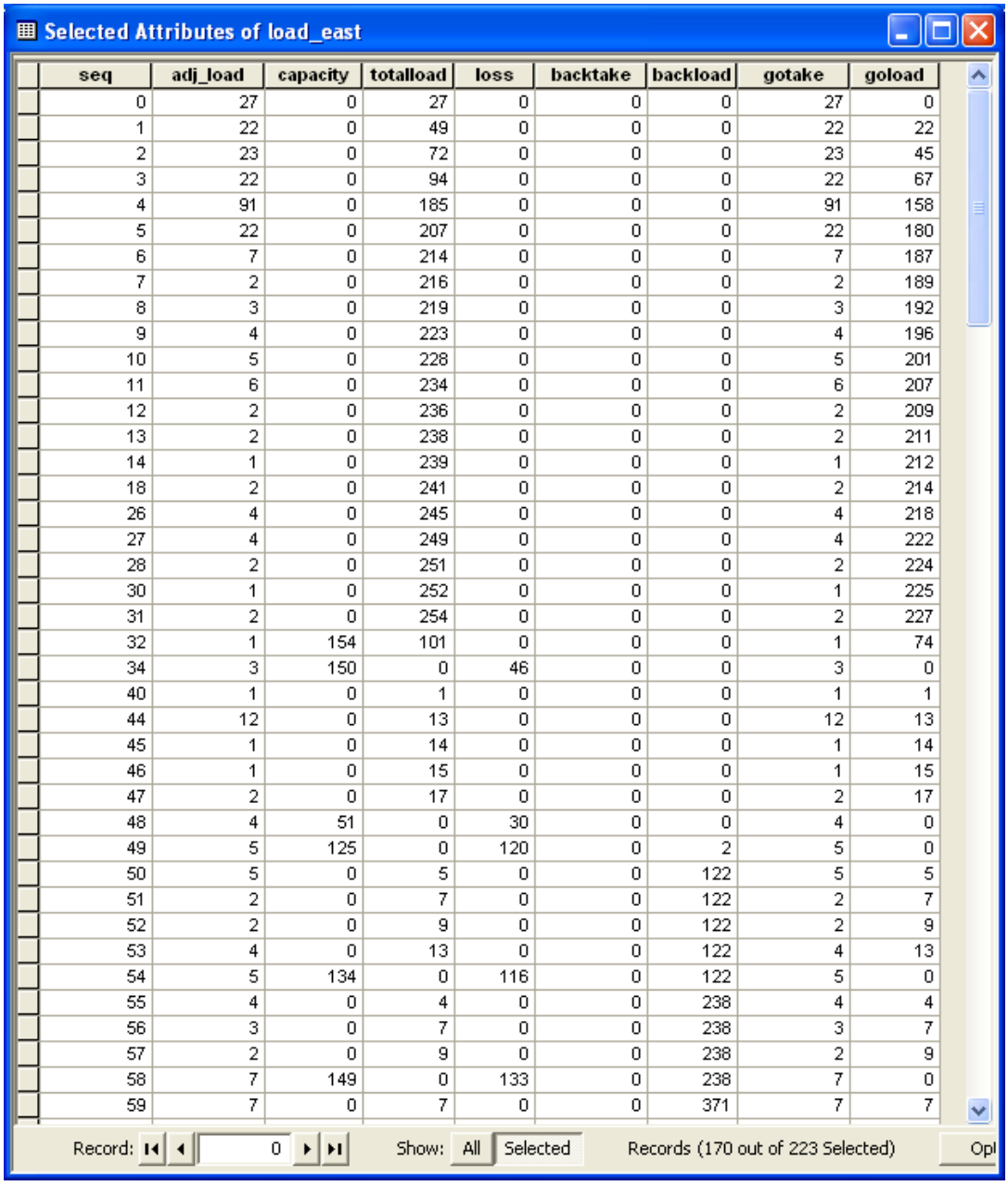



**Figure 5.15** The south route

This section has shown the results of the processes that have been explained in the methodology chapter. By ending this section, this research has completed the routing stage and will follow with the analyst stage in next section.

## 5.6 Load Analyst Result

In the load analyst process, each route in the Routes class is segmented by dividing the route per 300 meters. Each segment is then equipped with a necessary field like those explained in section 4.10.1. There is an AdjLoad field that needs to be filled in with a calculated and adjusted number of needy surrounding the segment. There is also an additional Capacity field that will be filled in with the number of school capacity as in Table 5.5. The table of the result analyst is shown in Figure 5.16 below.


Selected Attributes of load_east

| seq | adj_load | capacity | totalload | loss | backtake | backload | gotake | goload |
|---|---|---|---|---|---|---|---|---|
| 0 | 27 | 0 | 27 | 0 | 0 | 0 | 27 | 0 |
| 1 | 22 | 0 | 49 | 0 | 0 | 0 | 22 | 22 |
| 2 | 23 | 0 | 72 | 0 | 0 | 0 | 23 | 45 |
| 3 | 22 | 0 | 94 | 0 | 0 | 0 | 22 | 67 |
| 4 | 91 | 0 | 185 | 0 | 0 | 0 | 91 | 158 |
| 5 | 22 | 0 | 207 | 0 | 0 | 0 | 22 | 180 |
| 6 | 7 | 0 | 214 | 0 | 0 | 0 | 7 | 187 |
| 7 | 2 | 0 | 216 | 0 | 0 | 0 | 2 | 189 |
| 8 | 3 | 0 | 219 | 0 | 0 | 0 | 3 | 192 |
| 9 | 4 | 0 | 223 | 0 | 0 | 0 | 4 | 196 |
| 10 | 5 | 0 | 228 | 0 | 0 | 0 | 5 | 201 |
| 11 | 6 | 0 | 234 | 0 | 0 | 0 | 6 | 207 |
| 12 | 2 | 0 | 236 | 0 | 0 | 0 | 2 | 209 |
| 13 | 2 | 0 | 238 | 0 | 0 | 0 | 2 | 211 |
| 14 | 1 | 0 | 239 | 0 | 0 | 0 | 1 | 212 |
| 18 | 2 | 0 | 241 | 0 | 0 | 0 | 2 | 214 |
| 26 | 4 | 0 | 245 | 0 | 0 | 0 | 4 | 218 |
| 27 | 4 | 0 | 249 | 0 | 0 | 0 | 4 | 222 |
| 28 | 2 | 0 | 251 | 0 | 0 | 0 | 2 | 224 |
| 30 | 1 | 0 | 252 | 0 | 0 | 0 | 1 | 225 |
| 31 | 2 | 0 | 254 | 0 | 0 | 0 | 2 | 227 |
| 32 | 1 | 154 | 101 | 0 | 0 | 0 | 1 | 74 |
| 34 | 3 | 150 | 0 | 46 | 0 | 0 | 3 | 0 |
| 40 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 44 | 12 | 0 | 13 | 0 | 0 | 0 | 12 | 13 |
| 45 | 1 | 0 | 14 | 0 | 0 | 0 | 1 | 14 |
| 46 | 1 | 0 | 15 | 0 | 0 | 0 | 1 | 15 |
| 47 | 2 | 0 | 17 | 0 | 0 | 0 | 2 | 17 |
| 48 | 4 | 51 | 0 | 30 | 0 | 0 | 4 | 0 |
| 49 | 5 | 125 | 0 | 120 | 0 | 2 | 5 | 0 |
| 50 | 5 | 0 | 5 | 0 | 0 | 122 | 5 | 5 |
| 51 | 2 | 0 | 7 | 0 | 0 | 122 | 2 | 7 |
| 52 | 2 | 0 | 9 | 0 | 0 | 122 | 2 | 9 |
| 53 | 4 | 0 | 13 | 0 | 0 | 122 | 4 | 13 |
| 54 | 5 | 134 | 0 | 116 | 0 | 122 | 5 | 0 |
| 55 | 4 | 0 | 4 | 0 | 0 | 238 | 4 | 4 |
| 56 | 3 | 0 | 7 | 0 | 0 | 238 | 3 | 7 |
| 57 | 2 | 0 | 9 | 0 | 0 | 238 | 2 | 9 |
| 58 | 7 | 149 | 0 | 133 | 0 | 238 | 7 | 0 |
| 59 | 7 | 0 | 7 | 0 | 0 | 371 | 7 | 7 |

Record: 0 Show: All Selected Records (170 out of 223 Selected) Opt

**Figure 5.16.** Table of the Load analyst

TotalLoad, Loss, BackTake, BackLoad, GoTake, and GoLoad fields are filled in by running the small application in Visual basic with the MapObject2.0 component, including the programming script that implemented the algorithm in Figure 4.41.

After the calculation step, the result of this load analyst is presented in the 3D view of ArcScene. There are two types of load that need to be presented here; the load of the route and the load of inverse route. This 3D is provided with data from the Street map layer, the Schools, and the needy area map layer. The street layer is presented in 2 dimensional red lines. The school is a point layer and is presented as a big point and the extruded height shows the value of school capacity. The needy area is also presented as extruded for the purposes of showing which area has the greatest number of needy compared with others. With respect to the main data, the route load is presented in two different layers; the First layer shows the direction route while the second indicates the inverse route. The directions routes are extruded with the value of GoLoad field while the inverse with the value of the BackLoad field. Figures 5.17, 5.18, 5.19-5.20, and 5.21 show the 3D representation of the west, east, north, and south routes respectively. It shows the alteration of passengers in each route, as well as where the potential crowded areas and lack of passengers will be.

The west route in Figure 5.17 needs an inverse route. This is necessary because the direction ended at a west depot rather than at a school. So, while traveling to the west depot, being the end of the journey, the bus still collects needy students. These passengers need to be picked up and transported in the inverse direction. From the calculation using the algorithm in Figure 4.41, the West route direction has a maximum number of 632, while the contra flow is 269. The main direction is colored with green while the inverse direction is colored with yellow. The maximum number can be seen in Figure 6.5 and occurs at the start of the journey. The passengers are becoming crowded while the bus is just beginning the journey. This overcrowding occurs because the bus is

going around in an area surrounding the center depot before visiting the first school. After the bus arrives at several schools, there are still low numbers of passengers until it finishes its journey.

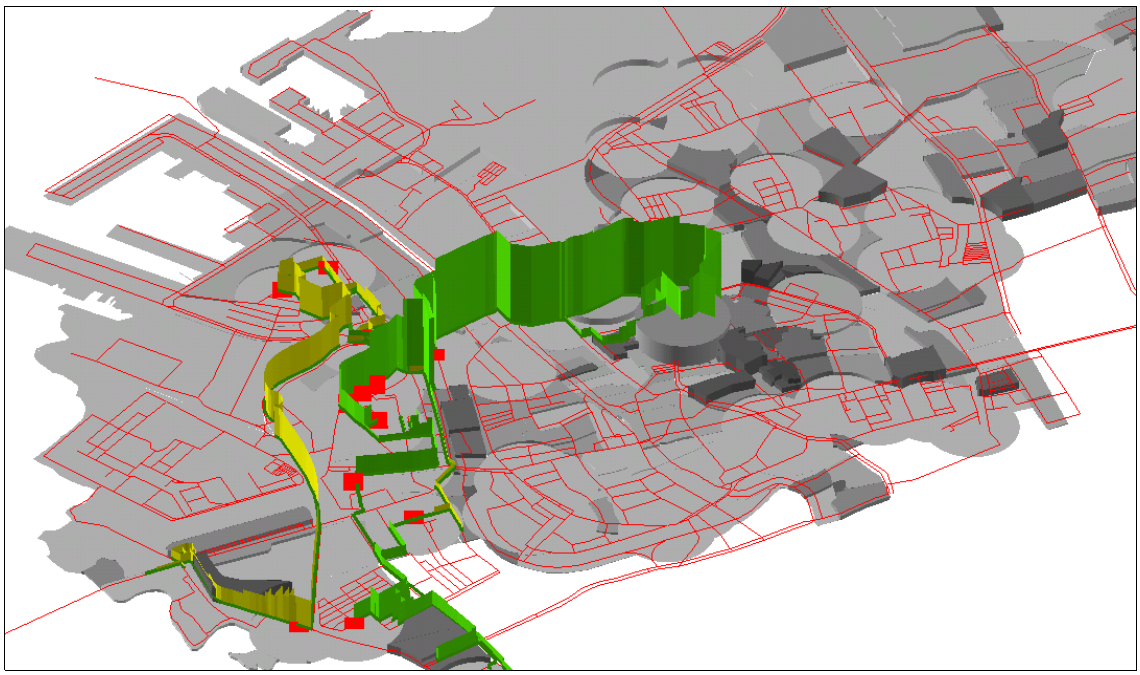


**Figure 5.17**. The 3D representation of the passenger load in the west route

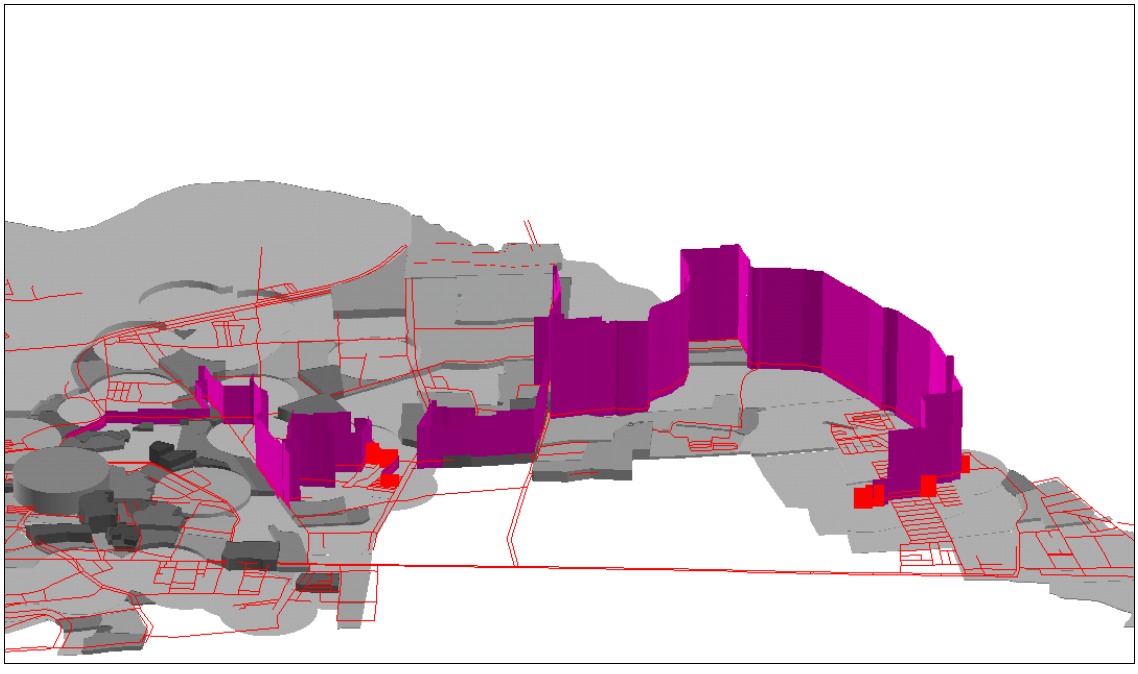


**Figure 5.18**. The 3D representation of the passenger load in the east route

In contrast, the east route can be seen in Figure 5.18, and crowds on that route appear at the end of the journey. In the first third of the journey the passengers are filling in the groups of schools. Continuing from here into the second third of the route, there is an excessive passenger load compared with the sixth school capacity. Therefore, a lot of passengers are still traveling in the last third of the route, and it becomes a sizeable crowd before arriving at the east group of schools. The maximum number of passengers on the bus is 761. The East route just requires one way service because a group of schools resides at the end of the route and fills in the rest of the available bus space for passengers.

The North route is a bit difficult to see as 3D in one figure. This is because the main direction and the inverse have a sufficient number of passengers. The difference from the two other routes is a result of having a school group in the west of the start depot that has plentiful capacity. This capacity cannot be filled by the short journey in the west to collect passengers. In the journey to the North East area, a number of passengers are exceeding the capacity of the schools. The greatest number occurs in the middle of the North East journey, with the maximum number of needy passengers at 475. Therefore, the inverse route will collect a number of needy in this area. This inverse route has 248, the maximum number of needy passengers. The needy will travel until filling in the group of schools in the west of center depot. Figure 5.19 shows the main direction of the north route while figure 5.20 shows the inverse.

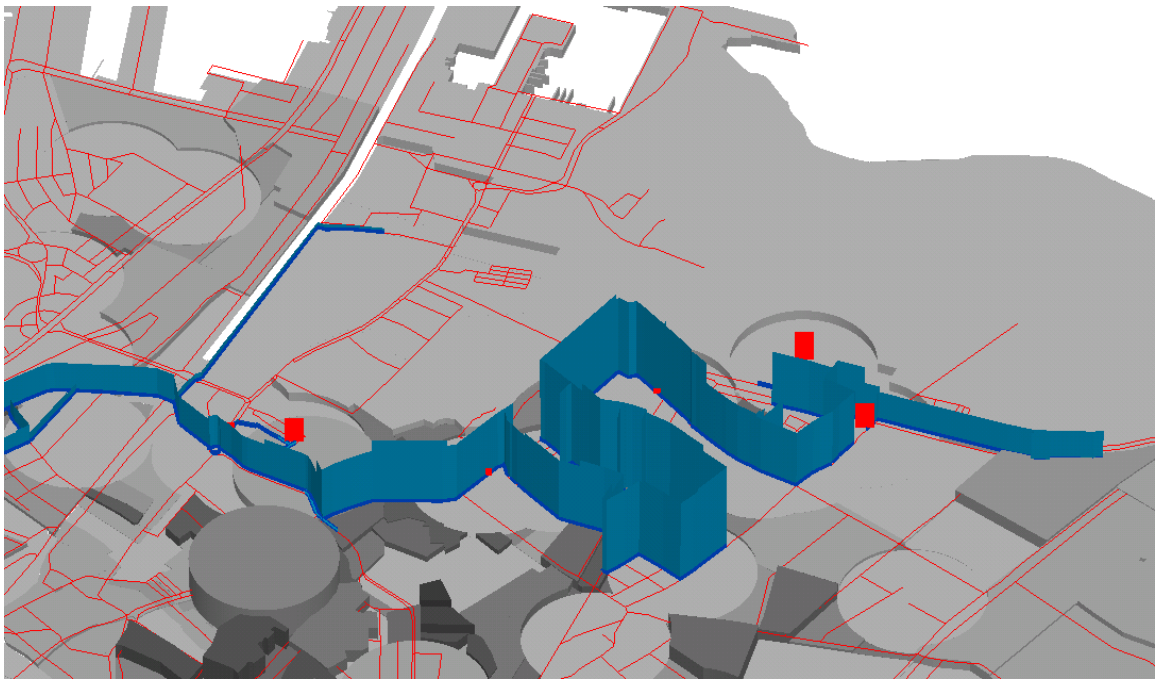


**Figure 5.19**. The 3D representation of the passenger load in the north route; the main direction

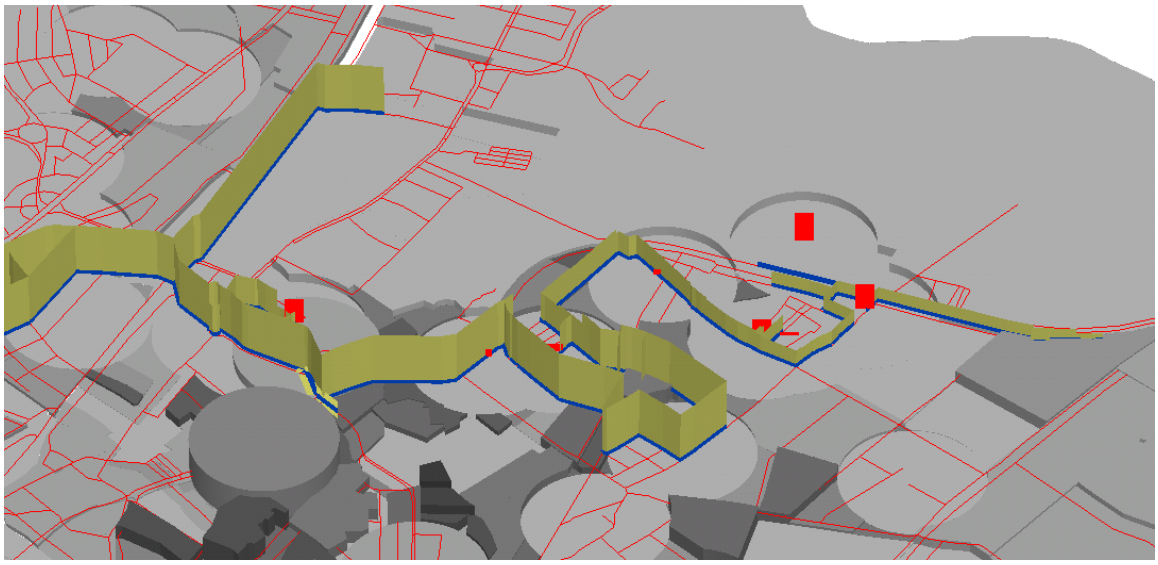


**Figure 5.20**. The 3D representation of the passenger load in the north route; the inverse direction.

The last route, the south, has the most crowded passengers. It followed as the route with the most capacity and the most covered needy described in the previous section. The route begins with the bus going around collecting passengers, and collects a plentiful number for more than one half of the journey. The visited schools cannot accommodate the needy because on the way to those schools, many passengers also get onto the bus. The bus is not busy for at last one third of the journey. The South route

will need the most number of bus fleets for the main direction, because the maximum capacity of passengers is 1115, whereas the contra flow needs slightly less because it has a maximum of 53. Figure 5.21 shows this last route.

**Figure 5.21**. the 3D representation of the passenger load in the south route

Importantly, this section shows the prediction of the numbers of passengers which will be loaded in each route. With this prediction, the government can make a decision regarding how many buses it needs to provide to offer optimum school bus transportation for its residents which also includes the needy. For example, let's say, the bus can carry about 70 needy (50 sitting down and 20 standing). The west route will need 9 fleets for the main direction and 4 fleets for the inverse. The east route needs 11 buses for its direction while the north route needs more buses in place for the inverse compared with others. For the main direction it needs 7 fleets and for the inverse it needs 4 fleets. The south route, which requires 16 fleets, has to provide the most fleets in the main direction. For accommodating a smaller number of passengers for the inverse, 1 fleet is enough. These numbers of buses required for optimal bus transportation may be a great number for the government. However, if at this point

these quantities cannot be provided to cover all the needy, the government can still use this calculated number as a reference for making well-informed decisions regarding effective distribution of the existing limited number of buses.

### 5.7 Accessibility Analyst Result

Accessibility analyst result involves calculating the accessibility level of transportation system media before and after the addition of certain buses. The number of added buses is taken from the number of buses needed in each route direction and its inverse. First, to refresh our knowledge about the characteristics of the existing transportation system, let's recall the existing transportation system map as shown in Figure 5.22 below.

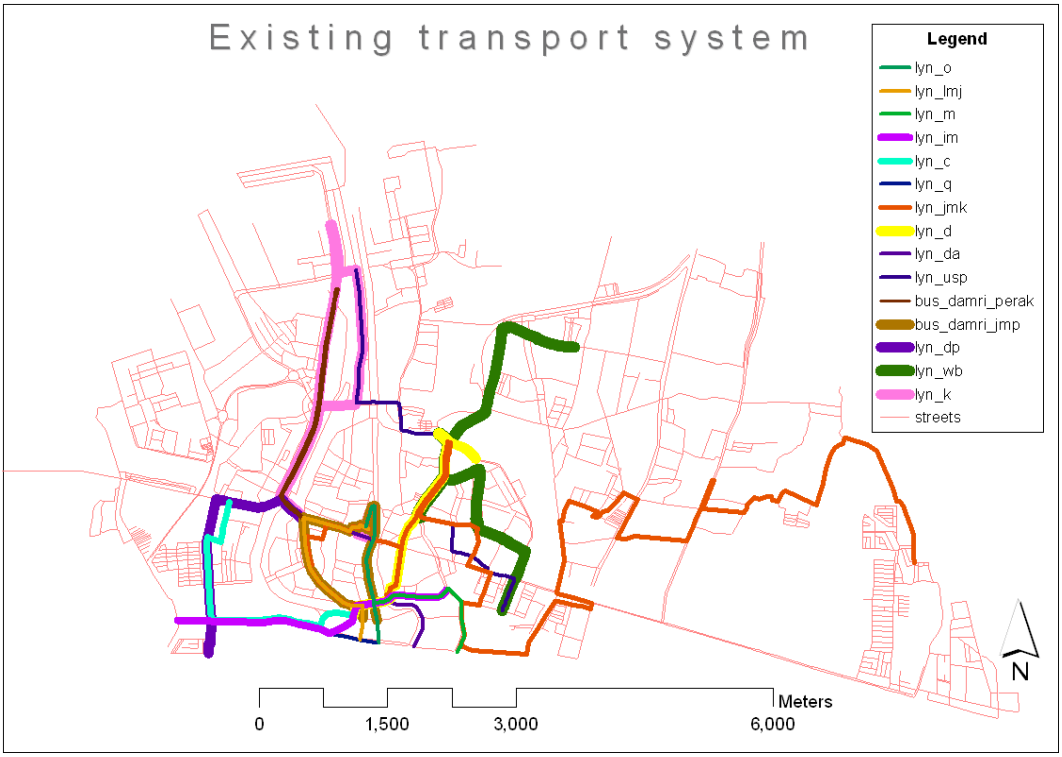



**Figure 5.22** The existing transportation system map

The numbers of buses that need to be provided in each route, then use for extending the existing transport media. Table 5.6 has been referenced with the existing transportation system in the section 4.2.6 and the number of bus fleets in the previous section. It shows the existing transportation media and the added school buses in 4 directions (green background). All transportation media have a number of fleets, a

capacity, and the number of secondary school students who use the media. In general, according to surveys that have been done simultaneously by surveying the existing transport media in section 4.2.6, the percentage of secondary school students who use these media in the morning is about 46%. The new provided school bus is especially applicable for the needy student within this age range. This means the percentage is 100%. This analyst is just derived by using the number of fleet in the morning. Fleets in the evening are omitted because they have a lot of fleets than in the morning. In other words, the students who can access transportation media in the morning can also access it in the evening, but not vice versa. Here, the new school bus is set with a 70 passenger capacity for the needy. This number is changeable to any number of bus capacities, but alterations will also make changes in the number of fleet referenced by the maximum number of passengers while the bus travels from the center depot to each destination, and the inverse routes mentioned in the previous section. The number of vehicles is summed from the number of fleets in the main direction and the inverse direction.

**Table 5.6.** Existing Transport System statistic plus new school bus routes

| Route Name | Capacity | Number of Vehicle passed | | % of sec. school age use | Total number of Seats |
|---|---|---|---|---|---|
| | | 05:00 - 07:00 | 12:00 - 15:00 | | |
| Bus Damri JMP | 50 | 18 | 56 | 46% | 414 |
| Bus Damri Perak | 50 | 27 | 26 | 46% | 621 |
| Lyn C | 10 | 18 | 60 | 46% | 82 |
| Lyn D | 10 | 25 | 76 | 46% | 115 |
| Lyn DA | 10 | 3 | 49 | 46% | 13 |
| Lyn DP | 10 | 23 | 48 | 46% | 105 |
| Lyn IM | 10 | 3 | 11 | 46% | 13 |
| Lyn JMK | 10 | 11 | 33 | 46% | 50 |
| Lyn K | 10 | 97 | 167 | 46% | 446 |
| Lyn LMJ | 10 | 32 | 41 | 46% | 147 |
| Lyn M | 10 | 10 | 50 | 46% | 46 |
| Lyn O | 10 | 34 | 78 | 46% | 156 |
| Lyn Q | 10 | 37 | 77 | 46% | 170 |
| Lyn USP | 10 | 51 | 106 | 46% | 234 |
| Lyn WB | 10 | 6 | 45 | 46% | 27 |
| School Bus North | 70 | 11 | 11 | 100% | 770 |
| School Bus East | 70 | 11 | 11 | 100% | 770 |
| School Bus South | 70 | 17 | 17 | 100% | 1190 |
| School Bus West | 70 | 13 | 13 | 100% | 910 |

The total number seats value then will be used as the value of the buffer area. Every buffer area then Sums one to another, with respect to the process model shown in Figure 4.44. There are two results that are notable: firstly, for the existing transport system, the sum is therefore ended with the last existing transport media in the above table (Lyn WB), and secondly the new transport system that continues with adding each bus route value. The result map is shown in Figures 5.23 and 5.24 below.

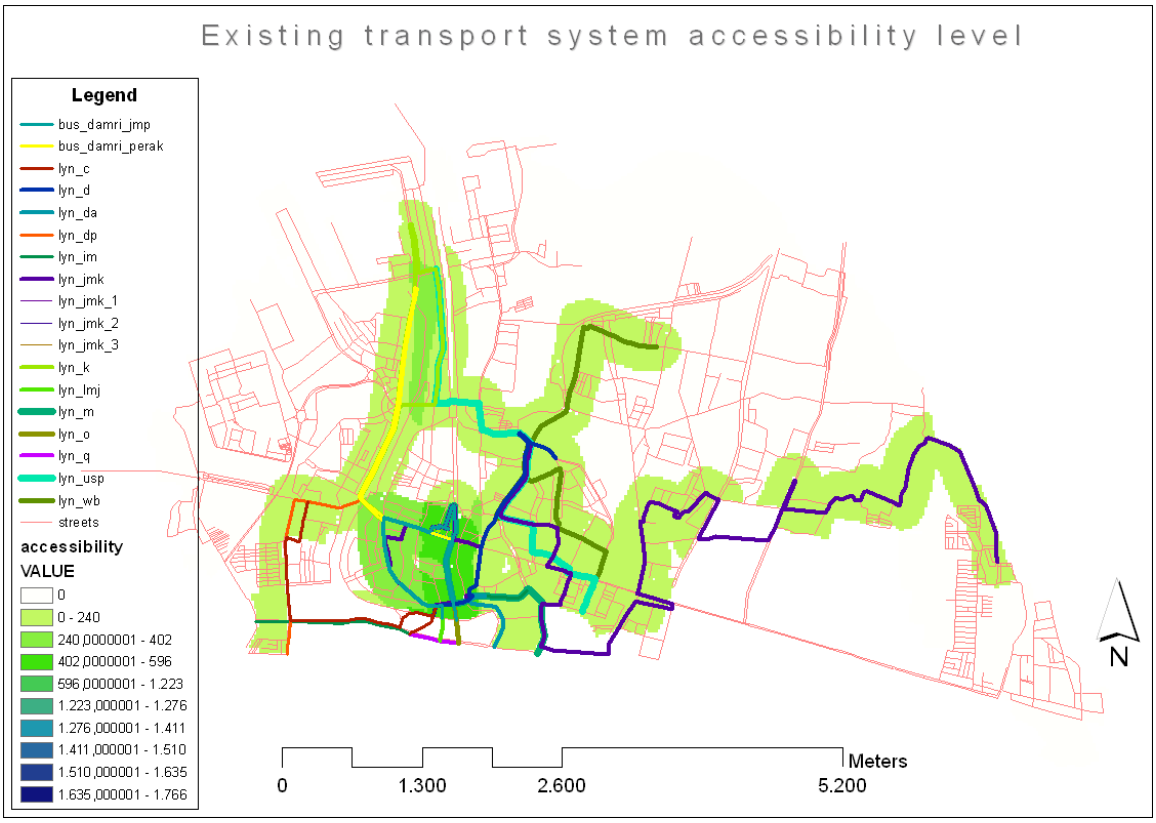



**Figure 5.23.** Accessibility map before school bus was added

The above figure shows the accessibility level in a gradation color of light green to dark blue to represent the range of accessibility levels from low to high respectively. From that figure it can be seen that most of region in the study area the one without color, does not have any accessibility to a transport system. The second position is the area with the lightest green accessibility level that spreads by the rare transportation route to west, east, north, and south. This area has an accessibility level which is not more than 240 points. It means that needy students who live in this area have an

opportunity to access seats in the transportation system up to as many as 240. The third and fourth position is the lightest shades of green respectively that lay in a small part in the north and center areas.

The next process is to make an accessibility map similar to the previous figure but after school buses have been added to the transportation system. The model for this process is similar to the model presented in Figure 5.23, but with 4 more entities for west, east, north and south routes. Using the same legend as the above map, the accessibility map with the added school bus is shown in Figure 5.24 below.

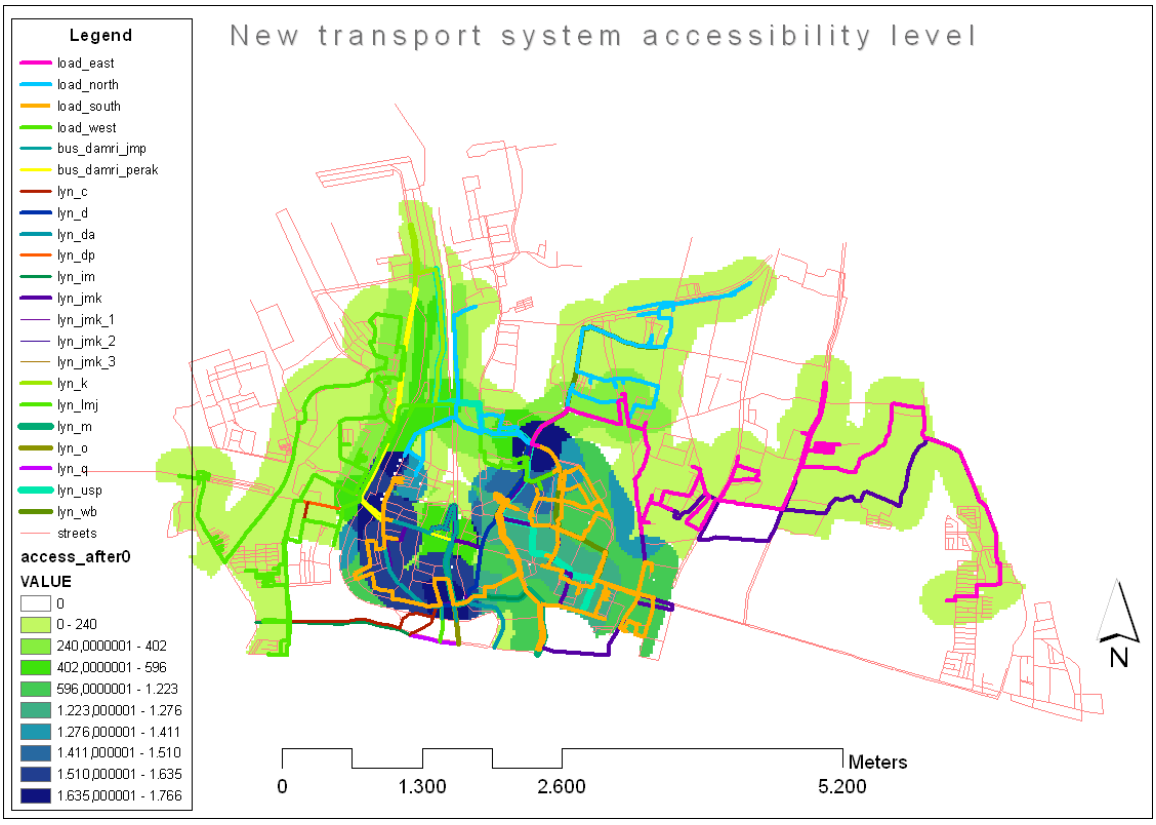



**Figure 5.24**. Accessibility map after school bus was added

Figure 5.24 above presents the accessibility level by a coloring and grouping legend. By comparing the two previous figures, it can be concluded the accessibility area has become wider because the white area is narrower. Some areas have increased their accessibility levels. A region with a high accessibility level area is wider in the center area. Before the additional school bus, the maximum level is about 1223 points

which has been presented in green color. Now, after the additional bus, the maximum level is 1766 which is presented in dark blue color. In this dark blue area, the needy student has an opportunity to access the transportation fleet with about 1766 seats in the morning from 05:00 AM to 07:00 AM. This occurs as a result of combining existing transportation fleet with the school bus fleet.

After obtaining the accessibility map, the analyst continues to see the opposite view which is the uncovered area. IT will discover how many needy are eliminated from the uncovered area after the transport system was added with school buses. The accessibility map of the existing transport system is used as an input for finding the uncovered needy process model in Figure 4.45. Output of this process is shown in figure 5.25 below.

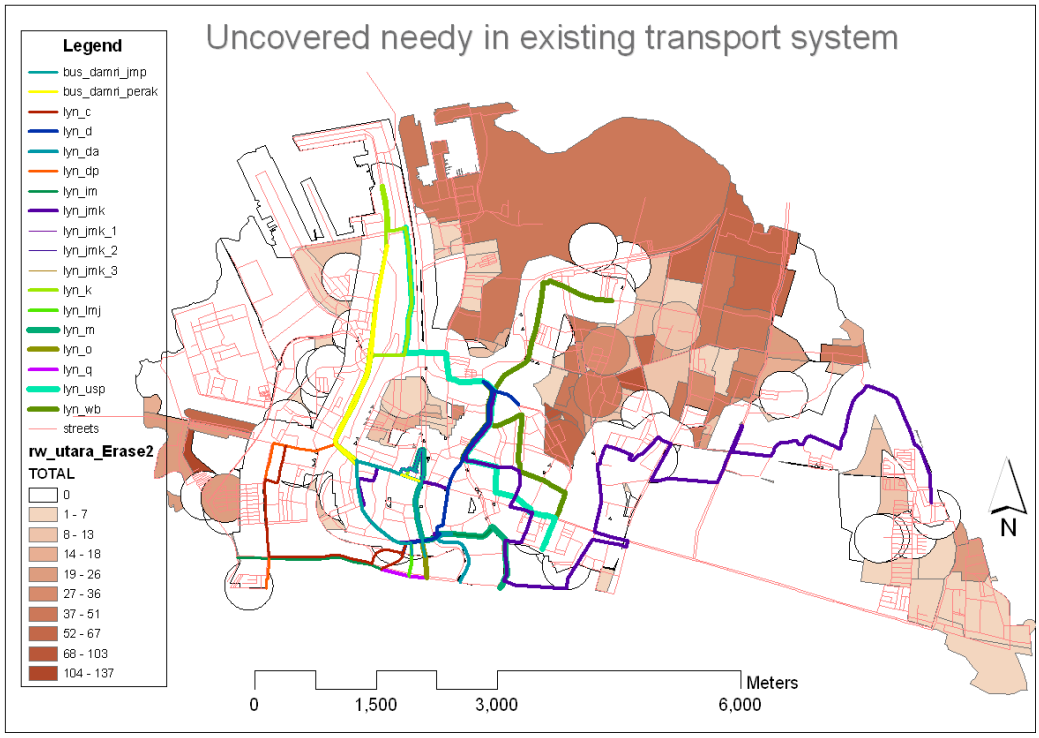



**Figure 5.25.** Uncovered needy in existing transport system

Following the same process, the accessibility map after the additional school bus has been added, will be used as input to get the uncovered needy number for the new transportation system. Figure 5.26 shows this map.

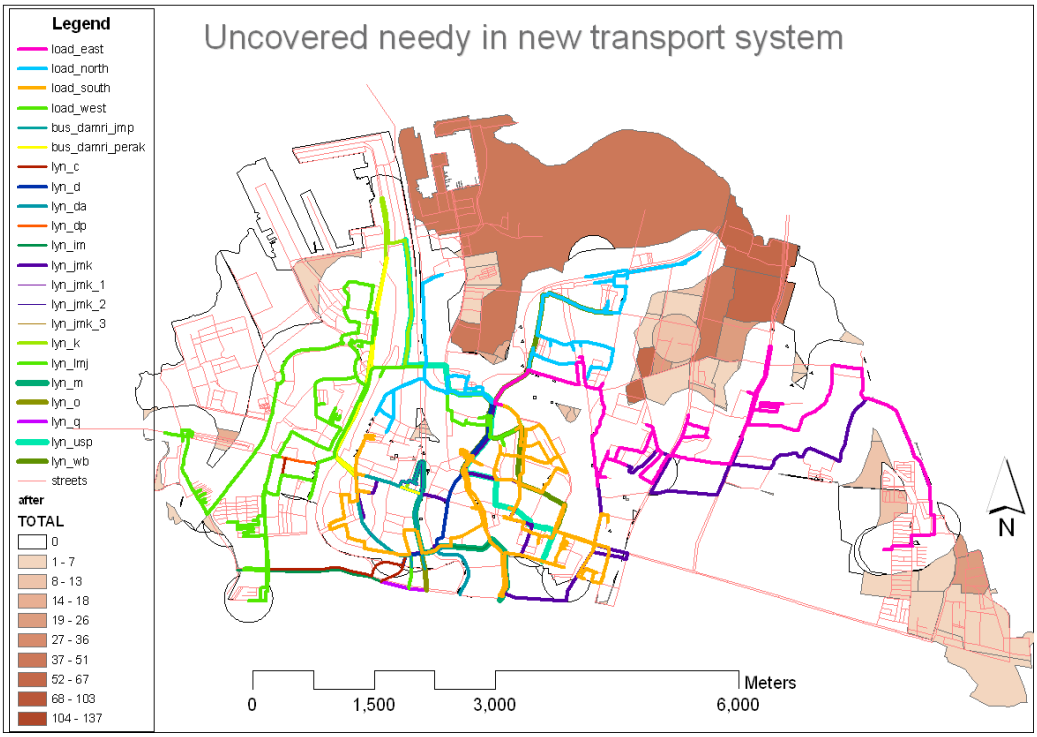



**Figure 5.26.** Uncovered needy in new transport system

Two figures above have a block map with color similar to the covered needy map shown in the previous chapter. The difference is that in those maps the gradation color resides in the area that is far from the street which is used for the transportation route. The second map has more streets that are included in the transportation route so the uncovered area is narrower. By calculating the total needy in the remaining area after cut with the accessibility map, it is found that in the existing transportation system, the needy number who cannot reach the transport media is 2251 and, after added with school buses, shrinks to 724 needy children.

## 5.8 Summary

This chapter has shown the result of the processes that have been explained in the methodology chapter. By ending this chapter, this research has completed the VRP process and continued with the result of analysis process. This chapter began with the result of undirected Orders design output, and continued with two kinds of directed Order design. In each result of different route design and setting is equipped with the value of assessment process. After comparing this assessment value, the most optimal route was then chosen. The chosen route then detailed the way to discover the characteristics of each route destination. After that, this chapter showed how to enhance the output of VRP process with another geospatial technology. The first enhancement was to predict the load of passengers in each route destination. This enhancement then continued this prediction with a calculation of the number of buses that are needed to run in each route. The second enhancement was to predict the accessibility level of transportation after a number of buses were added into the transportation system. Finally, by looking for the opposite area of the accessibility area, the uncovered area was then discovered.