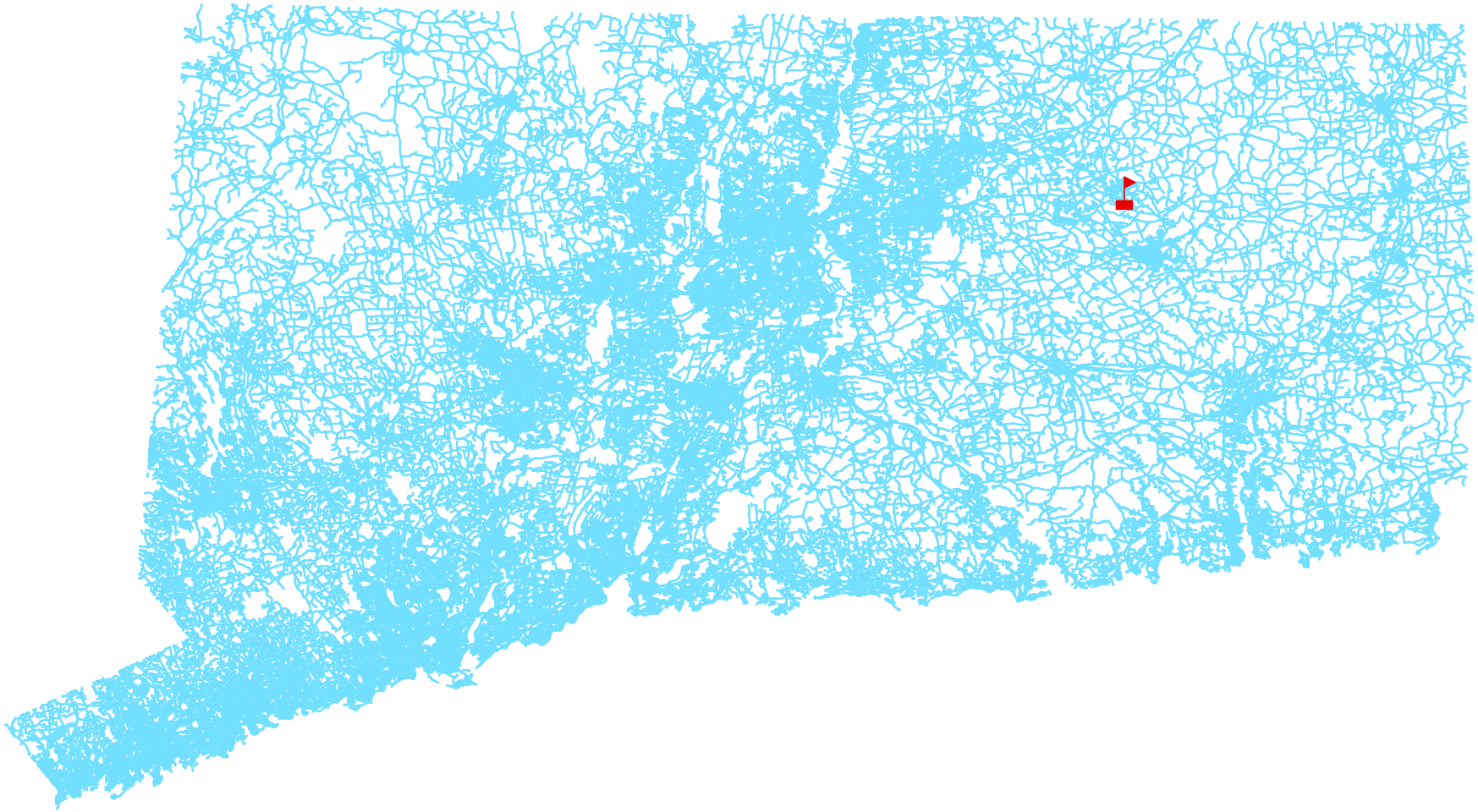
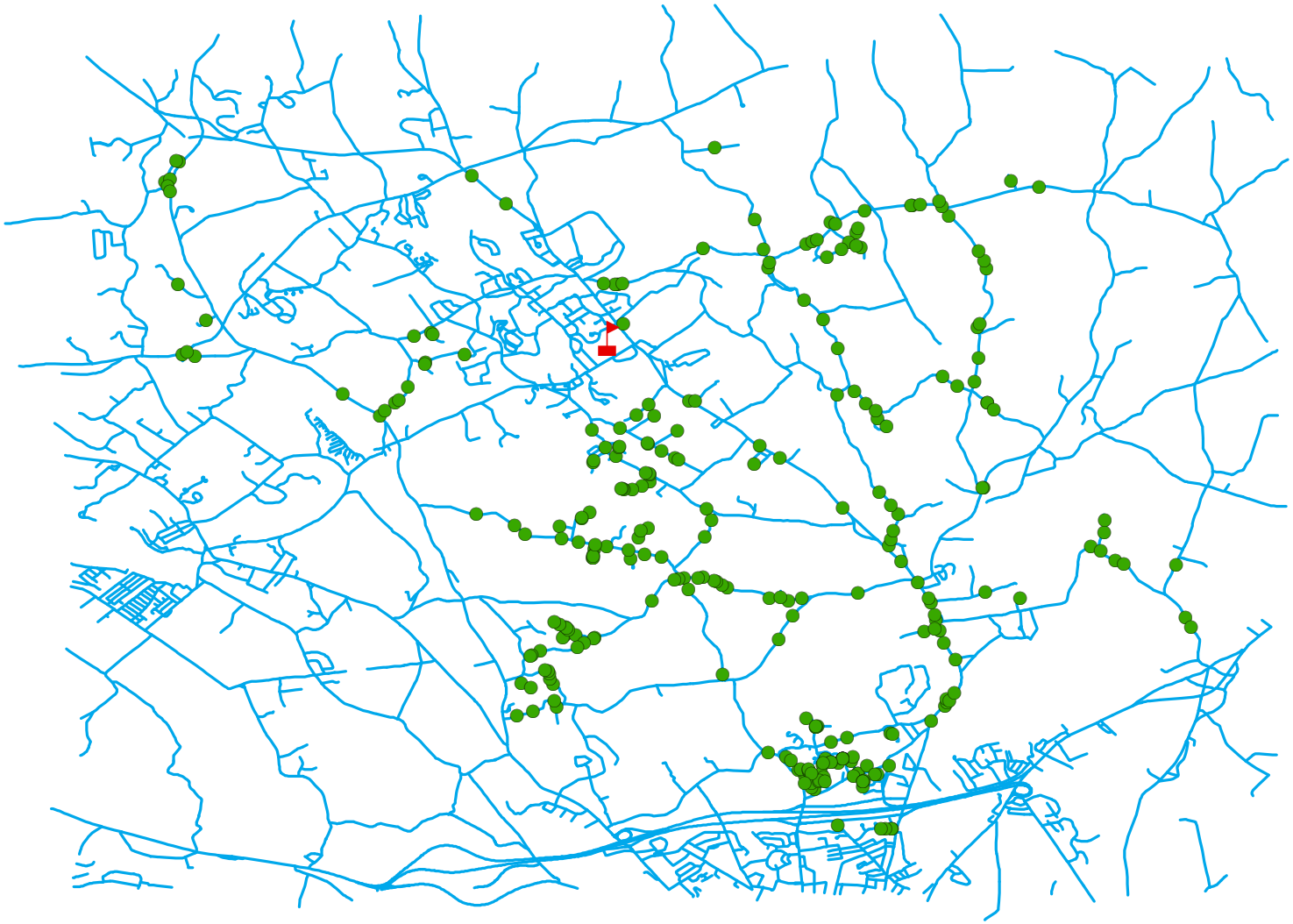
Adrita Islam
Question 1

School Location



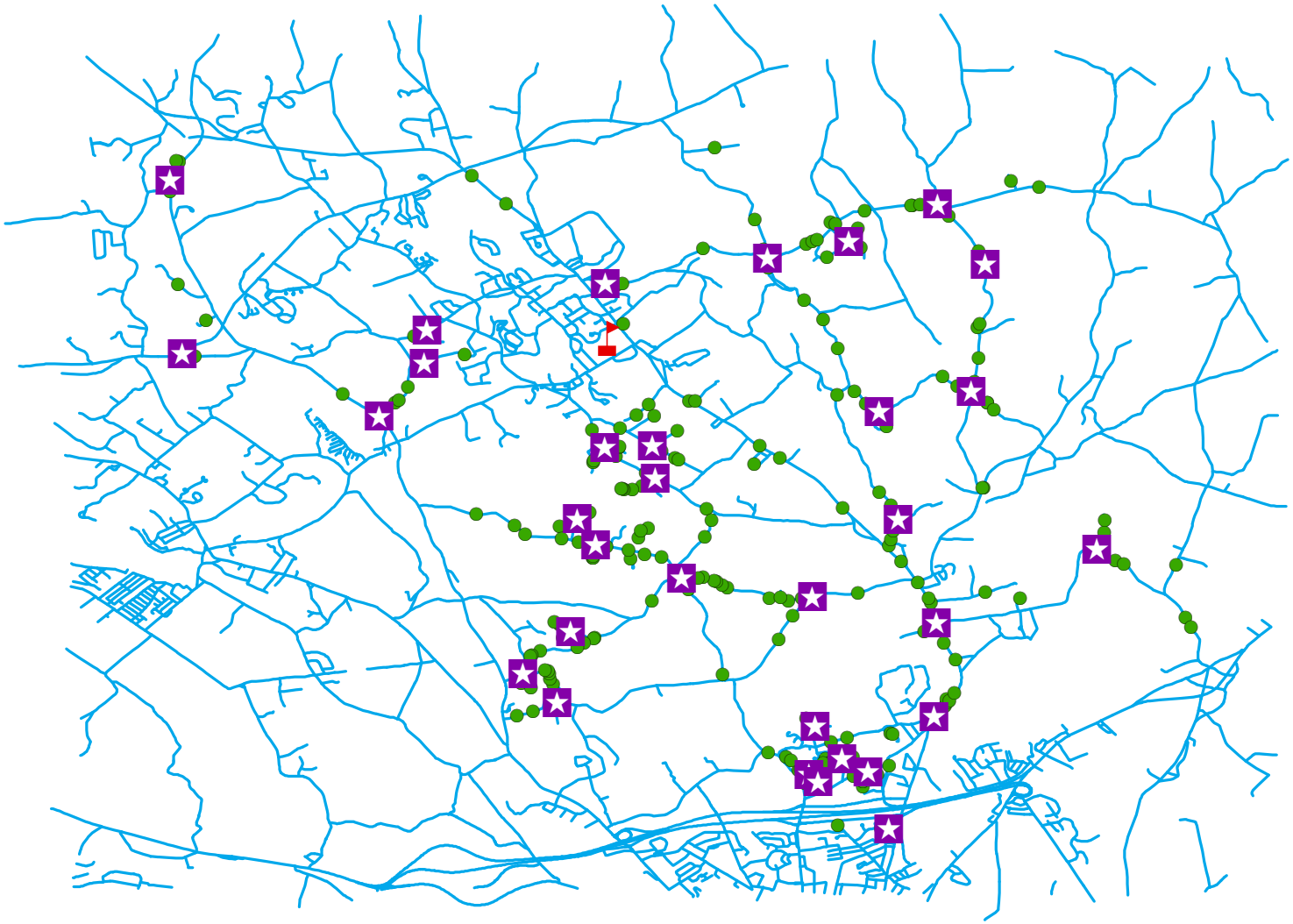
Adrita Islam
Question 2

Student Locations



Adrita Islam
Question 3

Bus Stops



Legend

- School
- Bus_Stops
- Student_Location
- Mansfield_Streets

0 0.5 1 2 Miles

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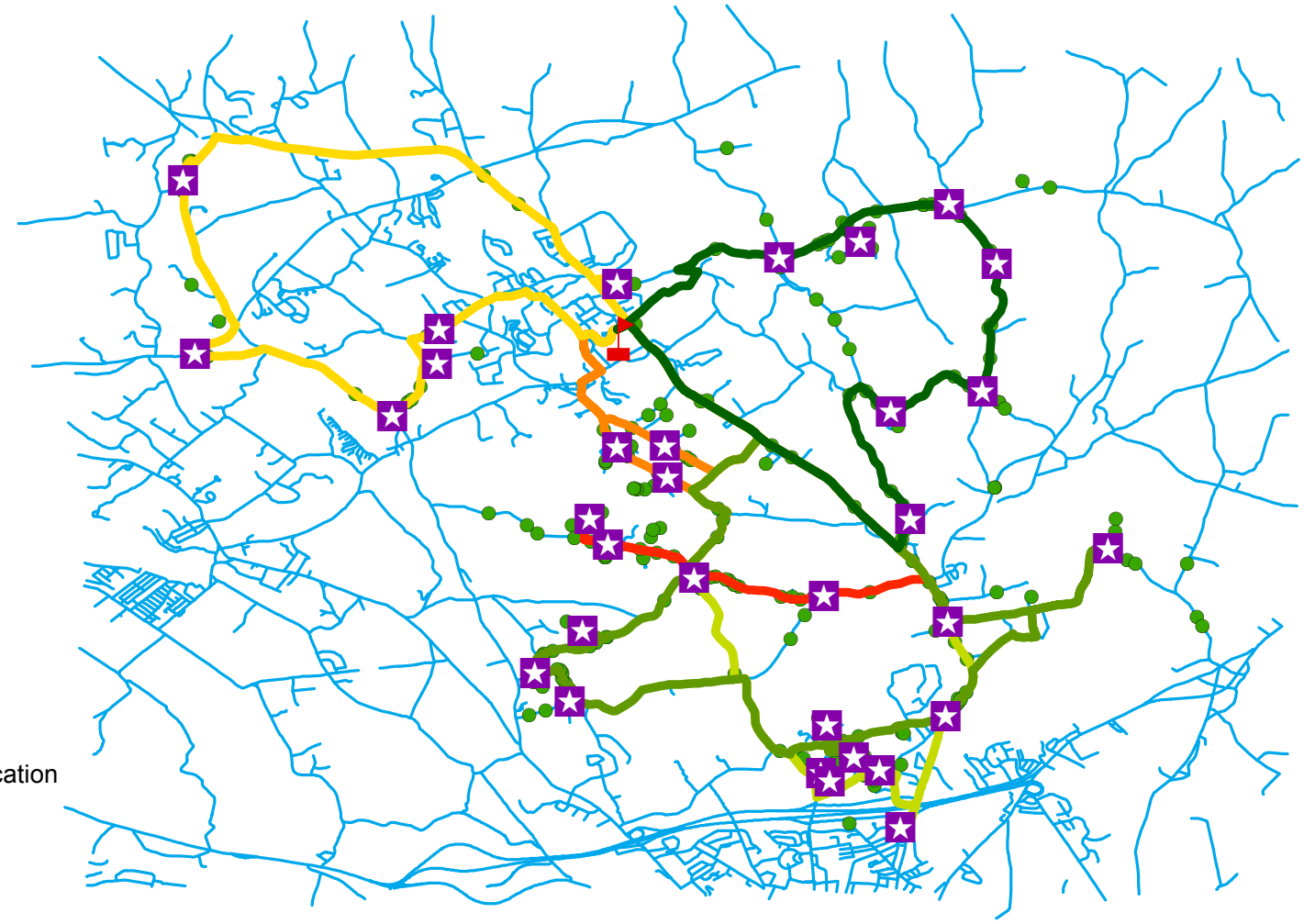
Question 4

New Bus Route



Legend

- School
- Student_Location
- Bus_Stops

Name

- Route 1
- Route 2
- Route 3
- Route 4
- Route 5
- Route 6

0 0.5 1 2 Miles

Routes Details

Route	Stops	Student Picked Up	Route
Route 1	9	6	57
	10	17	
	15	14	
	18	8	
	28	12	
Route 2	11	17	40
	13	12	
	14	11	
Route 3	1	9	46
	2	6	
	3	10	
	4	8	
	5	5	
	12	8	
Route 4	17	14	50
	20	8	
	23	13	
	25	8	
	27	7	
Route 5	6	9	50
	7	5	
	8	12	
	19	7	
	21	11	
	32	6	
Route 6	16	7	50
	22	11	
	24	7	
	26	8	
	29	6	
	30	7	
	31	4	
		Total Students =	293

Final Problem

INTRODUCTION

E.O. Wilson High School - Mansfield, CT Regional High School wishes to find a new bus route to cover the town of Mansfield. The school previously had 8 buses serving specific individual towns in Mansfield, CT. These routes were town specific. They were not necessarily optimized.

A problem was formulated using ArcGIS and solved to find the optimum number of routes and optimum bus stop locations. Each bus has a capacity of 50 students and total number of students is 293. So it is mandatory to have at least 6 buses to serve all the students.

This report contains the procedure of new proposed bus integrated routes for the school that has been optimized using AcrGIS and a set of recommendations.

MODELS EMPLOYED

The complete task included three major steps that used thee major models:

Tasks	Models employed
Geocoding the address of all students and the school	Geocode services- Locator tool
Find optimum bus stop location	Network Analyst: Location-Allocation
Find optimum bus routes	Network Analyst: Vehicle Routing Problem

Geocoding: Locator

The locator tool in geocoding is used in order to locate all the students' addresses. First a .csv file was produced form the word file containing student and bus information. Then using the locator tool in ArcGIS online and the results were downloaded in a shapefile. After adding the shapefile to ArcGIS, the aforementioned task was completed.

Network Analyst: Location-Allocation

Network analysis is one of the major approaches to the study of transportation geography. Location allocation is a powerful network analysis tool in ArcGIS. With a set of facility and demand points, this tool locates the facilities in a way that supplies the demand points most efficiently. It simultaneously locates facilities and allocates demand points to the facilities.

To solve location allocation, first a network dataset was created. In this problem, the facilities are all the nodes of CT streets. The demand points are the students' locations. After assigning the facilities and demand points, the model was run for the following properties:

- Travel from: Demand to Facility
- U-turn junctions: Allowed only at intersections or dead ends
- Restrictions: One-way
- Problem Type: Maximize Attendance
- Facilities to choose: 32
- Impedance cutoff: 500 meters

The solution gives ***32 optimized bus stops*** that maximizes attendance (all student location selected).

Network Analyst: Vehicle Routing Problem

Using the vehicle routing algorithm in ArcGIS, it is possible to identify an optimal or best way of performing transport related problem. The primary goal in VRP is to best service the orders and minimize the overall operating cost for the fleet of vehicles.

To solve vehicle routing, two new columns were created that contained segment length and time required to cross it. Speed was used from the given data. In this problem, the orders are the 32 bus stops that were generated from location allocation. The orders were assigned a pickup load equal to as many students chose that bus stops. The depot is the school. 8 routes were created in the beginning keeping in sync with the previous bus service that was available. The maximum capacity was fixed to 50 students. The maximum number of bus stops was restricted to 10 stops.

The solutions gave us ***6 optimized bus routes*** that will pick up less than 50 students.

MODEL STRENGTH & WEAKNESS

The strength for both the network analyst problems it that they solve the problem very quickly and easily. These have been standard practice for optimizing routes worldwide. The location allocation has various options that enable the bus stop location to be chosen with maximum students attending with an impedance cutoff. They can also be used for different allocation problems as well. The VRP produces a solution that honors practical time, capacity and distance constraints while minimizing an objective function composed of operating costs and user preferences, such as the importance of meeting time windows.

The weakness of these models are that they don't give the exact solution. They use heuristics and metaheuristics to provide a near optimal solution. This is because the solution space is huge. For our problem of 293 students choosing 32 stops, there is over 5.7e+42 solutions possible. It is impossible for any software to consider all the combinations. Instead, ArcGIS generates a set of semirandomized solutions and applies a vertex substitution heuristic (Teitz and Bart) to refine these solutions creating a group of good solutions. A metaheuristic then combines this group of good solutions to create better solutions. The VRP solver on the other hand starts from an initial solution. The heuristics used are based on tabu search metaheuristics. For example, in our problem, due to the cluster of student location in a few places, a lot of bus stops were provided in one place that are close to each other. Whereas some students home was too far away. So the models may not yield the best possible solution, but they are near optimal and are best practice for the task.

OTHER CONSIDERATIONS

Vehicle routing problem can take into account many other attributes. If enough information is give, the following things can also be taken into consideration:

- Service start time & Service end time: to enforce time constraints
- Time required for each student to board: to enforce time constraints
- Driver number and wage
- Vehicle gas usage: to restrict distance coverage
- Information about children requiring wheelchair assistance

RECOMMENDATIONS

For the E.O. Wilson High School, it is more appropriate to study the use an integrated system instead of town specific one.

My professional recommendation for the School authority is:

- An integrated bus system should be used
- The bus routes and stops attached to this report is optimized and should be implemented instead of the old one.
- The optimized routes can operate only with 6 buses instead of 8, which saves a lot of school and government resources.
- The optimized routes restrict unnecessary tours and thus is more environment friendly.
- More information can be gathered to even optimize the problem further.

Reference:

1. Edward J. Taaffe, Howard L. Gauthier, Morton E. O'kelly, *Geography of transportation*, 1996
2. Location-allocation analysis, ArcGIS desktop, http://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/location-allocation.htm
3. Algorithms used by the ArcGIS Network Analyst extension, ArcGIS desktop, http://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/algorithms-used-by-network-analyst.htm
4. Vehicle routing problem analysis, ArcGIS desktop, http://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/vehicle-routing-problem.htm