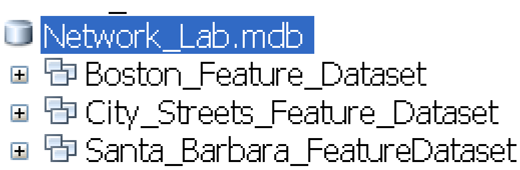
Network Analysis

Download and unzip the lab5 data from http://dverbyla.net/nrm435/data/
The unzipped geodatabase container will contain the following feature datasets:



The geodatabase contains three feature datasets, each with a line theme. The feature datasets are from different areas and are in different coordinate systems. All X,Y coordinates are in meters.

A network is a system of connected arcs. You will use a typical street network in today's lab. Networks in natural resource management might be mushing networks, hiking trail networks, logging system networks, etc.

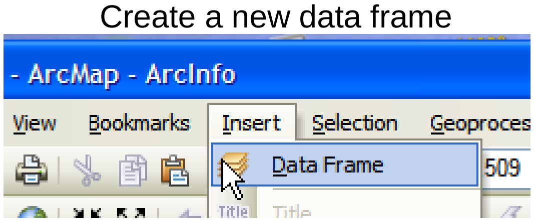
There are several types of network analyses:

- ***optimal routing***,
- ***finding closest facilities*** to an event location
- ***allocation of resources***, or ***service network*** areas.
- ***origin-destination matrix***
- ***source/destination allocation***

Optimal Paths in ArcGIS

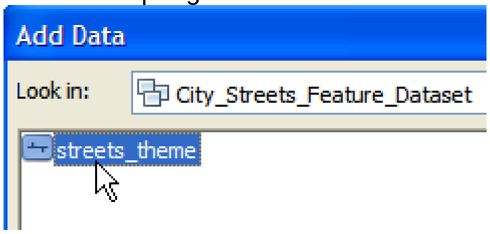
An optimal path may be the shortest path, the quickest route, or the least-cost route in terms of some user-specified attribute. We will determine the shortest route and the quickest route between two locations in a street network.

Create a new data frame



and name it Optimal Paths.

Add your ***streets_theme*** from the City_Streets Feature Dataset to this data frame.



Each line has an attribute representing the speed limit of the line in miles per hour and the length of each line in ***meters***…

SPEED	Shape_Length
30	6.316528
30	92.884466
45	6.739534
30	92.18086
30	73.885364
30	36.59088

Add new double precision fields for length in miles and speed in hours.

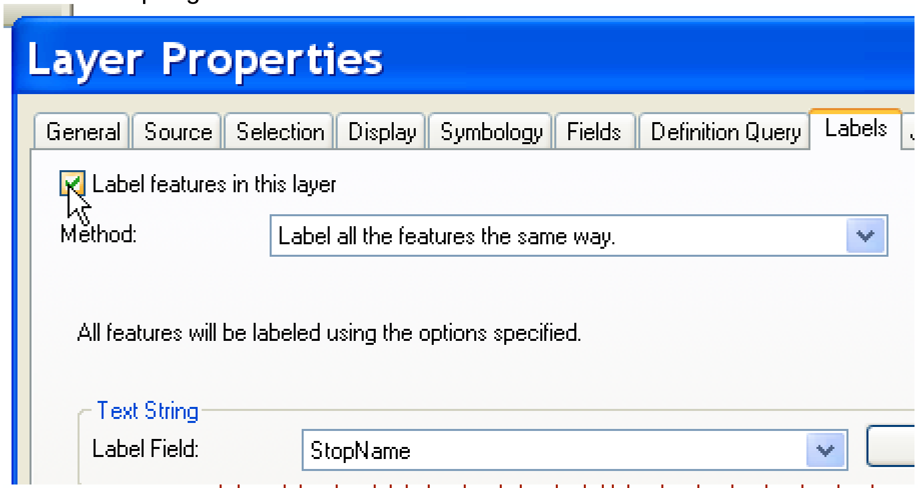
SPEE	Shape_Length	Miles	Hours
30	6.316528	<Null>	<Null>
30	92.884466	<Null>	<Null>
45	6.739534	<Null>	<Null>
30	92.18086	<Null>	<Null>

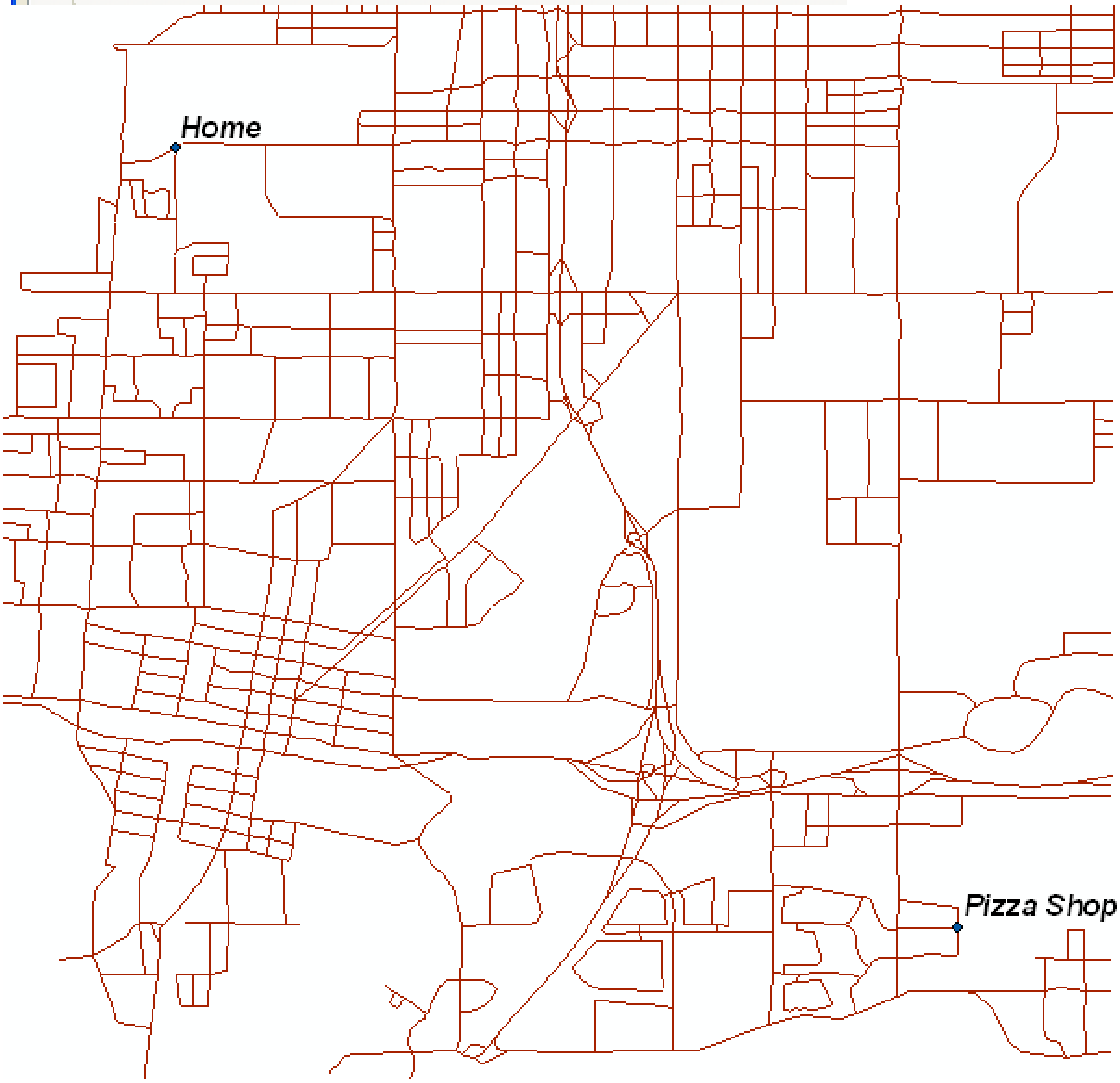
Compute your length of ***miles*** and (assuming the maximum speed limit) ***hours*** for each line. There are 3.281 feet in a meter and 5280 feet in a mile.

SPEED	Shape_Length	Miles	Hours
30	6.316528	0.003925	0.000131
30	92.884466	0.057719	0.001924
45	6.739534	0.004188	0.000093

Since the attribute SPEED is the speed limit in miles per hour, the time to drive each line is calculated as ***hours*** = miles / speed

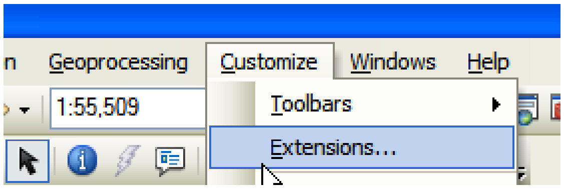
We want to find the shortest and quickest path from two locations (home and pizza shop), so add the point feature class named stops to your data frame. Use the layer properties to label each point using the text field…

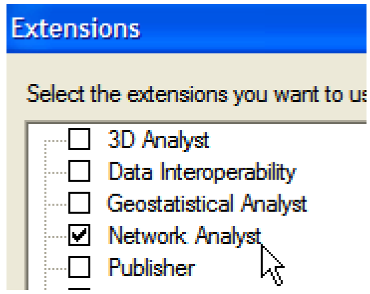




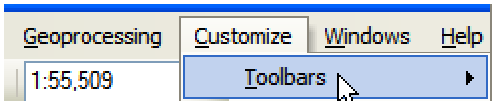
Next determine optimal path in terms of minimum driving distance.

First load the Network Analyst extension.



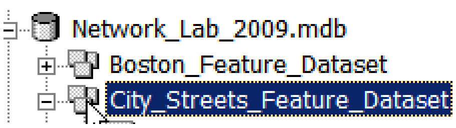


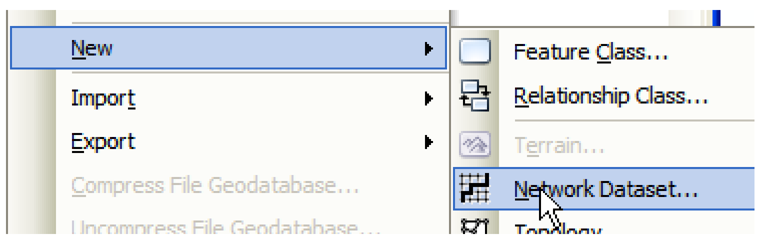
Then add the toolbar for that extension…



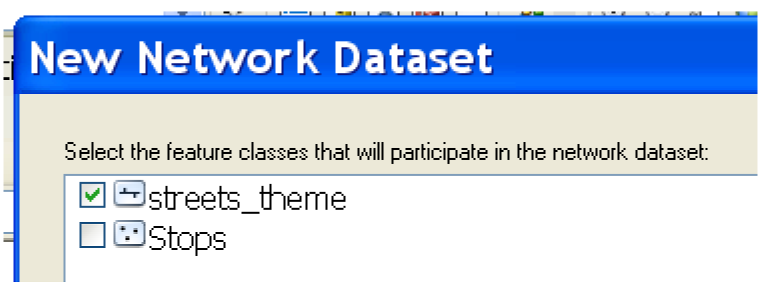
Save your Arcmap document.

Use your Arcmap Catalog window to create a network of streets from your streets line theme…

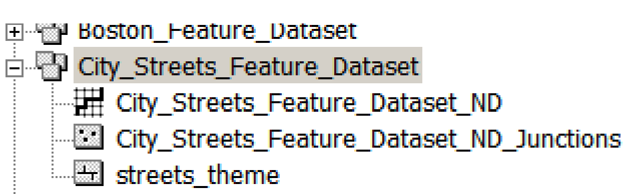




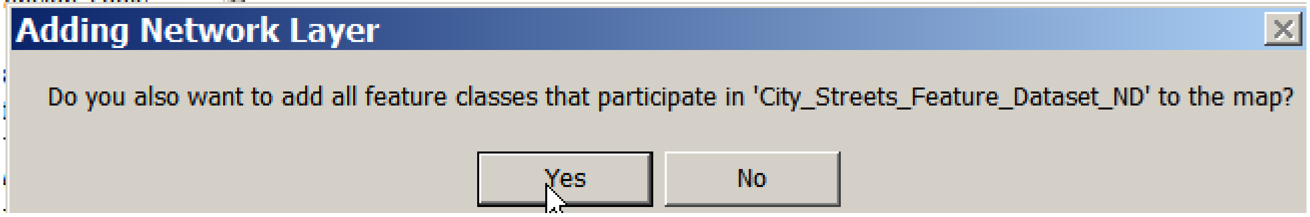
If the Network Dataset choice is disabled, it is probably because you have not loaded the Network Analyst extension



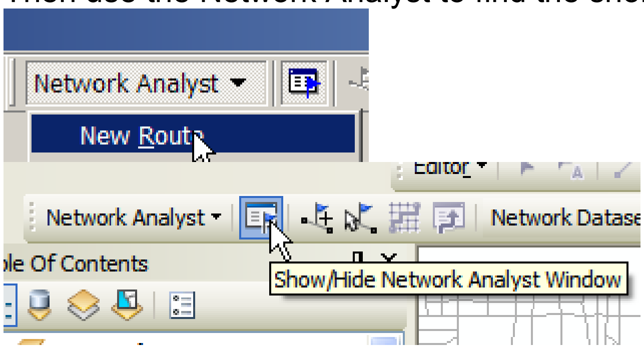
Take the defaults when building your network. The output will be a network dataset and junctions in your feature dataset:



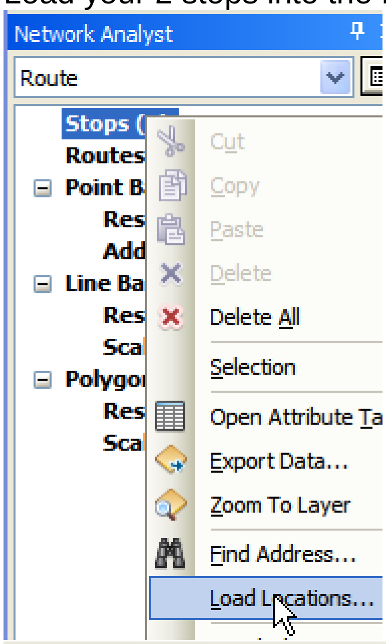
Add your network dataset to your data frame.

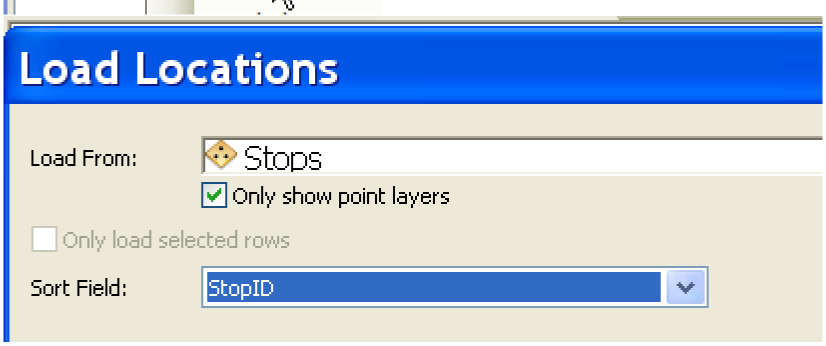


Then use the Network Analyst to find the shortest route….



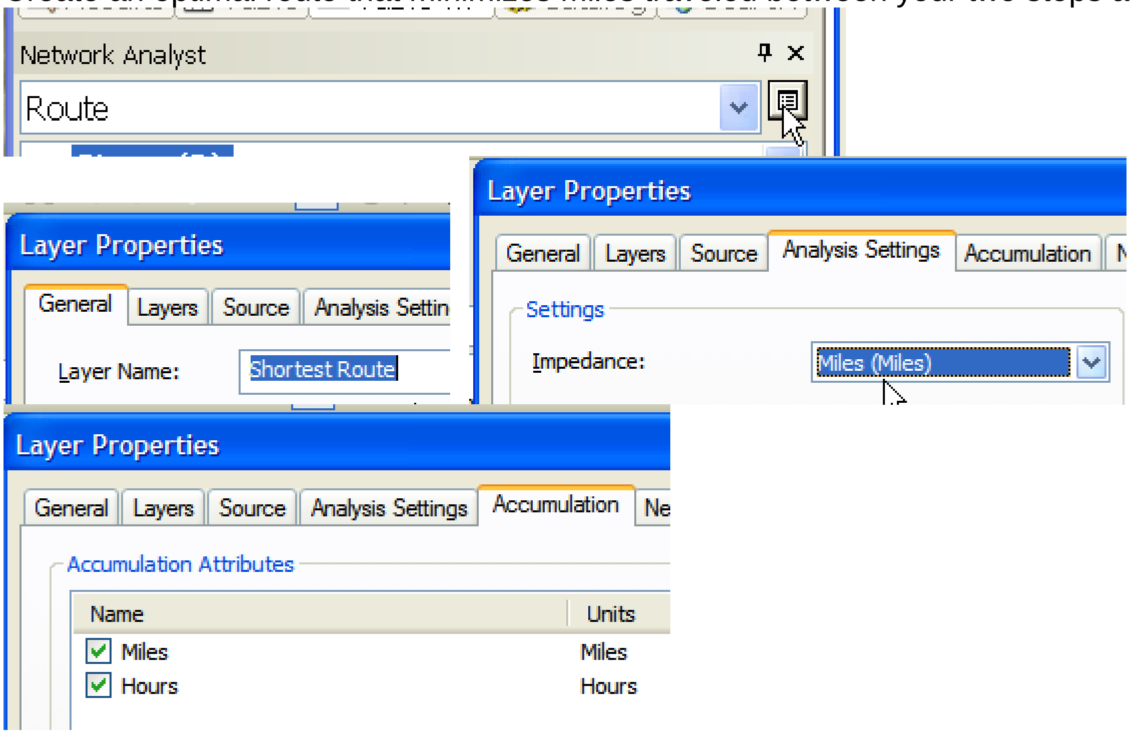
Load your 2 stops into the Network Analyst window..



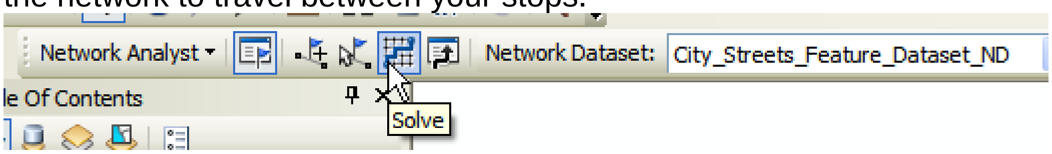


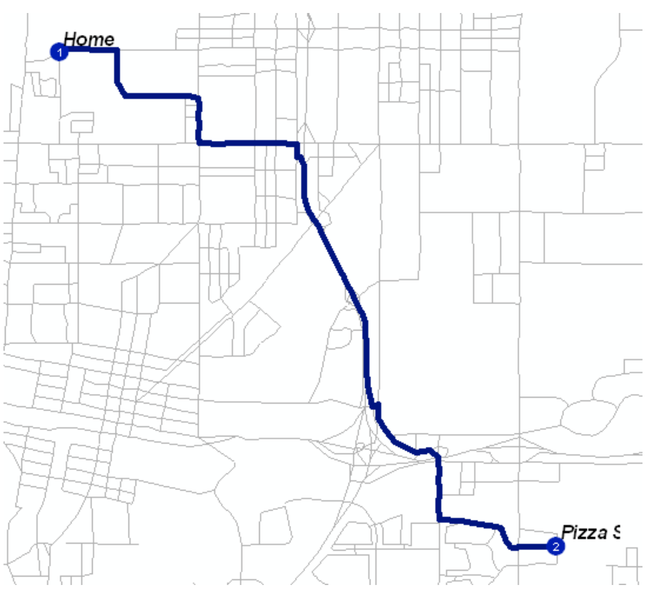
Sort by StopID, so we start at home as our first stop…

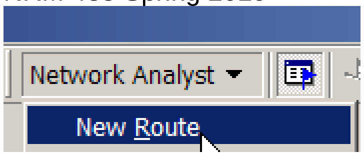
Create an optimal route that minimizes miles traveled between your two stops along the network…



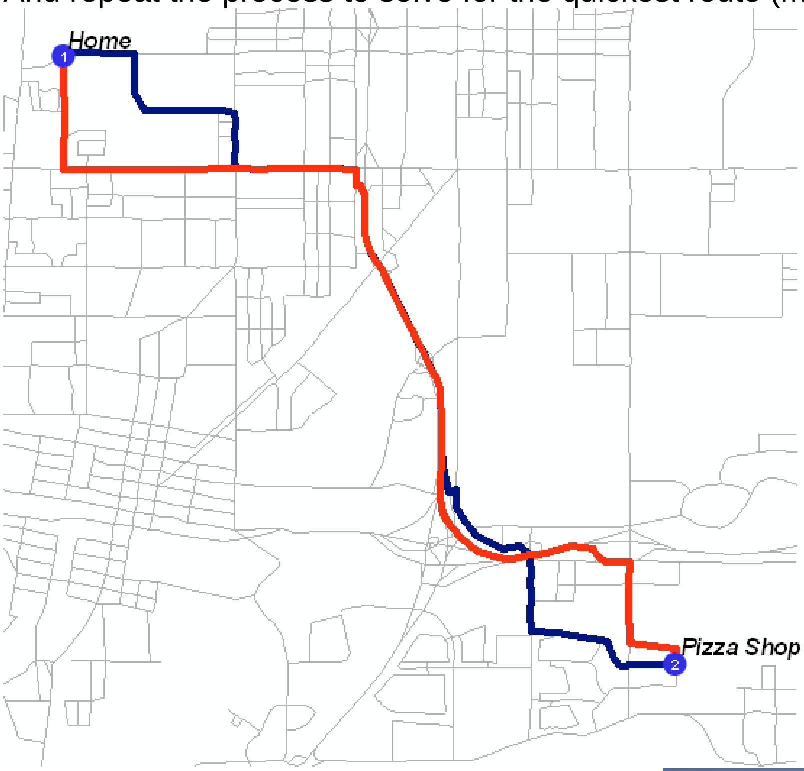
After setting your optimal route layer properties, solve the problem to minimize miles traveled along the network to travel between your stops.



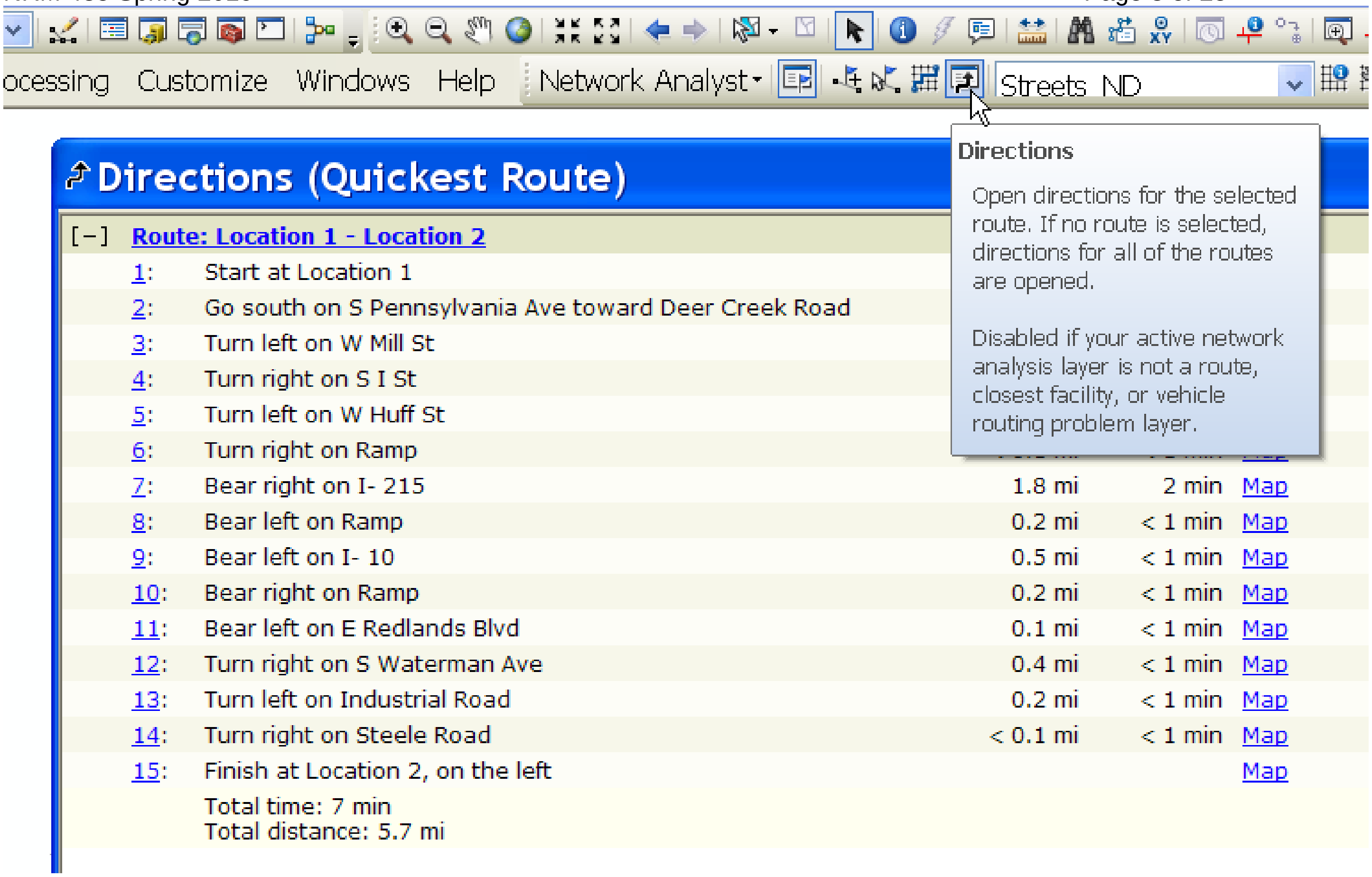




And repeat the process to solve for the quickest route (minimum driving time)

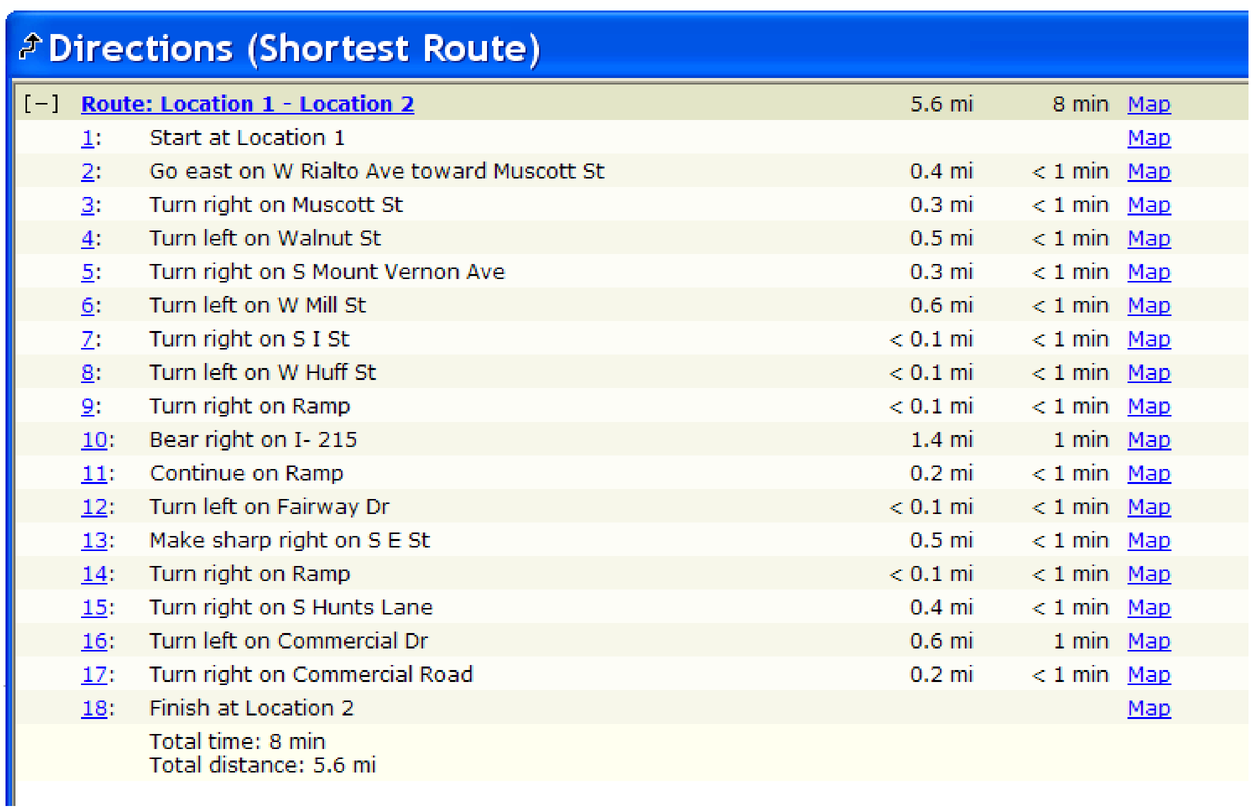


Use the Directions Window to get directions….



Directions (Quickest Route)

[−]	Route: Location 1 - Location 2			
1:	Start at Location 1			
2:	Go south on S Pennsylvania Ave toward Deer Creek Road			
3:	Turn left on W Mill St			
4:	Turn right on S I St			
5:	Turn left on W Huff St			
6:	Turn right on Ramp			
7:	Bear right on I- 215	1.8 mi	2 min	Map
8:	Bear left on Ramp	0.2 mi	< 1 min	Map
9:	Bear left on I- 10	0.5 mi	< 1 min	Map
10:	Bear right on Ramp	0.2 mi	< 1 min	Map
11:	Bear left on E Redlands Blvd	0.1 mi	< 1 min	Map
12:	Turn right on S Waterman Ave	0.4 mi	< 1 min	Map
13:	Turn left on Industrial Road	0.2 mi	< 1 min	Map
14:	Turn right on Steele Road	< 0.1 mi	< 1 min	Map
15:	Finish at Location 2, on the left			Map
	Total time: 7 min Total distance: 5.7 mi			

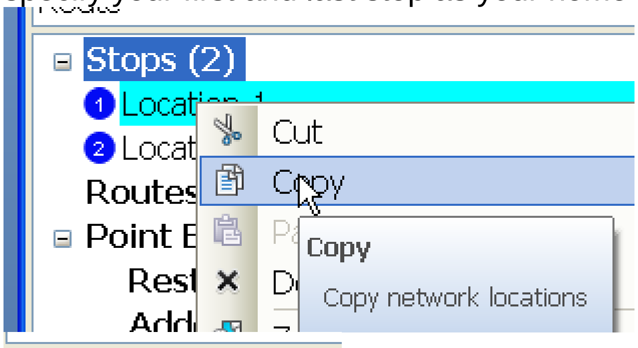


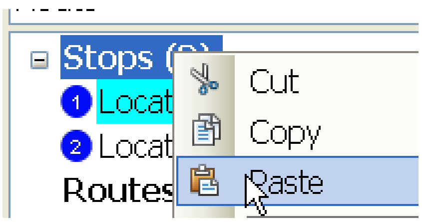
Directions (Shortest Route)

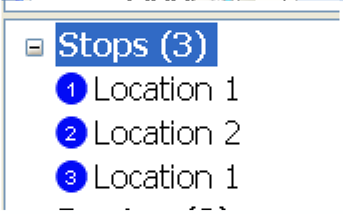
[−]	Route: Location 1 - Location 2	5.6 mi	8 min	Map
1:	Start at Location 1			Map
2:	Go east on W Rialto Ave toward Muscott St	0.4 mi	< 1 min	Map
3:	Turn right on Muscott St	0.3 mi	< 1 min	Map
4:	Turn left on Walnut St	0.5 mi	< 1 min	Map
5:	Turn right on S Mount Vernon Ave	0.3 mi	< 1 min	Map
6:	Turn left on W Mill St	0.6 mi	< 1 min	Map
7:	Turn right on S I St	< 0.1 mi	< 1 min	Map
8:	Turn left on W Huff St	< 0.1 mi	< 1 min	Map
9:	Turn right on Ramp	< 0.1 mi	< 1 min	Map
10:	Bear right on I- 215	1.4 mi	1 min	Map
11:	Continue on Ramp	0.2 mi	< 1 min	Map
12:	Turn left on Fairway Dr	< 0.1 mi	< 1 min	Map
13:	Make sharp right on S E St	0.5 mi	< 1 min	Map
14:	Turn right on Ramp	< 0.1 mi	< 1 min	Map
15:	Turn right on S Hunts Lane	0.4 mi	< 1 min	Map
16:	Turn left on Commercial Dr	0.6 mi	1 min	Map
17:	Turn right on Commercial Road	0.2 mi	< 1 min	Map
18:	Finish at Location 2			Map
	Total time: 8 min Total distance: 5.6 mi			

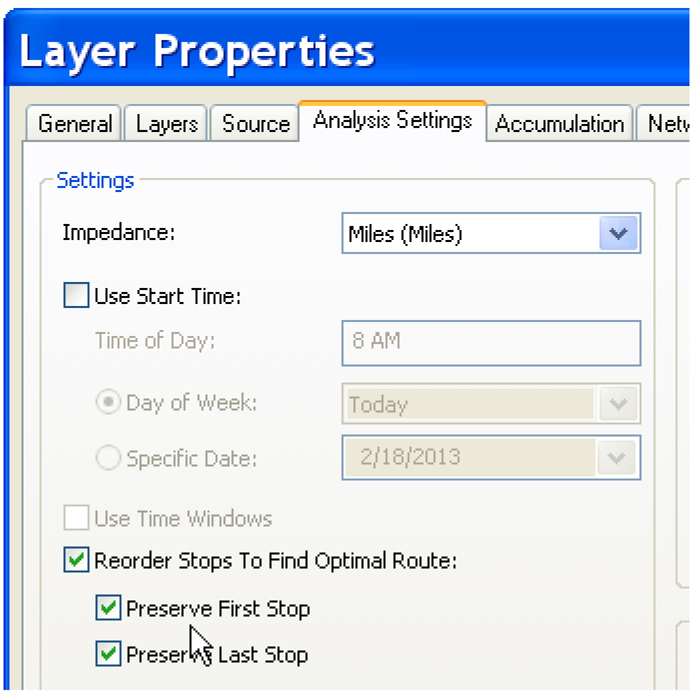
So the quickest route is 7 minutes of driving time (5.7miles), the shortest route is 8 minutes of driving time (5.6 miles)

Delete your routes..this time we want the shortest route, including driving back home. Easy..simply specify your first and last stop as your home location..

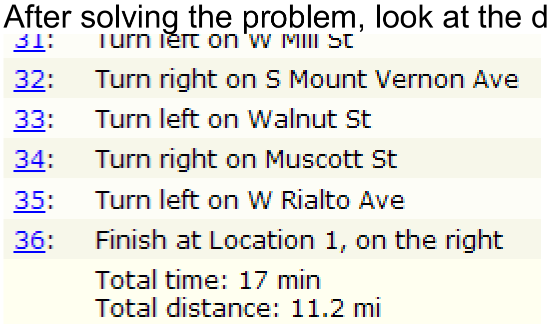








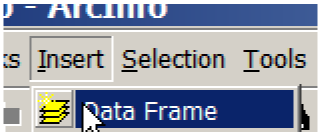
After solving the problem, look at the driving directions…



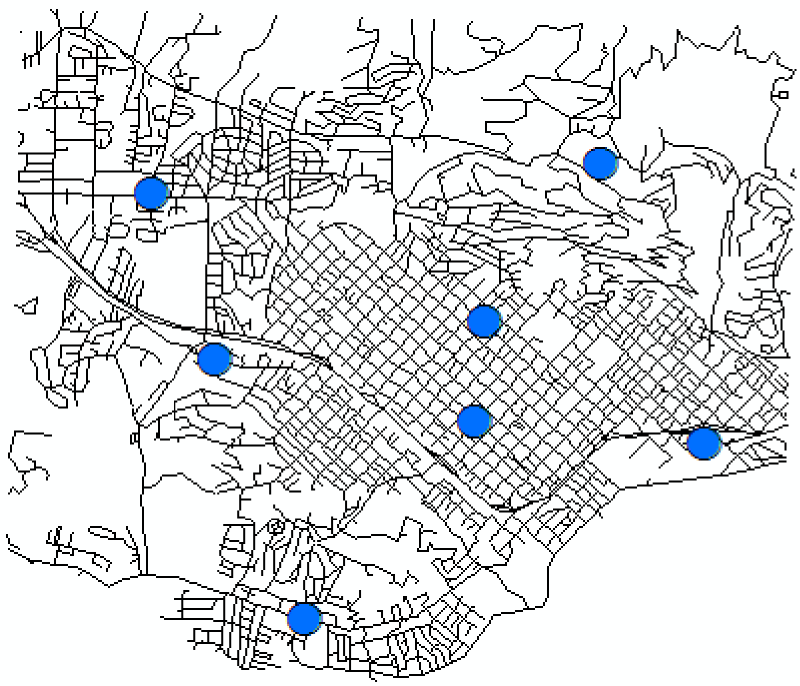
so this route is 11.2 miles since we are driving from home to get a pizza, then driving back home

.Finding Closest Facilities

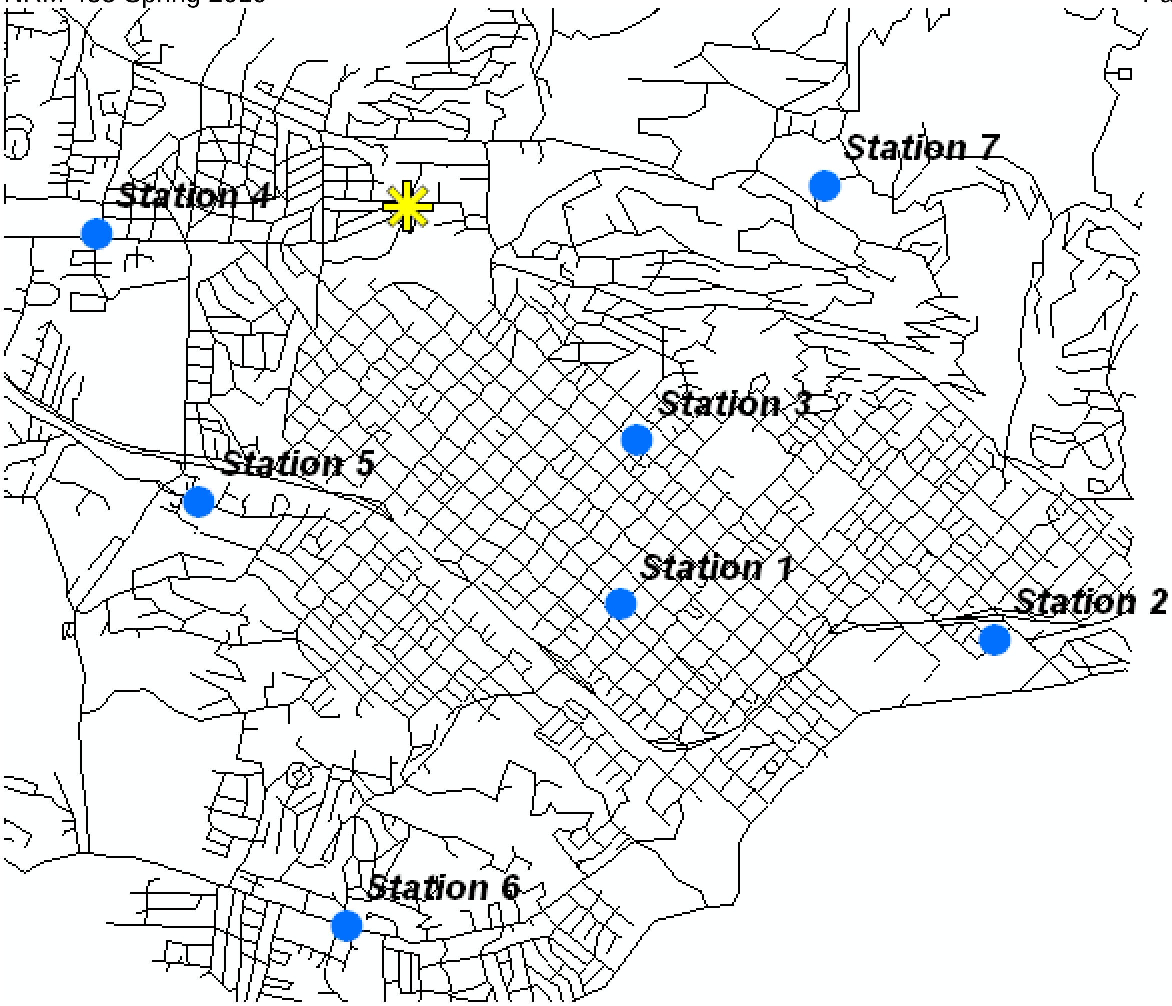
Create a new data frame and name it ***Closest Facilities***



Add two new themes from your Santa Barbara Feature Dataset.



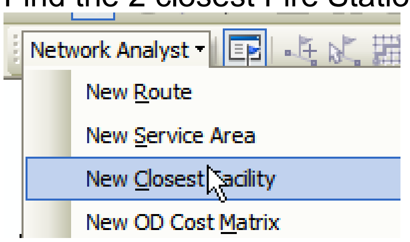
Add the point House_Fire_Location to your data frame

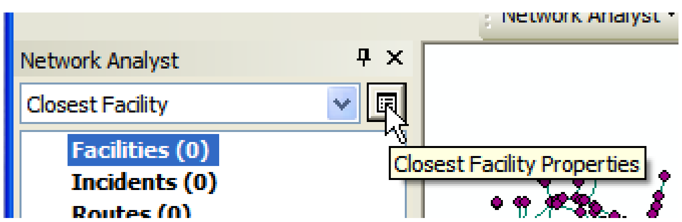


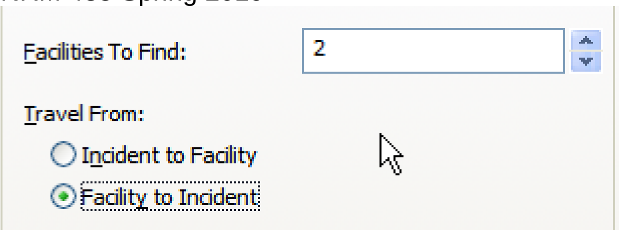
Using your Catalog window, build a network for the streets

and add that network to your Arcmap data frame.

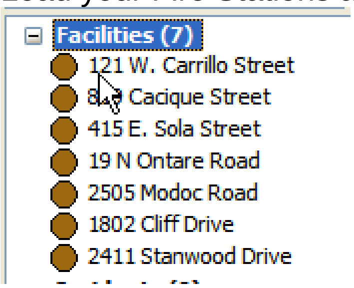
Find the 2 closest Fire Stations in terms of response time…



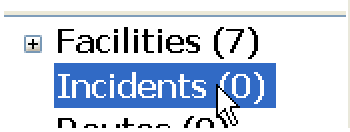




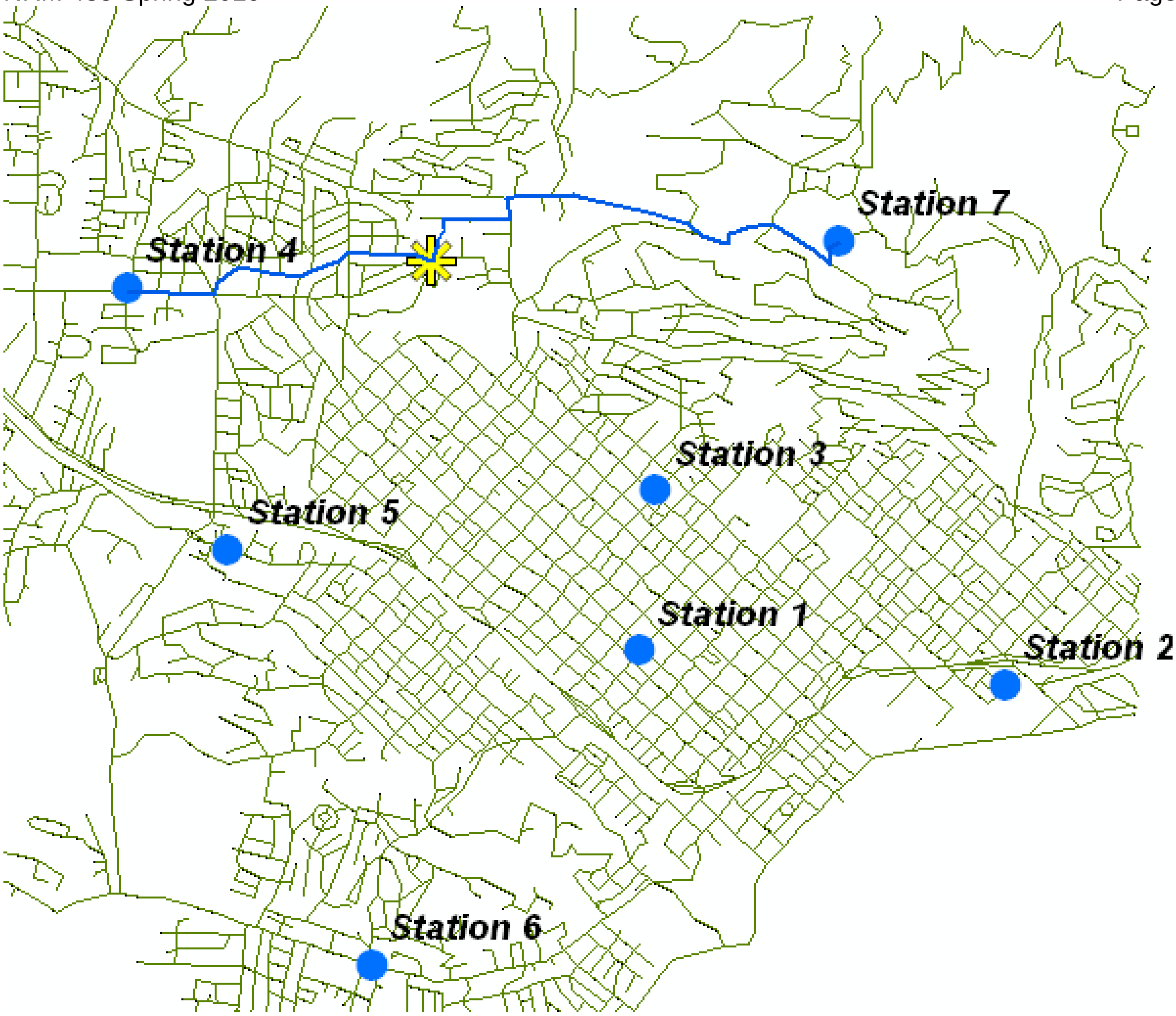
Load your Fire Stations as Facilities



Then specify the location of the fire…

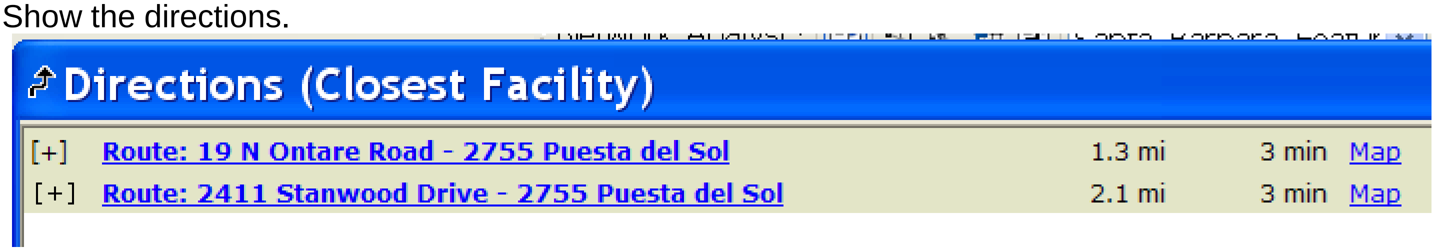


Then solve your problem…



So Station 7 and Station 4 are the closest facilities using the road network…

Show the directions.

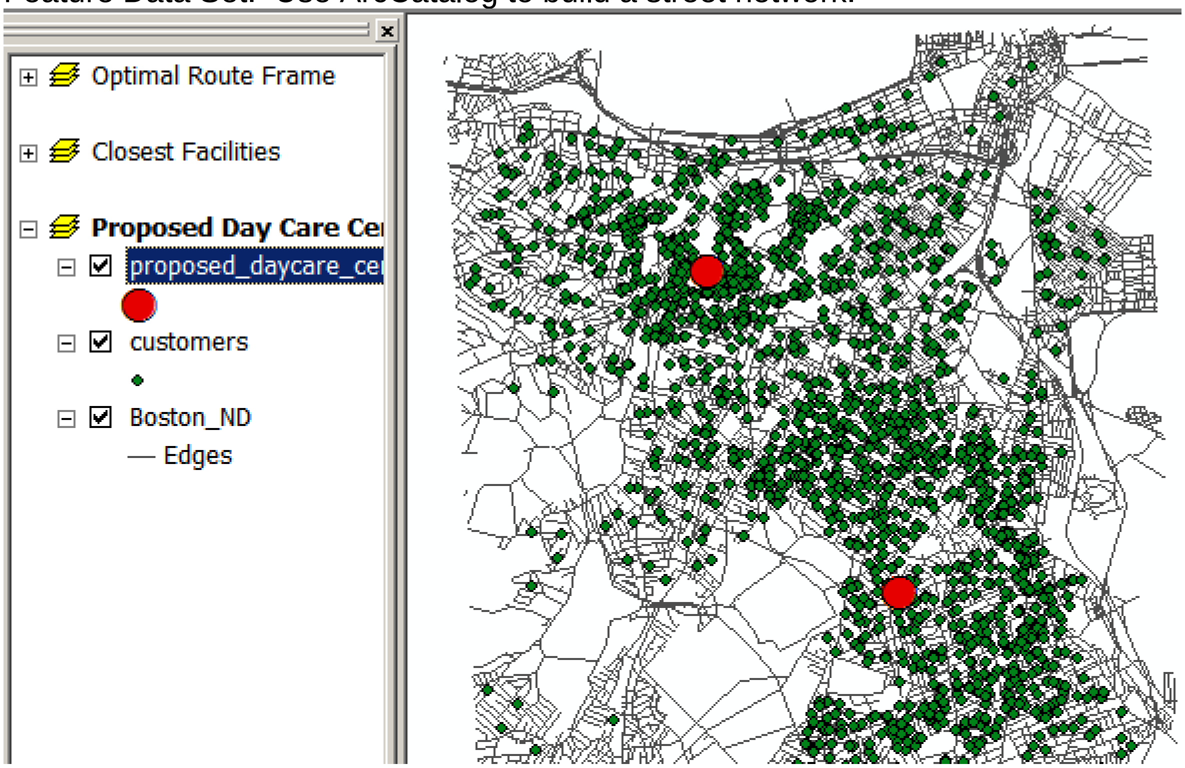


Resource Allocation Along Service Networks

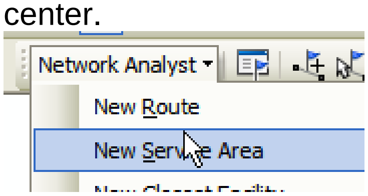
Resource allocation is the spread of resources from some resource center(s) out along a linear network. The resource center could be a source or destination center. For example, a newspaper dispenser box and all sidewalks within 1km of the box (source center). A recycling center and all houses within a 5 minute drive (destination center).

There are two proposed locations for a new day care center in Boston. Your job is to determine the total number of potential customers within a five and ten minute drive of each candidate location.

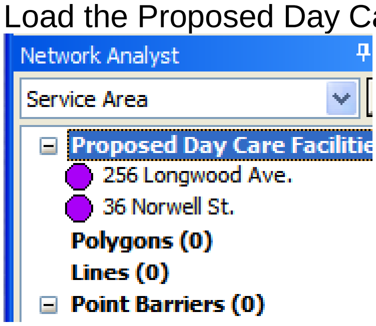
Create a data frame and name it ***Proposed Day Care Centers.*** Add the themes from the Boston Feature Data Set. Use ArcCatalog to build a street network.



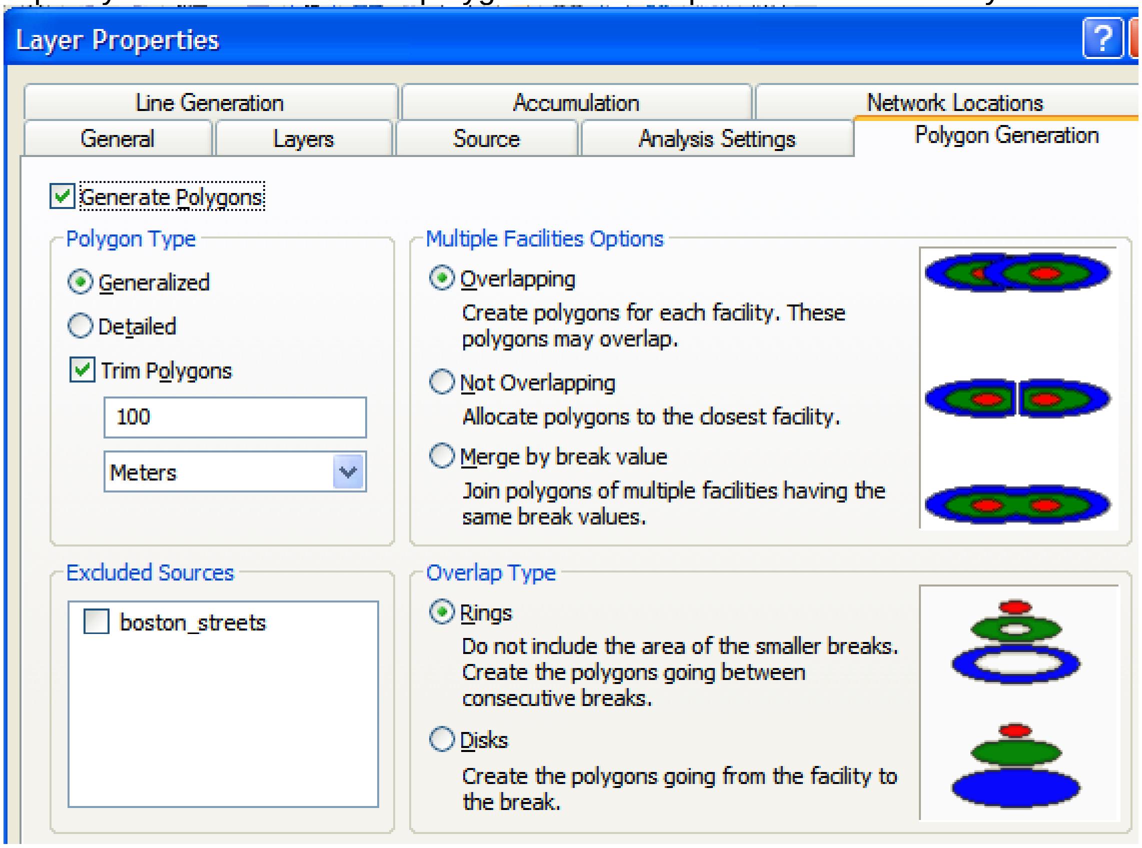
We want to determine the service area within a 5 and 10 minute drive of each proposed day care center.



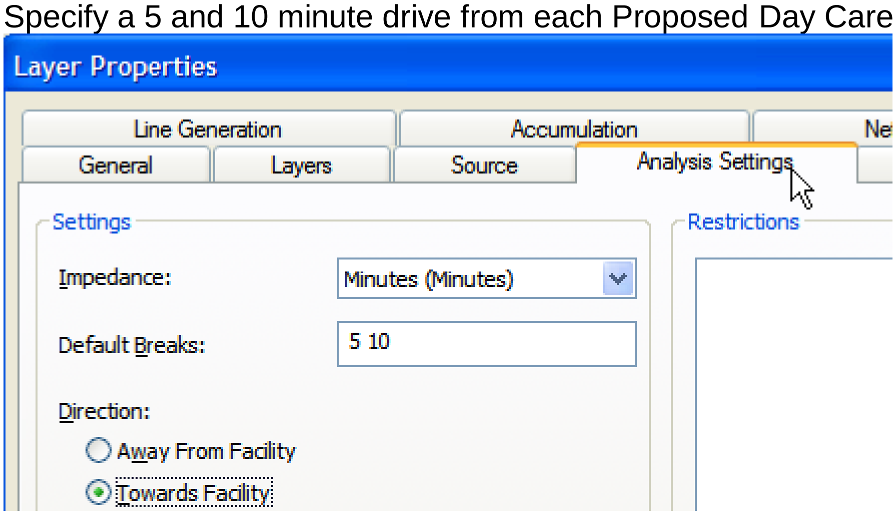
Load the Proposed Day Care Centers as Service Facilities



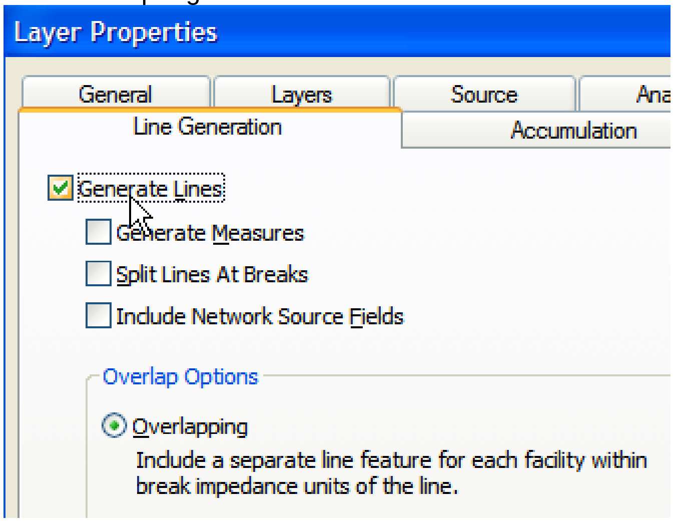
Specify that service network polygons will be separate for each facility.



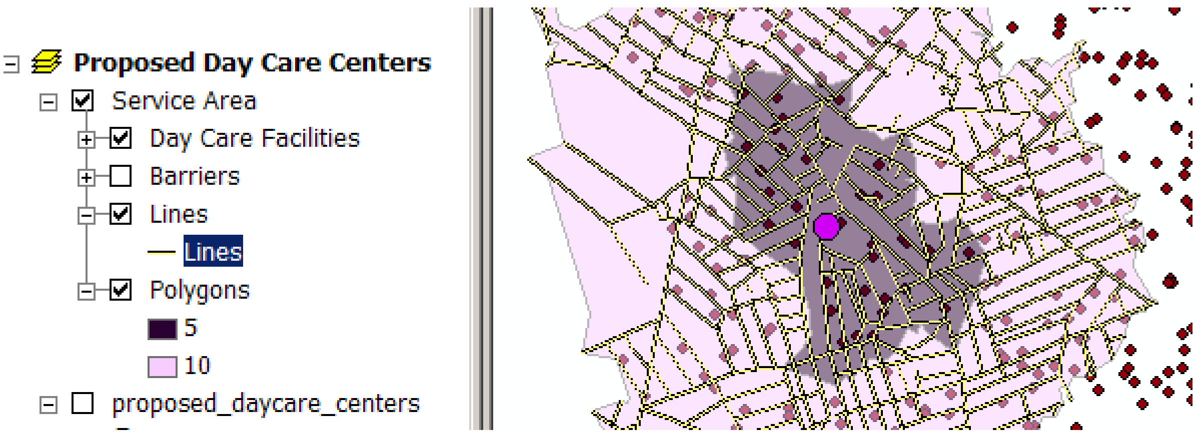
Specify a 5 and 10 minute drive from each Proposed Day Care Centers



Specify Service Network:



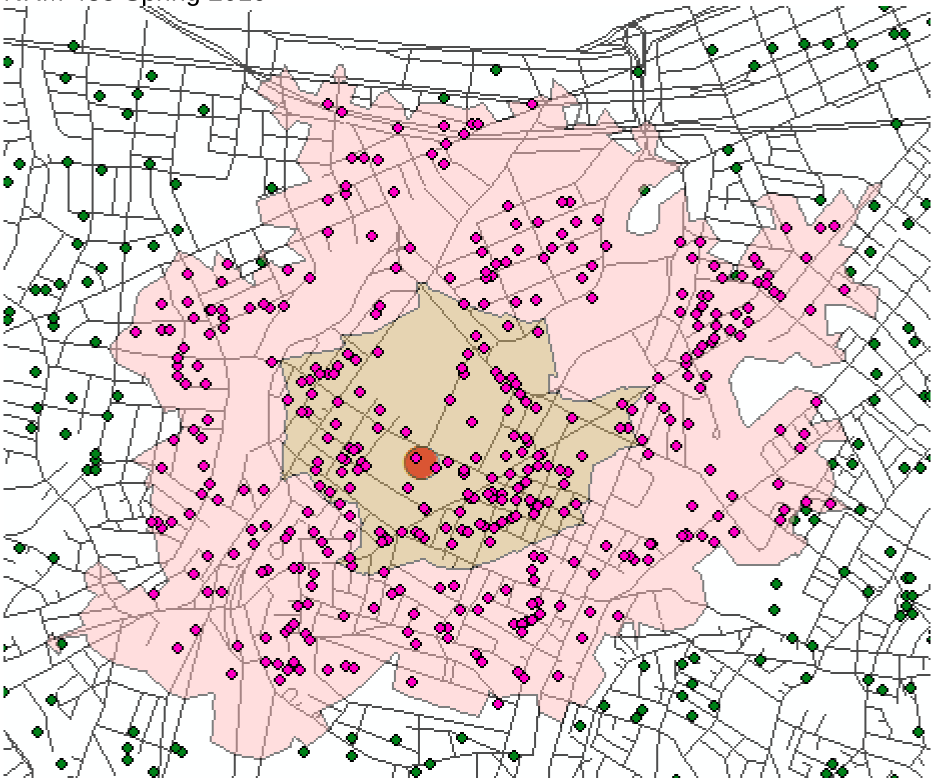
Solve your problem to create a service area network and a service area representing 5 and 10 minutes travel time to the proposed daycare centers.



Polygons

ObjectID	Shape	FacilityID	Name	FromBreak	ToBreak
1	Polygon	1	256 Longwood Ave. : 5 - 10	5	10
2	Polygon	2	36 Norwell St. : 5 - 10	5	10
3	Polygon	2	36 Norwell St. : 0 - 5	0	5
4	Polygon	1	256 Longwood Ave. : 0 - 5	0	5

Use your ***Spatial Join*** or ***Intersect*** tool to transfer the polygon information to each potential customer point.



PotentialCustomers

FID	Shape *	Join_C	TARG	ID	ZIP	FacilityID	Name	FromBreak	ToBreak
0	Point	1	1	0	02124	2	36 Norwell St. : 5 - 10	5	10
1	Point	1	2	1	02124	2	36 Norwell St. : 5 - 10	5	10
2	Point	1	3	2	02124	2	36 Norwell St. : 5 - 10	5	10
3	Point	1	4	3	02124	2	36 Norwell St. : 5 - 10	5	10
4	Point	1	5	4	02121	2	36 Norwell St. : 5 - 10	5	10
5	Point	1	6	5	02121	2	36 Norwell St. : 5 - 10	5	10
6	Point	1	7	6	02122	2	36 Norwell St. : 5 - 10	5	10

or

SAPolygons_Intersect

Shape *	FacilityID	Name	FromBreak	ToBreak	FID_customer
Point	2	36 Norwell St. : 5 - 10	5	10	1325
Point	2	36 Norwell St. : 5 - 10	5	10	1511
Point	2	36 Norwell St. : 5 - 10	5	10	1502
Point	2	36 Norwell St. : 5 - 10	5	10	1328
Point	2	36 Norwell St. : 5 - 10	5	10	62
Point	2	36 Norwell St. : 5 - 10	5	10	687

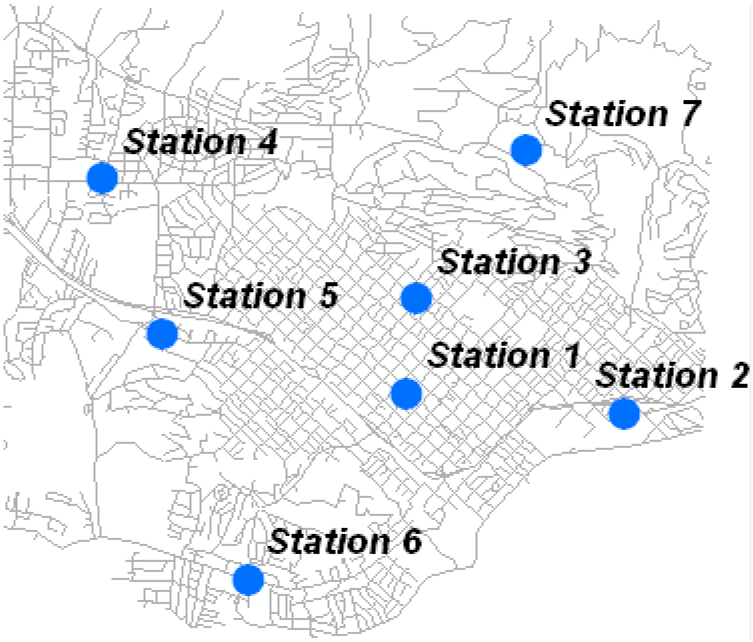
Determine the number of potential customers within 5 and 10-minutes of each proposed day care center, by using the ***Frequency*** tool. There are more potential customers within service network of 256 Longwood Ave…

36 Norwell St. : 0 - 5	34
256 Longwood Ave. : 0 - 5	128
36 Norwell St. : 5 - 10	169
256 Longwood Ave. : 5 - 10	274

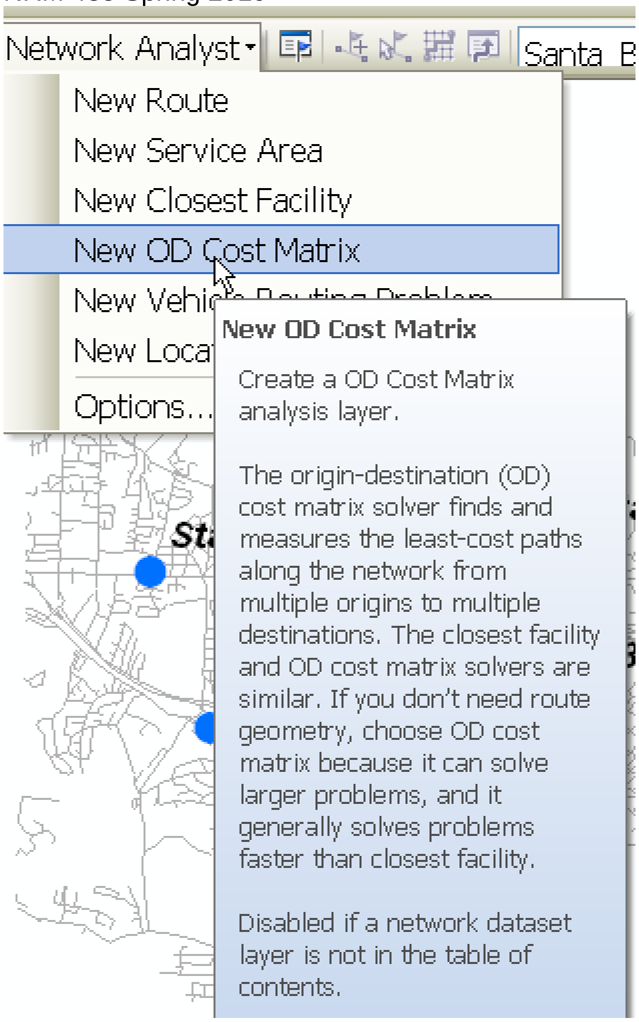
So there are more potential customers in the street network in terms of 5 or 10 minutes time to travel to the proposed center at 256 Longwood (128 compared to 34 within 5 minutes travel time, 274 compared to 169 within 5-10 minutes travel time).

Origin-Destination Matrix

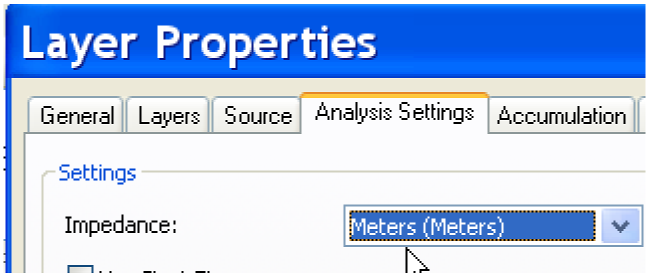
An origin destination matrix is a table containing all the network distances to travel from each origin to all destinations. As an example, create a new data frame and add your fire stations and network dataset from the Santa Barbara feature dataset.



We want a table of shortest network driving distances from each station to all other stations.

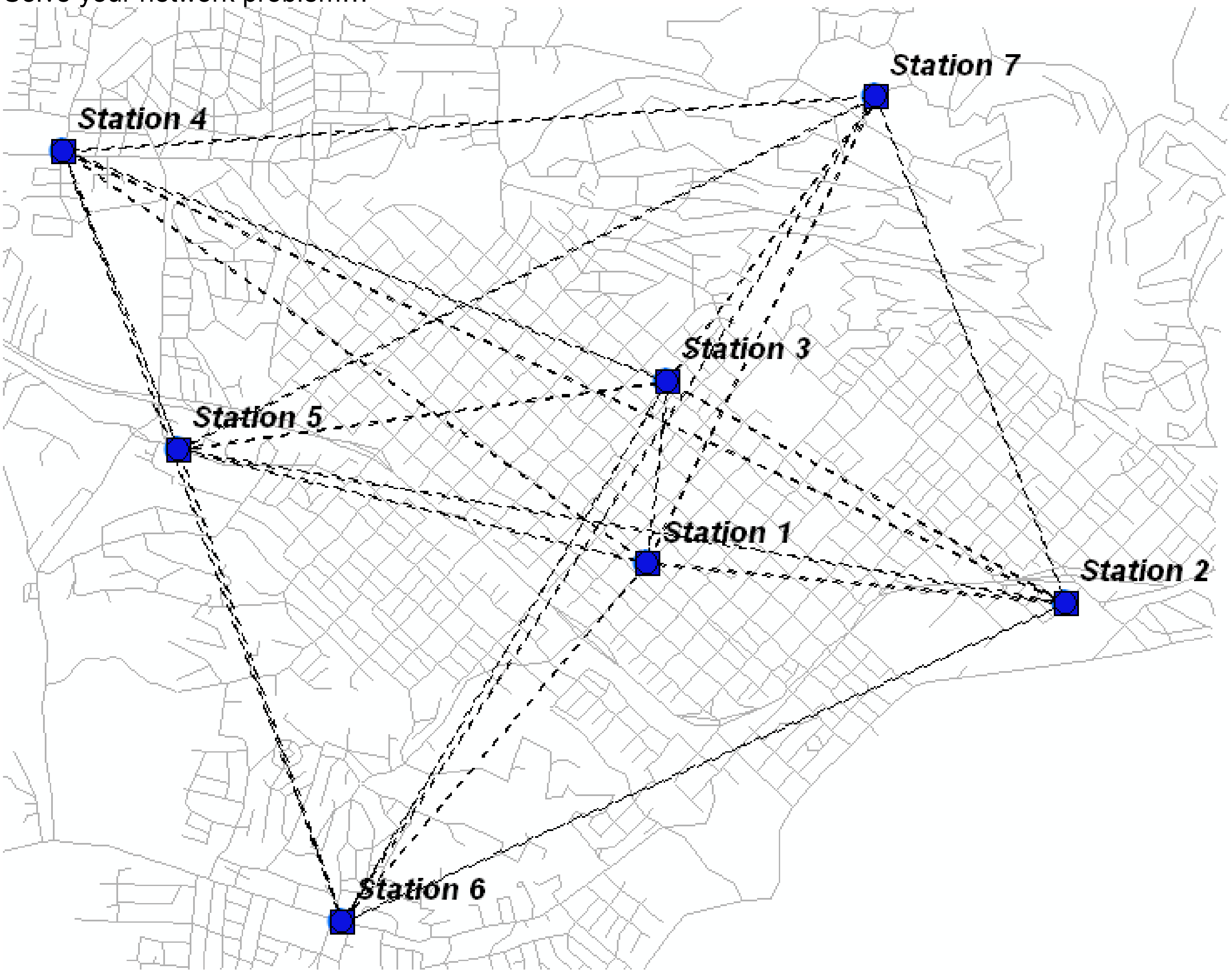


Load all seven fire station points as your Origins and Destinations



Since we want the shortest paths to travel

Solve your network problem…



The resulting 49 lines contain the shortest driving distance between each station and all other stations…

Lines

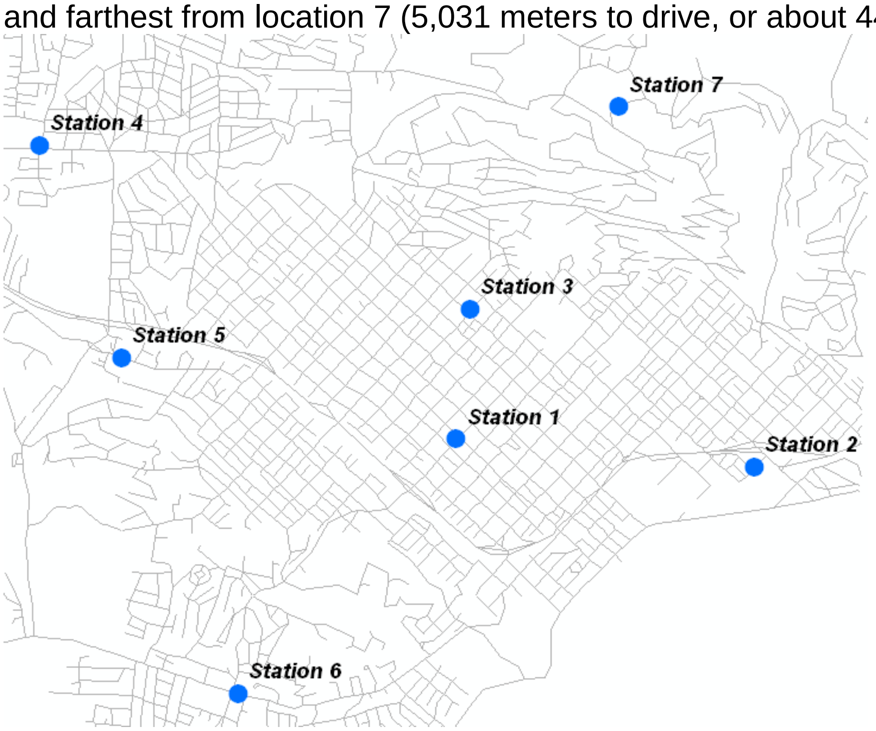
Shape	Name	Total_Meters	Total_Seconds
Polyline	Location 1 - Location 1	0	0
Polyline	Location 1 - Location 3	1417.528012	126.984674
Polyline	Location 1 - Location 2	2924.291329	219.292744
Polyline	Location 1 - Location 6	3029.0771	271.205921
Polyline	Location 1 - Location 5	3245.333096	257.498139
Polyline	Location 1 - Location 4	4383.363899	392.18387
Polyline	Location 1 - Location 7	5031.034662	442.456152
Polyline	Location 2 - Location 2	0	0
Polyline	Location 2 - Location 1	2924.291329	219.292744
Polyline	Location 2 - Location 3	2950.763316	251.346071

Modify the layer properties to exclude origin-destination of zero distance (same location)

Lines

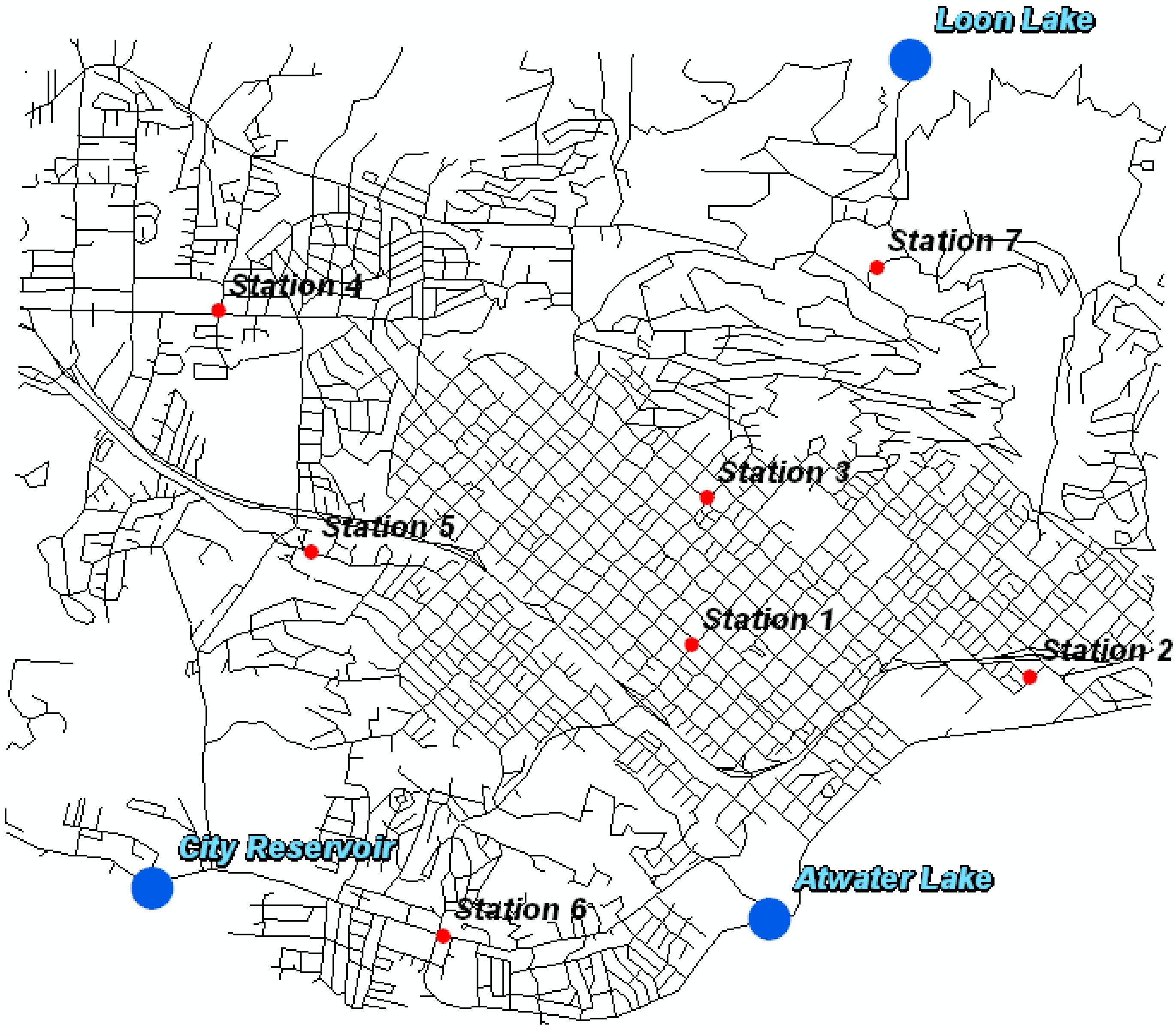
Shape	Name	Total_Meters	Total_Seconds
Polyline	Location 1 - Location 3	1417.528012	126.984674
Polyline	Location 1 - Location 2	2924.291329	219.292744
Polyline	Location 1 - Location 6	3029.0771	271.205921
Polyline	Location 1 - Location 5	3245.333096	257.498139
Polyline	Location 1 - Location 4	4383.363899	392.18387
Polyline	Location 1 - Location 7	5031.034662	442.456152
Polyline	Location 2 - Location 1	2924.291329	219.292744
Polyline	Location 2 - Location 3	2950.763316	251.346071
Polyline	Location 2 - Location 7	5040.743334	443.10941
Polyline	Location 2 - Location 6	5068.872603	419.732272
Polyline	Location 2 - Location 5	6034.624425	316.844883
Polyline	Location 2 - Location 4	6951.655227	579.488616
Polyline	Location 3 - Location 1	1417.528012	126.984674

So for example, the first location is closest to location 3 (1,417 meters to drive,or about 126 seconds) and farthest from location 7 (5,031 meters to drive, or about 442 seconds)

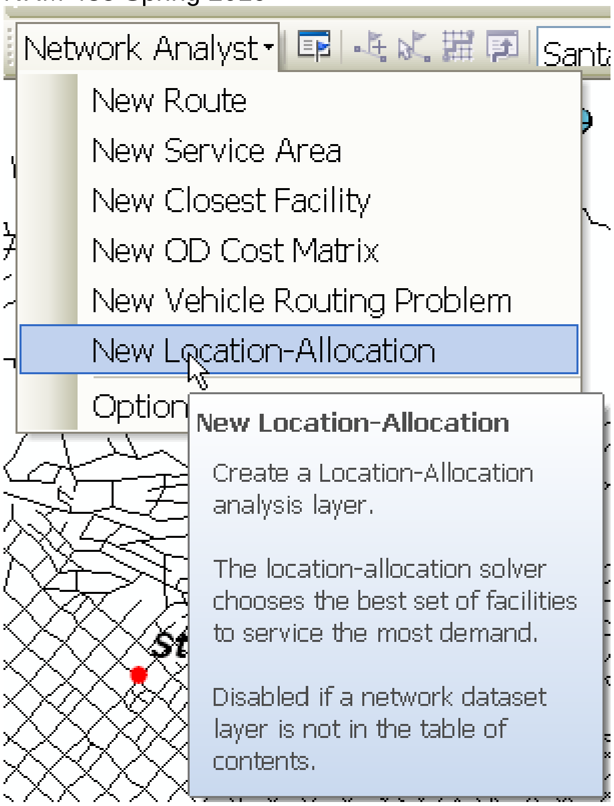


Location-Allocation Problem

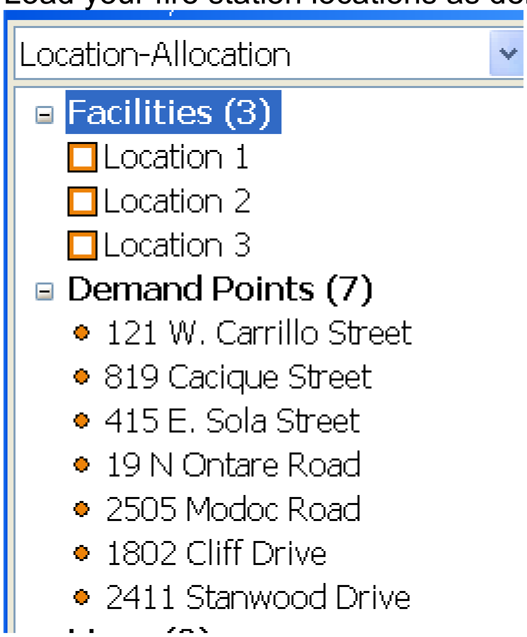
Create a new data frame and add your Santa Barbara network dataset, your fire stations, and the points representing water supply locations to your data frame.

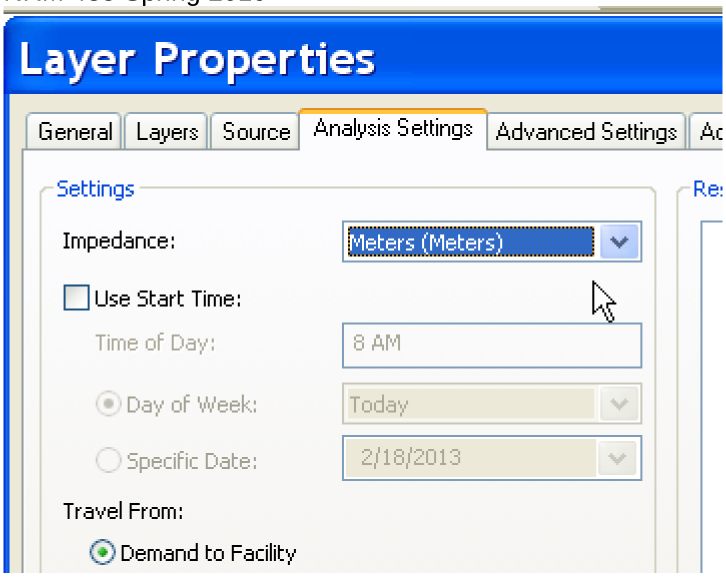


The tankers from each station will fill up at one of these three water supply centers (City Reservoir, Atwater Lake or Loon Lake).



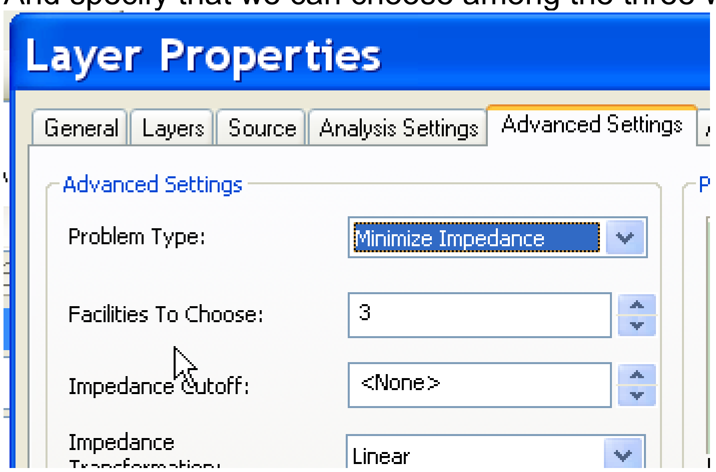
Load your fire station locations as demand points and your water locations as facility locations…





in this example, we want to allocate based on the shortest road distance to each water resource

And specify that we can choose among the three water resource centers…



So Station 7 should use Loon Lake, Stations 1,2,3 use Atwater Lake and Stations 4,5,6 use City Reservoir to minimize travel distance along the street network…

DemandID	FacilityID	Total_Meters	Total_Seconds
1	7	2,636.8	231.7
2	7	3,422.9	306.5
3	7	4,017.4	355.3
4	8	5,149.1	296.1
5	8	3,189.1	186.8
6	8	2,139.8	191.8
7	9	1,780.1	150.4