GEOG653 – Spatial Analysis

Lecture 7

1

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Outline

- Announcements & Updates
- Network Analysis
  - Closest Facility Analysis
  - OD Cost Matrix Analysis
  - Location-Allocation Analysis
  - Vehicle Routing Problem Analysis (*new!*)
- Network Analysis with Different Platforms
- Geocoding with Different Platforms

Updates

- Lab 3
- TA Office Hours
  - Tuesdays, 4-5pm
  - Fridays, 6-7pm

Network Analysis

- Routing
- Service Area
- Closest Facility
- OD Cost Matrix
- Location-Allocation Analysis
- Network Analysis using different platforms
  - ArcGIS Pro
  - ArcMap
  - ArcGIS Online

Network Analysis

- Closest Facility
  - This tool helps find the route(s) that minimizes travel cost between incidents and facilities.
  - Options:
    - Set impedance
    - Define cutoff value
    - Set number of facilities to find
    - Specify direction of travel
    - Generate directions

Network Analysis

- Closest Facility
  - You can specify how many to find and whether the direction of travel is toward or away from them.
  - You can display the best route to or from them, return the travel cost for each route, and display directions to each facility.
  - You can specify an impedance cutoff beyond which ArcGIS Network Analyst should not search for a facility.

Network Analysis

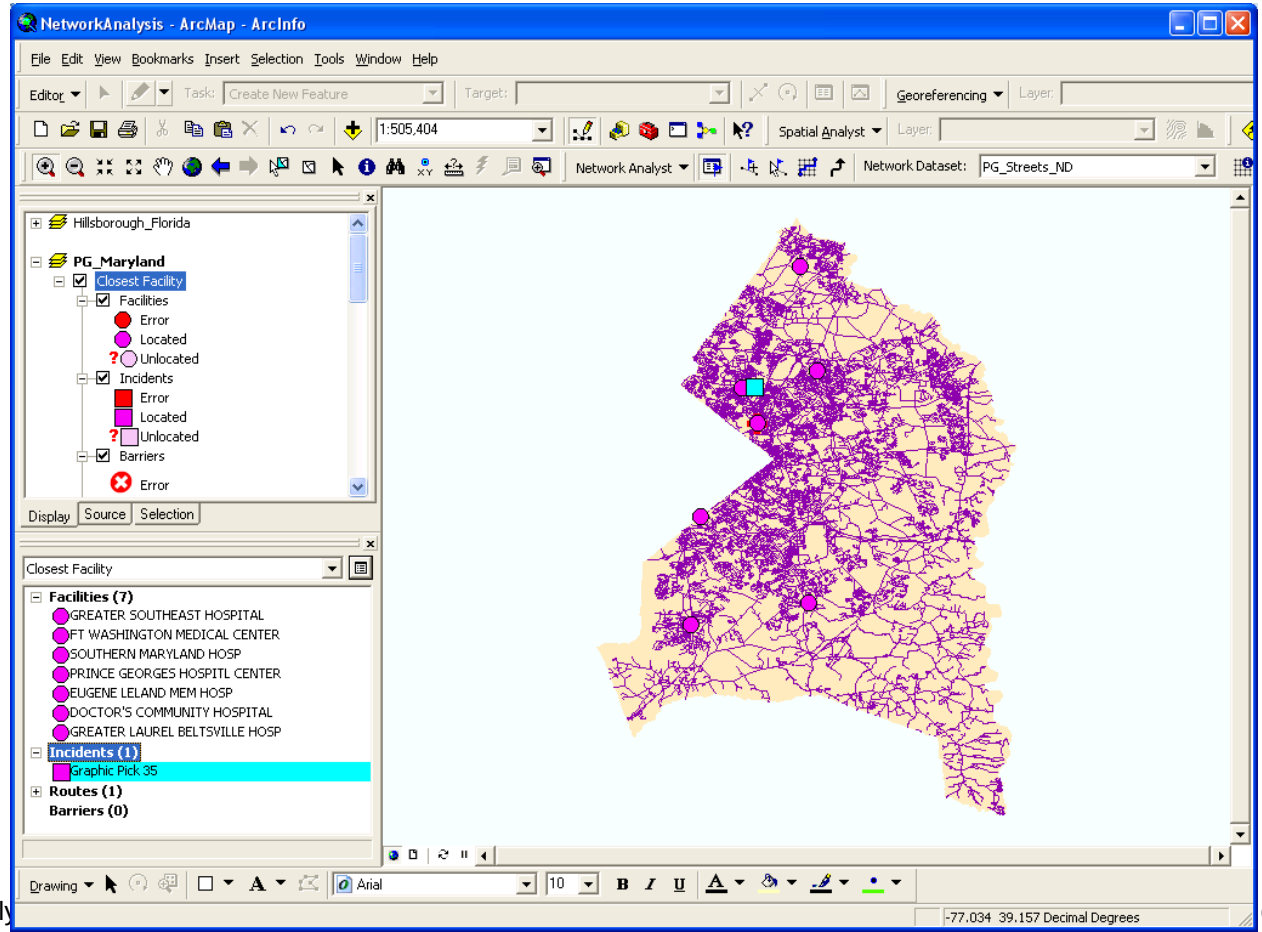
- Closest Facility
  - Applications
    - Emergency vehicle dispatch
    - Customer to stores

Network Analysis

- Closest Facility
  - Components:
    - Facilities feature layer
      - This layer stores the network locations that are used as facilities in closest facility analysis.
    - Incidents feature layer
      - The layer stores network locations used as incidents for closest facility analysis.
    - Barriers feature layer
      - Barriers are used in closest facility analysis to denote points where a closest facility route can't traverse.
    - Routes feature layer
      - The Routes layer stores the resultant paths of the closest facility analysis.

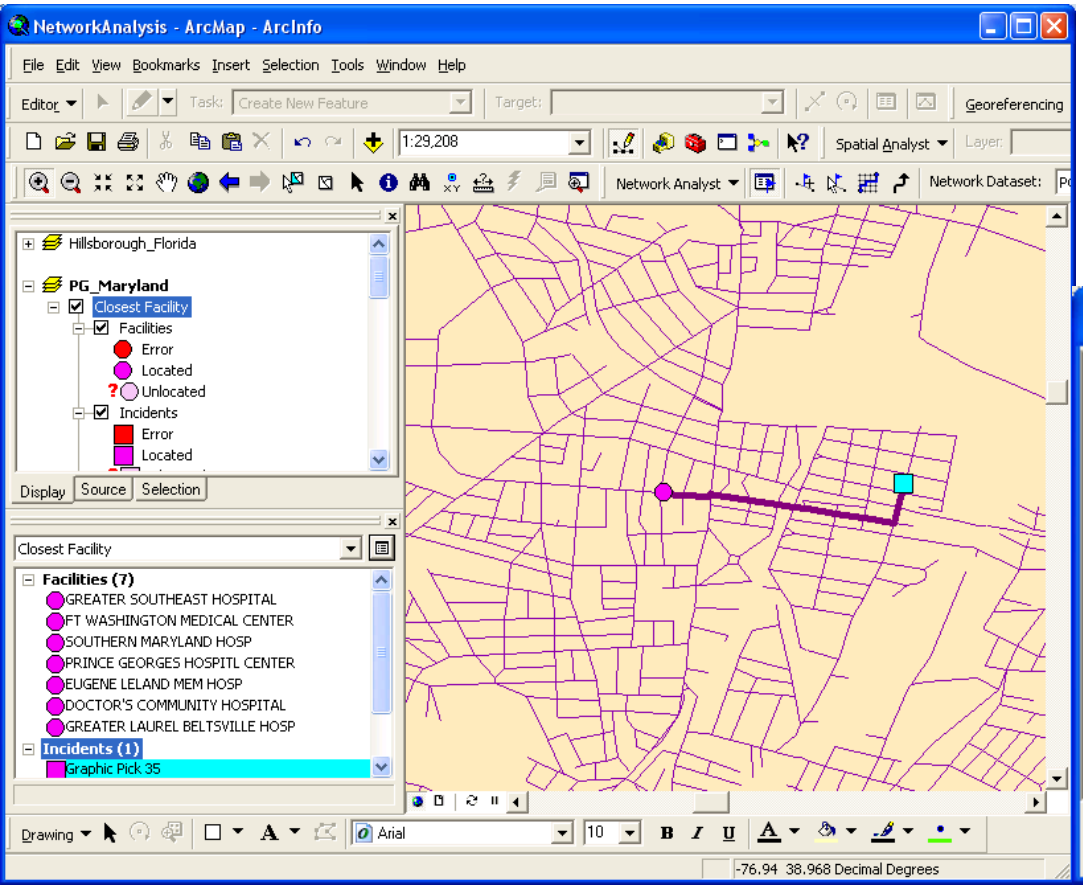
Network Analysis

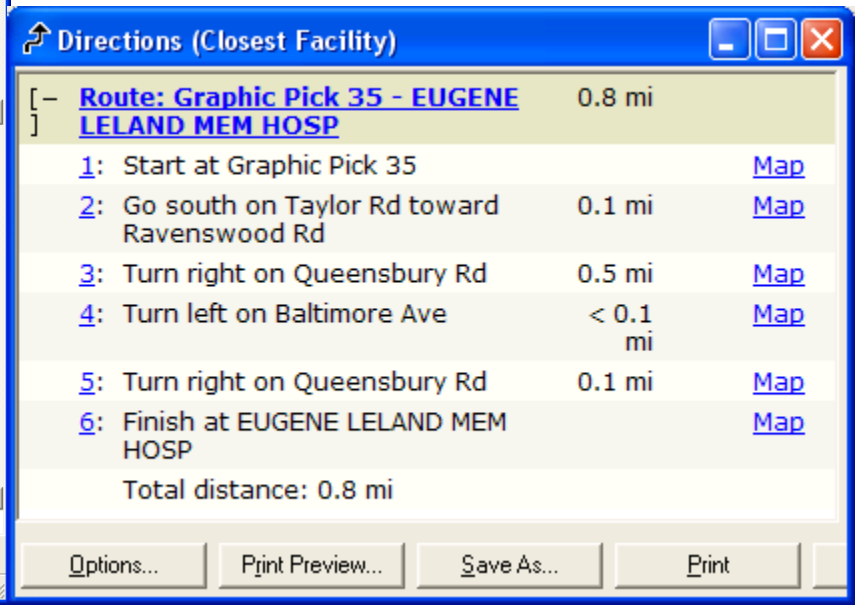
- Closest Facility
  - Example: finding the closest hospital to my home in Prince George's County.



Network Analysis

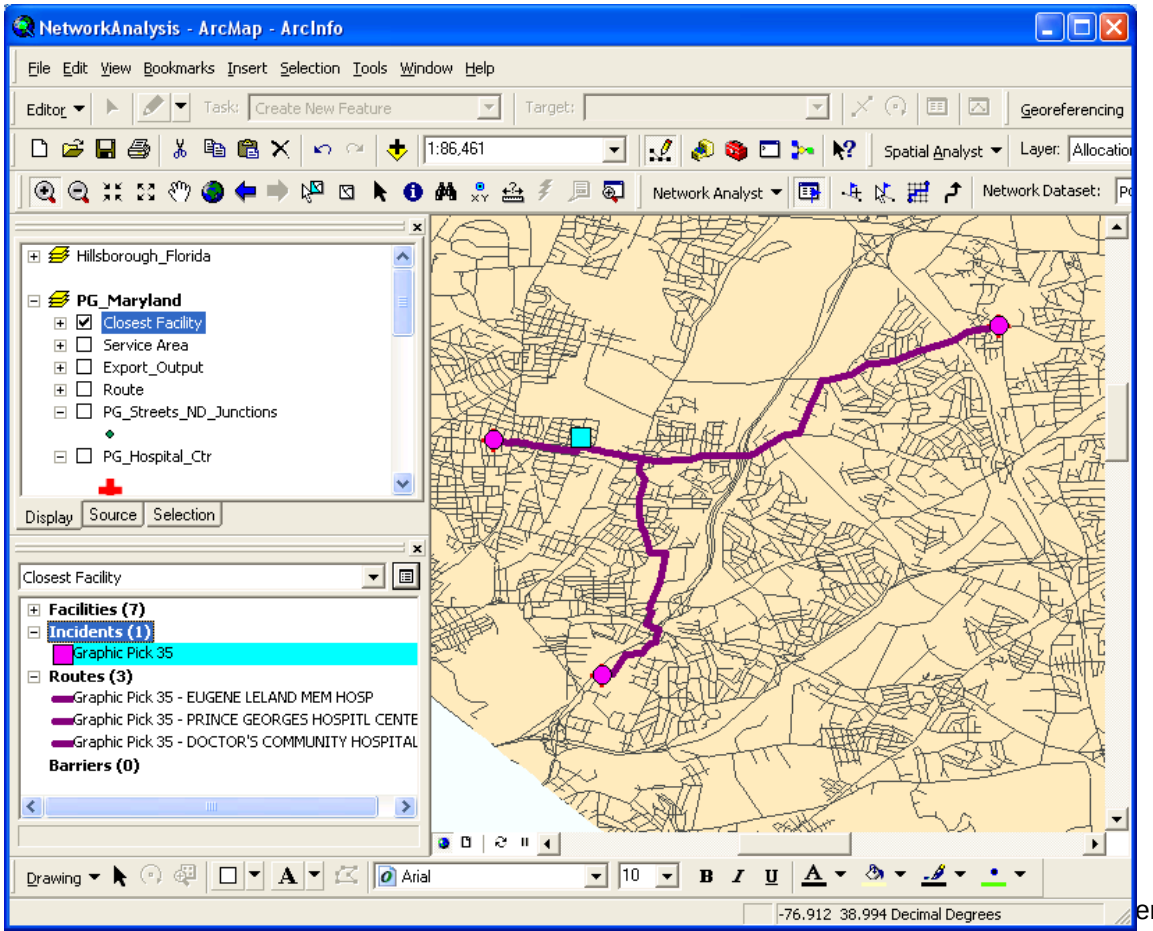
- Closest Facility
  - Example: finding the closest hospital to my home in Prince George's County.





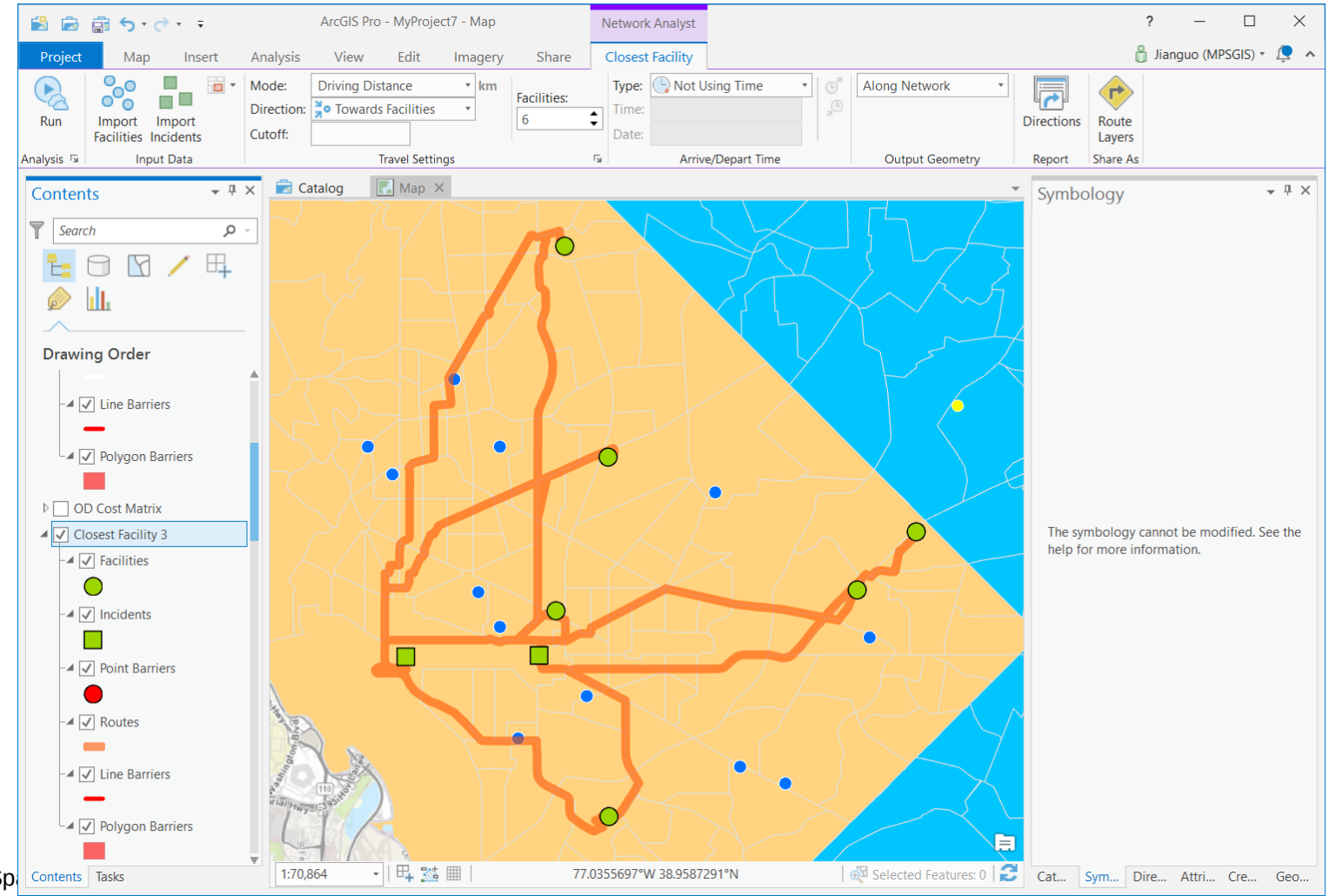
Network Analysis

- Closest Facility
  - Example: finding three closest hospitals to my home in Prince George's County.



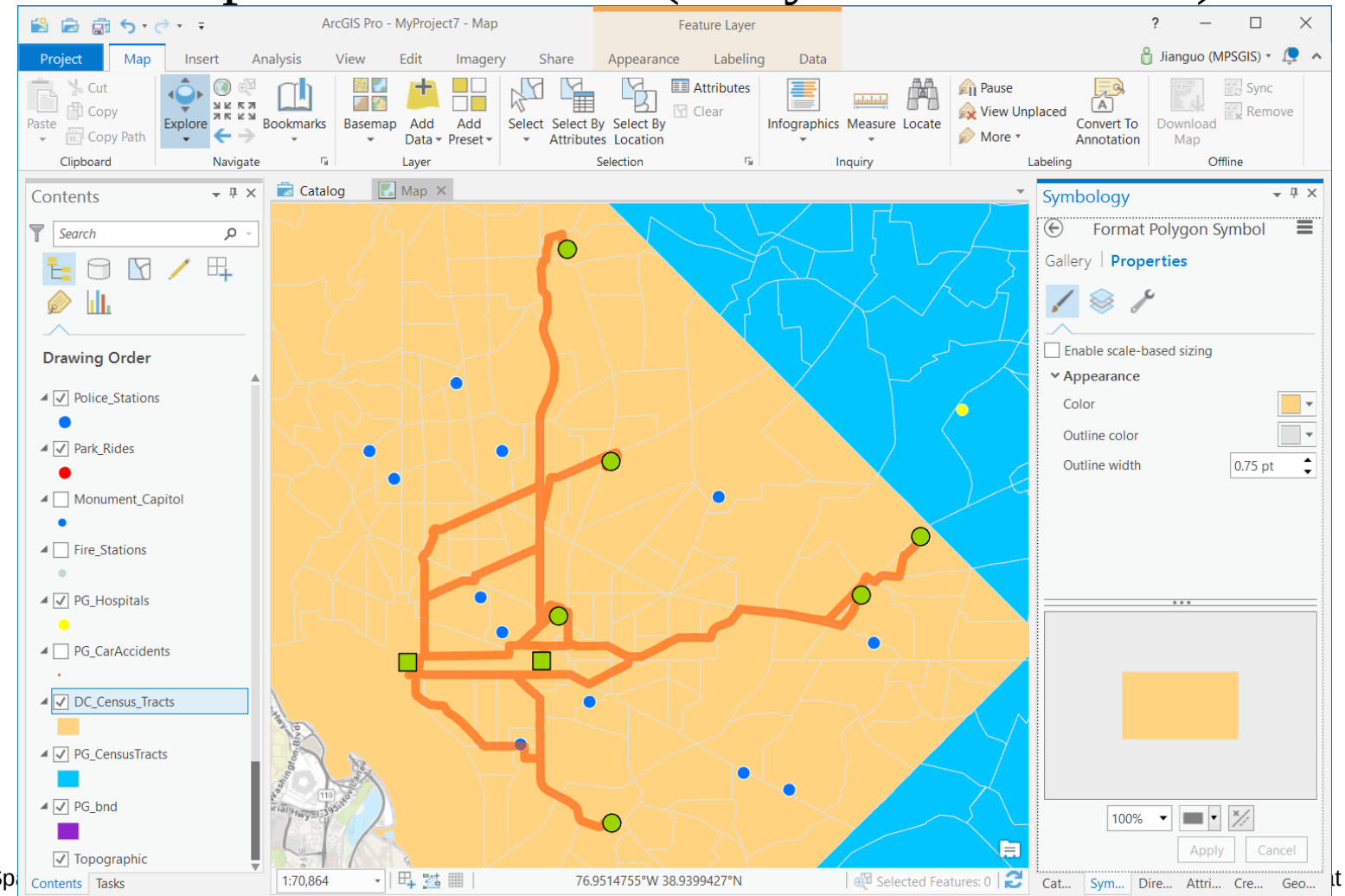
Network Analysis

- Closest Facility
  - Example: ArcGIS Pro (towards facilities)



Network Analysis

- Closest Facility
  - Example: ArcGIS Pro (away from facilities)

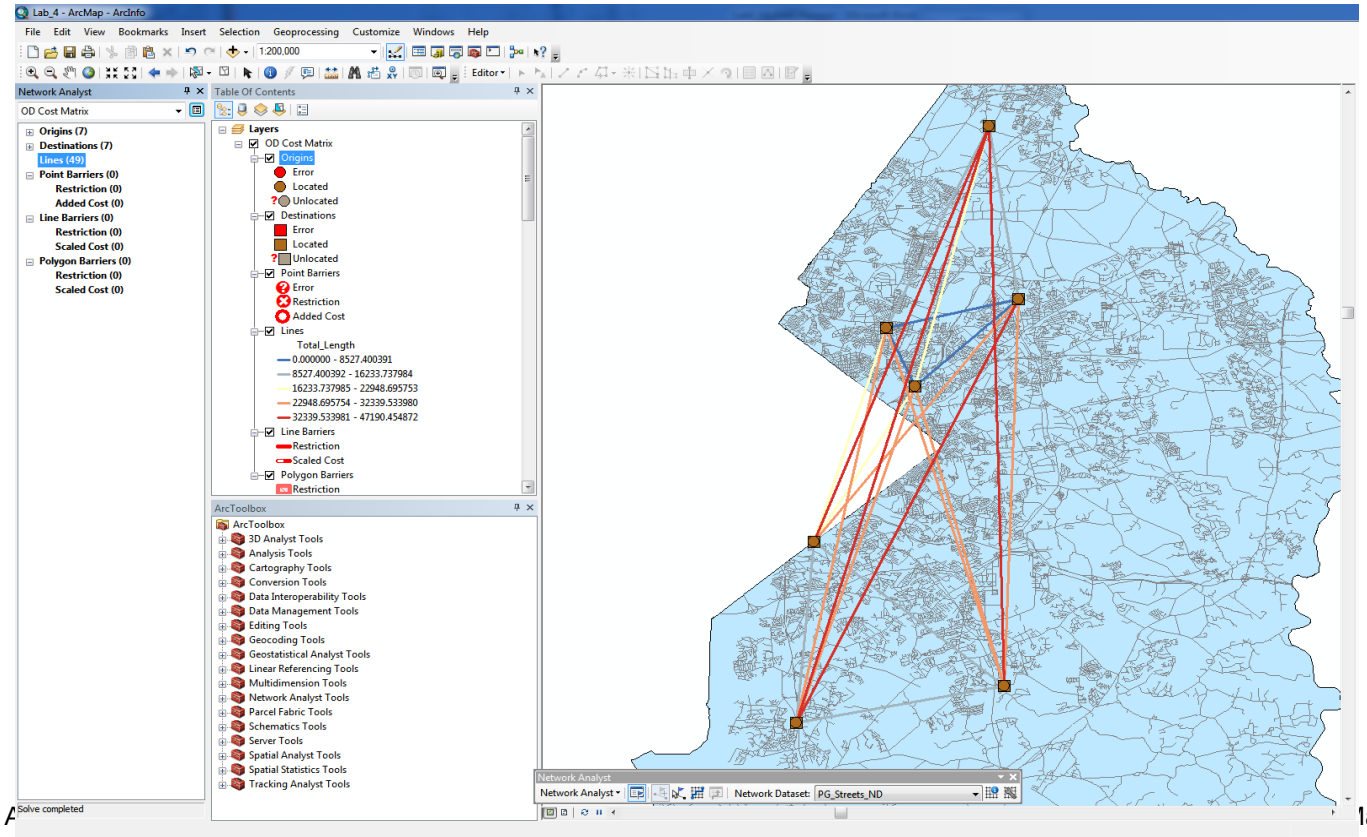


Network Analysis

- OD Cost Matrix
  - Finds and measures the least-cost paths along the network from multiple origins to multiple destinations.
  - Options:
    - Set impedance
    - Define cutoff value
    - Specify number of destinations to find

Network Analysis

- OD Cost Matrix
  - Generates an "OD" matrix of the cost from each origin to each destination



Network Analysis

- OD Cost Matrix
  - An OD cost matrix is a table that contains the network impedance from each origin to each destination.

Table

Lines

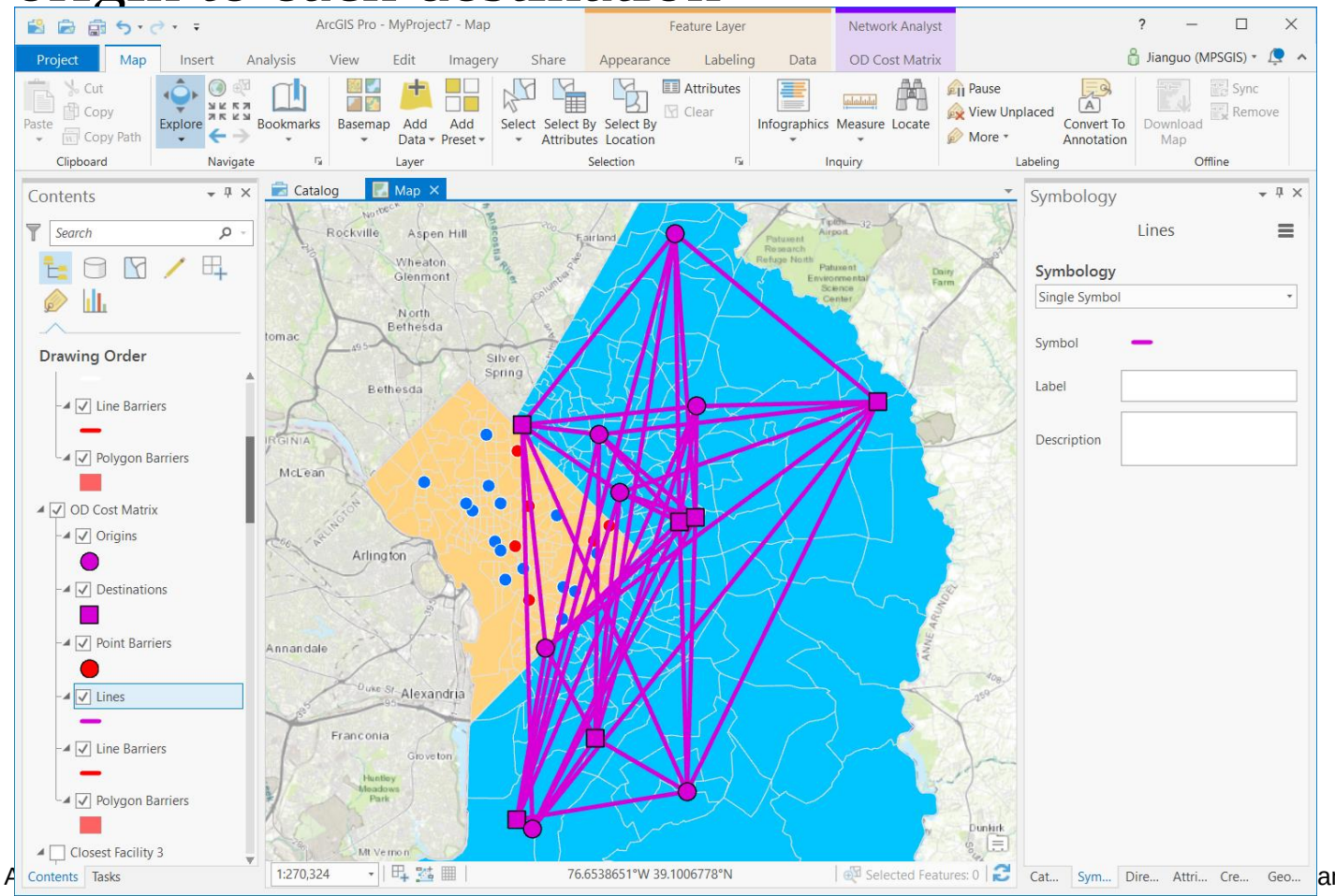
ObjectID	Shape	Name	OriginID	DestinationID	DestinationRank	Total_Length
1	Polyline	GREATER SOUTHEAST HOSPITAL - GREATER SOUTHEAST HOSPITAL	1	1	1	0
2	Polyline	GREATER SOUTHEAST HOSPITAL - FT WASHINGTON MEDICAL CENTER	1	2	2	14348.266698
3	Polyline	GREATER SOUTHEAST HOSPITAL - SOUTHERN MARYLAND HOSP	1	3	3	16233.737984
4	Polyline	GREATER SOUTHEAST HOSPITAL - PRINCE GEORGES HOSPITL CENTER	1	4	4	18668.333272
5	Polyline	GREATER SOUTHEAST HOSPITAL - EUGENE LELAND MEM HOSP	1	5	5	22948.695753
6	Polyline	GREATER SOUTHEAST HOSPITAL - DOCTOR'S COMMUNITY HOSPITAL	1	6	6	25264.233456
7	Polyline	GREATER SOUTHEAST HOSPITAL - GREATER LAUREL BELTSVILLE HOSP	1	7	7	37799.616645
8	Polyline	FT WASHINGTON MEDICAL CENTER - FT WASHINGTON MEDICAL CENTER	2	2	1	0
9	Polyline	FT WASHINGTON MEDICAL CENTER - GREATER SOUTHEAST HOSPITAL	2	1	2	14348.266698
10	Polyline	FT WASHINGTON MEDICAL CENTER - SOUTHERN MARYLAND HOSP	2	3	3	15954.688929
11	Polyline	FT WASHINGTON MEDICAL CENTER - PRINCE GEORGES HOSPITL CENTER	2	4	4	28059.171499
12	Polyline	FT WASHINGTON MEDICAL CENTER - EUGENE LELAND MEM HOSP	2	5	5	32339.53398
13	Polyline	FT WASHINGTON MEDICAL CENTER - DOCTOR'S COMMUNITY HOSPITAL	2	6	6	34655.071682
14	Polyline	FT WASHINGTON MEDICAL CENTER - GREATER LAUREL BELTSVILLE HOSP	2	7	7	47190.454872
15	Polyline	SOUTHERN MARYLAND HOSP - SOUTHERN MARYLAND HOSP	3	3	1	0
16	Polyline	SOUTHERN MARYLAND HOSP - FT WASHINGTON MEDICAL CENTER	3	2	2	15954.688929
17	Polyline	SOUTHERN MARYLAND HOSP - GREATER SOUTHEAST HOSPITAL	3	1	3	16233.737984
18	Polyline	SOUTHERN MARYLAND HOSP - PRINCE GEORGES HOSPITL CENTER	3	4	4	24988.317201
19	Polyline	SOUTHERN MARYLAND HOSP - DOCTOR'S COMMUNITY HOSPITAL	3	6	5	28599.850597
20	Polyline	SOUTHERN MARYLAND HOSP - EUGENE LELAND MEM HOSP	3	5	6	29268.679682
21	Polyline	SOUTHERN MARYLAND HOSP - GREATER LAUREL BELTSVILLE HOSP	3	7	7	42228.293262
22	Polyline	PRINCE GEORGES HOSPITL CENTER - PRINCE GEORGES HOSPITL CENTER	4	4	1	0
23	Polyline	PRINCE GEORGES HOSPITL CENTER - EUGENE LELAND MEM HOSP	4	5	2	5210.795583
24	Polyline	PRINCE GEORGES HOSPITL CENTER - DOCTOR'S COMMUNITY HOSPITAL	4	6	3	8527.400391
25	Polyline	PRINCE GEORGES HOSPITL CENTER - GREATER SOUTHEAST HOSPITAL	4	1	4	18668.333272
26	Polyline	PRINCE GEORGES HOSPITL CENTER - GREATER LAUREL BELTSVILLE HOSP	4	7	5	20003.066593
27	Polyline	PRINCE GEORGES HOSPITL CENTER - SOUTHERN MARYLAND HOSP	4	3	6	24988.317201
28	Polyline	PRINCE GEORGES HOSPITL CENTER - FT WASHINGTON MEDICAL CENTER	4	2	7	28059.171499

Network Analysis

- OD Cost Matrix
  - The matrix ranks the destinations that each origin connects to in ascending order based on the minimum network impedance required to travel from that origin to each destination.
    - The impedance/cost can be distance or time.
  - The best network path is discovered for each origin-destination pair, and the cost is stored in the attribute table of the output lines.

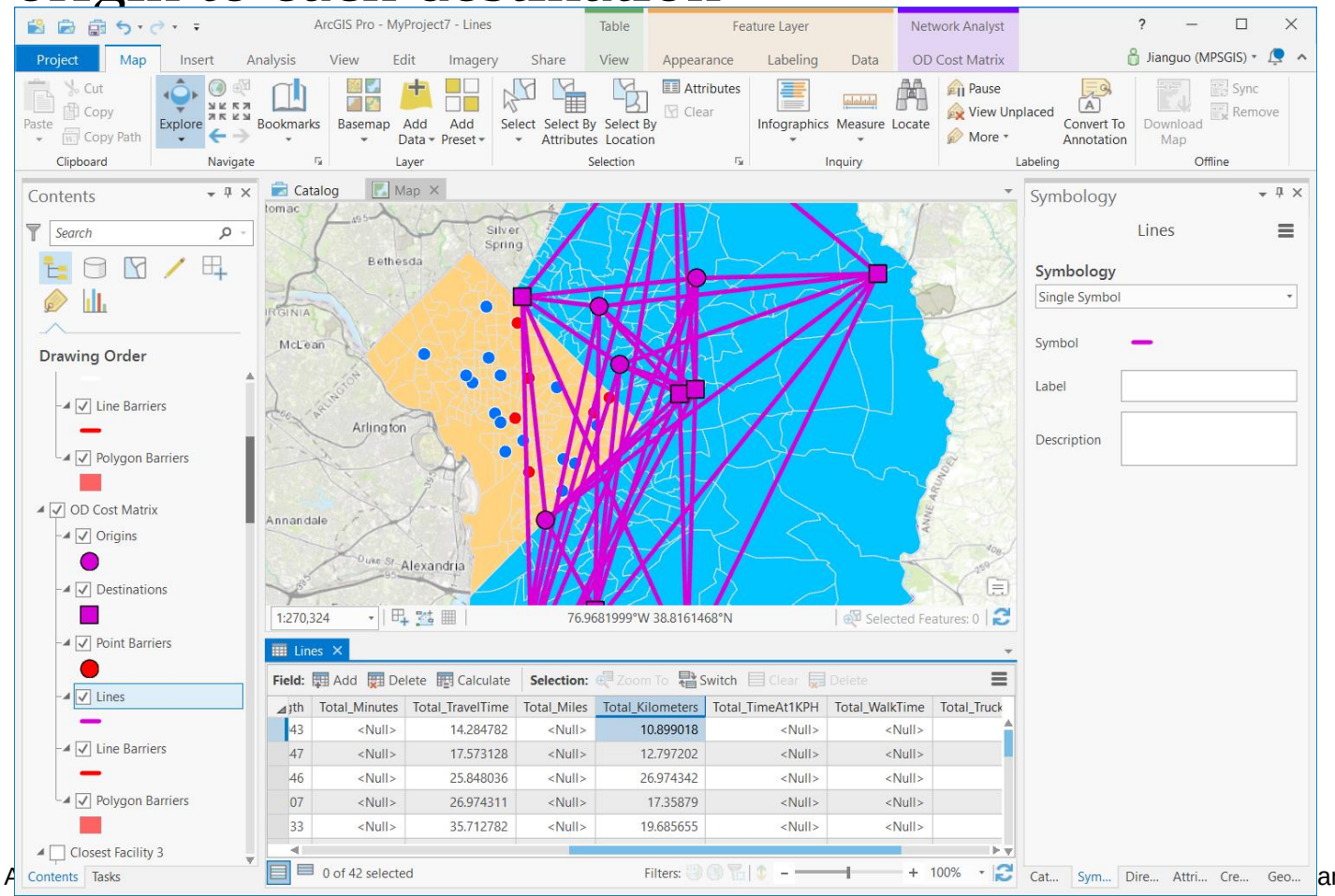
Network Analysis

- OD Cost Matrix
  - Generates an "OD" matrix of the cost from each origin to each destination



Network Analysis

- OD Cost Matrix
  - Generates an "OD" matrix of the cost from each origin to each destination



Network Analysis

- OD Cost Matrix
  - Even though the graphic output lines seem to be straight and does not follow the network (for performance reasons), the distances stored in the attribute table actually reflect the travel distances along the network.
  - Therefore, the results of OD cost matrix analyses often become input for other spatial analyses where the network cost is more appropriate than straight-line cost.

Network Analysis

- OD Cost Matrix
  - OD Cost Matrix vs. Closest Facility
    - The closest facility and OD cost matrix solvers perform very similar analyses.
    - If you need driving directions or true shapes of routes, use the closest facility solver; otherwise, use the OD cost matrix solver to reduce the computation time.

Network Analysis

- OD Cost Matrix
  - OD Cost Matrix vs. Closest Facility
    - The main difference is in the output and the computation speed.
      - OD cost matrix generates results more quickly but cannot return the true shapes of routes or their driving directions. It is designed to quickly solve large M x N problems and, as a result, does not internally contain the information required to generate route shapes and driving directions.
      - Alternatively, the closest facility solver returns routes and directions but performs the analysis more slowly than the OD cost matrix solver.

Network Analysis

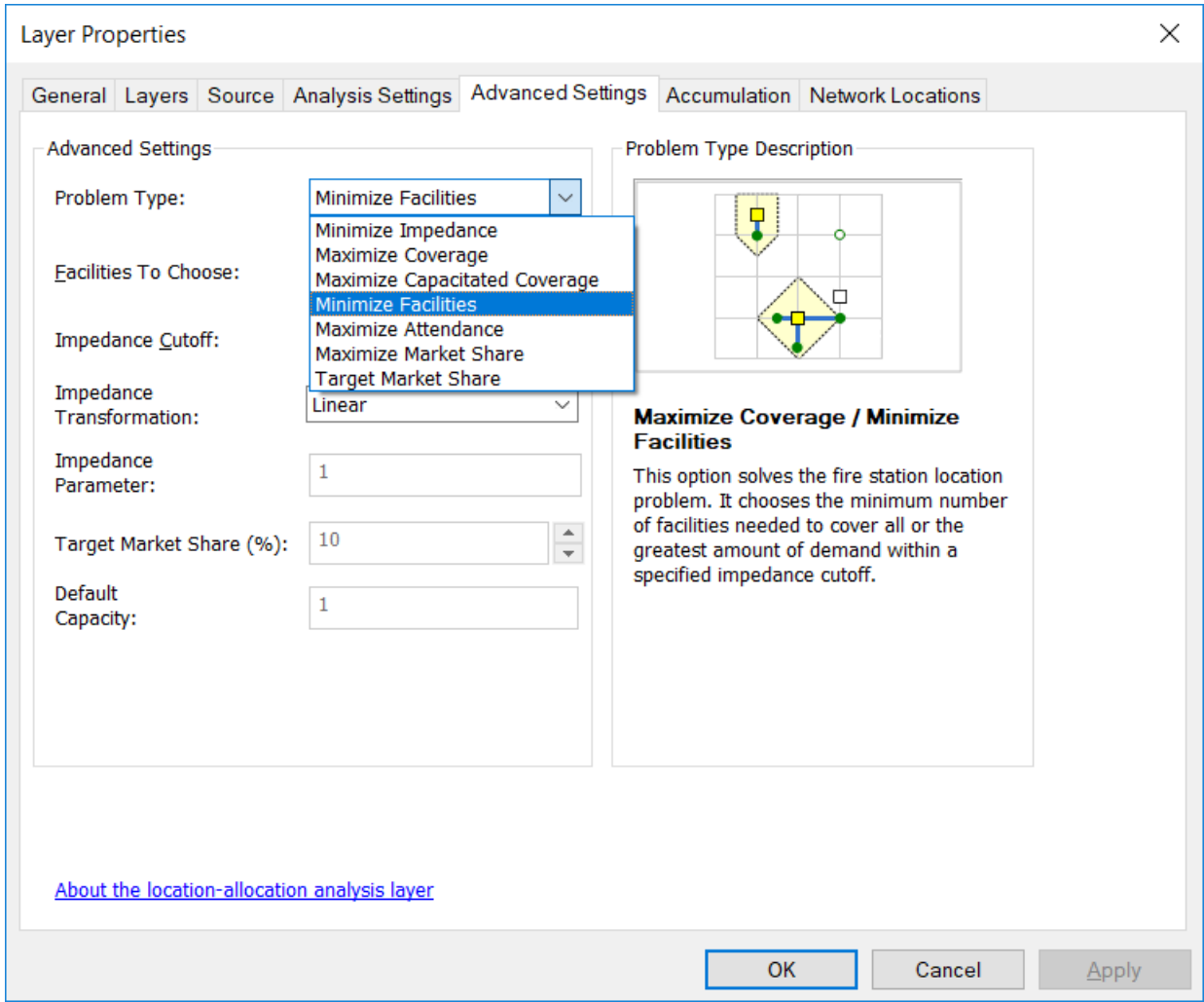
- Location-Allocation Analysis
  - This analysis can help locate the facilities in a way that supplies the demand points most efficiently.
  - It can solve the twofold location-allocation problem that simultaneously locates facilities and allocates demand points to the facilities.

Network Analysis

- Location-Allocation Analysis
  - Problem types:
    - Minimize Impedance
    - Maximize Coverage
    - Maximize Capacitated Coverage
    - Minimize Facilities/Maximize Coverage
    - Maximize Attendance
    - Maximize Market Share
    - Target Market Share

Network Analysis

- Location-Allocation Analysis
  - Problem types:



Network Analysis

- Location-Allocation Analysis
  - Problem types:
    - Minimize impedance
      - Facilities are located such that the sum of all weighted costs between demand points and solution facilities is minimized.
      - This problem type is traditionally used to locate warehouses, because it can reduce the overall transportation costs of delivering goods to outlets.

Network Analysis

- Location-Allocation Analysis
  - Problem types:
    - Maximize coverage
      - Facilities are located such that as many demand points as possible are allocated to solution facilities within the impedance cutoff.
      - Maximize Coverage is frequently used to locate fire stations, police stations, and ERS centers, because emergency services are often required to arrive at all demand points within a specified response time.

Network Analysis

- Location-Allocation Analysis
  - Problem types:
    - Maximize capacitated coverage
      - Facilities are located such that as many demand points as possible are allocated to solution facilities within the impedance cutoff; additionally, the weighted demand allocated to a facility can't exceed the facility's capacity.
      - Maximize Capacitated Coverage chooses facilities such that all or the greatest amount of demand can be served without exceeding the capacity of any facility.

Network Analysis

- Location-Allocation Analysis
  - Problem types:
    - Minimize facilities
      - Facilities are located such that as many demand points as possible are allocated to solution facilities within the impedance cutoff; additionally, the number of facilities required to cover demand points is minimized.
        - » Minimize Facilities/Maximize Coverage
      - Minimize Facilities is the same as Maximize Coverage but with the exception of the number of facilities to locate, which in this case is determined by the solver.

Network Analysis

- Location-Allocation Analysis
  - Problem types:
    - Maximize attendance
      - Facilities are chosen such that as much demand weight as possible is allocated to facilities while assuming the demand weight decreases in relation to the distance between the facility and the demand point.
      - Specialty stores that have little or no competition benefit from this problem type, but it may also be beneficial to general retailers and restaurants that don't have the data on competitors necessary to perform market share problem types. Some businesses that might benefit from this problem type include coffee shops, fitness centers, dental and medical offices, bowling alleys, and electronics stores. Public transit bus stops are often chosen with the help of Maximize Attendance.

Network Analysis

- Location-Allocation Analysis
  - Problem types:
    - Maximize market share
      - A specific number of facilities are chosen such that the allocated demand is maximized in the presence of competitors. The goal is to capture as much of the total market share as possible with a given number of facilities, which you specify. The total market share is the sum of all demand weight for valid demand points.
      - The market share problem types require the most data because, along with knowing your own facilities' weight, you also need to know that of your competitors' facilities. The same types of facilities that use the Maximize Attendance problem type can also use market share problem types given that they have comprehensive information that includes competitor data.

Network Analysis

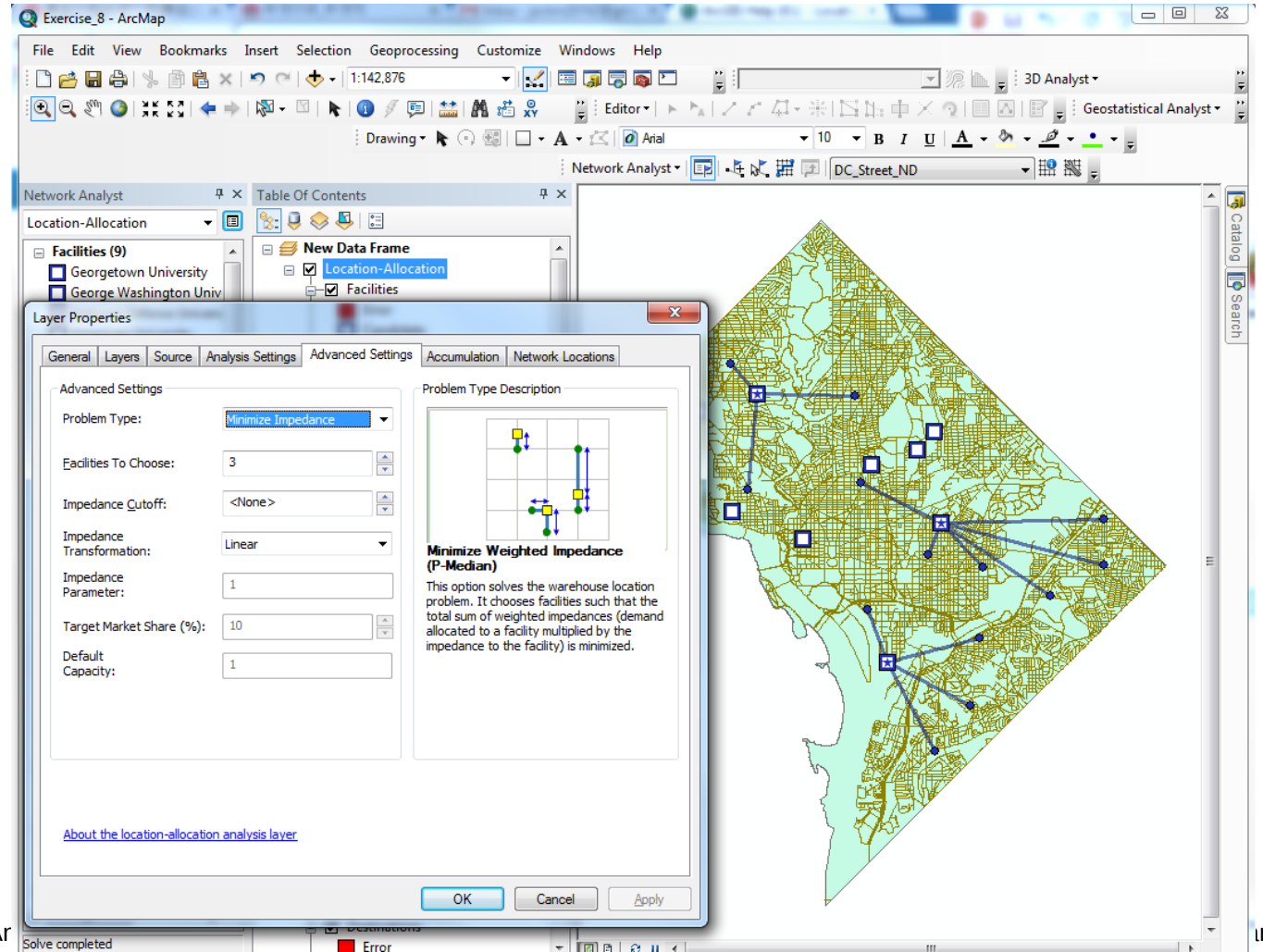
- Location-Allocation Analysis
  - Problem types:
    - Target market share
      - Target Market Share chooses the minimum number of facilities necessary to capture a specific percentage of the total market share in the presence of competitors. The total market share is the sum of all demand weight for valid demand points. You set the percent of the market share you want to reach and let the solver choose the fewest number of facilities necessary to meet that threshold.

Network Analysis

- Location-Allocation Analysis

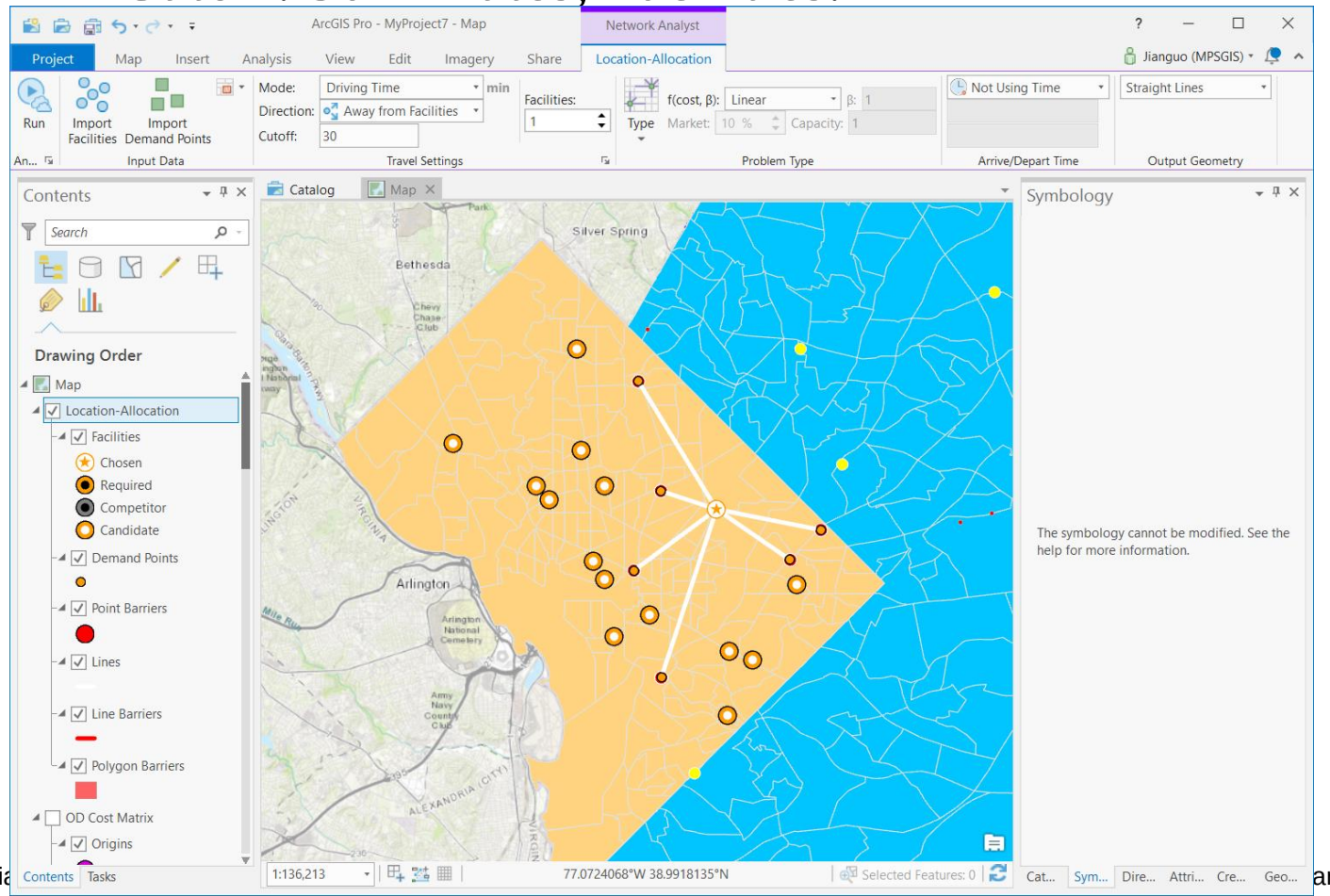
Network Analysis

- Location-Allocation Analysis
  - Example



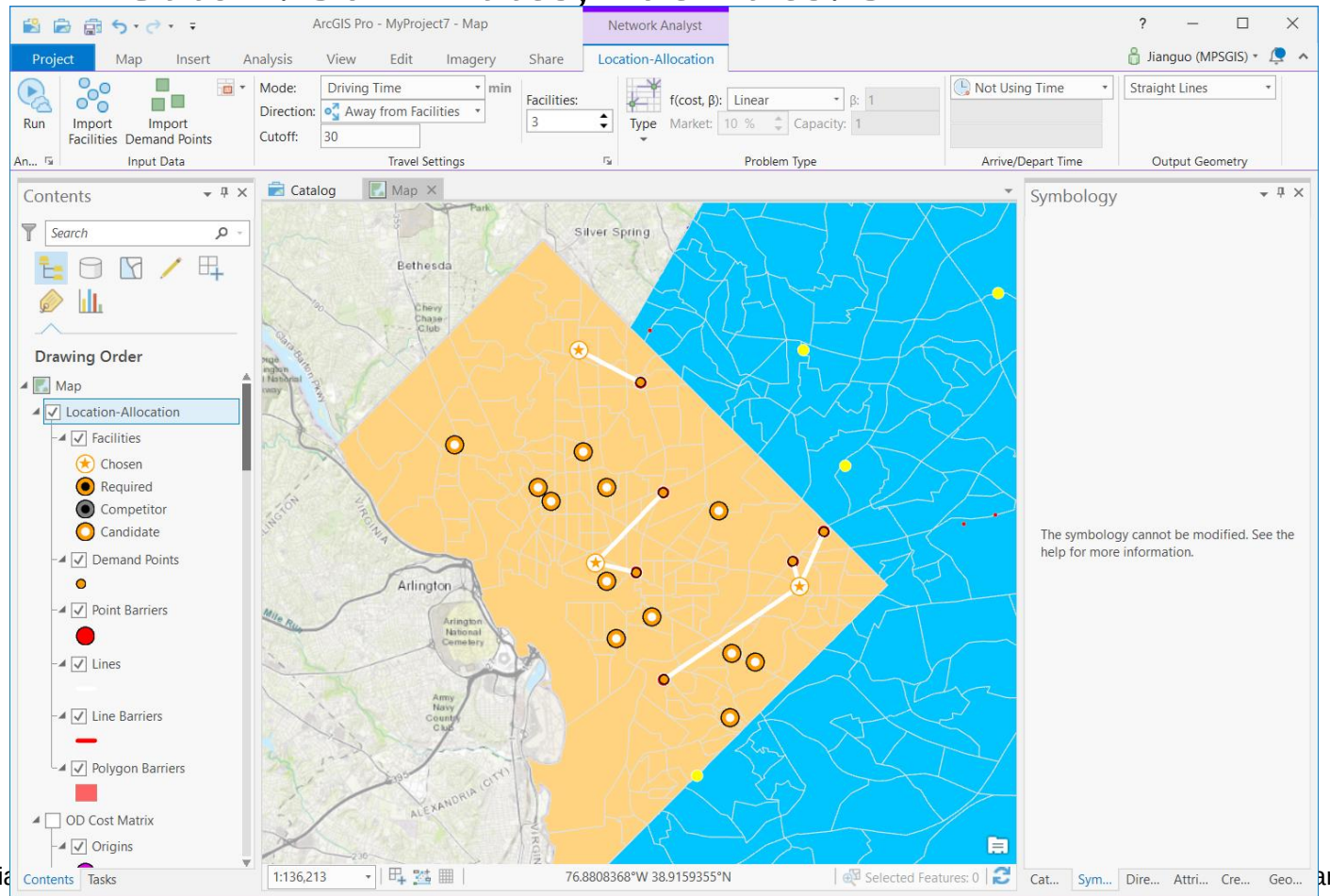
Network Analysis

- Location-Allocation Analysis
  - Example (Problem Type: minimize impedance)
    - Cutoff: 30 minutes; Facilities: 1



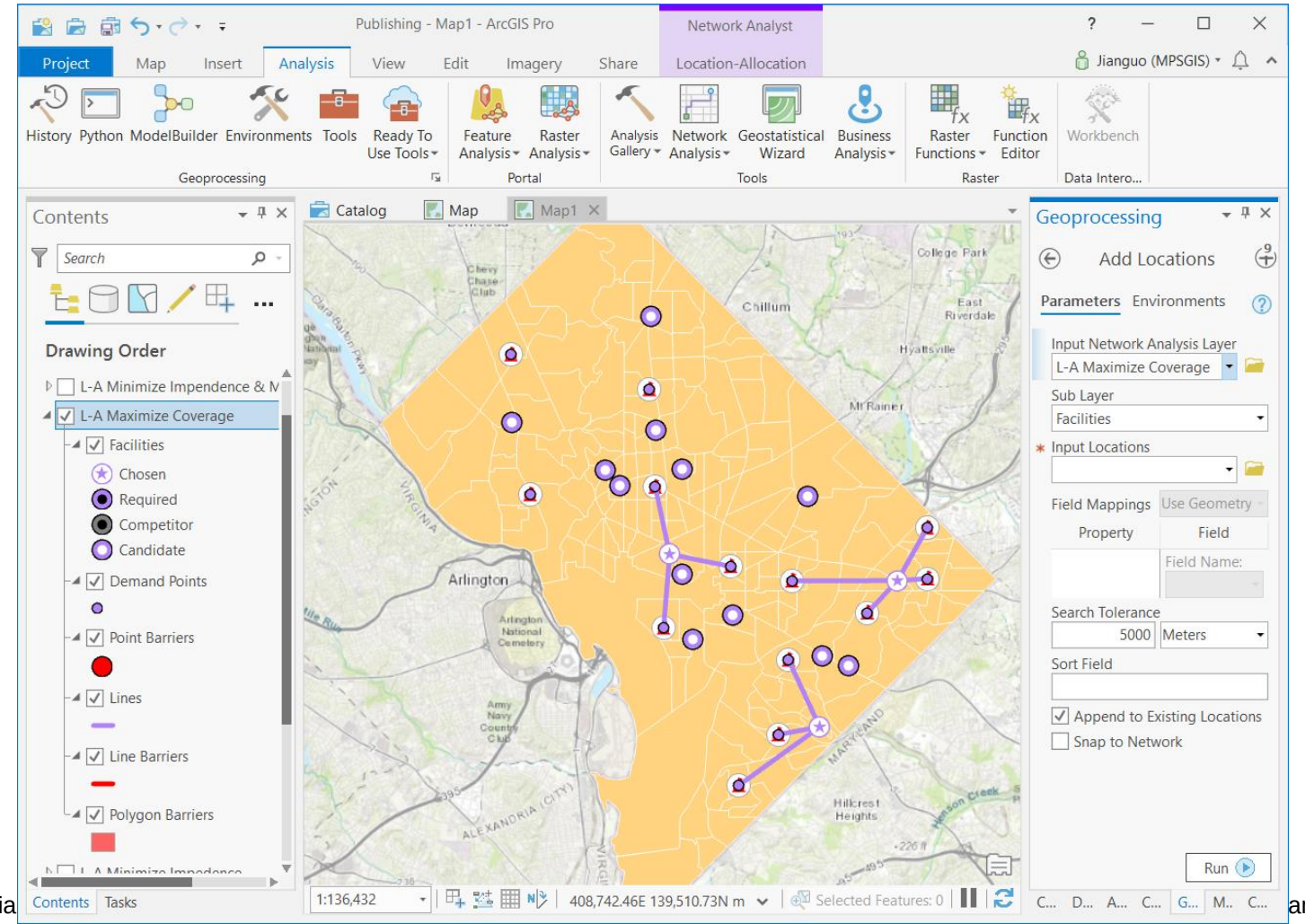
Network Analysis

- Location-Allocation Analysis
  - Example (Problem Type: minimize impedance)
    - Cutoff: 30 minutes; Facilities: 3



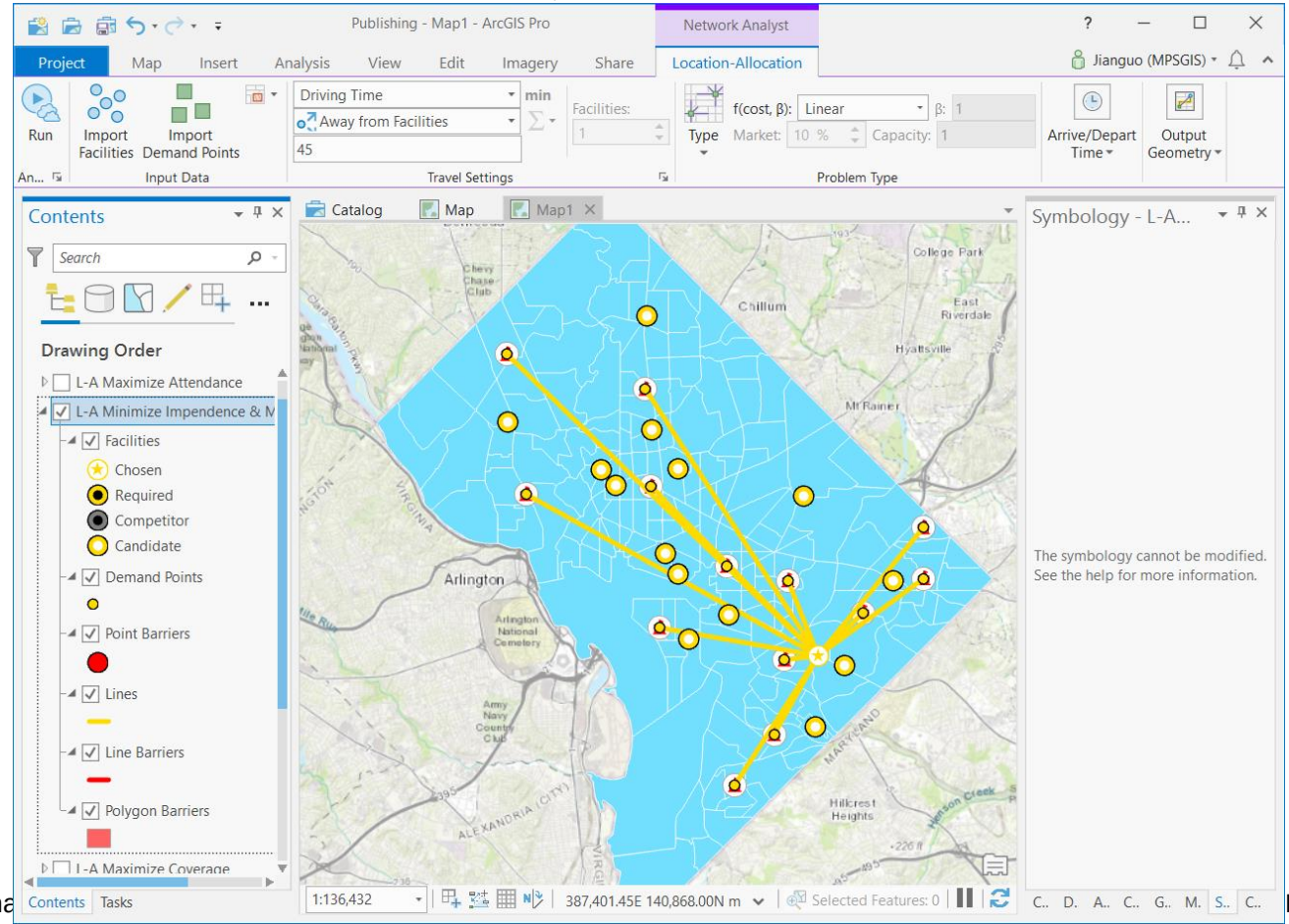
Network Analysis

- Location-Allocation Analysis
  - Example (Problem Type: Maximize Coverage)



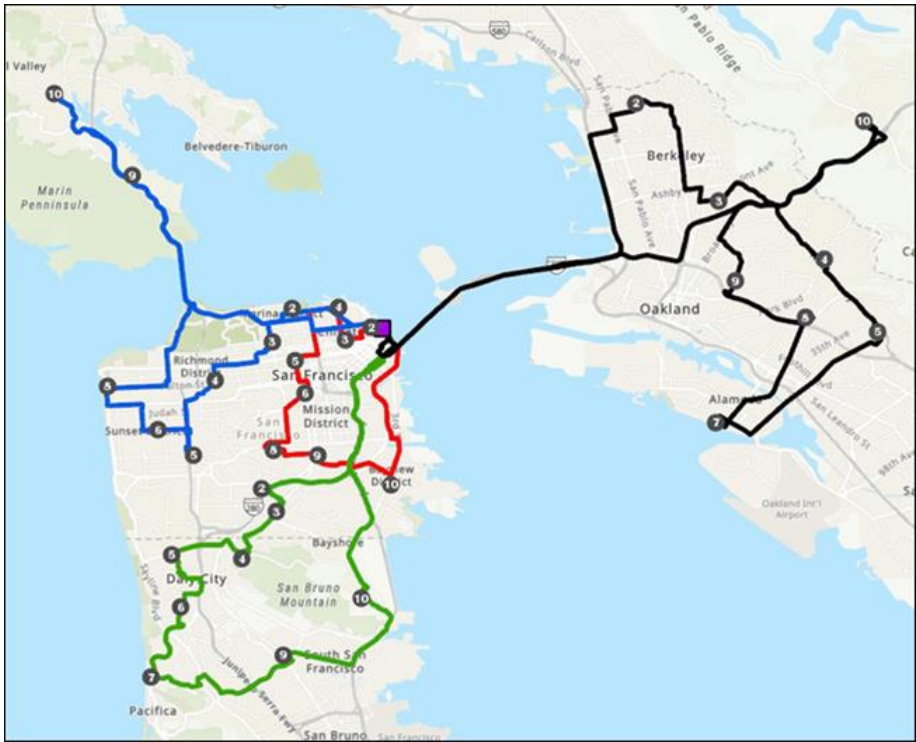
Network Analysis

- Location-Allocation Analysis
  - Example (Problem Type: Maximize Coverage and Minimize Facilities)



Network Analysis

- Vehicle Routing Problem Analysis
  - Routing analysis finds the best route for a single vehicle to visit many stops.
  - The VRP solver finds the best routes for a fleet of vehicles to service many orders.



Network Analysis

- Vehicle Routing Problem Analysis
  - Much more complexed version of Routing Analysis
    - Routing analysis for a fleet of vehicles
    - More input information (e.g. restrictions)
    - More output information

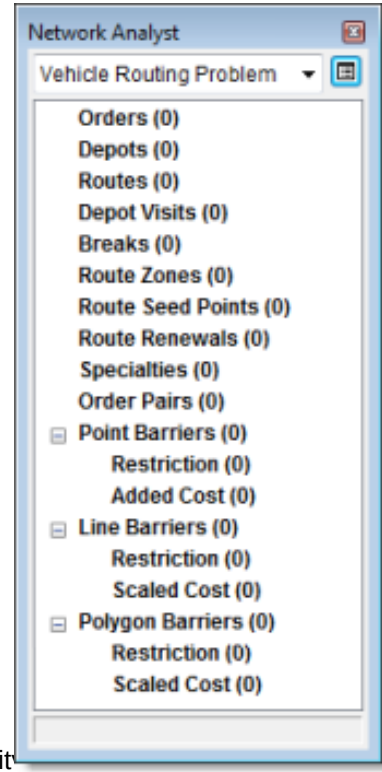
- https://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/vehicle-routing-problem.htm

Network Analysis

- Vehicle Routing Problem Analysis
  - Much more complexed version of Routing Analysis
    - Example: A fleet of Walmart trucks are trying to deliver merchandise to many stores.
      - Need to determine which orders (homes, restaurants, or inspection sites) should be serviced by each route (truck or inspector) and in what sequence the orders should be visited.
      - The primary goal is to best service the orders and minimize the overall operating cost for the fleet of vehicles.
      - In addition, the VRP solver can solve more specific problems because numerous options are available, such as matching vehicle capacities with order quantities, giving breaks to drivers, and pairing orders so they are serviced by the same route.

Network Analysis

- Vehicle Routing Problem Analysis
  - VRP analysis layer
    - Many inputs: Orders, Depots, Routes, Depot Visits, Breaks, Route Zones, Route Seed Points, Route Renewals, Specialties, Order Pairs, Point Barriers, Line Barriers, and Polygon Barriers.



Network Analysis

- Network Analysis with Different Platforms
  - ArcMap
  - ArcGIS Pro
  - **ArcGIS Online**
    - Demos

Network Analysis

- Geocoding with Different Platforms
  - ArcMap
  - ArcGIS Pro
  - ArcGIS Online

Geocoding

- What is Geocoding?
  - The process of assigning a location, usually in the form of coordinate values, to an address by comparing the descriptive location elements in the address to those present in the reference material.

Geocoding

- What is Geocoding?
  - Geocoding with ArcGIS Desktop
    - A single address
    - A table of addresses
  - Geocoding with ArcGIS Online
    - A single address
    - A table of addresses
  - Geocoding with ArcGIS Pro

Geocoding

- What do you need?
  - An address table / Customers Table
  - A set of reference data
  - Address locator
    - A file that specifies the reference data and its relevant attributes, the relevant attributes from the address table, and various geocoding rules and tolerances.
  - How does geocoding work?

Geocoding

- Application Scenarios
  - Convert single address interactively
  - Convert a list of addresses automatically
  - Find driving route between two or more stops
    - Distance
    - Travel time
    - Driving directions

Geocoding

- Application Scenarios
  - Convert a list of addresses automatically
    - Create a Table of Addresses
    - The table can be in DBF, CSV or XLS format.

Microsoft Excel - Restaurants.dbf

File Edit View Insert Format Tools Data Window Help Adobe PDF — Type a question for help

Arial 10 — A1 — NAME

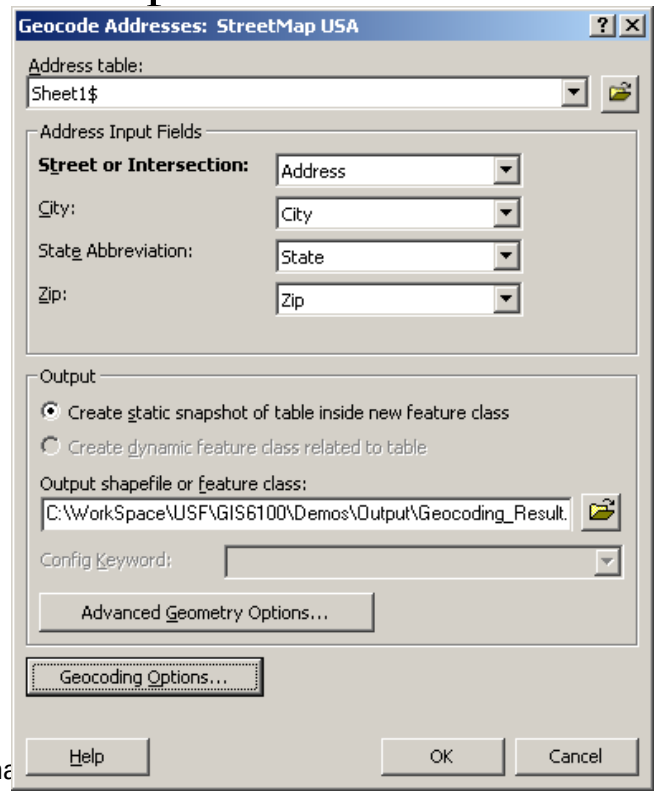
	A	B	C	D	E	F	G	H
1	NAME	ADDRESS	CITY	ZIP	STATE	PHONE		
2	Panera Bread	112 S West Shore Blvd	Tampa	33609	Florida	(813) 286-7119		
3	Panera Bread	11860 Bruce B Downs Blvd	Tampa	33612	Florida	(813) 866-9333		
4	Panera Bread	709 S Howard Ave	Tampa	33606	Florida	(813) 253-5888		
5	Pizza Hut	614 W Platt St	Tampa	33606	Florida	(813) 251-3399		
6	Pizza Hut	14799 N Dale Mabry Hwy	Tampa	33618	Florida	(813) 963-1512		
7	Pizza Hut	402 S Dale Mabry Hwy	Tampa	33609	Florida	(813) 879-3311		
8	Chili's	13050 N Dale Mabry Hwy	Tampa	33618	Florida	(813) 963-3882		
9	Chili's	8510 W Hillsborough Ave	Tampa	33615	Florida	(813) 887-5955		
10								

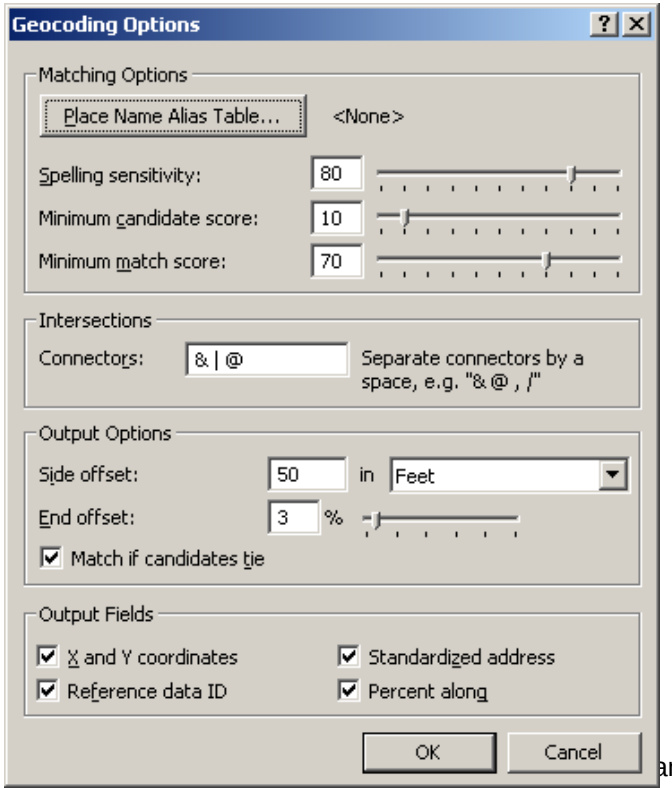
Restaurants

Ready SCRL

Geocoding

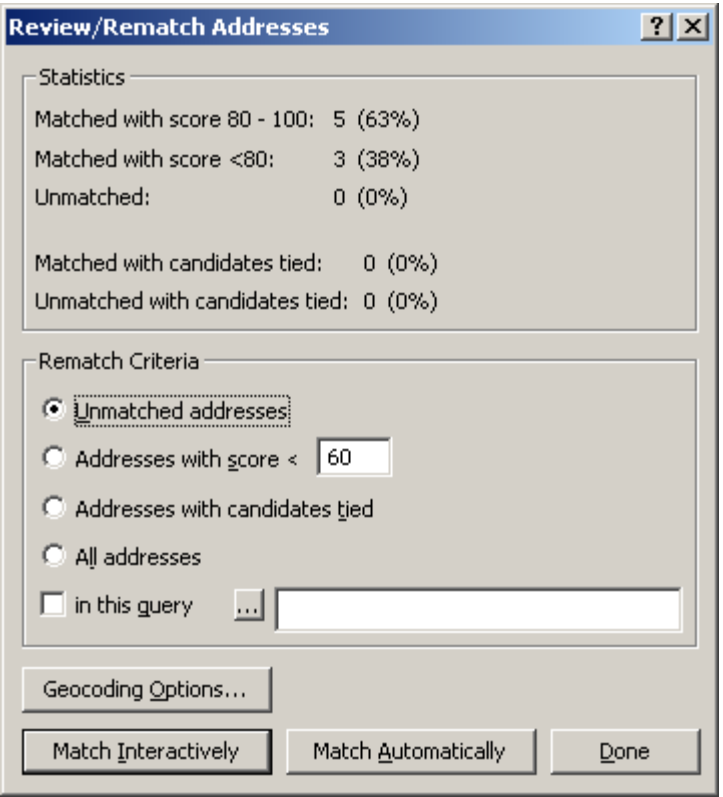
- Application Scenarios
  - Convert a list of addresses automatically
    - You may want to modify the Geocoding Options to determine some of the attributes to be shown in the output dataset.

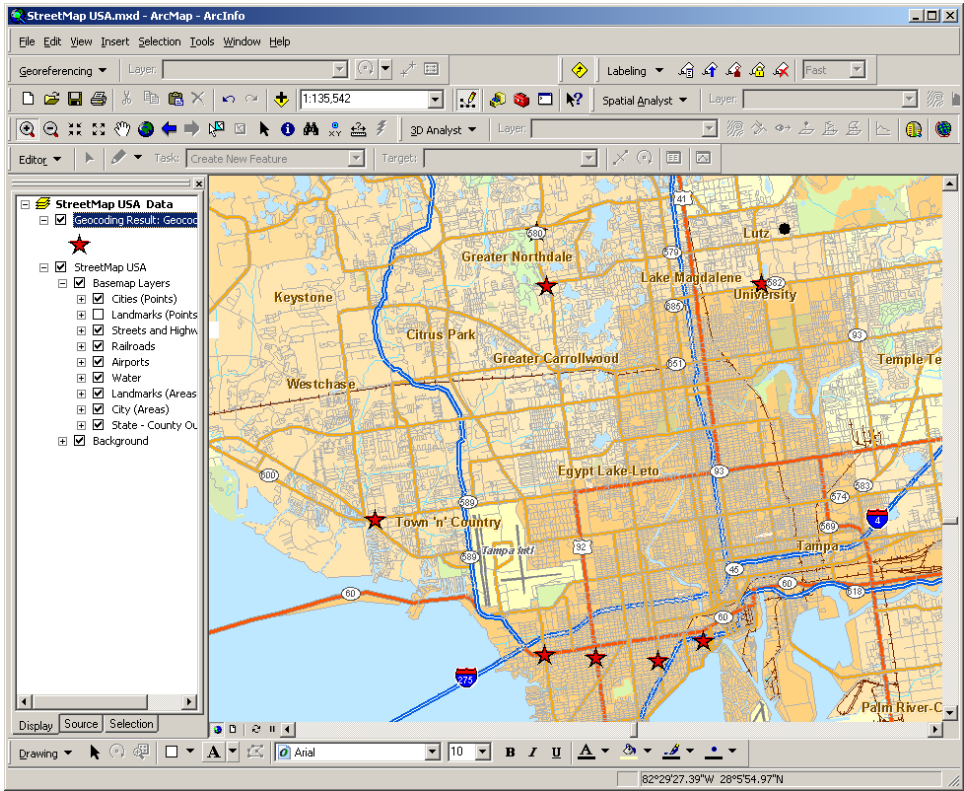




Geocoding

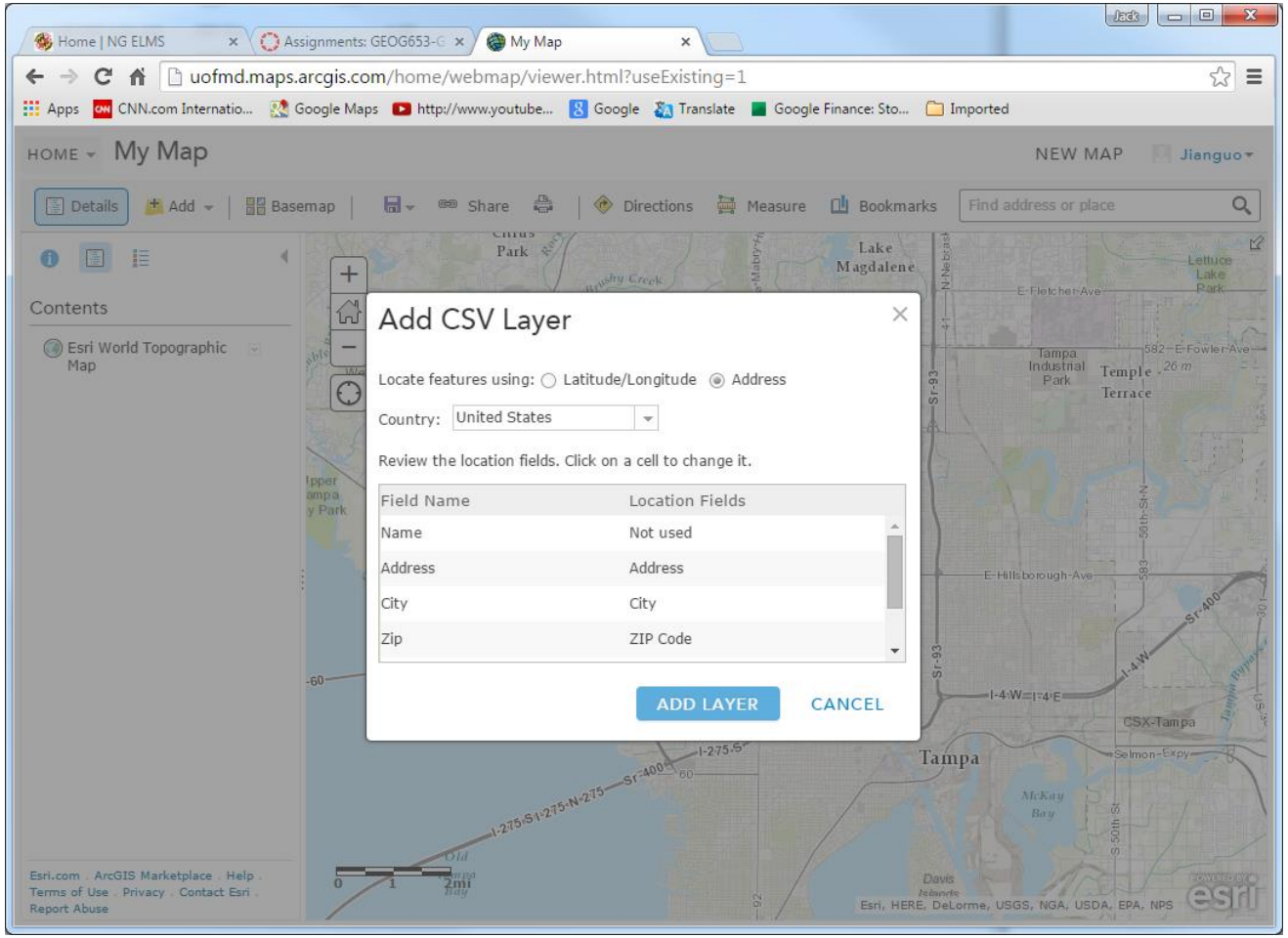
- Application Scenarios
  - Convert a list of addresses automatically
    - Mismatches happen often.
    - Match interactively.





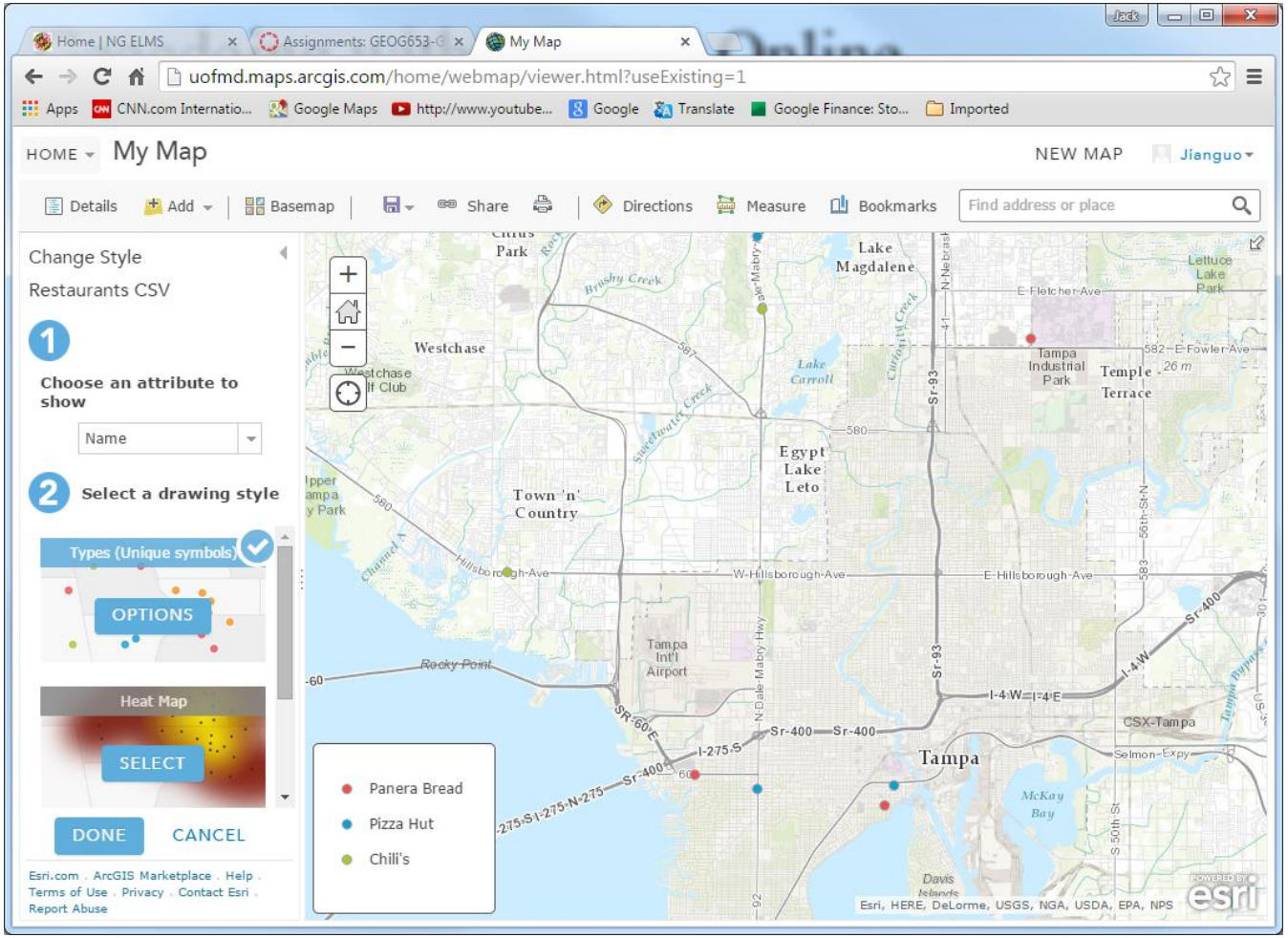
Geocoding

- Geocoding with ArcGIS Online
  - Example: using a table of addresses



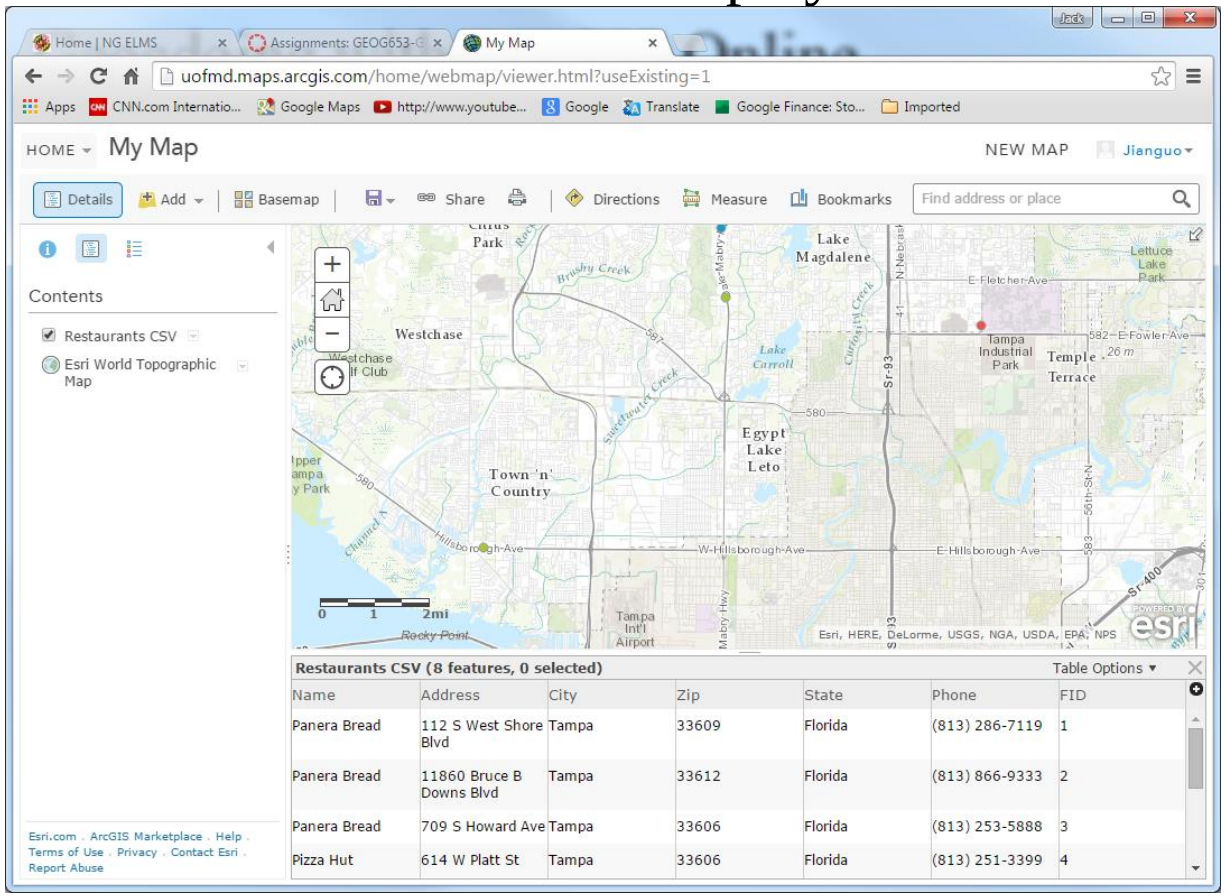
Geocoding

- Geocoding with ArcGIS Online
  - Example: using a table of addresses



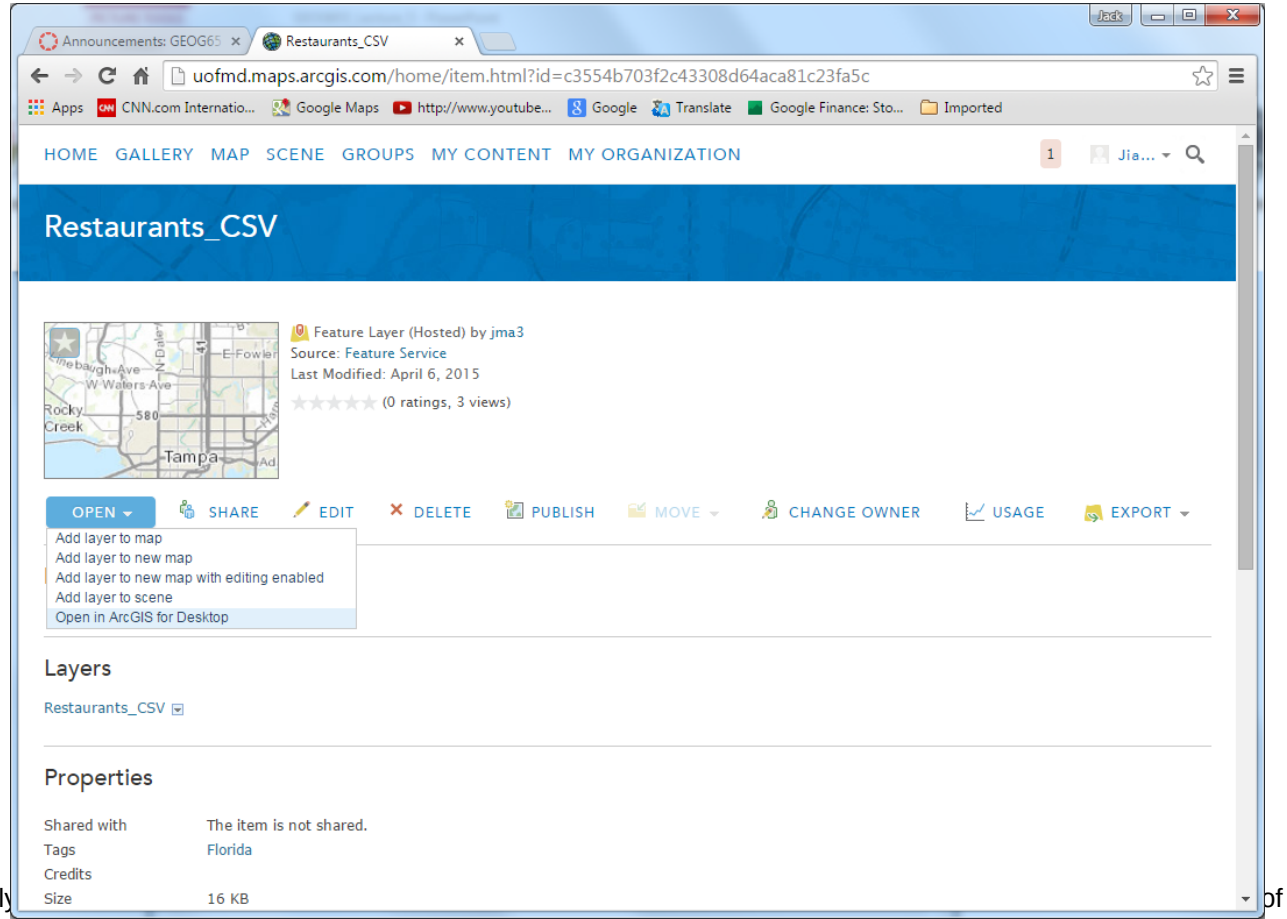
Geocoding

- Geocoding with ArcGIS Online
  - Example: using a table of addresses
    - Address table can be displayed



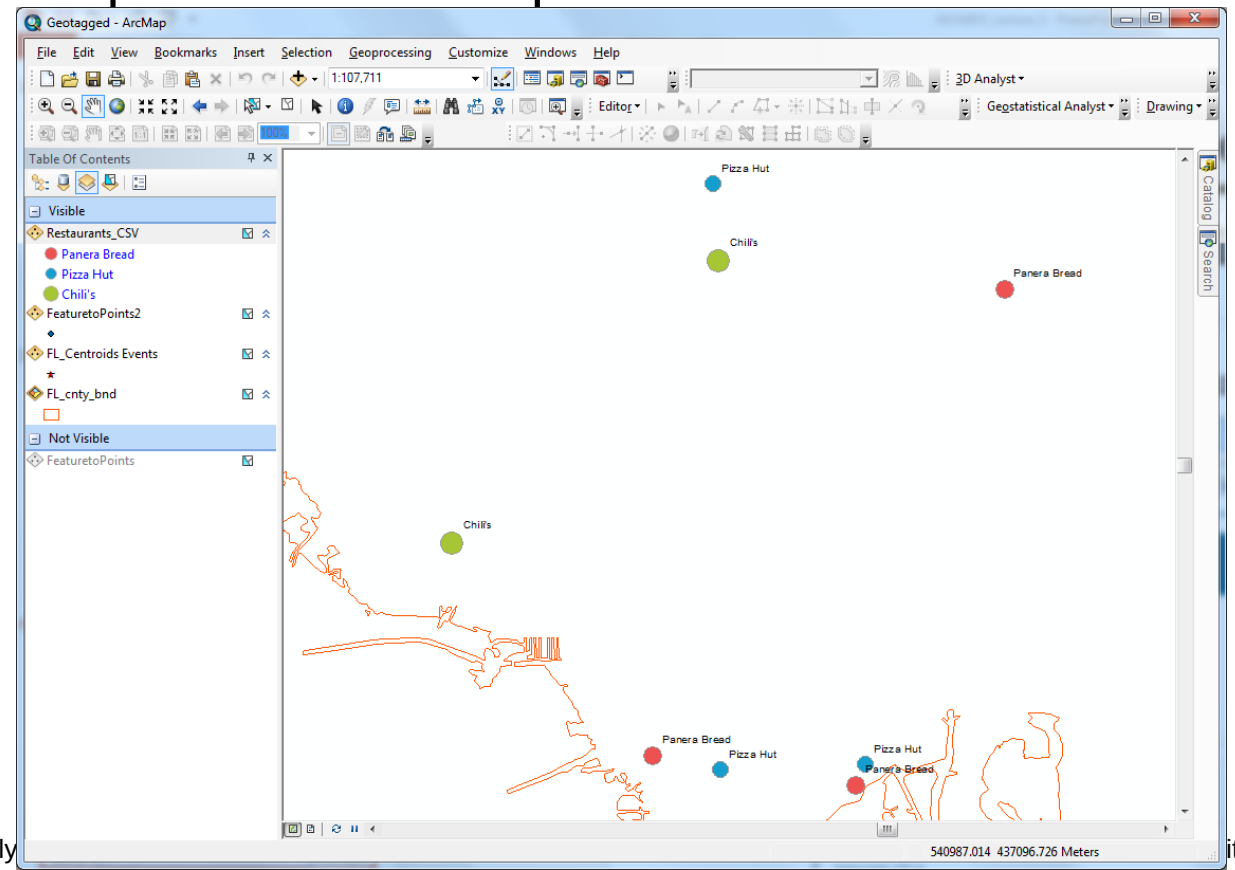
Geocoding

- Geocoding with ArcGIS Online
  - Example: using a table of addresses
    - The geocoded points can be published into a service



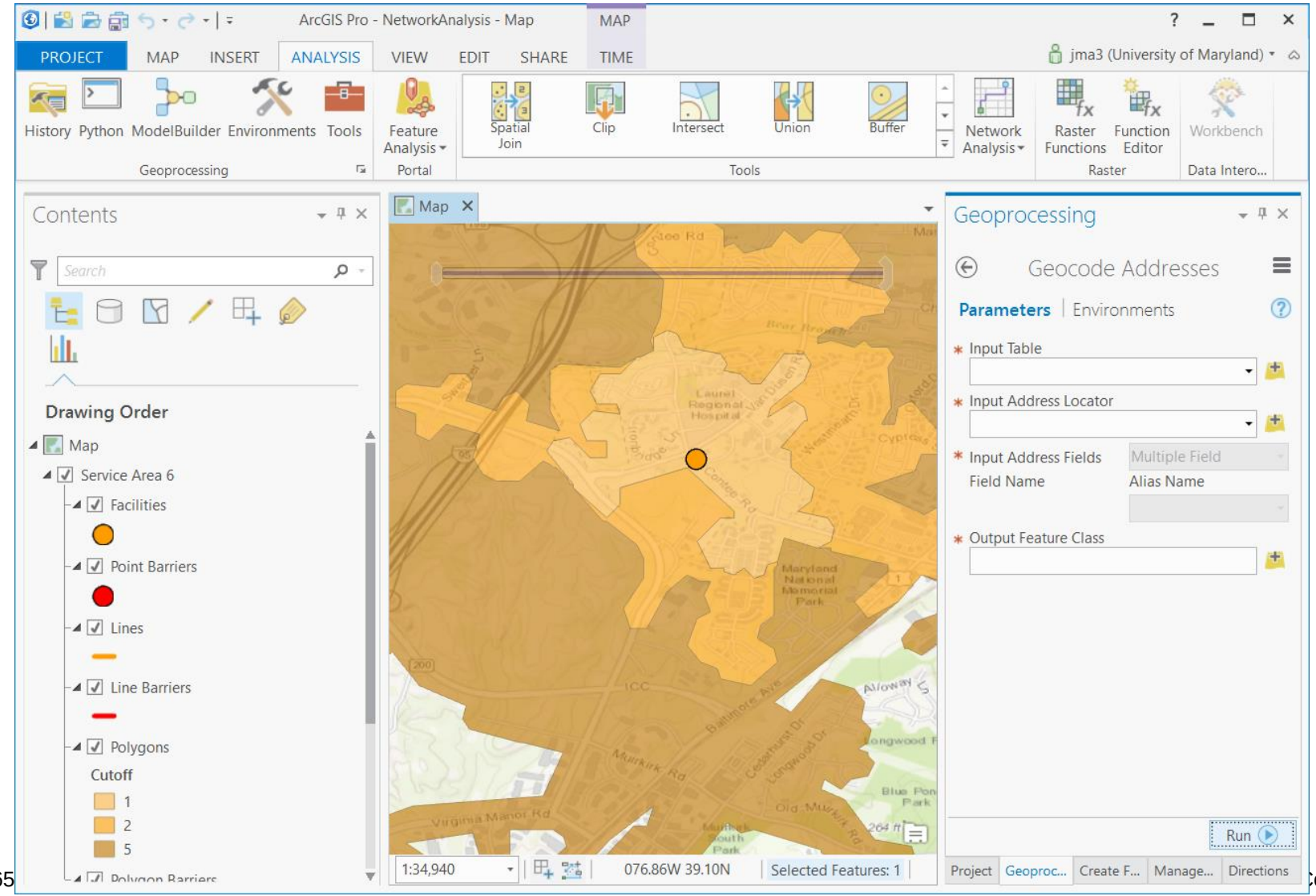
Geocoding

- Geocoding with ArcGIS Online
  - Example: using a table of addresses
    - The service layer can be added into ArcMap and then exported into a shapefile



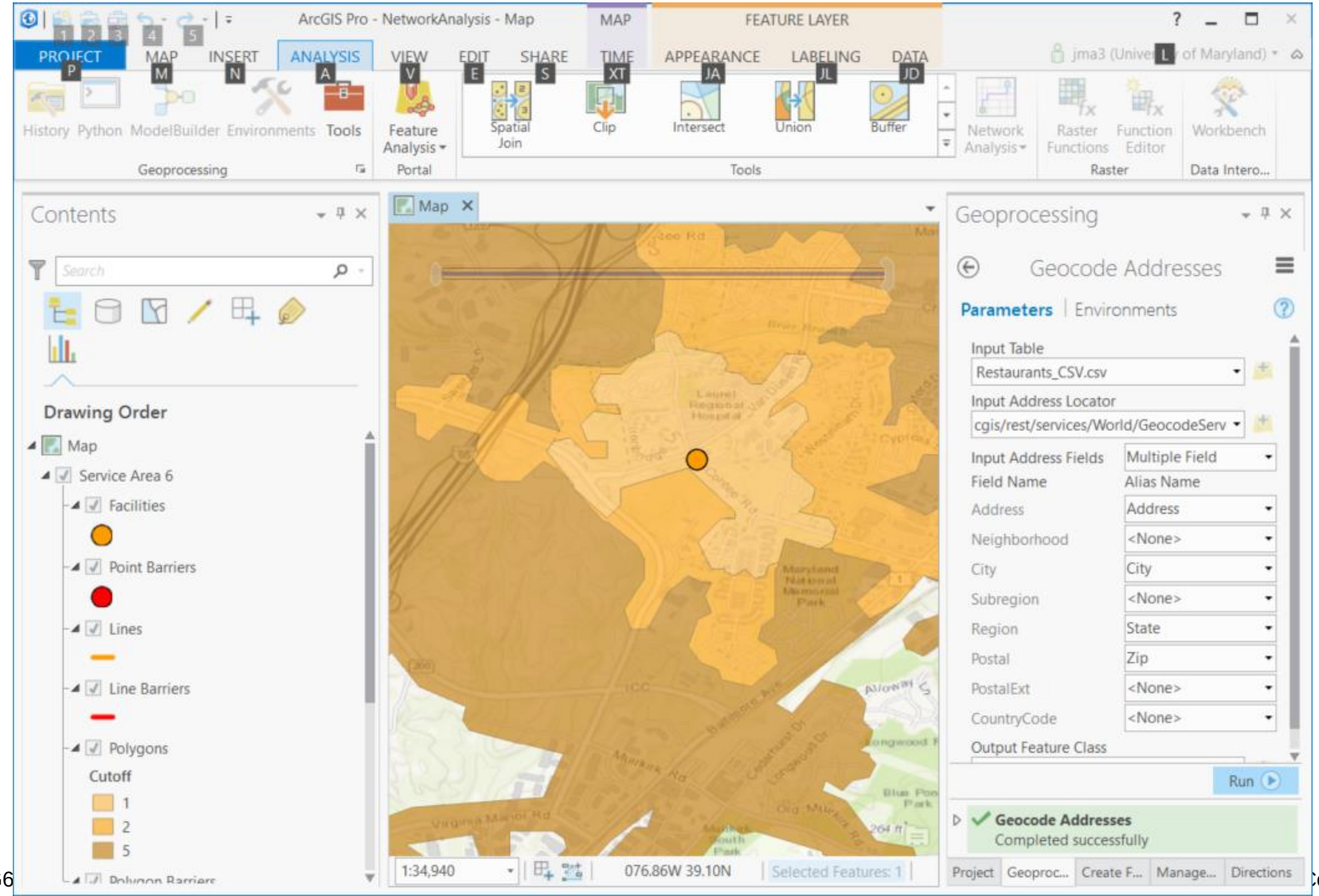
Geocoding

- Geocoding with ArcGIS Pro



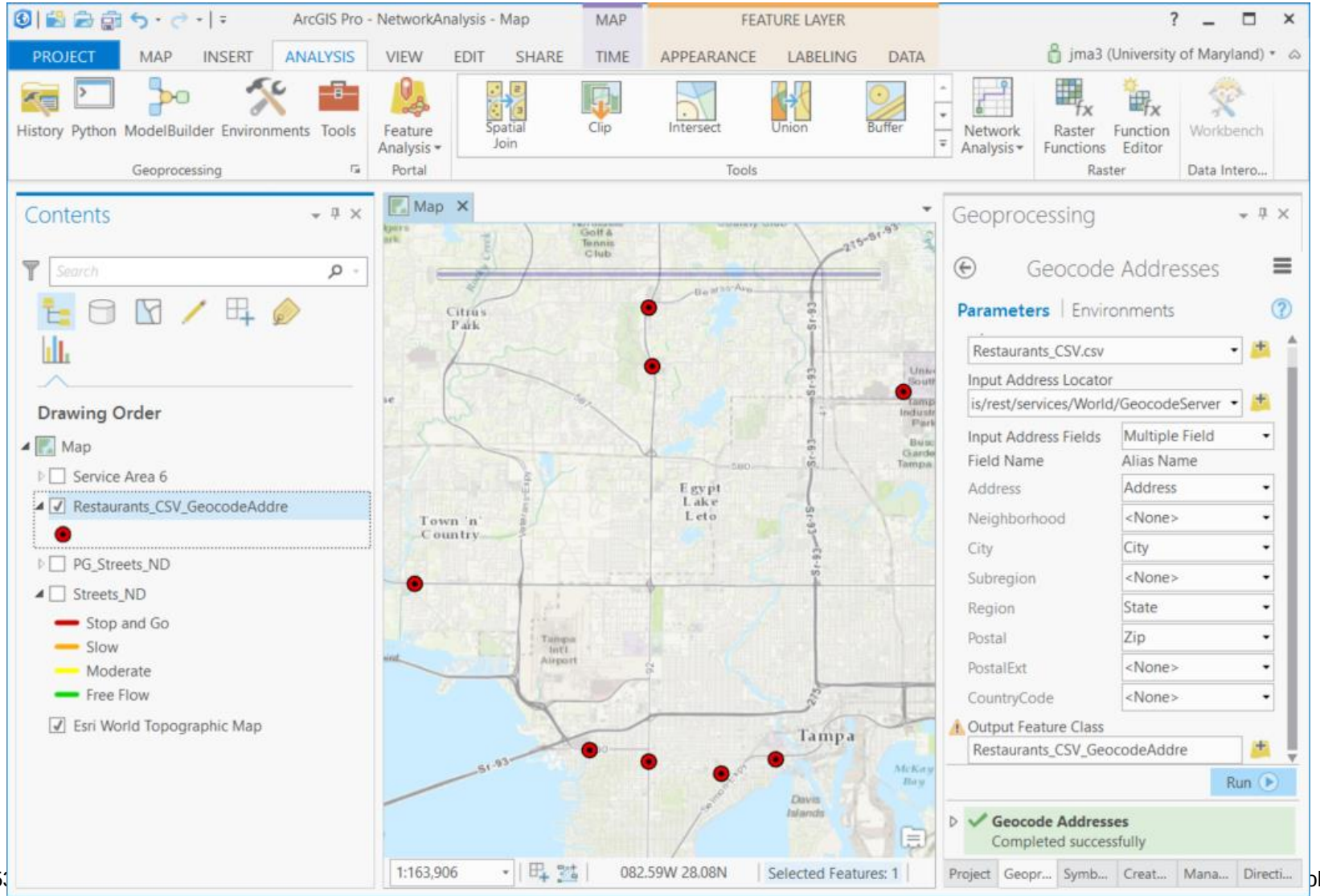
Geocoding

- Geocoding with ArcGIS Pro



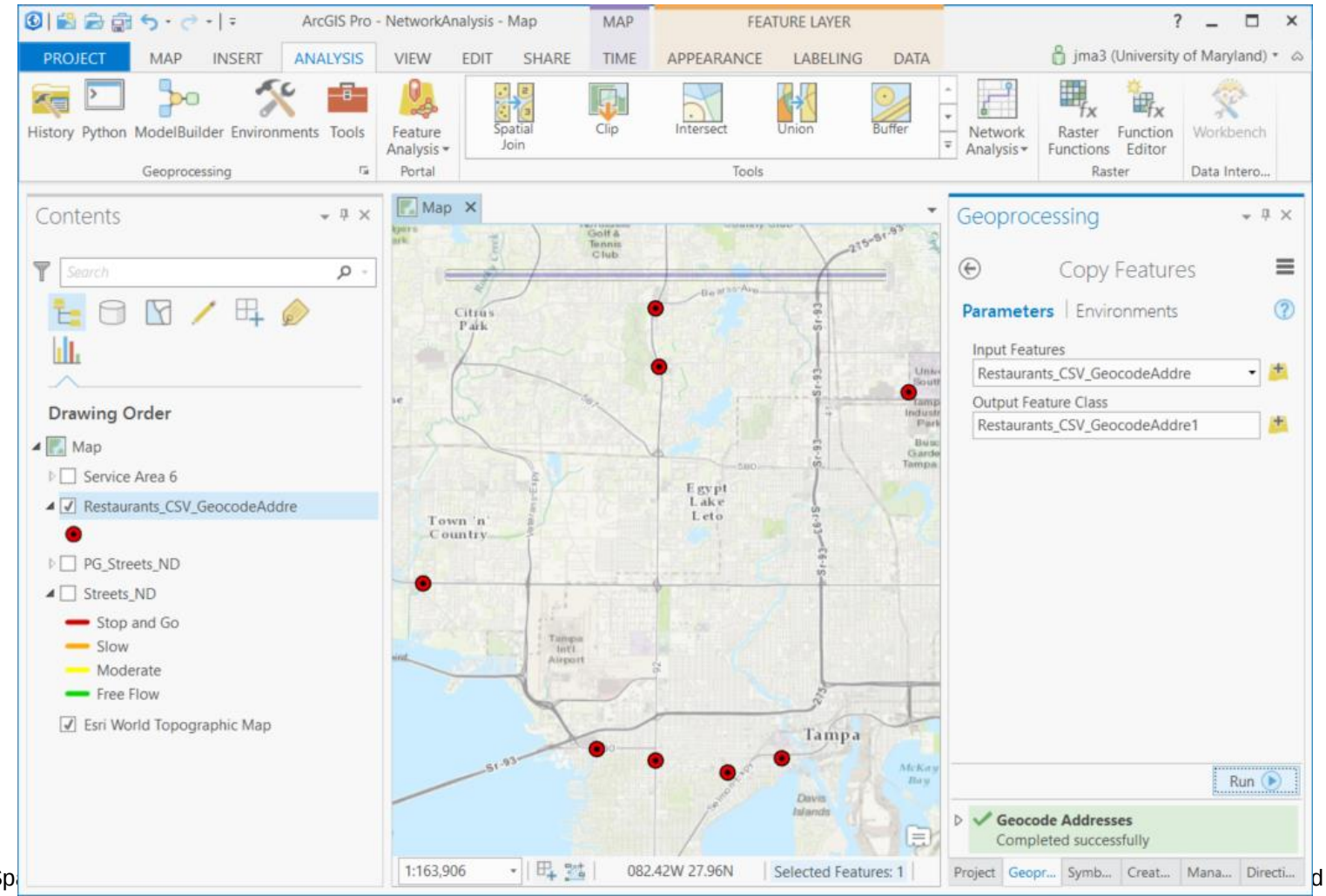
Geocoding

- Geocoding with ArcGIS Pro



Geocoding

- Geocoding with ArcGIS Pro
  - Export features



THE END