DCFD – NE Fire Company Location Optimizing

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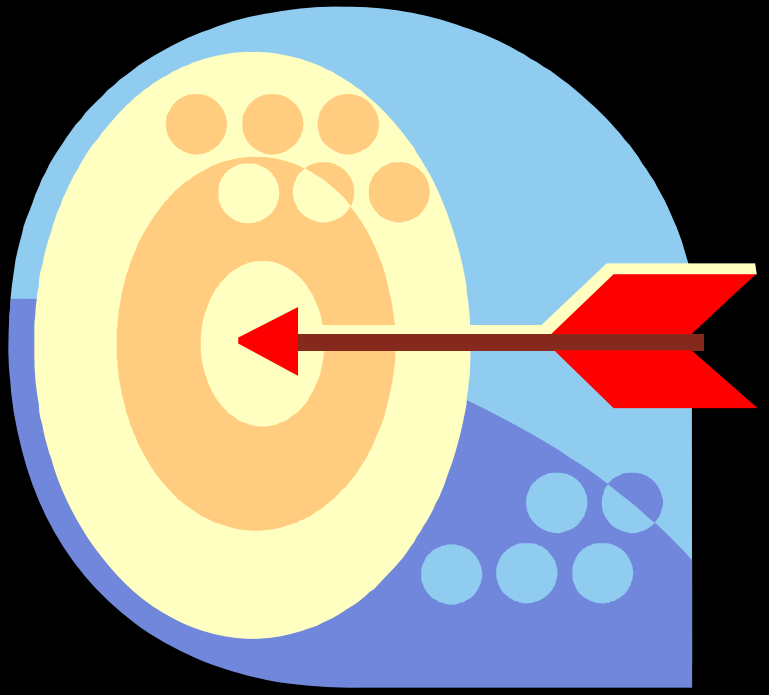
ENCE 360 – Spring 2005

Overview of Project

1. Study Washington, DC Northeast District
2. Use Fire Run Data
3. Use Property Value Data
4. Use Census Data
5. Use ArcGIS to pick possible locations
6. Write a Decision Model to pick best Locations

Objective of Project

- To minimize number of Fire Stations
  - Budget constraints
  - Duplication of services
- To minimize travel times
  - Decision of routes
- Conform to NFPA 1710
  - Accepted travel times



Fire Department Response Time

(**Traditional**)

(*Total*)

- ignition and pre-burn
- smoke detector activates and sends alarm
- alarm arrives to central station & is processed to dispatch center
- dispatch center processes alarm
- *dispatch*
- *turn-out time: i.e. leave the fire station*
- ***travel time – where optimal programming will help***
- set-up time

Project Performance Measurement

- NFPA 1710-4.1.2.1

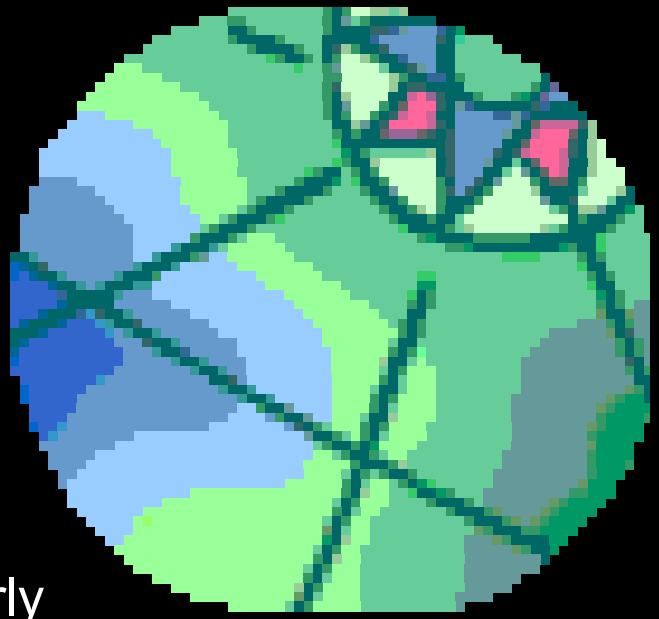
1. One minute (60 s) for turnout time
2. Four minutes (240 s) or less for the arrival of the first arriving engine company at a fire suppression incident and/or 8 minutes (480 s) or less for the deployment of a full first alarm assignment at a fire suppression incident

Project Performance Measurement

3. Four minutes (240 s) or less for the arrival of a unit with first responder or higher level capability at an emergency medical incident
4. Eight minutes (480 s) or less for the arrival of an advanced life support unit at an emergency medical incident, where this service is provided by the fire department

Response Area

- Consider current response area radius
- Average was 1441.3 meters
  - Converts to 0.8956 miles
    - Multiply by 60 (for MPH) = 53.736MPH
      - 4mins @ 13.4MPH
    - Considering that D.C. traffic rarely exceeds 20-25MPH, these are fairly reasonable numbers.



Goal

NFPA 1710 – 4.1.2.2

The fire department shall establish a performance objective or not less than 90% for the achievement of each response time objective specified in 4.1.2.1

Project Description

- Use ArcGIS to map NE DC
  - Call Volume Locations
    - Highest Needs Historically
  - Fire Companies Current Locations
  - Response Routes
    - Shortest Distance by node
  - Fire Company Possible Locations

Project Description

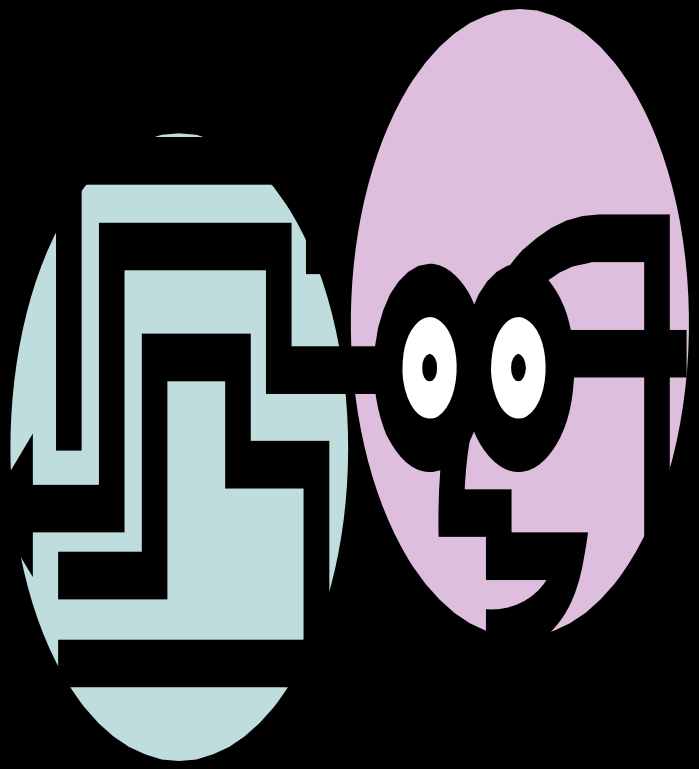
- Determine If:
  - Adequate Fire Companies
    - Proper location or need to be moved
  - Need More Fire Companies
  - Need Less Fire Companies
- Constraints of:
  - Meet NFPA 1710 – will determine how many needed
  - Locate Fire Houses where highest call volume are within response area

Current Fire Company - NE

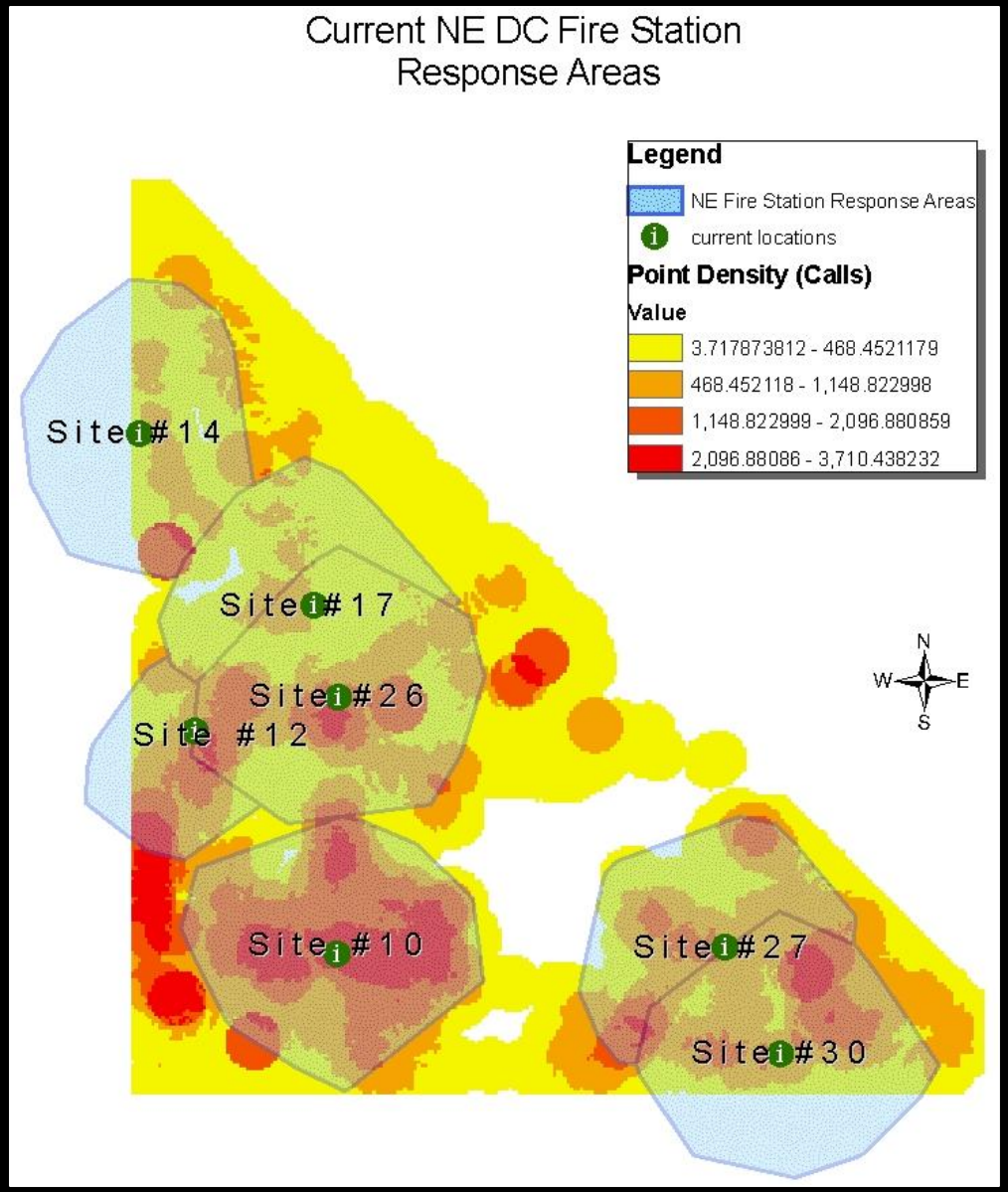
Site #	Address or Intersection
1	1342 Florida Ave. NE
2	2225 5th St. NE
3	4801 N. Capitol St. NE
4	1227 Monroe St. NE
5	1340 Rhode Island Ave. NE
6	4201 Minnesota Ave. NE
7	50 49th St. NE

ArcGIS

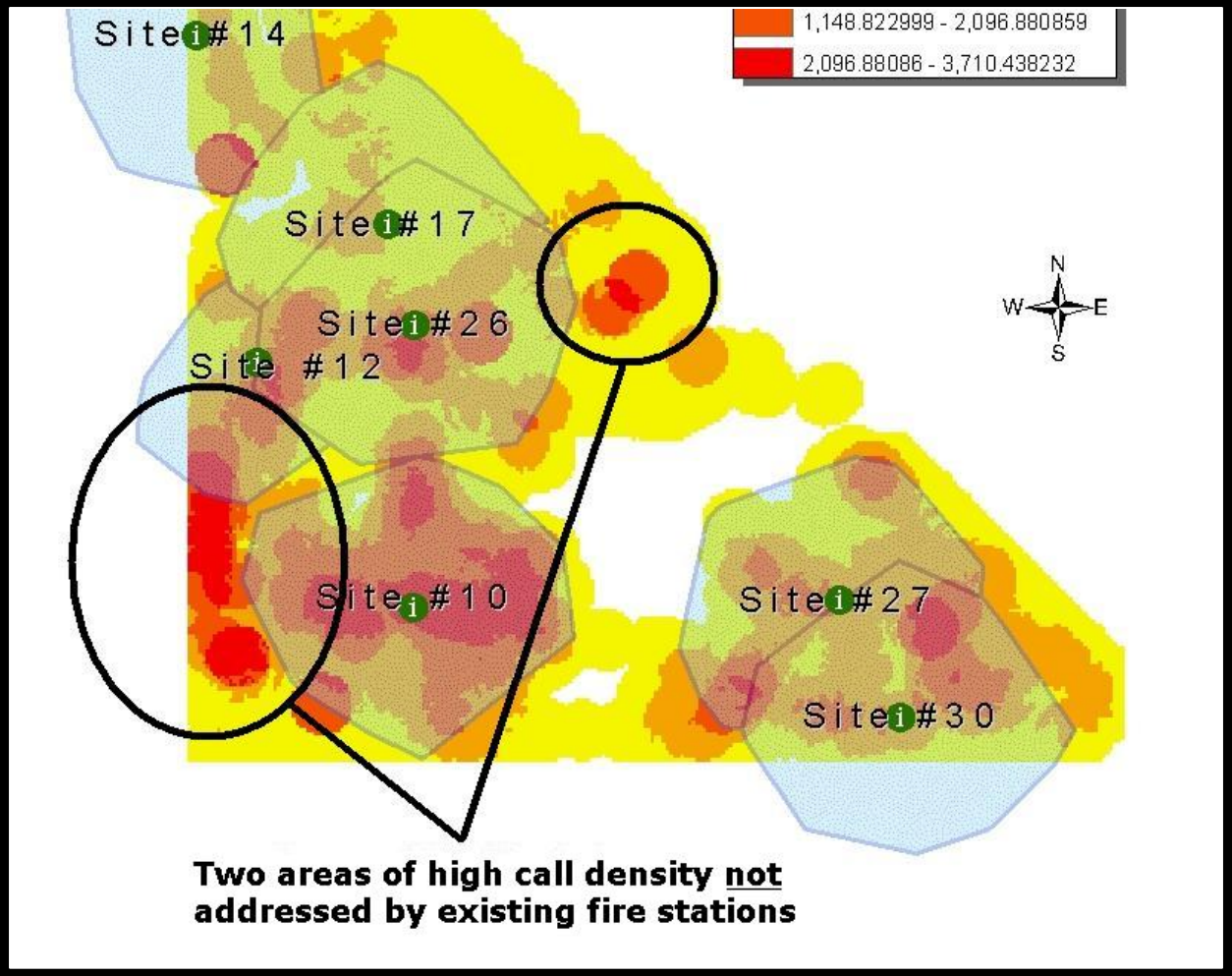
- Mapping Washington, D.C by:
- Call Density
- Current Fire House Locations
- New Possible Locations



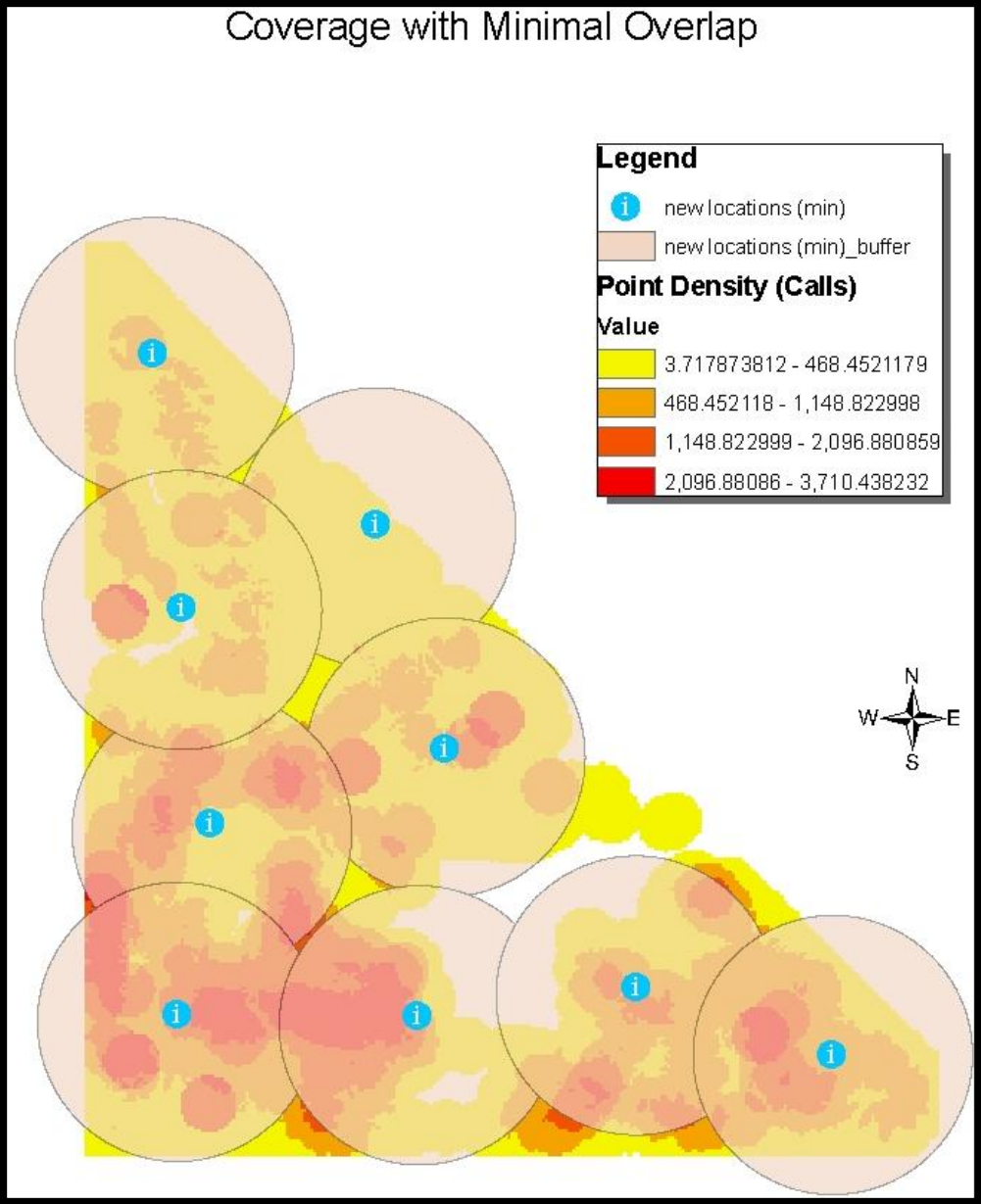
Current Locations



Areas Not Addressed



Minimize Stations



Linear Programming

- Used Integer Programming to recommend best location of stations based on
  - Call Density
  - Best Response Time to Location
  - Largest Area that could be covered by station

Integer Program Setup

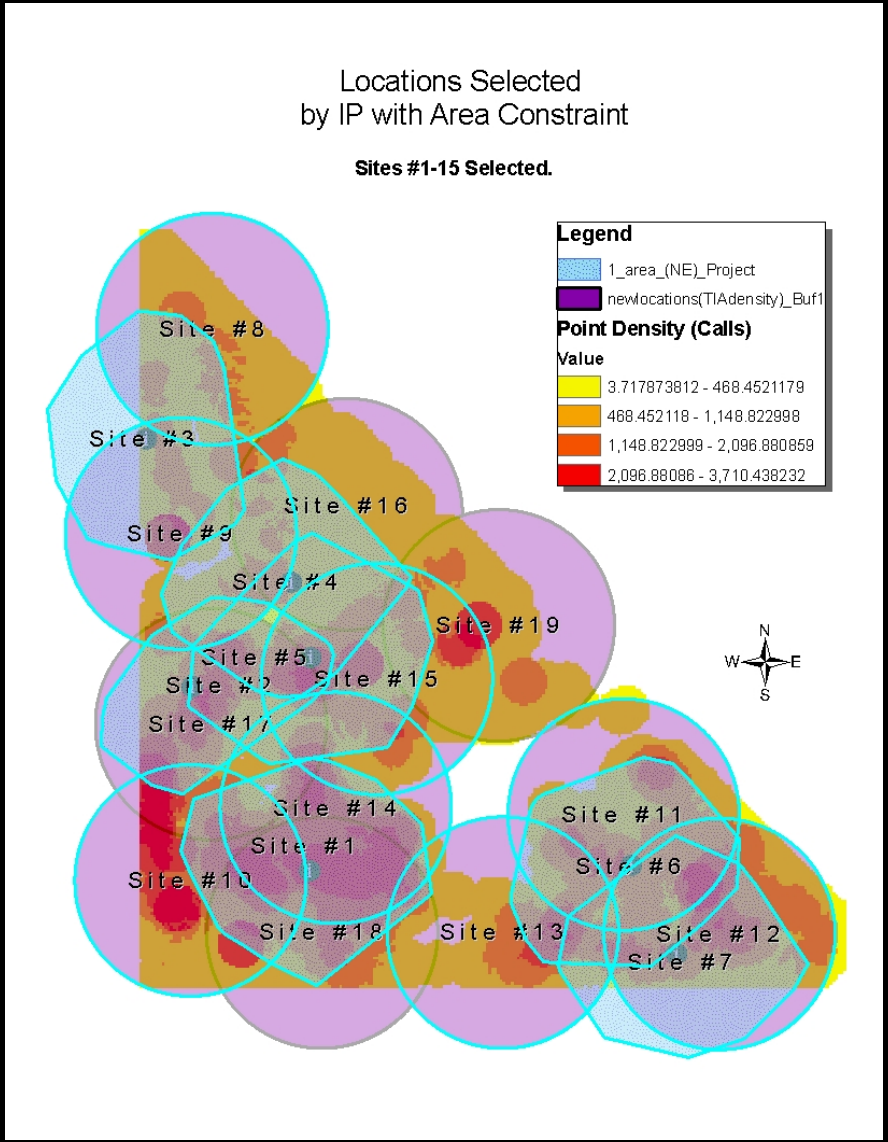
- Integer Program 1
- Chose by Response Area Constraint:
- Objective Call Density Function:
- Min Z = 9571S1 + 3392S2 + 3150S3 + 2771S4 5685S5 + 4905S6 + 7843S7 + 1342S8 + 2308S9 + 6808S10 + 3642S11 + 4494S12 + 2595S13 + 7848S14 + 3955S15 + 1869F16 + 5731S17 + 7069S18 + 1732S19
- Response Area (m^2) Constraint:
- 7700397S1 + 5168719S2 + 7046172S3 + 6216097S4 + 5355697S5 + 7074423S6 + 980474S7 + 6522865S8 + 6522865S9 + 6522865S10 + 6522865S11 + 6522865S12 + 6522865S13 + 6522865S14 + 6522865S15 + 6522865S16 + 6522865S17 + 6522865S18 + 6522865S19 ≥ 45266484
- Where: S*i* = Site number

Integer Program Setup

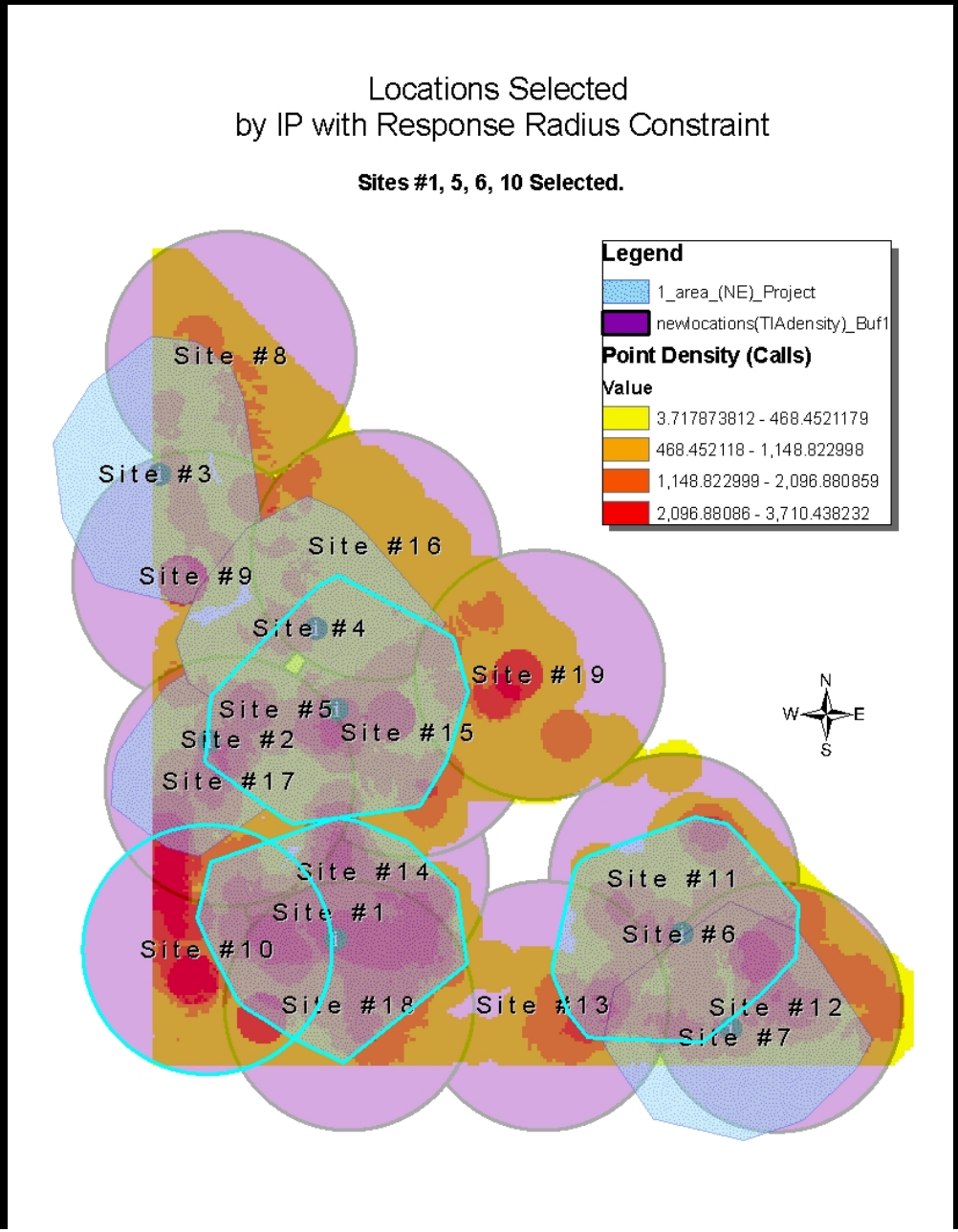
- Integer Program 2
- Chose by maximum response time to any point in response area:
- Objective Function: Max Z = 9571S1 + 3392S2 + 3150S3 + 2771S4 5685S5 + 4905S6 + 7843S7 + 1342S8 + 2308S9 + 6808S10 + 3642S11 + 4494S12 + 2595S13 + 7848S14 + 3955S15 + 1869F16 + 5731S17 + 7069S18 + 1732S19
- Response distance constraint (m) by velocity/time to any point in response area:
- 3132S1 + 2566S2 + 2996S3 + 2814S4 + 2612S5 + 1002S6 + 2982S7 + 2882.6S8 + 2882.6S9 + 2882.6S9 + 2882.6S10 + 2882.6S11 + 2882.6S12 + 2882.6S13 + 2882.6S14 + 2882.6S15 + 2882.6S16 + 2882.6S17 + 2882.6S18 + 2882.6S19 ≤ 9816
- Where: S*i* = Site number

Conclusions

Area Constraint



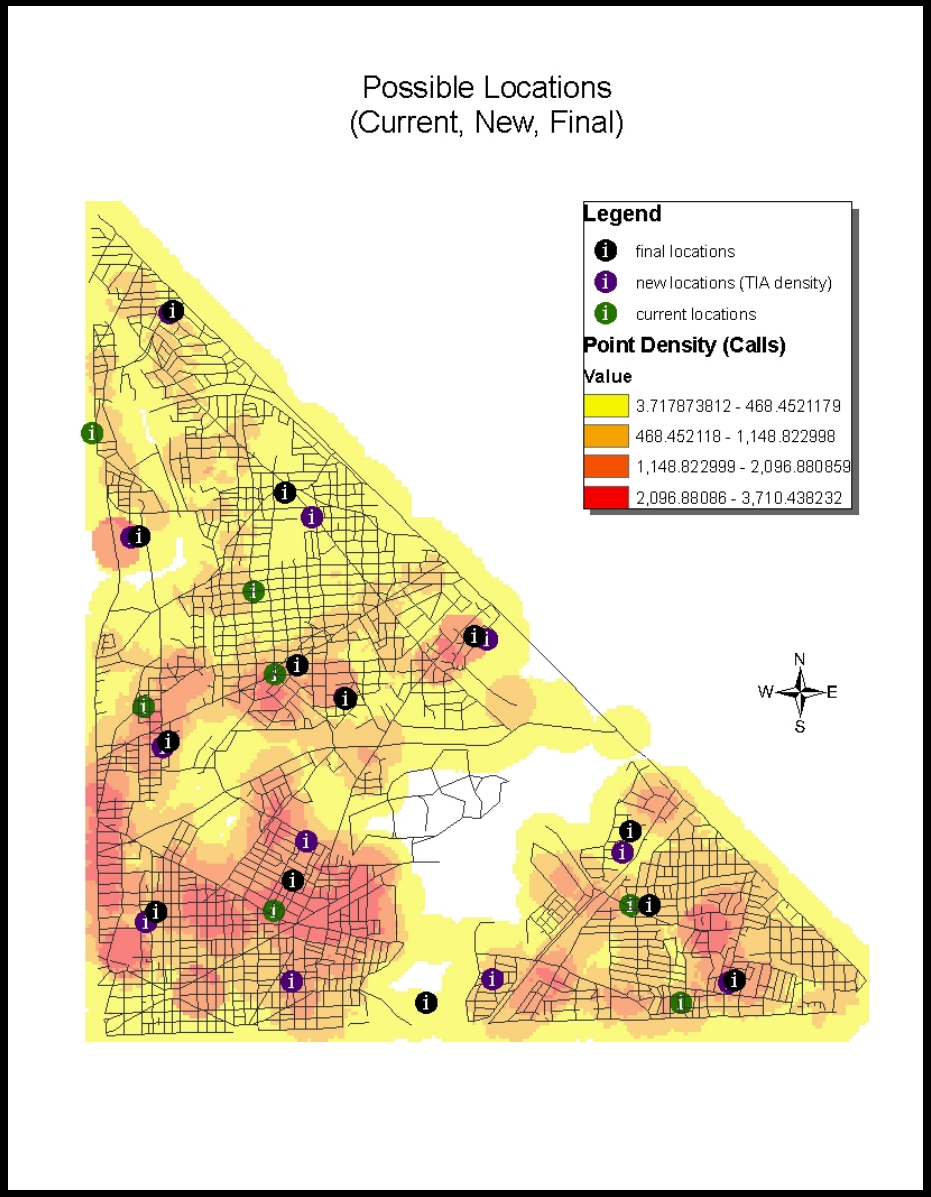
Response Distance Constraint



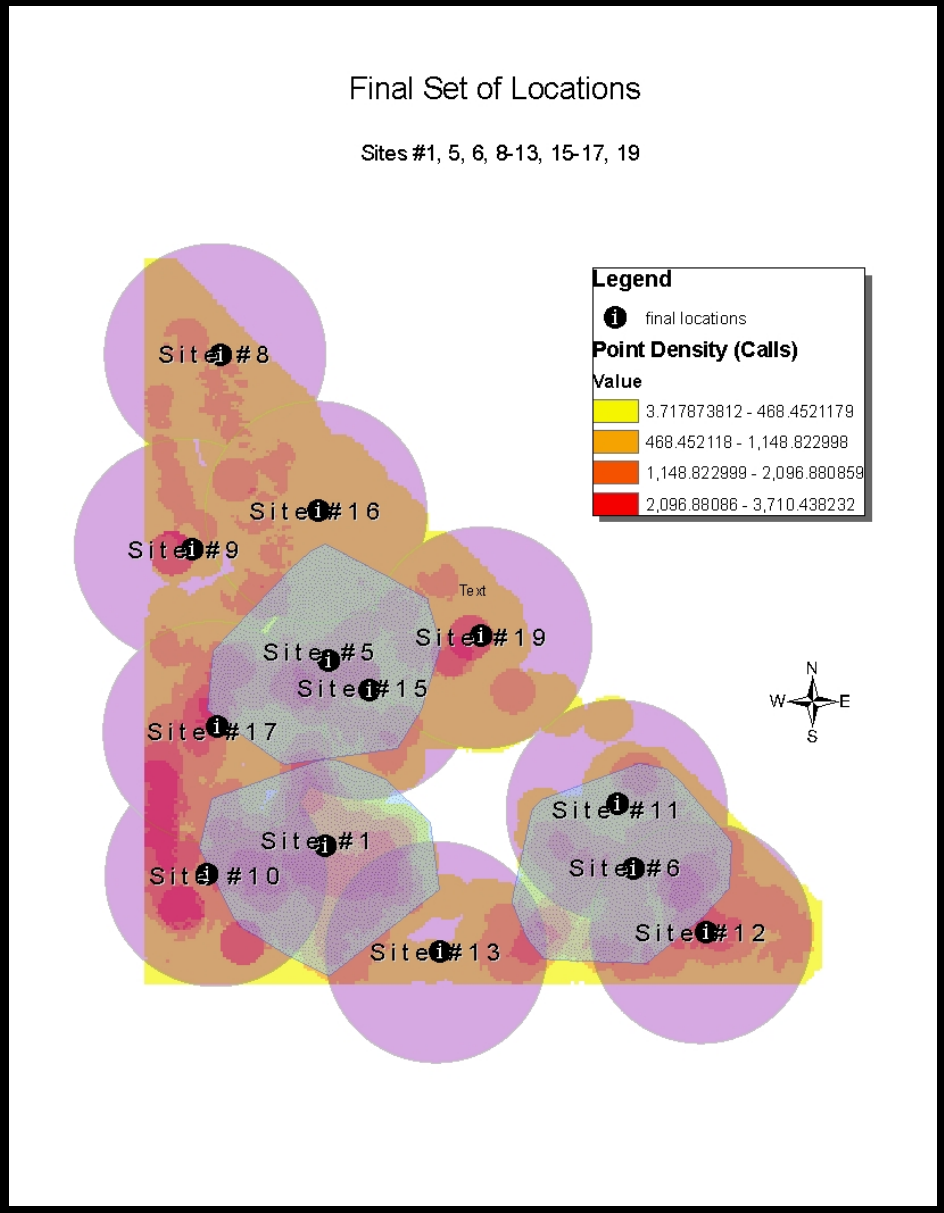
All Possible Site Locations In the Sample Space

Site #	Address or Intersection
1	1342 Florida Ave. NE
2	2225 5th St. NE
3	4801 N. Capitol St. NE
4	1227 Monroe St. NE
5	1340 Rhode Island Ave. NE
6	4201 Minnesota Ave. NE
7	50 49th St. NE
8	Corner of 6th and Riggs St.
9	Intersection of 2nd and Taylor St.
10	Intersection of H and 3rd St.
11	Intersection of Marne and 44th St.
12	Intersection of Division Ave. and Banks Pl.
13	Intersection of Clay Pl. and 34th St.
14	Intersection of Mount Olivet Rd. and Orren St.
15	Intersection of 19th Pl. and Channing St.
16	Intersection South Dakota Ave. and 18th St.
17	Intersection V and 4th St.
18	Intersection15th and D St.
19	End of Commodore Joshua Barney Dr.
	current
	others suggested

Possible Locations



Final Locations



Project Setbacks

- ArcGIS Network Analyst Extension to do location optimality *by route* rather than *by node* out end of June 2005 – **too late!**
  - Capabilities: Location analysis, drive time analysis, and spatial interaction modeling
- Getting census and fire department data for ArcGIS
- Obtaining delays expected for streets due to obstructions such as traffic

Future Work

- Use updated census and NFRIS data to prove optimally
- Revisit the Study on a annual basis
  - To plan for changing needs of the city
  - To consider budgeting for the future
    - i.e. more firehouses or changing locations
  - Conform to NFPA 1710 – 4.1.2.3.1 and 4.1.2.3.1
  - Provide AHJ with a quadrennial report – NFPA 1710 – 4.1.2.4

Questions ?

Thank God this is Done!!