



# Facilities Location Project

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# Acknowledgements

## SSYMCA

- President & CEO,  
*Ralph Yohe*
- VP of Operations,  
*Natalie Sheard*
- Former intern,  
*Emily Sutton*



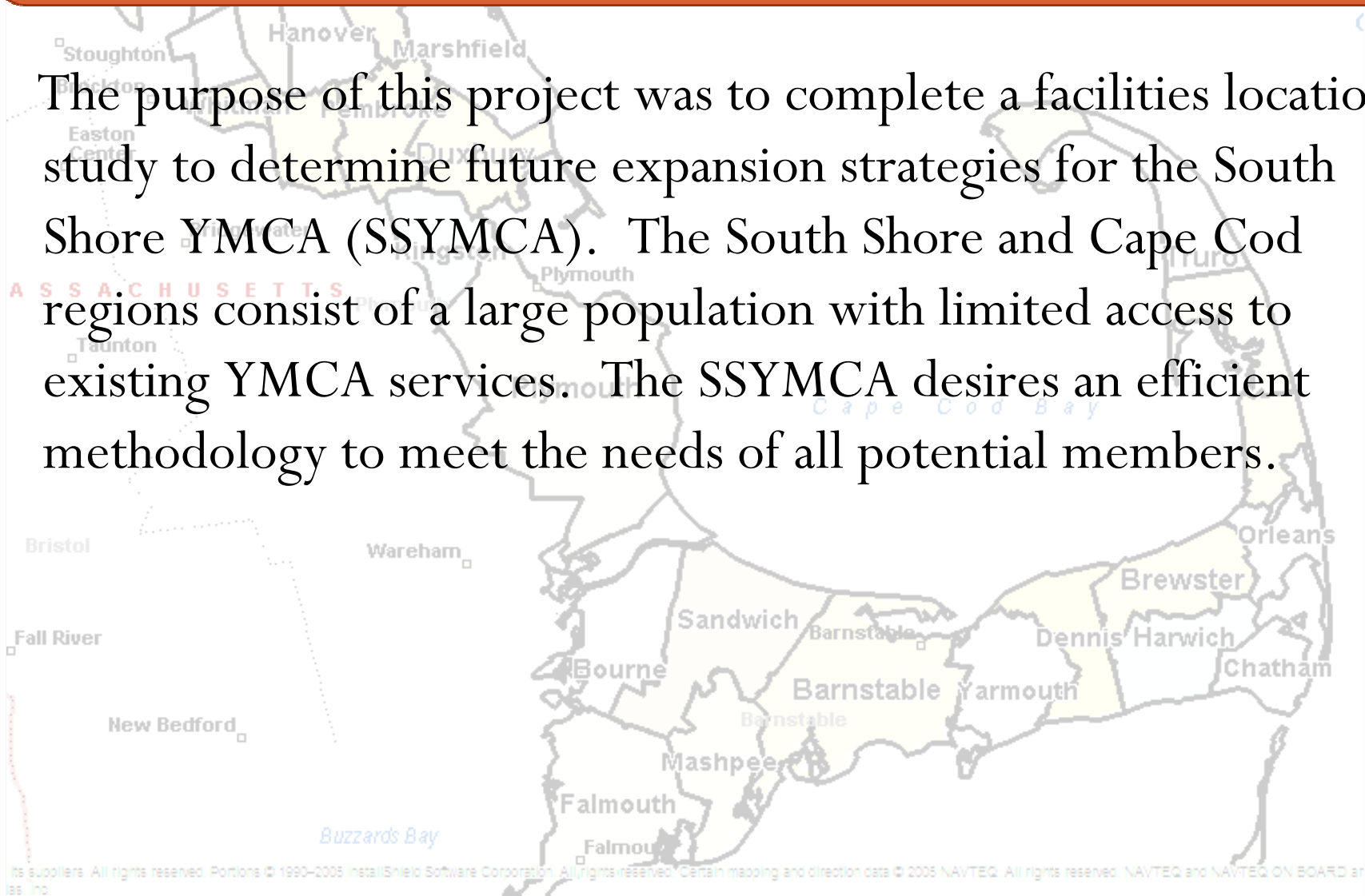
## Northeastern Faculty

- Prof. Thomas Cullinane
- Prof. Gregory Kowalski
- Prof. Emanuel Melachrinoudis



# Purpose

The purpose of this project was to complete a facilities location study to determine future expansion strategies for the South Shore YMCA (SSYMCA). The South Shore and Cape Cod regions consist of a large population with limited access to existing YMCA services. The SSYMCA desires an efficient methodology to meet the needs of all potential members.



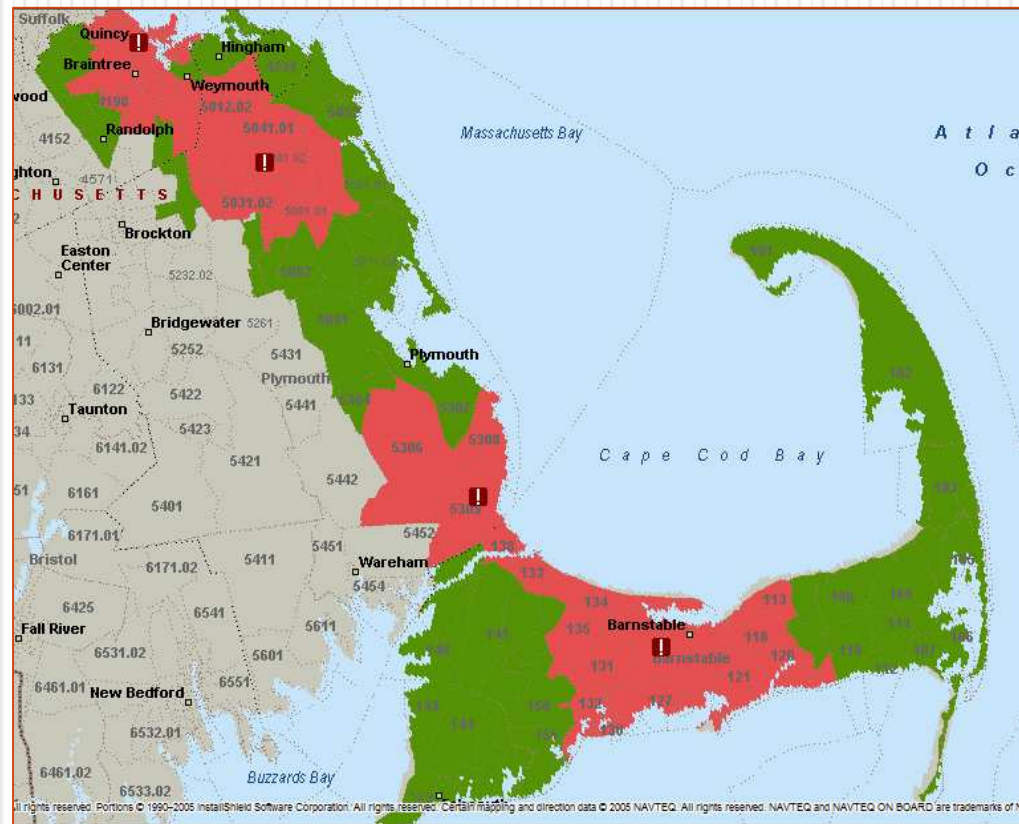
# YMCA Background

- Largest not-for-profit organization in America
- 2,617 locations nationwide, 20.2 million members
- Community Based and Driven
- Variety of Programming for Every Age
- Helping Raise America's Children
- Beyond Health and Fitness
- More than a Gym - a Community



# Present Locations

- Mill Pond Branch  
(Hanover)
- Quincy Facility
- Barnstable Branch
- Plymouth Branch  
(planned facility)



# Needs & Requirements

- Identify target customers and areas of need
- Determine relative location and accessibility
- Minimize cannibalization between facilities
- Develop long term strategic vision
- Activities and services



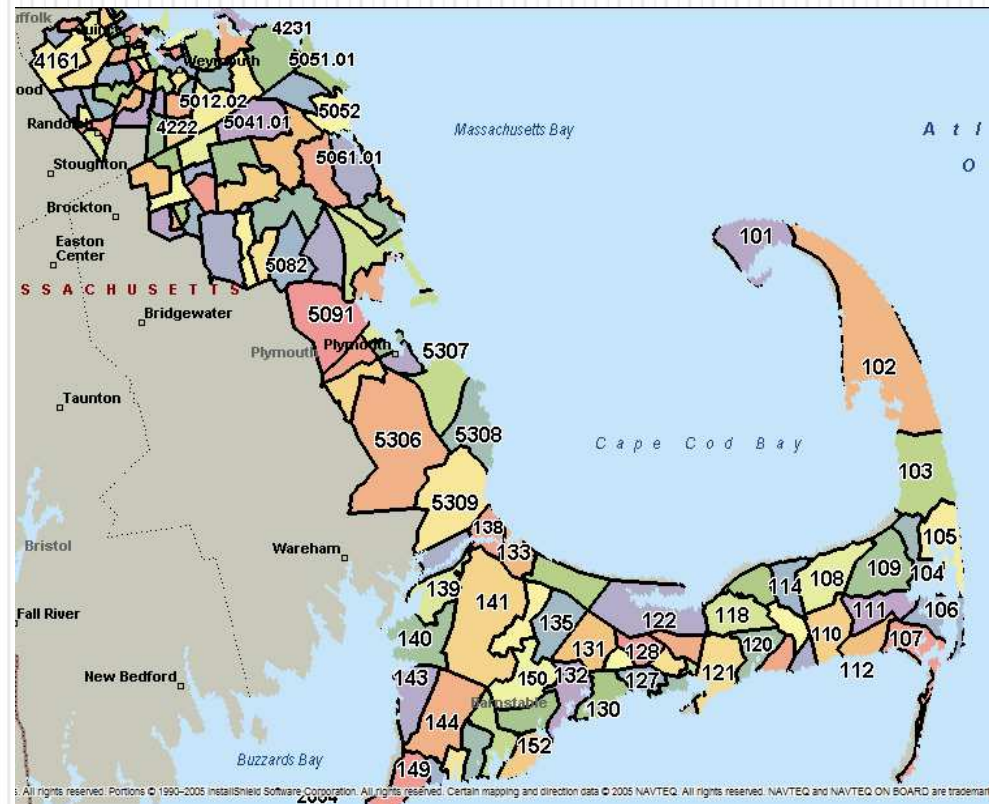
# Data Collection

- Determining potential locations
  - Accessibility
    - Reduce distance between potential facilities and demands
- Traffic data
  - Identified heavy traffic areas
- 15 minute drive time requirement
  - Validated by membership data and survey
- Public transportation
  - Insignificant presence in region



# Data Collection

- Defining demand
  - Census — Segmenting population into census tracts
  - SEER/PMA Studies — Establishing market penetration
  - Survey — Reasons for joining
  - Member Database — Activity enrollment



# Research

- Types of Models
  - Set covering – Minimize facilities to cover all demand
  - Accessibility – Minimize distance between facility and demand
- Characteristics of the Model
  - Network vs. planar mapping
  - Capacitated vs. uncapacitated constraint
  - Deterministic vs. probabilistic input data
  - Inelastic demand, static locations
  - Single vs. multiple facility model
  - Output vs. input number of facilities

# Bi-Objective Minimization Model

Inputs:

$w$  = scaling factor

$h_j$  = demand at node  $j$

$d_{ij}$  = distance from candidate site  $i$  to demand node  $j$

Decision Variables:

$X_i$  = candidate site  $i$

$Y_{ij}$  = demand node  $j$  assigned to candidate node  $i$

Minimize Objective Function:

$$Z = \sum_i wX_i + \sum_i \sum_j h_j d_{ij} Y_{ij} \quad (1)$$

# Bi-Objective Minimization Model

Minimize:

$$Z = \sum_i wX_i + \sum_i \sum_j h_j d_{ij} Y_{ij} \quad (1)$$

Subject to:  $\sum_i Y_{ij} = 1 \quad \forall j \quad (2)$

$$Y_{ij} - X_i \leq 0 \quad \forall i, j \quad (3)$$

$$\sum_j Y_{ij} h_j \leq c_i X_i \quad \forall i \quad (4)$$

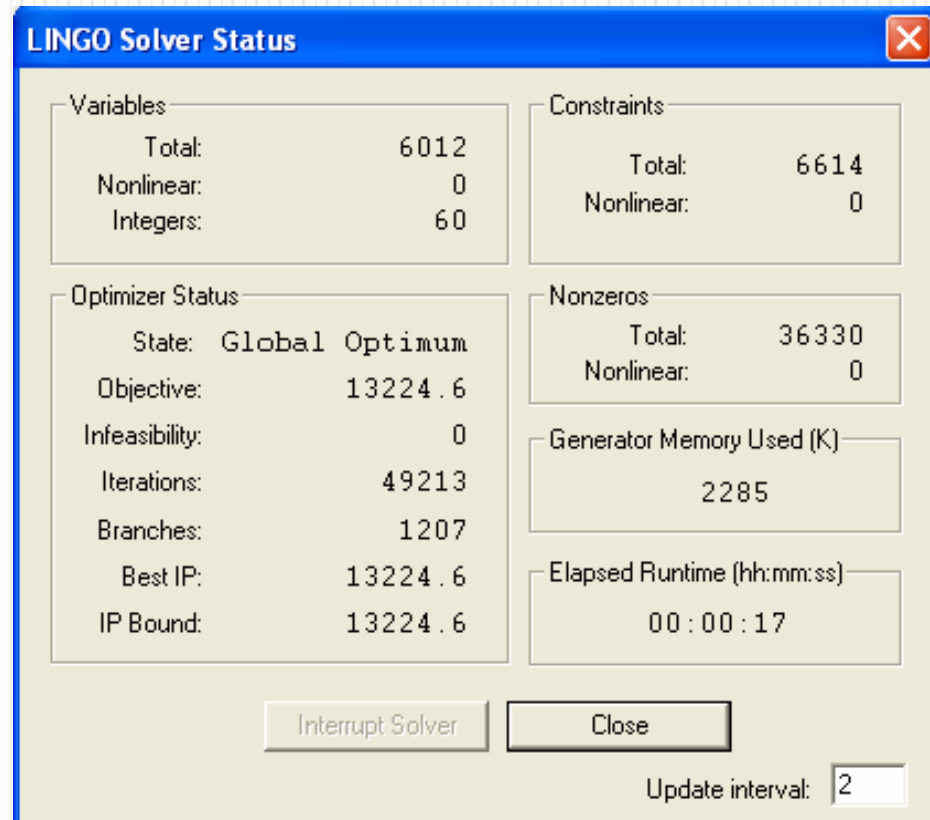
$$X_i = 0, 1 \quad \forall i \quad (5)$$

$$Y_{ij} = 0, 1 \quad \forall i, j \quad (6)$$

# Implementing the Model

Automation and Integration:

- Excel-Data Management
- Lingo-Optimization Application
- MapPoint-Data Mapping Software



The screenshot shows the 'LINGO Solver Status' dialog box with the following data:

Variables		Constraints	
Total:	6012	Total:	6614
Nonlinear:	0	Nonlinear:	0
Integers:	60		

Optimizer Status		Nonzeros	
State:	Global Optimum	Total:	36330
Objective:	13224.6	Nonlinear:	0
Infeasibility:	0		
Iterations:	49213	Generator Memory Used (K)	
Branches:	1207	2285	
Best IP:	13224.6	Elapsed Runtime (hh:mm:ss)	
IP Bound:	13224.6	00:00:17	

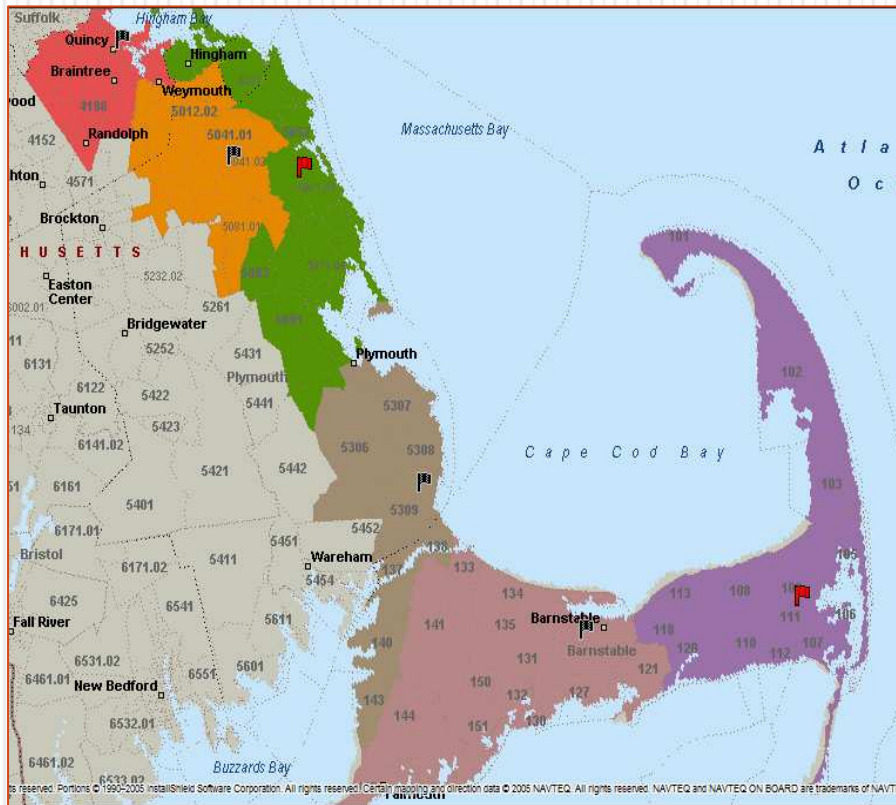
Buttons: Interrupt Solver, Close

Update interval: 2

# Model Results

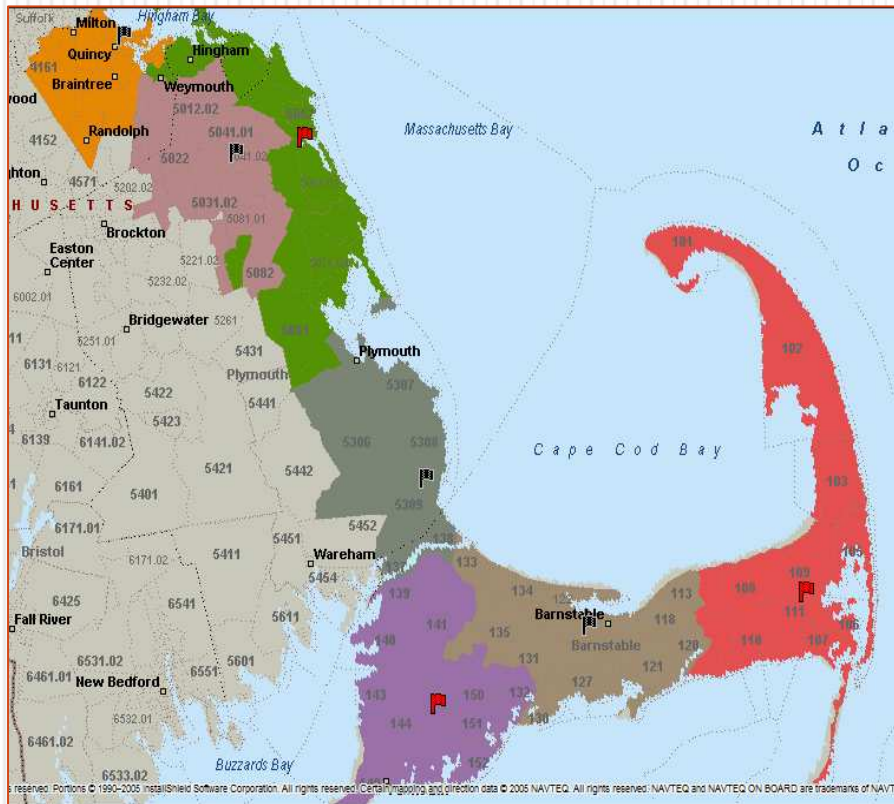
- Four Approaches
  1. Maximized Set Covering Approach
  2. Weighted Set Covering Approach
  3. Weighted Accessibility Approach
  4. Maximized Accessibility Approach
- Activity Recommendations
  - Compared to existing regional facilities
  - General suggestions of activities at each facility

# Maximized Set Covering Approach



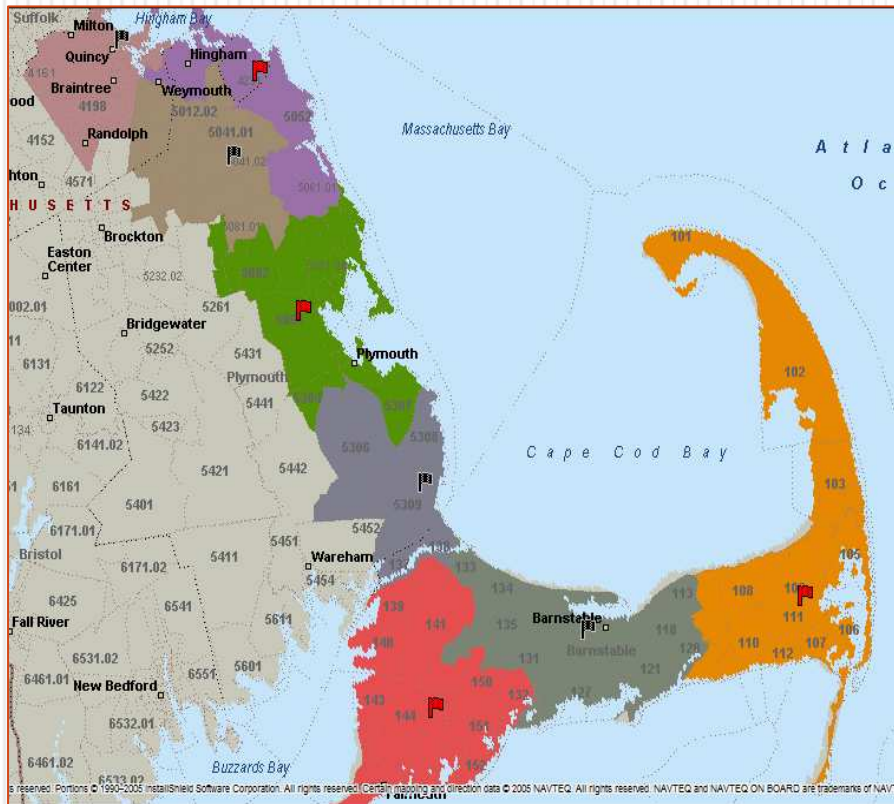
- Minimize number of facilities used to cover demand
- Locations
  1. Marshfield
    - Route 3 & Pine Street
  2. Harwich
    - Route 6 & Route 137

# Weighted Set Covering Approach



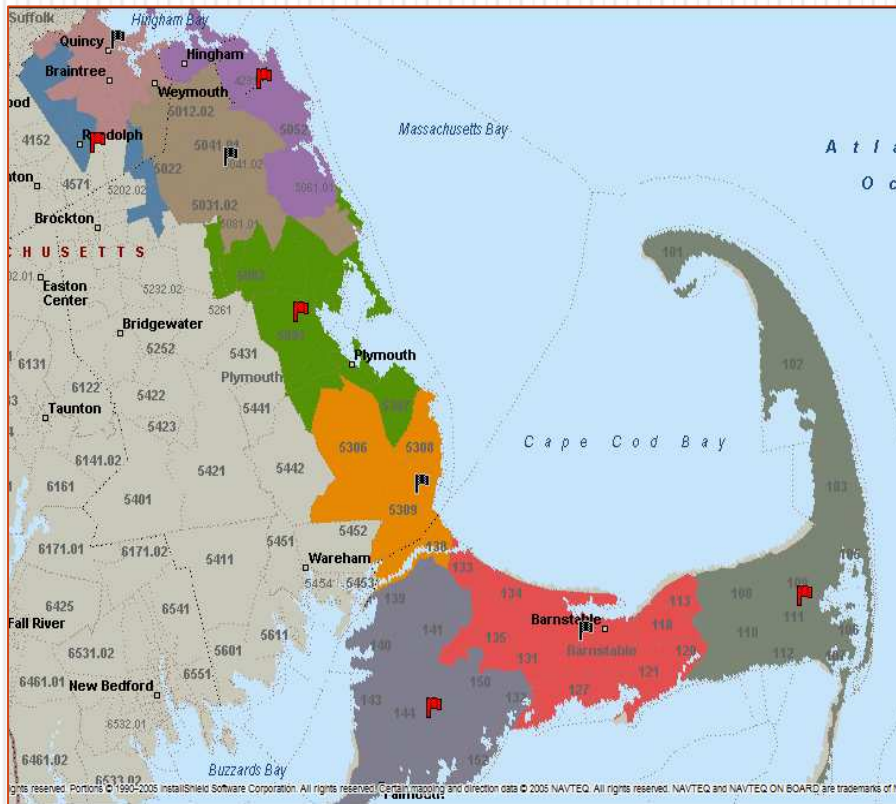
- Reduce number of facilities while giving some weight to accessibility
- Locations
  1. Marshfield
    - Route 3 & Pine Street
  2. Falmouth
    - Sandwich Rd & Hayway Rd
  3. Harwich
    - Route 6 & Route 137

# Weighted Accessibility Approach



- Maximize accessibility to demand nodes with some weight to minimizing facilities
- Locations
  1. Kingston
    - Route 27 & Route 106
  2. Cohasset
    - Route 3A & Beechwood St
  3. Falmouth
    - Sandwich Rd & Hayway Rd
  4. Harwich
    - Route 6 & Route 137

# Maximized Accessibility Approach

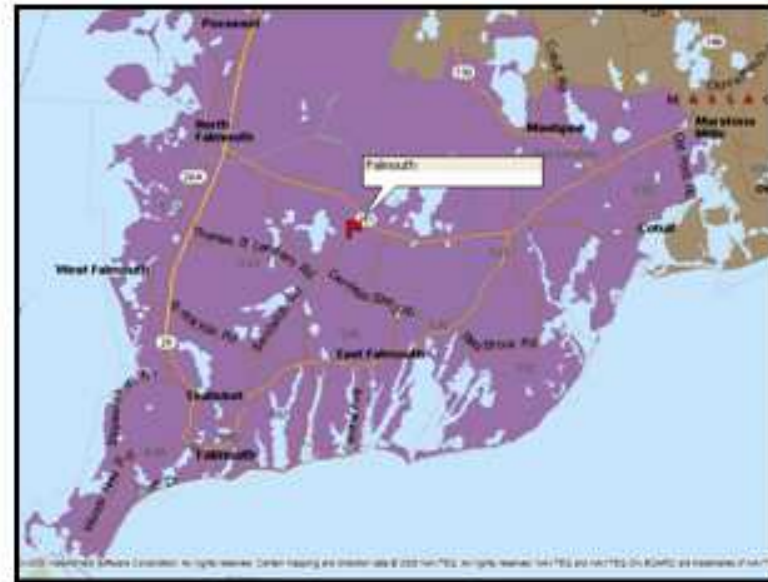


- Maximize accessibility of facilities to demand nodes
- Locations
  1. Kingston
    - Route 27 & Route 106
  2. Falmouth
    - Sandwich Rd & Hayway Rd
  3. Harwich
    - Route 6 & Route 137
  4. Scituate
    - Route 3A & Henry Turner Bailey Rd
  5. Randolph
    - Route 139 & Mill Street

# Projected Membership & Recommended Services

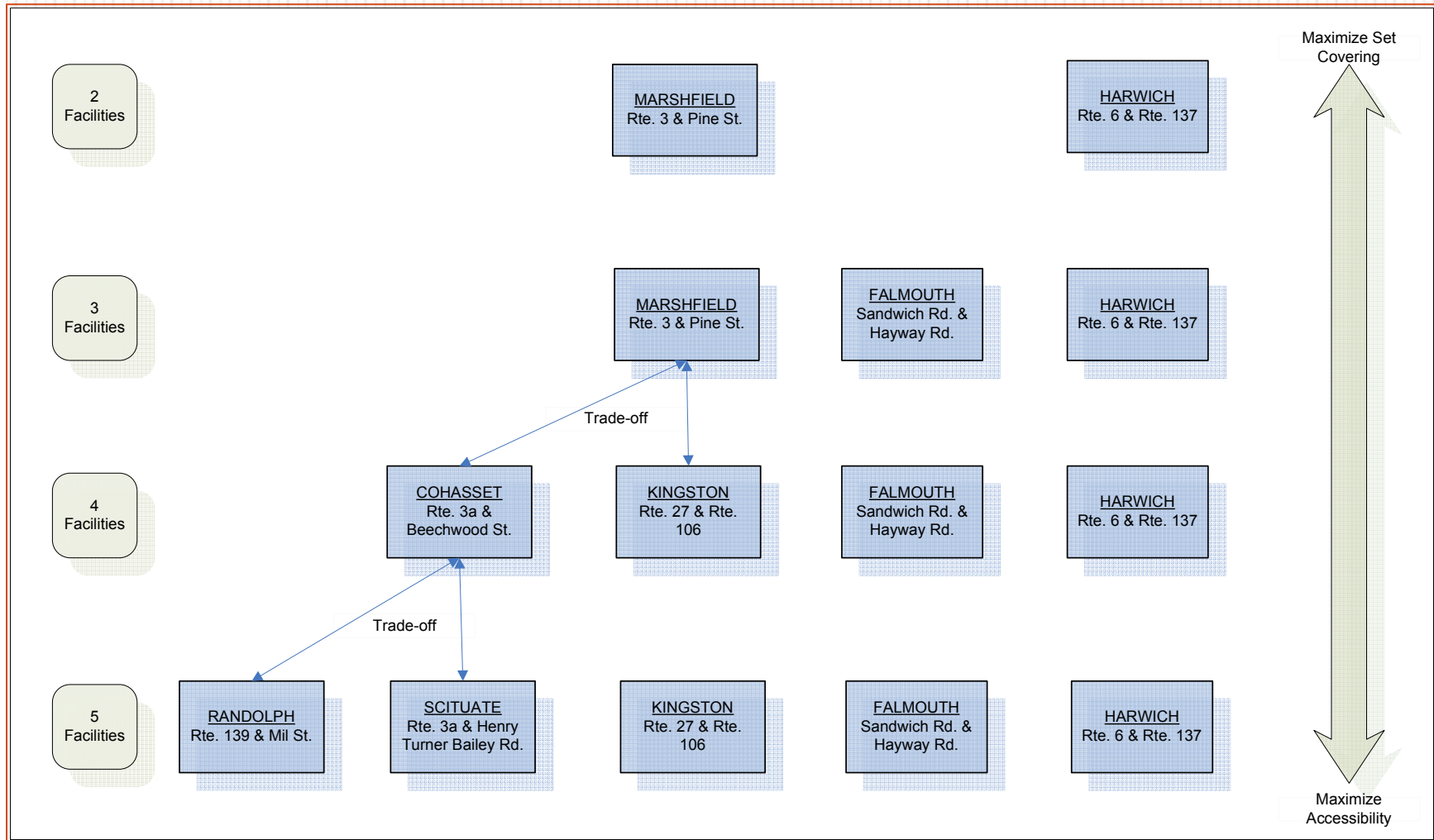
- **Falmouth**

Suggested Activities	Total	6054
<b>Adult Fitness</b>	Age	Percentage
<b>Aquatics</b>	0 to 9	11.4%
<b>Arts &amp; Humanities</b>	10 to 19	12.3%
<b>Family</b>	20 to 29	7.5%
<b>Teen</b>	30 to 39	13.6%
<b>Teen Fitness</b>	40 to 49	15.4%
<b>Vacation Camp</b>	50 to 59	13.5%
<b>Youth Sports/Fitness</b>	60 to 69	11.5%
	70 to 79	9.9%
	80 and up	4.8%



- Recommended Services
- Projected Membership Demographics
- Relative Facility Size

# Sensitivity Analysis



# Recommended Expansion

- **Kingston**

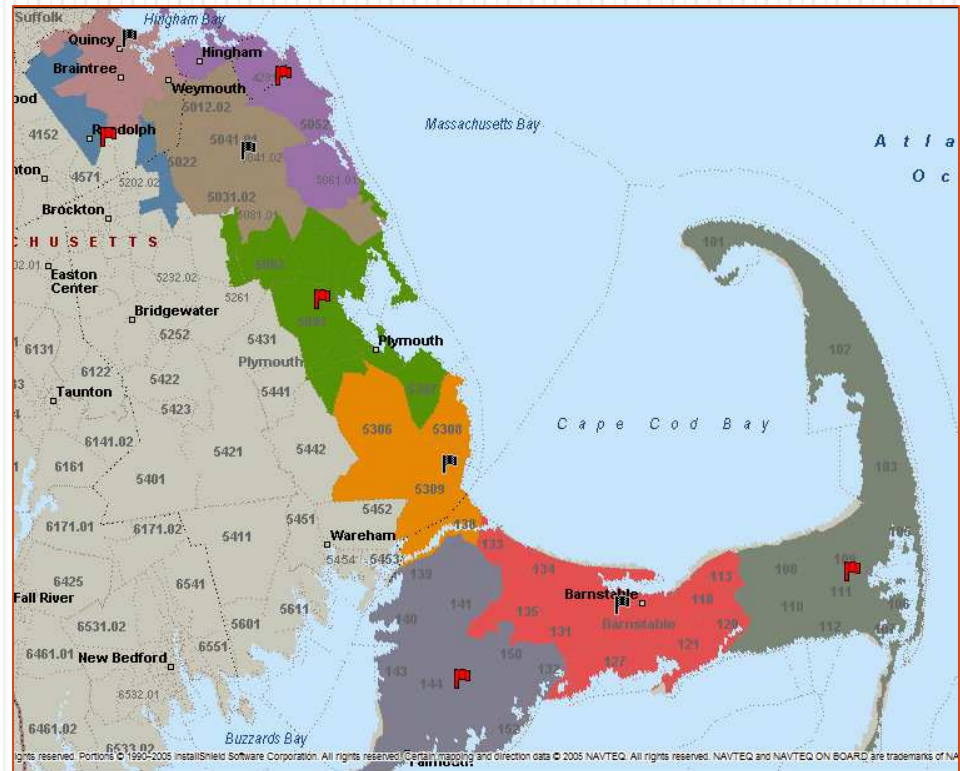
Suggested Activities	Total	7882
<b>Adult Fitness</b>	<b>Age</b>	<b>Percentage</b>
<b>Aquatics</b>	0 to 9	14.6%
<b>Arts &amp; Humanities</b>	10 to 19	13.9%
<b>Family</b>	20 to 29	8.8%
<b>Gymnastics</b>	30 to 39	15.9%
<b>Teen</b>	40 to 49	17.0%
<b>Teen Fitness</b>	50 to 59	13.6%
<b>Vacation Camp</b>	60 to 69	6.9%
<b>Youth Sports/Fitness</b>	70 to 79	5.4%
	80 and up	4.0%



- Greatest need
- Between Hanover and Plymouth facilities
- Full-scale facility
- Minimal cannibalization potential

# Conclusions

- Suggested new facility in Kingston, MA
- Falmouth & Harwich facilities for underserved Cape Cod demand
- Strong cannibalization concerns for Cohasset/Scituate and Randolph regions



# Future Considerations

- Computational Efficiency and Tools
  - Software selection
- What-if Scenarios
  - More usability in model
- Interchangeability & Scalability
  - Transfer of model to any region

# Questions?



# Bi-Objective Minimization Model

Minimize:

$$Z = \sum_i wX_i + \sum_i \sum_j h_j d_{ij} Y_{ij} \quad (1)$$

Subject to:  $\sum_i Y_{ij} = 1 \quad \forall j \quad (2)$

$$Y_{ij} - X_i \leq 0 \quad \forall i, j \quad (3)$$

$$\sum_j Y_{ij} h_j \leq c_i X_i \quad \forall i \quad (4)$$

$$X_i = 0, 1 \quad \forall i \quad (5)$$

$$Y_{ij} = 0, 1 \quad \forall i, j \quad (6)$$

# Weight Factor Table

<b>Weight Coefficient</b>	<b>Number of Additional Facilities</b>	<b>Estimated Solver Run Time</b>
0-40	13	0 - 5 sec
40-85	12	0 - 5 sec
85-135	11	0 - 5 sec
135-215	10	0 - 5 sec
215-230	9	5 - 10 sec
230-265	8	5 - 10 sec
265-335	7	5 - 15 sec
335-400	6	5 - 15 sec
400-700	5	20 sec - 2 min
700-1375	4	50 sec - 6 min
1375-1550	3	5 - 8 min
1550-4000	2	45 sec - 5 min
>4000	1	0 - 50 sec

# Survey

## YMCA Demographic Survey

The South Shore YMCA is working with a group of five Northeastern University Engineers on their Senior Capstone Project. They are looking to collect data from real YMCA members as to what motivated you to join the YMCA instead of another organization.

Please take a moment to help these students with their project.

**Age:** \_\_\_\_\_ **Gender:** M F **(please circle one)**

**Town you live in:** \_\_\_\_\_

**Town you work in:** \_\_\_\_\_

**Years as an YMCA Member:** \_\_\_\_\_

**Type of Membership:** Household Adult Junior Senior Youth  
**(please circle one)**

**Where do you travel from most frequently to use the YMCA?**

School Work Home Other: \_\_\_\_\_  
**(please circle one)**

**How long do you travel to get to the YMCA: (please circle one)**

0-10 minutes 11-20 minutes 21-30 minute 30+ minutes

**Primary reason for joining YMCA: (please check as many as apply)**

\_\_\_ Family Friendly

\_\_\_ Nearby/Accessible

\_\_\_ Affordability

\_\_\_ Other: \_\_\_\_\_

**Program/Service you use the most at the YMCA:**