RAIN IN THE FORECAST: Siting Green Stormwater Infrastructure in the Mystic River Watershed to Adapt to a Changing Climate

INTRODUCTION

AS CLIMATE CHANGE brings more intense precipitation to Metro Boston, it is critical that municipalities consider the current capacity of their stormwater management systems—many of which may date back to the nineteenth-century. Replacing these old systems with higher capacity traditional infrastructure can be prohibitively expensive. Installing green infrastructure (GI) elements for stormwater management such as rain gardens or bioswales can supplement our current systems, and mitigate problems associated with excess stormwater such as pollution and flooding.

The Mystic River Watershed faces particular stormwater challenges since 56% of its surfaces are impervious, and it is the most densely populated watershed in the Commonwealth. It is important to consider stormwater management strategies at the watershed scale since the watershed serves as a natural boundary for stormwater flow. Methodology such as that from the *Climate Smart Cities* initiative, a program run by the Trust for Public Land and the Metropolitan Area Planning Council, can be used to find suitable sites for GI for stormwater management at a variety of scales and locations, including the Mystic River Watershed.

Finding locations that are suitable for GI elements throughout the watershed is an important initial step towards improved stormwater management as the region strives to adapt to climate change. Understanding *who* owns this land can inform effective policy decisions for encouraging GI installation: if suitable parcels are public, then the government can make decisions to install GI like any other public infrastructure project without running into issues of land ownership. If suitable parcels are private property, however, then regulations or incentives for private property owners need to be considered.

DATA SOURCES AND REFERENCES

Map Projection: NAD 1983 Massachusetts State Plain, Mainland Zone (2001)
Data Layers: MassGIS (2018), and Massachusetts Environmental and Energy Affairs Data Portal: Mass Department of Environmental Protection Well Database (2018)
References:

"Climate Smart Cities™ Boston Metro Mayors." Planning and GIS. Accessed November 25, 2018. https://web.tplgis.org/metromayors_csc/.

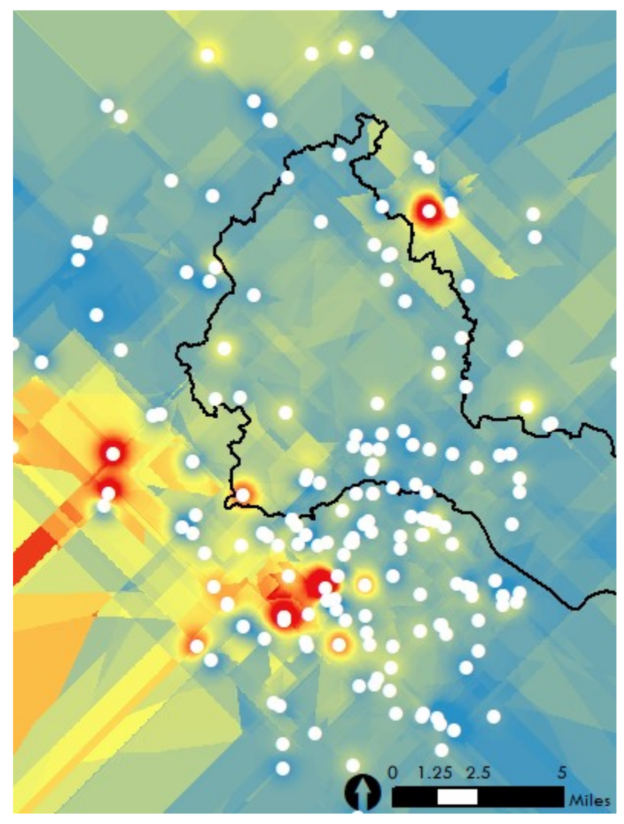
Warganda, Tina Kesuma, and Dwita Sutjiningsih. "Placement of BMPs in Urban Catchment Area Using SUSTAIN Model: Case Study at Universitas Indonesia Campus, Depok, West Java, Indonesia." MATEC Web of Conferences 138 (2017): 06007. https://doi.org/10.1051/matecconf/201713806007.

Martin-Mikle, Chelsea J., Kirsten M. de Beurs, Jason P. Julian and Paul M. Mayer. "Identifying priority sites for low impact development (LID) in a mixed-used watershed." Landscape and Urban Planning, vol. 140, 2015, pp. 29 – 41, https://doi.org/10.1016/j.landurbplan.2015.04.002.

Snyder, Daniel T. "Scientific Investigations Report 2008 -5059: Estimated Depth to Ground Water and Configuration of the Water Table in the Portland, Oregon Area." U.S. Geological Survey, 2008. https://pubs.usgs.gov/sir/2008/5059/section3.html.

Water Infrastructure Finance Commission. "Massachusetts's Water Infrastructure: Toward Financial Sustainability." Commonwealth of Massachusetts, February 7, 2112.

PREPARING DATA LAYERS



High Depth to Water (92 feet)
Low Depth to Water (-2.5 feet)

GROUNDWATER

WHY? | A critical factor to consider when siting GI is the water table: if it is located where the water table is close to the surface, stormwater will not drain properly and may contaminate the groundwater supply.

DATA | The MA Dept of Environmental Protection maintains a well-driller database which measures depth to water at each private well.

METHOD | Depth to water between measured well points was estimated using kriging, a method of spatial interpolation on ArcMap.

LAND OWNERSHIP

WHY? | Understanding the best policy mechanisms for encouraging GI installation depends on whether suitable land is publicly or privately owned: projects on land owned by public agencies would require public funding, while projects on private property would need to be incentivized or regulated.

Private | Public

DATA | MassGIS compiles data from municipal assessors across the Commonwealth. The Open Space data from MassGIS also indicates type of parcel ownership (municipal, state, federal, NGO or private party).

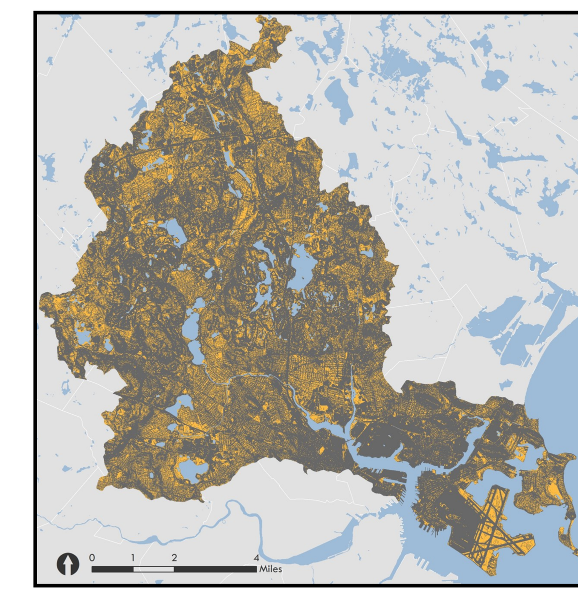
METHOD | As there is no attribute that differentiates between publicly owned and privately owned land in assessor's data, I searched through the "owner_name" attribute to find those parcels owned by municipal, state or federal agencies. I added parcels from the MassGIS open space layer upon realizing that some critical public parks (like the Middlesex Fells) were missing from the assessor's data.

METHODOLOGY: SUITABILITY ANALYSIS

SITING REQUIREMENTS

WHY? | Some physical characteristics are required for GI to function effectively:

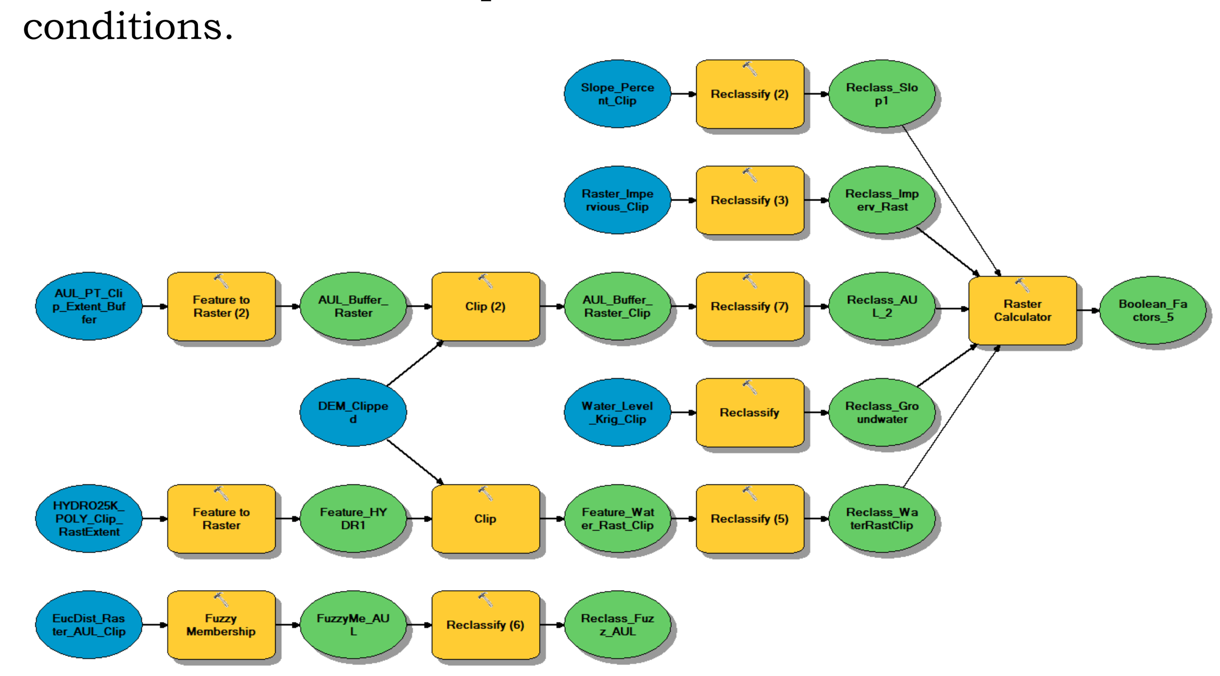
- *Slope* must be 5% grade or less
- *Water table* must be more than two feet below the surface
- *Land cover* cannot be impervious
- *Soil* cannot have with high concentrations of contaminants

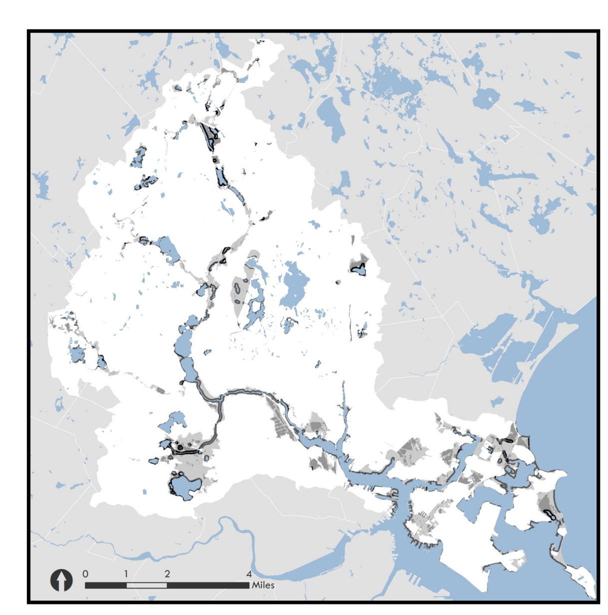


Meet Requirements
Do Not Meet Requirements

DATA | The MassGIS Digital Elevation Model is used to derive slope. MassGIS also compiles impervious surface data, and points representing sites with Activity and Use Limitations because of sediment contamination.

METHOD | The model below was used to rasterize and reclass each layer so that the favorable condition equals zero and the unfavorable condition equals one. Once added using raster calculator, areas that equal zero meet all favorable conditions.





3 Resiliency Factors
2 Resiliency Factors
1 Resiliency Factor
No Resiliency Factors

RESILIENCE SCORE

WHY? | Sites that are optimally located for preventing runoff from entering bodies of water *or* absorbing floodwaters will increase the resilience of the region in the face of more intense precipitation events. These locations include flood zones and natural sinks in the landscape.

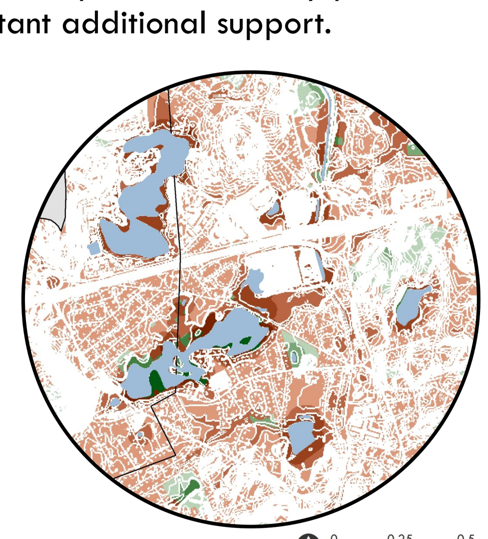
DATA | MassGIS maintains flood zone data from FEMA, including both 100-year and 500-year floodplains. I used the MassGIS Digital Elevation Model to find areas of negative elevation, and I used the buffer tool in ArcMap to find areas 200 ft from the edge of a water body.

METHOD | Areas were scored using raster calculator based on how many out of these three criteria were met.

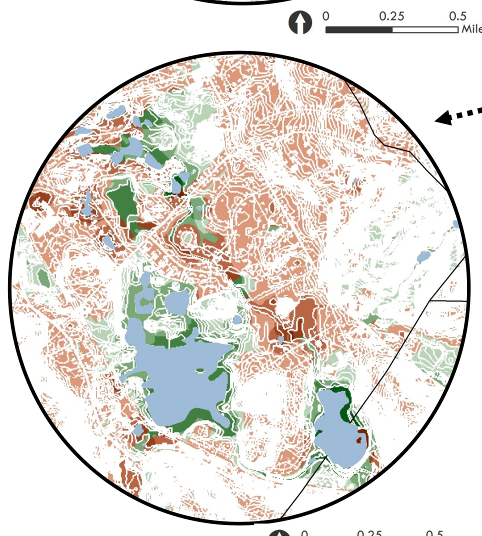
OVERALL SUITABILITY:

DOES IT MEET BASIC GI REQUIREMENTS? DOES IT MEET ANY RESILIENCE FACTORS? WHO OWNS IT- PUBLIC OR PRIVATE?

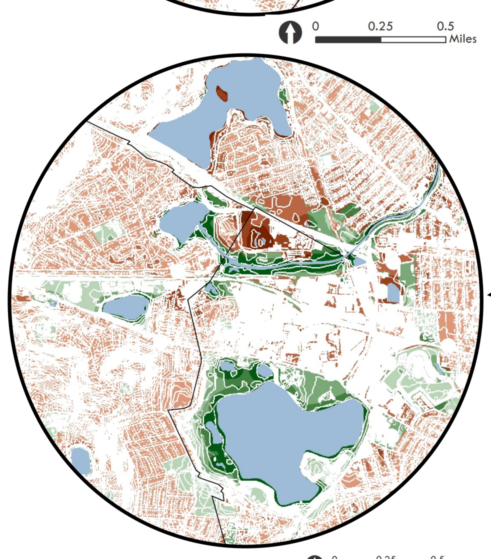
Areas of darker shades of green are the most suitable since they are already publicly owned and meet the most resilience factors. However, these areas also appear near clusters of darker shades of red, indicating GI projects on private land may provide important additional support.



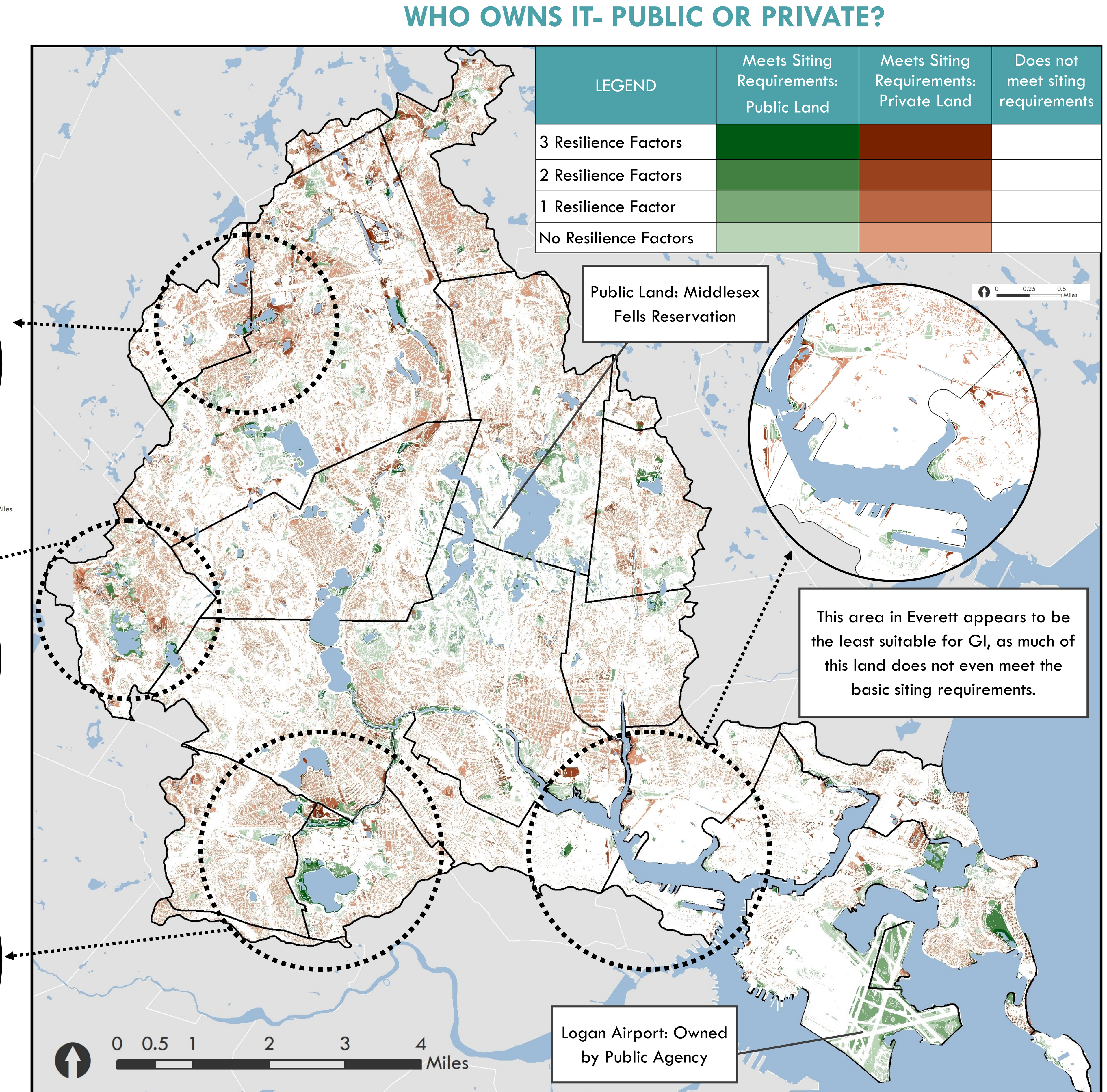
BURLINGTON/WOBURN BORDER



GREAT MEADOW & ARLINGTON RESERVOIR



FRESH POND, CAMBRIDGE



DISCUSSION

Percent of land area within watershed on which...	GI cannot be sited	80%
	GI can be sited	20%
Of the land on which GI can be sited...	Owned by public agency	30%
	Privately owned	70%

From calculating the zonal geometry in ArcMap, I determined that only 20% of land area in the watershed is suitable for installing GI, and of that 20%, 70% is under private ownership. This suggests that policies that encourage private GI installation projects, such as a stormwater utility fee and a corresponding incentive program, could greatly improve stormwater management throughout the watershed in the face of more intense precipitation events.

However, it is important to note that the total area of land that is owned by public agencies *and* meets all three resilience factors is larger than the total area of land that is privately owned and meets all three resilience factors. Therefore any given individual public GI project may be more impactful than any given individual private GI project, suggesting that public investment will also significantly increase the resiliency of the region.

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UEP 294 Advanced Geo-Spatial Modeling | Fall 2018