

# Evaluation of Bridge Functional Obsolescence Using Congestion Performance Measures Determined from Anonymous Probe Vehicle Data

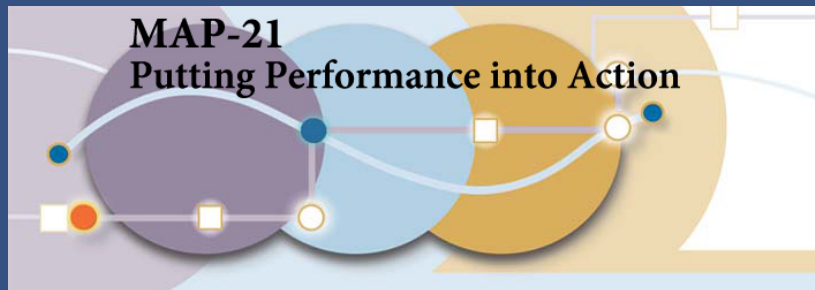
Andrew J. Bechtel PhD

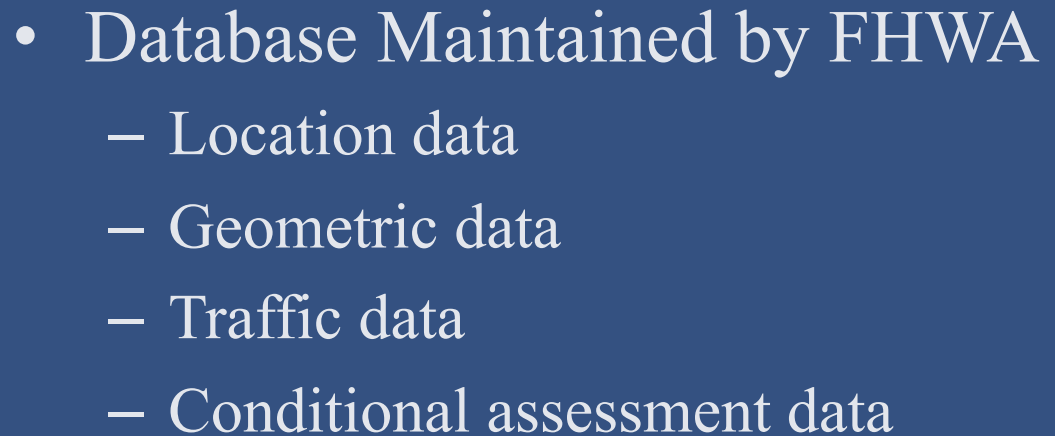
Thomas M. Brennan Jr. PhD, PE



# Moving Ahead for Progress in the 21<sup>st</sup> Century Act

- MAP 21
    - Seeks to implement Risk Based Asset Management of US Infrastructure
  - Risk Based Asset Management involves identifying, assessing, and minimizing unacceptable risk
    - Loss of Life
    - Loss of Money
- Structural Failure:  
Structurally Deficient
- Poor Function:  
Functionally Obsolete



[illegible]

# Functional Obsolescence

- State where a bridges no longer meets the current standards for design and performance

Categories	NBI Item Number	Deficiency Score
Waterway Adequacy (W)	71	$\leq 3$
Deck Geometry (D)	68	$\leq 3$
Approach Roadway Alignment (A)	72	$\leq 3$

Can't carry enough load

Floods

Not wide enough for volume

Not high enough

Traffic must slow at approach



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# Structurally Deficiency

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- State that requires significant maintenance, rehabilitation, or replacement due to deterioration or damage of main load carrying elements

Categories	NBI Item Number	Deficiency Score
Deck Condition	58	$\leq 4$
Superstructure	59	$\leq 4$
Substructure	60	$\leq 4$
Structural Evaluation	67	$\leq 2$
Waterway Adequacy	71	$\leq 2$

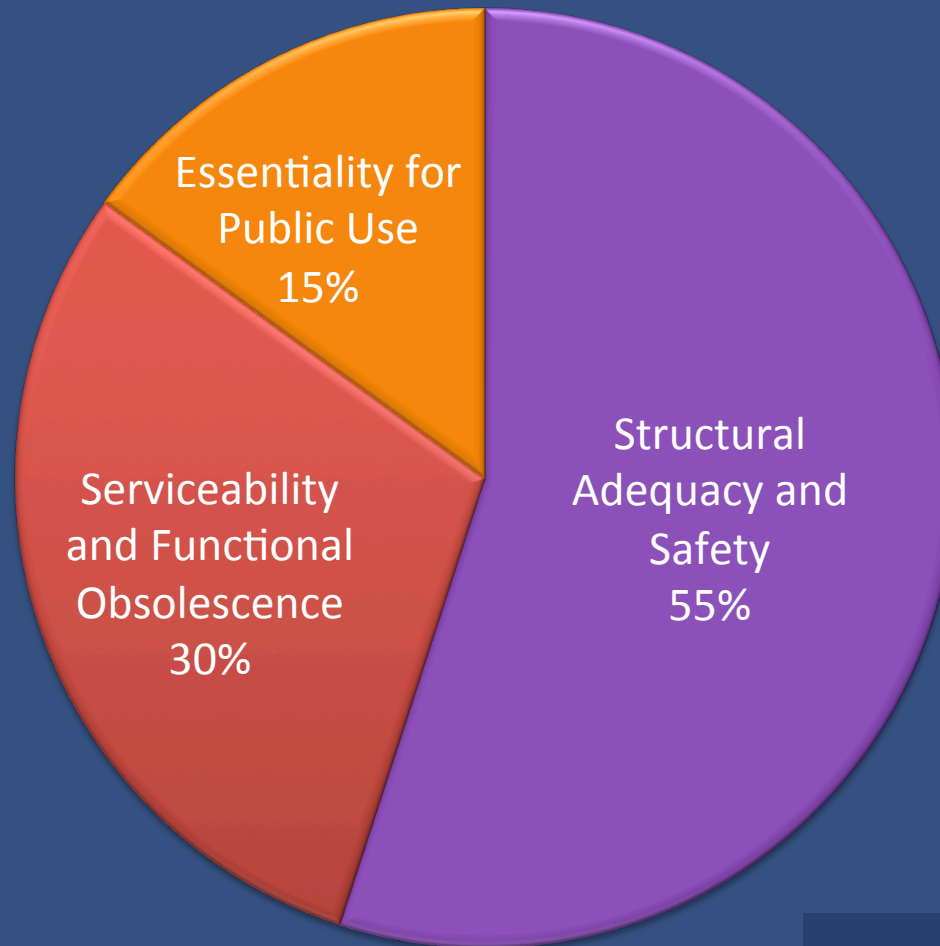


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# NBI Sufficiency Rating

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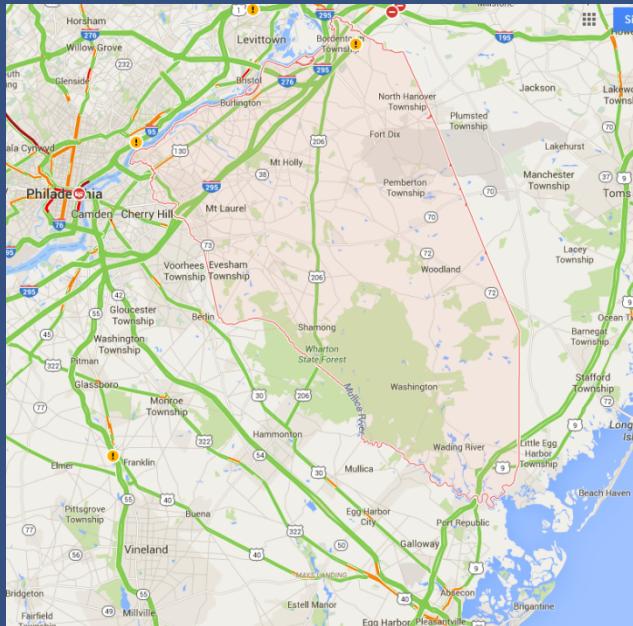
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# Objectives and Scope

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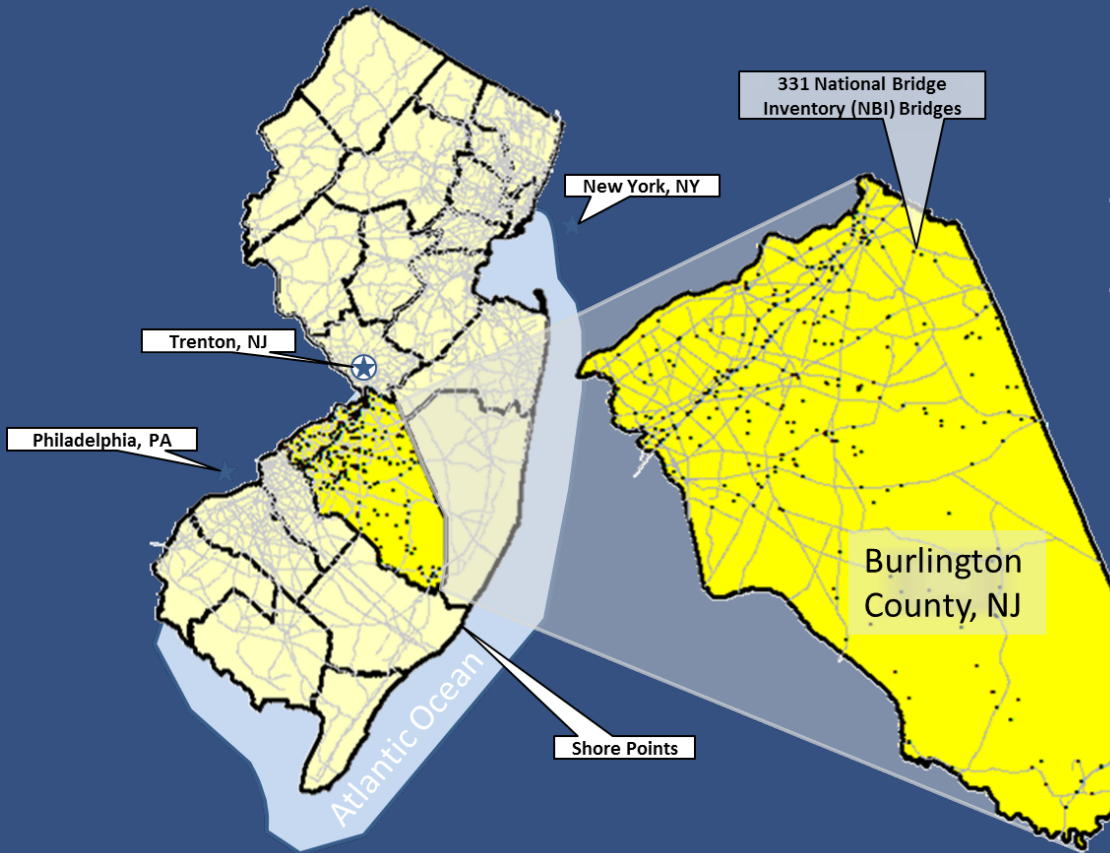
- Use crowd sourced anonymous probe vehicle data to measure and evaluate congestion at bridges in Burlington County, New Jersey considered to be Functionally Obsolete
- Use the congestion analysis as a bridge management tool



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# Burlington County, NJ



- 7% Structurally Deficient
- 38% Functionally Obsolete
  - 21% Deck Geometry
  - 12% Under Clearance
  - 5% Other

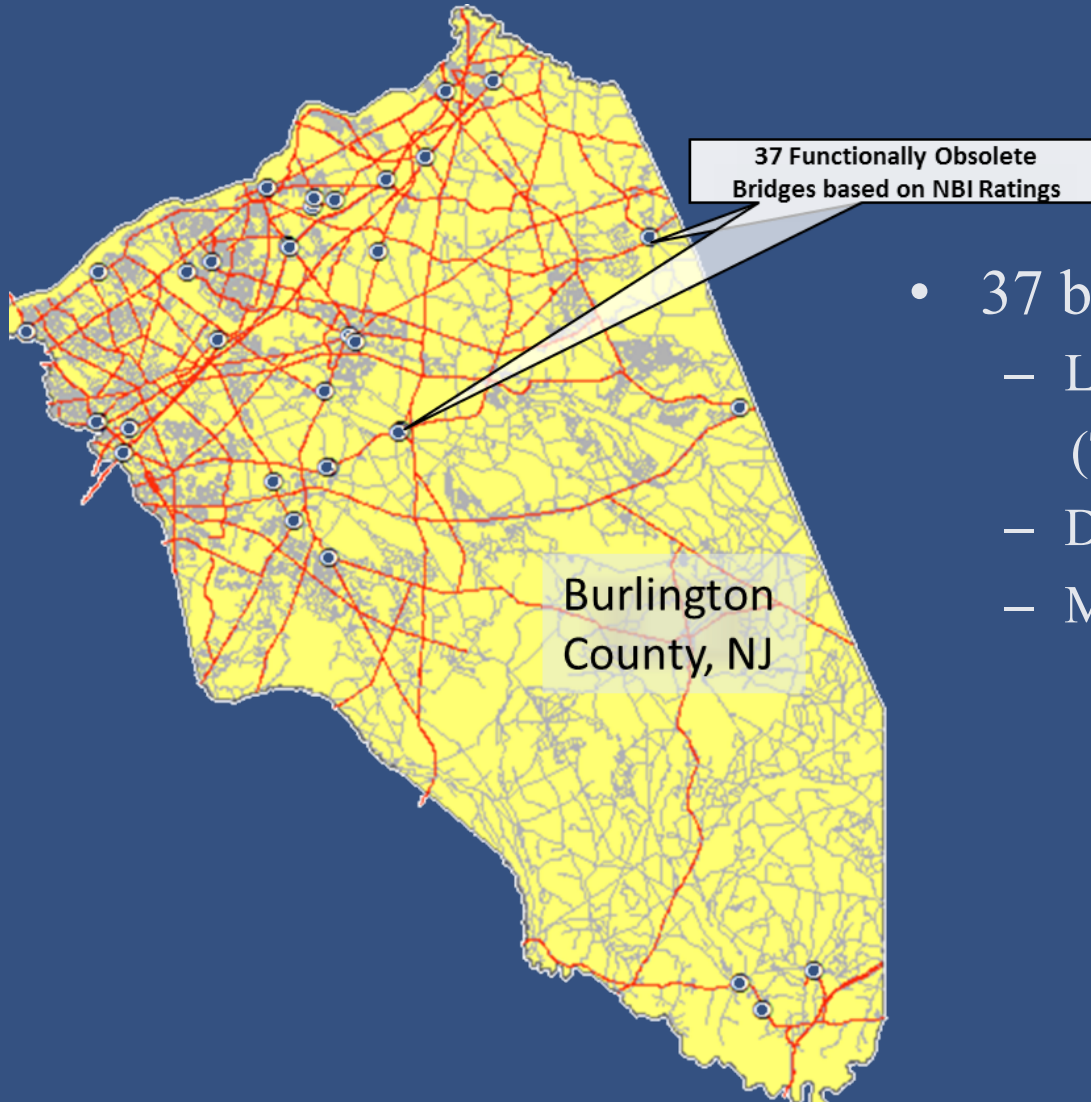


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# Burlington County, NJ



- 37 bridges evaluated
  - Located adjacent to TMC (Traffic Message Chanel)
  - Deficient due to Deck Geometry
  - Many located on county roads

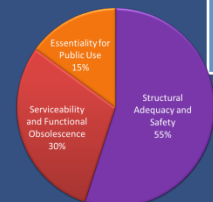


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# Burlington County, NJ

NBI Rank	Structure Number	Deficiency	Serviceability and Functional Obsolescence (Out of 30)
#1	03C4004	SD/ FO-D	19
#2	03D3063	FO-D	20
#2	03D4560	FO-D	20
#4	M033940	FO-DU	21
#5	327153	FO-DU	22
#5	3000004	FO-DU	22
#5	03E4550	SD/ FO-D	22
#5	M055100	FO-DU	22
#9	327174	FO-D	24
#9	328157	FO-D	24

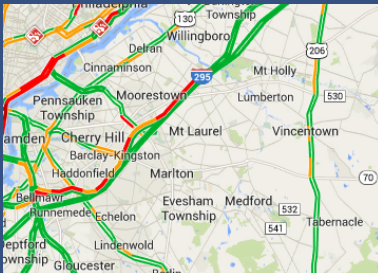


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# Data

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- Speed data is calculated from GPS Locations
  - GPS is pinged entering and exiting a TMC
  - The time between pings is divided by the TMC length to produce space mean speed
- Time stamped speed data is reported
  - Approximately 35 million speed records for the 37 bridges studied (2013).

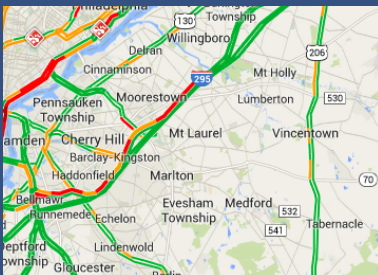


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# Data Processing

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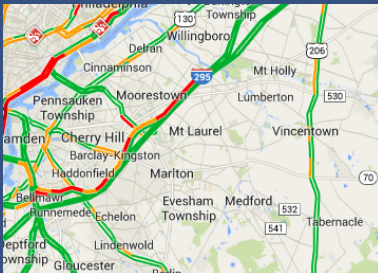
- Data is sorted into 15 min bins for each day of the year
  - The data points in each bin are averaged for that 15 min period
- Congestion is tied to a reduction in speed
  - Significant speed reduction was considered to be 70% of the free-flow speed
  - Free-flow speed was calculated for each TMC by finding the space mean speed for the year between 2AM and 6AM



# Data Processing

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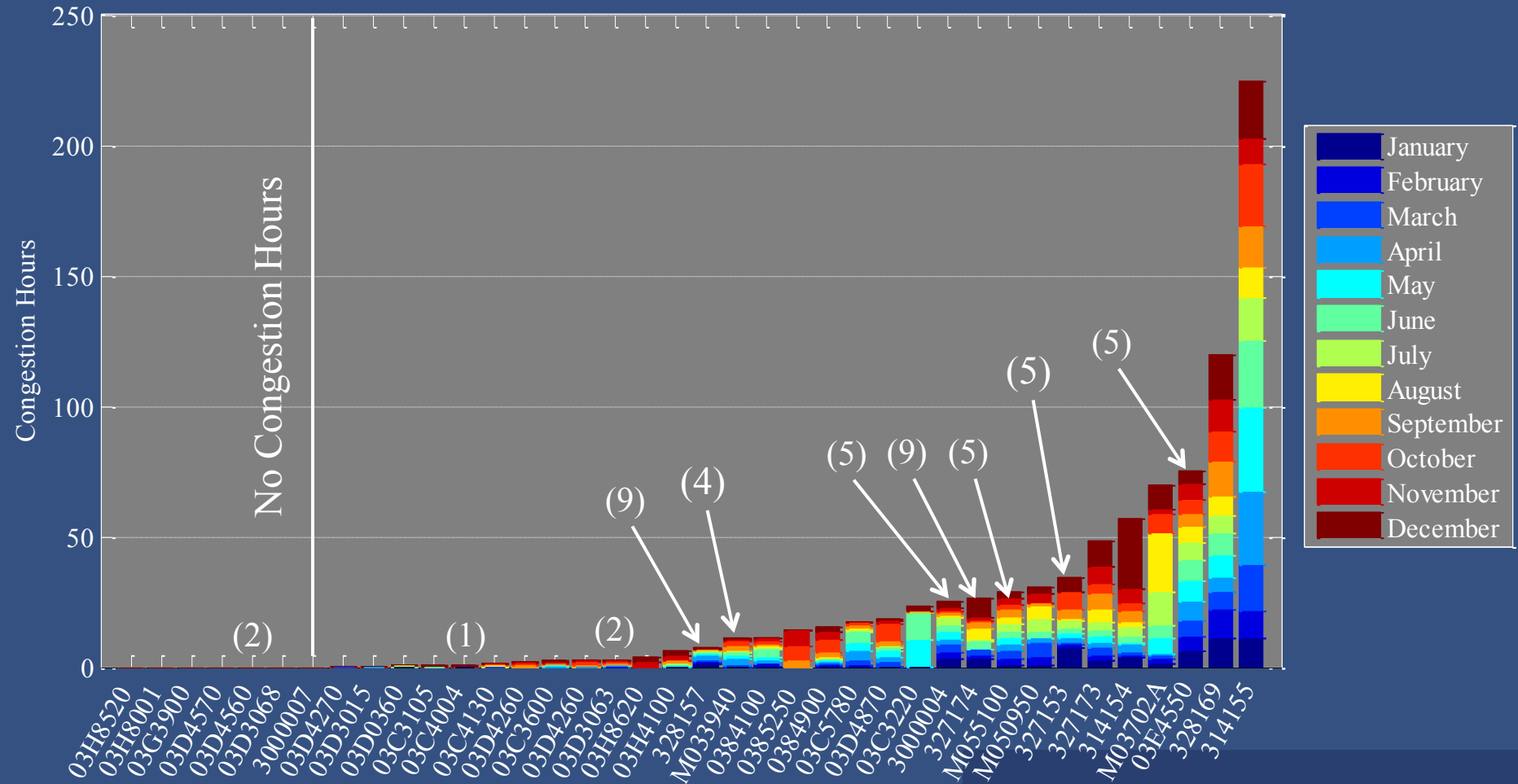
- The data is evaluated using a binary indicator
  - If the average space mean speed drops below 70% of the free-flow speed, the 15 min period is assigned a value of 1
  - If the average space mean speed does not drop below 70% of the free-flow speed, the 15 min period is assigned a value of 0
- The binary indicators can then be summed and divided by 4 to calculate congestion hours
  - The hours can then be aggregated as desired (day, month, etc.)



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# Congestion Analysis



- Approximately 258 work days a year
- Approximately 6 peak travel hours a work day (7AM-10AM, 4PM-7PM)
- For Bridge 314155 →  $224.75/1548 = 15\%$



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# Management Strategies

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- Examine three bridges to evaluate congestion analysis as a bridge management tool

Bridge	NBI Rank	Congestion Rank	Congestion Hours
03C4004	#1	#26	1
03E4550	#5	#3	75.5
314155	—	#1	224.75



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# Bridge Management

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- Bridge management is a complicated process involving a complex cost and benefit analysis, but ultimately it will result in the following recommendations:
  - 1) Do nothing
  - 2) Repair or Retrofit the Existing Structure
  - 3) Replace the Existing Structure
- Congestion analysis will be used to evaluate serviceability, and the structural condition will be evaluated using the NBI rating



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# Bridge 03C4004 (Worst NBI Ranking)

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- Constructed in 1909, and improved in 2007
- Carries a city street across the Rancocus Creek
- NBI Rating Factors
  - Structural Evaluation: 2 out of 10
    - Structurally Deficient
  - Serviceability and Functional Obsolescence: 19 out of 30
    - Obsolete due to Deck Geometry
- Congestion Analysis
  - 1 Congestion Hour for 2013



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# Bridge 03C4004 (Worst NBI Ranking)



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# Bridge 03C4004 (Worst NBI Ranking)

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- Conclusion
  - Serves residential area
  - Low number of Congestion Hours (1/year)
  - Close proximity to I-295 lessens need to carry heavy loads
- Recommendation: Do nothing
  - If structure becomes unsafe for the needs of the community, repair or retrofit



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# Bridge 03E4550 (Best Agreement)

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- Constructed in 1932, and improved in 1977
- Carries Burlington County Route 616 across the Rancocus Creek
- NBI Rating Factors
  - Structural Evaluation: 2 out of 10
    - Structurally Deficient
  - Serviceability and Functional Obsolescence: 22 out of 30
    - Obsolete due to Deck Geometry
- Congestion Analysis
  - 75.5 Congestion Hour for 2013

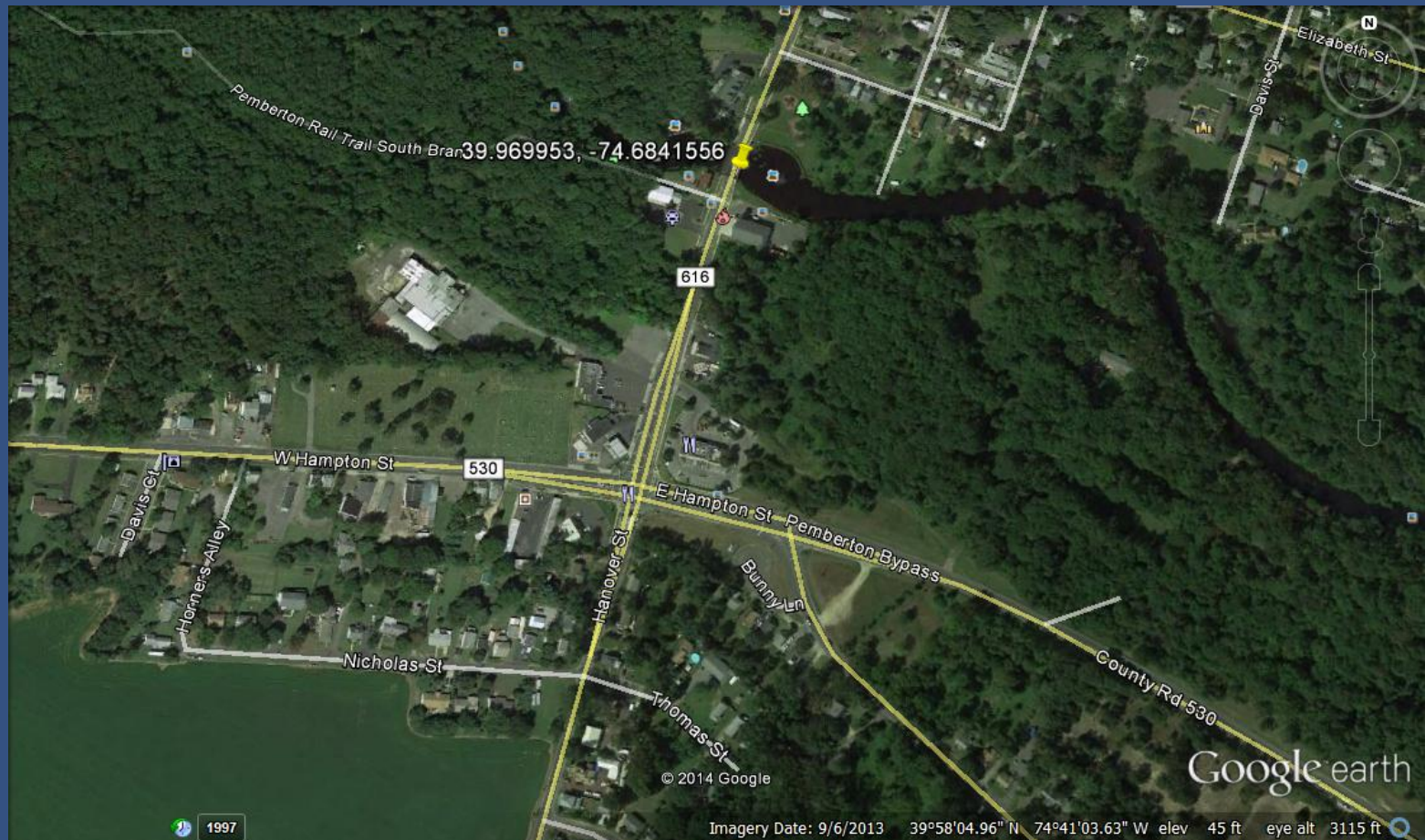


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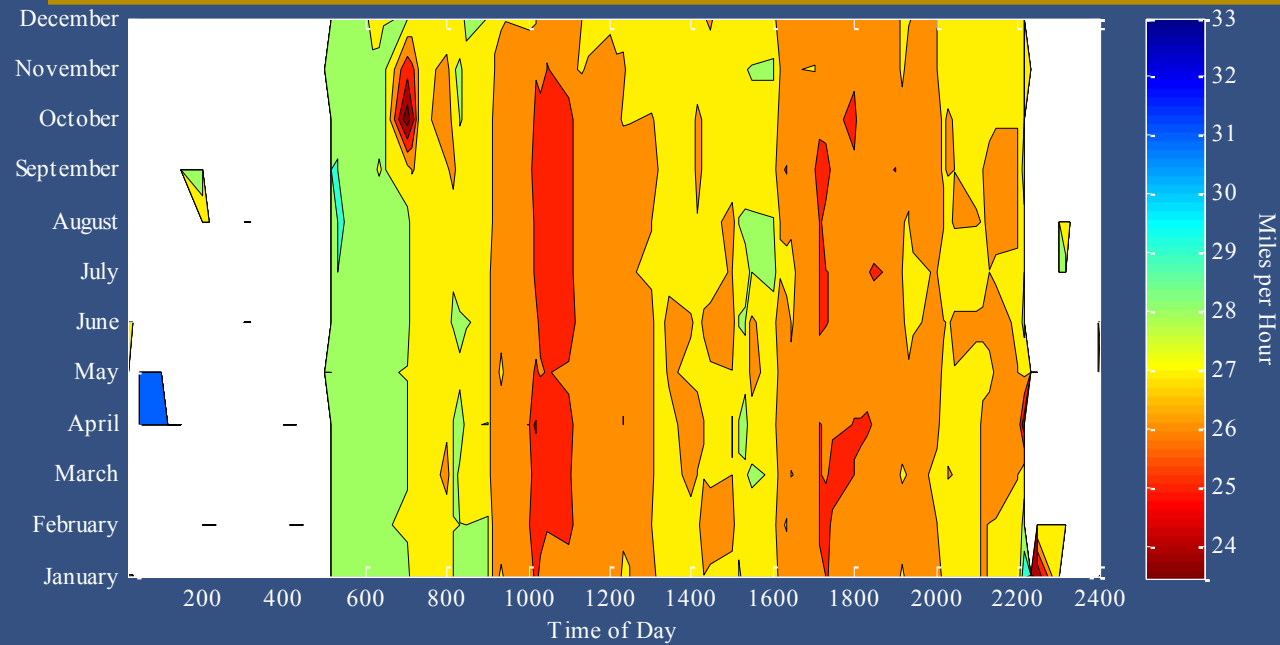


# Bridge 03E4550 (Best Agreement)



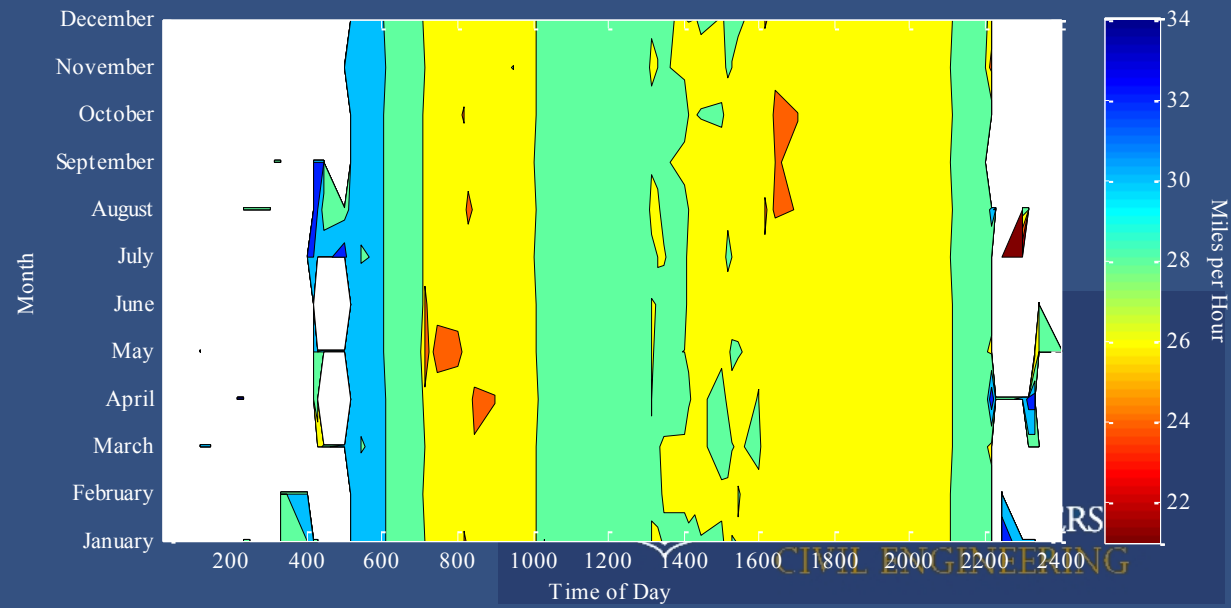
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# Best Agreement



Southbound

Northbound



# Bridge 03E4550 (Best Agreement)

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- Conclusion
  - Bridge is structurally deficient
  - Causes congestion in both directions (75.5 CH/year)
- Recommendation: Replace



# Bridge 314155 (Worst Congestion)

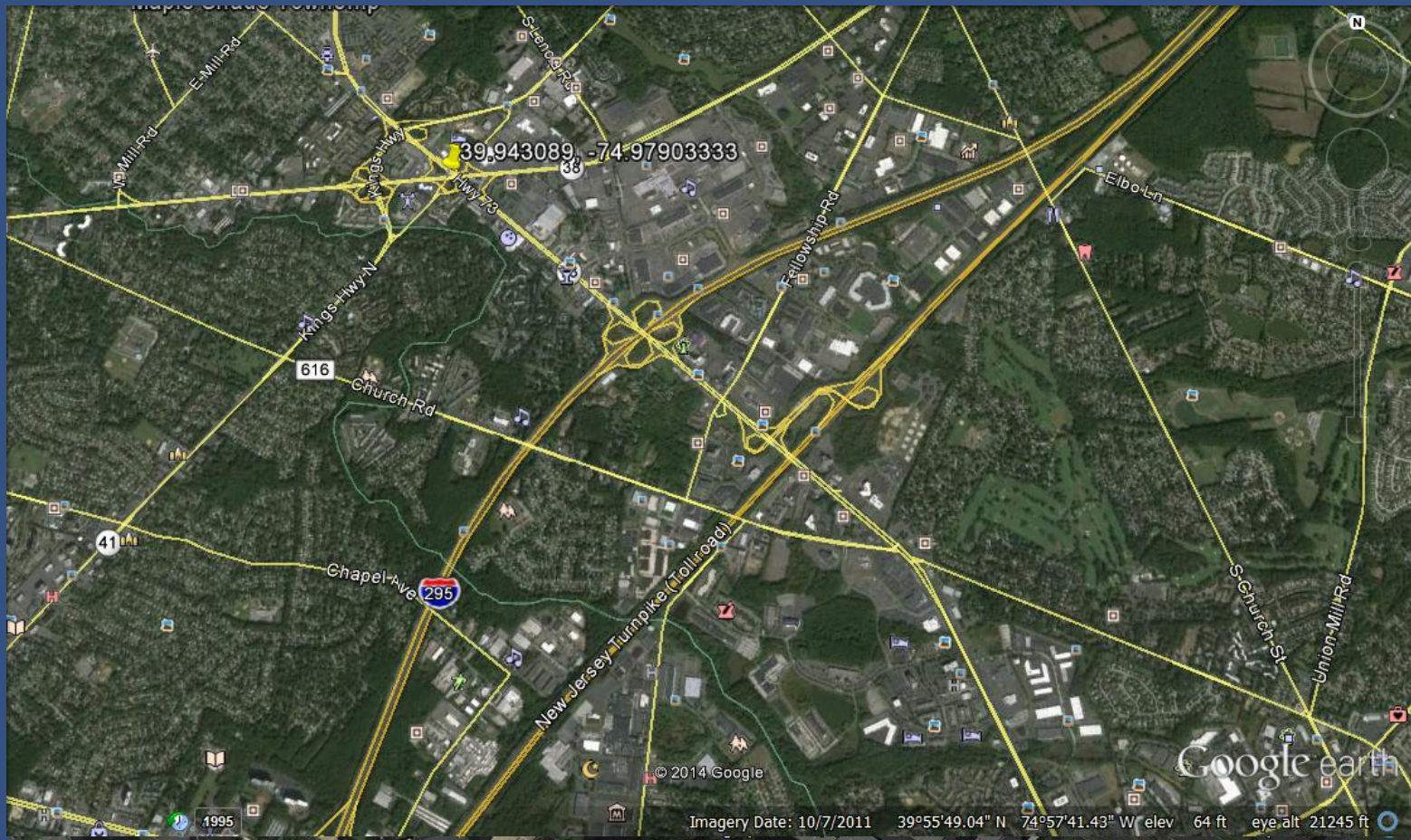
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- Carries NJ Route 73 South connecting Philadelphia to I-295
- Bridge 314154 carries 74 North (56.75 CH/year)
- NBI Rating Factors
  - Structural Evaluation: 6 out of 10
  - Serviceability and Functional Obsolescence: 25 out of 30
    - Obsolete due to Deck Geometry
- Congestion Analysis
  - 224.75 Congestion Hour for 2013





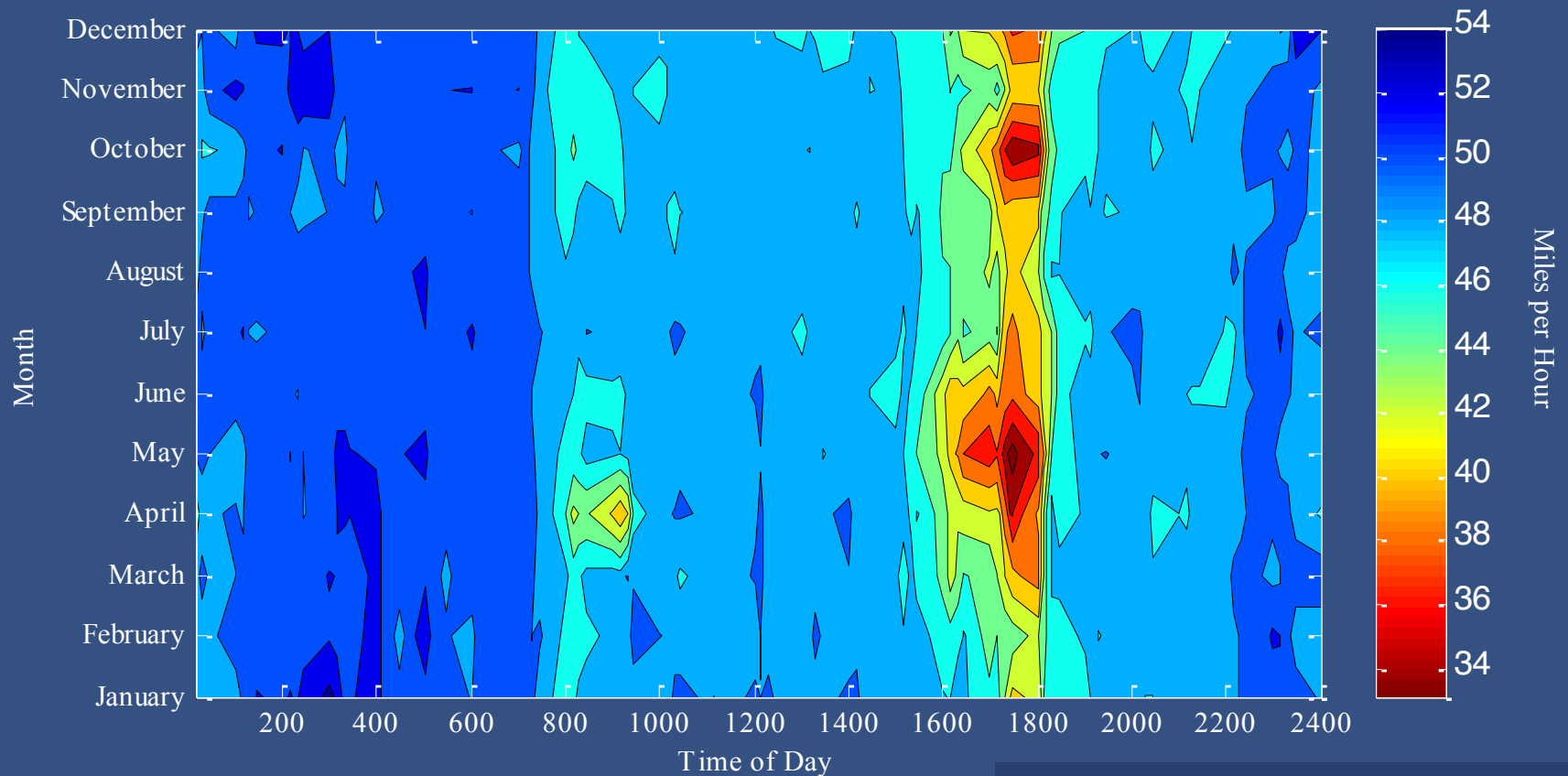
# Bridge 314155 (Worst Congestion)



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# Bridge 314155 (Worst Congestion)



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# Bridge 314155 (Worst Congestion)

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- Conclusion
  - Bridge is structurally adequate
  - Congestion is present at bridge
    - Signalized Intersections?
    - Proximity to I295?
    - Deck Geometry?
- Recommendation: Perform field evaluation of the bridge and adjacent roadways
  - If bridge is found to be source of congestion, widen the bridge



# Conclusions

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- 37 functionally obsolete bridges (due to deck geometry) were evaluated for congestion using anonymous crowd sourced vehicle data
  - FO was not necessarily an indicator of congestion
    - 7 bridges experienced no congestion hours
    - 28 experienced less than 100 hrs. ( $< 6\%$  of peak hrs.)
    - 2 bridges experienced more than 100 hrs
  - Only 5 of the 10 bridges with the worst NBI ranking appeared in the 10 bridges with the worst congestion



# Conclusions

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- A bridge assessment methodology using the congestion analysis was demonstrated
  - The congestion analysis served to actually measure if the bridge was affecting traffic flow
  - Understanding if congestion actually existed made making a recommendation for a course of action clearer



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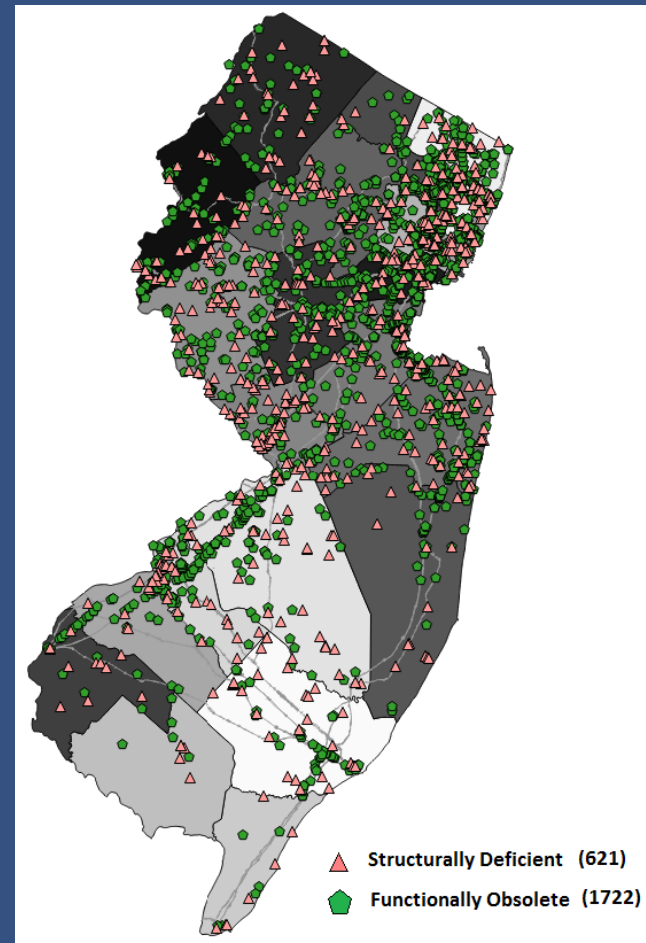
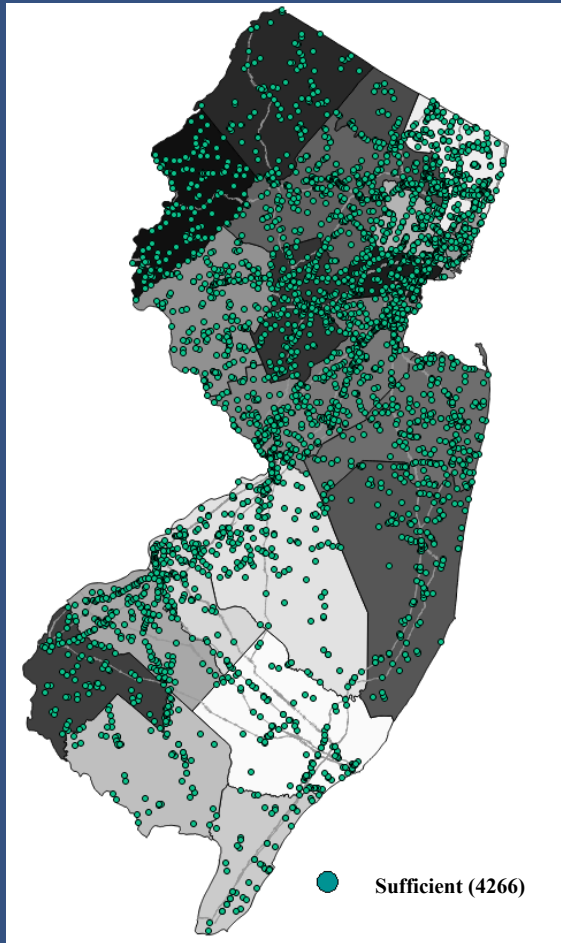
# Future Work

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- 1) Accident data must be incorporated
  - If a structure is causing accidents it would warrant further investigation
- 2) An economic factor must be tied to congestion hours
  - Provide a basis for cost benefit analyses
- 3) The congestion analysis needs to be performed agency wide.
  - It must be used on Functionally Obsolete and Non-functionally Obsolete bridges

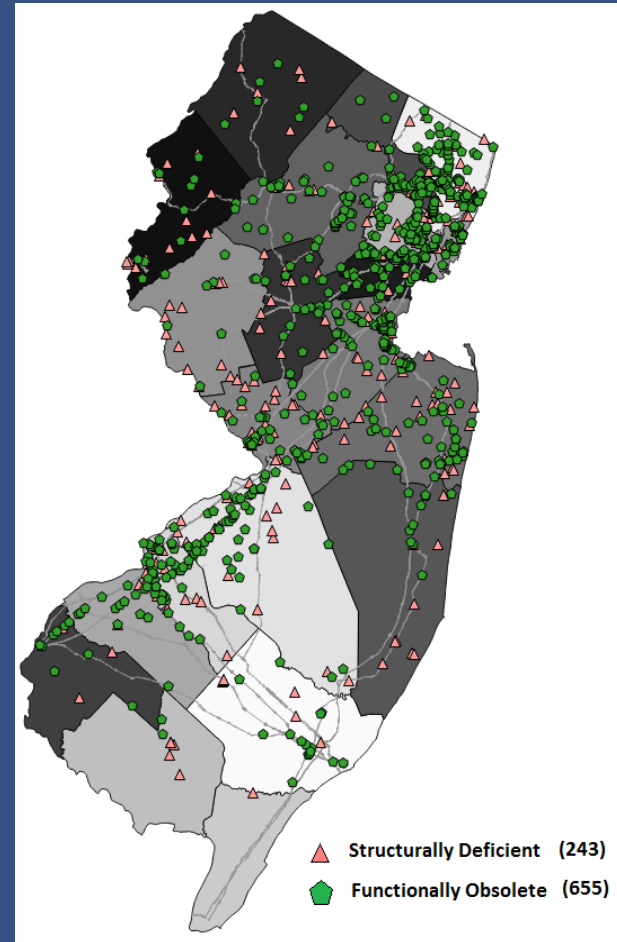
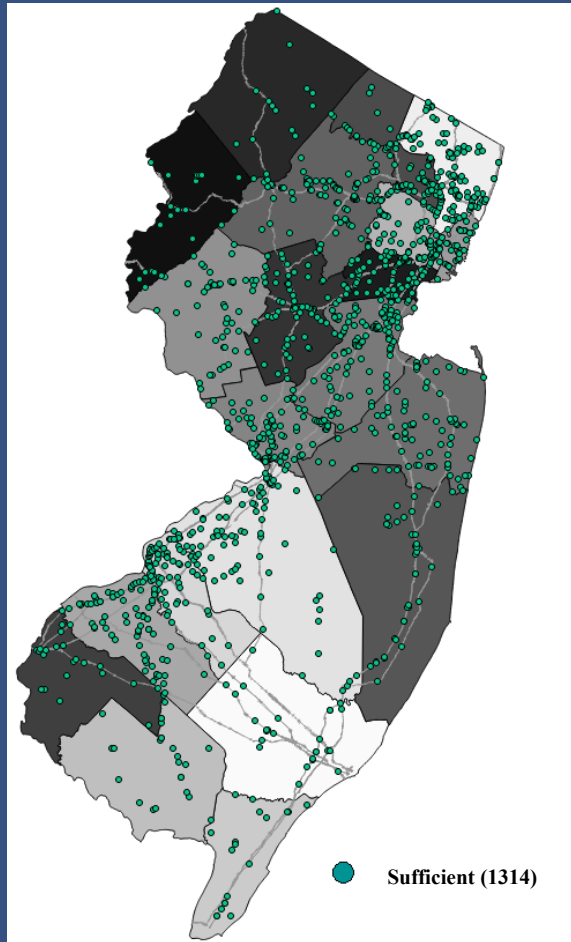


# Future Work



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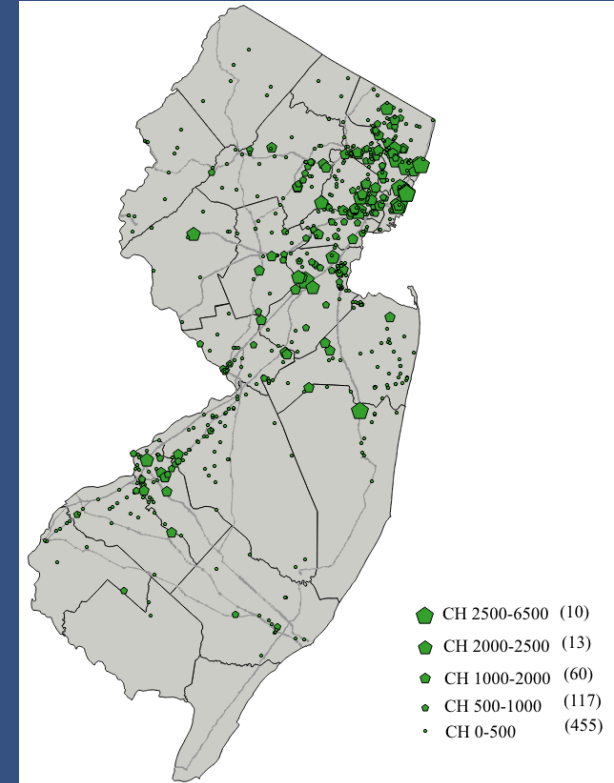
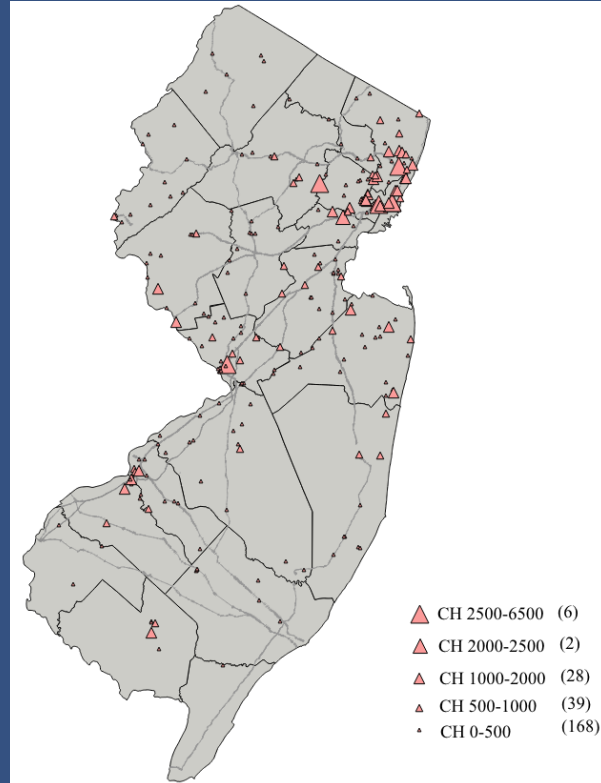
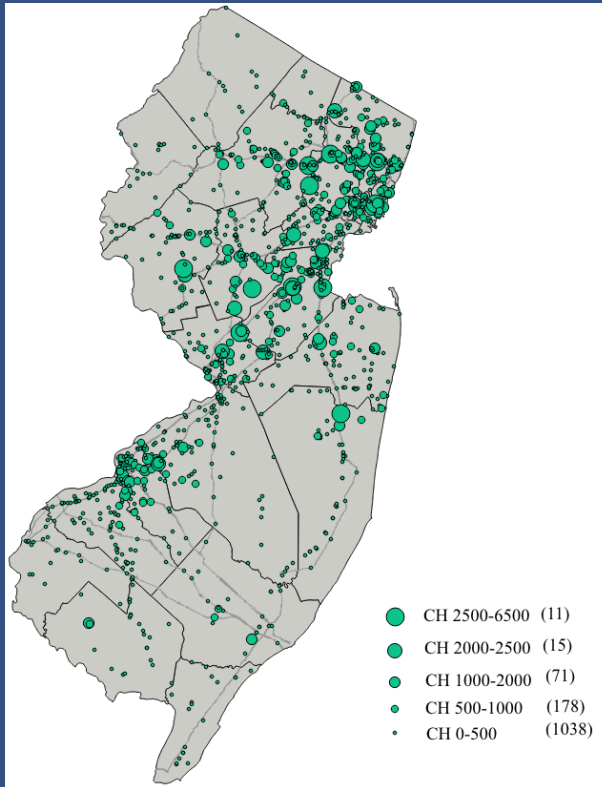
# Future Work



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# Future Work



# Contacts:

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