Implementing a risk based GIS prioritization model to optimize routine maintenance of the sanitary sewer system.

ELIZABETH RENTSCHLAR
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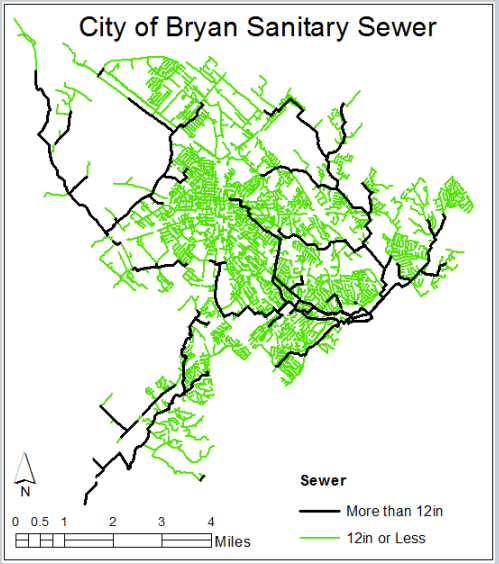
CITY OF BRYAN

Introduction:

- Line cleaning programs
  - maintain sewer line flow velocity
  - help prevent sewage from becoming septic
  - reduce the number of stoppages and sanitary sewer overflows (SSO) by as much as 85% (TEEX 2013)

Introduction:

- The City of Bryan
  - 404 miles of sewer line, ~80% need routine maintenance (RM)
  - 2010 cleaning program
    - 116 SSOs in 2010
    - Increased RM to 80 miles a year and smoke testing
    - 55 in 2015



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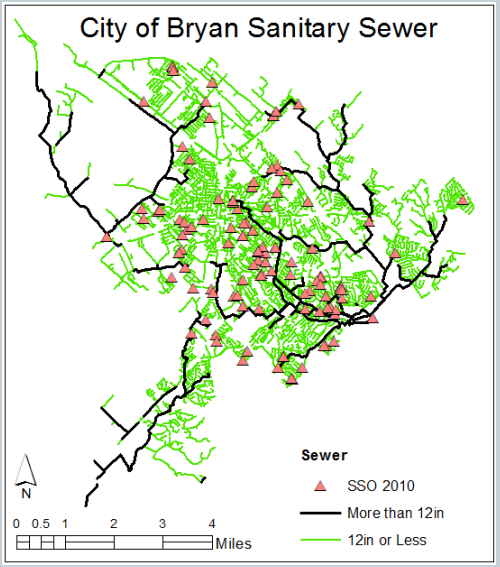

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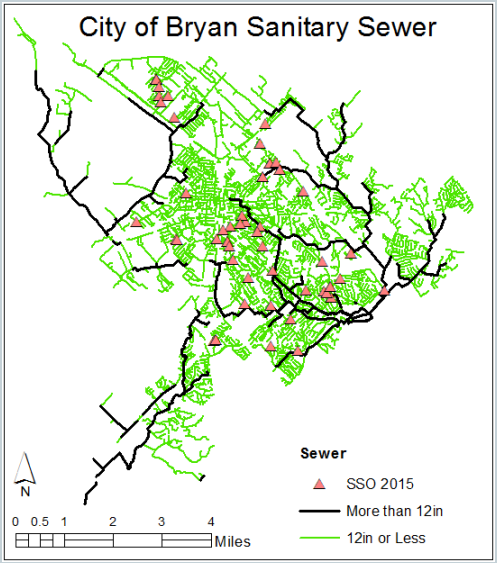
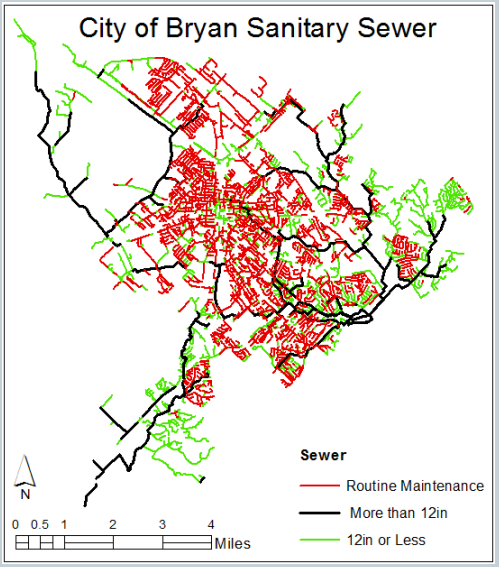


The Problem:

- RM location is haphazard and often repetitive



Solution:

- SSO and sewer stop risk model
  - Consequence of an SSO x Likelihood of an SSO or sewer stop
- GIS + Data
- Python (ArcPy)

Risk Model:

- Based on the Risk Model from Flores et al. 2011
- Data → Processing → Consequence Score and a Likelihood Score → Risk Score

In-House Data:

- Sewer line data (all pipes GIS sewer model)
  - Sewer Line Diameter
  - Year Sewer was Installed
- Routine Maintenance data
  - Date of Maintenance
- Work order data
  - Sanitary Sewer Overflows
  - Sanitary Sewer Stops

External Data:

- Stream Data
- Road Data
- Parcel Data (Brazos CAD)
  - Property Value
  - Land Use Type

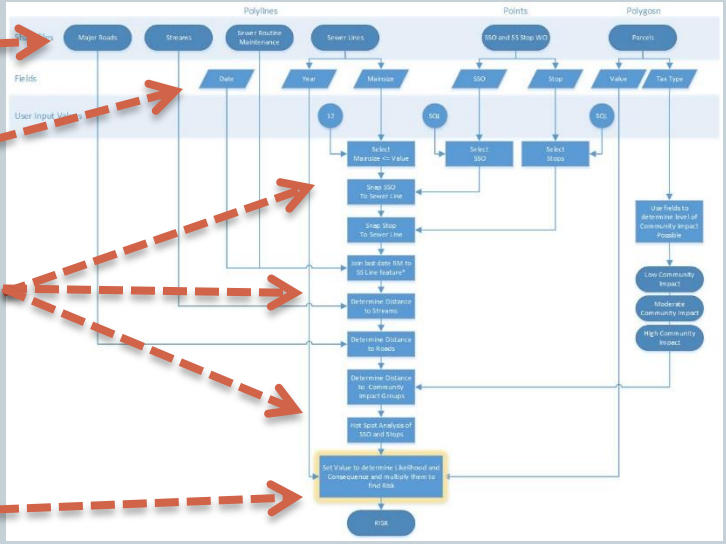
Methodology

Shape Files

Attributes

Geo-processing

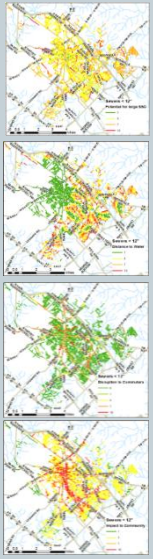
Risk Model and Score



Consequence:

- Factors Considered:
  - Potential for Large SSO
  - Distance to Water
  - Disruption to Commuters
  - Impact to Community

Consequence:



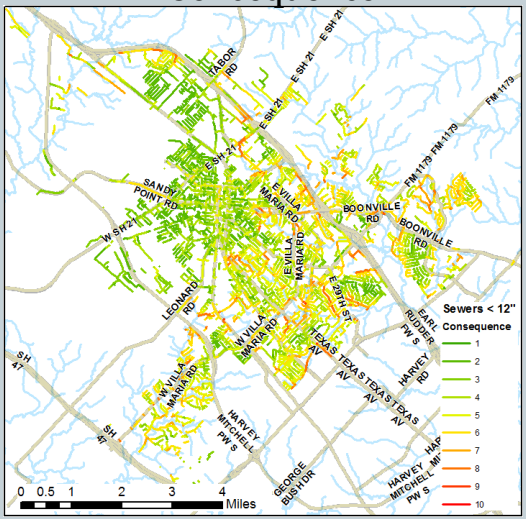
30%
Potential for Large SSO

40%
Distance to Water

10%
Disruption to Commuters

20%
Impact to Community

Consequence

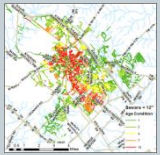


Likelihood:

- Factors Considered:
  - Age Condition
  - Physical Condition
  - WO Likelihoods
  - WO Density
  - Home Values
  - Potential for Stoppage

Likelihood:

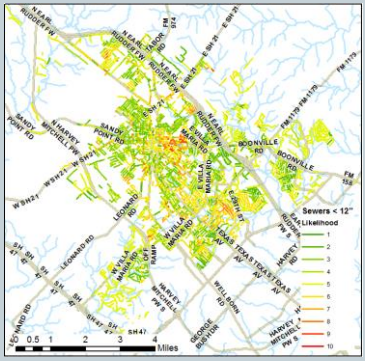
5% Age Condition



35% Physical Condition

15% WO Likelihood

Likelihood



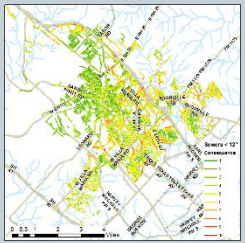
20% WO Density

10% Home Values

15% Potential for Stoppage

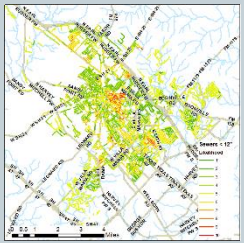
Risk Model:

Consequence



X

Likelihood



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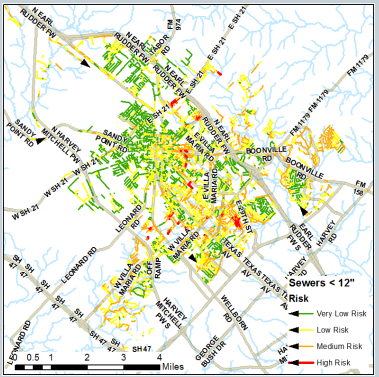
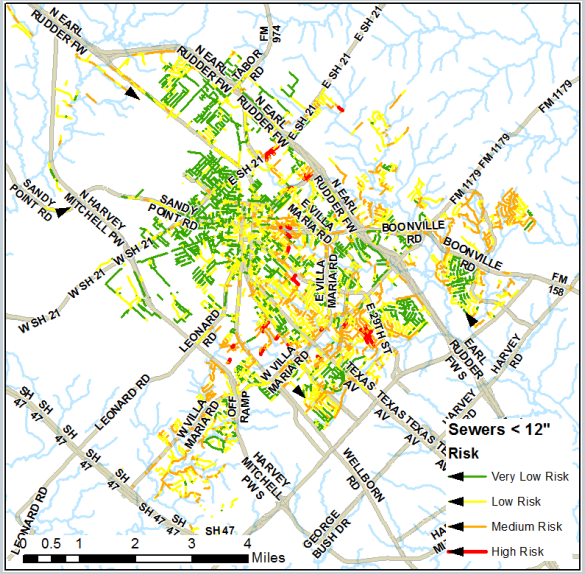
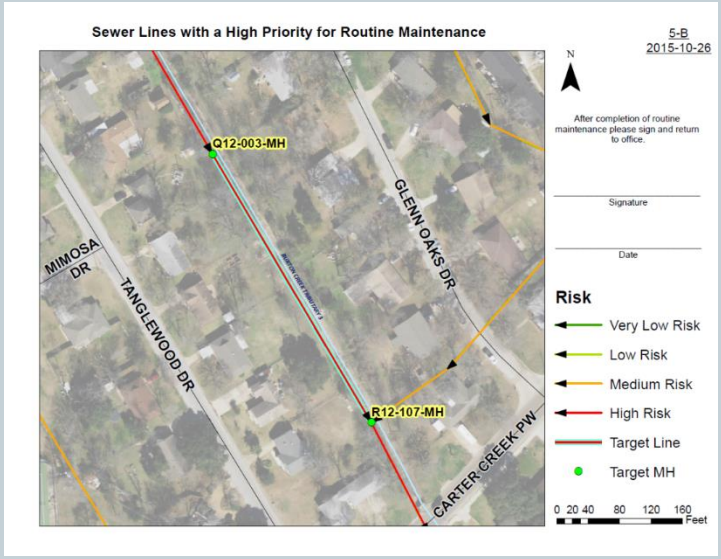
Risk



Map Automation:



Implementation:



Future Directions

- Incorporate material type
- Incorporate data from CCTV'ing
- Reassess the model after a pilot period

Summary:

- Used GIS to create risk score
  - 4 factors go into Consequence
  - 6 factors go into Likelihood
- Used Python to produce maps of highest risk lines

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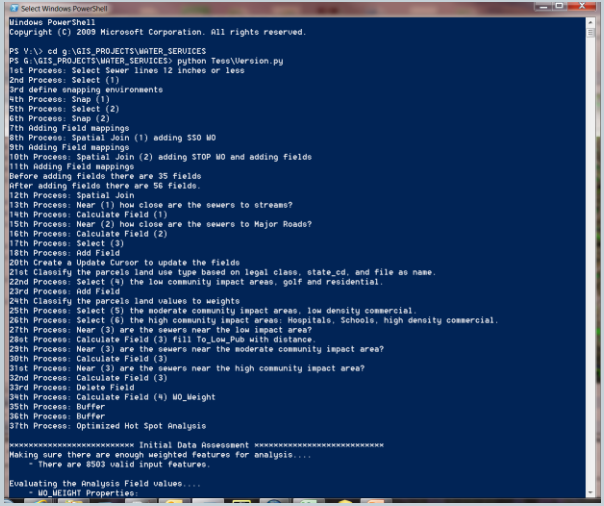
https://github.com/bryansandw/Sewer_Maintenance

Running the Script



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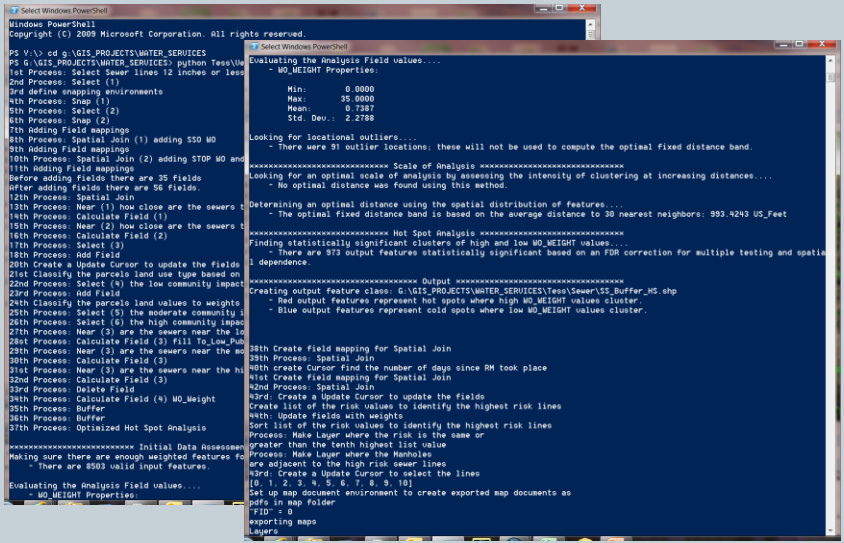

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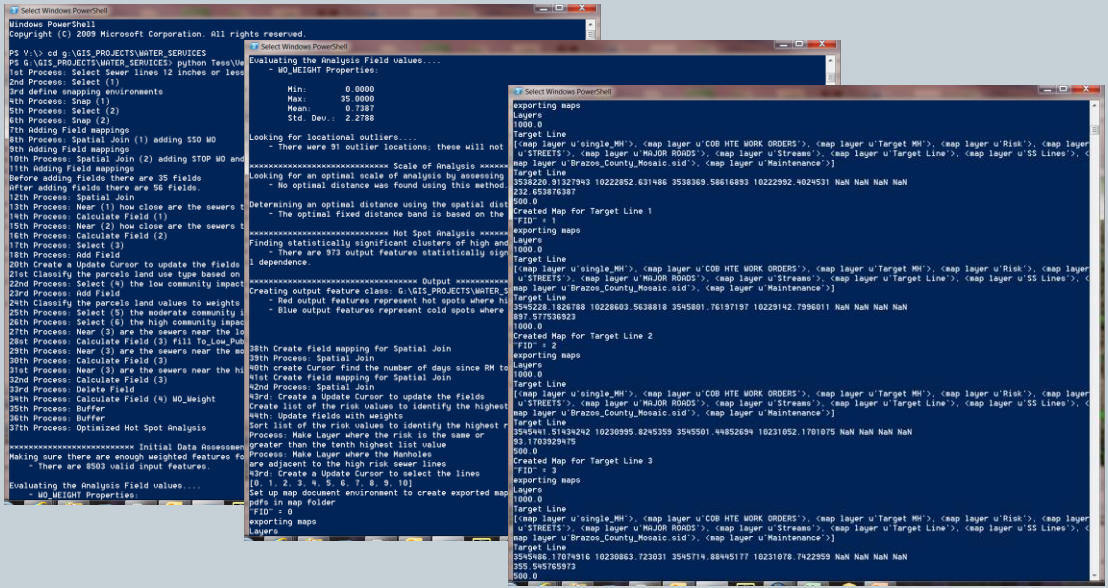
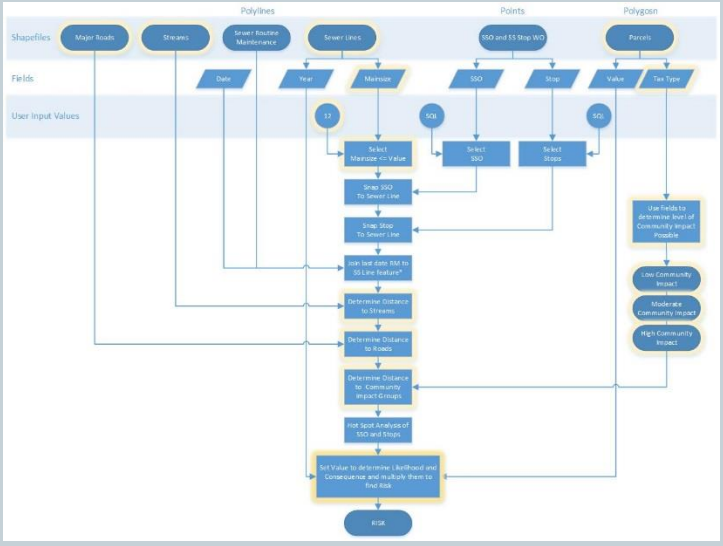


Consequence:

Consequence	Data Used	Weight	1 Values	4 values	7 Values	10 Values
Potential for Large SSO	Size of Sewer	30%	MAINSIZE ≤ 4 in.	MAINSIZE > 4 in. and MAINSIZE ≤ 6 in.	MAINSIZE > 6 in. and MAINSIZE ≤ 8 in.	MAINSIZE > 8 in.
Distance to Water	FEMA Stream	40%	To Water > 1000 ft.	To Water > 500 ft. and To Water ≤ 1000 ft.	To Water > 100 ft. and To Water ≤ 500 ft.	To Water ≤ 100 ft.
Disruption to Commuters	Major Roads	10%	To Road > 50 ft. and To Road ≤ 100 ft.	To Road > 20 ft. and To Road ≤ 50 ft.	To Road > 5 ft. and To Road ≤ 20 ft.	To Road ≤ 5 ft.
Impact to Community	Parcel	20%	Near Open Spaces or Parks	Near Residential and Golf Courses	Near Low Density Commercial	Near Hospital, School, High Density Commercial

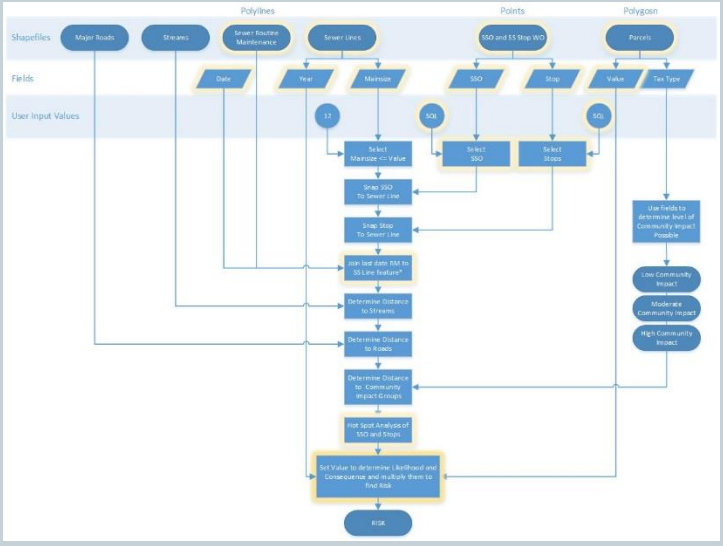
Consequence:



Likelihood:

Likelihood	Dada Used	Weight	1 Value	2 Value	4 Value	7 Value	10 Value
Age Condition	Age of Sewer	5%	Age < 30 yr.	30 to 39 yr.	40 to 49 yr.	50 to 59 yr.	Age > 60 yr.
Physical Condition	RM	35%	< 366 days since RM	366 - 731 days since RM	731 -1097 days since RM	1097 -1460 days since RM	1460 + days since RM
WO Likelihood	SSO and STOP WO	15%	None	1 STOP	≥ 2 STOPs	1 SSO	≥ 2 SSO
WO Density	SSO and STOP WO *	20%	Gi Bin < 0	Gi Bin = 0	Gi Bin > 0	Gi Bin > 1	Gi Bin > 2
Home Values	Parcels	10%	Market ≥ $230,000	Market < $230,000	Market < $165,000	Market < $130,000	Market < $75,000
Potential for Stoppage	Size of Sewer	15%	None	MAINSIZE >8 in. and MAINSIZE < 12 in.	MAINSIZE > 6 in. and MAINSIZE ≤ 8 in.	MAINSIZE > 4 in. and MAINSIZE ≤ 6 in.	MAINSIZE ≤ 4 in.

Likelihood:


Polylines
Points
Polygosn
Shapefiles
Major Roads
Streams
Sewer Routine Maintenance
Sewer Lines
SSO and SS Stop WO
Parcels
Fields
Date
Year
Mainsize
SSO
Stop
Value
Tax Type
User Input Values
12
SQL
SQL
Select Mainsize <= Value
Select SSO
Select Stops
Snap SSO To Sewer Line
Snap Stop To Sewer Line
Use fields to determine level of Community Impact Possible
Join last date BM to SS Line feature*
Low Community Impact
Moderate Community Impact
High Community Impact
Determine Distance to Streams
Determine Distance to Roads
Determine Distance to Community Impact Groups
Hot Spot Analysis of SSO and Stops
Set Value to determine Likelihood and Consequence and multiply them to find Risk
RISK

Weight Values

Consequence	Data Used	Weight	1 Values	4 values	7 Values	10 Values	Field Name
Potential for Large SSO	Size of Sewer	30%	MAINSIZE <= 4 in	MAINSIZE > 4 in and MAINSIZE <= 6 in	MAINSIZE > 6 in and MAINSIZE <= 8 in	MAINSIZE > 8 in	Con_Size
Distance to Water	FEMA Stream	40%	To_Water > 1000 ft	To_Water > 500 ft and To_Water <= 1000 ft	To_Water > 100 ft and To_Water <= 500 ft	To_Water <= 100 ft	Con_Water
Disruption to Commuters	Major Roads	10%	To_Road > 50ft and To_Road <= 100ft	To_Road > 20 ft and To_Road <= 50 ft	To_Road > 5 ft and To_Road <= 20 ft	To_Road <= 5 ft	Con_Road
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WO Likelihood	SSO and STOP WO	10%	None	1 STOP	>= 2 STOPs	1 SSO	>= 2 SSO	Failure_
WO Density	SSO and STOP WO *	30%	Gi_Bin < 0	Gi_Bin == 0	Gi_Bin > 0	Gi_Bin > 1	Gi_Bin > 2	Fail_Den
Home Values	Parcels	10%	Market >= $230,000	Market < $230,000	Market < $165,000	Market < $130,000	Market < $75,000	Mark_Weigh
Potential for Stoppage	Size of Sewer	10%	None	MAINSIZE >8 in and MAINSIZE < 12 in	MAINSIZE > 6 in and MAINSIZE < =8 in	MAINSIZE > 4 in and MAINSIZE < =6 in	MAINSIZE <= 4 in	STOP_like

Variable Significance

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.397410171
R Square	0.157934844
Adjusted R Square	0.156740708
Standard Error	1.890917182
Observations	8475

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	12	5674.797	472.900	132.259	0
Residual	8462	30256.455	3.576		
Total	8474	35931.251			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.528	0.131	4.040	0.000	0.272	0.785	0.272	0.785
MAINSIZE	-0.098	0.012	-8.060	0.000	-0.122	-0.074	-0.122	-0.074
LENGTH (did not use)	0.003	0.000	21.878	0.000	0.002	0.003	0.002	0.003
YEAR	0.000	0.000	-4.395	0.000	0.000	0.000	0.000	0.000
To_Water	0.000	0.000	-1.668	0.095	0.000	0.000	0.000	0.000
To_Road	0.000	0.000	-0.042	0.966	0.000	0.000	0.000	0.000
To_Low_Pub	0.000	0.000	-0.803	0.422	0.000	0.000	0.000	0.000
To_Mod_Pub	0.000	0.000	-1.076	0.282	0.000	0.000	0.000	0.000
To_High_Pub	0.000	0.000	-0.698	0.485	0.000	0.000	0.000	0.000
DaySinRM (Physical Condition)	0.000	0.000	-2.339	0.019	0.000	0.000	0.000	0.000
RM_Count (did not use)	0.030	0.016	1.906	0.057	-0.001	0.061	-0.001	0.061