



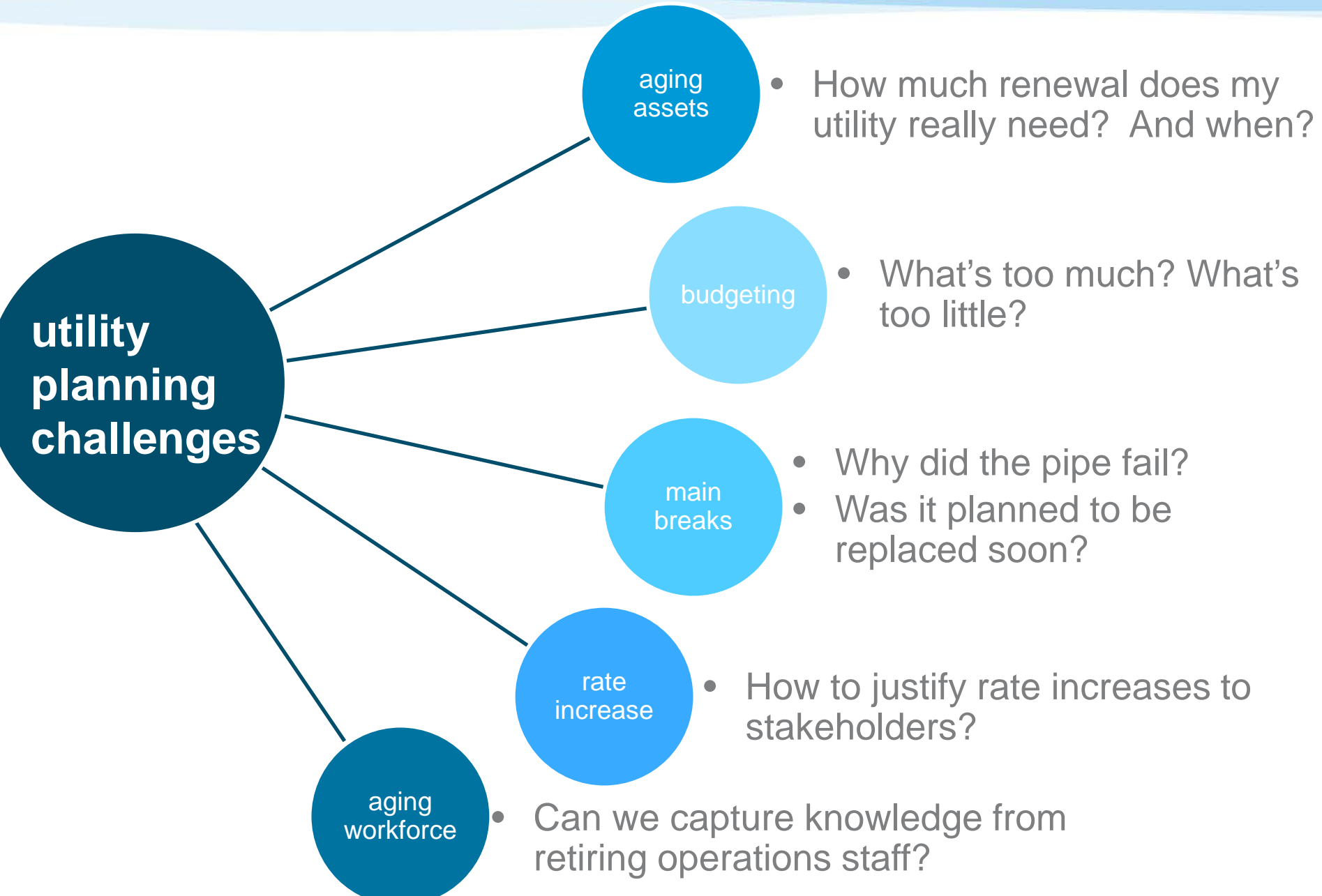
AMERICAN WATER

Leveraging GIS & InfoMaster® for Capital Investment Planning

Save millions in miss-allocated investment

Rajan Ray
Client Service Manager
Innoyze

Christopher Kahn, MGIS, GISP
Senior GIS Project Manager
New Jersey American Water



Traditional Capital Improvement Plans (CIPs)

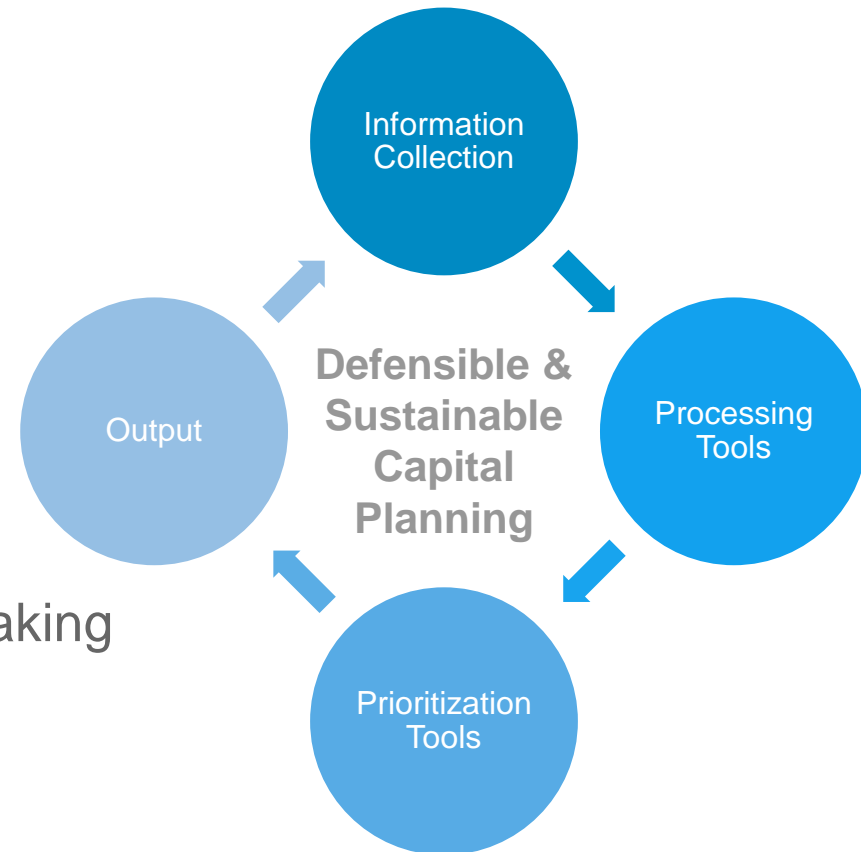
Challenges

- “Black Box” – not very defensible or repeatable
- Hard to quickly decipher, visualize, and share the results
- Difficult (time consuming and costly) to maintain



InfoMaster Platform Overview

- Software for asset integrity management, and capital planning
- Water and wastewater systems
- Built on and runs inside ArcGIS infrastructure
- Out-of-the-Box
- Independent of hydraulic model
- Framework for risk-based decision making
- Defensible decision logic



Defendable & Repeatable Analysis Tools Within GIS

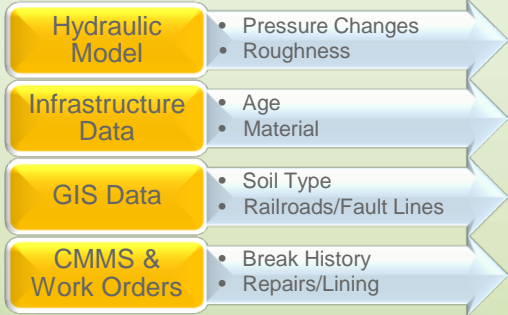
- Risk Calculation
- Failure Prediction Modeling
- Valve Criticality Assessment
- Rehabilitation & Budgeting Engine



InfoMaster[®]

Risk Calculation

Likelihood of Failure

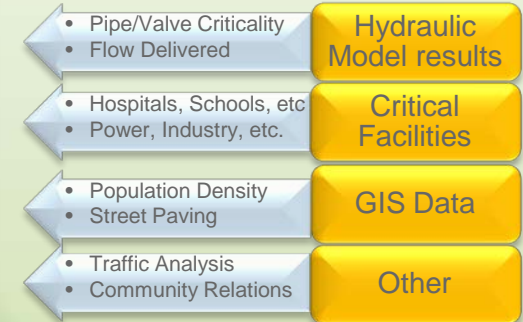


Multiple Calculation Options



Calculation of Risk

Consequence of Failure



Pipe Risk Summary

Graph | Report | Report By Risk Tiles

	LOF - Low	LOF - Medium Low	LOF - Medium	LOF - Medium High	LOF - High
Conseq. - High	16 pipe, 1.36 mile	18 pipe, 1.24 mile	6 pipe, 0.42 mile	4 pipe, 0.57 mile	28 pipe, 2.71 mile
Conseq. - Medium High	22 pipe, 1.60 mile	17 pipe, 1.07 mile	2 pipe, 0.11 mile	2 pipe, 0.05 mile	7 pipe, 0.66 mile
Conseq. - Medium	23 pipe, 1.67 mile	9 pipe, 0.35 mile	1 pipe, 0.12 mile	0 pipe, 0.00 mile	8 pipe, 0.48 mile
Conseq. - Medium Low	91 pipe, 5.36 mile	68 pipe, 4.58 mile	91 pipe, 5.29 mile	40 pipe, 3.12 mile	127 pipe, 8.43 mile
Conseq. - Low	75 pipe, 3.84 mile	23 pipe, 1.66 mile	53 pipe, 3.20 mile	13 pipe, 0.65 mile	127 pipe, 6.61 mile

Risk Class	Capital Action
Extreme	High Priority in CIP / Yearly Operational Frequency
High	Standard Priority in CIP / Biannual Operational Frequency
Medium	Low Priority in CIP / 1 in 5 Years Operational Frequency
Low	1 in 10 Years Operational Frequency
Minimal	1 in 20 Years Operational Frequency

Risk Calculation

Davis_InfoMaster - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

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Table of Contents

- IMID_VCMDetail
- VCM_Valves
- Customized Task Layer
- Break_History
- Water_Breaks_Repaired
- Customer_Calls
- Future_Road_Pave
- Tank
- Clear Well
- Pump
- Fitting
- Network Structure
- Control Valve
- Pressurized Main
 - <all other values>
 - 1
 - 2
 - 3
 - 4
 - 5
- Hydrant

InfoMaster

Facility Explorer - Pressurized Main '388'

Run Report - Map Display...

Risk ID	Description	Method	Risk Category
Risk1	New Pipe Risk	Bi-Direct...	●●●●●
Risk2	Failure Histor...	Bi-Direct...	●●●●●

Consequence of Failure

COF1 (Population Density)	2
COF2 (Critical Facilities)	1
COF3 (Critical Facilities)	1
COF4 (Diameter)	4
COF5 (Critical Facilities)	1
COF6 (Est_Depth)	5
Total Consequence of Failure	14

Likelihood of Failure

LOF1 (InstallDate)	1
LOF2 (Material)	1

Risk Results - Risk1

ID	Consequence of Failure	Likelihood of Failure	Total Risk	Normalized Risk	Risk(By Grading)	Diameter	Material	Install Date	Length
1	Total	23495	26954	830753					
2	1882	19.0000	19.0000	361.0000	1000.0000	5-Extreme	10.0000	DI	157.5681
3	1884	19.0000	19.0000	361.0000	1000.0000	5-Extreme	10.0000	DI	163.0406
4	1906	19.0000	19.0000	361.0000	1000.0000	5-Extreme	6.0000	DI	551.6729
5	1880	18.0000	19.0000	342.0000	947.3684	5-Extreme	10.0000	DI	158.3857
6	1908	16.0000	21.0000	336.0000	930.7479	5-Extreme	6.0000	DI	555.9386
7	1886	17.0000	19.0000	323.0000	894.7368	5-Extreme	10.0000	DI	156.4932
8	1804	13.0000	24.0000	312.0000	864.2659	5-Extreme	6.0000	DI	663.4615
9	2464	13.0000	24.0000	312.0000	864.2659	5-Extreme	8.0000	Steel	547.2180
10	1874	14.0000	22.0000	308.0000	853.1856	5-Extreme	8.0000	DI	314.8938
11	1736	16.0000	19.0000	304.0000	842.1053	5-Extreme	8.0000	DI	687.8844
12	1924	16.0000	19.0000	304.0000	842.1053	5-Extreme	8.0000	DI	317.5594
13	1848	13.0000	23.0000	299.0000	828.2548	5-Extreme	6.0000	DI	491.2490
14	1902	13.0000	23.0000	299.0000	828.2548	5-Extreme	8.0000	Steel	341.4212
15	1312	15.0000	19.0000	285.0000	789.4737	5-Extreme	8.0000	Steel	217.3893
16	1738	15.0000	19.0000	285.0000	789.4737	5-Extreme	6.0000	DI	298.0804
17	1740	15.0000	19.0000	285.0000	789.4737	5-Extreme	6.0000	DI	395.2961
18	1826	16.0000	19.0000	286.0000	786.4727	5-Extreme	8.0000	DI	163.5623

Consequence of Failure Distribution - Risk1

Consequence of Failure Distribution - Risk1

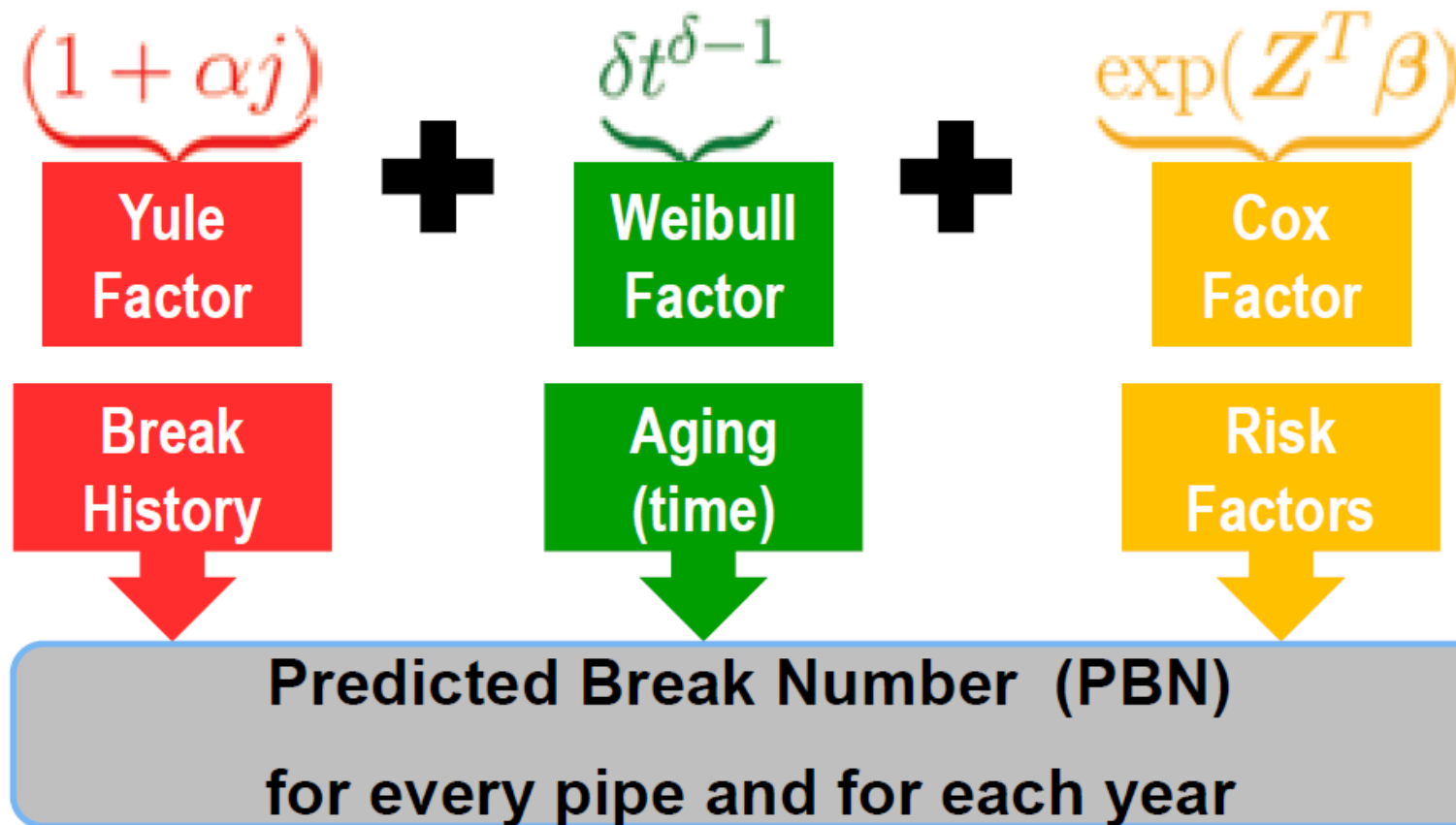
- COF1 (Population Densi...): 20%
- COF2 (Critical Facilities...): 9%
- COF3 (Critical Facilities...): 9%
- COF4 (Diameter): 27%
- COF5 (Critical Facilities...): 10%
- COF6 (Est_Depth): 25%

0 out of 2089 records selected | Full Network | 0 out of 2088 Pressurized Main Selected in ArcMap

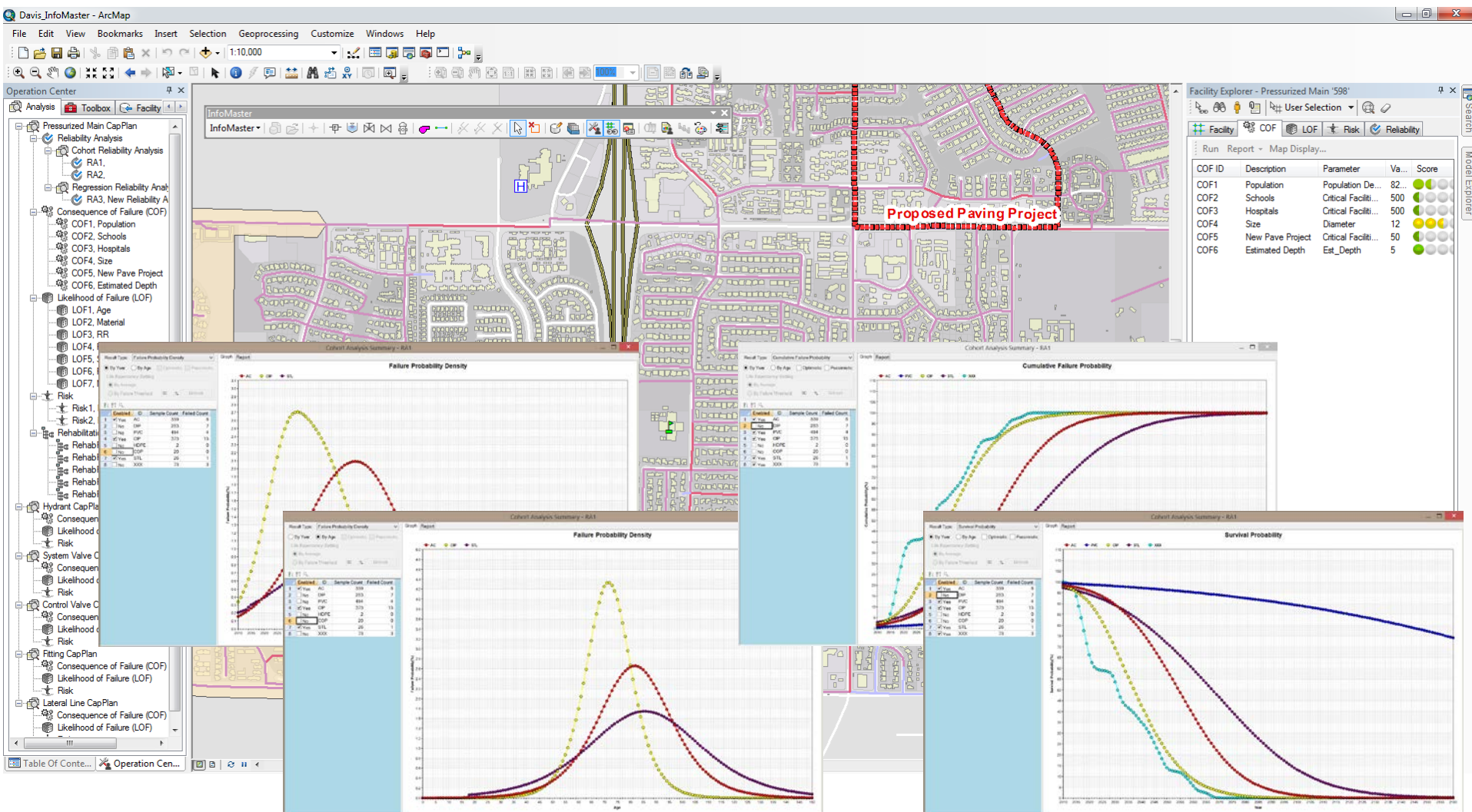
Failure Prediction Modeling

LEYP = Linear Extended Yule Process

Multi-Variable Regression Analysis for Failure Prediction

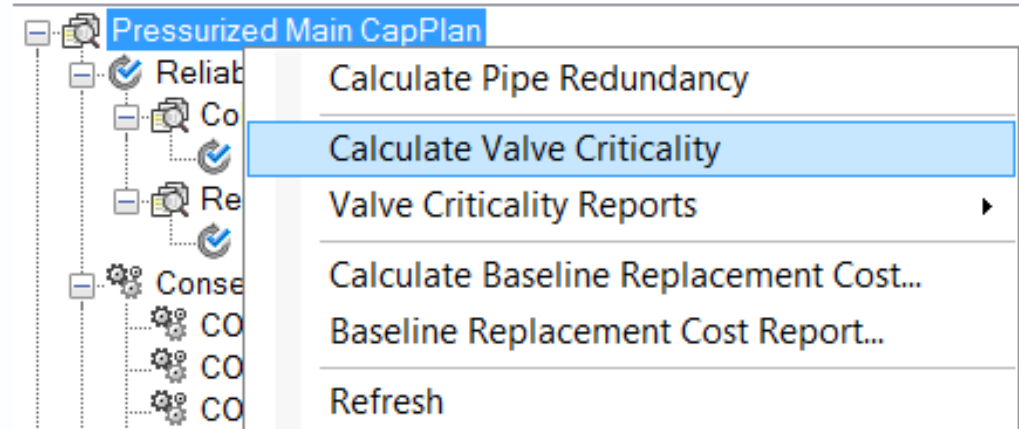


Failure Prediction Modeling



Valve Criticality Assessment

- Each valve analyzed individually
- Consequence of Failure rated by
 - No. valves needed to close
 - No. hydrants out of service
 - Length of main out of service
 - Quantity of demands out of service
 - Critical users out of service
 - Etc.



Valve Criticality Assessment

Davis_InfoMaster - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

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InfoMaster - Analysis Toolbox Facility Query

Operation Center

- Pressurized Main CapPlan
 - Calculate Pipe Redundancy
 - Calculate Valve Criticality
 - Valve Criticality Reports
 - Calculate Baseline Replacement Cost...
 - Baseline Replacement Cost Report...
 - Refresh

Valve Criticality Analysis Pound Summary

Query Builder...

Pound Index	Highlight Color	Count of Pipes	Total Length Of Pipes	Count Of Isolation Valves	Count Of Laterals	Summation Value
1	1	69	25088.7190	31	496	4954.8036
2	2	230	75351.4814	96	1350	9252.9684
3	3	7	2994.8065	2	53	236.9928
4	4	7	1913.4715	5	11	501.9378
5	5	6	951.7434	5	11	646.1724
6	6	7	1316.0641	5	6	137.6448
7	7	3	1543.4040	3	28	212.6334
8	8	9	3422.9143	5	79	339.8820
9	9	8	2628.8211	4	6	18.8598
10	10	10	5269.9391	7	93	1291.3164
11	11	10	1008.2243	6	5	89.2602
12	12	12	2692.4122	7	57	593.1204
13	13	15	4974.9121	7	76	753.5514
14	14	7	2704.7152	5	53	602.5428
15	15	45	14128.9075	12	245	1226.8518
16	16	29	5711.6758	2	61	0.0000
17	17	9	2481.7531	4	57	132.9324
18	18	3	537.5054	2	5	0.0000
19	19	4	1762.3212	2	37	330.5232
20	20	8	1697.2182	3	12	29.8176
21	21	20	6394.9096	4	124	697.3810
22	22	5	1656.4399	4	11	60.2910

261 out of 261 records selected Full Network 0 out of 2088 Pressurized Main Selected in ArcMap

Table Of... Facility E... Operatio...

6620771.638 1965731.405 Feet

Valve Criticality Assessment

The screenshot displays the ArcGIS interface with a water network map on the left and a data table on the right. The map shows a network of pipes and valves, with some pipes highlighted in green and others in blue. The data table, titled 'Valve Criticality Analysis Pound Summary', provides a detailed breakdown of valve criticality metrics for 22 different pounds.

Pound Index	Highlight Color	Count of Pipes	Total Length Of Pipes	Count Of Isolation Valves	Count Of Laterals	Summation Value
1		69	25068.7190	31	496	4954.8036
2		230	75351.4814	96	1350	9252.9684
3		7	2994.8065	2	53	236.9928
4		7	1913.4715	5	11	501.9378
5		6	951.7434	5	11	646.1724
6		7	1316.0641	5	6	137.6448
7		3	1543.4040	3	28	212.6334
8		9	3422.9143	5	79	339.8820
9		8	2628.8211	4	6	18.8598
10		10	5269.9391	7	93	1291.3164
11		10	1008.2243	6	5	89.2602
12		12	2692.4122	7	57	593.1204
13		15	4974.9121	7	76	753.5514
14		7	2704.7152	5	53	602.5428
15		45	14128.9075	12	245	1226.8518
16		29	5711.6758	2	61	0.0000
17		9	2481.7531	4	57	132.9324
18		3	537.5054	2	5	0.0000
19		4	1762.3212	2	37	330.5232
20		8	1697.2182	3	12	29.8176
21		20	6394.9096	4	124	697.3810
22		5	1656.4399	4	11	60.2910

1 out of 261 records selected ● Full Network ○ 0 out of 2088 Pressurized Main Selected in ArcMap

Rehabilitation & Budgeting Engine

Davis_InfoMaster - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

1:10,000

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- VCM_Zone_1_Overview
- IMD_VCMDetail
- VCM_Valves
- Customized Task Layer
- Break_History
- Water_Breaks_Repaired
- Customer_Calls
- Future_Road_Pave
- Tank
- Clear Well
- Pump
- Fitting
- Network Structure
- Control Valve
- Pressurized Main
 - < all other values >
 - Lining
 - No Action
 - Repair
 - Replace
- Hydrant
- Meter
- Wholesale Meter
- Gravity Main
- Lateral Line
- RailRoads
- Hospitals
- Schools
- Meter_Sales
- FlushZones
- Break_History_Multiple
- Water_Breaks_Repaired
- buildings
- streets
- census2000
- Yolo_Soil
- subdivision
- propuse

Flowchart - Default

Print Preview Open Save Save To Route New Chart Add Condition Add End Run

```

    graph TD
      Start([Start]) --> Risk{[Risk] >= (High)}
      Risk -- No --> NoAction[No Action]
      Risk -- Yes --> InstallDate{[PressurizedMain.INSTALLDATE] <= (1950)}
      InstallDate -- Yes --> ReplacePVC[Replace with PVC (Polyvinyl Chloride)]
      InstallDate -- No --> Material{[PressurizedMain.MATERIAL] = (CP)}
      Material -- Yes --> Lining[Lining]
      Material -- No --> Repair[Repair]
  
```

Report Graph Manager

Budget Plan Phasing

Budget Plan

Rehabilitation Plan Summary - RehabPlan5

Query Builder...

ID	Rehab Actions	Reason	Flowchart Branch	Number of Rehab.	Total Cost	Work Order Created
43	846 Replace with PVC (Polyvinyl Chloride)	[PressurizedMain.INSTALLDATE] <= (1950) is Yes	Y-Y	1	73094.6104	Yes
44	848 Replace with PVC (Polyvinyl Chloride)	[PressurizedMain.INSTALLDATE] <= (1950) is Yes	Y-Y	1	50398.0918	Yes
45	850 Replace with PVC (Polyvinyl Chloride)	[PressurizedMain.INSTALLDATE] <= (1950) is Yes	Y-Y	1	23087.5206	
46	860 Replace with PVC (Polyvinyl Chloride)	[PressurizedMain.INSTALLDATE] <= (1950) is Yes	Y-Y	1	43123.9559	
47	905 Replace with PVC (Polyvinyl Chloride)	[PressurizedMain.INSTALLDATE] <= (1950) is Yes	Y-Y	1	17559.3176	
48	10 Repair	[PressurizedMain.MATERIAL] = (CP) is No	Y-N-N	1	25359.2436	
49	100 Repair	[PressurizedMain.MATERIAL] = (CP) is No	Y-N-N	1	54883.8291	
50	1014 Repair	[PressurizedMain.MATERIAL] = (CP) is No	Y-N-N	1	88054.4998	
51	1016 Repair	[PressurizedMain.MATERIAL] = (CP) is No	Y-N-N	1	82283.0861	
52	102 Repair	[PressurizedMain.MATERIAL] = (CP) is No	Y-N-N	1	47488.4183	

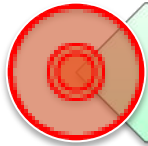
InfoMaster Validation Process



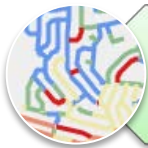
Installed & Trained / Provided Innovyze Feedback



Engineers Determined Variables / Weights



GIS Staff Developed Spatial Analysis & GIS Layers



Iteratively Ran IM, Compared Results, Adjusted Model



Shared & Collaborated on Final Results

Predecessor Work Flow – Stepwise Variables

PAIRWISE COMPARISON OF VARIABLES (Scale = 0 to 6)

VARIABLE WEIGHTING	Decade Installed	Existing Diameter	Existing Pipe Material	Pressure Class Adequacy	Joint Type	Internal Lining	Exterior Protection	Soil Corrosivity	Service Line Material	Main Break Frequency	Complaint Frequency	Difficulty to Repair	Insurance Claims	Current Hydraulic Adequacy	Future Hydraulic Adequacy	Current Fire Flow Adequacy	Future Fire Flow Adequacy	Residential Customers	Commercial Customers	Critical Customers	Shutdown Tolerance	Coordination with Others	Affect on Community	Sum	% of Total Sum	Variable Weighting	
Decade Installed	1	2	1	2	2	2	0	2	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	15	1.0%	13
Existing Diameter	5	2	1	2	3	2	0	2	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	20	1.3%	17
Existing Pipe Material	4	4	1	3	3	2	3	5	0	1	1	0	0	0	1	0	1	1	1	0	0	0	0	0	31	2.0%	27
Pressure Class Adequacy	5	5	5	5	5	5	2	5	0	2	2	1	3	2	3	2	2	2	2	1	1	0	0	0	58	3.8%	50
Joint Type	4	4	3	1	3	3	1	4	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	26	1.7%	22
Internal Lining	4	2	3	1	3	3	2	4	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	25	1.7%	22
Exterior Protection	4	3	4	1	3	3	3	4	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	28	1.8%	24
Soil Corrosivity	6	4	3	4	5	4	3	5	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	38	2.5%	33
Service Line Material	4	4	1	1	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	1.1%	15
Main Break Frequency	6	6	6	6	6	6	6	6	6	5	5	2	3	4	3	4	5	5	2	2	2	2	2	2	98	6.5%	84
Complaint Frequency	6	6	5	4	6	6	6	5	6	1	4	2	2	3	2	3	4	4	1	1	1	1	1	1	79	5.2%	68
Difficulty to Repair	6	6	5	4	6	6	6	6	6	1	2	1	1	2	1	2	1	1	0	1	0	1	0	1	65	4.3%	56
Insurance Claims	6	6	6	5	6	6	6	6	6	4	4	5	3	3	4	3	4	4	3	2	3	2	2	2	96	6.3%	83
Current Hydraulic Adequacy	6	6	6	3	6	6	6	6	6	3	4	5	3	4	4	5	4	4	3	2	4	2	2	2	96	6.3%	83
Future Hydraulic Adequacy	5	5	5	4	5	5	5	5	6	2	3	4	2	2	4	2	4	3	2	1	3	1	1	1	75	5.0%	65
Current Fire Flow Adequacy	6	6	6	3	6	6	6	6	6	3	4	5	3	2	4	5	3	2	1	3	1	1	1	1	88	5.8%	76
Future Fire Flow Adequacy	5	5	5	4	5	5	5	5	6	2	3	4	2	1	2	1	2	2	1	0	2	0	0	0	65	4.3%	56
Residential Customers	5	5	5	4	5	5	5	5	6	1	2	5	2	2	3	3	4	4	2	1	2	1	0	0	73	4.8%	63
Commercial Customers	6	6	5	4	6	6	6	6	6	1	2	5	3	3	4	4	5	4	4	2	2	1	0	0	87	5.7%	75
Critical Customers	6	6	6	5	6	6	6	6	6	4	5	6	4	4	5	5	6	5	4	5	5	5	5	5	116	7.7%	100
Shutdown Tolerance	6	6	6	5	6	6	6	6	6	4	5	5	3	2	3	3	4	4	4	1	4	2	3	3	96	6.3%	83
Coordination with Others	6	6	6	6	6	6	6	6	6	4	5	6	4	4	5	6	5	6	5	5	1	4	2	2	110	7.3%	95
Affect on Community	6	6	6	6	6	6	6	6	6	4	5	5	4	4	5	5	6	6	6	1	3	4	2	2	112	7.4%	97
																									1514		

Predecessor Work Flow – Stepwise Methodology

Anyone See Problems?



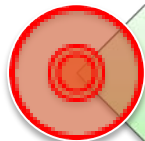
Operational Triggers (Quality, Fire Flow, Breaks, Pressure)



Human Interpretation of Potential Project Areas



Limited & Multiple Forms Defect / Consequence Data



Limited *Precise* Location Data



Data Entry Into Stepwise Comparison of Identified Projects

New InfoMaster Work Flow

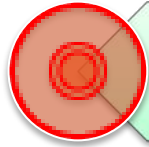
Bottoms Up!



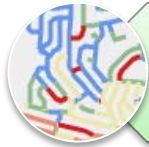
All Pipe GIS Analysis



Single GIS format of input data



Precise Location Data



Objective, Defendable All-Pipe Ranking



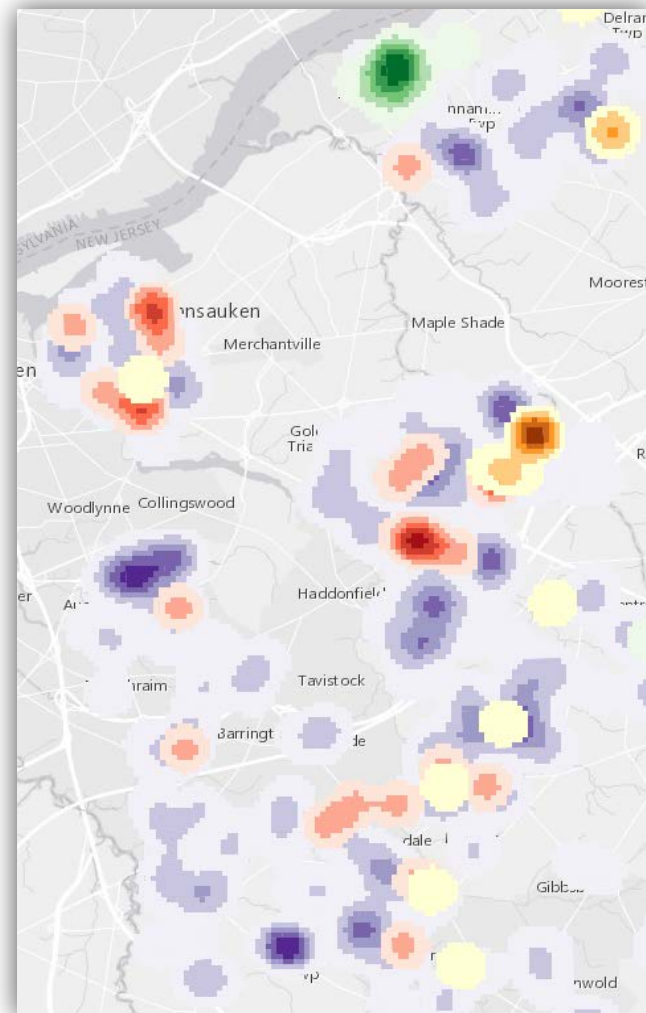
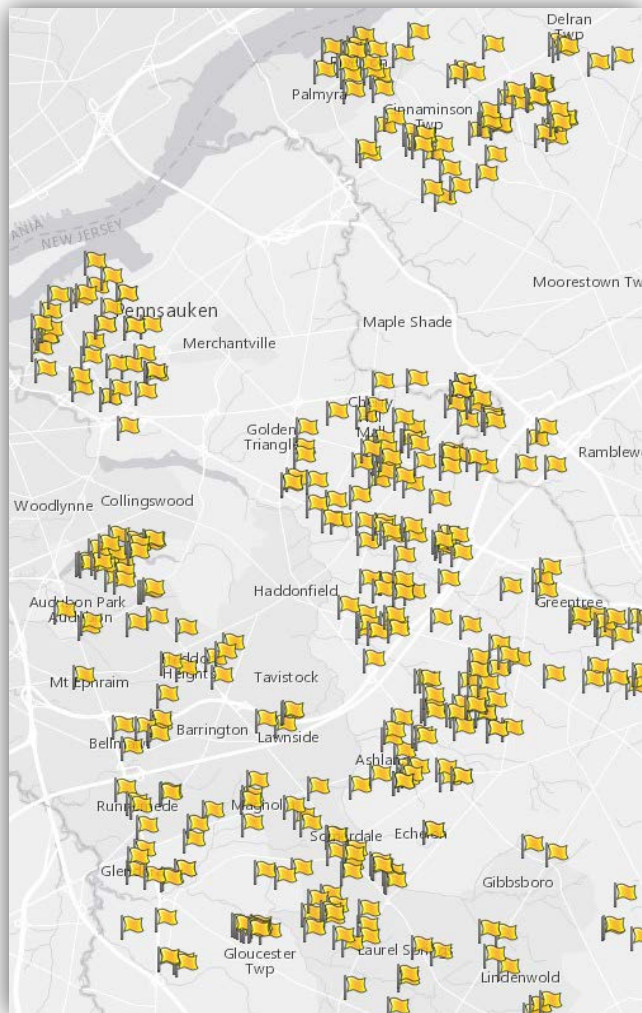
Human Collaboration & Planning

New InfoMaster Work Flow – Variables

InfoMaster Prioritization Criteria Variables & Weights			
Likelihood of Failure (LOF)	Weight	Consequence of Failure (COF)	Weight
Segment Break Frequency	10	Stream Crossing	9
Break Density (Material 1 - Cast Iron)	8	Large Water Body Crossing	9
Break Density (Material 2 - Ductile Iron)	8	Available Fire Flow	8
Break Density (Material 3 - Asbestos)	8	Commercial Customer Density	8
Break Density (Material 4 - Cement)	8	Water Quality Complaint Density	7
Break Density (continue as required)	*	Railroad Crossing	6
Water Velocity	8	Major Road Easement or Crossing	6
Cohort Survival Probability	4	Connection Count	6
Material	2	Medical Facilities	5
Age	2	Company Critical Customers	5
		School Facilities	4
		Main Diameter	2

Break Rates & the Problem of Very Small Numbers

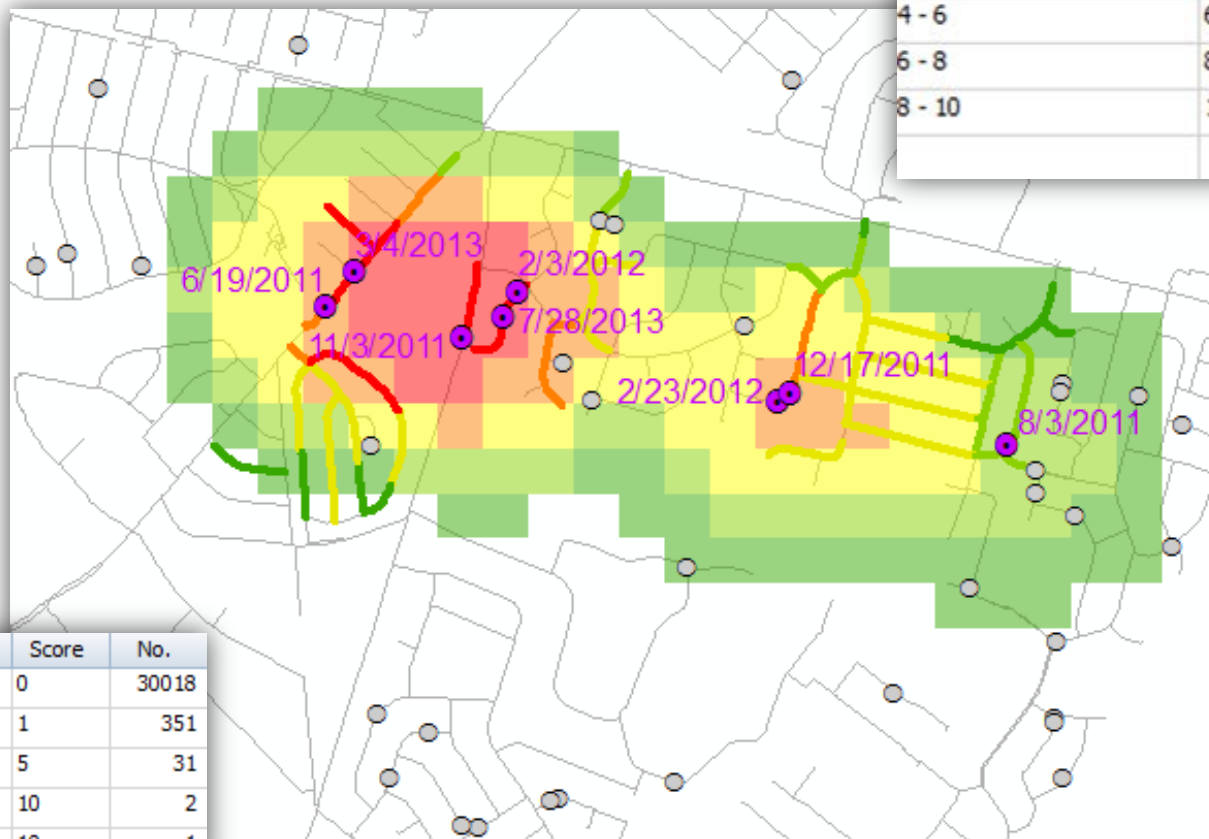
Solution - Add Kernel Density Scoring



InfoMaster Work Flow – GIS Kernel Density Scoring

AC Break Density Scores

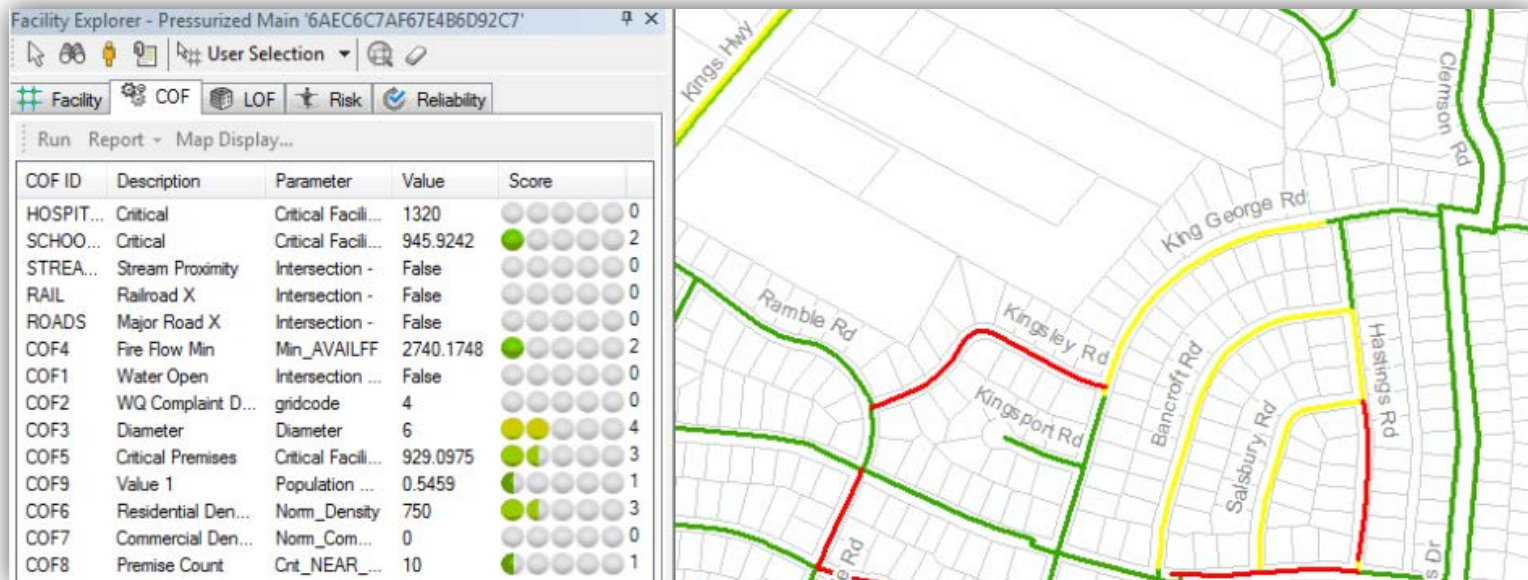
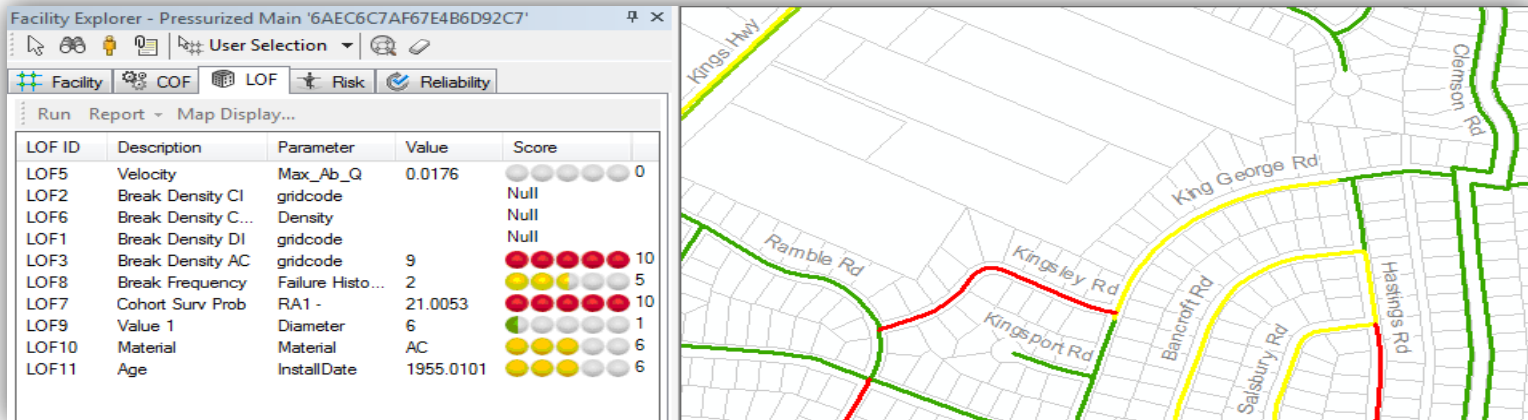
Range	Score	No.
<= 2	1	401
2 - 4	2	256
4 - 6	6	48
6 - 8	8	51
8 - 10	10	21
		29851



Range	Score	No.
<= 0	0	30018
0 - 1	1	351
1 - 2	5	31
2 - 3	10	2
3 - 4	10	1

Segment Break Scores

Pro-Active, Interactive, Scientific, Defendable Main Replacement Tool



Demo - Collaborate & Share with Engineers, Operations, Regulators

HOME ▾ Infomaster Results Map - Delran System NEW MAP CREATE PRESENTATION Chris ▾

Details + Add ▾ Basemap Save ▾ Share Print Directions Measure Bookmarks Search

Contents

- IM - Comprehensive Risk
- 1 - LOW
- 2
- 3
- 4
- 5 - HIGH
- IM - Comp. Details (zoom to view)
- IM - Likelihood (LOF) Details (zoom to view)
- IM - Consequence (COF) Details (zoom to view)
- Critical Premise
- Non Residential Premise
- Medical Sites
- School
- Major Roadway
- Streams
- Railways
- High Velocity Main
- Fire Flow Below 3500

Likelihood Raw Score: 140.40

Velocity Score 8.3x	0
CI Brk Density 8.4x	6
CEM Brk Den. 8.4x	0
DI Brk Density 8.4x	0
AC Brk Den. 8.4x	0
Brk Frequency 10x	6
Material Score 5x	6
Material	CI
Diameter (inches)	8
Install Date	December 31, 1954

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