

# MONETIZING AND SPATIALLY REPRESENTING THE IMPACT OF FAILING WATER MAIN INFRASTRUCTURE

*Wednesday, April 25<sup>th</sup>*  
*2:15pm – 2:45pm*  
*Room #317*



Presented By:

Andy Simpson  
Keith Burdette

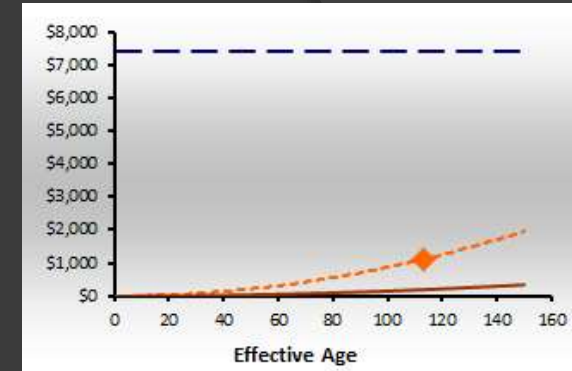
# INTRODUCTION

- 💧 What is the TW Economic Model?
- 💧 GIS Analysis Inputs
- 💧 Automated Data Analysis using ESRI Model Builder
- 💧 GIS Model Outputs and their visualization
- 💧 Multiple Asset Decision Module



# WHAT IS THE TACOMA WATER ECONOMIC MODEL?

- Conceptually, it's a planning tool that helps Tacoma Water System Engineers and Planners to make better more informed decisions when deciding:
  - When is the best time to replace an Asset?
  - How an Asset is replaced?
  - Where the Asset is replaced?
- Known Asset Characteristics Are Evaluated Such As:
  - Age of the Asset
  - Pavement Type
  - Location in the System
  - Size
  - Soil Conditions
  - Length
  - Services Impacted
  - Many Other Attributes
- Each Asset Is Examined and Scored Based on a Complex Set of Parameters
- Spatially Represent Potential Future Infrastructure Failures and the Costs associated with those failures
- Ultimately, this tool helps us build a better Construction Improvement Programs or CIPs



# WHAT IS THE TACOMA WATER ECONOMIC MODEL?

More Specifically:

- The model itself is an Excel based tool comprised of 2 workbooks
- First Workbook Interacts with Tacoma Water's GIS through a series of spatial questions and creates a profile for each asset
- Second Workbook, called the Multiple Asset Decision Module or MAD Module Allows end users to evaluate optimal replacement timing for a group of specific main segments into a Project
- GIS Analysis + Unique Project Parameters = Economic Modeled Project Results
- End User can make adjustments to the input parameters for specific circumstances that are unique to individual projects
- Publish the Project Results to the GIS System

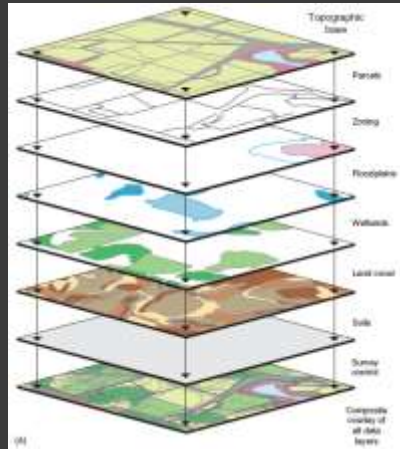
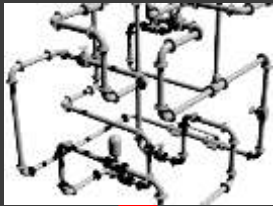


# WHAT IS THE TACOMA WATER ECONOMIC MODEL?



**Geodatabase**

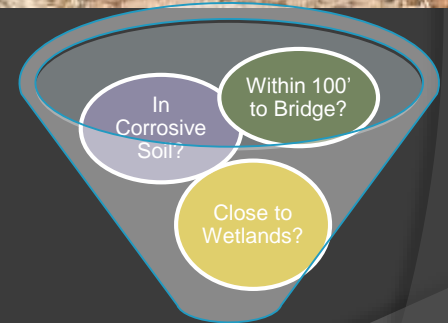
GIS Pipe Network Dataset



For Each Pipe:



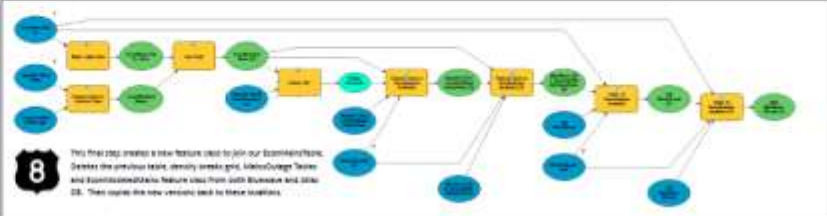
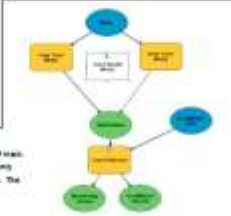
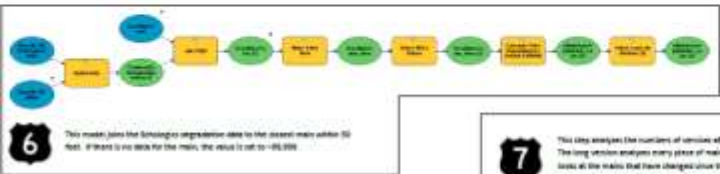
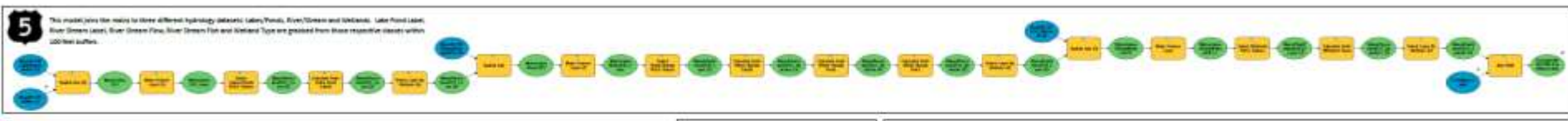
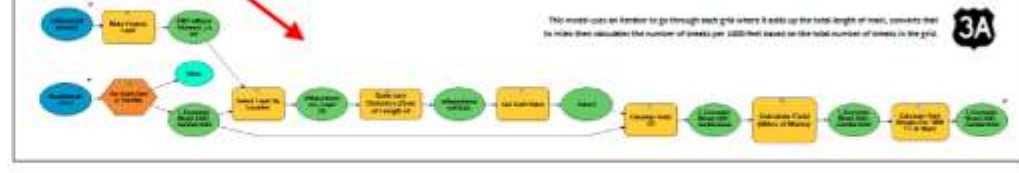
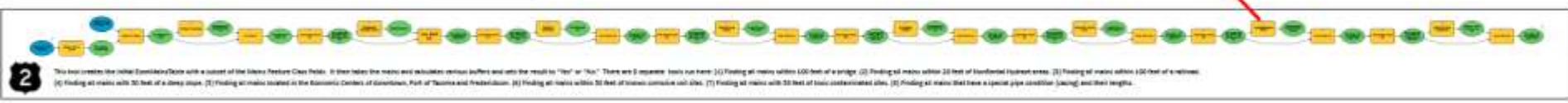
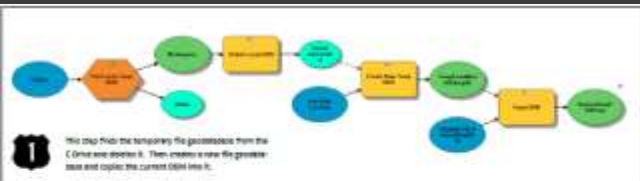
- Install Date
- Material
- Size
- Length
- Geometry







# GIS ANALYSIS WITH ESRI MODEL BUILDER

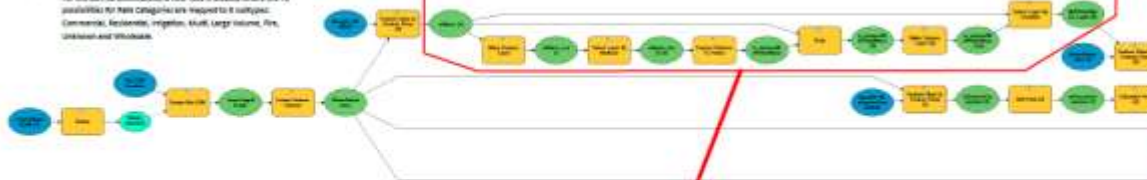


# GIS ANALYSIS SERVICE IMPACT COUNT

## Network Trace

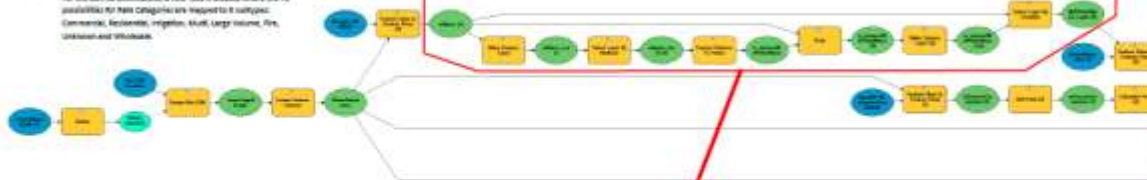
**7A**

The trace master starts by creating a trace for the production and copying over a count of the main distribution network with the main, lateral lines, service connections and system valves. These are built into a geometric network on which we can run the trace for the service connections. A new field is created where the TS possibilities for Main Categories are required to be nullified. Comments, Seasonality, Vegetation, Small, Large, Income, Fire, Unknown and Attributes.



**7B**

Flag points are needed to run the trace function so we create them by taking the midpoints of the distribution mains. The trace function doesn't work if the flag points aren't nested on a main. There are a lot of mains in the system where the midpoints don't fall on the main. This problem is solved by snapping any midpoints which are not on the main to that main another creating all midpoints that intersect mains.



**7C**

In test runs, running the trace on all 65,000 mains in the system took around 20 hours. On a weekly basis, only a small fraction of that 65,000 actually change. Finding the editing process, we make the change or get more get a new Facility ID. To this alternate version of the model, the Facility IDs of the most recent set of installed mains are compared to the current set of mains in actual. Any mains with Facility IDs that are new are then turned into midpoints and back are brought into the Trace Function as flag points.

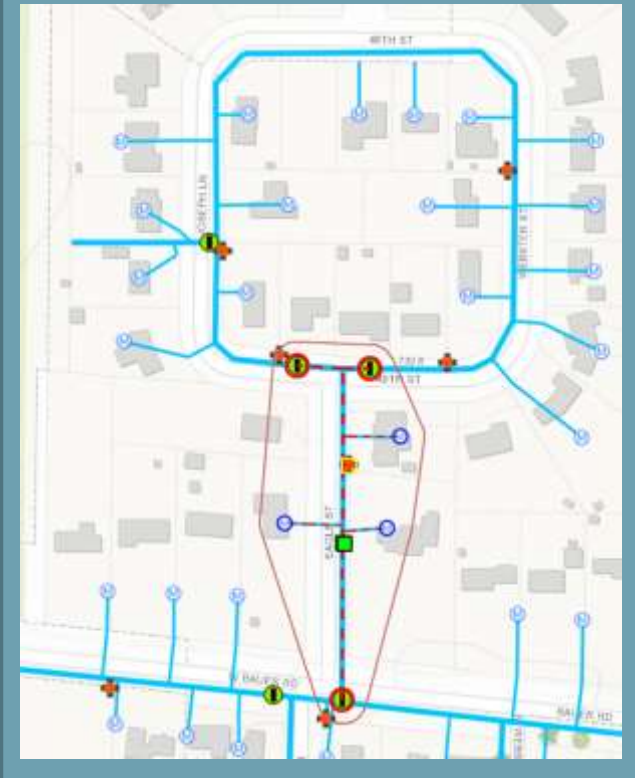


**7E**

This is the midpoints network. These midpoints use the trace function. For every midpoint, a trace is run to find all connected service connections. These service connections are then summarized with counts of the subtypes of services set defined earlier. For each service type connected to that section of main, an entry is put into a table with the facility ID, service type and count.

Facility ID	Service Type	Count
100001	Water	1
100001	Sewer	1
100001	Gas	1
100001	Electric	1
100001	Other	1
100002	Water	2
100002	Sewer	1
100002	Gas	1
100002	Electric	1
100002	Other	1
100003	Water	1
100003	Sewer	1
100003	Gas	1
100003	Electric	1
100003	Other	1
100004	Water	1
100004	Sewer	1
100004	Gas	1
100004	Electric	1
100004	Other	1
100005	Water	1
100005	Sewer	1
100005	Gas	1
100005	Electric	1
100005	Other	1
100006	Water	1
100006	Sewer	1
100006	Gas	1
100006	Electric	1
100006	Other	1
100007	Water	1
100007	Sewer	1
100007	Gas	1
100007	Electric	1
100007	Other	1
100008	Water	1
100008	Sewer	1
100008	Gas	1
100008	Electric	1
100008	Other	1
100009	Water	1
100009	Sewer	1
100009	Gas	1
100009	Electric	1
100009	Other	1
100010	Water	1
100010	Sewer	1
100010	Gas	1
100010	Electric	1
100010	Other	1

PIVOT TABLE



**7G**

This is the final step of the trace method called the summarization. After copying out the Main Categories, it is then joined to the summary table. Facility IDs that don't make up in the SummaryTable are assigned NULL values. These NULL values are extended and calculated to it to give every entry a non-null value. This table is now ready to be merged with the production data.

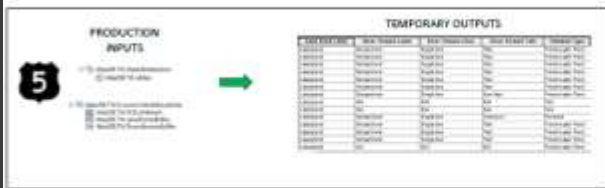
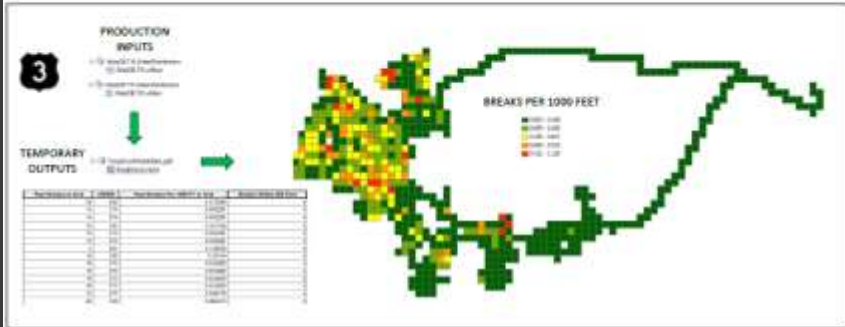


# GIS ANALYSIS INPUTS AND OUTPUTS



**TEMPORARY OUTPUTS**

Asset ID	Asset Name	Asset Type	Material	Year Inst	Condition	Service Life	Age	Health Index	Failure Rate	Failure Mode	Failure Date	Failure Location	Failure Description	Failure Severity	Failure Cost	Failure Status
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...



**NEW DATA CREATED BY MODEL**

Asset ID	Asset Name	Asset Type	Material	Year Inst	Condition	Service Life	Age	Health Index	Failure Rate	Failure Mode	Failure Date	Failure Location	Failure Description	Failure Severity	Failure Cost	Failure Status
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

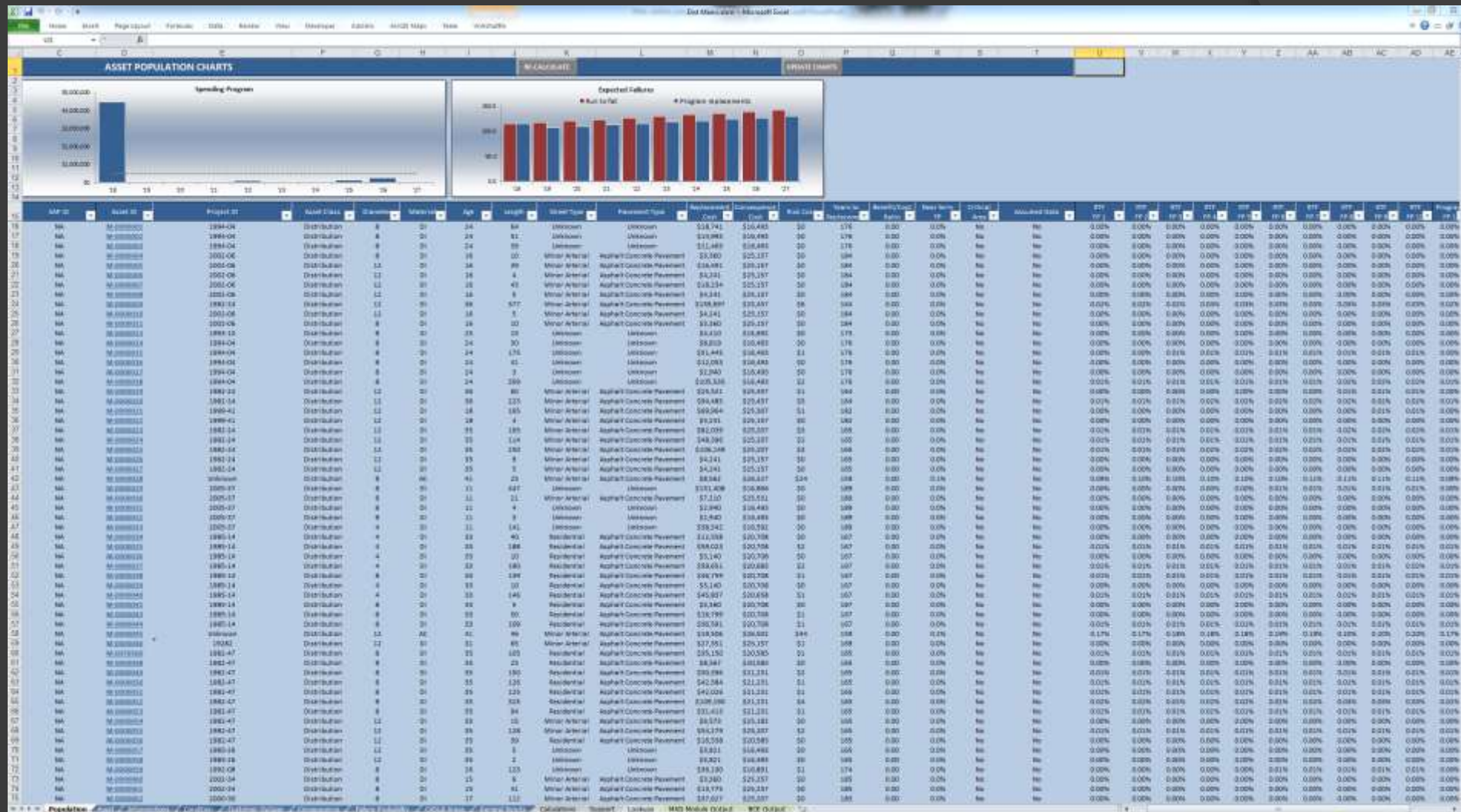


# SPATIAL ANALYSIS RESULTS IN EXCEL

- Each main segment is analyzed based on the answers to our spatial questions
- Assumptions based on material, age and other risk factors determine the failure probability
- 3 levels of failure analyzed and weighted to create a consequence cost
- Replacement cost with and without pavement restoration
- All values collected together to be exported back to GIS

	A	B	C	D	E	F
1	DISTRIBUTION MAINS			SAVE ASSET TO MAD		RELOAD ASSET
2						
3	DEMOGRAPHICS					
4	Asset ID	M-0099801				
5	Pipe diameter	12				
6	Existing material code	CIP				
7	Pipe length (ft)	730				
8	Installation year	1905				
9	Transmission Main Name	NA				
10	Project Type	UNK				
11	Project ID	Unknown				
12	Pipe class	UNK				
13	Approximate Location	<a href="#">BlueWave Link</a>				
14	Pressure Zone	478				
15	Calculated Static Pressure	52.55210291				
16	Jurisdiction	City of Tacoma				
17	Road type	Collector				
18	Pavement type	Portland Cement Concrete				
19	Effective age (yrs)	113				
20						
21	INTERVENTIONS					
22	Existing material	CI OLD				
23	Replacement type	DI				
24	Replacement cost, base	\$268,800				
25	Pavement Restoration	\$102,247				
26	Replacement cost, total	\$371,047				
27						
28	ADDITIONAL DEMOGRAPHICS					
29	Joint type	Lead				
30	SAP ID	NA				
31	Zoning code	UP				
32	Economic Center (if applicable?)	No				
33	Estimated Install Year	UNK				
34	Manufacturer	UNK				
35	Installation Contractor	UNK				
36	In Pavement?	Yes				
37	Pavement Width	28				
38	Zoning description					
39						
40	CRITICAL AREAS					
41	Bridge crossing	No				
42	Highway crossing	No				
43	Railroad crossing	No				
44	Stream crossing	No				
45	Wetland crossing	No				
46	Contaminated soils	Yes				
47	Corrosive Soils	No				
48	Environmental issues					
49	Erosion					
50	Steep Slope	No				
51	Hydrant Non-Rental	No				
52	Property Damage					
	RESULTS					
	Age at replacement	200				
	Years To replacement	87				
	Year of replacement	2105				
	Benefit/cost ratio	0.00				
	Lifecycle cost of new asset	\$7,419				
	Net benefit of replacement	-\$236,049				
	Assumed data?	No				
	Lifecycle of new asset	200				
	PROBABILITY OF FAILURE					
	Breaks by project 1000'	0.18930192				
	Degradation Percent (Condition Assessment)	-99999.00				
	Corrosive Soils	No				
	Abnormal breaks per 1000'	Yes				
	Existing multiplier	1.75				
	Replacement multiplier	0.73				
	Probability of failure	1.99%				
	CONSEQUENCE OF FAILURE EXISTING					
	Services Affected	22				
	Services Cost Per Hour	\$644.28				
	Minor leak or break	\$33,829				
	Major leak or break	\$16,355				
	Catastrophic break	\$5,731				
	Consequence of failure	\$55,915				
	RISK COST					
	Near-term Risk	\$1,112				
	DATA SUPPORT					
	Location					
	C FID	M-0010884				
	Jurisdiction	City of Tacoma				
	Pavement Type	Portland Cement Concrete				
	Road Type	Collector				
	Number of Street Lanes	2				

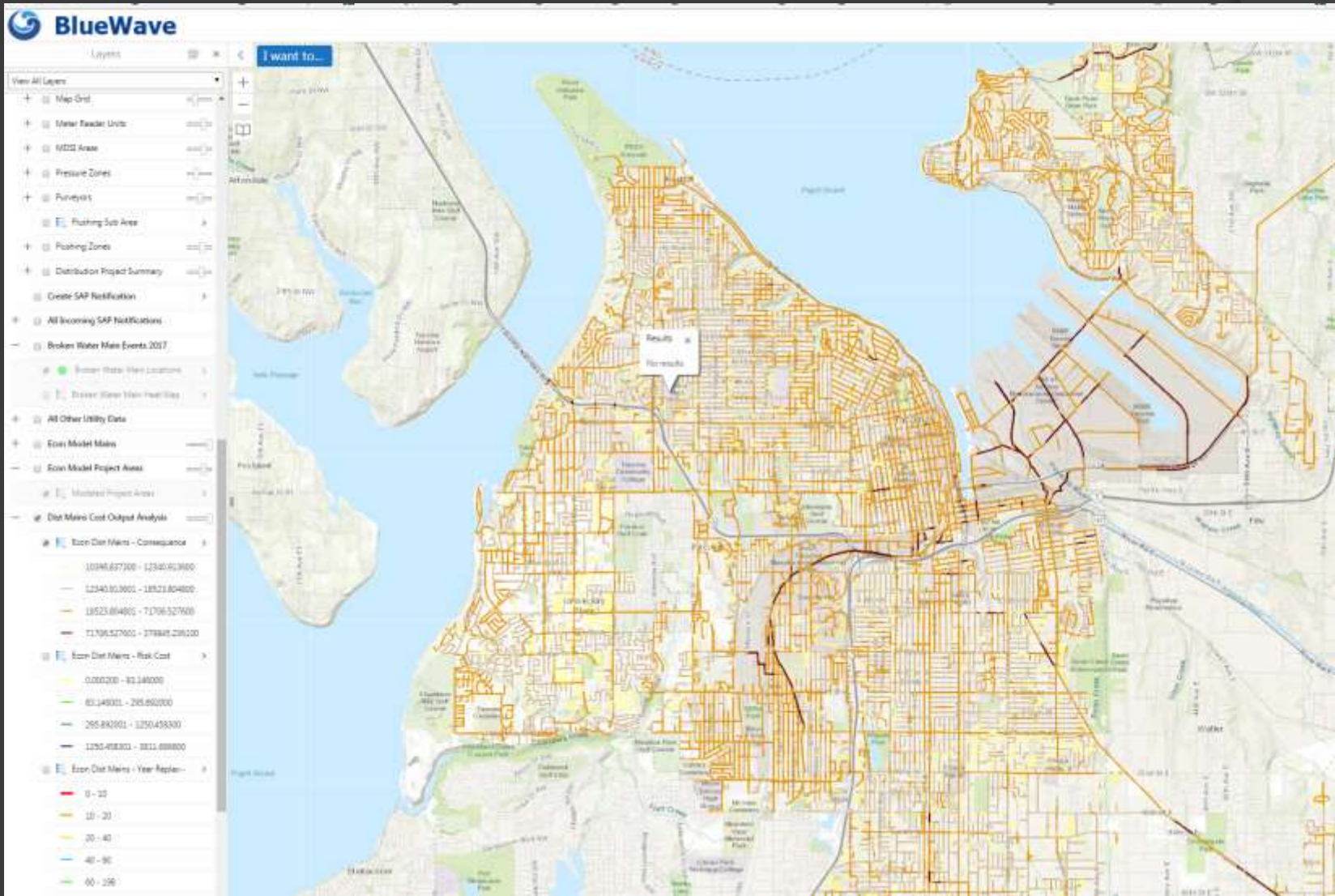
# MODELED MAINS IMPORTED INTO EXCEL



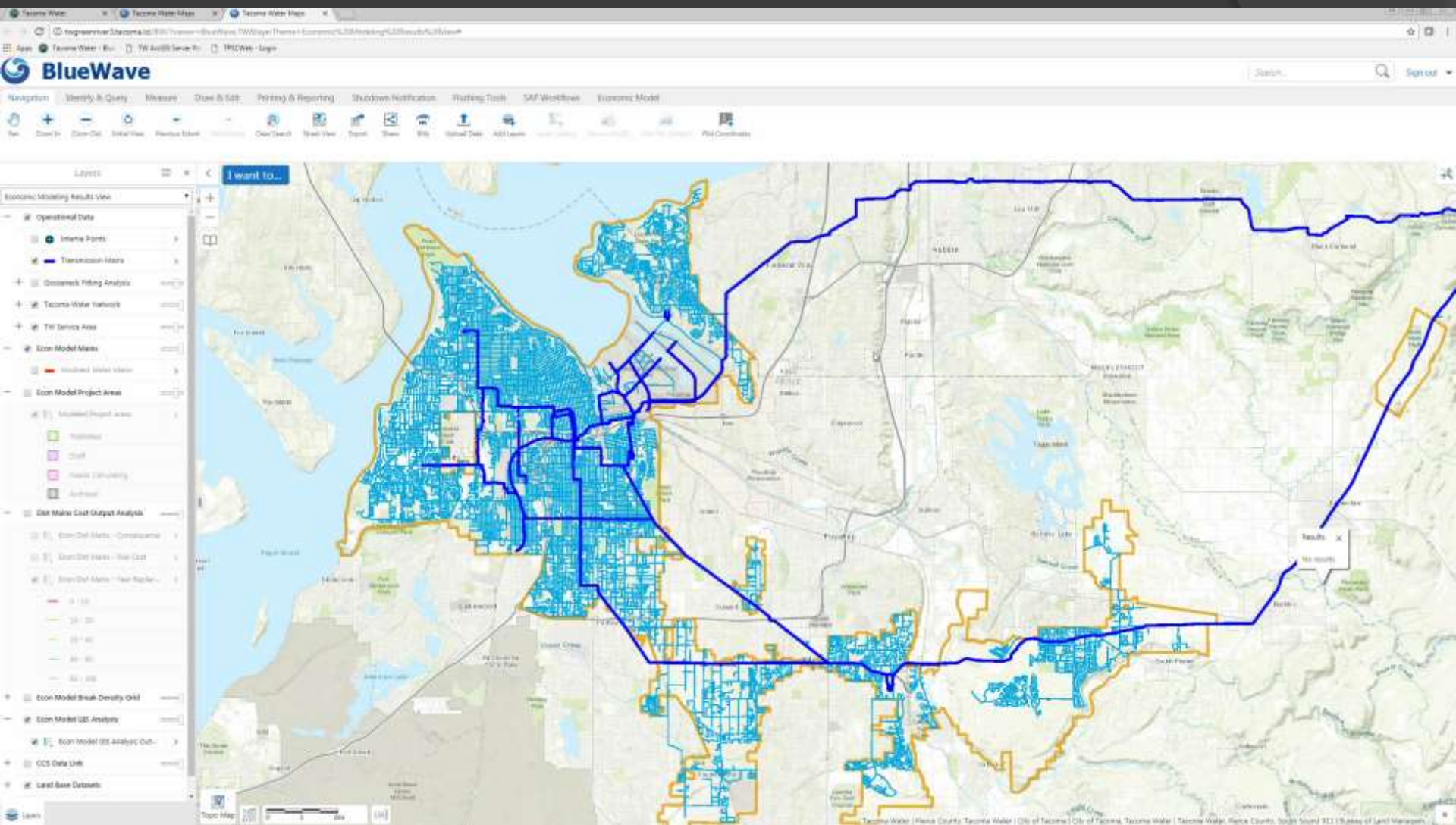
Costs for each main segment calculated and exported back to GIS



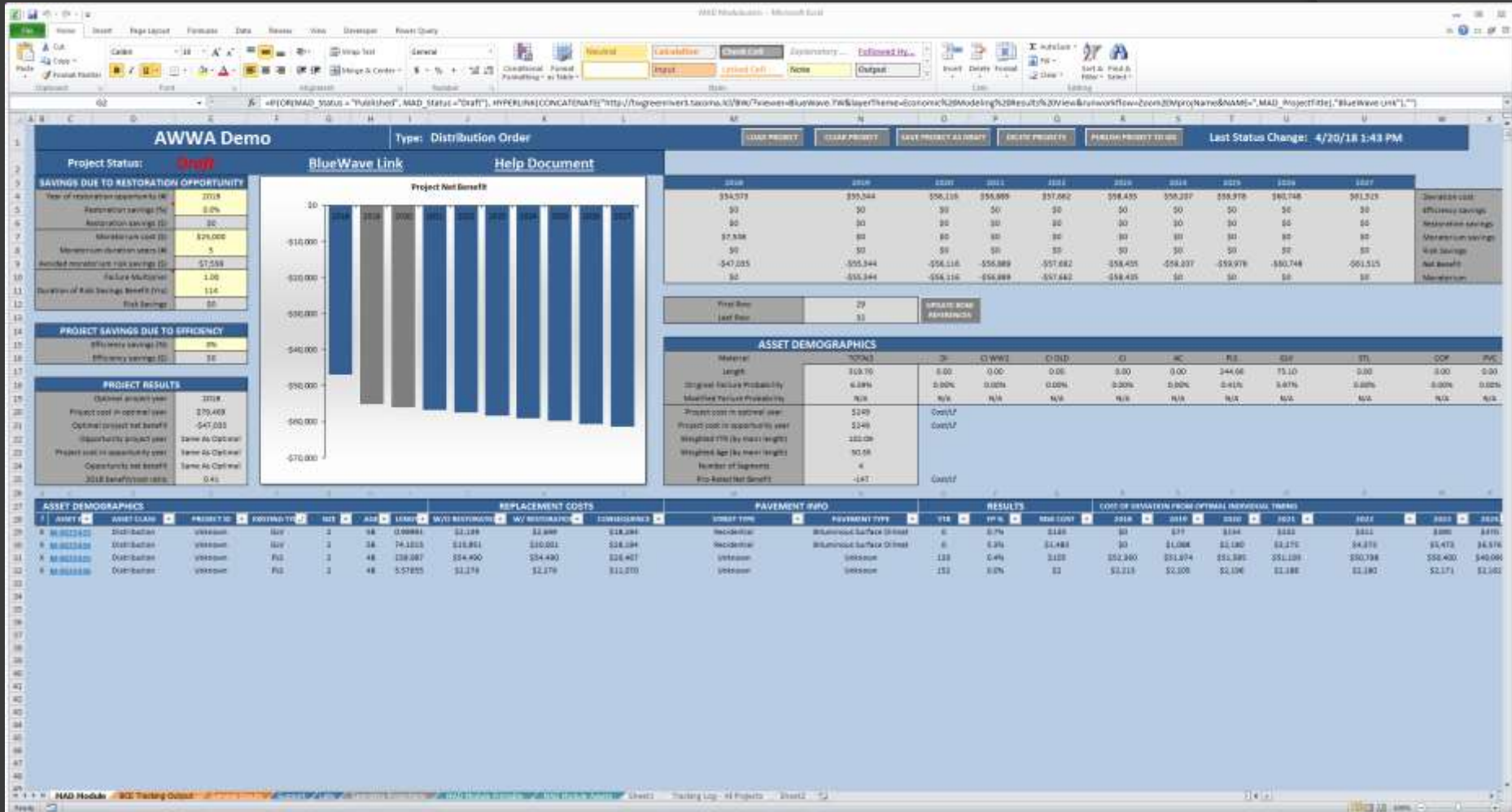
# MODELED MAINS DISPLAYED ON THE MAP



# ECONOMIC MODEL MAP DEMO



# MAD MODULE – MULTIPLE ASSET DECISION MODEL



Tool that groups main segments into projects to determine viability



# MAD MODULE DEMO

Microsoft Excel - MAD Module Demo

View: Basic | Page Layout | Formulas | Data | Review | Home | Developer | Power Query

Normal | Bold | Italic | Underline | Paragraph | Styles | Font Color | Fill Color | Text Color | Font Size | Text Background Color | Text Color | Font Size | Text Background Color | Text Color

MSA

Type: [LIAR PROJECT] [CLEAR PROJECT] [SAVE PROJECT AS PART] [DELETE PROJECT] [FINISH PROJECT TO GO] | Last Status Change: 3/12/18 12:01 PM

### Project Status:

Help Document

**SAVINGS DUE TO RESTORATION OPPORTUNITY**

Year of project an opportunity to	
Reduce asset savings (\$)	25
Maximum cost (\$)	20,000
Maximum duration years (R)	5
Avoided maintenance savings (\$)	20
Net savings	4,000
Division of Risk Savings Benefit (\$)	220
Risk Savings	20

**PROJECT SAVINGS DUE TO EFFICIENCY**

Efficiency savings (%)	
Efficiency savings (\$)	20

**PROJECT RESULTS**

Optimal project cost	2018
Project cost in optimal year	20
Annual project net benefit	20
Remaining project cost	0%
Project cost in opportunity year	0%
Remaining net benefit	0%
2018 benefit total	0%

**Project Net Benefit**

**2018-2027 Data:**

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Net Benefit	0	20	20	20	20	20	20	20	20	20

Division cost: 20  
Efficiency savings: 20  
Restoration savings: 20,000  
Total savings: 20  
Net benefit: 20  
Maintenance: 20

First Row: 29 | Last Row: 28 | DIVISION FROM: 2018/01/01

### ASSET DEMOGRAPHICS

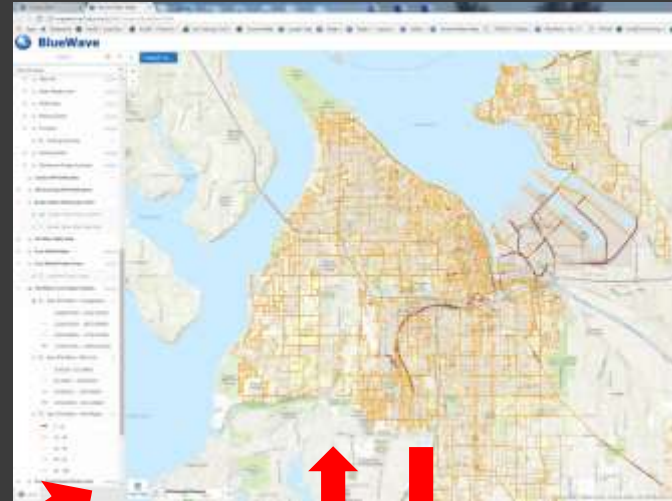
Measure	TRM20	R	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Length	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Original Failure Probability	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Modified Failure Probability	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Project cost in optimal year	40,000													
Project cost in opportunity year	40,000	Class 1												
Original TTB for main length	40,000													
Original Age for main length	40,000													
Number of segments	0													
Worked net benefit	40,000	Class 1												

**ASSET DEMOGRAPHICS** | **REPLACEMENT COSTS** | **PAVEMENT INFO** | **RESULTS** | **LOOK UP BENEFITS FROM OPTIMAL INDIVIDUAL YEARS**

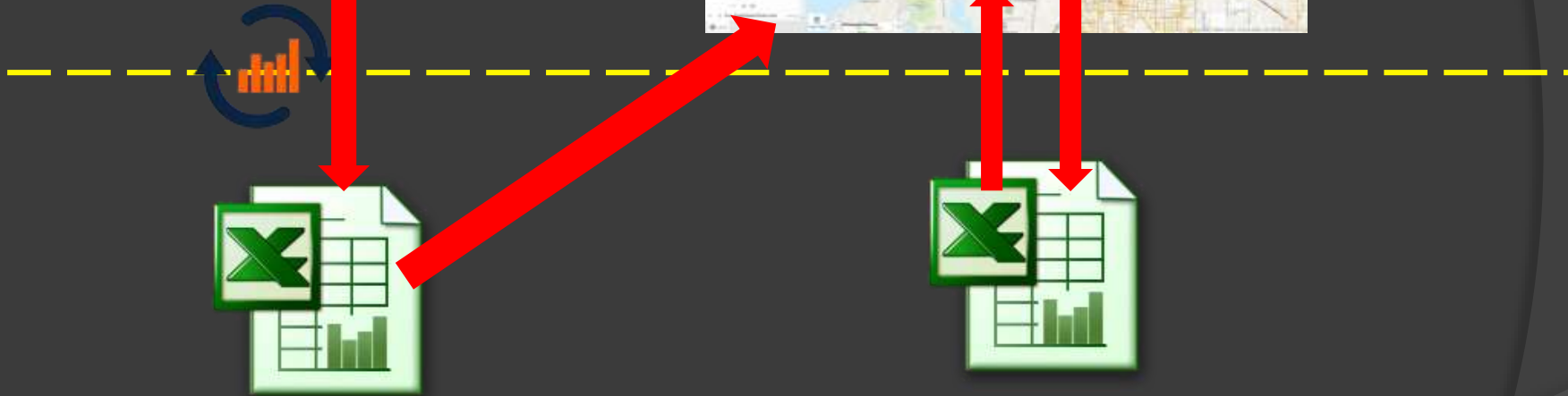
ASSET | ASSET CLASS | PROJECT ID | EMPLOYER | SIZE | AGE | LENGTH | MULTI-BENEFIT | 1% | 2% | 3% | 4% | CONFIDENCE | STREET TYPE | PAVEMENT TYPE | YEAR | YEAR | YEAR | YEAR | YEAR | YEAR | YEAR | YEAR | YEAR | YEAR

# MAJOR ECONOMIC MODEL COMPONENTS

## 1) Input GIS Analysis



## 3) Visualize Potential Asset Failure locations



## 2) Asset Profile For Each Pipe

- Probability of Failure
- Years To Replacement
- Consequence of Failure Cost
- Other Asset Assumptions

4) User selects mains in the Multiple Asset Decision Module and performs Benefit/Risk/Cost project level analysis that can be published back to the map

# MORE ON THE ECONOMIC MODEL USAGE AT TACOMA WATER

## Next Session On This Topic:

*“The Right Money, on the Right Mains, at the Right Time: Tacoma's Strategic Main Replacement Program Through Economic Modeling”*

Presented By: Matt Hubbard

When: Thursday April 26<sup>th</sup>, 11:00 -11:30am in room #316



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[mhubbard@cityoftacoma.org](mailto:mhubbard@cityoftacoma.org)



# QUESTIONS?



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