



# 2018 Midwest Geotechnical Workshop

## Geotechnical Asset Management Implementation for Transportation Agencies - Outcomes from Project 24-46

Mark Vessely, P.E.  
*BGC Engineering, Golden, Colorado*

**[bgcengineering.com](http://bgcengineering.com)**





# The GAM Planner Tool

- Microsoft Excel spreadsheet designed to run in Microsoft Excel 2010 or higher
- One can use the tool to:
  - Define a geotechnical asset inventory
  - Characterize geotechnical asset conditions and risk
  - Define deterioration based life cycle models or use default models in program
  - Simulate future conditions and prioritize GAM investments given an expected budget

# The GAM Planner Tool

NCHRP Project 24-46 GAM Planner
4/2/18

## Main Menu

**MODEL PARAMETERS**

**ASSET MODEL ADMINISTRATION**

Opens worksheet to enter or edit information for an asset model. You will be asked to name the model if creating a new model, or to select an existing model if editing or deleting a model.

**ASSET INVENTORY**

Opens the Inventory worksheet to enter or edit information for the inventory of assets.

**PROGRAM SIMULATION**

Opens the Summary Results worksheet to enter budgets by year and view summary results.

Opens the Detailed Results worksheet to show details on a selected asset.

**SUMMARY STATISTICS**

**ASSET DATA**

Number of Asset Models	7
Number of Assets	10
Asset Reconstruction Value	\$8,500,000

**% of Segments by Level of Risk**

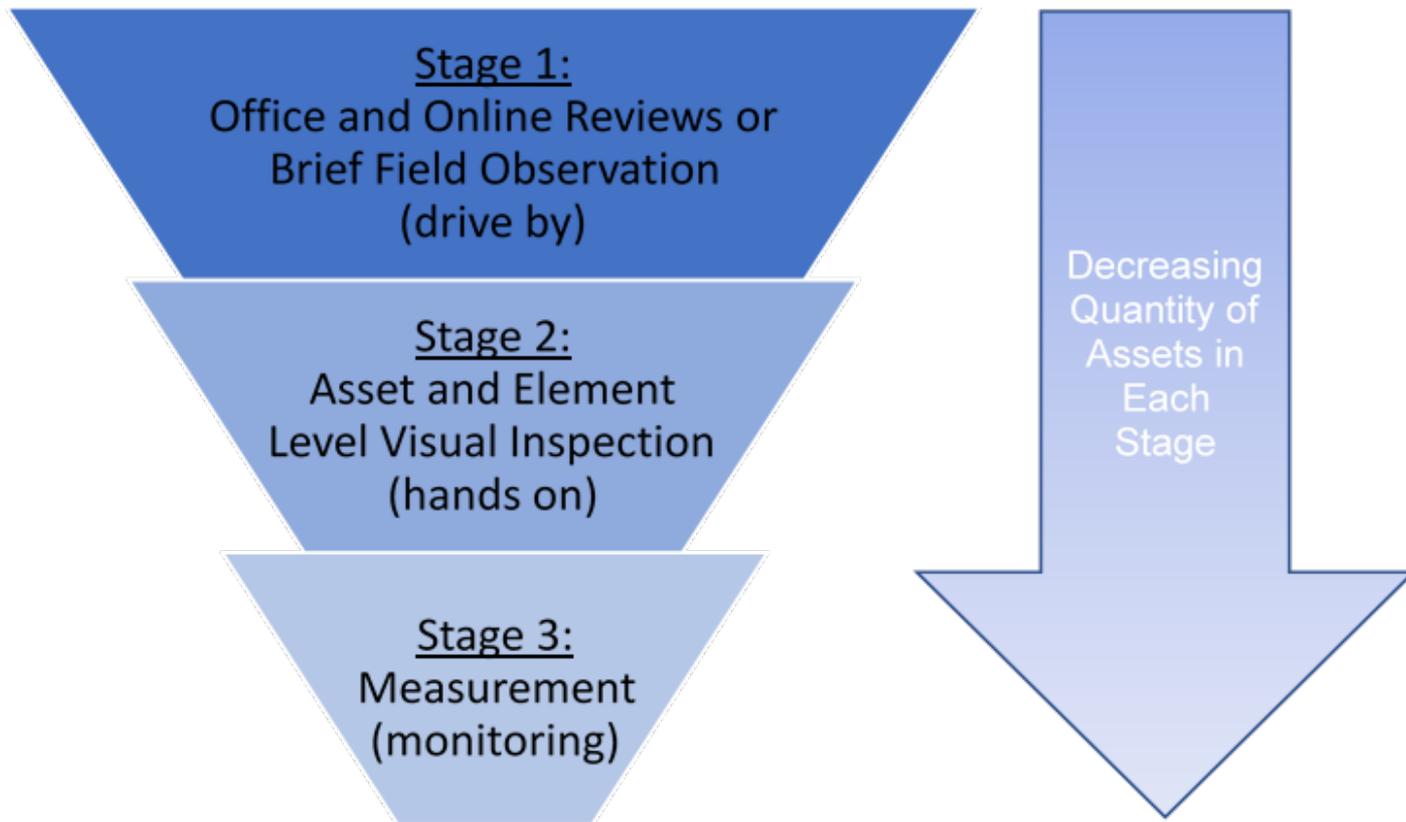
**% of Value by Level of Risk**

<b>ANALYSIS RESULTS</b>	
Initial Needs	\$47,500
Spent Over 10 Years	\$0
Remaining Backlog	\$0

- Will be part of upcoming Geotechnical Asset Management Implementation Manual

# Inventory Development

- Staged development approach recommended



## Step 1: Identify and Locate

- Per the International Infrastructure Management Manual:

*A rule of thumb is often 80% of the data can be collected for half the cost of 100% of the data. Seeking 100% coverage and accuracy may not be justified, except for the most critical assets.*

- Focus on what level of data is need to support decisions and communicate results

# Step 1: Identify and Locate

- Start with existing data sources:
  - Known inventory information  
(e.g. existing wall and slope programs, maintenance data)
  - Anecdotal data and institutional knowledge
  - Others?

# Step 1: Identify Asset Model

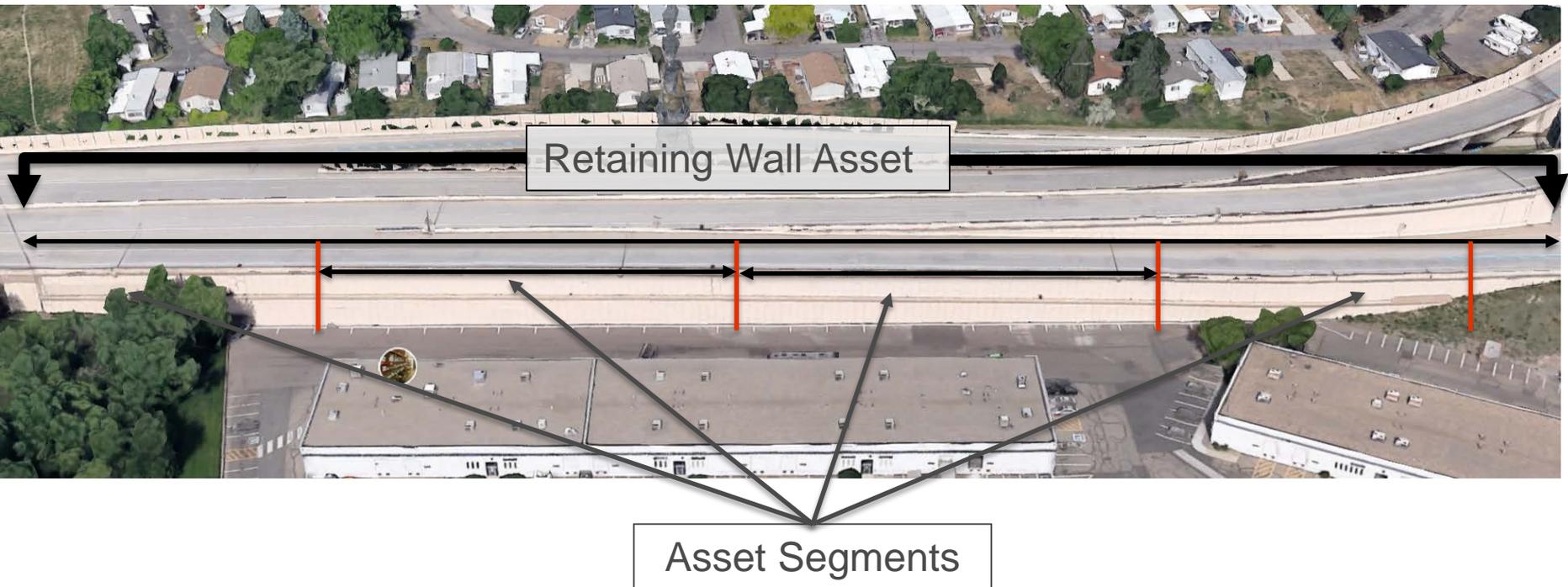
Model	Description	Asset Category
Cut	Soil, rock, or mixed cut slopes with a minimum height of 10 feet within the ROW. In general, cut slope assets will have a higher deterioration rate when compared to natural slopes.	Slope Asset
Natural Hazard – Rock and Debris	Natural hazard site that contributes rockfall, debris flows, or other rapid slope movements that may have a safety threat in addition to mobility and maintenance impacts. The deterioration rate associated with this model is assumed to be slower than a cut slope asset and/or based on recurrence intervals.	Slope (Beyond ROW Feature <sup>1</sup> )
Natural Hazard - Landslide	Landslide hazard sites that may be included in a GAM inventory. Typically, these assets will consist of natural slides that originate beyond the ROW but impact the agency performance objectives.	Slope (Beyond ROW Feature <sup>1</sup> )
Embankment	Used for constructed earthwork fills with a minimum height of 10 feet that contribute to the support of a roadway or other transportation assets.	Embankment Asset
Subgrade	Engineered subgrades that have been improved through ground modification/improvement works and support a roadway asset. The subgrade model can also apply to unimproved subgrades with geologic or other subsurface hazards such as expansive or collapsible materials, frost susceptible soil, or karst and underground mining activity.	Subgrade Asset
Retaining Wall Above Roadway	Applicable to retaining walls where the consequences of deterioration or a failure would be confined to at or above the roadway elevation.	Retaining Wall Asset
Retaining Wall Below Roadway	Applicable where a wall supports traffic directly or the deterioration or failure of the wall would have an impact to the roadway integrity or mobility.	Retaining Wall Asset

# Step 1: Identify and Locate

- Assets and Segments
  - Asset: Individual asset with start and end point
  - Segment: 0.1 mile (~500 ft) length of asset
    - Many segments can comprise an asset
    - Several assets can be within a segment
- Suggested segment naming convention:
  - Nearest 1/10<sup>th</sup> mile point and rounded down (e.g. MP 78.6 for a segment from 78.6 to 78.7)

# Step 1: Identify and Locate

- Assets and Segments



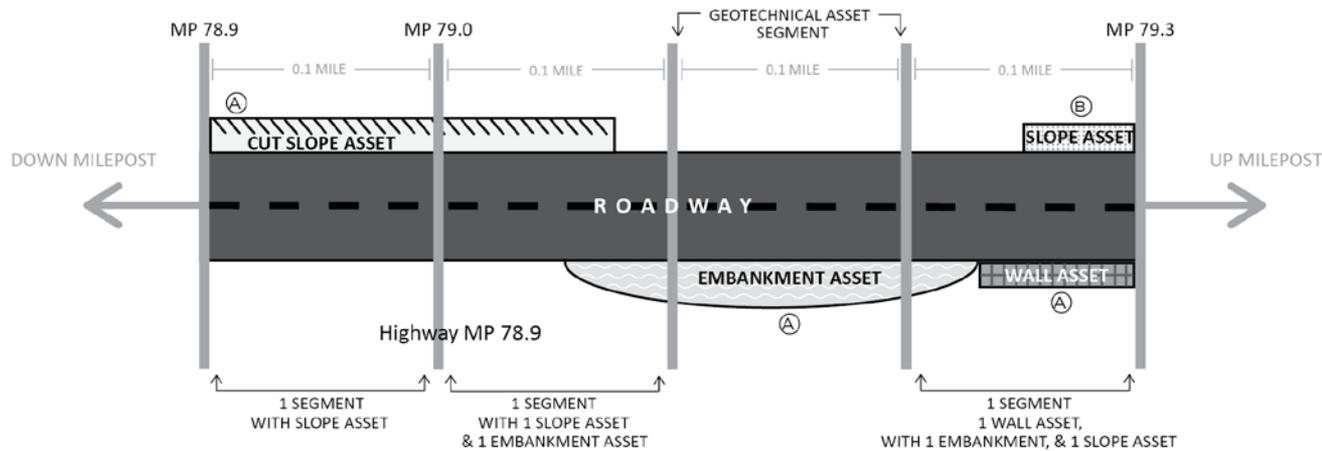
# Step 1: Identify and Locate

- Considering Multiple Assets



# Step 1: Identify and Locate

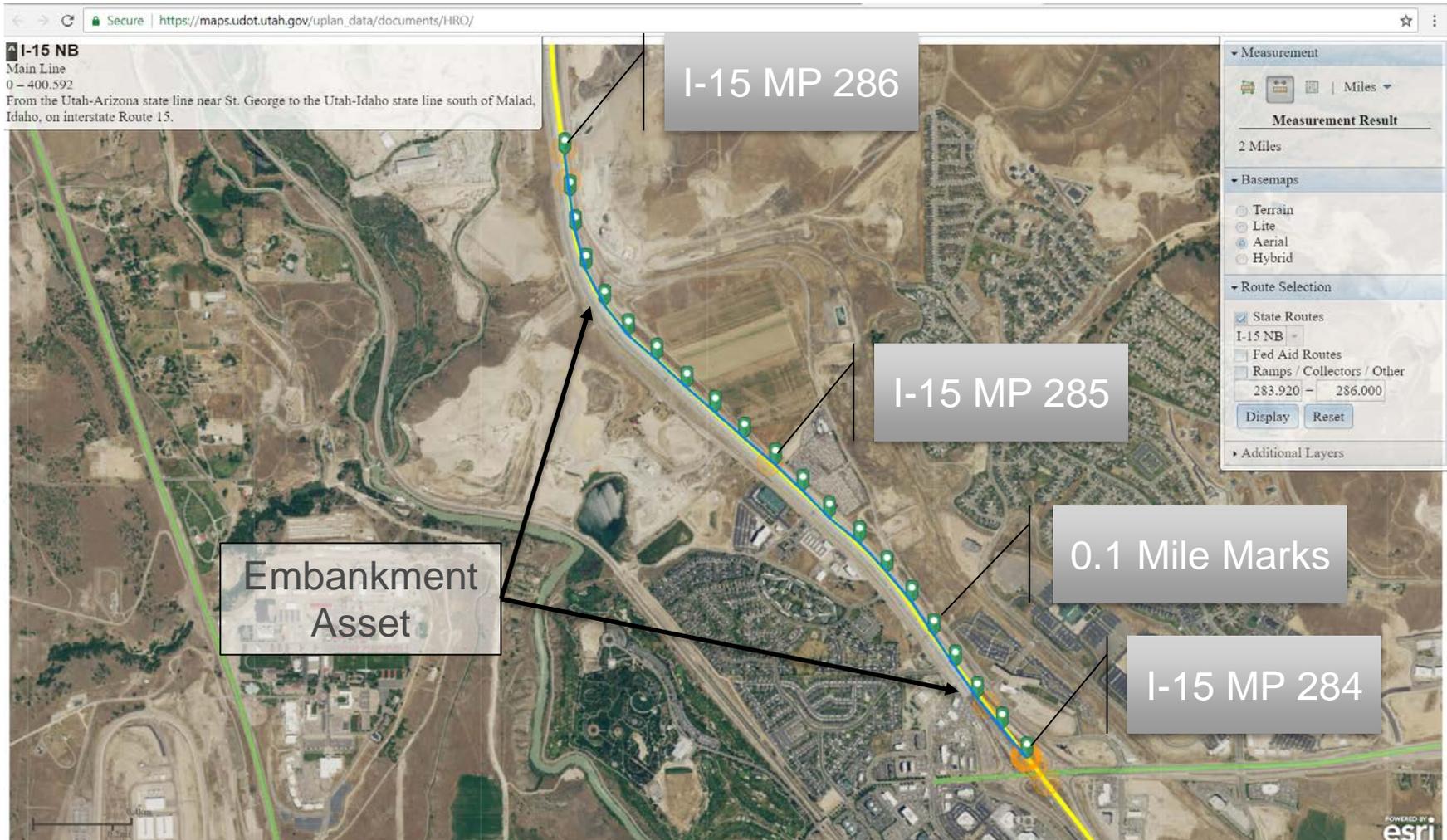
- Multiple Assets and Segments



**GAM Inventory Example**

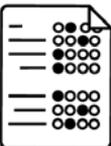
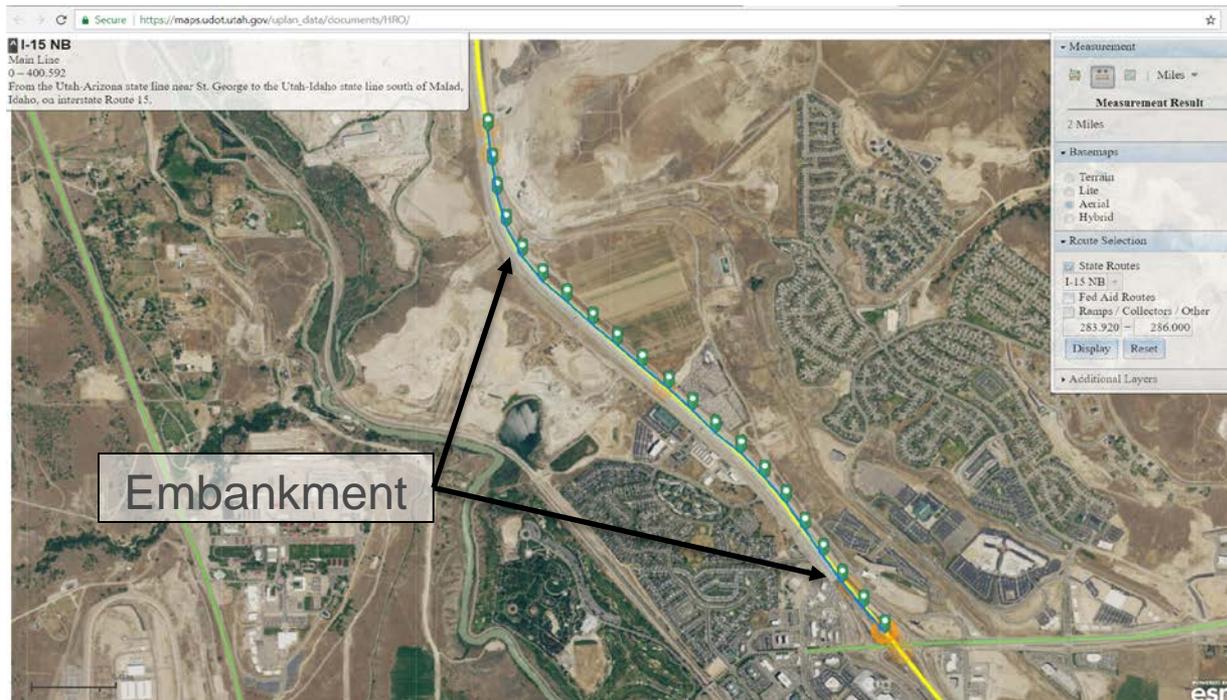
ASSET ID	SEGMENT	ASSET TYPE	TOTAL LENGTH IN SEGMENT
1	Highway MP 78.9	Cut Slope (A)	400 feet
	Highway MP 79.0	Cut Slope (A)	400 feet
2	Highway MP 79.1	Embankment (A)	250 feet
	Highway MP 79.2	Embankment (A)	200 feet
3	Highway MP 79.2	Wall (A)	300 feet
4		Slope (B)	100 feet

# Step 1: Identify and Locate – Example 1

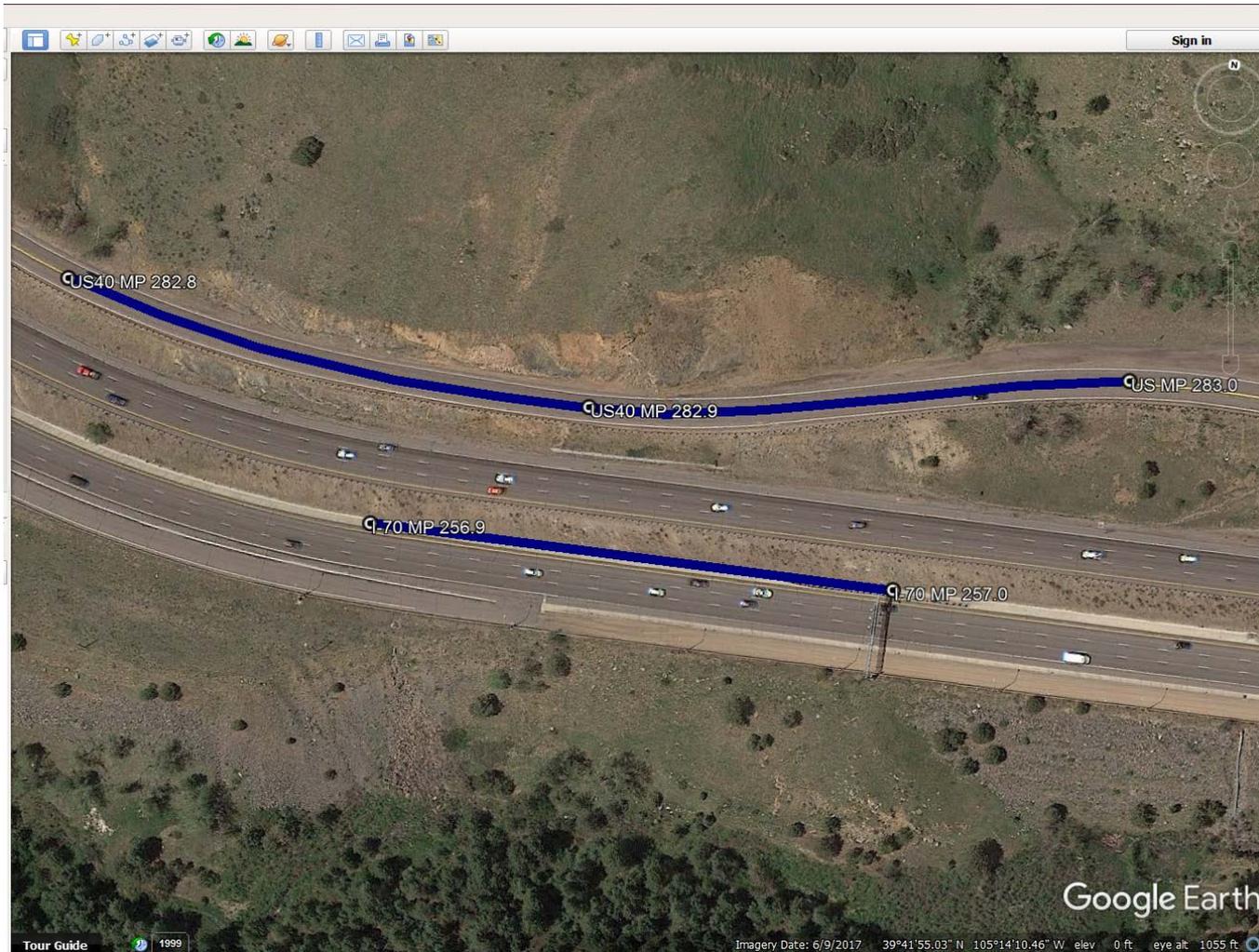


# Step 1: Identify and Locate – Example 1

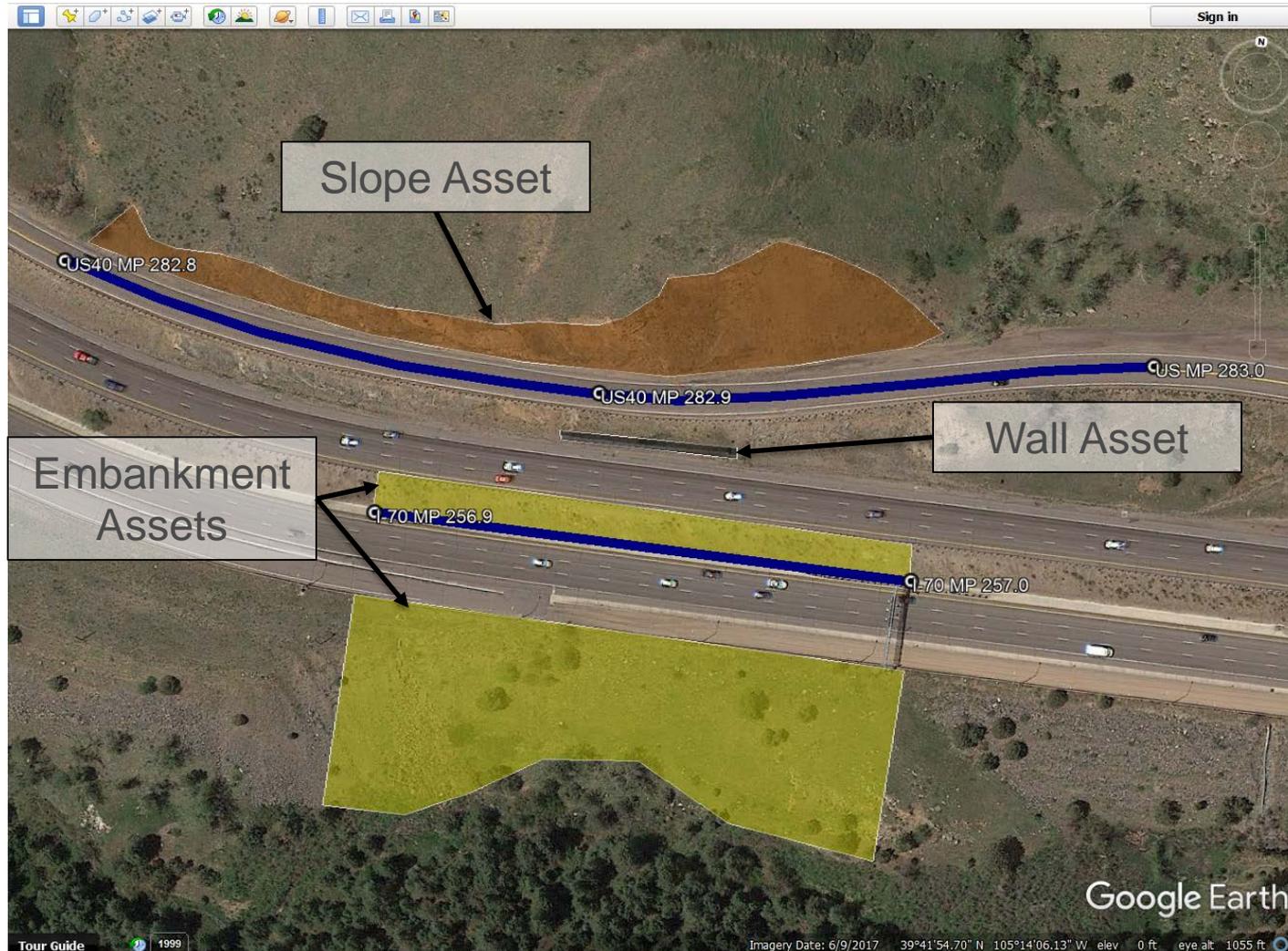
- One Asset: Embankment, MP 284.2 - 285.6  
– 16 Segments (MP 284.2, MP 284.3, etc.)



## Step 1: Identify and Locate – Example 2



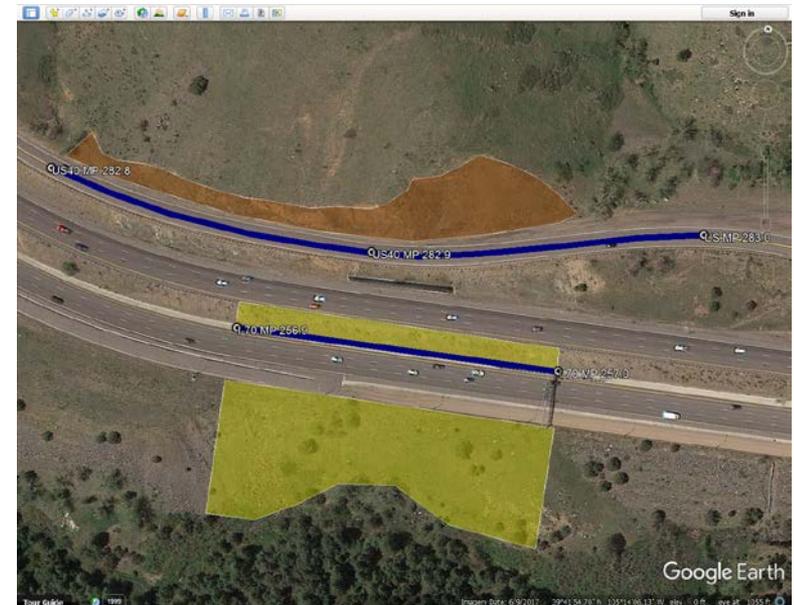
# Step 1: Identify and Locate – Example 2



## Step 1: Identify and Locate – Example 2

- Asset summary

Segment	Asset
US 40 MP 282.8	Slope
US 40 MP 282.9	Slope
I-70 MP 256.9 WB	Embankment
I-70 MP 256.9 EB	Embankment
I-70 MP 256.9	Wall



Note: Two embankments in same segment could be distinguished further using agency location practices, such as eastbound (EB). In GAM Planner this distinction occurs with an Asset ID.

# Step 1: Identify and Locate – Example 2

- Enter data into GAM Planner inventory

The screenshot shows the Microsoft Excel interface with the 'gam\_planner\_populated\_20180402(Ex2) - Excel' file open. The active cell is M13, containing the text 'Wall below US40 & above I-70'. The spreadsheet displays the 'Asset Inventory' table with the following data:

Asset ID	Type	Route	Milepost	Description	Fixed Seg. Length	Total Seg. Length	Cost Scale Factor	Effective Quantity	O&M Condition
1	Cut-All	US40	282.8	Rock Cut Slope	0.1	0.1	1	1	
1	Cut-All	US40	282.9	Rock Cut Slope	0.1	0.09	1	1	
2	Embankment	I-70	256.9	Embankment	0.1	0.1	1	1	
3	Embankment	I-70	256.9	Embankment	0.1	0.1	1	1	
4	Wall Below	I-70	256.9	Wall below US40 & above I-70 (Note: Wall asset could be inventoried as a US 40 asset)	0.1	0.04	1	0	

# Step 1: Identify and Locate – Example 2

NCHRP Project 24-46 GAM Planner

## Asset Inventory

**INVENTORY**

Asset ID	Type	Route
1	Cut-All	US40
1	Cut-All	US40
2	Embankment	I-70
3	Embankment	I-70
4	Wall Below	US40

Select GAM Planner Model Based on Asset Type (Default models described in Table 2.1 of Implementation Manual)

- GAM Planner pre-populated with 7 default models selected via drop down in Excel
- Default models can be revised
- Up to 50 models can be created

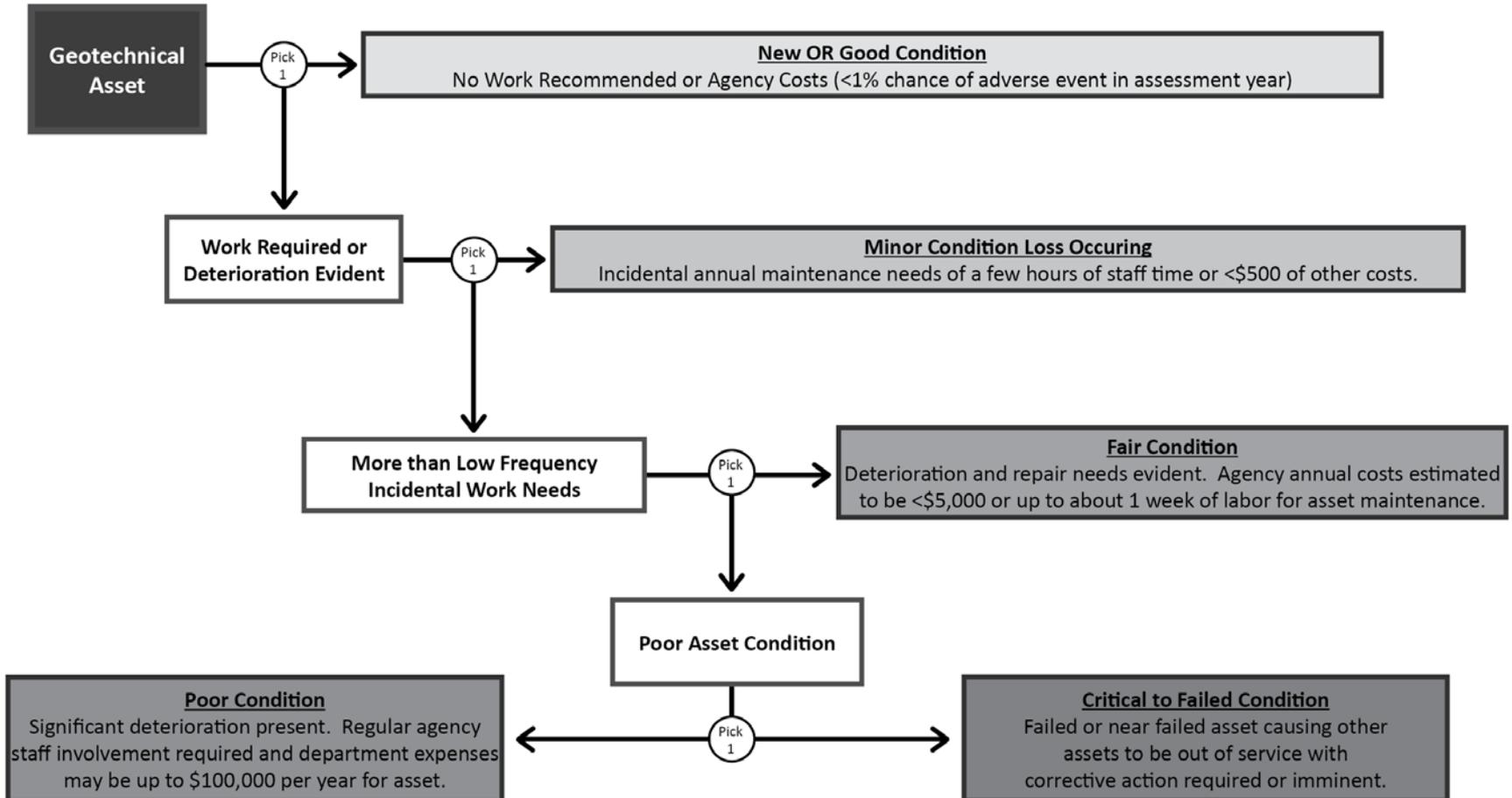
## Step 2: Assign Operation and Maintenance (O&M) Condition

- Purpose
  - Estimate the condition of the asset by segment
  - Based on visual condition and/or level of effort to operate and maintain the asset
- Judgment required
  - Expect variations between raters

## Step 2: Using Judgment

- Having confidence with judgment
  - Expected and desirable
  - Relative condition is an important input
    - There is established precedent for relying on judgment in visual bridge inspection processes
- Condition assessment can improve or be calibrated with time
  - Acceptable to move forward with uncertainty!

# Step 2: O&M Condition Tree

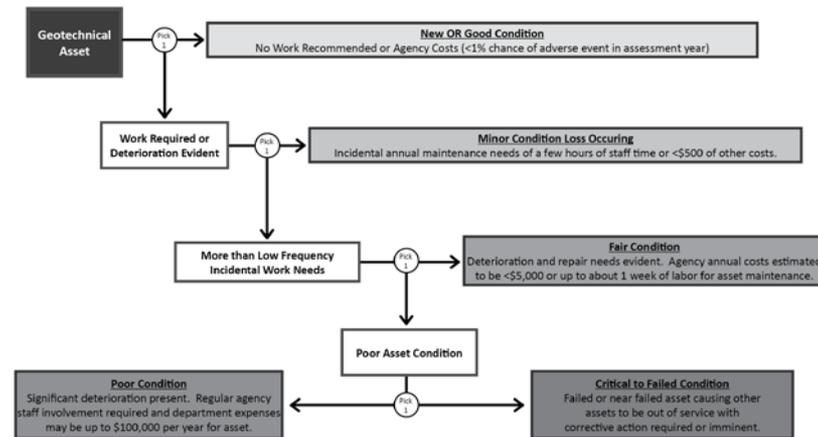


## Step 2: Example 1



- Slope asset at US 40 MP 282.8

# Step 2: Example 1



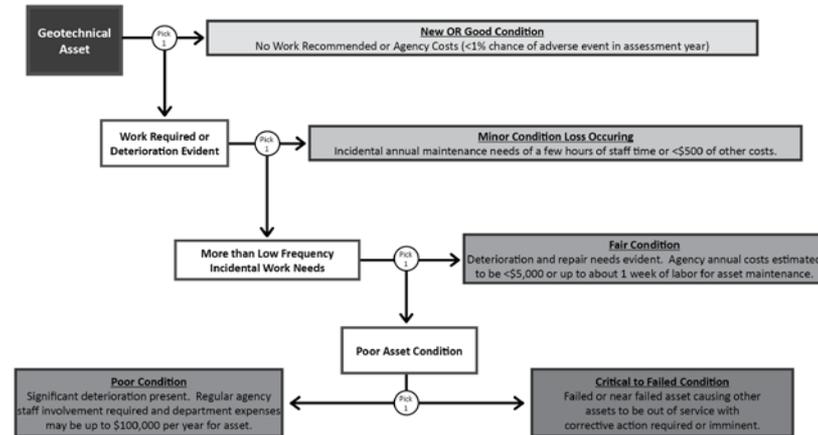
- Fair condition assigned
  - Catchment ditch is full of sediment with recent rockfall on shoulder. Several work hours and equipment required to clean ditch and possibly scale slope

## Step 2: Example 2



- Wall asset at I-70 MP 256.9

# Step 2: Example 2

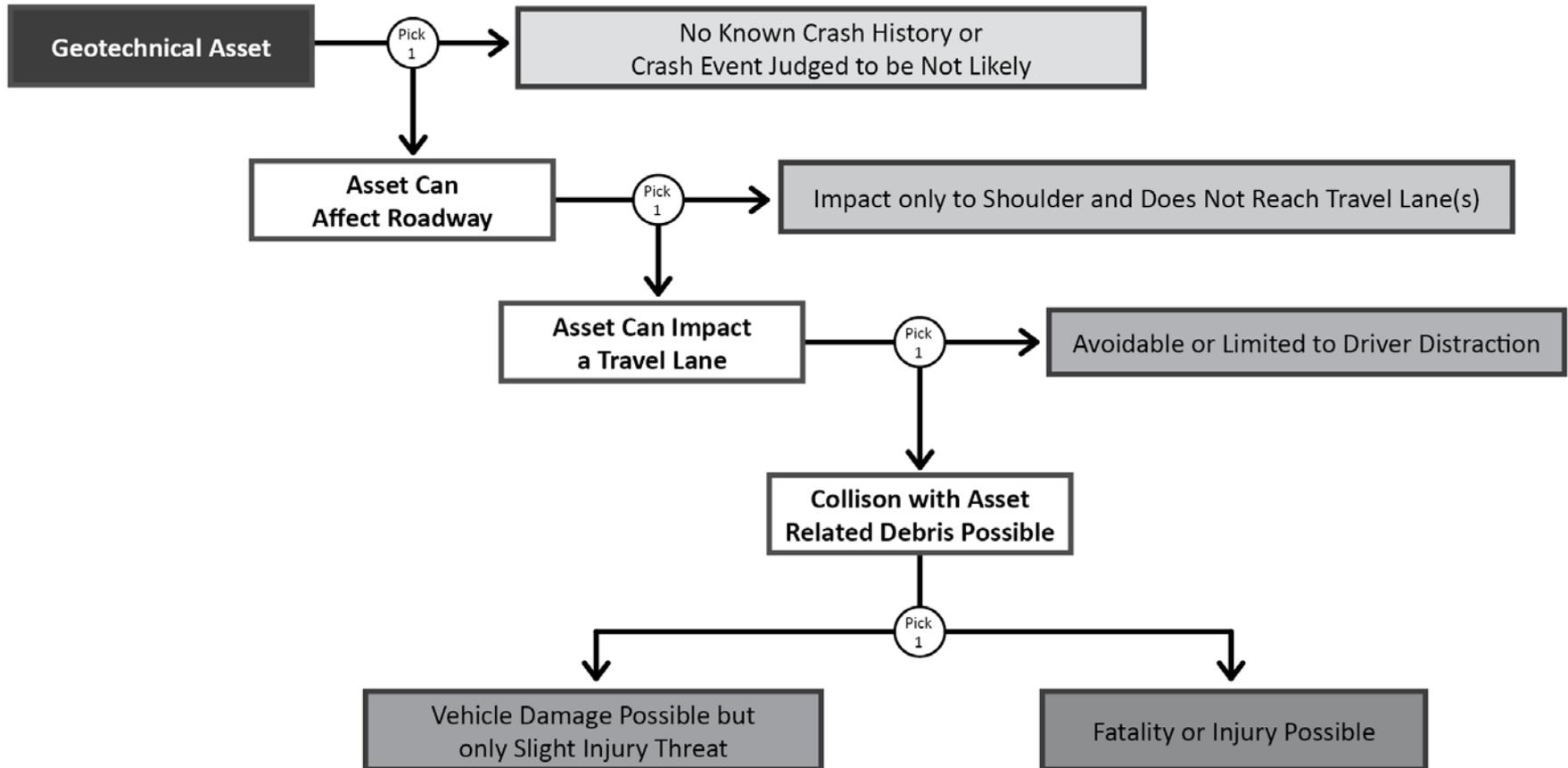


- Fair condition assigned
  - Deterioration of metal elements on wall present and repairs are necessary. Once repaired annual O&M should be reduced versus needing recurring annual repair.

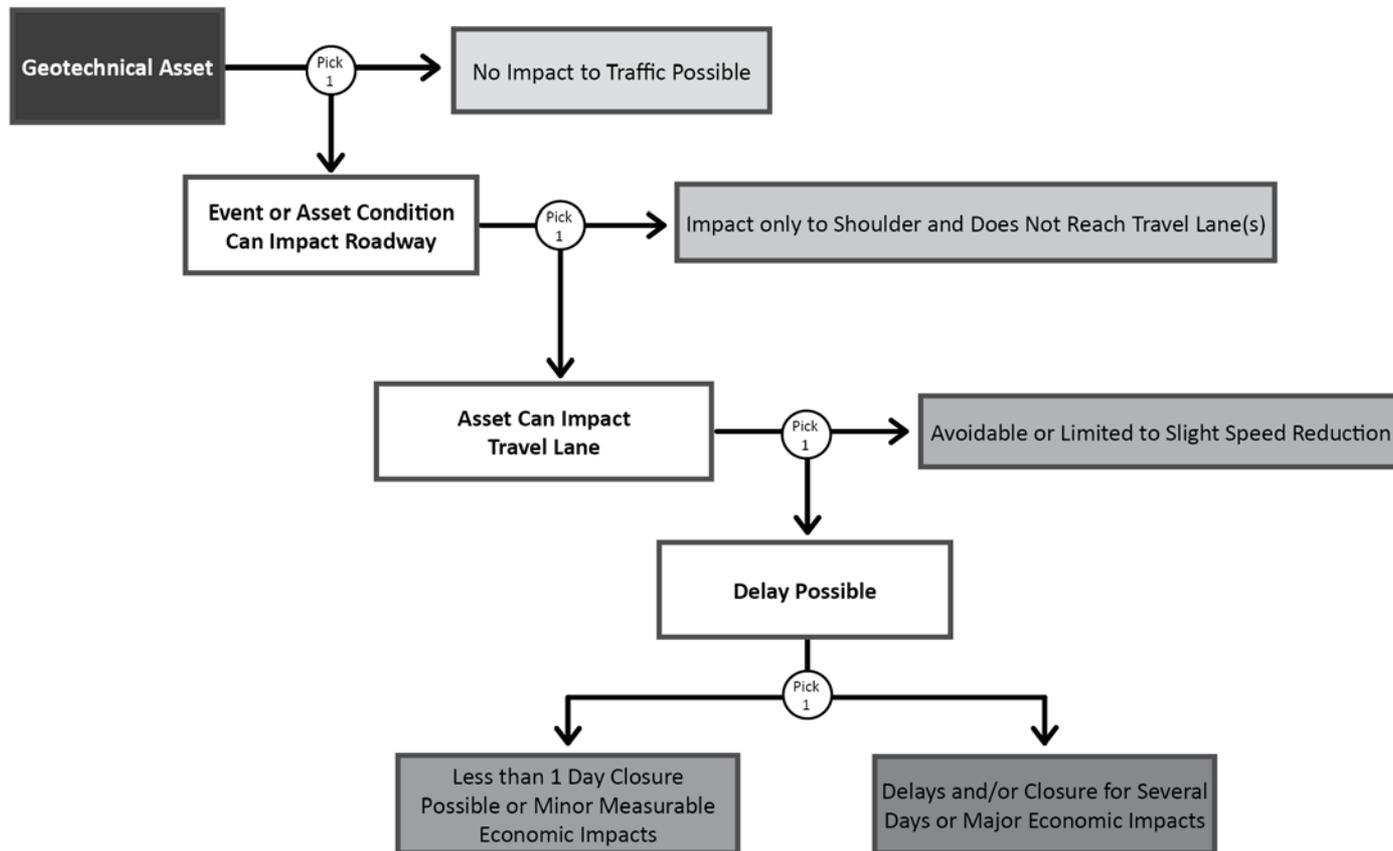
## Step 3: Assign Performance Consequences

- Risk based GAM considers how the asset affects performance of agency
  - Safety Consequences
  - Mobility and Economic Vitality Consequences

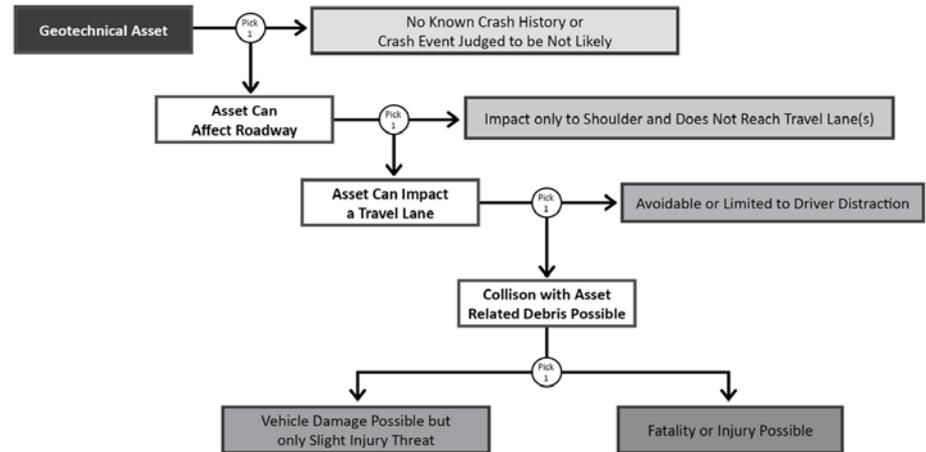
## Step 3: Safety Consequence Tree



# Step 3: Mobility and Economic Vitality Consequence Tree

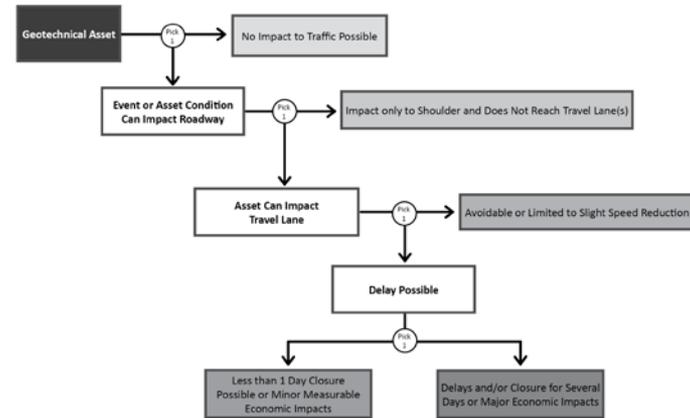


### Step 3: Example 1 - Safety



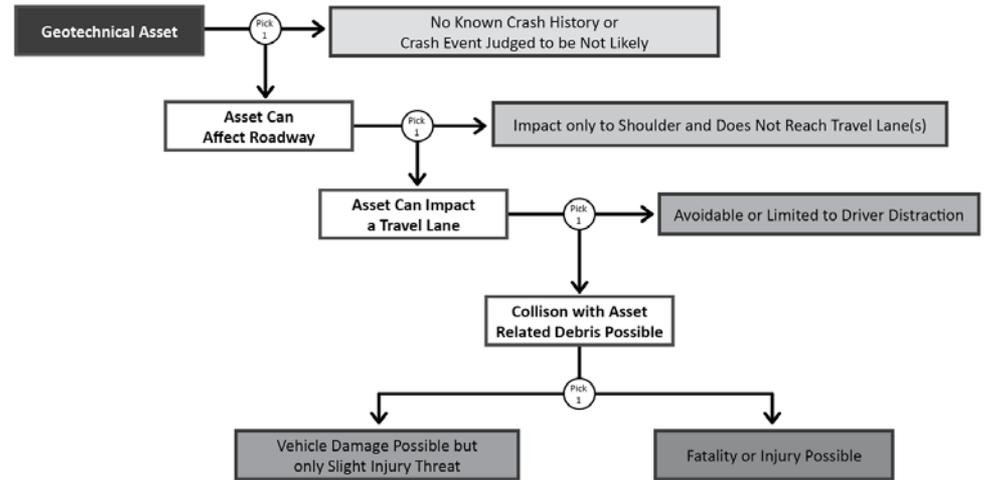
- Fatality or Injury rating assigned
  - Due to height of slope and size of rockfall, the highest safety threat rating is assigned.

# Step 3: Example 1 – Mobility



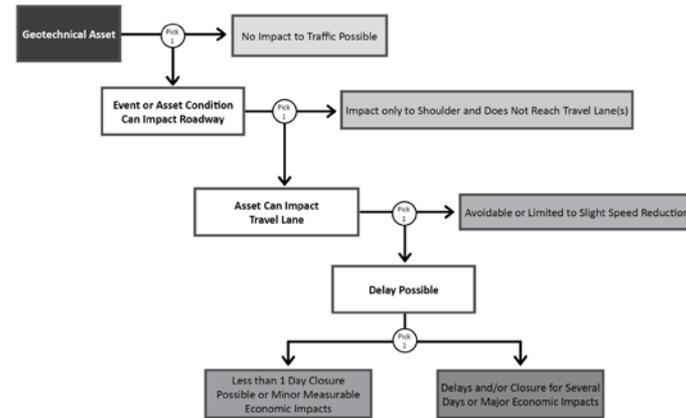
- Less than 1 Day Closure category selected
  - Because of adjacent highway, detour option is available following a potential large event

### Step 3: Example 2 - Safety



- Impact only to Shoulder consequence assigned
  - Based on judgment a failure of the elements and/or wall would likely only impact the shoulder and not threaten the safety of vehicles in the travel lanes

# Step 3: Example 2 - Mobility



- Avoidable consequence assigned
  - Failure of wall could impact shoulders or edges of travel lanes of highway below and above, but would be avoidable through use of temporary traffic control and lane shifts.

# Step 3: Update GAM Planner

Asset ID	Type	Route	Milepost	Description	Fixed Seg. Length	Total Seg. Length	Cost	Scale Factor	Effective Quantity	O&M Condition	Safety Consequence	Mobility Consequence
1	Cut-All	US40	282.8	Rock Cut Slope	0.1	0.1	1	1	1	3-Fair	5-Fatality or Injury Possible	4-Road Closure Possible: 1 Day or Less
1	Cut-All	US40	282.9	Rock Cut Slope	0.1	0.09	1	1	1	3-Fair	5-Fatality or Injury Possible	4-Road Closure Possible: 1 Day or Less
2	Embankment	I-70	256.9	Embankment	0.1	0.1	1	1	1	2-Minor Loss	1-No Impact Possible	3-Impact to Travel Lane Possible
3	Embankment	I-70	256.9	Embankment	0.1	0.1	1	1	1	2-Minor Loss	1-No Impact Possible	3-Impact to Travel Lane Possible
4	Wall Below	I-70	256.9	Wall below US40 & above I-70 (Note: Wall asset could be inventoried as a US 40 asset)	0.1	0.04	1	1	0	3-Fair	2-Impact to Shoulder Possible	3-Impact to Travel Lane Possible

- Safety and Mobility Consequence Columns completed

- Embankment judged to have lowest safety threat level but has a similar consequence level as the wall asset.

# Step 4: Review Treatment Recommendations

- From GAM Planner output
  - Program will recommend a life-cycle treatment option for each segment based on O&M, Safety, and Mobility inputs

Asset ID	Type	Route	Milepos	Description	Fixed Seg. Length	Total Seg. Length	Cost Scale Factor	Effective Quantity	O&M Condition	Safety Consequence	Mobility Consequence	Accel. Det.	Initial Recommendation
1	Cut-All	US40	282.8	Rock Cut Slope	0.1	0.1	1	1	3-Fair	5-Fatality or Injury Possible	4-Road Closure Possible: 1 Day or Less		Maintain
1	Cut-All	US40	282.9	Rock Cut Slope	0.1	0.09	1	1	3-Fair	5-Fatality or Injury Possible	4-Road Closure Possible: 1 Day or Less		Maintain
2	Embankment	I-70	256.9	Embankment	0.1	0.1	1	1	2-Minor Loss	1-No Impact Possible	3-Impact to Travel Lane Possible		Maintain
3	Embankment	I-70	256.9	Embankment	0.1	0.1	1	1	2-Minor Loss	1-No Impact Possible	3-Impact to Travel Lane Possible		Maintain
4	Wall Below	I-70	256.9	Wall below US40 & above I-70 (Note: Wall asset could be inventoried as a US 40 asset)	0.1	0.04	1	1	0 3-Fair	2-Impact to Shoulder Possible	3-Impact to Travel Lane Possible		Maintain

Treatment Recommendation

# Break Time!!!!!!

## Step 4: Understanding Treatments

- Four treatment categories
  - Do Minimum
  - Maintain
  - Rehabilitation (Rehab)
  - Reconstruction

# Step 4: Treatment Type – Do Minimum

- Do Minimum:
  - Not a \$0 (no) cost option
  - Considered a hands off approach
  - Expect accelerated deterioration and service interruptions
- Example:
  - Removing rock from travel lane, leveling pavement on a moving landslide, rebuilding after failure/loss of service

# Step 4: Treatment Type – Maintain

- Maintain:
  - Maintained with frequent, short activities that preserve the function of the asset
- Examples:
  - Cleaning rockfall catchment ditches
  - Managing vegetation or erosion on embankment
  - Cleaning and maintaining drainage features to ensure good function

# Step 4: Treatment Type – Rehabilitation

- Rehab:
  - Actions that improve the O&M condition at least one level
- Examples:
  - Drainage improvements that slow asset movement/deterioration
  - Slope improvements such as draped mesh
  - Replacing/improving deteriorated retaining wall facing

# Step 4: Treatment Type – Reconstruction

- Reconstruction:
  - Actions that improve O&M condition to a new or near new state, effectively resetting service life
- Examples:
  - Rebuilding a wall to current design standards
  - Reconstructing a distressed embankment with engineered fill
  - Highway and asset realignments
  - Ground reinforcement, such as ground anchors, to stabilize slope/embankment with high reliability

# Next Steps: Financial and Investment Planning

- Financial Plan:
  - A several year projection of expected and desired funding to reach objectives
  - E.g the GAM Planner provides a 10-year plan
- Investment Strategy:
  - The inputs that support the Financial Plan such as sources of funding
    - E.g. federal and state fund sources

# Start Group Exercise with GAM Planner

# Implementation of Geotechnical Asset and Performance Management

Why GAM

Starting GAM

Connecting to TAM

Steps to Success

## Assessment Example to follow if needed

# Step 5: Analyze Investment Levels

- Even with just 4 assets this process can and **should start** now!
- In GAM Planner, Program Simulation section (Main Menu) navigate to the Summary Results (yearly program level) and Detailed Results (asset level) worksheets

**PROGRAM SIMULATION**

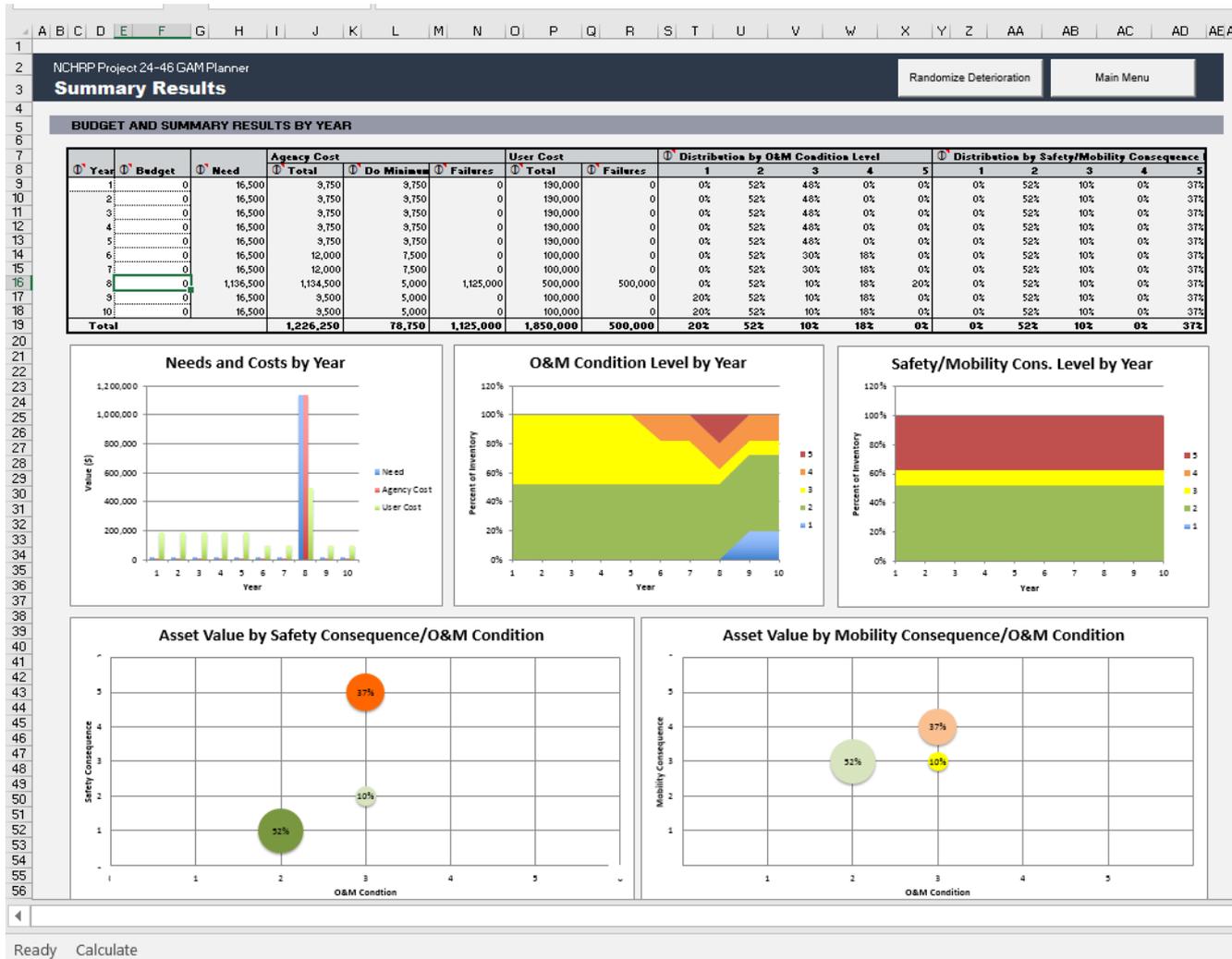
Opens the Summary Results worksheet to enter budgets by year and view summary results.

Summary Results

Opens the Detailed Results worksheet to show details on a selected asset.

Detailed Results

# Step 5: Summary Results



# Step 5: Understanding Summary Results

NCHRP Project 24-46 GAM Planner

### Summary Results

**BUDGET AND SUMMARY RESULTS BY YEAR**

Year	Budget	Need	Agency Cost			User Cost	
			Total	Do Minimum	Failures	Total	
1	0	16,500	3,750	3,750	0	130,000	
2	0	16,500	3,750	3,750	0	130,000	
3	0	16,500	3,750	3,750	0	130,000	
4	0	16,500	3,750	3,750	0	130,000	
5	0	16,500	3,750	3,750	0	130,000	
6	0	16,500	12,000	7,500	0	100,000	
7	0	16,500	12,000	7,500	0	100,000	
8	0	1,136,500	1,134,500	5,000	1,125,000	500,000	
9	0	16,500	3,500	5,000	0	100,000	
10	0	16,500	3,500	5,000	0	100,000	
<b>Total</b>			<b>1,226,250</b>	<b>78,750</b>	<b>1,125,000</b>	<b>1,850,000</b>	

- Need: agency cost to support the least life-cycle cost recommendations by year. Actual expenditures may exceed this amount as a result of do-minimum and/or failure costs.
  - This is the “Maintain” cost for the 4 assets in this example

# Step 5: Understanding Summary Results

NCHRP Project 24-46 GAM Planner

### Summary Results

**BUDGET AND SUMMARY RESULTS BY YEAR**

Year	Budget	Need	Agency Cost			User Cost	
			Total	Do Minimum	Failures	Total	
1	0	16,500	3,750	3,750	0	130,000	
2	0	16,500	3,750	3,750	0	130,000	
3	0	16,500	3,750	3,750	0	130,000	
4	0	16,500	3,750	3,750	0	130,000	
5	0	16,500	3,750	3,750	0	130,000	
6	0	16,500	12,000	7,500	0	100,000	
7	0	16,500	12,000	7,500	0	100,000	
8	0	1,136,500	1,134,500	5,000	1,125,000	500,000	
9	0	16,500	3,500	5,000	0	100,000	
10	0	16,500	3,500	5,000	0	100,000	
<b>Total</b>			<b>1,226,250</b>	<b>78,750</b>	<b>1,125,000</b>	<b>1,850,000</b>	

- Total: annual agency cost, including treatment, do-minimum, and failure costs.
  - With no budget, Do Minimum is the outcome cost and an asset failure is estimated in year 8 based on model deterioration rates

# Step 5: Evaluating Summary Results

NCHRP Project 24-46 GAM Planner  
**Summary Results**

**BUDGET AND SUMMARY RESULTS BY YEAR**

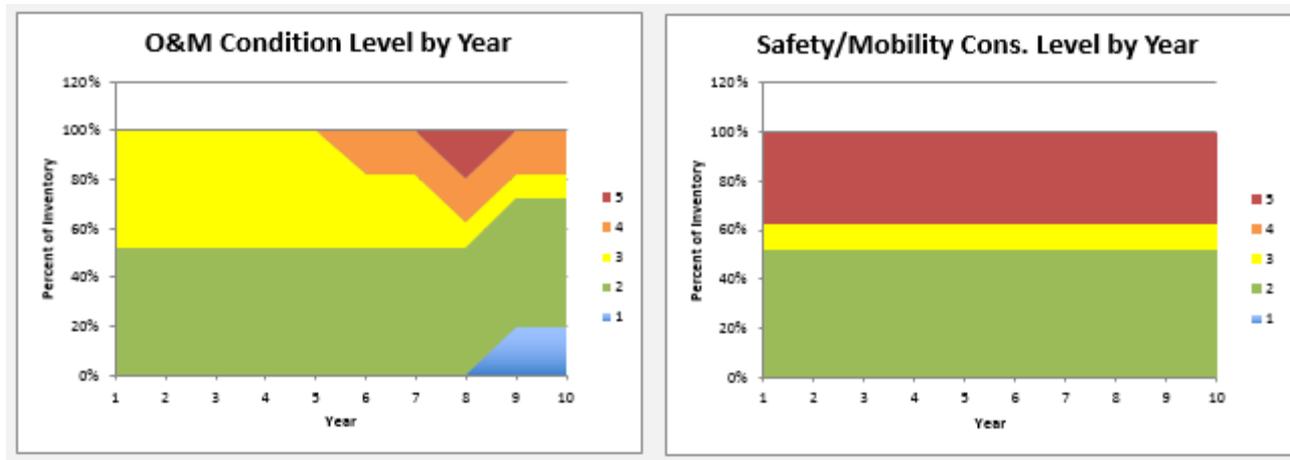
Year	Budget	Need	Agency Cost		Do Minimum	Failures
			Total			
1	20,000	16,500	16,500		0	0
2	20,000	16,500	16,500		0	0
3	20,000	16,500	16,500		0	0
4	20,000	16,500	16,500		0	0
5	20,000	16,500	16,500		0	0
6	20,000	16,500	16,500		0	0
7	20,000	16,500	16,500		0	0
8	20,000	16,500	16,500		0	0
9	20,000	16,500	16,500		0	0
10	20,000	16,500	16,500		0	0
<b>Total</b>			<b>165,000</b>		<b>0</b>	<b>0</b>

- By adding a budget to cover the annual need, the agency can perform required preservation work

# Step 5: Summary Results

- For this hypothetical GAM program:
  - No budget for GAM treatment has an agency 10-year cost of \$1.2M with low yearly cost **Do Minimum** treatments and a deterioration failure during the period
  - With a budget to cover **Maintain** recommendation for assets, total estimated 10-year cost is \$0.16M
- Model example shows the importance of need for preservation (Maintain) work

# Step 5: Other Summary Results

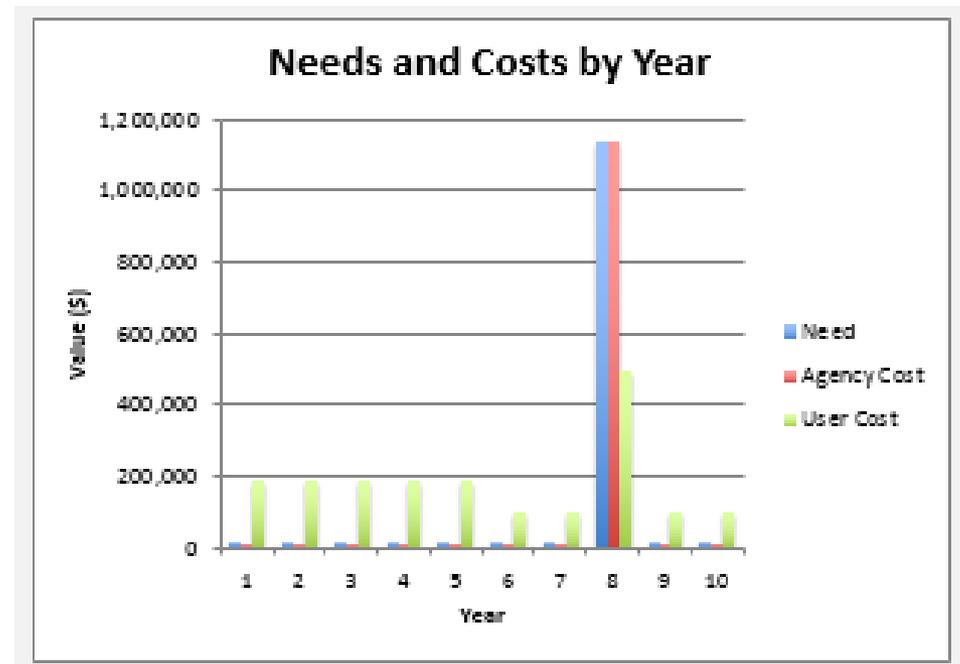


- GAM Planner estimates the change in asset condition and asset performance consequences with time (Do Minimum shown)

# Step 5: Other Summary Results

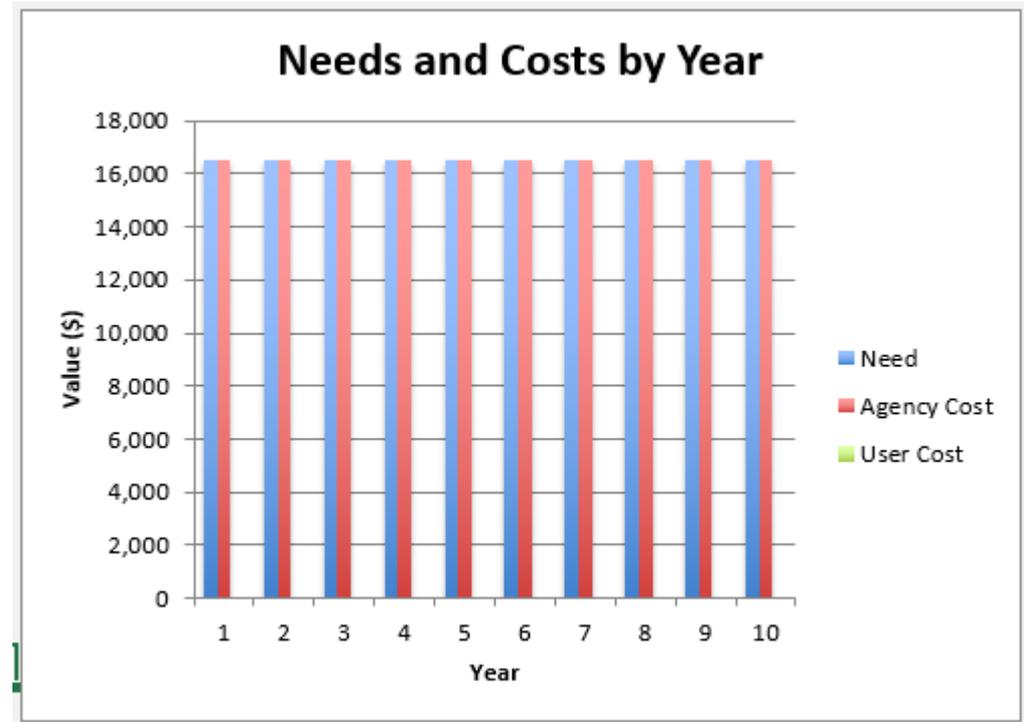
- GAM Planner also illustrates the economic impacts to agency and users over 10-year period

(Do Minimum shown here)

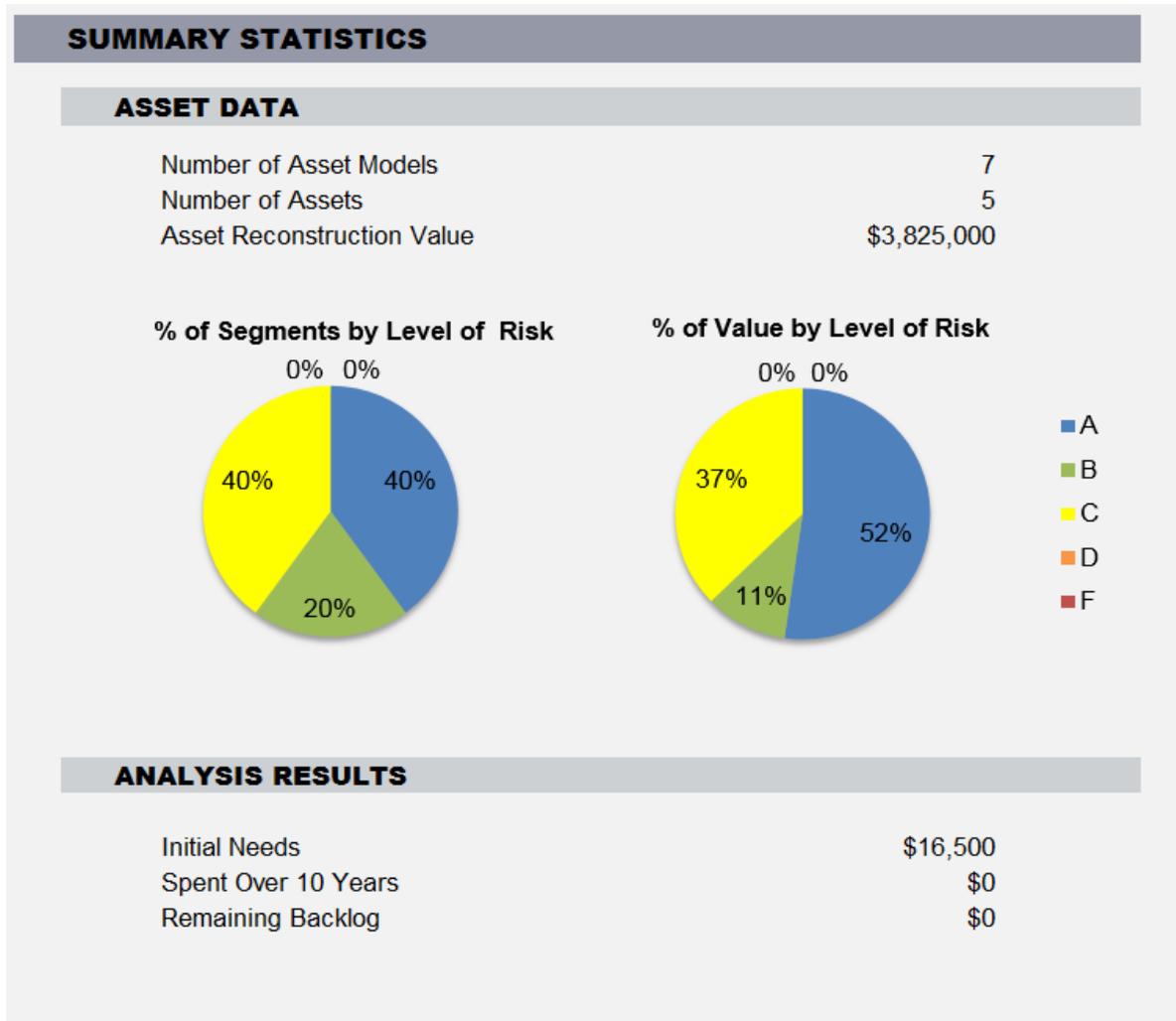


# Step 5: Other Summary Results

- Funding for Maintain option shows agency can reduce future needs in this comparison.

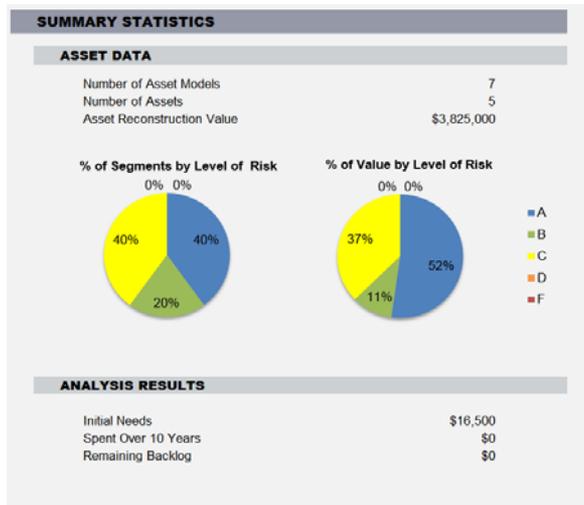


# Step 6: Communicate Results



# Step 6: Communicate Results

- Output from Step 5 provides several different cost-benefit scenarios to support GAM treatment



- GAM Planner summary also provides inventory status to communicate current size, investment needs, and risk-based performance measure distribution

# Options for Next Steps

- Expand inventory
  - Consider options for help from other agency staff for inventory growth (e.g. maintenance and bridge inspection staff)
- Calibrate and/or develop new asset models
- Data management programs that align with agency data management and communication
- Author a GAM plan document
- Add measures based on executive or stakeholder feedback

# Implementation of Geotechnical Asset and Performance Management

Why GAM

Starting GAM

Connecting to TAM

Steps to Success