



# NDDOT Bridge Management System (BrM) & the TAMP

Nancy Huether, P.E.

Bridge Division



I have been with the NDDOT bridge division for 6 years. I spent the first two years in hydraulics; I then was asked to get our bridge preservation program going and after a couple of years, began getting more involved in our bridge management system. Less than a year ago, Gary Doerr, who many of you know, decided to retire and I took over my current role. I think a good part of why he decided to retire is the prospect of dealing with the TAMP.

I am going to talk just a bit about the history of our bridge management up to the point of preparing for the TAMP.

# Presentation Outline

- Bridge Management at the NDDOT
- Customizing and Refining our BMS (BrM)
- Using BrM to develop our TAMP
  - Challenges
  - Some solutions



Some states use other programs to get info; to do bridge management. At the end of this presentation, I would like to have a few of you share what you have done and maybe some pros and /or cons of your systems.

# Bridge Management at NDDOT

- Prior to 1995 used only main frame for bridge data/inspection/reporting
- 1995-1996 began using Pontis for Element inspection
- 2011 Transitioned to using only Pontis
  - Database
    - All data migrated forward to Pontis
  - Inspection
    - NBI Component Rating
    - Element Condition State
  - Reporting
- 2015-2016 NBIAS
  - Needed to do some modeling for internal study



# Bridge Management at NDDOT Cont. . .

- Currently use BrM 6.2
  - Inspections
    - In-house developed web app
  - Deterioration Modeling
  - Long-term Planning
  - Recommending Rehabilitation and Replacement work
  - Optimizing Costs
  - Meeting Performance Measures
  - **Supporting FHWA TAMP requirements**



# FHWA TAMP Requirements

“...develop a **risk-based** asset management plan . . . describe NHS will be managed to achieve system **performance effectiveness** and State DOT **targets for asset condition**, while managing the **risks**, in a **financially responsible** manner, at a **minimum practicable cost** over the **life cycle** of its assets . . .” using the following processes :

- Conduct Performance Gap analysis
- Conduct Life Cycle Planning Analysis
- Develop Risk Management Plan
- Develop Financial Plan
- Develop Investment Strategies
- Obtain Data from other NHS owners
- **Utilize Bridge and Pavement Management Systems per 23 CFR 515.17**



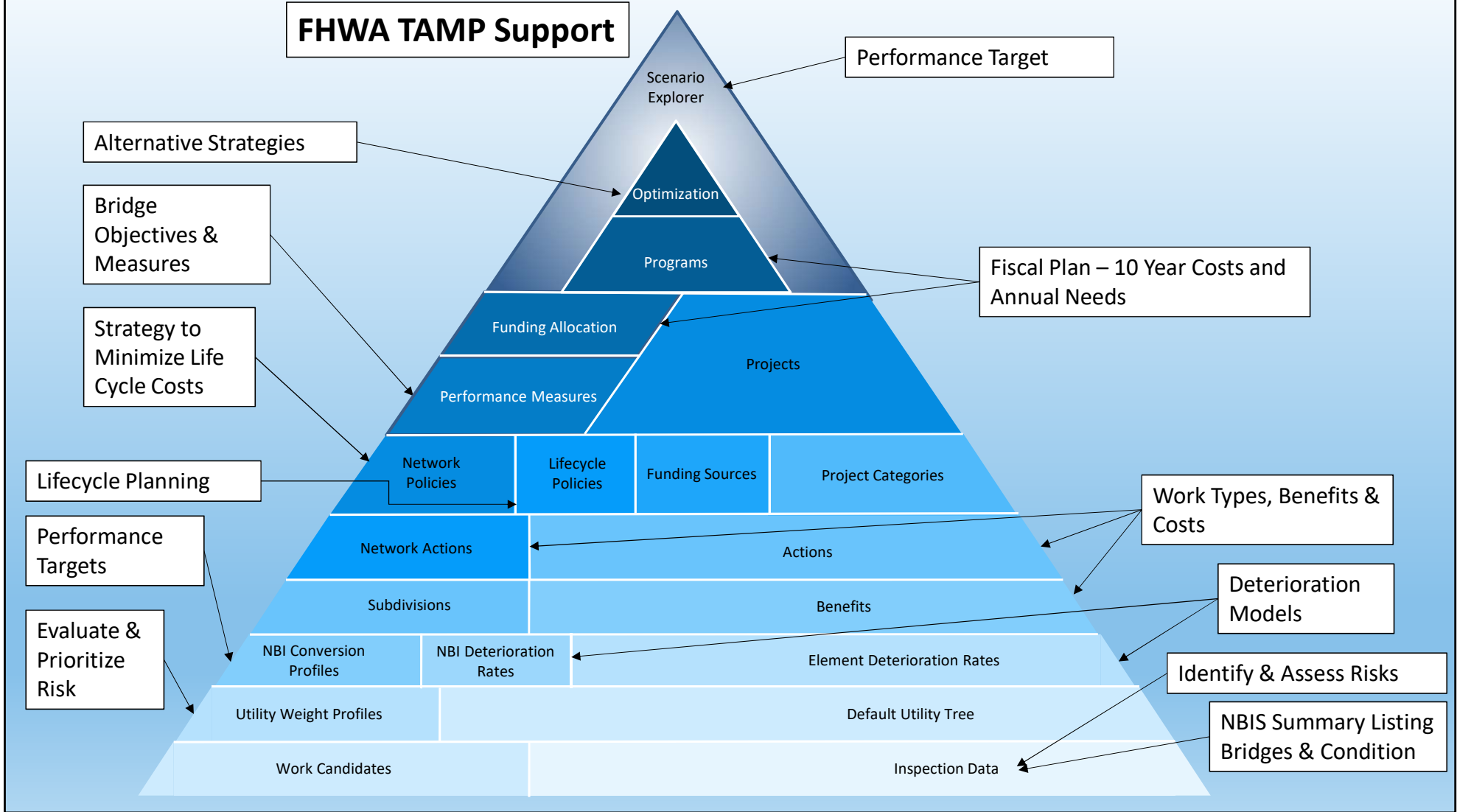
A State shall develop a risk-based asset management plan that describes how the NHS will be managed to achieve system performance effectiveness and State DOT targets for asset condition, while managing the risks, in a financially responsible manner, at a minimum practicable cost over the life cycle of its assets. The State DOT shall develop and use, at a minimum the following processes to prepare its asset management plan:

# FHWA TAMP Requirements for a BMS (23 CFR 515.17)

- a) Collect, Process, Store, and Update NHS Inventory and Condition data
- b) Forecast Deterioration for NHS Bridge Assets
- c) Determine Benefit-Cost over Life Cycle to evaluate Alternative Actions for NHS Bridge Assets
- d) Identify Short- and Long-Term Budget Needs for NHS Bridges
- e) Determine Strategies to Identify Potential NHS Bridge Projects to Maximize Benefits within Financial Constraints
- f) Recommend Programs and Implementation Schedules to manage Condition of NHS Bridges within Policy and Budget Constraints



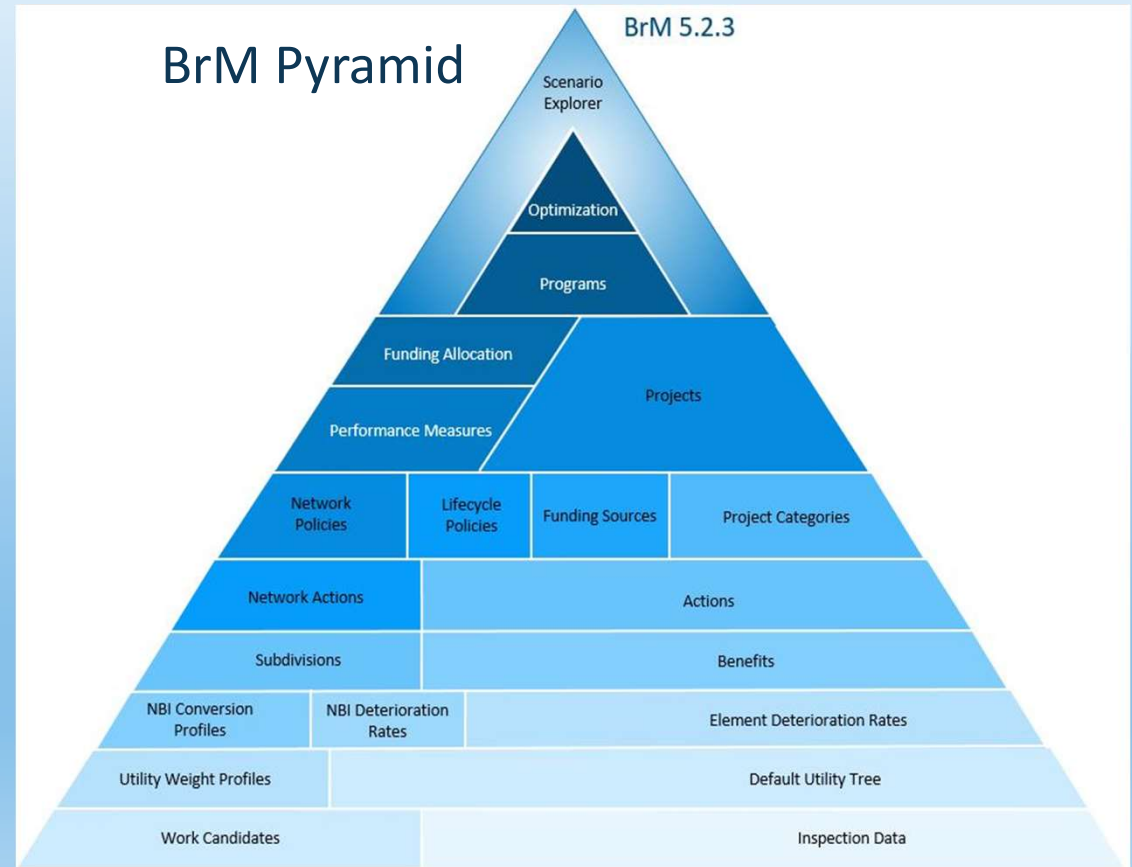
Slightly paraphrased – left off pavements. As I was once told by a very wise person in a ring, Pavement is like the band and the Bridge is the diamond. Some states have other bridge management programs that they have been using. We have not.



Same pyramid, how different portions meet FHWA TAMP requirements. Base of pyramid addresses the first requirement – Collect, Process, Store and Update Inventory and Condition Data

# Preparation for TAMP

- October 2017
  - BrM 5.2.3
  - Understanding of Functionality
  - Basics of Customization
  - “Building the Pyramid”
- August 2019
  - BrM 6.2
  - Increased Customization
  - Improved Deterioration Modeling



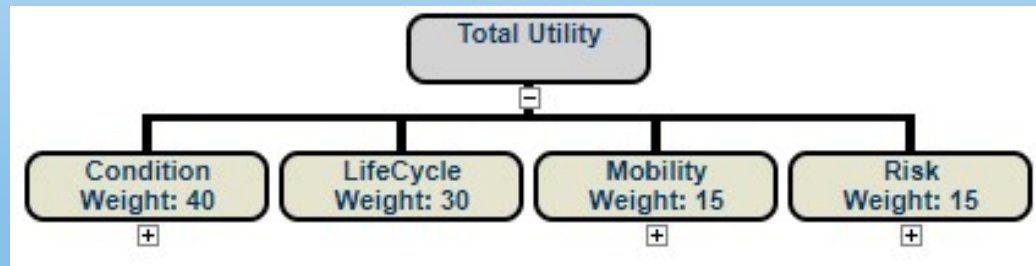
Initial training Oct. 2017 BrM 5.2.3. Lots to learn! My experience bridge preservation; working with inspection data for program planning, STIP. Basic functionality,



# Risk-Based Assessment

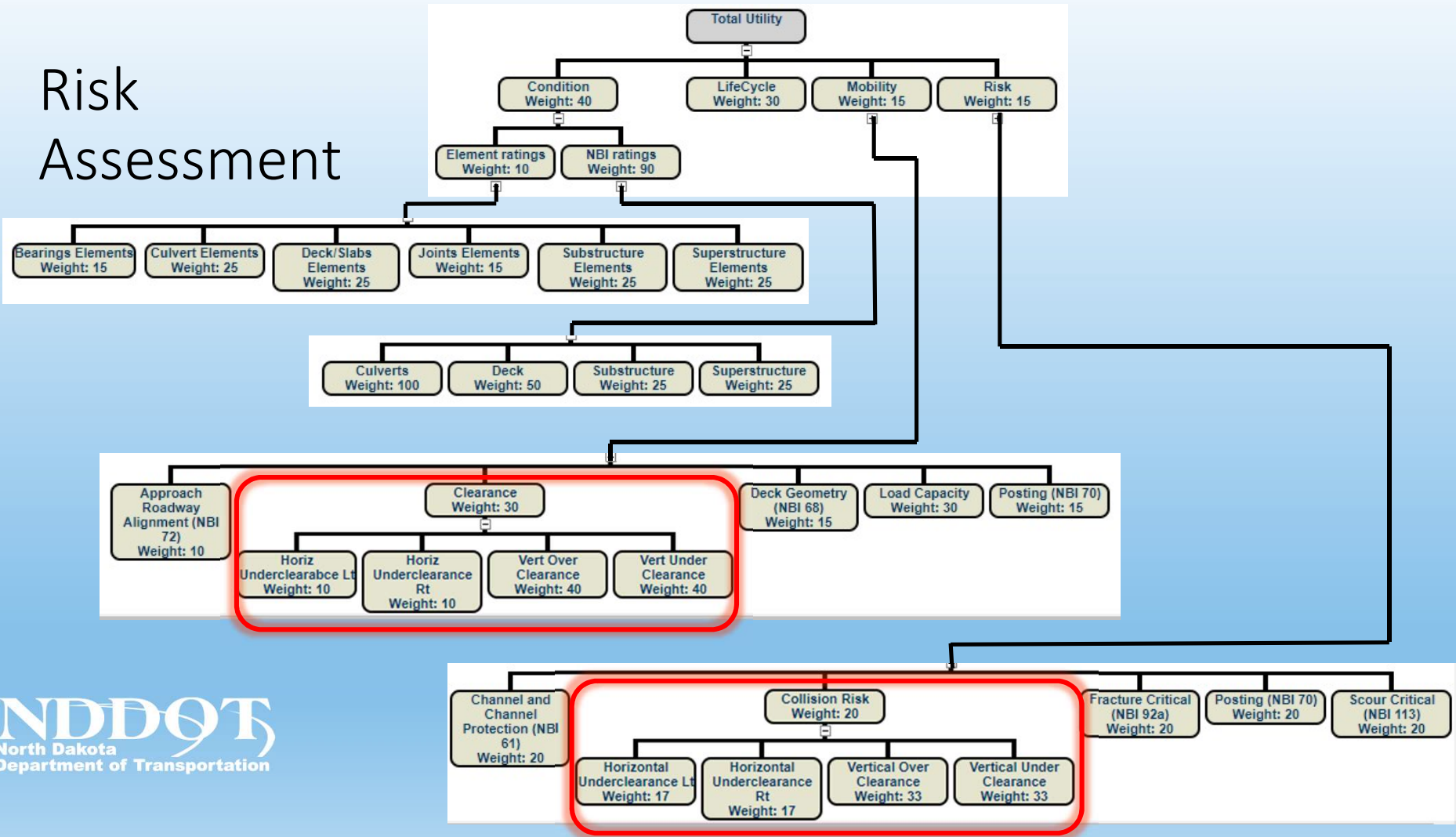
## Utility Tree and Utility Weights

- Utility Value
- Utility Tree
- Utility Weights
  - Customize to fit NDDOT Priorities & Known Risks



One of the requirements of the TAMP is that it must be risk based. In BrM the Utility Tree has a specific risk component which is customizable so states can weight their most significant risks.

# Risk Assessment



Condition – measure of structural adequacy

Life Cycle Cost evaluates timing of work – least cost over time

Mobility – effect on traveling public – Added a Clearance Weight – took into account horizontal and vertical clearances and their effect on mobility

Risk – how bridge attributes and external factors affect the vulnerability of the bridge – added Collision Risk based on the horizontal and vertical clearances (Columbus Ohio bridge hit resulting in a death)

# FHWA TAMP Requirements for a BMS (23 CFR 515.17)

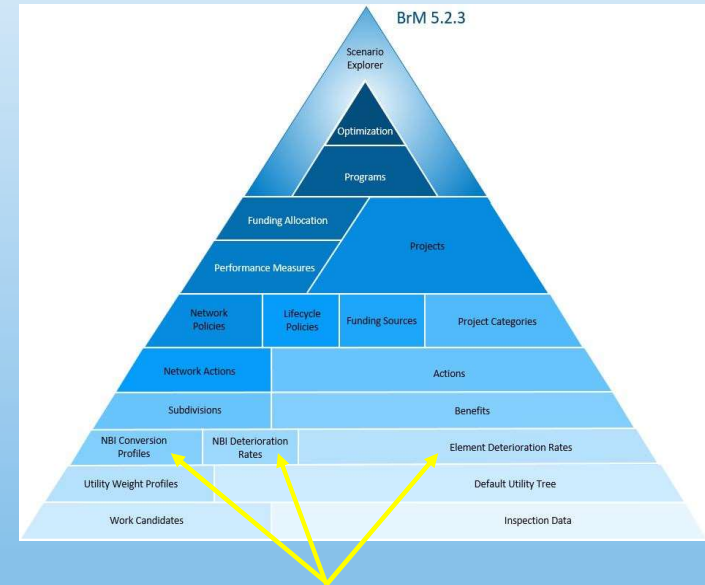
- a) Collect, Process, Store, and Update Inventory and Condition data
- b) Forecast Deterioration for Bridge Assets**
- c) Determine Benefit-Cost over Life Cycle to evaluate alternative actions
- d) Identify Short- and Long-Term Budget Needs
- e) Determine Strategies to Identify Potential Projects to maximize benefits within financial constraints
- f) Recommend Programs and Implementation Schedules to manage condition within Policy and Budget Constraints



I mentioned that the BMS will support the FHWA TAMP. The recent Transportation Asset Management requirements set forth by FHWA set for the following minimum standards for developing and operating a bridge management system.

# Deterioration Modeling

- Deterioration Rates are affected by
  - Climate
  - ADT
  - Design
  - Materials
  - Construction Quality
  - Maintenance, Repair, and Rehab Practices
- Realistic/Reasonable Deterioration Rates



Deterioration rates vary between States/Regions. Need to calibrate to climate, practices

# Deterioration Modeling

- Element Deterioration Rates
  - Health Index
- NBI Conversion Profiles
  - Element deterioration to NBI deterioration
- NBI Deterioration Rates – components (deck, superstructure, substructure)
  - Based on time in each NBI rating

**Components**

Component Name

- Deck
- Superstructure
- Substructure
- Culvert

**Component Specification**

Name: Deck

Description:

Category: Decks/Slabs

Table Name: inspevnt      Column Name: dkrating

Min NBI Value: 1      Max NBI Value: 9

**Component Deterioration Modeling**

Model

**Model Parameters**

NBI Transition Time in Years 9: 2

NBI Transition Time in Years 8: 12

NBI Transition Time in Years 7: 17

NBI Transition Time in Years 6: 17

NBI Transition Time in Years 5: 14

NBI Transition Time in Years 4: 5

NBI Transition Time in Years 3: 2.6

NBI Transition Time in Years 2: 0

NBI Transition Time in Years 1: 0

Bridge Health Index:

**Network NBI Rating distributions**

Bridge Filter: Entire Network Re-estimate results

Component: Bridge-Level

	Latest Inspection Reported	Current	+5 Years	+10 Years
NBI Rating 9	369	94	0	0
NBI Rating 8	860	606	633	519
NBI Rating 7	1596	1242	1169	1142
NBI Rating 6	1160	1528	1576	1615
NBI Rating 5	869	945	966	927
NBI Rating 4	525	660	612	490
NBI Rating 3	222	434	287	546
NBI Rating 2	66	105	288	131
NBI Rating 1	20	47	101	133

**Bridge**

Year	Health Index (%)
2020	100
2040	60
2060	35
2080	20
2100	10

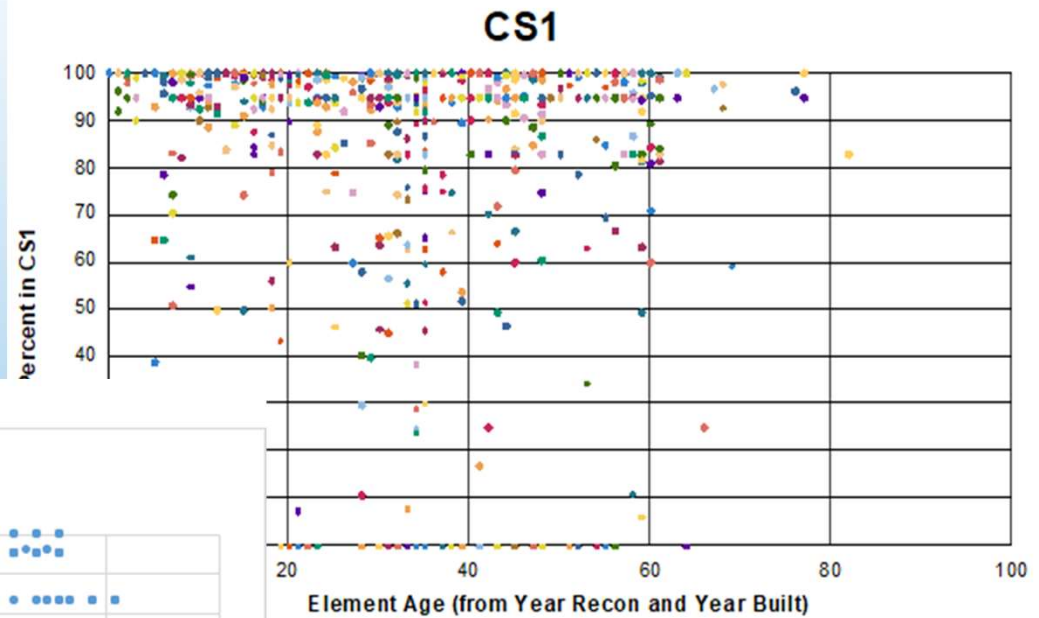
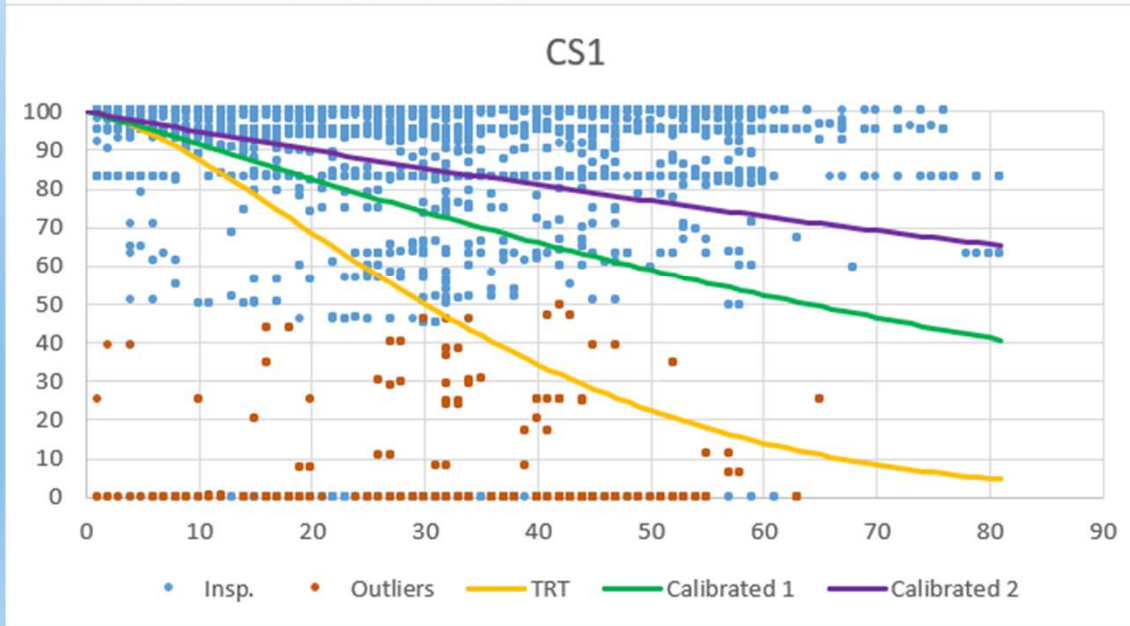


Sounds simple, but we all know it is not! Currently Transportation Pooled Fund study to better define Deterioration Models in the Midwest States.

# Deterioration Modeling

- Element Deterioration Rates

## Element 12 - Re Concrete Deck



Sounds simple, but we all know it is not! Currently Transportation Pooled Fund study to better define Deterioration Models in the Midwest States. This graph is one of the I created with the help of Zac for our TAMP.  
One Zac created from our database.

# Deterioration Modeling

- NBI Conversion

### NBI Profiles

NBI Profile Name	
✖	NDDOT Proposed
✖	NDDOT 2019
▶	FHWA Profile
▶	BrM Default

### Profile Details:

Name:

Profile enabled

#### Generic Upper Limits

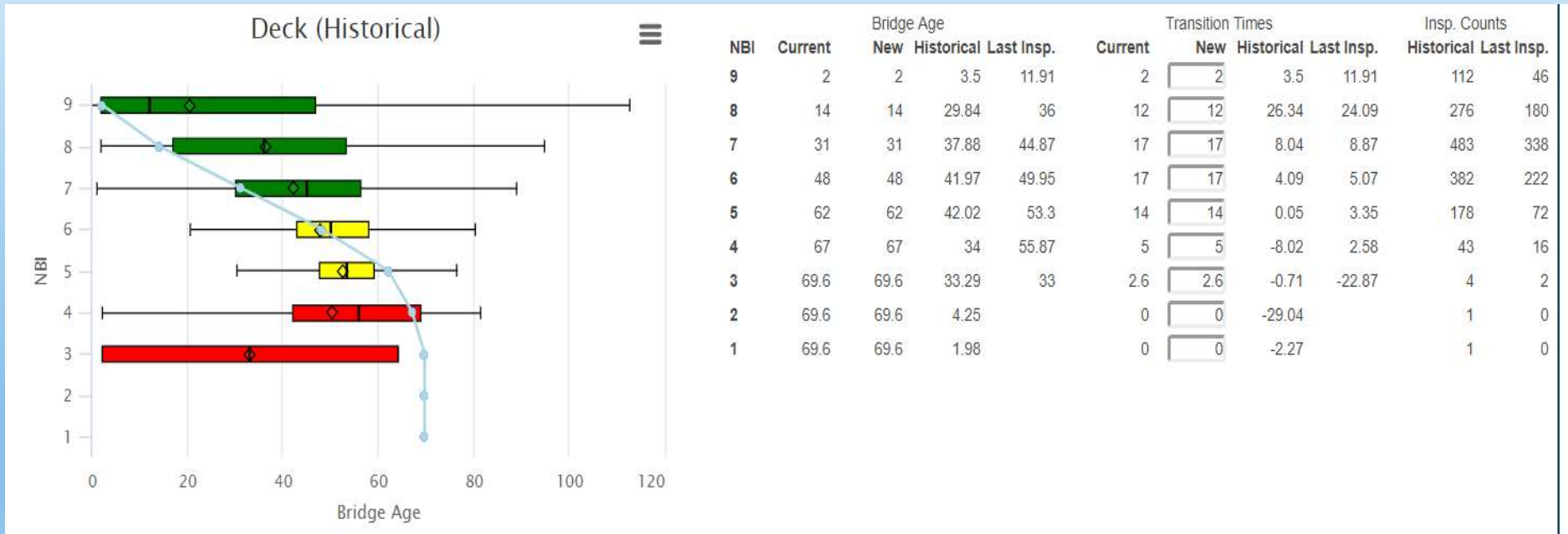
Group enabled

Method of CS average

NBI	Enabled	CS1 %	CS2 %	CS3 %	CS4 %
9	<input checked="" type="checkbox"/>	<input type="text"/>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="text" value="0"/>
8	<input checked="" type="checkbox"/>	<input type="text"/>	<input type="text" value="5"/>	<input type="text" value="5"/>	<input type="text" value="1"/>
7	<input checked="" type="checkbox"/>	<input type="text"/>	<input type="text" value="20"/>	<input type="text" value="5"/>	<input type="text" value="2"/>
6	<input checked="" type="checkbox"/>	<input type="text"/>	<input type="text"/>	<input type="text" value="10"/>	<input type="text" value="3"/>
5	<input checked="" type="checkbox"/>	<input type="text"/>	<input type="text"/>	<input type="text" value="20"/>	<input type="text" value="5"/>
4	<input checked="" type="checkbox"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text" value="15"/>
3	<input checked="" type="checkbox"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text" value="100"/>
2	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
1	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

# Deterioration Modeling

- NBI Deterioration



Sounds simple, but we all know it is not! Currently Transportation Pooled Fund study to better define Deterioration Models in the Midwest States. This graph is one of the I created with the help of Zac for our TAMP.  
 One Zac created from our database.



# Deterioration Modeling

- NBI Deterioration

**Components**

Component Name
Deck
Superstructure
Substructure
Culvert

**Component Specification**

Name:

Description:

Category:

Table Name:  Column Name:

Min NBI Value:  Max NBI Value:

**Component Deterioration Modeling**

Model

**Model Parameters**

NBI Transition Time in Years 9:

NBI Transition Time in Years 8:

NBI Transition Time in Years 7:

NBI Transition Time in Years 6:

NBI Transition Time in Years 5:

NBI Transition Time in Years 4:

NBI Transition Time in Years 3:

NBI Transition Time in Years 2:

NBI Transition Time in Years 1:

**Network NBI Rating distributions**

Bridge Filter:

Component:

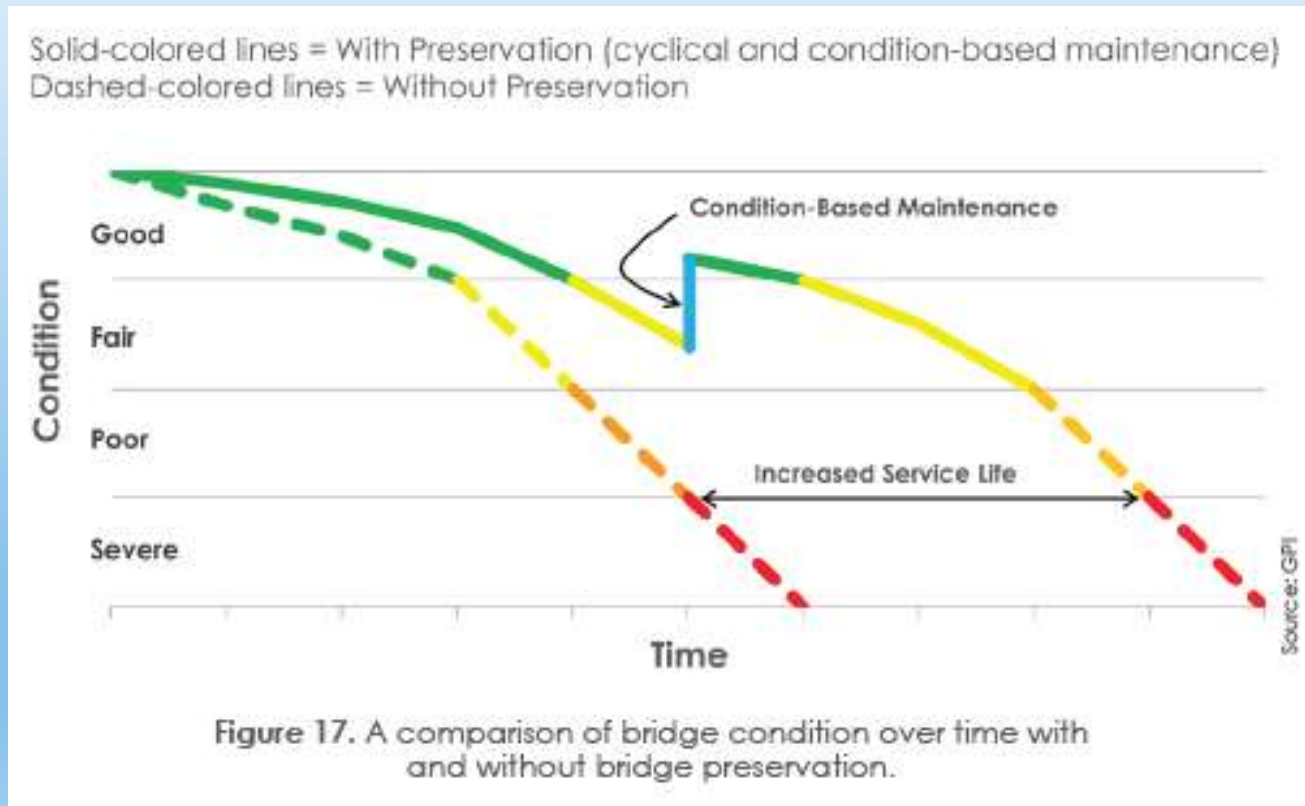
	Latest Inspection Reported	Current	+5 Years	+10 Years
<b>NBI Rating 9</b>	42	23	0	0
<b>NBI Rating 8</b>	147	122	106	73
<b>NBI Rating 7</b>	289	255	222	216
<b>NBI Rating 6</b>	179	234	276	281
<b>NBI Rating 5</b>	58	78	101	105
<b>NBI Rating 4</b>	5	8	10	30
<b>NBI Rating 3</b>	0	0	3	7
<b>NBI Rating 2</b>	0	0	2	3
<b>NBI Rating 1</b>	0	0	0	2
<b>NBI Rating 0</b>	0	0	0	3



Sounds simple, but we all know it is not! Currently Transportation Pooled Fund study to better define Deterioration Models in the Midwest States. This graph is one of the I created with the help of Zac for our TAMP. One Zac created from our database.

# Preservation Effects on Deterioration

## *Minimum Practicable Costs over Life Cycle of Asset*



Source: FHWA Bridge Preservation Guide, Spring 2018

# FHWA TAMP Requirements for a BMS (23 CFR 515.17)

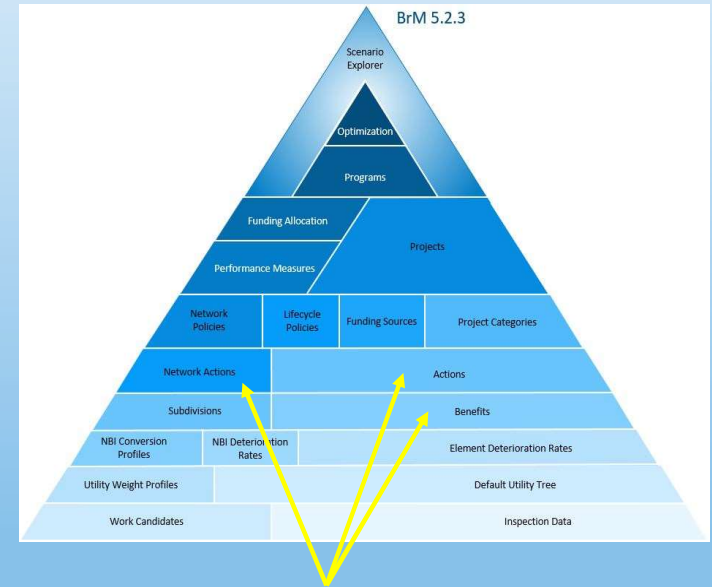
- a) Collect, Process, Store, and Update Inventory and Condition data
- b) Forecast Deterioration for Bridge Assets
- c) Determine Benefit-Cost over Life Cycle to evaluate alternative actions**
- d) Identify Short- and Long-Term Budget Needs
- e) Determine Strategies to Identify Potential Projects to maximize benefits within financial constraints
- f) Recommend Programs and Implementation Schedules to manage condition within Policy and Budget Constraints



I mentioned that the BMS will support the FHWA TAMP. The recent Transportation Asset Management requirements set forth by FHWA set for the following minimum standards for developing and operating a bridge management system.

# Actions, Benefits, Costs

- Maintenance, Rehabilitation, and Replacement Actions
  - Define typical NDDOT Actions
- Benefits
  - Define Benefits of Actions
- Costs
  - Develop Realistic Costs



Need to define all actions, benefits, and related costs so that the program can “do it’s thing”. The program will use defined benefit of an action and compare to the costs of that action to determine which actions to do.

# Life Cycle Cost Analysis

- Define Policy Rules for timing of work based on NDDOT policies
- Considers Short-Term Benefits/Costs and Long-Term Impacts of work over the Life of the bridge.

Admin > Modeling Config > LCCA Policy Rules

**Rule Editor**

Policy:  Rule:  [Create New](#)

**Rule Details**

Name:  Resulting Action:

**Summary**

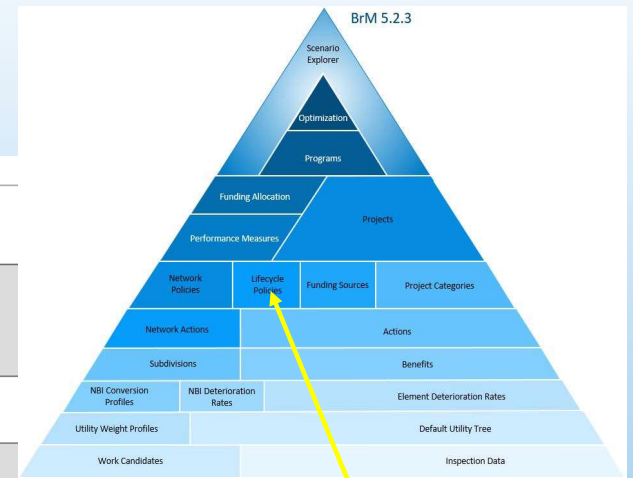
((Health Index of Category 'Decks/Slabs' Must Be Greater Than Or Equal To Number Value 50 **AND** Health Index of Category 'Decks/Slabs' Must Be Less Than Or Equal To Number Value 90) **AND** (NBI Component Rating of 'Deck' Must Be Greater Than Or Equal To Number Value 6 **AND** NBI Component Rating of 'Deck' Must Be Less Than Or Equal To Number Value 8))

**Rule Builder**

[Add Condition](#) [Add Group](#)

We can also create rules to restrict when to consider specific actions based on Health Index, condition (both NBI and Element? – verify whether element CS can be used in this policy)

# Life Cycle Cost Analysis Policy



**Group**

Add Condition Add Group Remove Group

Type:

Field:  As Number Must Be:  Number Value:

AND

Type:

Field:  As Number Must Be:  Number Value:

AND

**Group**

Add Condition Add Group Remove Group

Type:

Field:  As Number Must Be:  Number Value:

AND

Type:

Field:  As Number Must Be:  Number Value:



# Network Policies

Admin > Modeling Config > Network Policies

**Network Policy Editor**

Network Policy: Rehab Deck Create New

**Network Policy Details**

Network Policy Name: Rehab Deck

**Actions**

- Rehab Deck - Network
  - Do Nothing
  - Repaint Super/Sub - Network
    - Do Nothing
    - Rehab Sub - Network
  - Rehab Sub - Network
  - Rehab Super - Network
    - Do Nothing
    - Rehab Sub - Network

**Details**

Action: Rehab Deck - Network Project Category: Select a project category

**Action Conditional Rule**

**Summary**

(Column 'dkrating' of Table 'inspevnt' Is In Set '4 Poor, 5 Fair, 6 Satisfactory, 7 Good')

**Rule Builder**

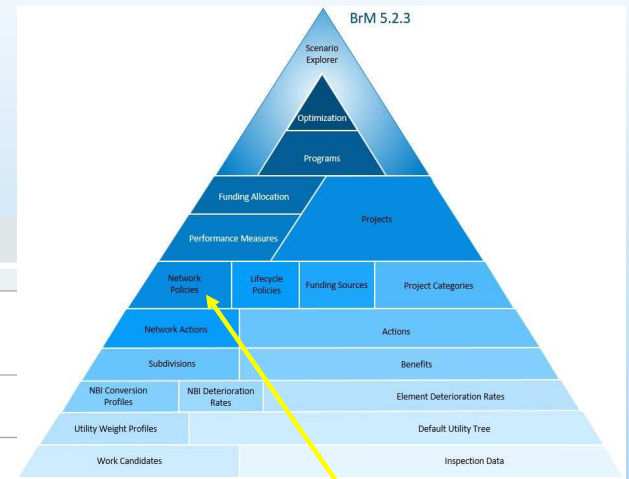
Add Condition Add Group

Type: Column Value in Param Set

Table: inspevnt Column: dkrating Value Is In Set

- Unknown (NBI)
- 0 Failed
- 1 Imminent failure
- 2 Critical
- 3 Serious
- 4 Poor
- 5 Fair
- 6 Satisfactory
- 7 Good
- 8 Very Good

Remove Condition



- Defines combinations of Actions and conditional logic for them to assist with Optimization

# FHWA TAMP Requirements for a BMS (23 CFR 515.17)

- a) Collect, Process, Store, and Update Inventory and Condition data
- b) Forecast Deterioration for Bridge Assets
- c) Determine Benefit-Cost over Life Cycle to evaluate alternative actions
- d) Identify Short- and Long-Term Budget Needs**
- e) Determine Strategies to Identify Potential Projects to maximize benefits within financial constraints
- f) Recommend Programs and Implementation Schedules to manage condition within Policy and Budget Constraints

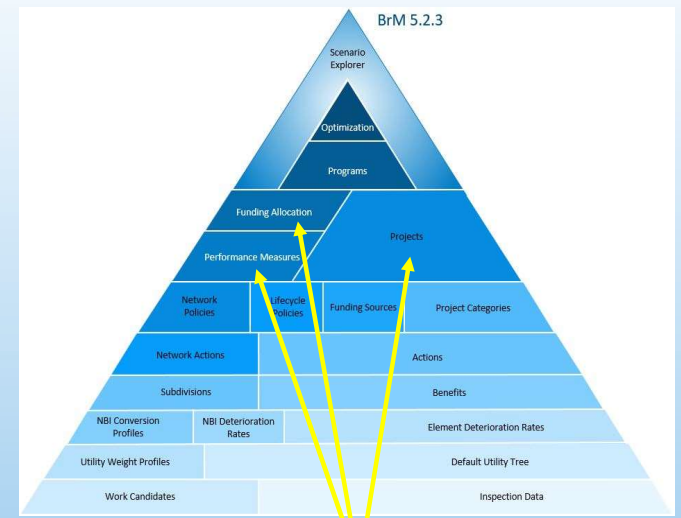


I mentioned that the BMS will support the FHWA TAMP. The recent Transportation Asset Management requirements set forth by FHWA set for the following minimum standards for developing and operating a bridge management system.



# Projects, Performance Measures, Funding Allocation

- Define
  - Projects
    - User developed
    - BrM recommended
  - Performance Measures
    - Mandated by FHWA
    - Additional measures defined by NDDOT
  - Funding
    - Budgets
    - Sources



**Performance Measures**

Program:  Scenario:

**Select Performance Measures**

Performance Measures	Best Value	Worst Value		
Health Index	100.00	0.00		
Utility	100.00	0.00		
Pct. Poor (Surface-Based)	0.00	100.00		

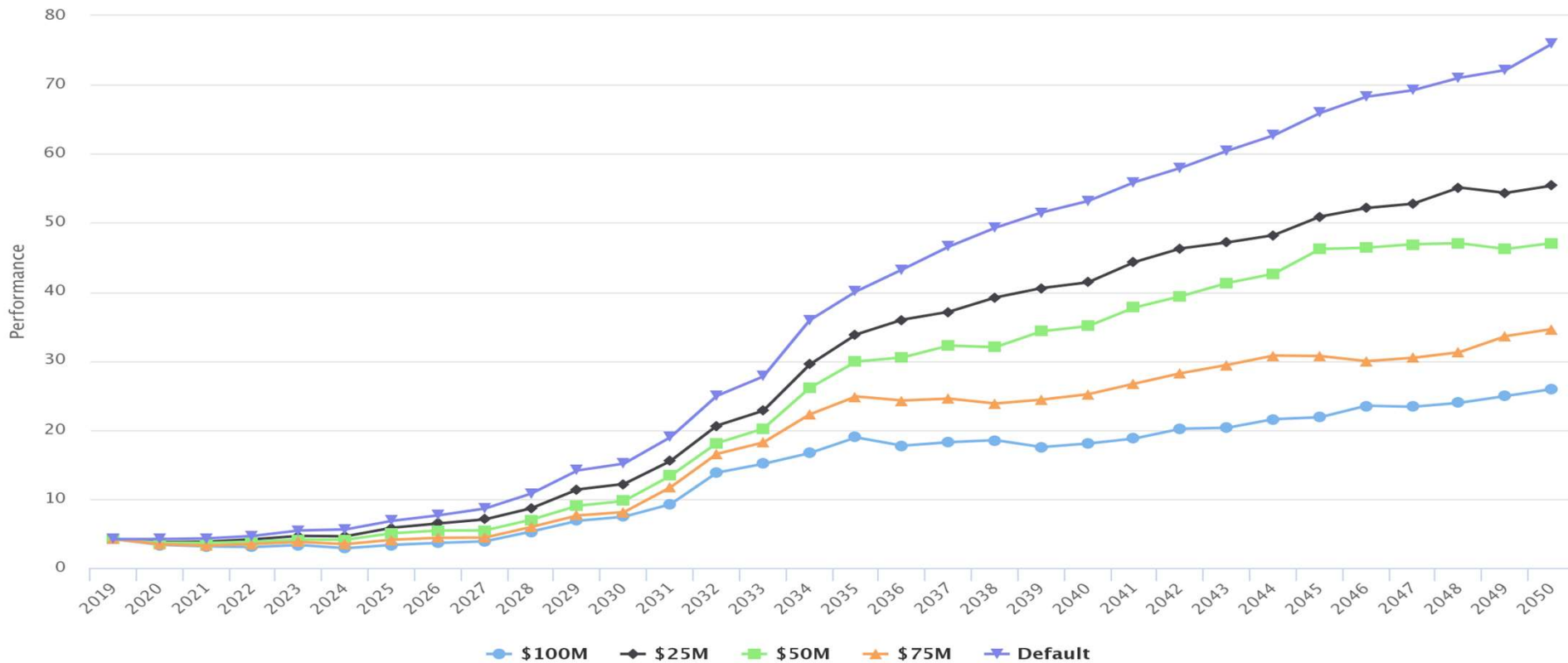
**Performance Constraints by Segment**

Segment	Health Index		Utility		Pct. Poor (Surface-Based)
ALL	Min: <input type="text" value="88"/>	Target: <input type="text" value="94"/>	Min: <input type="text" value="80"/>	Target: <input type="text" value="90"/>	Target: <input type="text" value="4"/>

# Projects, Performance Measures, Funding Allocation

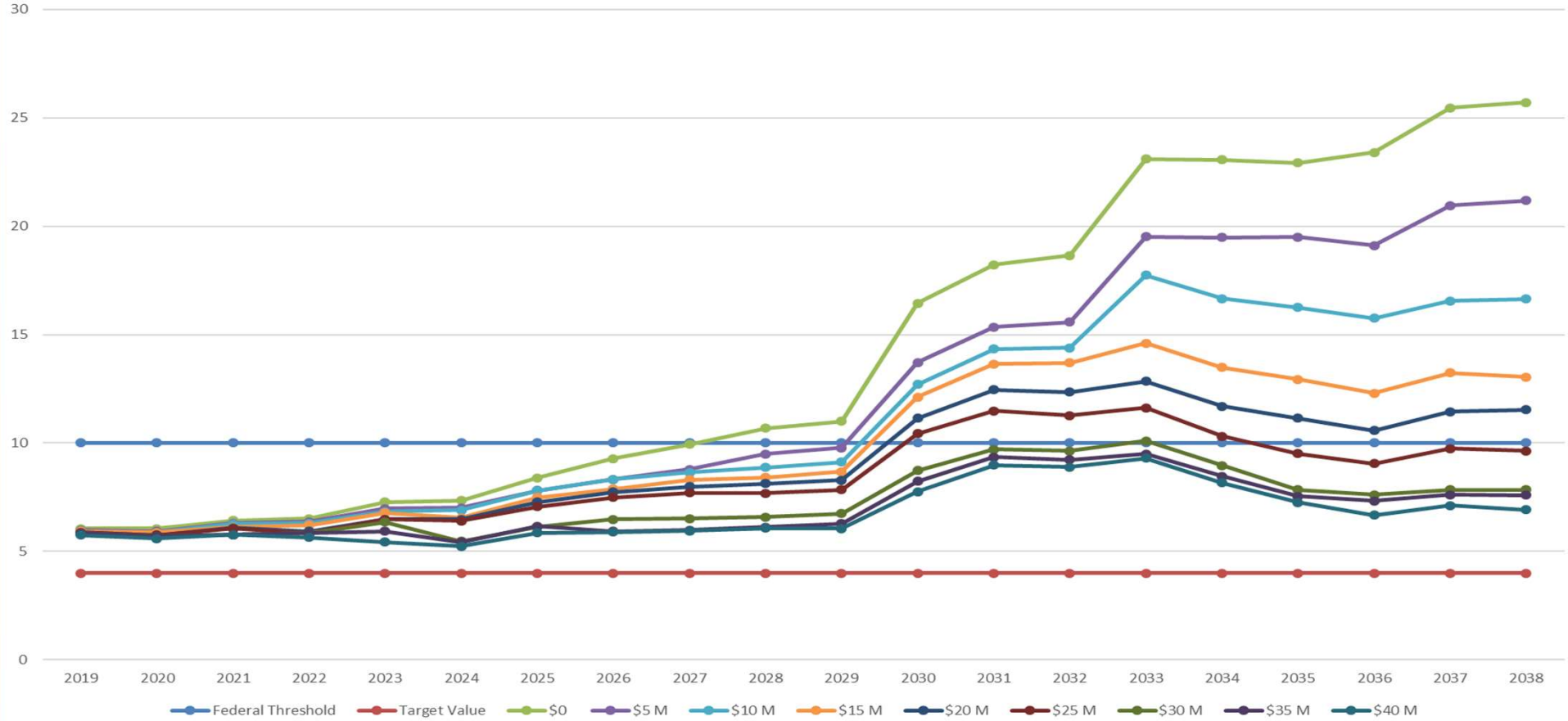
## Performance

Performance: Pct. Poor (Surface-Based)  
Segments: ALL

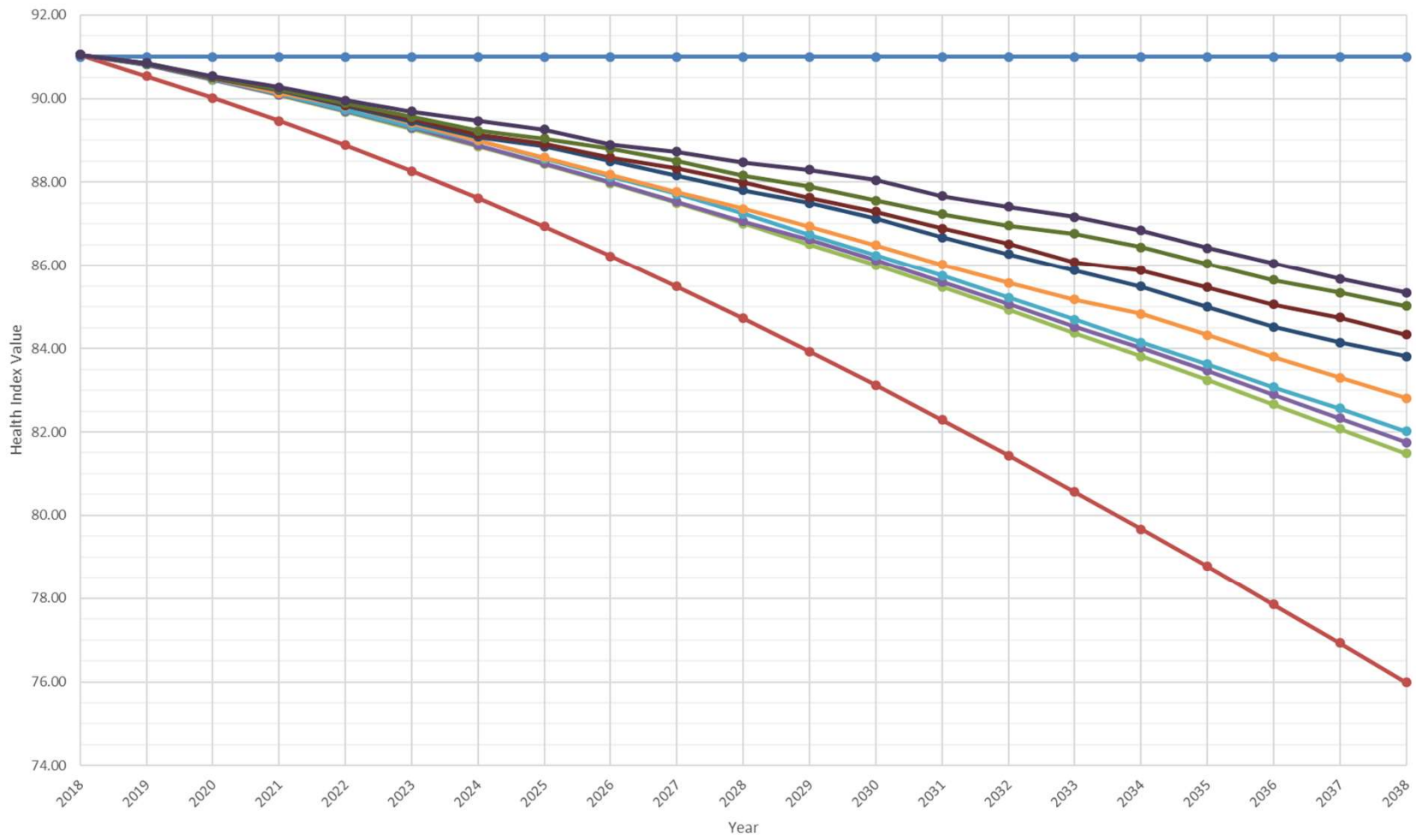


# Projects, Performance Measures, Funding Allocation

% Poor Surface-Based



Bridge Health Index



● Target 
 ● \$0 
 ● \$5 M/Yr 
 ● \$10 M/Yr 
 ● \$15 M/Yr 
 ● \$20 M/Yr 
 ● \$25 M/Yr 
 ● \$30 M/Yr 
 ● \$35 M/Yr 
 ● \$40 M/Yr

# FHWA TAMP Requirements for a BMS (23 CFR 515.17)

- a) Collect, Process, Store, and Update Inventory and Condition data
- b) Forecast Deterioration for Bridge Assets
- c) Determine Benefit-Cost over Life Cycle to evaluate alternative actions
- d) Identify Short- and Long-Term Budget Needs
- e) Determine Strategies to Identify Potential Projects to maximize benefits within financial constraints**
- f) Recommend Programs and Implementation Schedules to manage condition within Policy and Budget Constraints

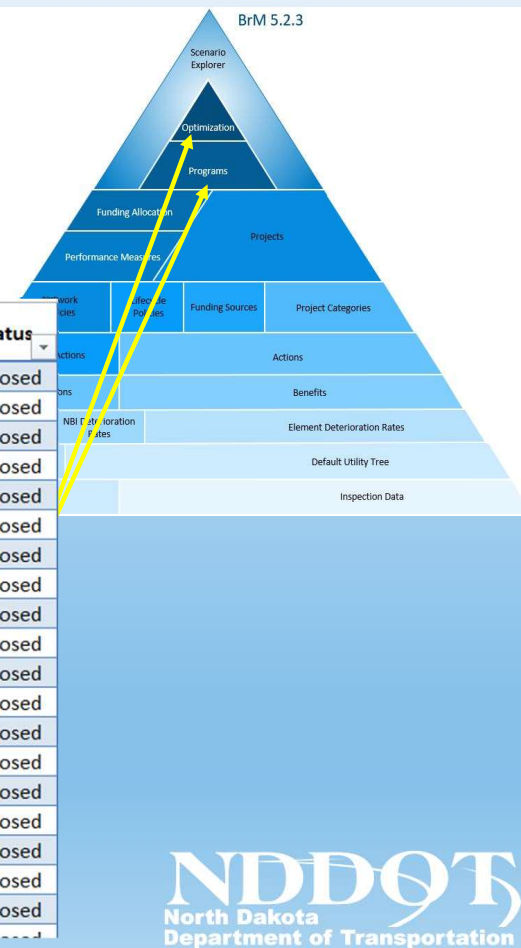


I mentioned that the BMS will support the FHWA TAMP. The recent Transportation Asset Management requirements set forth by FHWA set for the following minimum standards for developing and operating a bridge management system.

# Planning, Programming, Optimization

- BrM will perform Multi-Criteria Optimization
- Consider Program Alternatives
- Recommend Work based on Optimally meeting Performance Measures

Project Name	Category	Autom atic	Cost	Utility Chang	Benefit/C ost (\$k)	Cost (\$k) / Benefit	Year	Froze n	Status
0001-078.696(Rehab Deck)	No Category	Yes	\$266,990	3.71	0.0139	71.9648	2036	No	Proposed
0001-143.430(Rehab Deck, _Rehab Super (copy), _Reh	No Category	Yes	\$331,900	6.57	0.0198	50.5175	2020	No	Proposed
0001-226.090(Rehab Deck, _Rehab Sub (copy))	No Category	Yes	\$234,565	4.01	0.0171	58.495	2036	No	Proposed
0002-073.218 L(Rehab Deck)	No Category	Yes	\$230,418	3.14	0.0136	73.3815	2021	No	Proposed
0002-116.450 L(Rehab Deck)	No Category	Yes	\$524,367	6.14	0.0117	85.4018	2019	No	Proposed
0002-116.480 R(Rehab Deck)	No Category	Yes	\$575,789	3.2	0.0056	179.9339	2034	No	Proposed
0002-133.443(Rehab Deck, _Rehab Super (copy))	No Category	Yes	\$689,930	7.62	0.011	90.542	2020	No	Proposed
0002-144.200 R(Rehab Deck)	No Category	Yes	\$386,001	3.5	0.0091	110.286	2027	No	Proposed
0002-145.343(Rehab Deck)	No Category	Yes	\$1,041,485	3.14	0.003	331.683	2027	No	Proposed
0002-148.930(Rehab Deck, _Rehab Sub (copy))	No Category	Yes	\$787,607	4.07	0.0052	193.5153	2026	No	Proposed
0002-149.111 L(Rehab Deck, _Rehab Sub (copy))	No Category	Yes	\$326,468	4.09	0.0125	79.8209	2027	No	Proposed
0002-149.111 R(Rehab Deck)	No Category	Yes	\$297,833	3.08	0.0103	96.6989	2030	No	Proposed
0002-149.663 L(Rehab Deck)	No Category	Yes	\$375,926	3.07	0.0082	122.4513	2031	No	Proposed
0002-149.663 R(Rehab Deck, _Rehab Super (copy), _	No Category	Yes	\$324,631	7.96	0.0245	40.7828	2023	No	Proposed
0002-154.989 L(Rehab Deck)	No Category	Yes	\$189,896	6.69	0.0352	28.385	2020	No	Proposed
0002-154.989 R(Rehab Deck)	No Category	Yes	\$268,875	3.09	0.0115	87.0146	2035	No	Proposed
0002-187.740 L(Rehab Deck)	No Category	Yes	\$357,035	3.09	0.0087	115.5451	2020	No	Proposed
0002-187.740 R(Rehab Deck)	No Category	Yes	\$357,035	3.1	0.0087	115.1724	2021	No	Proposed
0002-250.546 L(Rehab Deck)	No Category	Yes	\$384,111	3.1	0.0081	123.9068	2037	No	Proposed
0002-250.546 R(Rehab Deck)	No Category	Yes	\$384,111	3.1	0.0081	123.9068	2037	No	Proposed



BrM will use the defined and customized criteria (deterioration, actions, costs, benefits, Life cycle and network policies) to optimize a Program

# FHWA TAMP Requirements for a BMS (23 CFR 515.17)

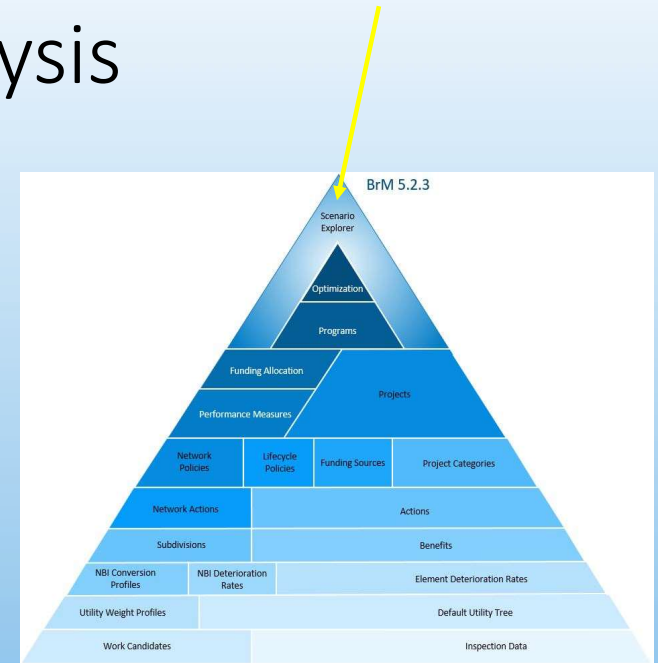
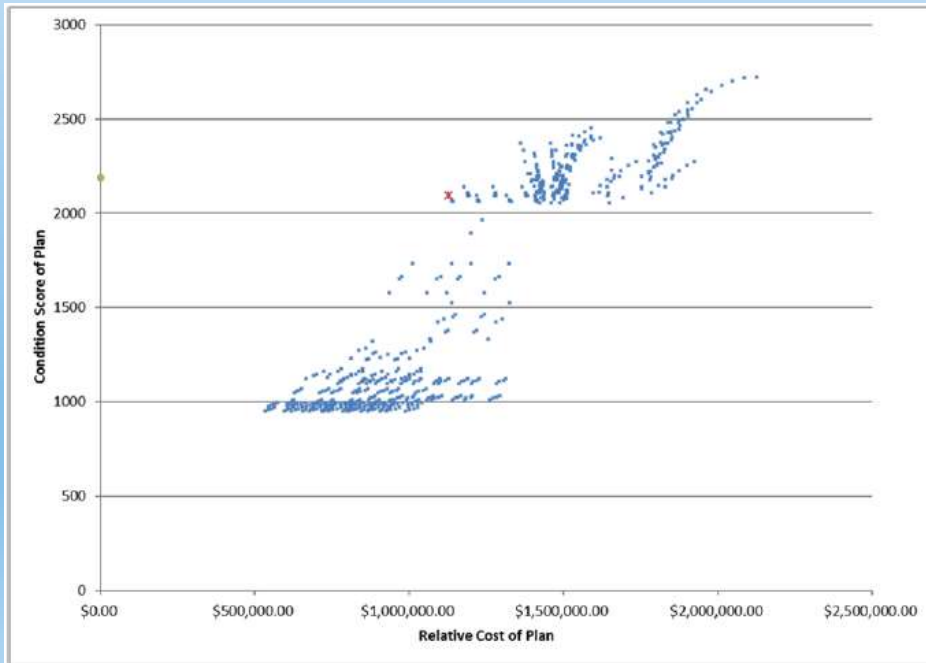
- a) Collect, Process, Store, and Update Inventory and Condition data
- b) Forecast Deterioration for Bridge Assets
- c) Determine Benefit-Cost over Life Cycle to evaluate alternative actions
- d) Identify Short- and Long-Term Budget Needs
- e) Determine Strategies to Identify Potential Projects to maximize benefits within financial constraints
- f) Recommend Programs and Implementation Schedules to manage condition within Policy and Budget Constraints**



I mentioned that the BMS will support the FHWA TAMP. The recent Transportation Asset Management requirements set forth by FHWA set for the following minimum standards for developing and operating a bridge management system.

# Scenario Explorer/Trade-Off Analysis

- Compare Results of Optimizations
- Compare Funding levels
- Find the Optimal Combination



**NDDOT**  
North Dakota  
Department of Transportation

Parieto Horizon



How did you  
meet your  
TAMP  
requirements?

Questions??



*Thank you!*



**NDDOT**  
North Dakota  
Department of Transportation

The river's not always frozen in ND!