AASHTOWare™ BRIDGE MANAGEMENT

Bridging Theory and Practice

Applying BrM Optimization for NJDOT's Transportation Asset Management Plan

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Disclaimer

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This presentation reflects work in progress and is intended to share lessons learned, experiences, and observations from ongoing bridge management implementation efforts. It is not a formal report or study.

The views, opinions, findings, and conclusions presented are solely those of the presenter and do not necessarily reflect the official views, policies, or positions of NJDOT, or their respective staff.

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Agenda

- The Need for Bridge Program Optimization
- BrM Implementation Challenges
- Solutions and Practical Approaches
- Optimization Results and Lessons Learned

The Need for Bridge Program Optimization

- Transportation Asset Management Plan (TAMP)
- Transportation Performance Management
- State of Good Repair
- Bridge Preservation Management
- Needs Analysis
- Risk Analysis
- Signature Bridge Analysis

The Need for Bridge Program Optimization

Exhibit 4-5: SHS NBIS Bridges – State of Good Repair Gap Analysis Summary

Performance	Baseline CY 2021	CY 2032 Planned
NHPP Measures[1]	**Good or Fair**	**Good or Fair**
State of Good Repair Objective (%)	94.0	94.0
Condition (%)	90.5	93.6
Performance Gap[1] (percentage points)	**-3.5**	**-0.4**
Investment	**Average Annual Investment, FY 2023–2032**	
Investment Required to Achieve Objective	$790 million[3]	
Planned Funding[2]	$755 million[3]	
Funding Gap	**-$35 million**[3]	

Note: SHS Bridges include all NJDOT maintained NBIS bridges.

[1] Using measures defined in 23 CFR 490. Positive and negative signs indicate extent of performance above and below goal respectively.

[2] Consistent with FY 2023 NJ Transportation Capital Program. Includes funding for NBIS bridge maintenance, preservation, rehabilitation, replacement. Excludes funding for inspections, administration of the bridge management system, and management of other structures (culverts, sign structures, etc.), which averages approximately $45 million per year. All dollar totals are rounded to the nearest multiple of $5 million.

[3] Indicates amount of additional funding required to meet a state of good repair goal. See Section 4.4.3 for an important caveat about the size of the funding gap in light of the anticipated completion of the Pulaski Skyway Rehabilitation Project.

Exhibit 3-6: TAMP
State of Good Repair Objectives

Pavements

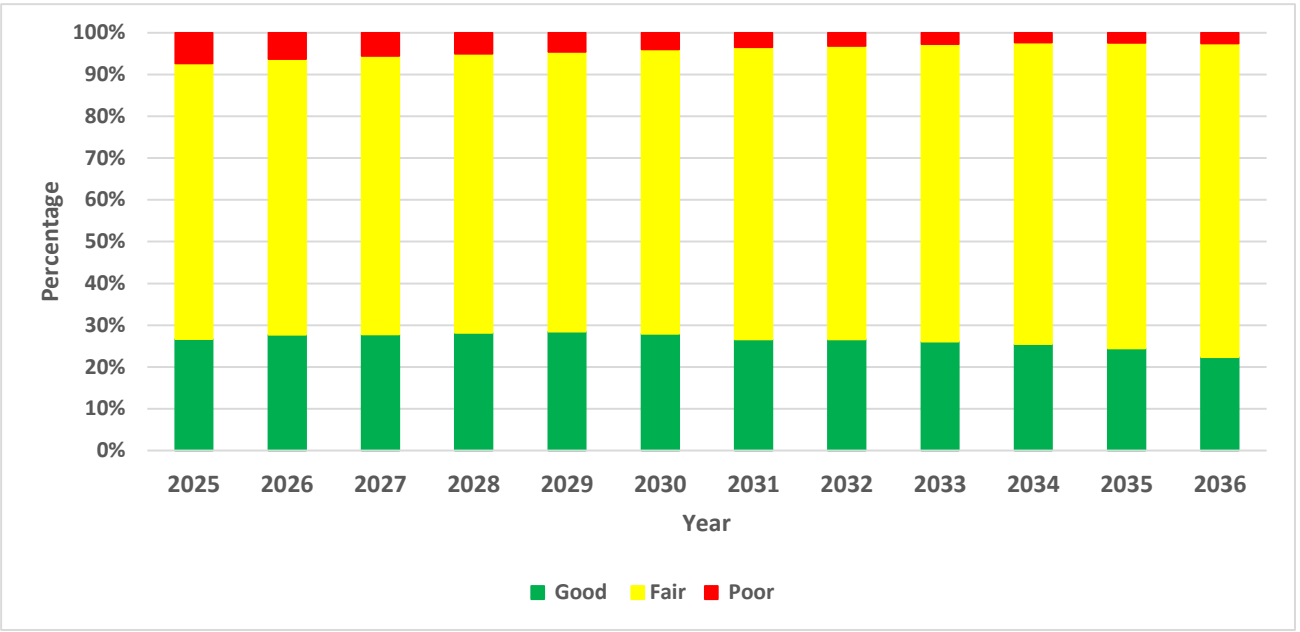
> 80 percent of pavement lane miles on State Highway System roadways in a state of good repair (*Good* or *Fair* condition) as measured by NJDOT's Condition Status performance metric.

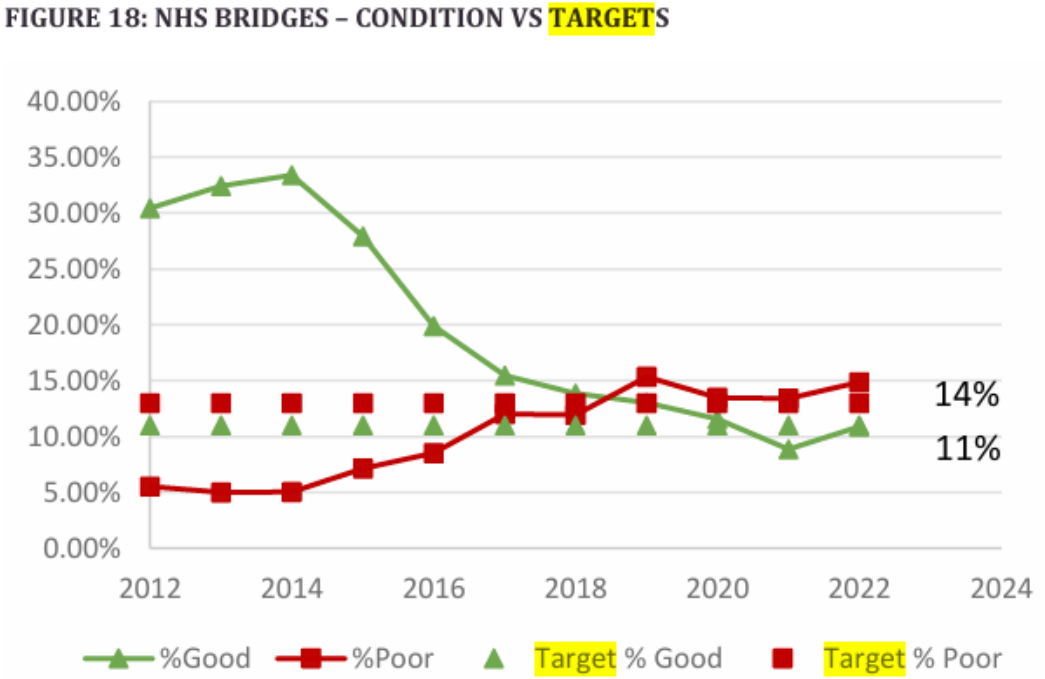
Bridges

> 94 percent of State Highway System National Bridge Inspection Standard (NBIS) bridges (measured by deck area) in state of good repair (Good or Fair condition).

> 95 percent of National Highway System NBIS bridges (measured by deck area) in state of good repair (Good or Fair condition).

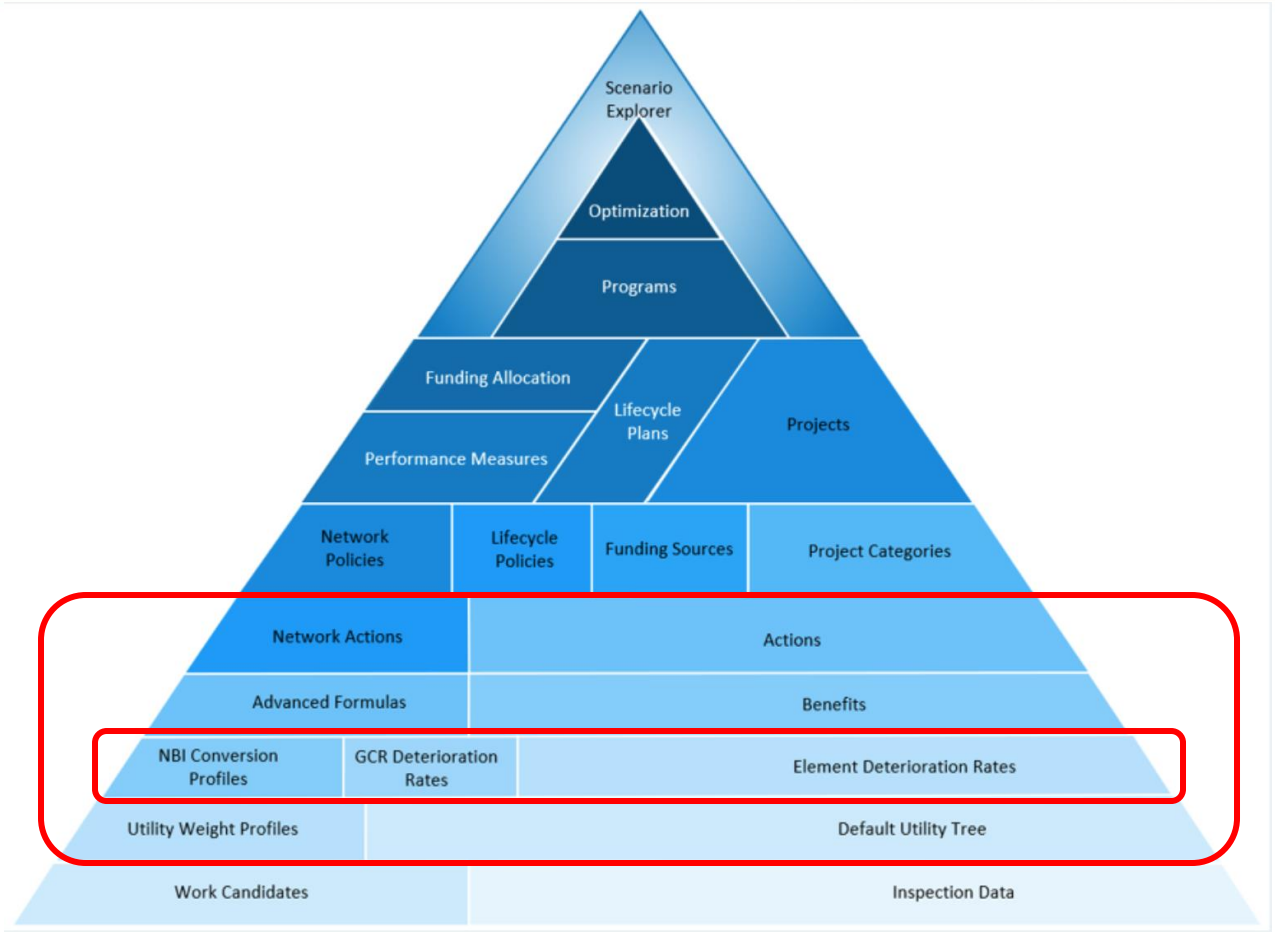
The Need for Bridge Program Optimization





BrM Pyramid

- NBI Conversion Profile
- Deterioration Models



AASHTOWare Bridge Management

Number of Bridges: ~2400

BrM Version 7.1.5

BrM Version 6.7.1

Conversion Profiles

- When deteriorating elements and your performance measures are in NBI GCR's, the BrM Conversion Profiles settings are very important.

Three methodologies used to develop the conversion profile:

1. Calculate average element condition states
2. Optimize thresholds and weights to match calculated GCRs

   with observed GCRs as much as possible
3. Use an empirical approach

NBI	Enabled	CS2 %	CS3 %	CS4 %
9	☑	1	0.5	0.5
8	☑	3	0.5	0.5
7	☑	11	1	0.5
6	☑	21	4	1
5	☑	100	11	1
4	☑	100	22	6
3	☑	100	100	100
2	☐			
1	☐			

Conversion Profiles

Average Equivalent CS by GCR from Inspection (9 to 0)				
GCR from Inspection	**Avg CS1**	**Avg CS2**	**Avg CS3**	**Avg CS4**
9	0.96	0.03	0.01	0.00
8	0.99	0.01	0.00	-
7	0.94	0.06	0.00	0.00
6	0.81	0.17	0.01	0.00
5	0.67	0.26	0.07	0.00
4	0.46	0.34	0.19	0.02
3	0.36	0.23	0.30	0.11
2				
1				
0				

Conversion Profiles

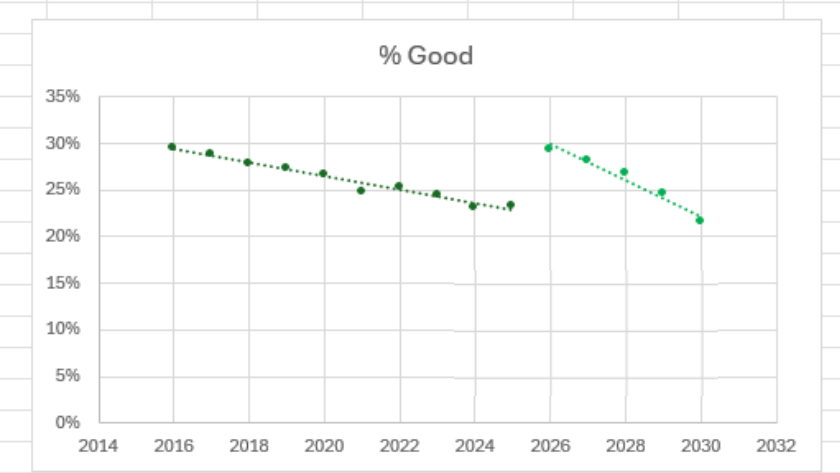
Manual Pivot (COUNTIFS on Converted NBI-Manual)												
GCR \ Pred	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Row Total**	**Accurate predicted GCRs**
0	0	0	0	0	0	0	0	0	0	0	0	0.00
1	0	0	0	0	0	0	0	0	0	0	0	0.00
2	0	0	0	0	0	0	0	0	0	0	0	0.00
3	0	0	0	1	0	9	0	0	0	1	11	0.09
4	0	0	0	0	0	82	0	0	0	7	89	0.00
5	0	0	0	0	0	595	0	29	1	67	692	0.86
6	0	0	0	0	0	1436	21	479	0	103	2039	0.01
7	0	0	0	0	0	489	17	1211	0	557	2274	0.53
8	0	0	0	0	0	14	0	87	0	220	321	0.00
9	0	0	0	0	0	3	0	5	0	68	76	0.89
Total Accuracy	**0.34**											
Total Accuracy (+/-1)	**0.77**											

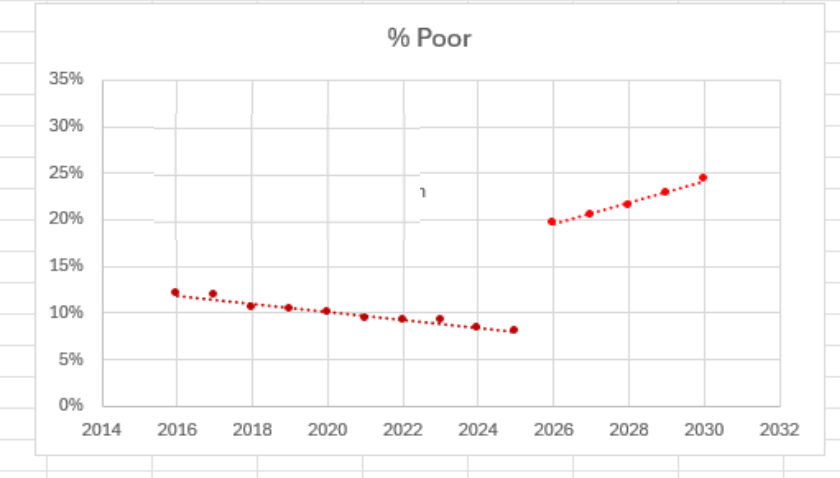
Threshold of Good and Fair

Threshold of Fair and Poor

Manual Pivot (SUMIFS of DECK_AREA_AC by Converted NBI-Manual)												
GCR \ Pred	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Row Total**	Diagonal Deck Area Share
0	0	0	0	0	0	0	0	0	0	0	0	0.00
1	0	0	0	0	0	0	0	0	0	0	0	0.00
2	0	0	0	0	0	0	0	0	0	0	0	0.00
3	0	0	0	88	0	10,461	0	0	0	424	10,974	0.01
4	0	0	0	0	0	81,772	0	0	0	1,255	83,026	0.00
5	0	0	0	0	0	786,384	0	55,320	396	19,243	861,344	0.91
6	0	0	0	0	0	1,745,022	27,147	719,505	0	48,343	2,540,017	0.01
7	0	0	0	0	0	670,306	11,659	2,019,586	0	487,879	3,189,430	0.63
8	0	0	0	0	0	44,547	0	154,944	0	149,594	349,085	0.00
9	0	0	0	0	0	1,446	0	17,415	0	102,733	121,594	0.84
Total Accuracy (deck, diagonal/total)	0.41											
Total Accuracy (+/-1) (deck)	0.81											0.77

Challenge - Big Drop or Increase the First Year





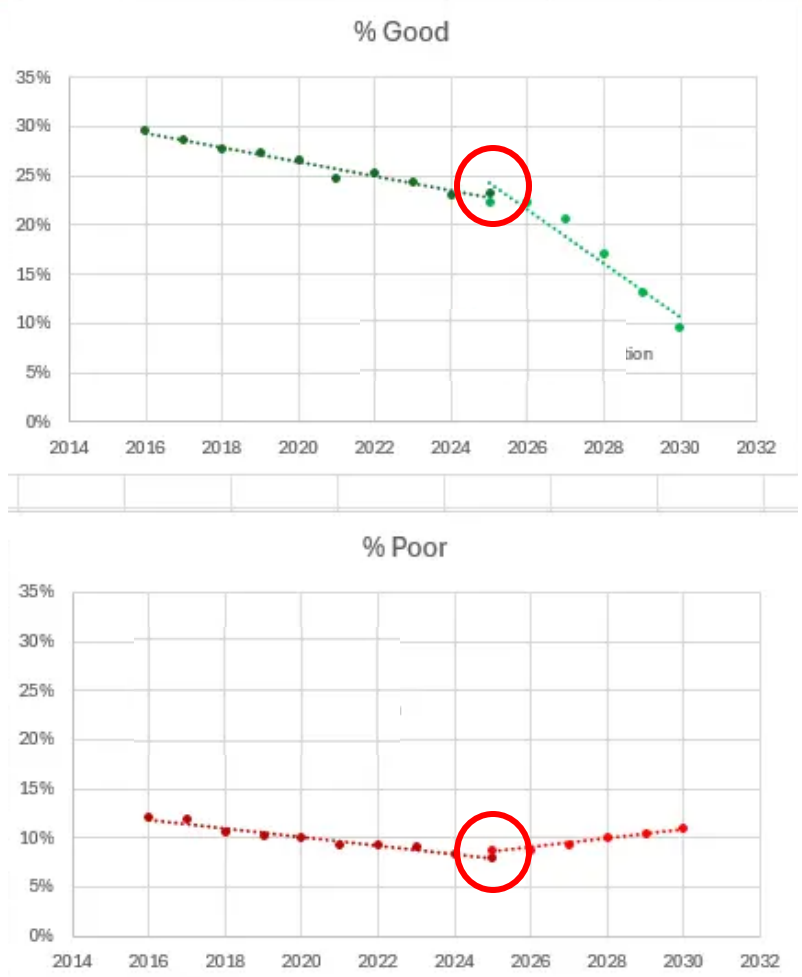
Cause:

- **NBI Conversion Profiles Result in changes in NBI GCRs "Biased" in one direction.**
- **To a lesser degree, element deterioration models**

How to Resolve:

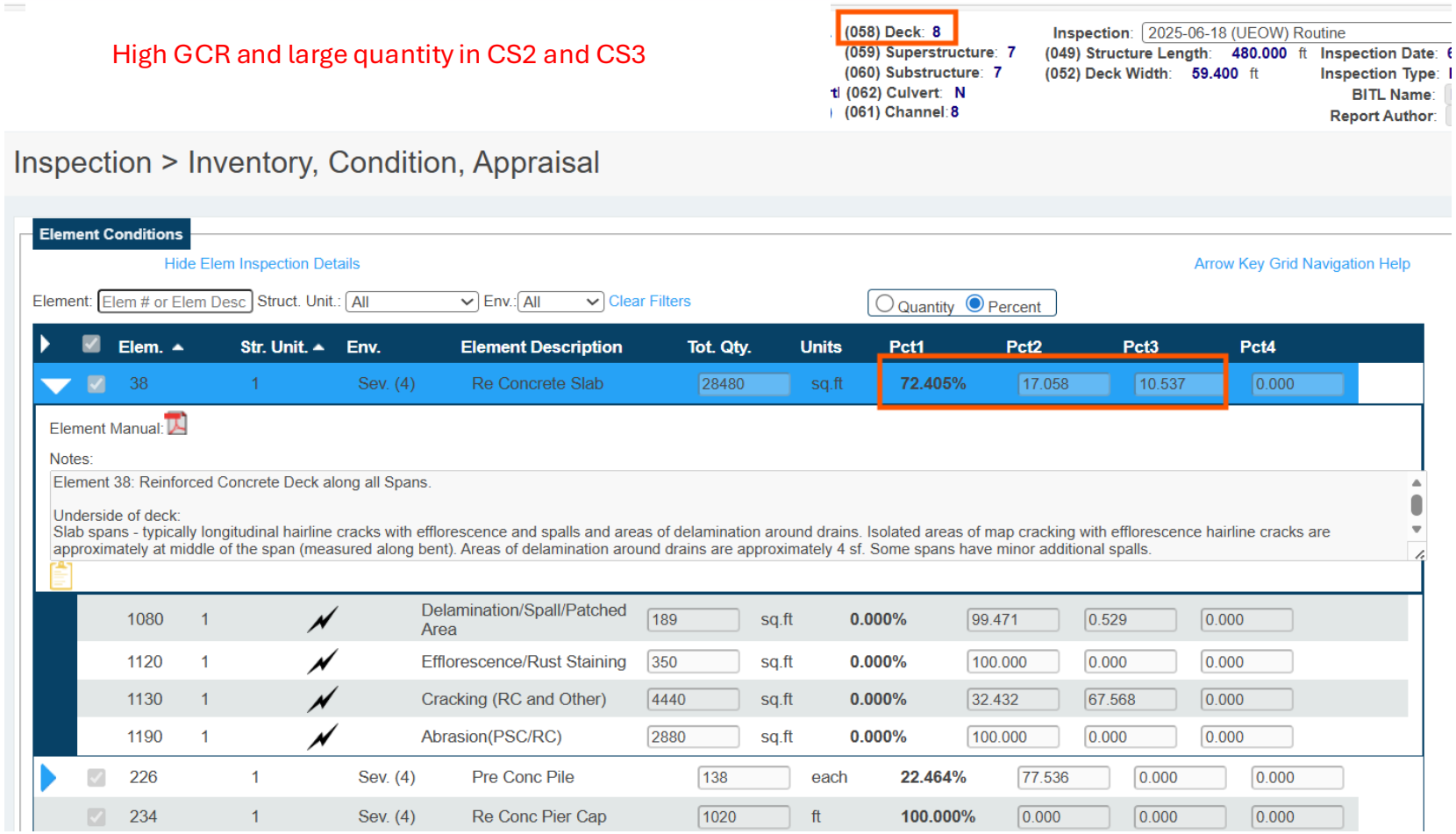
- **Use an empirical approach**
- **Review the NBI Conversion Profiles**
- **Adjust as needed to remove bias.**

Challenge - Big Drop or Increase the First Year



Inconsistencies Between Element and GCR Ratings

High GCR and large quantity in CS2 and CS3



Inconsistencies Between Element and GCR Ratings

Condition

Condition Ratings

Deck Condition Rating (B.C.01): 5 Fair — 8

Superstructure Condition Rating (B.C.02): 5 Fair — 6

Substructure Condition Rating (B.C.03): 7 Good — 8

Culvert Condition Rating (B.C.04): N Not Applicable — N

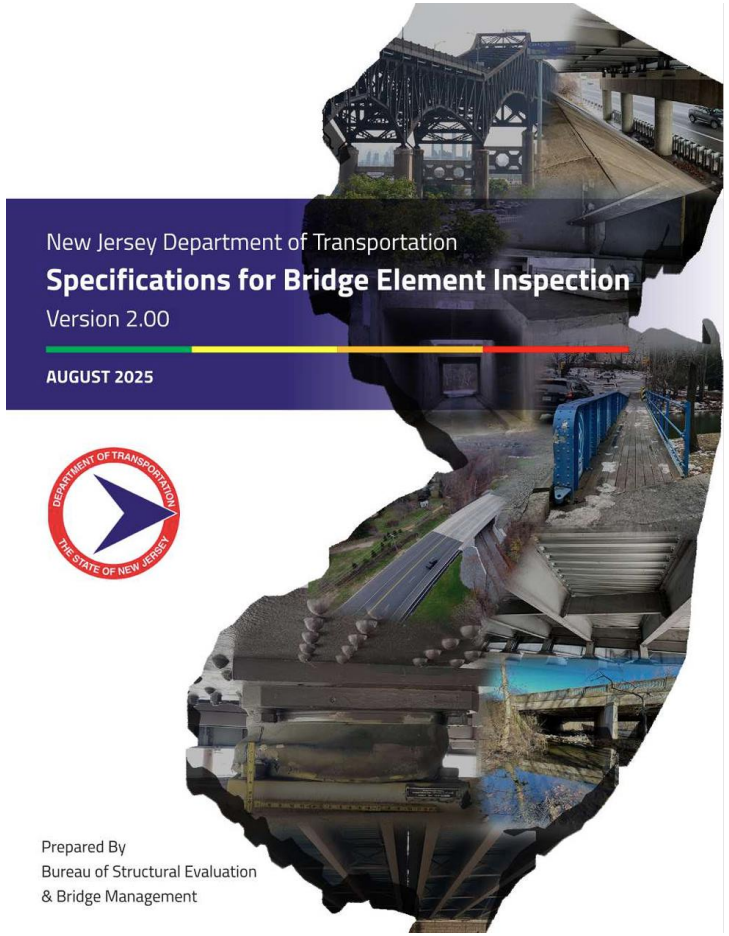
Element Conditions

Quantity/Percentage: Percentage | Structure Unit: All | Environment: All

Search

Inspected	ID	Name	Structure Unit	Type	Environment	Total Quantity	Units	CS 1 Pct	CS 2 Pct	CS 3 Pct	CS 4 Pct
☑	12	Re Concrete Deck	0	Element	Moderate	25785	sq.ft	100	0	0	0
	510	Wearing Surfaces	0	Protective System / Wearing Surface	Moderate	21971	sq.ft	89.573	10.145	0.282	0
	520	Conc Re Prot Sys	0	Protective System / Wearing Surface	Moderate	25785	sq.ft	100	0	0	0
☑	107	Steel Opn Girder/Beam	0	Element	Moderate	3384	ft	97.045	0	0	2.955
☑	202	Steel Column	0	Element	Moderate	16	each	100	0	0	0

SNBI- GCR Consistency

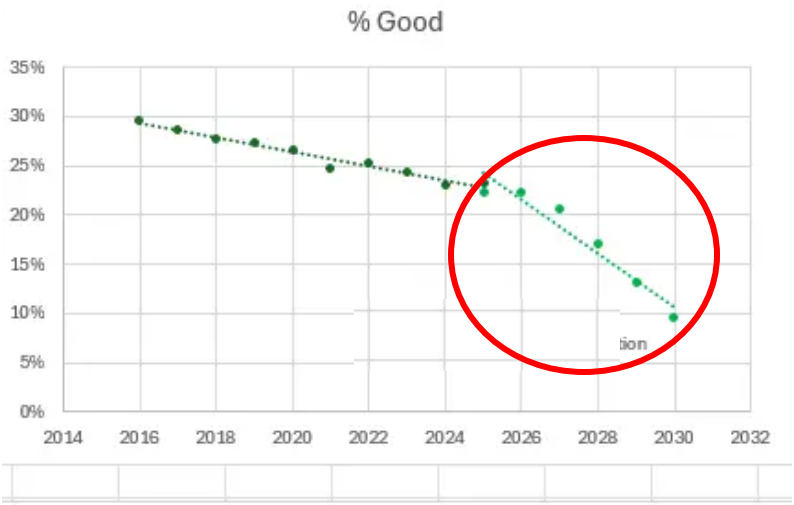


https://dot.nj.gov/transportation/eng/structeval/pdf/NJDOT_SBEI.pdf

SNBI Items B.C.01 through B.C.07, B.C.14, and B.C.15 (Deck, Superstructure, Substructure, Culvert, Bridge Railings, Bridge Railing Transitions, and Bridge Bearings Condition Ratings; and NSTM Inspection and Underwater Inspection Conditions)

SNBI Table 20			Severity and Typical Condition State								Description	
Class	Rating	Condition	Inherent *CS 1*		Minor *CS 2*		Moderate *CS 3*		Major *CS 4*		Strength &/or Performance	Other
	N	Not Applicable	Component does not exist.									
Good	9	Excellent	Isolated	<10%								*Or no defects.*
	8	Very Good	Some	10% - 40%	*Isolated*	*<10%*						
	7	Good	*Widespread*	*>40%*	Some	10% - 40%						
Fair	6	Satisfactory			Widespread	>40%	Isolated	<10%				
	5	Fair					Some	10% - 40%			Not Affected	
Poor	4	Poor					Widespread	>40%	Isolated	<10%	Affected	
	3	Serious							Isolated to Widespread	up to 100%	Seriously Affected	Condition typically necessitates more frequent monitoring, load restrictions, and/or corrective actions. Critical Finding for NSTM Inspection Condition.
	2	Critical							Isolated to Widespread	up to 100%	Severely Compromised	Condition typically necessitates frequent monitoring, significant load restrictions, and/or corrective actions to keep the bridge open. Critical Finding for Deck, Super, Sub, or Culvert.
	1	Imminent Failure	Bridge is closed to traffic due to component condition. Repair or rehabilitation may return the bridge to service.									
	0	Failed	Bridge is closed due to component condition, and is beyond corrective action. Replacement is required to restore service.									

Challenge- Forecast trends differ from previous year trends



Cause:

- **Element or GCR deterioration models are too aggressive**

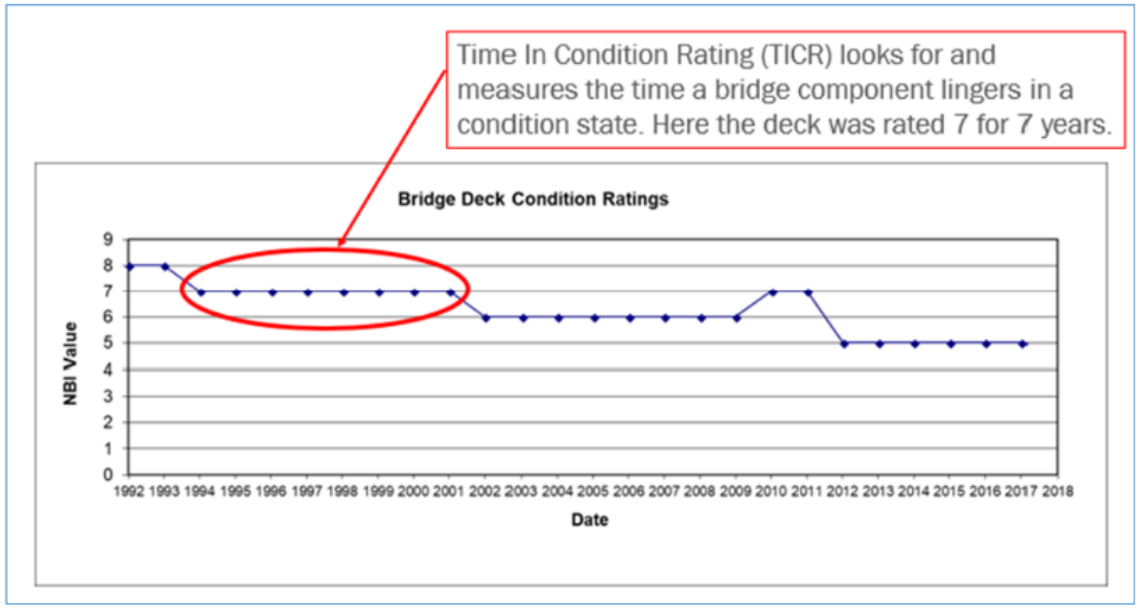
How to Resolve:

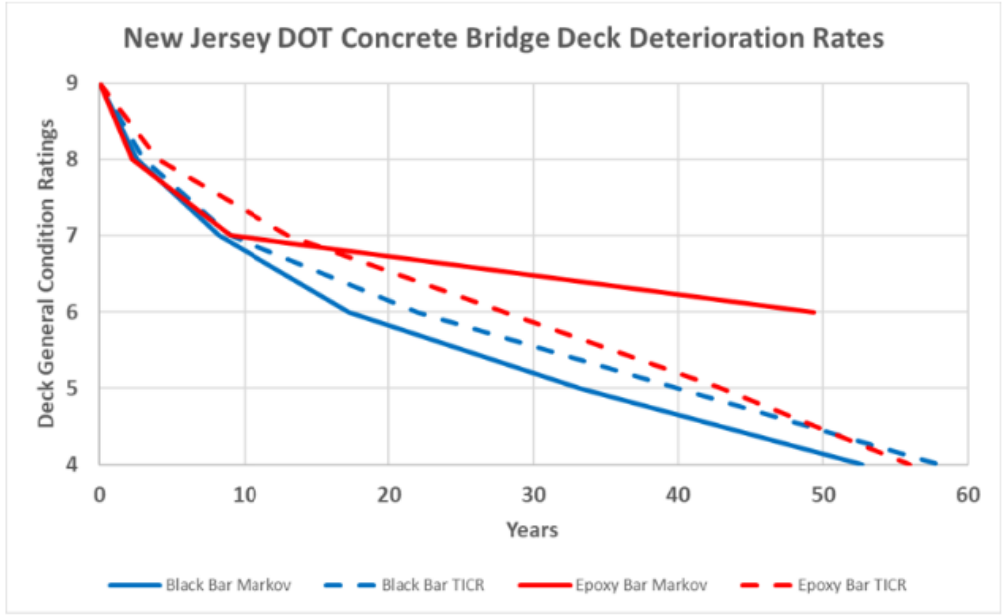
- **Review and adjust the deterioration models**
- **Review to see if you can identify a reason for the change in trends.**

This is assuming we are using the same budget and strategy that has been used in recent years.

Deterioration Models – GCR Level

- Time in Condition Rating
- Age of Bridge
- Markov Transition Probability





Deterioration Models – Element Level

- Markov-Weibull Transition Probability

Table 15 – Concrete Deck Elements (12, 13, 15, 16, & 38) Transition Probability & Median Time in Condition State

Markov Transition Probability			Median Time in Condition State		
CS1(Good)	CS2(Fair)	CS3(Poor)	CS1(Good)	CS2(Fair)	CS3(Poor)
0.987325431	0.98364539	0.990889933	54	42	76

Equation 1:

$$n = \frac{Log(.5)}{Log(T)}$$

Equation 2[1]:

$$T = 0.5^{\frac{1}{n}}$$

Where:

n = average TICR number of years until next GCR change.

T = transition probability

Figure 29 – NJDOT Deck and Slab Element Area Chart

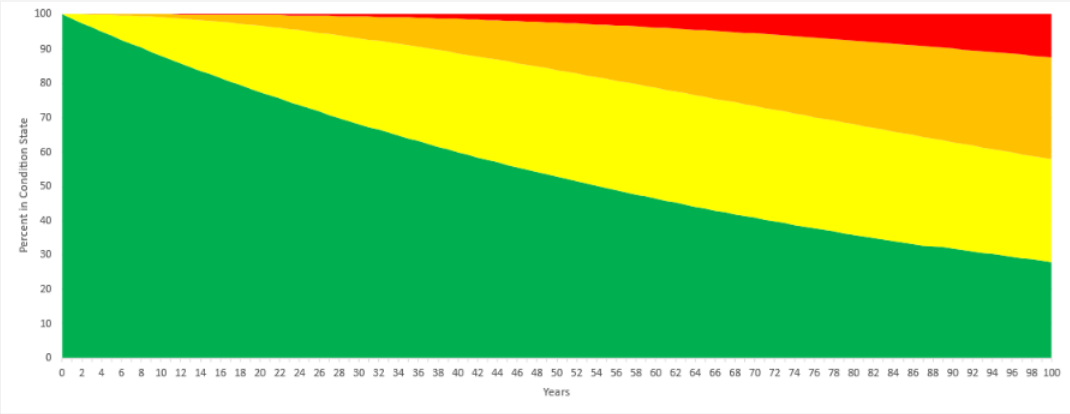
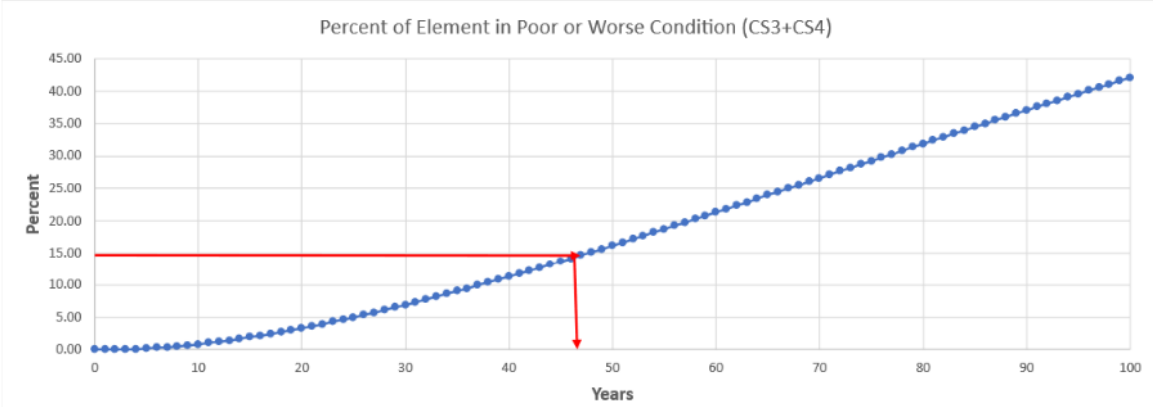


Figure 30 – NJDOT Deck and Slab Elements - Percentage CS3+CS4 Over Time



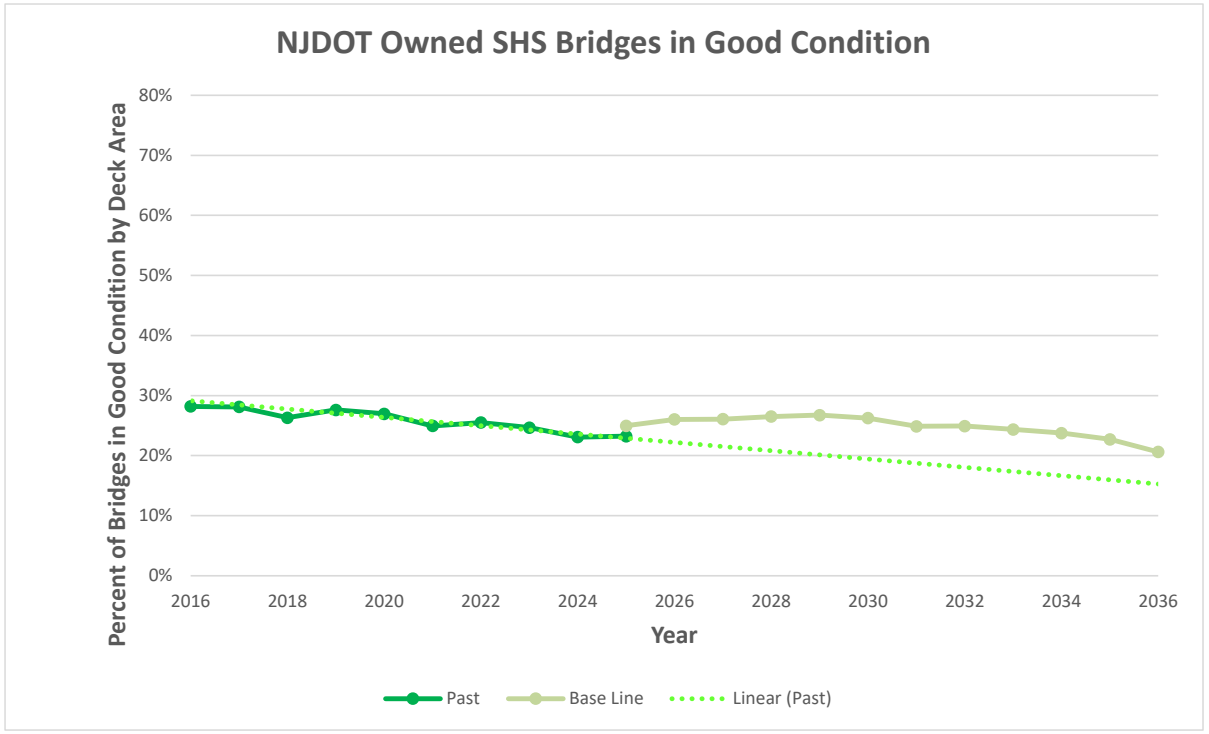
Deterioration Models Compatibility

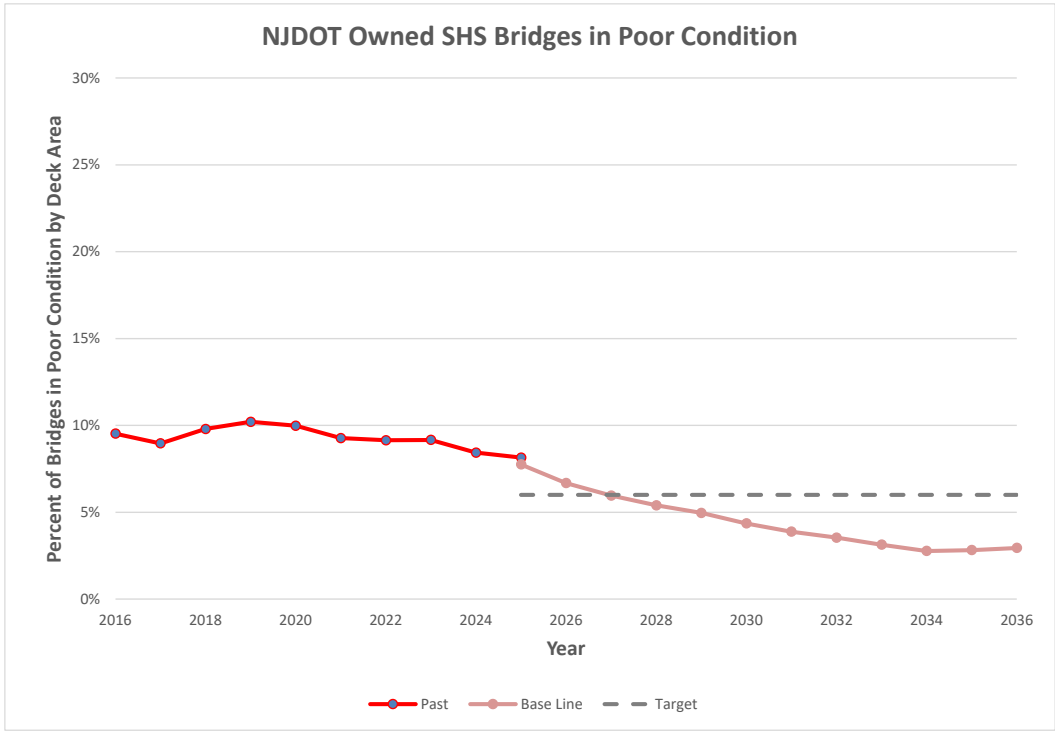
- Element to GCR Deterioration Solver

Calculates the element Median Time in Condition State that when run through the NBI Conversion Profiles will best match the GCR deterioration curve.

Practical Point – Always Do Trend Analysis

- Review of a previous ten-year trend is very helpful when reviewing forecast reasonableness





Bridge Condition Trends (Percent Good and Poor) tend to Trend Fairly Consistently

Identifying the Committed (a.k.a. - Fixed or Frozen) Projects

When committed projects are included the most accurate forecast is achieved!

Forecasting the Condition of Large/Signature Bridges

Challenge:

- **The NHS is a subset of a state's bridges, and some large deck area bridges may have an exaggerated impact on the TAMP performance measures.**

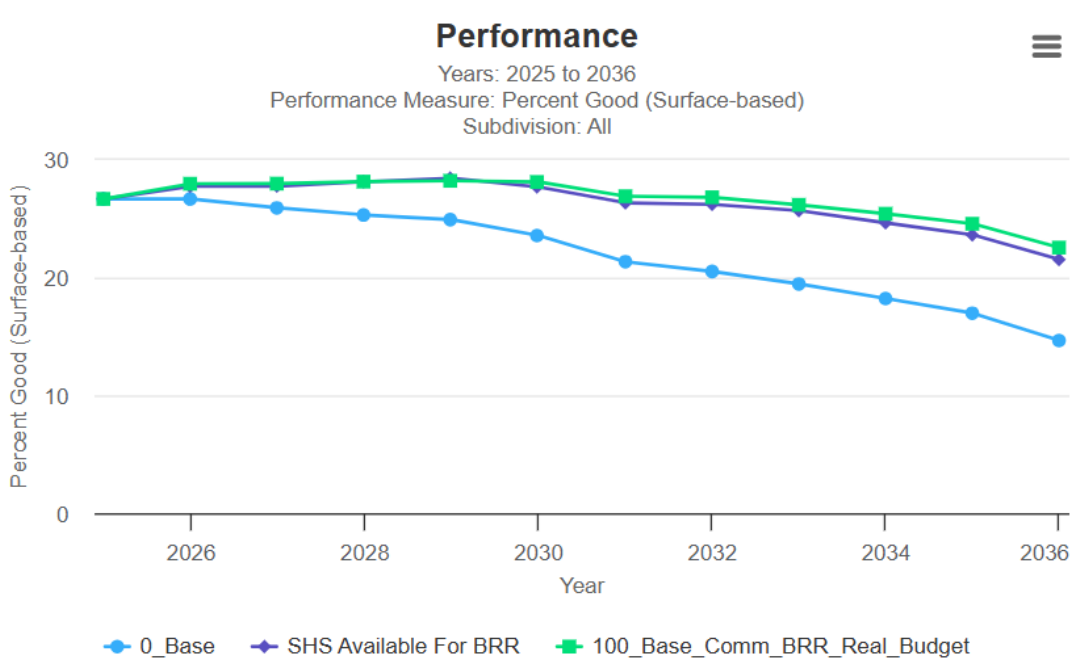
How to Resolve:

- **Do extra review of large deck area and complex NHS bridges, trying to identify bridges that may go from good to fair, or fair to poor, and identify which of these bridges are scheduled for projects which will result in improvement in condition.**

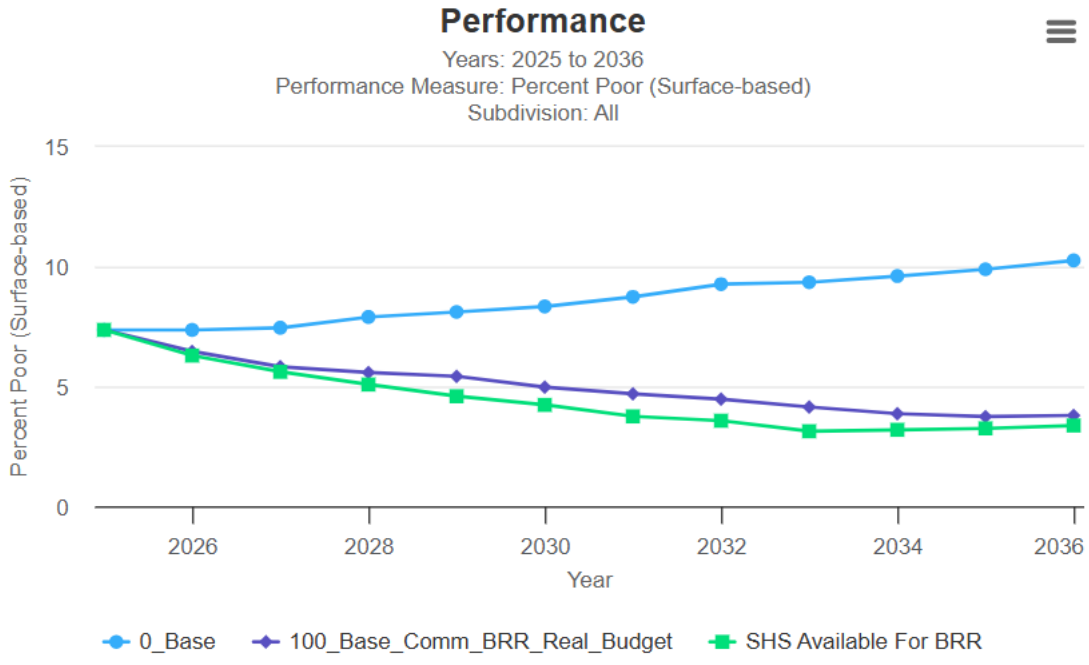
Pulaski Skyway crossing the Hackensack River

Running Various Scenarios in BrM 7.1.5

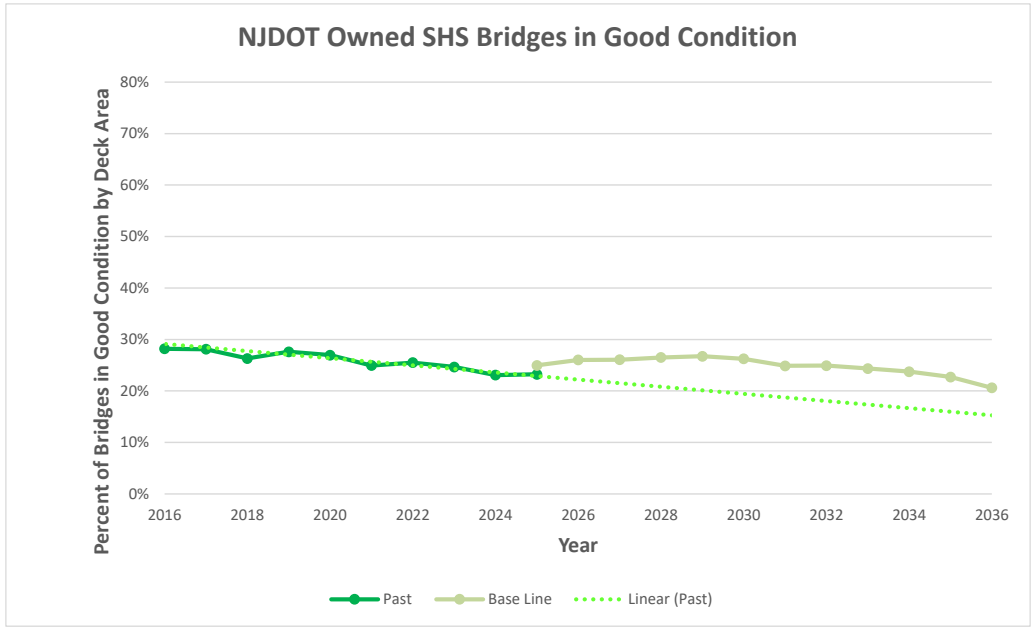
Percentage of Good

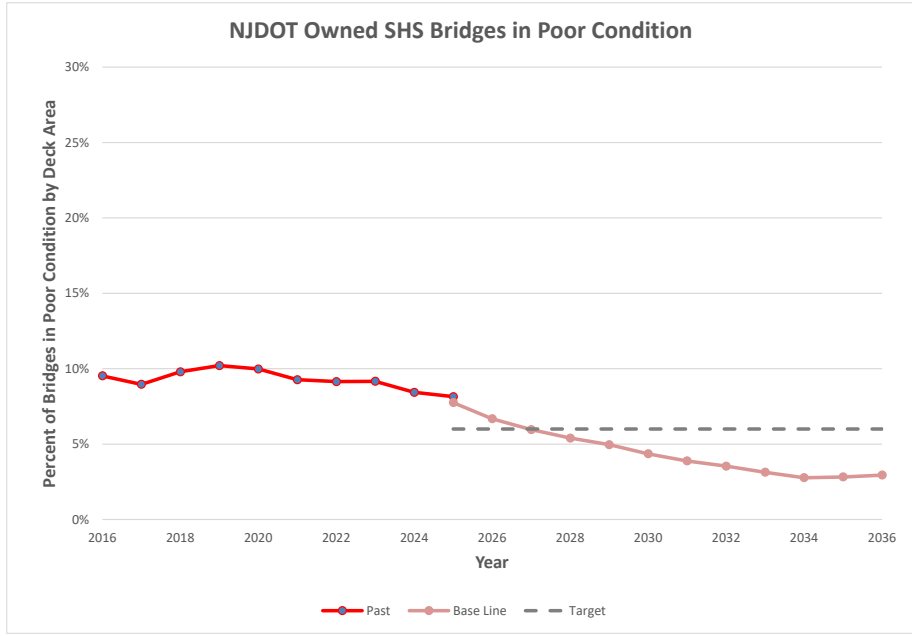


Percentage of Poor



Examples of Calibrated Forecast Models





Summary and Recommendations

- ❑ Consistency in bridge rating is important. Consider using NBI conversion profile as a feedback loop for inspectors.
- ❑ Calibrate conversion profiles to avoid significant, unrealistic condition changes in the first year of analysis.
- ❑ Use a hybrid methodology that considers both element-level and component-level conditions to produce more realistic deterioration trends.
- ❑ Include as much information as possible on committed or “frozen” projects to improve the accuracy of projected conditions and funding needs.
- ❑ Closely monitor significant bridges, as changes in their condition ratings can substantially affect network-level performance measures.
- ❑ Use BrM to evaluate alternative investment strategies and identify approaches that maximize return on investment.

Thank you!

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