

**Maintenance Projections  
and  
Annualized Costs**

**REPORT OF FINDINGS**

**STILLWATER LIFT BRIDGE**

(Mn/DOT Br. No. 4654 – Wis/DOT Br. No. B-55-919)

Over the St. Croix River



For:  
**Minnesota Department of Transportation  
and  
Wisconsin Department of Transportation**

By:  
**HNTB Corporation**

**August 6, 2003**

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and  
Annualized Costs**

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FOR  
**STILLWATER LIFT BRIDGE**  
(Mn/DOT Br. No. 4654 – Wis/DOT Br. No. B-55-919)  
**Over the St. Croix River**  
Stillwater, Minnesota / Houlton (St. Joseph Township), Wisconsin


August 6, 2003

This report presents the findings of HNTB's consideration of future operations and maintenance needs of the Stillwater Lift Bridge and the associated costs. The opinions presented within this report are based on limited information gained through inspection of the bridge, review of information made available to HNTB, engineering judgment, and projections of maintenance and repair needs as well as projections of future deterioration of the bridge.

The level of detail that forms the basis of the report was determined by the Agreement for engineering services. The opinions and statements made in this report are based solely on conditions revealed by the inspection and opinions regarding future maintenance and deterioration. No representation or warranty is made that all defects or deficiencies have been discovered or that additional defects or deficiencies will not later appear. Nothing contained in this report shall be deemed to give any third party a claim or right of action against HNTB Corporation, nor to create a duty on behalf of HNTB Corporation to such third party. Responsibility for actions subsequent to this report rests entirely with other parties.

The document should not be considered as the final product or conclusion of historic preservation considerations related to the \$5M repair project of the Stillwater Lift Bridge. Application of the Secretary of Interior's Standards for Historic Preservation Projects as they relate to the \$5M repair project was applied as described within this document. Application of the Secretary of Interior's Standards for Historic Preservation Project as they relate to repairs subsequent to the \$5M repair project have not be considered with will be required to be addressed at the time of said repairs are designed.

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly licensed professional engineer under the laws of the State of Minnesota.

Signed:  Reg. No. 17809

Printed Name: Richard M. Johnson

Date: 8.6.03

# Maintenance Projections and Annualized Costs

## Report of Findings

### Stillwater Lift Bridge

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## **EXECUTIVE SUMMARY**

This report presents projected future operations, maintenance and structural preservation needs and associated cost for the Stillwater Lift Bridge assuming the \$5M repair project is completed as proposed in 2005. The lift bridge is a vertical lift bridge commissioned in 1931 and is presently listed in the National Register of Historic Places. Application of the Secretary of the Interior's Standards for Historic Preservation Projects was considered throughout the development of the \$5M repair project and will be presented in a subsequent report titled *Stillwater Lift Bridge Repair Needs, Report of Findings*.

The projection of future operations and maintenance needs is based on the existing condition of the lift bridge as documented within separate reports, application of an assumed level of maintenance and preservation and probable deterioration of the lift bridge over time, and several principal assumptions including:

- The \$5M repair project will be substantially completed in 2005.
- The lift bridge will be maintained by Mn/DOT until such time as a new St. Croix River crossing is operational.
- The lift bridge will carry vehicular and pedestrian traffic until such time as a new St. Croix River crossing is operational.
- Ownership of the lift bridge will be transferred to another party when a new St. Croix River crossing is operational.
- A new St. Croix River transportation crossing will be operational in 2010.
- The lift bridge will carry only pedestrian traffic once ownership is transferred.
- The lift bridge will be maintained subsequent to transfer of ownership at a level as described within this report.

The maintenance and preservation projections are considered over a 45-year period from 2010 through 2055. This period of time is organized into three 15-year increments between 2010 and 2055 for purposes of projecting maintenance and structural preservation activities and their associated costs.

Upon completion of the \$5M repair project, the lift bridge will be structurally adequate to carry Mn/DOT's minimum structure preservation project live load through 2010, which can be thought of as 72% of the standard design live load. The lifting mechanism is projected to provide reliable lifting operations through 2055 provided routine maintenance is applied. The projected level of work to retain utility of the lift bridge is anticipated to consist of significant structural preservation efforts during the first 15 years, an increased repair effort in the second 15-year period, followed by continued preservation efforts in the third 15-year period. The lift bridge will require substantial structural preservation efforts to extend its useful life beyond 2055.

The annualized cost of operation, maintenance, and preservation efforts is projected to be \$322,000 over the 45-year period. Of this annualized cost, \$104,000 is attributed to operation of the bridge, \$43,000 to routine maintenance, and \$175,000 to structure preservation efforts. The sum total of these annualized costs is roughly \$14,500,000 over the 45-year period. Additionally, the future owner of the lift bridge will also be at risk for a projected \$4,800,000 in component failure costs. It can be reasonably expected that the future owner of the lift bridge will incur some portion of the component failure cost prior to 2055. Provided on page 3 in Figure 1 is a graphic presentation of projected operations, maintenance, preservation and component failure costs.

The condition of the primary structural systems, that being the truss spans and substructure, is anticipated to fall between “serious” (serious loss of section, local failure possible) and “critical” (advanced deterioration, monitoring necessary) for decades and finally decline toward “imminent failure” (bridge closed, corrective action possible) towards 2055.

If a low volume of personal passenger vehicles and pick-up trucks are allowed to use the lift bridge at a reduced speed and the use of de-icing chemicals is restricted, additional maintenance and preservation efforts are anticipated and the probability of component failure will increase. The additional annualized cost is projected to be on the order of \$51,000, or roughly \$2,300,000 over the 45-year period.

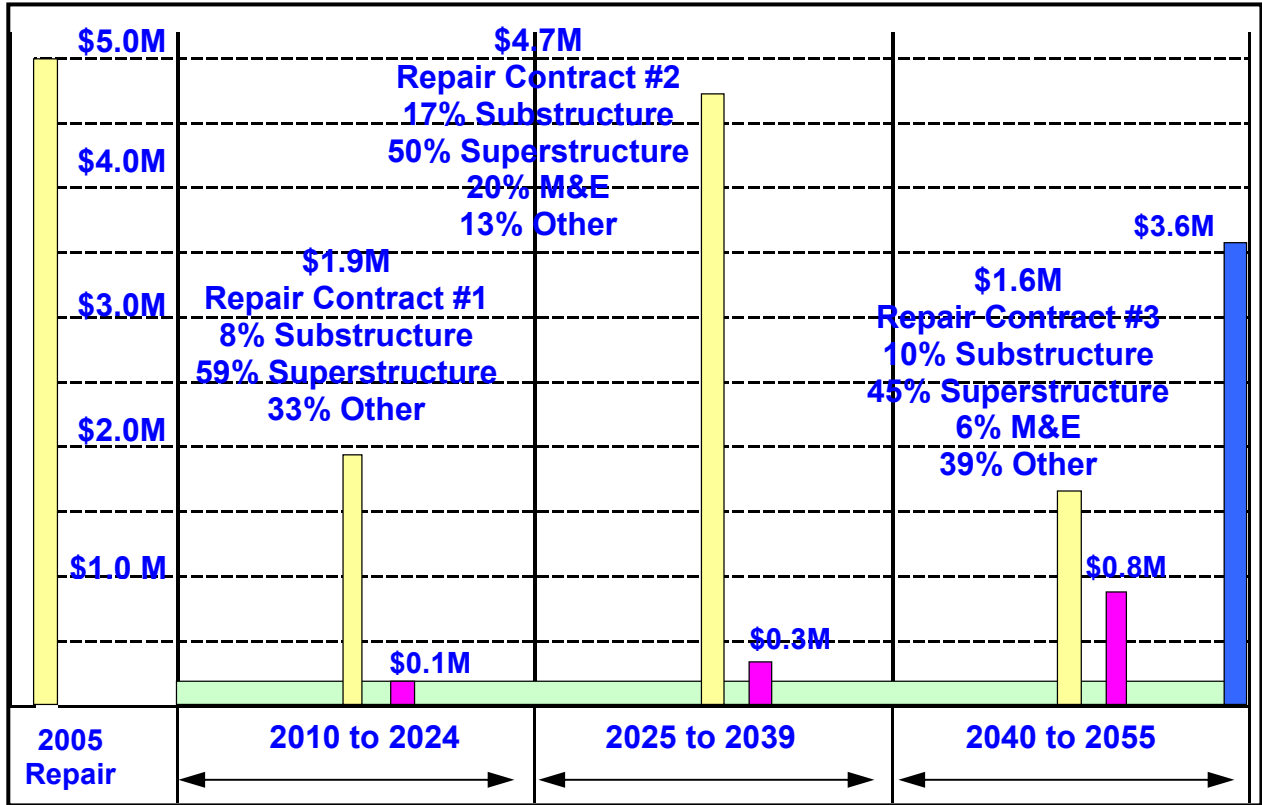
If a high volume of unrestricted vehicular traffic (passenger and commercial vehicles) is sustained on the lift bridge through 2055, the structure will require extensive structural preservation efforts, up to and including wholesale replacement of individual components, construction of secondary and redundant structural systems, and/or replacement of trusses in their entirety. The majority of the structural preservation efforts will require the bridge to be closed to vehicular traffic for extended periods of time. Closure to vehicular traffic will eventually be required on a semi-regular basis. The lift bridge will be unable to effectively serve meaningful transportation needs through 2055 due to the extent and duration of traffic closures. The additional cost to maintain the lift bridge with unrestricted traffic is projected to be several times that of allowing no vehicular traffic on the bridge.

Should the future owner of the lift bridge be unable or unwilling to maintain the structure in a serviceable condition, the USCG will likely require the bridge be removed. The Secretary of Interior’s Standards for Historic Preservation Projects will be required to be applied to repairs completed subsequent to the \$5M repair project.

All costs are provided in 2003 US dollars, without consideration of escalation and without an allowance for contingency.

**Figure 1: Projected Operations, Maintenance and Preservation Costs**

(Without vehicular traffic - \$1,000 US, 2003 – preservation efforts consolidated in single contracts within 15-year increments of time)



Key:

Operations and Routine Maintenance @ \$147,100 per year.	Structure Preservation (Repair Contracts)
Programmed Component Failure Costs	Additional At-Risk Component Failure Costs (May occur at any time)

## **INTRODUCTION**

The Stillwater Lift Bridge was commissioned in 1931 and includes a span-drive vertical lift span fashioned after designs developed by J.A.L. Waddell and J.L. Harrington. The structure consists of a total of 10 spans – two concrete slab spans, one vertical lift-span, six riveted steel fracture critical through-truss fixed spans, and one rolled-beam jump span. The lift bridge was nominated for inclusion and subsequently listed in the National Register of Historic Places.

The States of Minnesota and Wisconsin acting through the Minnesota Department of Transportation (Mn/DOT) have engaged HNTB Corporation (HNTB) to evaluate the present condition of the Stillwater Lift Bridge, to establish potential repair needs and to determine a repair strategy based on urgency of needs, the associated repair costs, and available funding. Additionally, HNTB has projected future operation, routine maintenance and repair (preservation) needs, and rendered an opinion regarding the associated costs.

This report documents HNTB's projection of maintenance and preservation needs for the Stillwater Lift Bridge (a.k.a. St. Croix River Bridge at Stillwater, Mn/DOT Br. No. 4654 and Wis/DOT Br. No. B-55-919). The findings of HNTB's inspection and condition evaluation of the Stillwater Lift Bridge are presented in the following reports:

- *Structural Inspection and Preliminary Condition Evaluation – Report of Findings, Volume 1 of 2 – Narrative* dated March 17, 2003.
- *Structural Inspection and Preliminary Condition Evaluation – Report of Findings, Volume 2 of 2 – Representative Photographs and Inspection Notes* dated March 17, 2003.
- *Mechanical / Electrical Inspection and Evaluation – Report of Findings, Volume 1 of 2 – Narrative* dated March 18, 2003.
- *Mechanical / Electrical Inspection and Evaluation – Report of Findings, Volume 2 of 2 – Representative Photographs and Inspection Notes* dated March 18, 2003.
- *Pedestrian Railing Repair Study – Report of Findings*, dated March 20, 2003.
- *Deck Replacement Study – Report of Findings*, dated March 21, 2003.

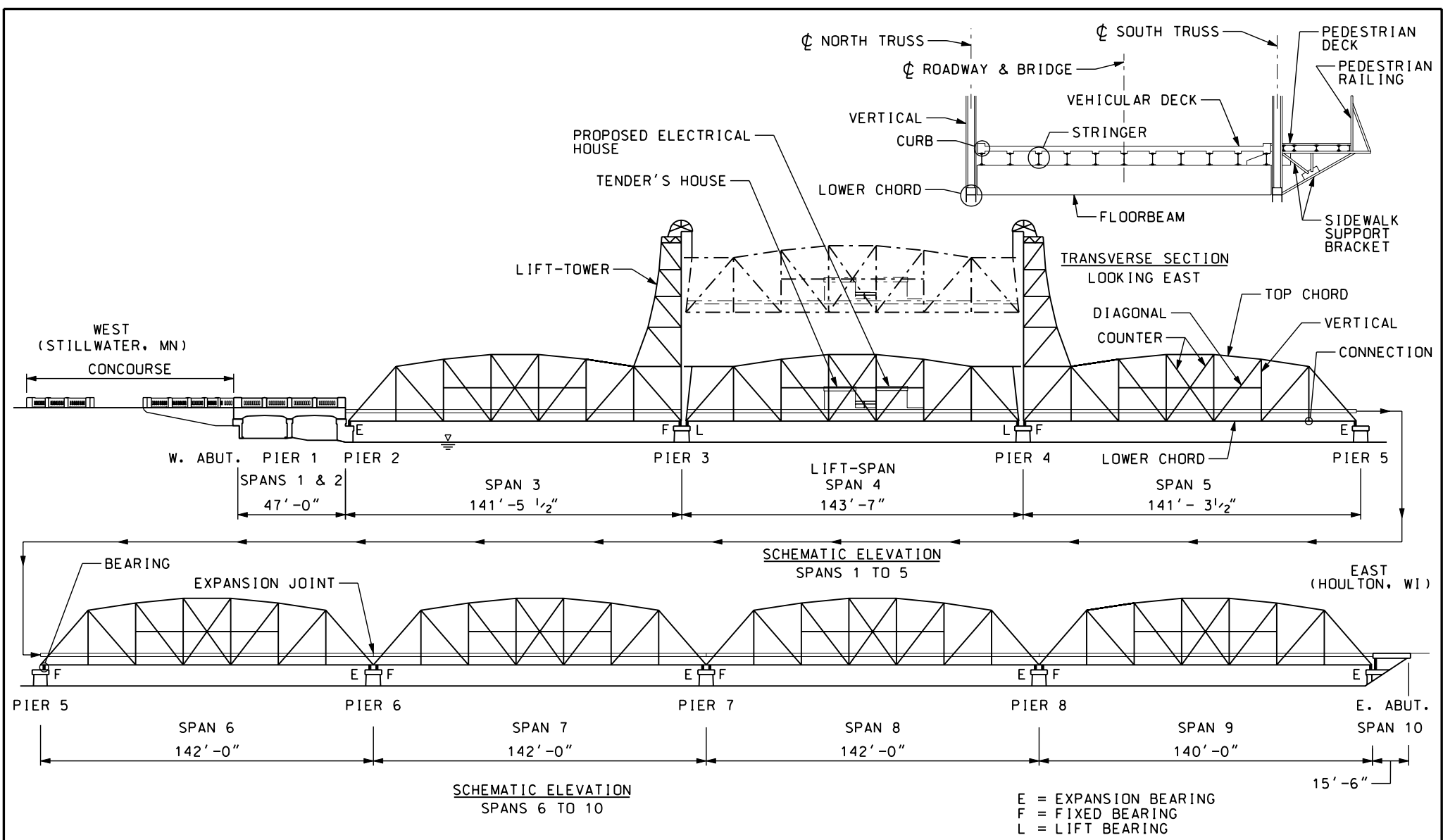
The 106<sup>th</sup> United States Congress provided \$4,989,000 in funding for the repair of the Stillwater Lift Bridge. An extensive list of repair needs was identified through inspection and evaluation of the lift bridge. From the list of repair needs, repairs estimated to cost the same amount as the funding provided were selected to be employed. The selected repairs are planned to be made in 2005.

Mn/DOT is anticipated to retain ownership of the lift bridge until a new St. Croix River transportation crossing is operational, anticipated to be 2010. At that point the ownership of the bridge is anticipated to be transferred to a party yet to be determined.

Within the context of this report, repairs planned to be completed in 2005 as a result of dedicated funding made available by the 106<sup>th</sup> United States Congress is referred to as the “\$5M repair project.” Anticipated needs, repairs and actions subsequent to the transfer of ownership of the lift bridge from Mn/DOT are referred to as to as “future” needs, repairs and actions.

A more in-depth application of the Secretary of Interior’s Standards for Historic Preservation Projects with respect to the \$5M repair project has taken place at public meetings with the State Historic Preservation Offices (SHPO) of Minnesota and Wisconsin, the Cultural Resources staff of the Minnesota and Wisconsin Departments of Transportation, and local preservation groups. The results of those discussions were taken into consideration as the repair options were selected for the \$5M repair project. A narrative discussion that integrates the Secretary’s Standards as they apply to the proposed repair options of the \$5M repair project and to the overall preservation of the lift bridge property will appear in the pending *Stillwater Lift Bridge Repair Needs, Report of Findings*. This work will be completed by a historian that meets the Secretary of Interior’s Professional Standards, in collaboration with HNTB.

Application of the Secretary of Interior’s Standards for Historic Preservation Projects with respect to future repairs has not been addressed because the future repair needs and proposed response to the future repair needs can not be determined with any degree of accuracy. The Secretary of Interior’s Standards for Historic Preservation Projects will be required to be applied to future repairs.



AUGUST 2003



STILLWATER LIFT BRIDGE  
MAINTENANCE PROJECTIONS  
AND ANNUAL COSTS

FIGURE 2  
BRIDGE CONFIGURATION  
AND NOMENCLATURE

## **BASIS FOR MAINTENANCE NEEDS**

The projected maintenance and preservation needs are based on information made available through previous inspections or other means, and the principal assumptions listed below.

Principal Assumptions: Those fundamental assumptions that form the basis of the forecasted maintenance and preservation needs and associated costs are as follows:

- The \$5M repair project will be substantially completed as described within this report in 2005.
- The lift bridge will be maintained by Mn/DOT until such time as a new St. Croix River crossing is operational.
- The lift bridge will carry vehicular and pedestrian traffic until such time as a new St. Croix River crossing is operational.
- Ownership of the lift bridge will be transferred to another party when a new river crossing is operational.
- A new St. Croix River transportation crossing will be operational in 2010.
- The lift bridge will be painted to present a uniform appearance<sup>1</sup> and pack rust sealed<sup>2</sup> prior to transfer of ownership to a new party.
- The lift bridge will carry only pedestrian traffic once ownership is transferred.
- The lift-span operations will increase when vehicular traffic is removed from the structure due to a revised agreement with the U.S. Coast Guard (USCG)<sup>3</sup>.
- The lift bridge will be maintained subsequent to transfer of ownership at a level as described within this report.

Scope of \$5M Repair Project: The projected maintenance and preservation needs and associated costs are based on the understanding that the \$5M repair project will include repairs as described below. For additional detail, the readers' attention is directed to previously cited reports.

*Tender's/Electrical House:* The existing tender's house will be repaired in-kind, blast cleaned, and painted. A new electrical house will be constructed with architectural treatment similar to the existing tender's house. The electrical and tender's house will be fitted with heating, ventilation, and air-conditioning as well as smoke detection.

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<sup>1</sup> The funds available for the \$5M repair project are not anticipated to be adequate to paint the entire bridge.

<sup>2</sup> Sealing of pack rust is intended to be accomplished by removal of pack rust around the perimeter of the connection, rounding the edges of the adjacent steel plates, saturating the exposed pack rust with a flowing penetrant/sealer to neutralize the corrosion process, and subsequent striping and overtopping with a barrier coating.

<sup>3</sup> The USCG has indicated a preference to require the lift bridge to lift on demand of marine traffic.

*Mechanical and Electrical (M&E) Support System:* The repair of the support system will include refurbishing the span guides, counterweight guides, strike plates, and live load shoes.

*M&E Balance System:* The repair of the balance system will include replacement of the sheave trunnion bushings, the counterweight wire ropes, and repair of the counterweight. The existing sheave trunnion shaft is anticipated to be inspected and reused, with only polishing of the bearing surface required rather than replacement of the trunnion shaft.

*M&E Drive System:* The repair will essentially result in replacement of the majority of the drive system. Elements of the drive system to be reused are the auxiliary drive motor and auxiliary gear reducer (installed in 1997) and the existing operating drums.

*M&E Distribution/Control System and Interlock System, Navigation Guidance System, and Traffic Control System:* The repairs will essentially replace the motor controls, switch gear, the majority of wire and conduit and junction boxes, as well as the control console, relay control system, festoon cables, transformer, and power supply system.

*Substructure:* The repair includes the patching of concrete spalls and filling of concrete cracks and concrete surface treatment.

No foundation stabilization measures are planned to be employed. It is anticipated that little or no additional differential settlement will occur on the west abutment and concourse. Presently, it is unknown if the east abutment and Pier 8 continue to move (settle/translate/rotate) due to global instability of the earthen embankment and/or inadequate foundations. The east abutment and Pier 8 will be monitored in the future for movement. No underwater repair of concrete is planned.

*Superstructure – Spans 1 and 2:* The repairs will consist of resurfacing the deck of the concrete structure as well as concrete repairs and concrete surface treatment.

*Superstructure – Trusses:* The repair of the trusses includes retrofitting selected portions of the lower chord to address advanced section loss due to corrosion, straightening of selected vertical members damaged by vehicular impact, removal of the lower lateral bracing except for the lift-span, replacement of stringers at the ends of each truss, retrofitting the floor beams to improve structural capacity, and retrofitting the anchorage of the trusses to the substructure units.

*Superstructure – Span 10:* Repairs to Span 10 will consist of removal of a portion of the deck to allow construction of a concrete barrier and removal and replacement of the existing strip seal. The repairs will also include resurfacing of the deck after the barrier and strip seal are constructed, as well as concrete surface repairs and concrete surface treatment.

*Sidewalk Support System:* The repair will include removal of two lines of original stringers that were abandoned in-place, replacement of the fascia stringer in-kind, repair of selected upper connection gusset plates, and retrofitting of intermediate rail post connection.

*Deck:* The repair will include replacement of the existing deck on Spans 3 to 9 inclusive, with a cast-in-place concrete deck and replacement of the expansion joints with strip-seal joints.

*Pedestrian Railing:* The repair will include removal of the railing, blast cleaning, repair and replacement of individual members, galvanizing, painting and reinstallation of the railing.

Level of Maintenance and Preservation: The \$5M repair project will renovate the majority of the mechanical and electrical components of the lift bridge through substantial replacement of components. Within limitations, the substantial replacement of mechanical and electrical components will restore a large portion of the lifting mechanisms to new or near new condition. As such, outside of predictable routine maintenance and planned preservation, no substantial preservation of the renovated mechanical and electrical components is anticipated prior to 2055.

The \$5M repair project will address immediate deficiencies of several structural components of the lift bridge through isolated repairs rather than substantial replacement. Repair of the structural components of the lift bridge will not restore these components to a new or near new condition. Rather, the structural repairs will mitigate isolated deteriorated conditions of selected structural components. Upon completion of the \$5M repair project, latent structural deficiencies will exist in the form of corroded structural steel members, presumably chloride saturated concrete, presumably inadequate foundation of the east abutment, and the early- to mid-stages of pack rust development. Because of the age of the structural components and the anticipated post \$5M repair project condition, the structural components will be sensitive to the future level of maintenance and preservation applied.

Repair and preservation efforts have been applied to the bridge throughout the life of the structure. These efforts include the following:

Original commissioning	1931
East abutment repaired due to settlement	1936
Pier 2 scour repaired	1938
Retrofit with traffic gates	1940
Repaint (lead system)	1953
Controls, warning lights, traffic gates, navigation lights	1954
East abutment repaired due to settlement	1958
Counterweight wire ropes replaced	1971
Deck replaced	1973
Scour damage repair at Piers 6, 7 and 8	1974
Replacement of gas powered engine with elect. motor	1980
Present power distribution system installed	1980
Present control system installed	1980
Span 10 replaced	1981
Repainted	1982
Roller bearings replaced	1990
Auxiliary drive motor installed	1998
Manual drive (capstan) removed	1998
Sidewalk deck and longitudinal stringers replaced	1998
Repainted below deck	2002
Expansion bearing replaced	2002
Bottom chord repaired (3 locations)	2003

Lift Bridge Service: Anticipated future removal of vehicular traffic from the lift bridge will influence the rate of deterioration and wear. This change in service of the lift bridge will presumably eliminate the application of de-icing chemicals, substantially reduce the live load applied to the structure, and all but eliminate the potential for damage due to vehicular impact. However, the anticipated elimination of vehicular traffic will increase the number of annual lift operations.

#### Lift Operations:

The lifting schedule to accommodate marine traffic is governed by federal regulations. The underlying premise of federal regulations is that marine traffic has the right-of-way with regard to vehicular and pedestrian traffic. Presently the lift bridge operates under a schedule approved by the USCG. The mid-May to mid-October schedule requires marine traffic to wait for between ½ hour and 1½ hours during ordinary recreational and commercial hours of operation and to provide a two-hour advance notice of need for a lift bridge opening during the early morning hours. Otherwise the schedule calls for the lift bridge to open with a 24 hour notice.

During the 1950s, the number of annual lift bridge openings was as little as 200 and spiked at 2000 in 1957. Similarly, from a period between 1976 and 1988, the minimum and maximum number of annual lift bridge openings was 300 and 2000, respectively. Presently, the lift bridge opens on average 1900 times per year (1998 to 2002 average). The number of vessels that pass beneath the lift bridge tends toward one per opening during the early morning and late evening hours. During mid-day it is not uncommon for numerous vessels to pass beneath the lift bridge during a single lift operation.

With the anticipated elimination of vehicular traffic, the USCG has requested revisions of the lifting schedule to favor marine traffic, even to the extent of requiring the lift bridge to open on demand of marine traffic. It is anticipated that the number of lift bridge openings could double and may quadruple. The future owner of the lift bridge would be required to negotiate a revised lift schedule with the USCG upon removal of vehicular traffic.

It is anticipated that increasing the number of openings by a factor of two to four will affect wear of the mechanical and electrical system, but that the effect will not be linear. Said differently, doubling the number of openings will not reduce the useful life of the mechanical and electrical components in half.

An increase in the number of openings the lift bridge makes will influence the wear of the mechanical and electrical system. However, deterioration of the mechanical and electrical components is also influenced by age and level of maintenance applied to the components. This deterioration of the mechanical components is more influenced by the number of openings than is the deterioration of electrical components.

#### De-icing Chemicals:

Anticipated elimination of vehicular traffic from the lift bridge will presumably eliminate the need to apply de-icing chemicals to the lift bridge. The resulting effect of the elimination of de-icing chemicals to the lift bridge will be to extend the useful life of the paint system, steel, concrete decks, and concrete in the upper portions of the substructure units.

At the time vehicular traffic is removed from the lift bridge, the concrete deck is anticipated to have residual chloride content from five years of vehicular traffic. Similarly, the upper portions of the substructure units are anticipated to have residual chloride content from nearly 80 years of service.

Vehicle Impact:

Anticipated elimination of vehicular traffic from the lift bridge will effectively eliminate the potential for damage to the lift bridge from vehicle impact. (Snow removal equipment may still damage the bridge). As such, no future repair of damage due to vehicle impact is anticipated or included in projected maintenance needs.

## **MAINTENANCE NEEDS**

### **Operations Projections**

Lift bridge operations are considered those efforts required to operate the lift bridge that are independent of maintenance and preservation efforts. The activities included in lift bridge operations include the following:

- Payment for utility costs of electricity and telephones
- Administration as necessary to arrange for maintenance, maintain operation and maintenance records, administer contracts, process paperwork, etc.
- Coordination as necessary to communicate with the USCG, general public, mariners, media, etc.
- Training as necessary to operate the lift bridge and perform routine maintenance
- Insurance<sup>4</sup>
- Bridge tenders to operate the lift bridge during scheduled operations

### **Maintenance and Preservation Projections**

The window of time considered with respect to maintenance projections is 50 years from the 2005 repairs. This period of time was utilized because it is the typical duration that bridge repairs are expected to extend the useful life of a structure and because projections beyond 50 years tend toward speculation rather than projections. Mn/DOT forces are assumed to retain responsibility of maintenance of the lift bridge from 2005 through 2010. Therefore, this report addresses the remaining 45 years of the 50-year window. The 45 years between 2010 and 2055 was organized in three 15-year increments for purposes of projecting maintenance and preservation activities and their associated costs.

The level of maintenance and preservation anticipated to be required to sustain the future operation of the lift bridge through 2055 is described within this section. Maintenance and preservation efforts necessary to preserve the serviceability of the lift bridge and sustain an acceptable level of performance and can be organized into three categories: Routine Maintenance, Structure Preservation and, Component Failure.

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<sup>4</sup> Insurance is recognized as operational need. However, because most municipalities are self-insured and estimating the cost of self-insurance is beyond the scope of this report, the cost of insurance has not been included in the probable costs presented within this report.

Routine Maintenance: Routine maintenance is considered to be bridge inspections and annually scheduled maintenance activities that should be performed independent of the condition of the lift bridge. The routine maintenance could likely be performed by the lift bridge owner. The owner of the lift bridge may need to rent equipment to gain access to the lift bridge from the water and to gain access to the upper reaches of the structure. Use of an engineering consultant was assumed as a basis of estimating the cost of lift bridge inspections. Routine maintenance includes the following efforts:

- Flushing deck, drains, and expansion joints with water
- Removal of flood water debris
- Annual structural inspection
- In-depth structural inspection at four-year intervals
- Structural analysis and rating
- Bi-annual mechanical and electrical inspection
- Underwater inspections at five-year intervals
- Sweep cleaning the decks
- Snow removal from the decks
- Minor railing repairs
- Cleaning and adjusting strike plates and live load shoes
- Cleaning and lubricating counterweight wire ropes
- Cleaning and lubricating gears, bearings, couplings, and shafts
- Cleaning and lubricating operating wire ropes and take-up devices
- Cleaning and lubricating gear reducers, limit switches, and traffic barriers

Structure Preservation: Structure preservation is considered to be planned activities that are intended to circumvent excessive deterioration and maintain the functional systems and components in normal serviceable condition, as well as reactions to minor malfunctions or damage. It is anticipated that these efforts would be accomplished by a construction contractor rather than the lift bridge owner's forces. An abbreviated list of anticipated structure preservation includes the following efforts:

- Repair of scour damage
- Repair of concrete deterioration of the piers above and below the waterline
- Repairs of differential settlement of the abutments
- Sealing of pack rust and painting the lift bridge
- Structural repairs to the stringers, floorbeams, and lower chords
- Structural repairs to the verticals and diagonals of the trusses
- Replacement of the strip seal between Span 9 and Span 10
- Patching and sealing of the decks
- Replacement of the counterweight wire ropes
- Replacement of the operating wire ropes

- Minor repairs to the sidewalk support system
- Replacement of radio transmitter and receiver
- Miscellaneous minor repairs of the motor controls, switchgear, drive motor, and motor brakes

Component Failure: Component failure is considered a reactive action to an unplanned failed system or component. The owner of the bridge is essentially at risk of reacting to component failures. These actions are intended to quickly restore the lift bridge to an acceptable level of operation and can be costly compared to structure preservation. If an acceptable level of operation can not be achieved and maintained, demolition of the lift bridge may be required by the USGC. An abbreviated list of potential component failure maintenance includes the following efforts:

- Replacement of entire piers
- Stabilization of the east abutment
- Replacement of bearings
- Replacement of the rivets in the lower chord connections with bolts
- Replacement or retrofitting of the lower chord connection gusset plates
- Replacement of the vehicular and sidewalk decks
- Replacement of sidewalk deck expansion joints
- Repair or replacement of counterweight sheave(s)
- Repair or replacement of counterweight sheave trunnion shaft(s)
- Repair or replacement of operating drum(s)
- Demolition and removal of the lift bridge

Maintenance Needs Conclusion:

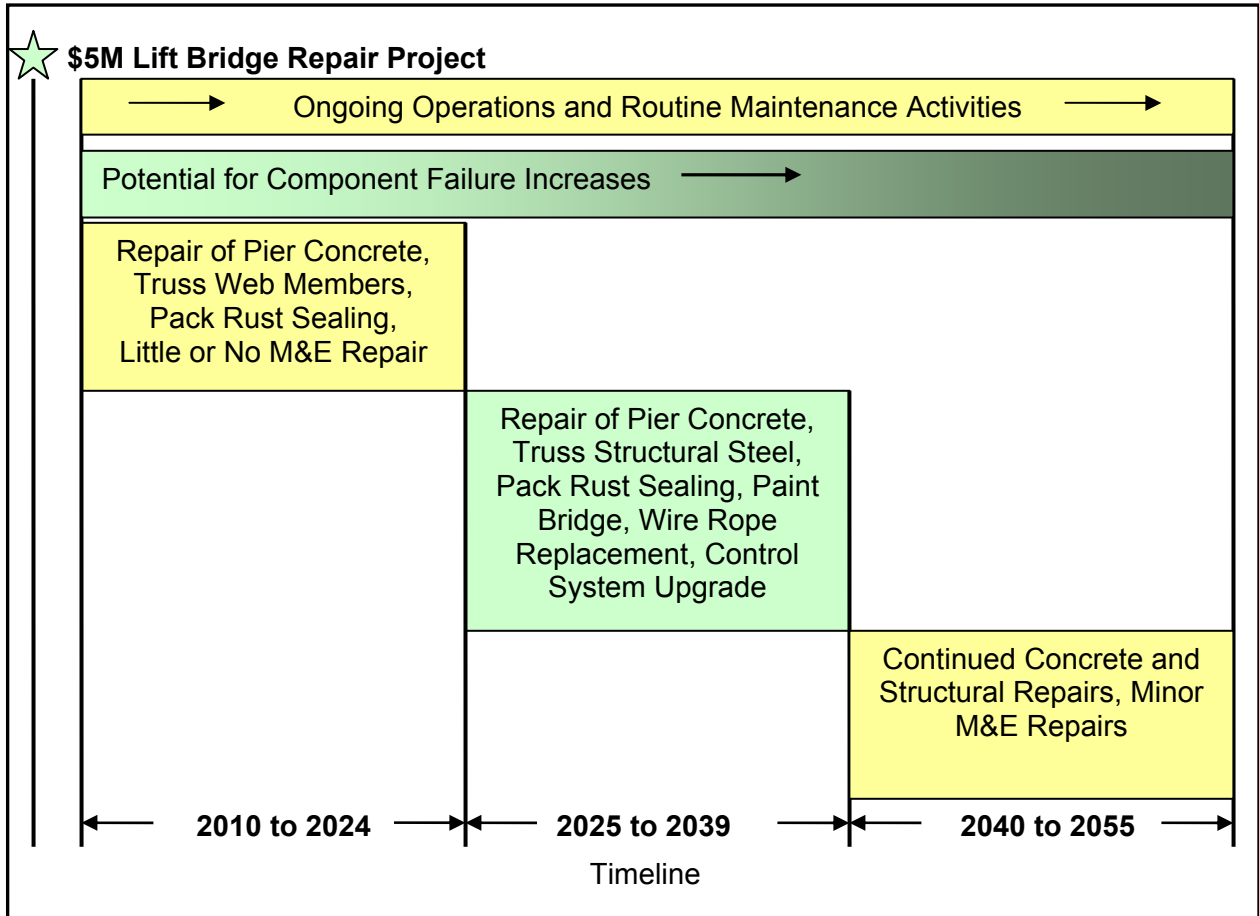
In broad and general terms, the future level of work to sustain the bridge can be characterized by:

- Significant repairs to piers and the truss webs members and sealing of lower chord connections prior to year 2024.
- Significant repairs to address concrete deterioration of the piers, structural repairs to the trusses, pack rust sealing, painting of the lift bridge, counterweight wire rope and operating wire rope replacement between the years 2025 and 2039, and replacement of the programmable logic controls.
- Continued repairs to the concrete and structural steel and miscellaneous repairs to the mechanical and electrical aspects of the lift bridge between the years 2040 and 2055.

A graphic representation of anticipated operation, maintenance and preservation needs is provided below. A more detailed list of anticipated operations, maintenance and preservation needs and costs is presented in Appendix A – *Anticipated Maintenance/Preservation Activities and Associated Costs (Present Worth)*.

**Figure 3: Anticipated Operations, Maintenance and Preservation Efforts**

(Without vehicular traffic)



**PROJECTED MAINTENANCE COSTS**

The opinions of probable costs are based on information presently available and projected maintenance and preservation needs and anticipated deterioration of the lift bridge over an extended period of time. HNTB has no control over the level of maintenance and preservation that will be applied to the lift bridge or the rate of future deterioration of the lift bridge. The cost of labor, equipment, and materials for operations and maintenance are subject to market forces that HNTB has no control over. The opinions of probable maintenance and preservation costs provided herein are made on the basis of engineering judgment and construction experience. These opinions represent HNTB’s best judgment as experienced qualified professionals familiar with bridges. However, no warranty or guarantee is provided or implied that the actual cost of operations, maintenance and preservation will not vary significantly from the opinions of cost presented herein.

The probable cost of operating and maintaining the Stillwater Lift Bridge over a 45-year period was estimated assuming no vehicular traffic on the lift bridge. The costs are based on the assumed level of maintenance and preservation as described within this report and are presented in 2003 U.S. dollars. The estimated costs do not include consideration of inflation or a contingency to account for unanticipated conditions. For purposes of developing the costs, three 15-year periods were considered from 2010 to 2024, from 2025 to 2039, and finally from 2040 to 2055.

Presented below in Table 1 are probable costs of operations and routine maintenance of the Stillwater Lift Bridge from 2010 through 2055.

**Table 1: Probable Operation and Routine Maintenance Costs** (\$1,000 US Dollars, 2003)

Item	Cost - Years 2010 to 2024	Cost – Years 2025 to 2039	Cost - Years 2040 to 2055	Annualized Cost	45 Year Cost
<b>Operations</b>	\$ 1,561	\$ 1,561	\$ 1,561	<b>\$ 104</b>	\$ 4,684
<b>Routine Maint.</b>	\$ 639	\$ 649	\$ 40	<b>\$ 43</b>	\$ 1,928
	\$ 2,201	\$ 2,210	\$ 2,201	<b>\$ 147</b>	\$ 6,611

Presented on the following page in Table 2 are probable costs of structure preservation for the Stillwater Lift Bridge from 2010 through 2055.

**Table 2: Probable Structure Preservation Costs** (\$1,000 US Dollars, 2003)

Item	Cost - Years 2010 to 2024	Cost – Years 2025 to 2039	Cost - Years 2040 to 2055	Annualized Cost	45 Year Cost
Engineering	\$ 585	\$ 585	\$ 585	\$ 39	\$ 1,755
Substructure	\$ 148	\$ 779	\$ 148	\$ 24	\$ 1,074
Spans 1 and 2	\$ -	\$ -	\$ 5	\$ 0	\$ 5
Truss Spans	\$ 1,050	\$ 2,052	\$ 596	\$ 82	\$ 3,697
Span 10	\$ 3	\$ 13	\$ 3	\$ 0	\$ 18
SW Support System	\$ -	\$ -	\$ 28	\$ 1	\$ 28
Deck	\$ 9	\$ 243	\$ 39	\$ 6	\$ 290
Railing	\$ -	\$ 2	\$ 18	\$ 0	\$ 20
Support System	\$ 2	\$ 3	\$ 21	\$ 1	\$ 26
Balance System	\$ -	\$ 768	\$ 15	\$ 17	\$ 783
Drive System	\$ -	\$ 102	\$ 7	\$ 2	\$ 109
Dist./Control System	\$ -	\$ 26	\$ 26	\$ 1	\$ 52
Nav. Guidance Sys.	\$ 2	\$ 3	\$ 4	\$ 0	\$ 9
Traffic Control Sys.	\$ 2	\$ 2	\$ 4	\$ 0	\$ 8
Tender's House	\$ 0	\$ 2	\$ 5	\$ 0	\$ 8
Bridge Lighting	\$ 2	\$ 2	\$ 2	\$ 0	\$ 7
	\$ 1,802	\$ 4,580	\$ 1,506	\$ 175	\$ 7,889

Presented below in Table 3 are potential component failure costs for the Stillwater Lift Bridge from 2010 through 2055. It is possible that some components could fail during the period between 2010 and 2055, but they are not necessarily anticipated to do so. As such, no specific failure period is projected. For purposes of forecasting costs, 30% of the component failure cost (without demolition costs) has been assumed to be incurred prior to 2055.

**Table 3: Potential Component Failure Costs** (\$1,000 US Dollars, 2003)

Item	Annualized Cost	45 Year Cost
Substructure	\$ 34	\$ 1,522
Superstructure	\$ 21	\$ 954
Vehicular & SW Deck	\$ 13	\$ 602
Mech. & Electrical	\$ 25	\$ 1,137
Demolition & Removal	\$ 13	\$ 600
	\$ 107	\$ 4,815

A more detailed list of anticipated cost by individual task is presented in Appendix A – *Anticipated Maintenance/Preservation Activities and Associated Costs (Present Worth)*. Presented in Appendix B – *Anticipated Maintenance/Preservation Activities and Associated Costs (Future Worth)* is anticipated cost by individual task escalated to future worth values using an assumed annual escalation of 2.5%<sup>5</sup>, compounded annually.

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<sup>5</sup> The annual escalation rate of 2.5% is based on the average annual escalation of Engineering News-Record's construction cost index from 1990 through 2022.

**PREVIOUS MAINTENANCE and PRESERVATION COSTS**

Records of costs associated with the Stillwater Lift Bridge were collected and reviewed for purposes of benchmarking the opinion of probable costs and documenting previous cost in recent years. The cost records collected and reviewed include costs from Mn/DOT’s fiscal years 1996 through 2003. Mn/DOT’s fiscal year spans from July 1 through June 30. For example, fiscal year 2002 runs from July 1, 2001, through June 30, 2002. The costs are presented in present worth 2003 US dollars using an annual escalation rate of 2.5%, compounded annually.

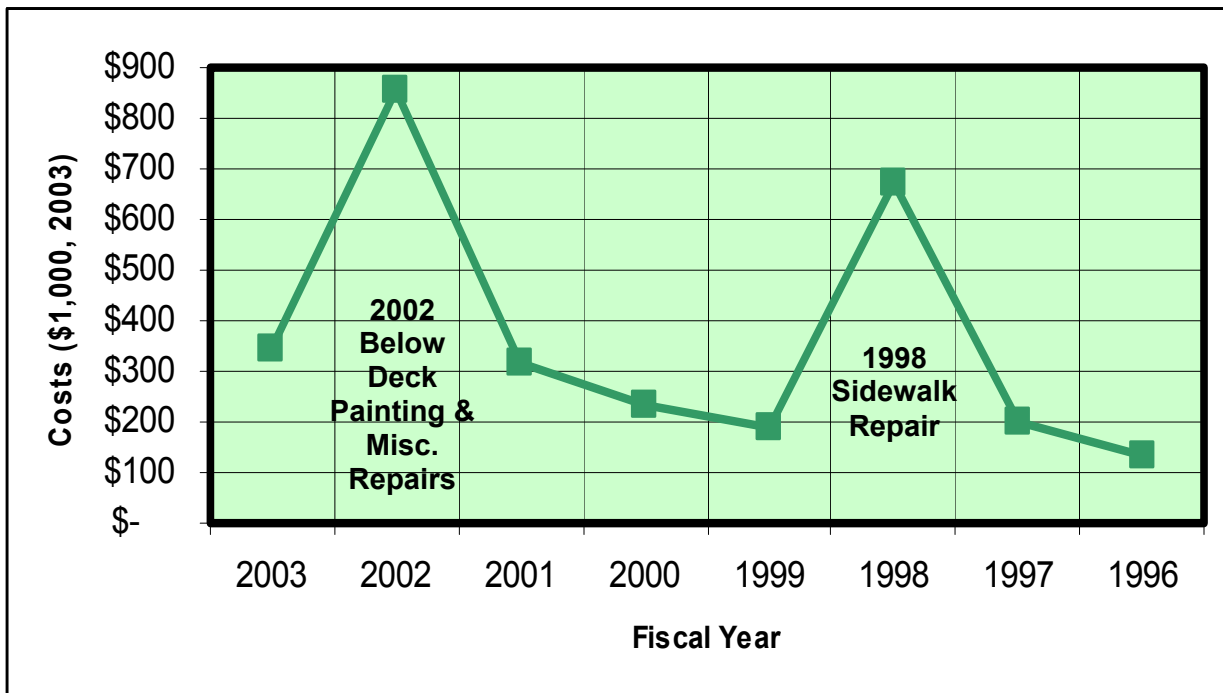
An attempt was made to organize the recorded costs into operations, routine maintenance, and structure preservation. Due to the absence of some activity descriptions, the organization should not be considered precise. Provided below in Table 4 are recorded costs.

**Table 4: Previous Annual Maintenance Costs** (\$1,000 US Dollars, 2003)

Category	Average	Median	Maximum	Minimum
Operations	\$ 79	\$ 79	\$ 101	\$ 9
Routine Maint.	\$ 33	\$ 26	\$ 93	\$ 5
Structure Preserv.	\$ 260	\$ 152	\$ 841	\$ 52
<b>Combined Total</b>	<b>\$ 366</b>	<b>\$ 273</b>	<b>\$ 855</b>	<b>\$ 133</b>

Provided below in Figure 4 is a graphic presentation of previous maintenance costs.

**Figure 4: Combined Previous Maintenance Costs**



## **CONDITION RATINGS**

The condition rating of various systems of the lift bridge and selected components of the lift bridge are projected in five-year increments from 2005 through 2050. These projections are based on the premise that the operations, maintenance, and preservation of the lift bridge will be applied as described within this report.

National Bridge Inspection (NBI) codes are used to convey the anticipated condition of the various structural aspects of the lift bridge. NBI condition codes are not typically used to convey the condition of mechanical and electrical aspects of a lift bridge. For purposes of consistency, the NBI condition codes have been adapted for the mechanical and electrical aspects of the lift bridge. Provided below are the condition rating codes and their intended meaning.

### **Structural Condition Rating Codes**

#### **Code Condition Description**

9	Excellent Condition – new condition
8	Very Good Condition – no problems noted
7	Good Condition – some minor problems noted
6	Satisfactory Condition – structural elements show minor deterioration
5	Fair Condition – primary elements sound, minor section loss
4	Poor Condition – advanced section loss, deterioration, spalling or scour
3	Serious Condition – serious loss of section, local failure possible
2	Critical Condition – advanced deterioration, monitoring necessary
1	Imminent Failure Condition – bridge closed, corrective action possible
0	Failed Condition – out of service, no corrective action possible

### **Mechanical and Electrical Condition Rating Codes**

#### **Code Condition Description**

9	Excellent Condition – new condition
8	Very Good Condition – no problems noted
7	Good Condition – some minor problems noted
6	Satisfactory Condition – isolated elements show minor wear
5	Fair Condition – obvious deterioration noted, no longer operating like new
4	Poor Condition – significant deterioration noted, but has remaining useful life
3	Serious Condition – significant deterioration, nearing the end of its useful life
2	Critical Condition – advanced deterioration, corrective action required soon
1	Imminent Failure Condition – bridge closed, corrective action possible
0	Failed Condition – out of service, no corrective action possible

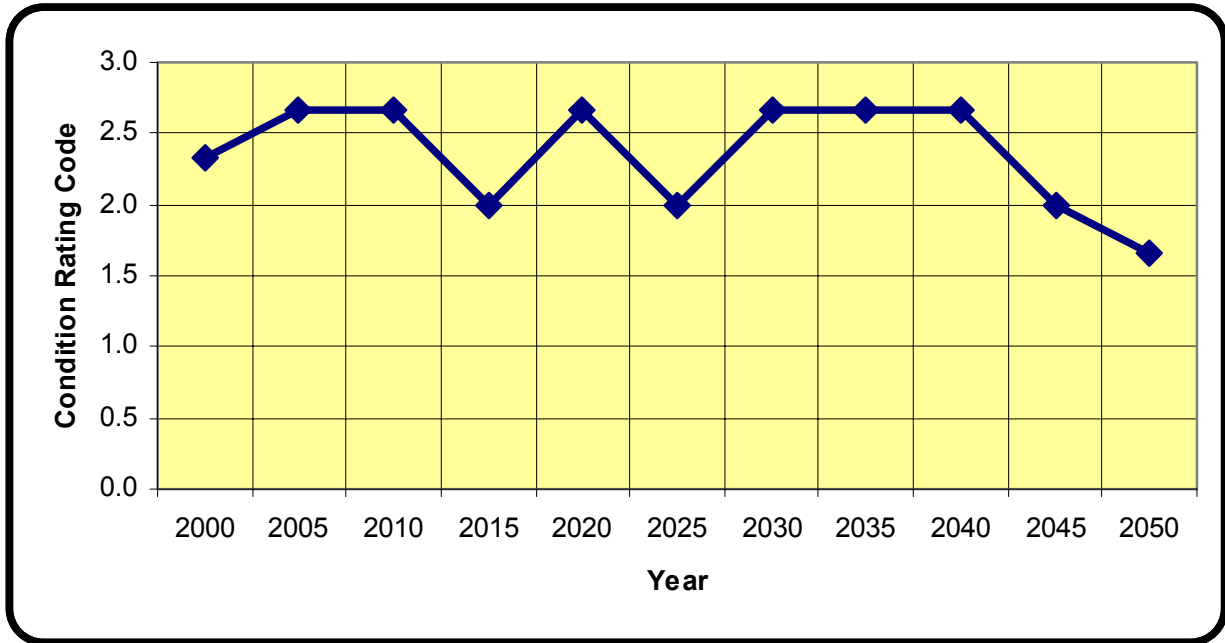
Provided below in Table 5 are projected system condition code ratings. Those condition codes shown under the year 2000 represent the conditions identified during the 2002 inspection. Those conditions codes shown under the year 2005 are projected condition codes subsequent to the \$5M repair project. The condition codes for years 2010 through 2050 represent projected condition ratings based on projected deterioration and maintenance efforts.

**Table 5: Projected System Condition Rating Codes**

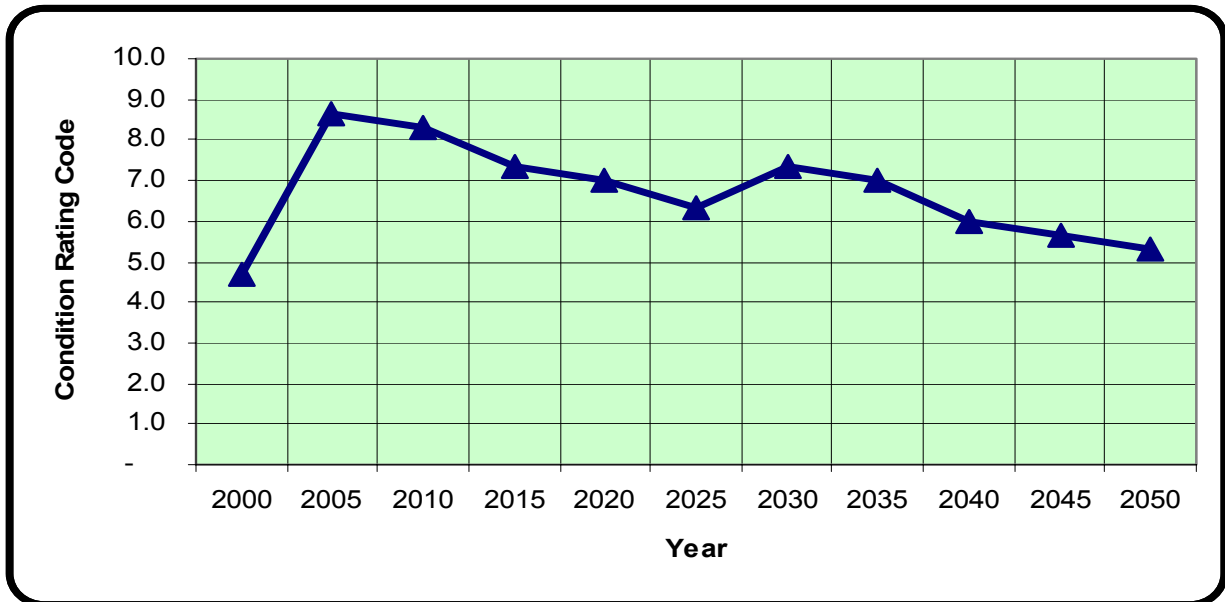
Years Beyond 2005	-5	0	5	10	15	20	25	30	35	40	45
Year	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Substructure	4	4	4	3	4	3	4	4	4	3	3
Super. - Spans 1 & 2	5	6	6	5	5	4	5	4	4	3	3
Super. - Truss Spans	3	4	4	3	4	3	4	4	4	3	2
Super. - Span 10	7	6	6	5	4	3	6	5	5	5	4
SW Support System	4	7	7	7	7	6	6	6	5	5	5
Deck	4	9	8	7	7	6	6	5	4	3	2
Pedestrian Railing	3	8	7	7	6	6	5	5	5	4	4
Tender's House	2	7	7	7	6	6	6	5	5	4	4
Support System	5	7	7	6	5	7	6	5	6	5	4
Balance System	5	8	7	6	5	4	8	7	6	5	4
Drive System	4	9	9	8	8	7	7	7	6	6	6
Dist./Contr. Sys.	5	9	9	8	8	8	7	7	6	6	6
Interlocking System	7	9	9	9	8	8	8	7	7	6	6
Nav. Guide. Sys.	4	9	9	8	8	8	7	7	6	6	5
Traf. Control Sys.	5	9	8	8	8	7	7	6	6	5	4
Bridge Lighting	3	9	8	8	7	7	6	6	5	5	4

The condition of some systems is of greater importance than others. For example, while the interlock system is important, addressing deficiencies of the interlock system is relatively easy compared to structural deficiencies. Provided on the following page in Figure 5 is the composite projected condition code ratings of what might be considered the structural backbone of the lift bridge, that being the substructure and truss spans. Similarly, the balance, drive, and distribution/control systems may be considered the backbone of the lift-span operations. Provided on the following page in Figure 6 is the projected composite condition rating codes for the balance, drive, and distribution/control system.

**Figure 5: Projected Composite Condition Rating Codes – Substructure and Truss Spans**



**Figure 6: Projected Composite Condition Rating Codes – Balance, Drive and Distribution/Control Systems**



The conditions of components of a system were considered when establishing condition rating for the system as a whole. Provided on the following page in Tables 6 and 7 are the projected condition code ratings for selected components of the substructure and trusses, respectively.

**Table 6: Projected Substructure Component Condition Rating Codes**

Years Beyond 2005	-5	0	5	10	15	20	25	30	35	40	45
Year	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Concourse	5	5	5	5	4	4	5	5	4	4	3
West Abutment	5	6	6	5	4	4	6	6	5	5	4
Piers 1 through 7	5	5	5	4	3	3	5	5	4	3	3
Pier 8	4	5	4	4	3	5	4	4	3	4	4
East Abutment	4	4	4	3	3	3	4	4	3	3	2
East Slope Protection	5	5	5	4	4	4	5	5	5	4	4

**Table 7: Projected Truss Component Condition Rating Codes**

Years Beyond 2005	-5	0	5	10	15	20	25	30	35	40	45
Year	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Stringers	5	6	6	5	4	4	6	5	5	4	4
Floor Beams	3	5	5	5	4	3	5	5	5	4	3
Lower Chords	3	4	4	3	3	2	4	3	3	2	2
Web Members	4	4	3	2	4	4	4	3	3	3	2
Lower Connections	3	3	4	3	3	2	4	3	3	2	2

The projected condition rating codes presented above in tabular form are presented in graphic form in Appendix C – Projected System Component Condition Ratings Graphs, and Appendix D – Projected Component (Selected) Condition Ratings Graphs.

## **REMAINING USEFUL LIFE**

The remaining useful life of the lift bridge is highly dependent on the level of maintenance and preservation and timing of maintenance and preservation applied to the lift bridge. Application of a negligible level of maintenance and preservation would shorten the remaining useful life of the lift bridge by decades. Application of a considerable level of maintenance and preservation would significantly extend the useful life of the lift bridge, but would not extend the useful life of the lift bridge into perpetuity without systematic replacement of individual component, and/or systems of the structure.

The mechanical and electrical components of the lift bridge are projected to remain serviceable beyond 2055 provided the \$5M repair project is completed as previously described and barring any previously mentioned component failure events that are relatively independent of maintenance and preservation.

However, beyond the \$5M repair project, there are structural components of the lift bridge that are projected to be vulnerable. In very general terms, these include:

**Lower chords:** The lower chords are comprised of four angle irons that vary in thickness from 3/8 inch to 9/16 inch. These are non-redundant tension members referred to as fracture critical. Failure of one of the lower chords would result in sudden and catastrophic collapse of a truss. Repairs were made to the lower chords in three locations in 2003 to address significant loss of section due to corrosion. Additional deficiencies in the form of section loss due to corrosion will be addressed in the \$5M repair project. However, isolated locations of corrosion will remain after the \$5M repair project and are anticipated to need repairs in the future. The lower chords are vulnerable to corrosion due to the cyclical wetting and drying, their exposure to chloride laden water, and a configuration which traps water.

**Lower chord connections:** If not properly maintained, the pack rust is anticipated to continue forming at an accelerating rate. The initial response to continued formation of pack rust would likely be to replace the rivets with bolts. Replacement of the rivets with bolts will not address the root cause of the problem, that being the pack rust itself. Left unchecked, pack rust will eventually render the gusset plates and members they connect inadequate to perform their structural task. Repair of pack rust once it reaches a critical point involves shoring the lift bridge and wholesale replacement of affected members, significant retrofitting or replacement of whole trusses.

**Seam Sealing:** Similar to the lower connections, several seams between build-up members exhibit the early- to mid-stages of pack rust development. Again, if the pack rust is not addressed, it will continue to form at an accelerating rate and may render isolated elements of the lift bridge inadequate to perform their intended structural task.

**Substructure Concrete:** The serviceability of the piers will be dependent on the repairs made in the 2005 and in the future. The repair of deteriorated concrete does not restore the element to new condition. Rather, the repairs tend to promote future deterioration of the concrete immediately surrounding the repairs. Passive cathodic protection, concrete admixtures, and surface applications can be employed to retard future deterioration, but will not eliminate it. As such, the piers have likely reached a stage where perpetual repairs to the concrete will be required on a 15- to 25-year cycle or more aggressive repairs (wholesale concrete replacement) or pier replacement employed. It is anticipated that the piers will be in need of substantial and costly repair or replacement to continue services beyond 2055.

**Vehicular and Sidewalk Deck:** In 2055, the vehicular deck and sidewalk deck will have been in service for 50 and 57 years, respectively. This length of service is well beyond that expected for a typical bridge carrying vehicular traffic and subject to de-icing chemicals. It is anticipated that both the vehicular and sidewalk decks will need to be replaced if the bridge is to remain in service beyond 2055.

**East Abutment:** The east abutment has experienced settlement and rotation about an axis parallel and perpendicular to the bridge since the construction of the bridge. The order of magnitude of this movement is several feet, rather than a few inches. It is possible that the east abutment continues to move. Should the east abutment continue to move several feet, the substructure unit will become unstable and require under-pinning and/or replacement.

## **SUSTAINED VEHICULAR USE**

The previously presented projections of maintenance and preservation costs, as well as condition ratings of the lift bridge are based on the assumption that the bridge will carry no vehicular traffic beyond 2010. Should vehicular traffic be sustained on the lift bridge through 2055, the maintenance and preservation needs will be affected depending on the volume and makeup of traffic. Sustained vehicular use was considered at two levels: 1) Restricted Vehicular Use and 2) Unrestricted Vehicular Use.

Restricted Vehicular Use: Consideration of this level is intended to represent a scenario where the future owner of the lift bridge allows vehicular use only in the form of passenger vehicles and pickup trucks. Additionally, a new river crossing is assumed to be in place and operational. Under this scenario, the volume of traffic carried by the bridge is anticipated to be substantially reduced. It is also assumed that de-icing chemicals would be used only in extreme icing conditions and the speed limit would be reduced. A reduction in the speed limit is assumed to be accomplished through use of speed bumps.

Provided below are anticipated consequences of allowing restricted vehicular use of the lift bridge.

1. The lift bridge will likely not be required to open as often, resulting in a nominal decrease in wear of the mechanical and electrical components of the bridge.
2. The lift bridge will be exposed to limited potential damage from errant vehicles.
3. The life cycle of the decks (vehicular and sidewalk) will likely be reduced to about 30 year resulting in the need to replace the decks around 2035. As such, replacement of the decks would be removed from the component failure category and considered to be structure preservation.
4. The rate of corrosion of the structural steel will increase due to the presumed use of de-icing chemicals. This will effectively increase the rate of corrosion of steel below the deck and increase the probability of component failure of the lower chord connections.
5. The rate of concrete deterioration will likely increase due to the presumed use of de-icing chemicals. This will effectively increase the probability of component failure of the pier concrete.

6. The rate of paint deterioration will likely increase due to the presumed use of de-icing chemicals.
7. The maintenance costs will increase due to the need to provide traffic control and maintenance of traffic during maintenance operations.

The resulting effect of restricted vehicular traffic on the lift bridge would likely be replacement of the decks, acceleration of structural repairs, and reduced condition rating codes for the structural portions of the bridge. The additional annual maintenance cost is anticipated to be roughly 118% of that without traffic, which is \$51,000 annualized over the 45-year period.

Unrestricted Vehicular Use: Consideration of this level is intended to represent a scenario where the bridge is continued to be used as a trunk highway. The vehicular traffic is assumed to consist of both passenger and commercial vehicles with a volume of traffic that exceeds the roadway capacity. Due to the need to maintain transportation, de-icing chemicals would be applied as necessary. Load restriction would be applied as deemed necessary by structural analysis and speed limits are assumed to remain as they are presently. Sustaining unrestricted vehicular of the lift bridge through 2055 without substantial structural retrofit and/or replacement of entire truss spans is considered unachievable from a structural standpoint.

Provided below are anticipated consequences of allowing unrestricted vehicular use of the lift bridge.

1. The lift bridge will likely not be required to open as often, resulting in a nominal decrease in wear of the mechanical and electrical components of the bridge.
2. The lift bridge will be damaged from over-height vehicles on a regular basis. Repair of damage will require the bridge to be closed to traffic for days at a time to complete the repairs.
3. The lift bridge will likely be damaged from the strain of heavy truck loads. The damage would likely manifest itself in the form of deterioration of expansion joints, cracks in the truss web members and/or lower chords at connections and cracks in the floor beam to truss connections.
4. The life cycle of the decks (vehicular and sidewalk) will likely be reduced to 20 to 25 years resulting in the need to replace the decks around 2030. As such, replacement of the decks would be removed from the component failure category and considered to be structure preservation.

5. The rate of corrosion of the structural steel will increase due to the presumed use of de-icing chemicals and the cyclical wetting and drying of the metal surfaces. The rate of corrosion of those structural steel members below the deck, particularly the elements on the south trusses, will likely approach 0.012 inch per year (0.25 inch per 21 years) or more.<sup>6</sup> This corrosion is anticipated to manifest itself in pitting and localized corrosion similar to that revealed in the 2002 inspection.

Because the lower chord members have already experienced substantial section loss due to corrosion and are comprised of steel member with thickness varying from 3/8 inch to 9/16 inch, repairs to the lower chords are anticipated to be required on a regular basis. Continued repair of the lower chords will ultimately lead to repair of previous repairs, wholesale replacement of entire lower chord members and/or retrofit of the trusses with a secondary and redundant structural system and/or replacement of entire truss spans.

Because corrosion of the lower chord is characterized by localized section loss at locations typically out-of-sight, there will exist the possibility that isolated areas of corrosion could be left undetected or develop between inspections. Substantial corrosion of a lower chord could result in failure. Failure of a fracture critical lower chord member would result in a sudden and catastrophic collapse of one of the truss spans.

Similarly, advanced corrosion of the lower portions of the truss web members and the connection gusset plates is anticipated. Repeated repair of these members would result in retrofitting the lift bridge with secondary structural systems, wholesale replacement of components, and/or replacement of entire truss spans. Completing repairs of the truss web members will require the bridge to be closed to traffic for weeks or months at a time.

6. The rate of concrete deterioration will increase due to the presumed use of de-icing chemicals. It is anticipated that concrete in the upper 2 feet of the river piers will need to be replaced due to concrete deterioration. Replacement of this concrete will require the truss spans to be removed, or otherwise supported while the upper portions of the river piers are repaired. Repair of the concrete in the upper portions of the piers will require the lift bridge to be closed to traffic for months at a time.

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<sup>6</sup> National Cooperative Highway Research Program Synthesis of Highway Practice 118 – Detecting Defects and Deterioration in Highway Structures.

7. The rate of paint deterioration will likely increase due to the presumed use of de-icing chemicals, thus requiring the bridge to be painted more often. Painting the lift bridge will require the structure to be closed to vehicular traffic for several weeks at a time.
8. The maintenance and preservation costs will substantially increase due to the need to provide traffic control and maintenance-of-traffic during maintenance and preservation operations.

The resulting effect of unrestricted vehicular use of the Stillwater Lift Bridge will be a radical increase in the number and extent of preservation repairs to the lift bridge in the first decades following the \$5M repair project. These preservation efforts would likely be concentrated on the structural steel components of the bridge below the deck and concrete repairs of the piers.

At some point, likely prior to 2035, previous repairs would be required to be repaired and/or secondary and redundant structural systems will likely need to be employed to preserve the structural capacity of the bridge. Eventually, wholesale replacement of individual elements, components and/or trusses would be required prior to 2055. Additionally, repairs to the overhead truss members would be required to address damage from vehicular impact and repair of the concrete piers would be required.

The lift bridge would be required to be closed to vehicular traffic for extended periods of time, likely months, on multiple occasions to accommodate preservation repairs. The load carrying capacity of the bridge would likely fluctuate as repair needs develop and are addressed. It is anticipated that the bridge would be posted to allow only personal passenger vehicles at some point and closed entirely at times due to concerns regarding its structural capacity.

Estimating the cost of maintaining and preserving the Stillwater Lift Bridge with unrestricted vehicular use is beyond the scope of this document and difficult to accomplish with any degree of accuracy due to the extent of variables involved. However, it is anticipated that the cost would be several times that of maintaining the bridge without vehicular traffic. It is anticipated that prior to 2055 the lift bridge would be unable to effectively serve meaningful transportation needs due to the frequency and duration that the lift bridge would be closed to traffic to accommodate preservation efforts, due to its projected insufficient structural capacity, and due to the susceptibility of the lift bridge to closure during flood events. Additionally, the required retrofit, secondary structural systems and/or wholesale replacement of components may compromise the historic integrity of the lift bridge<sup>7</sup>.

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<sup>7</sup> Application of the Secretary of Interior's Standards for Historic Preservation Projects to these future preservation efforts is not possible because preservation needs and response to the needs cannot be predicted with any accuracy.

## **CONCLUSIONS**

Upon completion of the \$5M repair project in 2005, the lift bridge will be structurally adequate to carry Mn/DOT's minimum structural preservation repair live load through 2010 and reduced thereafter. The lifting mechanism is projected to provide reliable operations through 2055.

The live load capacity of the bridge will be at the minimum allowed by Mn/DOT for structure preservation, or roughly 72% of what a new bridge would be designed to carry. The structural elements of the lift bridge will require maintenance and substantial preservation efforts throughout the period between 2010 and 2055. The structural components of the bridge will deteriorate rapidly if maintenance and preservation efforts are not sustained. The lift bridge is anticipated to require substantial additional preservation efforts to extend its useful life beyond 2055, up to an including retrofitting with secondary structural systems and/or replacement of entire trusses.

The mechanical and electrical system of the lift bridge will require routine maintenance and preservation in the form of replacement of the counterweight and operating wire ropes and likely replacement of the programmable logic control system. The mechanical and electrical systems are expected to be serviceable beyond 2055 with additional preservation efforts.

The future owner of the bridge will be at risk for component failures. It is not possible to accurately predict the probability of a particular component to fail or when it the failure will occur. It is prudent to assume that some form of component failure will occur prior to 2055.

The annualized cost of operations is projected at \$104,000. Additionally, the annualized routine maintenance cost and structure preservation is projected to be \$43,000 and \$175,000 respectively. The combined annualized cost for operations, routine maintenance, and structure preservation is \$322,000. The resulting cost of owning and operating the lift bridge from 2010 through 2055 is projected to be roughly \$14,500,000. The potential for component failure cost is roughly \$4,800,000 over the 45-year period. For purposes of projecting costs, 30% of the component failure cost (excluding demolition and removal) was programmed to occur prior to 2055. That adjusted component failure cost is \$1,250,000. The future owner of the lift bridge would be as risk for the remaining \$3,600,000 of component failure costs.

Should personal passenger vehicles and pickup trucks be allowed to use the bridge at a reduced speed with limited use of de-icing chemicals additional maintenance and preservation efforts are anticipated. The additional annualized cost is projected to be \$51,000 or about 2,300,000 over the 45-year period. Additionally, the probability of incurring component failure cost would increase.

Should unrestricted vehicular traffic be sustained on the bridge, the structure is anticipated to require additional maintenance and preservation efforts including construction of secondary and redundant structural components and/or wholesale replacement of structural components/systems including truss spans as a whole. The additional cost is projected to be several times that of allowing no vehicular traffic on the bridge. The lift bridge will be unable to effectively serve meaningful transportation needs through 2055 with unrestricted vehicular traffic sustained on the lift bridge due to the time the bridge would need to be closed to traffic to complete repairs and because the structure will have inadequate structural capacity.

Should the future owner of the lift bridge be unable or unwilling to maintain the structure in a serviceable condition, the USCG will likely require the lift bridge, or lift-span be removed. The Secretary of Interior's Standards for Historic Preservation Projects will be required to be applied to preservation efforts applied subsequent to the \$5M repair project.

All costs are provided in 2003 US dollars, without consideration of escalation and without an allowance for contingency.

**Appendix A**

**Anticipated Maintenance/Preservation Activities  
and Associated Costs (Present Worth)**

The following pages present operations and maintenance tasks and their projected costs in present worth (2003 US \$) without contingency or escalation.

**Operations**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
1	Bridge Tender	Operate Br.	\$ 98,700	15	15	15	\$ 4,441,500
2	Electricity & Phone	Provide Service	\$ 1,400	15	15	15	\$ 63,000
3	Administration	Main. Records	\$ 2,000	15	15	15	\$ 90,000
4	Coordination	Pub. & Agency	\$ 1,900	15	15	15	\$ 85,500
5	Training	Personnel Training	\$ 600	2	2	2	\$ 3,600
6	Not Used		\$ -				\$ -
<b>Projected Costs:</b>				<b>\$ 1,561,200</b>	<b>\$ 1,561,200</b>	<b>\$ 1,561,200</b>	<b>\$ 4,683,600</b>
<b>Annualized Cost:</b>				<b>\$ 104,100</b>			

**Routine Maintenance**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
7	Flush Deck, drains, exp. Joints, sub-struct.	Power Wash	\$ 2,800	15	15	15	\$ 126,000
8	Structural Inspection	Base Inspection	\$ 15,700	11	11	11	\$ 518,100
9	In-Depth Structural Inspection	4-Year Inspection	\$ 27,300	4	4	4	\$ 327,600
10	Structural Analysis & Rating	Struct. Rating	\$ 59,500		1		\$ 59,500
11	Mech. & Elect. Inspection	Base Inspection	\$ 5,900	7	7	7	\$ 123,900
12	Underwater Inspection	5-year Inspection	\$ 14,000	3	3	3	\$ 126,000
13	Lamp Replacement - LED (10 each)	Replace Lamps	\$ 50,400	2	1	2	\$ 252,000
14	Lamp Replacement - HP Sodium	Replace Lamps	\$ 800	3	3	3	\$ 7,200
15	Sweep Clean Deck	Sweep	\$ 600	15	15	15	\$ 27,000
16	Snow Removal	Snow Removal	\$ 450	90	90	90	\$ 121,500
17	Counterweight Wire Ropes	Clean & lubricate	\$ 2,000	15	15	15	\$ 90,000
18	Gears/Bearing/Couplings/Shaft	Clean & lubricate	\$ 1,000	3	3	3	\$ 9,000
19	Operating Wire Ropes & Take-Up Devices	Clean / Lub / Adj.	\$ 2,700	15	15	15	\$ 121,500
20	Main Drive Motor	Clean/Lub./Repair	\$ 100	15	15	15	\$ 4,500
21	Gear Reducers	Clean & lubricate	\$ 1,300	1	1	1	\$ 3,900
22	Auxiliary Drive Motor	Clean/Lub./Repair	\$ 100	15	15	15	\$ 4,500
23	Limit Switches	Clean & lubricate	\$ 300	2	2	2	\$ 1,800
24	Traffic Barriers (Veh. & Ped.)	Clean & lubricate	\$ 200	5	7	7	\$ 3,800
25	Not Used		\$ -				\$ -
26	Not Used		\$ -				\$ -
27	Not Used		\$ -				\$ -
<b>Projected Costs:</b>				<b>\$ 639,300</b>	<b>\$ 648,800</b>	<b>\$ 639,700</b>	<b>\$ 1,927,800</b>
<b>Annualized Cost:</b>				<b>\$ 42,800</b>			

**Structure Preservation - Engineering**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
28	Repair Design	Engineering	\$ 271,000	1	1	1	\$ 813,000
29	Repair Administration	Constr. Admin.	\$ 306,700	1	1	1	\$ 920,100
<b>Projected Costs:</b>				<b>\$ 585,100</b>	<b>\$ 585,100</b>	<b>\$ 585,100</b>	<b>\$ 1,755,300</b>
<b>Annualized Cost:</b>				<b>\$ 39,000</b>			

**Structure Preservation - Substructure**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
30	Foundations	None	\$ -				\$ -
31	Scour Repair	Aggregate on ice	\$ 5,000	2	2	2	\$ 30,000
32	W. Concourse Concrete Patching & Surf. Treat.	Repair	\$ 25,300		1		\$ 25,300
33	West Abut. Concrete Patching & Surf. Treat.	Repair	\$ 8,700		1		\$ 8,700
34	Piers 1 to 7 Concrete Repair Above Waterline	Sup. Br. - Replace	\$ 400,000		1		\$ 400,000
35	Pier 8 Concrete Repair Above Waterline	Sup. Br. - Replace	\$ 80,000	1		1	\$ 160,000
36	Pier 1 to 7 Concrete Repair Below Waterline	Repair	\$ 289,000		1		\$ 289,000
37	Pier 8 Concrete Repair Below Waterline	Repair	\$ 57,800	1		1	\$ 115,600
38	E. Abut Concrete Surface Repair	Repair	\$ 22,900		1		\$ 22,900
39	E. Abut Settlement Adjustments	Jack & Fill Pedestal	\$ 19,700		1		\$ 19,700
40	E. Abut. Slope Protection	Repair	\$ 2,900		1		\$ 2,900
<b>Projected Costs:</b>				<b>\$ 147,800</b>	<b>\$ 778,500</b>	<b>\$ 147,800</b>	<b>\$ 1,074,100</b>
<b>Annualized Cost:</b>				<b>\$ 23,900</b>			

**Structure Preservation - Superstructure - Spans 1 & 2**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
41	Mill and Overlay	Repair	\$ 5,400			1	\$ 5,400
<b>Projected Costs:</b>				\$ -	\$ -	\$ 5,400	\$ 5,400
<b>Annualized Cost:</b>				\$ 100			

**Structure Preservation - Superstructure - Truss Spans**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
42	Remove Flood Water Debris	Remove & Discard	\$ 10,100	3	3	3	\$ 90,900
43	Pack Rust Sealing	Paint Bridge	\$ 37,500	1	1	1	\$ 112,500
44	Bridge Painting - Below Deck	Paint Bridge	\$ 455,400	1		1	\$ 910,800
45	Bridge Painting - Full Structure	Paint Bridge	\$ 1,665,100		1		\$ 1,665,100
46	Bearings	Clean & lubricate	\$ 1,700	2	2	2	\$ 10,200
47	Stringers	Struct. Repair	\$ 28,500		1		\$ 28,500
48	Floor Beams	Struct. Repair	\$ 46,800		1		\$ 46,800
49	Lower Chord Members	Struct. Repair	\$ 190,200		1		\$ 190,200
50	Truss Webs (Vertical & Diagonals)	Repair	\$ 458,400	1			\$ 458,400
51	Truss Upper Lateral Bracing	Misc. Repair	\$ 10,000	1	1	1	\$ 30,000
52	Truss Lower Lateral Bracing	Lft. Span Only	\$ 4,000			1	\$ 4,000
53	Truss - Portal Frames	Misc. Repair	\$ 20,000	1	1	1	\$ 60,000
54	Truss - Interior Sway Bracing	Misc. Repair	\$ 20,000	1	1	1	\$ 60,000
55	Spot Painting	Misc. Repair	\$ 15,000	1		1	\$ 30,000
<b>Projected Costs:</b>				\$ 1,050,000	\$ 2,051,800	\$ 595,600	\$ 3,697,400
<b>Annualized Cost:</b>				\$ 82,200			

**Structure Preservation - Superstructure - Span 10**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
56	Deck	Patch/Crack Rep.	\$ 5,500			1	\$ 5,500
57	Strip Seal	Clean	\$ 400	7	7	7	\$ 8,400
58	Strip Seal	Rem. & Replace	\$ 4,300			1	\$ 4,300
<b>Projected Costs:</b>				\$ 2,800	\$ 12,600	\$ 2,800	\$ 18,200
<b>Annualized Cost:</b>				\$ 400			

**Structure Preservation - Sidewalk Support System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
59	Standard Support Brackets	Repair	\$ 6,800			1	\$ 6,800
60	Lift-Span Support Brackets	Repair	\$ 6,800			1	\$ 6,800
61	Fascia Stringer	Repair	\$ 6,800			1	\$ 6,800
62	Stringers	Repair	\$ 7,300			1	\$ 7,300
<b>Projected Costs:</b>				\$ -	\$ -	\$ 27,700	\$ 27,700
<b>Annualized Cost:</b>				\$ 600			

**Structure Preservation - Deck**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
63	Vehicular & Transition Deck	Patch	\$ 10,600		1	2	\$ 31,800
64	Vehicular & Transition Deck	Sealing	\$ 174,200		1		\$ 174,200
65	Span 9 to 10 Expansion Joints	Replace Gland	\$ 7,400	1	1	1	\$ 22,200
66	Drainage System	Repair	\$ 1,200		1	1	\$ 2,400
67	Pedestrian Deck	Seal	\$ 44,000		1		\$ 44,000
68	Pedestrian Deck	Patch	\$ 3,800		1	2	\$ 11,400
69	Ped. Deck Expansion Joints	Clean & Adjust	\$ 1,400	1	1	1	\$ 4,200
70	Ped. Deck Expansion Joints	Replace	\$ 9,600				\$ -
<b>Projected Costs:</b>				\$ 8,800	\$ 242,600	\$ 38,800	\$ 290,200
<b>Annualized Cost:</b>				\$ 6,400			

**Structure Preservation - Railing**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
71	Concrete Railing	Minor Repair	\$ 2,500	2	2	4	\$ 20,000
72	Pedestrian Railing	Minor Repair	\$ 900		2	3	\$ 4,500
73	Pedestrian Railing	Spot Repair	\$ 7,700			2	\$ 15,400
<b>Projected Costs:</b>				\$ -	\$ 1,800	\$ 18,100	\$ 19,900
<b>Annualized Cost:</b>				\$ 400			

**Structure Preservation - Support System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
74	Strike Plates & Live Load Shoes	Clean & adjust	\$ 2,300	1	1	1	\$ 6,900
75	Span & Counterweight Guides	Repair	\$ 18,200			1	\$ 18,200
76	Ladders/ Platforms	Repair	\$ 1,100		1		\$ 1,100
<b>Projected Costs:</b>				\$ 2,300	\$ 3,400	\$ 20,500	\$ 26,200
<b>Annualized Cost:</b>				\$ 600			

**Structure Preservation - Balance System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
77	Counterweight Wire Ropes	Replace	\$ 768,000		1		\$ 768,000
78	Counterweights	Concrete Repair	\$ 15,300			1	\$ 15,300
<b>Projected Costs:</b>				\$ -	\$ 768,000	\$ 15,300	\$ 783,300
<b>Annualized Cost:</b>				\$ 17,400			

**Preservation Main. - Drive System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
79	Operating Wire Ropes	Replace	\$ 94,500		1		\$ 94,500
80	Circ. Breakers / Brakes	Minor Repair	\$ 7,000		1	1	\$ 14,000
<b>Projected Costs:</b>				\$ -	\$ 101,500	\$ 7,000	\$ 108,500
<b>Annualized Cost:</b>				\$ 2,400			

**Structure Preservation - Distribution/Control System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
81	Motor Controls	Misc. Repair	\$ 5,100			1	\$ 5,100
82	Switchgear	Misc. Repair	\$ 2,200			1	\$ 2,200
83	Wire & Cable & Festoon Cables	Misc. Repair	\$ 12,800			1	\$ 12,800
84	Conduit and Junction Boxes	Misc. Repair	\$ 2,100			1	\$ 2,100
85	Control Console	Misc. Repair	\$ 2,200			1	\$ 2,200
86	Portable Traffic Controls	Misc. Repair	\$ 500			1	\$ 500
87	PLC Control System	Replace	\$ 25,700		1		\$ 25,700
88	Transformer	Misc. Repair	\$ 1,100			1	\$ 1,100
<b>Projected Costs:</b>				\$ -	\$ 25,700	\$ 26,000	\$ 51,700
<b>Annualized Cost:</b>				\$ 1,100			

**Structure Preservation - Navigation Guidance System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
89	Lights Fixtures	Misc. Repair	\$ 1,300	1	2	2	\$ 6,500
90	Signage Lighting	Misc. Repair	\$ 1,800			1	\$ 1,800
91	Radio Trans./Receiver	Replace	\$ 200	1			\$ 200
<b>Projected Costs:</b>				\$ 1,500	\$ 2,600	\$ 4,400	\$ 8,500
<b>Annualized Cost:</b>				\$ 200			

**Structure Preservation - Traffic Control System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
92	Traffic Barriers (Veh. & Ped.)	Misc. Repair	\$ 1,300	1	1	1	\$ 3,900
93	Traffic Signals / Bells & Gongs	Misc. Repair	\$ 500	1	1	1	\$ 1,500
94	Traffic Gate Support	Misc. Repair	\$ 2,500			1	\$ 2,500
<b>Projected Costs:</b>				\$ 1,800	\$ 1,800	\$ 4,300	\$ 7,900
<b>Annualized Cost:</b>				\$ 200			

**Structure Preservation - Machinery/Tender's House**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
95	Deck & Grating	Misc. Repair	\$ 1,300		1	1	\$ 2,600
96	Windows / Door / Lock Set	Misc. Repair	\$ 400		1	1	\$ 800
97	Sheathing & Roof	Misc. Repair	\$ 2,500			1	\$ 2,500
98	AC / Heating / Telephone / Detection / Suppres.	Misc. Repair	\$ 400	1	2	3	\$ 2,400
<b>Projected Costs:</b>				\$ 400	\$ 2,500	\$ 5,400	\$ 8,300
<b>Annualized Cost:</b>				\$ 200			

**Structure Preservation - Bridge Lighting**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Cost (2003 US \$)
99	Roadway Lighting	Misc. Repair	\$ 2,200	1	1	1	\$ 6,600
<b>Projected Costs:</b>				\$ 2,200	\$ 2,200	\$ 2,200	\$ 6,600
<b>Annualized Cost:</b>				\$ 100			

**Component Failure**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)				45 Yr. Cost (2003 US \$)
100	Substruct. E. Abut. Foundation Stabilization	Repair	\$ 350,000				\$ 500,000
101	Substructure Chloride Extraction (6 Piers)	Repair	\$ 571,500				\$ 572,000
102	Substructure - Pier Replacement (2 each)	Demo. & Replace	\$ 450,000				\$ 450,000
103	Superstructure Bearings	Rehab.	\$ 48,500				\$ 48,000
104	Lower Chord Connections - Bolts for Rivets	Repair	\$ 256,000				\$ 256,000
105	Low. Chrd. Gusset Plate Repair	Replace	\$ 650,000				\$ 650,000
106	Vehicular & Transition Deck	Replace	\$ 402,000				\$ 402,000
107	Pedestrian Deck	Replace	\$ 200,000				\$ 200,000
108	Cntrwght. Trunnion Replacement	Replace	\$ 425,000				\$ 425,000
109	Operating Drums Replacement (2 each)	Replace	\$ 62,000				\$ 62,000
110	Counterweight Sheave (1 each)	Replace	\$ 650,000				\$ 650,000
106	Demolition - One Time Cost If Bridge Removed	Remove Bridge	\$ 600,000				\$ 600,000
<b>Annualized Cost:</b>				\$ 107,000			\$ 4,815,000

These opinions of maintenance projections and annual cost are based on concepts without benefit of :

- 1) prel. design & plans, 2) final design & plans, 3) accurate quantities or 4) confirmation of the level of maintenance.

Therefore, the opinions cost are subject to change.

The cost of labor, equipment and materials for maintenance are subject to market forces, which HNTB has no control over. The opinions of probable construction costs provided herein are made on the basis of engineering experience and represent our best judgment as experienced design professionals. However, no warranty or guarantee is provided or implied that actual total maintenance and operations costs will not vary significantly from the opinions of cost presented herein.

## **Appendix B Anticipated Maintenance/Preservation Activities and Associated Costs (Future Worth)**

The following pages present operations and maintenance tasks and their projected costs in future worth without contingency. Future worth costs are based on 2003 US dollar values adjusted using an annual escalation rate of 2.5%.

**Operations**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
1	Bridge Tender	Operate Br.	\$ 98,700	15	15	15	\$ 9,564,000
2	Electricity & Phone	Provide Service	\$ 1,400	15	15	15	\$ 135,700
3	Administration	Main. Records	\$ 2,000	15	15	15	\$ 193,800
4	Coordination	Pub. & Agency	\$ 1,900	15	15	15	\$ 184,100
5	Training	Personnel Training	\$ 600	2	2	2	\$ 7,800
6	Not Used		\$ -				\$ -
			<b>Projected Escal. Cost:</b>	<b>\$ 2,218,500</b>	<b>\$ 3,212,900</b>	<b>\$ 4,653,900</b>	<b>\$ 10,085,300</b>
			<b>Annualized Escal. Cost:</b>	<b>\$ 224,100</b>			

**Routine Maintenance**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
7	Flush Deck, drains, exp. Joints, sub-struct.	Power Wash	\$ 2,800	15	15	15	\$ 271,300
8	Structural Inspection	Base Inspection	\$ 15,700	11	11	11	\$ 1,115,600
9	In-Depth Structural Inspection	4-Year Inspection	\$ 27,300	4	4	4	\$ 705,400
10	Structural Analysis & Rating	Struct. Rating	\$ 59,500		1		\$ 122,500
11	Mech. & Elect. Inspection	Base Inspection	\$ 5,900	7	7	7	\$ 266,800
12	Underwater Inspection	5-year Inspection	\$ 14,000	3	3	3	\$ 271,300
13	Lamp Replacement - LED (10 each)	Replace Lamps	\$ 50,400	2	1	2	\$ 547,400
14	Lamp Replacement - HP Sodium	Replace Lamps	\$ 800	3	3	3	\$ 15,500
15	Sweep Clean Deck	Sweep	\$ 600	15	15	15	\$ 58,100
16	Snow Removal	Snow Removal	\$ 450	90	90	90	\$ 261,600
17	Counterweight Wire Ropes	Clean & lubricate	\$ 2,000	15	15	15	\$ 193,800
18	Gears/Bearing/Couplings/Shaft	Clean & lubricate	\$ 1,000	3	3	3	\$ 19,400
19	Operating Wire Ropes & Take-Up Devices	Clean / Lub / Adj.	\$ 2,700	15	15	15	\$ 261,600
20	Main Drive Motor	Clean/Lub./Repair	\$ 100	15	15	15	\$ 9,700
21	Gear Reducers	Clean & lubricate	\$ 1,300	1	1	1	\$ 8,400
22	Auxiliary Drive Motor	Clean/Lub./Repair	\$ 100	15	15	15	\$ 9,700
23	Limit Switches	Clean & lubricate	\$ 300	2	2	2	\$ 3,900
24	Traffic Barriers (Veh. & Ped.)	Clean & lubricate	\$ 200	5	7	7	\$ 8,500
25	Not Used		\$ -				\$ -
26	Not Used		\$ -				\$ -
27	Not Used		\$ -				\$ -
			<b>Projected Escal. Cost:</b>	<b>\$ 908,400</b>	<b>\$ 1,335,200</b>	<b>\$ 1,906,900</b>	<b>\$ 4,150,500</b>
			<b>Annualized Escal. Cost:</b>	<b>\$ 92,200</b>			

**Structure Preservation - Engineering**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
28	Repair Design	Engineering	\$ 271,000	1	1	1	\$ 1,750,660
29	Repair Administration	Constr. Admin.	\$ 306,700	1	1	1	\$ 1,981,282
			<b>Projected Escal. Cost:</b>	<b>\$ 585,100</b>	<b>\$ 585,100</b>	<b>\$ 585,100</b>	<b>\$ 3,779,746</b>
			<b>Annualized Escal. Cost:</b>	<b>\$ 84,000</b>			

**Structure Preservation - Substructure**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
30	Foundations	None	\$ -				\$ -
31	Scour Repair	Aggregate on ice	\$ 5,000	2	2	2	\$ 64,600
32	W. Concourse Concrete Patching & Surf. Treat.	Repair	\$ 25,300		1		\$ 52,100
33	West Abut. Concrete Patching & Surf. Treat.	Repair	\$ 8,700		1		\$ 17,900
34	Piers 1 to 7 Concrete Repair Above Waterline	Sup. Br. - Replace	\$ 400,000		1		\$ 823,200
35	Pier 8 Concrete Repair Above Waterline	Sup. Br. - Replace	\$ 80,000	1		1	\$ 352,200
36	Pier 1 to 7 Concrete Repair Below Waterline	Repair	\$ 289,000		1		\$ 594,800
37	Pier 8 Concrete Repair Below Waterline	Repair	\$ 57,800	1		1	\$ 254,400
38	E. Abut Concrete Surface Repair	Repair	\$ 22,900		1		\$ 47,100
39	E. Abut Settlement Adjustments	Jack & Fill Pedestal	\$ 19,700		1		\$ 40,500
40	E. Abut. Slope Protection	Repair	\$ 2,900		1		\$ 6,000
			<b>Projected Escal. Cost:</b>	<b>\$ 210,000</b>	<b>\$ 1,602,200</b>	<b>\$ 440,600</b>	<b>\$ 2,252,800</b>
			<b>Annualized Escal. Cost:</b>	<b>\$ 50,100</b>			

**Structure Preservation - Superstructure - Spans 1 & 2**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
41	Mill and Overlay	Repair	\$ 5,400			1	\$ 16,100
<b>Projected Escal. Cost:</b>				\$ -	\$ -	\$ 16,100	\$ 16,100
<b>Annualized Escal. Cost:</b>				\$ 400			

**Structure Preservation - Superstructure - Truss Spans**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
42	Remove Flood Water Debris	Remove & Discard	\$ 10,100	3	3	3	\$ 195,700
43	Pack Rust Sealing	Paint Bridge	\$ 37,500	1	1	1	\$ 242,300
44	Bridge Painting - Below Deck	Paint Bridge	\$ 455,400	1		1	\$ 2,004,700
45	Bridge Painting - Full Structure	Paint Bridge	\$ 1,665,100		1		\$ 3,426,800
46	Bearings	Clean & lubricate	\$ 1,700	2	2	2	\$ 22,000
47	Stringers	Struct. Repair	\$ 28,500		1		\$ 58,700
48	Floor Beams	Struct. Repair	\$ 46,800		1		\$ 96,300
49	Lower Chord Members	Struct. Repair	\$ 190,200		1		\$ 391,400
50	Truss Webs (Vertical & Diagonals)	Repair	\$ 458,400	1			\$ 651,400
51	Truss Upper Lateral Bracing	Misc. Repair	\$ 10,000	1	1	1	\$ 64,600
52	Truss Lower Lateral Bracing	Lft. Span Only	\$ 4,000			1	\$ 11,900
53	Truss - Portal Frames	Misc. Repair	\$ 20,000	1	1	1	\$ 129,200
54	Truss - Interior Sway Bracing	Misc. Repair	\$ 20,000	1	1	1	\$ 129,200
55	Spot Painting	Misc. Repair	\$ 15,000	1		1	\$ 66,000
<b>Projected Escal. Cost:</b>				\$ 1,492,100	\$ 4,222,600	\$ 1,775,500	\$ 7,490,200
<b>Annualized Escal. Cost:</b>				\$ 166,400			

**Structure Preservation - Superstructure - Span 10**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
56	Deck	Patch/Crack Rep.	\$ 5,500		1		\$ 11,300
57	Strip Seal	Clean	\$ 400	7	7	7	\$ 18,100
58	Strip Seal	Rem. & Replace	\$ 4,300		1		\$ 8,800
<b>Projected Escal. Cost:</b>				\$ 4,000	\$ 25,900	\$ 8,300	\$ 38,200
<b>Annualized Escal. Cost:</b>				\$ 800			

**Structure Preservation - Sidewalk Support System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
59	Standard Support Brackets	Repair	\$ 6,800			1	\$ 20,300
60	Lift-Span Support Brackets	Repair	\$ 6,800			1	\$ 20,300
61	Fascia Stringer	Repair	\$ 6,800			1	\$ 20,300
62	Stringers	Repair	\$ 7,300			1	\$ 21,800
<b>Projected Escal. Cost:</b>				\$ -	\$ -	\$ 82,600	\$ 82,600
<b>Annualized Escal. Cost:</b>				\$ 1,800			

**Structure Preservation - Deck**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
63	Vehicular & Transition Deck	Patch	\$ 10,600		1	2	\$ 85,000
64	Vehicular & Transition Deck	Sealing	\$ 174,200		1		\$ 358,500
65	Span 9 to 10 Expansion Joints	Replace Gland	\$ 7,400	1	1	1	\$ 47,800
66	Drainage System	Repair	\$ 1,200		1	1	\$ 6,000
67	Pedestrian Deck	Seal	\$ 44,000		1		\$ 90,600
68	Pedestrian Deck	Patch	\$ 3,800		1	2	\$ 30,500
69	Ped. Deck Expansion Joints	Clean & Adjust	\$ 1,400	1	1	1	\$ 9,000
70	Ped. Deck Expansion Joints	Replace	\$ 9,600				\$ -
<b>Projected Escal. Cost:</b>				\$ 12,500	\$ 499,300	\$ 115,700	\$ 627,500
<b>Annualized Escal. Cost:</b>				\$ 13,900			

**Structure Preservation - Railing**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
71	Concrete Railing	Minor Repair	\$ 2,500	2	2	4	\$ 47,200
72	Pedestrian Railing	Minor Repair	\$ 900		2	3	\$ 11,800
73	Pedestrian Railing	Spot Repair	\$ 7,700			2	\$ 45,900
<b>Projected Escal. Cost:</b>				\$ -	\$ 3,700	\$ 54,000	\$ 57,700
<b>Annualized Escal. Cost:</b>				\$ 1,300			

**Structure Preservation - Support System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
74	Strike Plates & Live Load Shoes	Clean & adjust	\$ 2,300	1	1	1	\$ 14,900
75	Span & Counterweight Guides	Repair	\$ 18,200			1	\$ 54,300
76	Ladders/ Platforms	Repair	\$ 1,100		1		\$ 2,300
<b>Projected Escal. Cost:</b>				\$ 3,300	\$ 7,000	\$ 61,100	\$ 71,400
<b>Annualized Escal. Cost:</b>				\$ 1,600			

**Structure Preservation - Balance System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
77	Counterweight Wire Ropes	Replace	\$ 768,000		1		\$ 1,580,500
78	Counterweights	Concrete Repair	\$ 15,300			1	\$ 45,600
<b>Projected Escal. Cost:</b>				\$ -	\$ 1,580,500	\$ 45,600	\$ 1,626,100
<b>Annualized Escal. Cost:</b>				\$ 36,100			

**Preservation Main. - Drive System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
79	Operating Wire Ropes	Replace	\$ 94,500		1		\$ 194,500
80	Circ. Breakers / Brakes	Minor Repair	\$ 7,000		1	1	\$ 35,300
<b>Projected Escal. Cost:</b>				\$ -	\$ 208,900	\$ 20,900	\$ 229,800
<b>Annualized Escal. Cost:</b>				\$ 5,100			

**Structure Preservation - Distribution/Control System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
81	Motor Controls	Misc. Repair	\$ 5,100			1	\$ 15,200
82	Switchgear	Misc. Repair	\$ 2,200			1	\$ 6,600
83	Wire & Cable & Festoon Cables	Misc. Repair	\$ 12,800			1	\$ 38,200
84	Conduit and Junction Boxes	Misc. Repair	\$ 2,100			1	\$ 6,300
85	Control Console	Misc. Repair	\$ 2,200			1	\$ 6,600
86	Portable Traffic Controls	Misc. Repair	\$ 500			1	\$ 1,500
87	PLC Control System	Replace	\$ 25,700		1		\$ 52,900
88	Transformer	Misc. Repair	\$ 1,100			1	\$ 3,300
<b>Projected Escal. Cost:</b>				\$ -	\$ 52,900	\$ 77,500	\$ 130,400
<b>Annualized Escal. Cost:</b>				\$ 2,900			

**Structure Preservation - Navigation Guidance System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
89	Lights Fixtures	Misc. Repair	\$ 1,300	1	2	2	\$ 14,900
90	Signage Lighting	Misc. Repair	\$ 1,800			1	\$ 5,400
91	Radio Trans./Receiver	Replace	\$ 200	1			\$ 300
<b>Projected Escal. Cost:</b>				\$ 2,100	\$ 5,400	\$ 13,100	\$ 20,600
<b>Annualized Escal. Cost:</b>				\$ 500			

**Structure Preservation - Traffic Control System**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
92	Traffic Barriers (Veh. & Ped.)	Misc. Repair	\$ 1,300	1	1	1	\$ 8,400
93	Traffic Signals / Bells & Gongs	Misc. Repair	\$ 500	1	1	1	\$ 3,200
94	Traffic Gate Support	Misc. Repair	\$ 2,500			1	\$ 7,500
<b>Projected Escal. Cost:</b>				<b>\$ 2,600</b>	<b>\$ 3,700</b>	<b>\$ 12,800</b>	<b>\$ 19,100</b>
<b>Annualized Escal. Cost:</b>				<b>\$ 400</b>			

**Structure Preservation - Machinery/Tender's House**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
95	Deck & Grating	Misc. Repair	\$ 1,300		1	1	\$ 6,600
96	Windows / Door / Lock Set	Misc. Repair	\$ 400		1	1	\$ 2,000
97	Sheathing & Roof	Misc. Repair	\$ 2,500			1	\$ 7,500
98	AC / Heating / Telephone / Detection / Suppres	Misc. Repair	\$ 400	1	2	3	\$ 5,800
<b>Projected Escal. Cost:</b>				<b>\$ 600</b>	<b>\$ 5,100</b>	<b>\$ 16,100</b>	<b>\$ 21,800</b>
<b>Annualized Escal. Cost:</b>				<b>\$ 500</b>			

**Structure Preservation - Bridge Lighting**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)	Occurrences Years 2010 to 2024	Occurrences Years 2025 to 2039	Occurrences Years 2039 to 2055	45 Yr. Escalated Cost
99	Roadway Lighting	Misc. Repair	\$ 2,200	1	1	1	\$ 14,200
<b>Projected Escal. Cost:</b>				<b>\$ 3,100</b>	<b>\$ 4,500</b>	<b>\$ 6,600</b>	<b>\$ 14,200</b>
<b>Annualized Escal. Cost:</b>				<b>\$ 300</b>			

**Component Failure**

Ref. No.	Item	Action	Cost Per Event (2003 US\$)				45 Yr. Escalated Cost
100	Substruct. E. Abut. Foundation Stabilization	Repair	\$ 350,000				\$ 1,259,500
101	Substructure Chloride Extraction (6 Piers)	Repair	\$ 571,500				\$ 1,440,900
102	Substructure - Pier Replacement (2 each)	Demo. & Replace	\$ 450,000				\$ 1,133,600
103	Superstructure Bearings	Rehab.	\$ 48,500				\$ 120,900
104	Lower Chord Connections - Bolts for Rivets	Repair	\$ 256,000				\$ 644,900
105	Low. Chrd. Gusset Plate Repair	Replace	\$ 650,000				\$ 1,637,400
106	Vehicular & Transition Deck	Replace	\$ 402,000				\$ 1,012,600
107	Pedestrian Deck	Replace	\$ 200,000				\$ 503,800
108	Cntrwght. Trunnion Replacement	Replace	\$ 425,000				\$ 1,070,600
109	Operating Drums Replacement (2 each)	Replace	\$ 62,000				\$ 156,200
110	Counterweight Sheave (1 each)	Replace	\$ 650,000				\$ 1,637,400
106	Demolition - One Time Cost If Bridge Removed	Remove Bridge	\$ 600,000				\$ 1,511,400
<b>Average Annual Escal. Cost:</b>				<b>\$ 269,500</b>			<b>\$ 12,129,200</b>

These opinions of maintenance projections and annual cost are based on concepts without benefit of :  
 1) prel. design & plans, 2) final design & plans, 3) accurate quantities or 4) confirmation of the level of maintenance.  
 Therefore, the opinions cost are subject to change.

The cost of labor, equipment and materials for maintenance are subject to market forces, which HNTB has no control over. The opinions of probable construction costs provided herein are made on the basis of engineering experience and represent our best judgment as experienced design professionals. However, no warranty or guarantee is provided or implied that actual total maintenance and operations costs will not vary significantly from the opinions of cost presented herein.

**OPERATIONS& ROUTINE MAINTENANCE COST SUMMARY (\$1,000 - Escalated)**

Item	Cost - Years '10 to 24 (Escalated)	Cost - Years '25 to '39 (Escalated)	Cost - Years '40 to '55 (Escalated)	Annualized Cost (Escalated)	45 Yr. Cost (Escalated)
Operations	\$ 2,218	\$ 3,213	\$ 4,654	\$ 224	\$ 10,085
Routine Maintenance	\$ 908	\$ 1,335	\$ 1,907	\$ 92	\$ 4,151
	\$ 3,127	\$ 4,548	\$ 6,561	\$ 316	\$ 14,236

**STRUCTURE PRESERVATION COST SUMMARY (\$1,000 - Escalated)**

Item	Cost - Years '10 to 24 (Escalated)	Cost - Years '25 to '39 (Escalated)	Cost - Years '40 to '55 (Escalated)	Annualized Cost (Escalated)	45 Yr. Cost (Escalated)
Engineering	\$ 585	\$ 585	\$ 585	\$ 84	\$ 3,780
Substructure	\$ 210	\$ 1,602	\$ 441	\$ 50	\$ 2,253
Superstructure - Spans 1 & 2	\$ -	\$ -	\$ 16	\$ 0	\$ 16
Superstructure - Truss Spans	\$ 1,492	\$ 4,223	\$ 1,775	\$ 166	\$ 7,490
Superstructure - Span 10	\$ 4	\$ 26	\$ 8	\$ 1	\$ 38
Sidewalk Support System	\$ -	\$ -	\$ 83	\$ 2	\$ 83
Deck	\$ 13	\$ 499	\$ 116	\$ 14	\$ 627
Railing	\$ -	\$ 4	\$ 54	\$ 1	\$ 58
Support System	\$ 3	\$ 7	\$ 61	\$ 2	\$ 71
Balance System	\$ -	\$ 1,581	\$ 46	\$ 36	\$ 1,626
Drive System	\$ -	\$ 209	\$ 21	\$ 5	\$ 230
Distribution/Control System	\$ -	\$ 53	\$ 78	\$ 3	\$ 130
Navigation Guidance System	\$ 2	\$ 5	\$ 13	\$ 1	\$ 21
Traffic Control System	\$ 3	\$ 4	\$ 13	\$ 0	\$ 19
Machinery/Tender's House	\$ 1	\$ 5	\$ 16	\$ 1	\$ 22
Bridge Lighting	\$ 3	\$ 5	\$ 7	\$ 0	\$ 14
	\$ 2,315	\$ 8,807	\$ 3,331	\$ 366	\$ 16,478

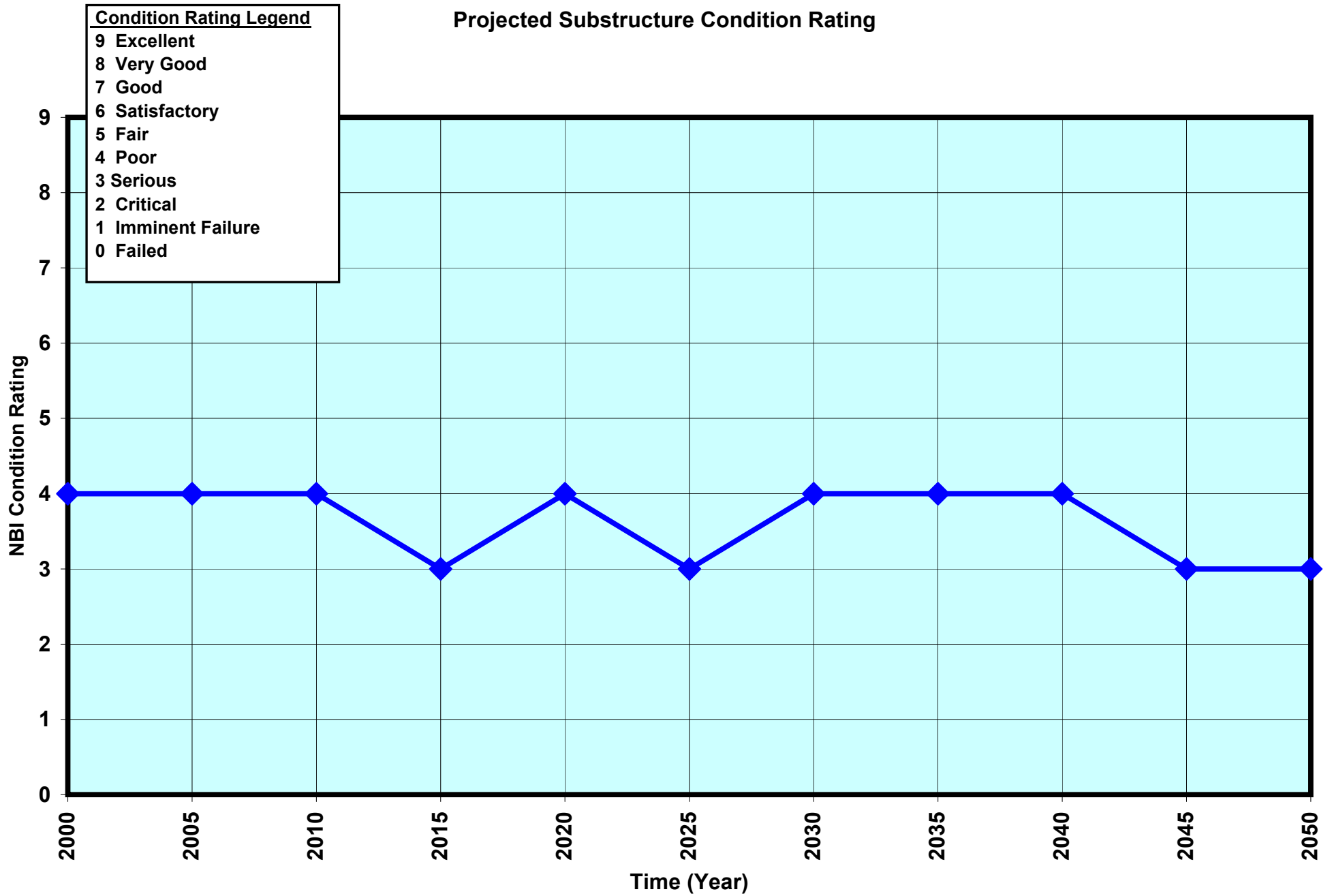
**COMPONENT FAILURE COST SUMMARY (\$1,000 - Escalated)**

Item	Annualized Cost (Escalated)	45 Yr. Cost (Escalated)
Substructure	\$ 85	\$ 3,834
Superstructure	\$ 53	\$ 2,403
Vehicular & Sidewalks Deck	\$ 34	\$ 1,516
Mech. & Electrical	\$ 64	\$ 2,864
Demolition & Removal	\$ 34	\$ 1,511
	\$ 270	\$ 12,129

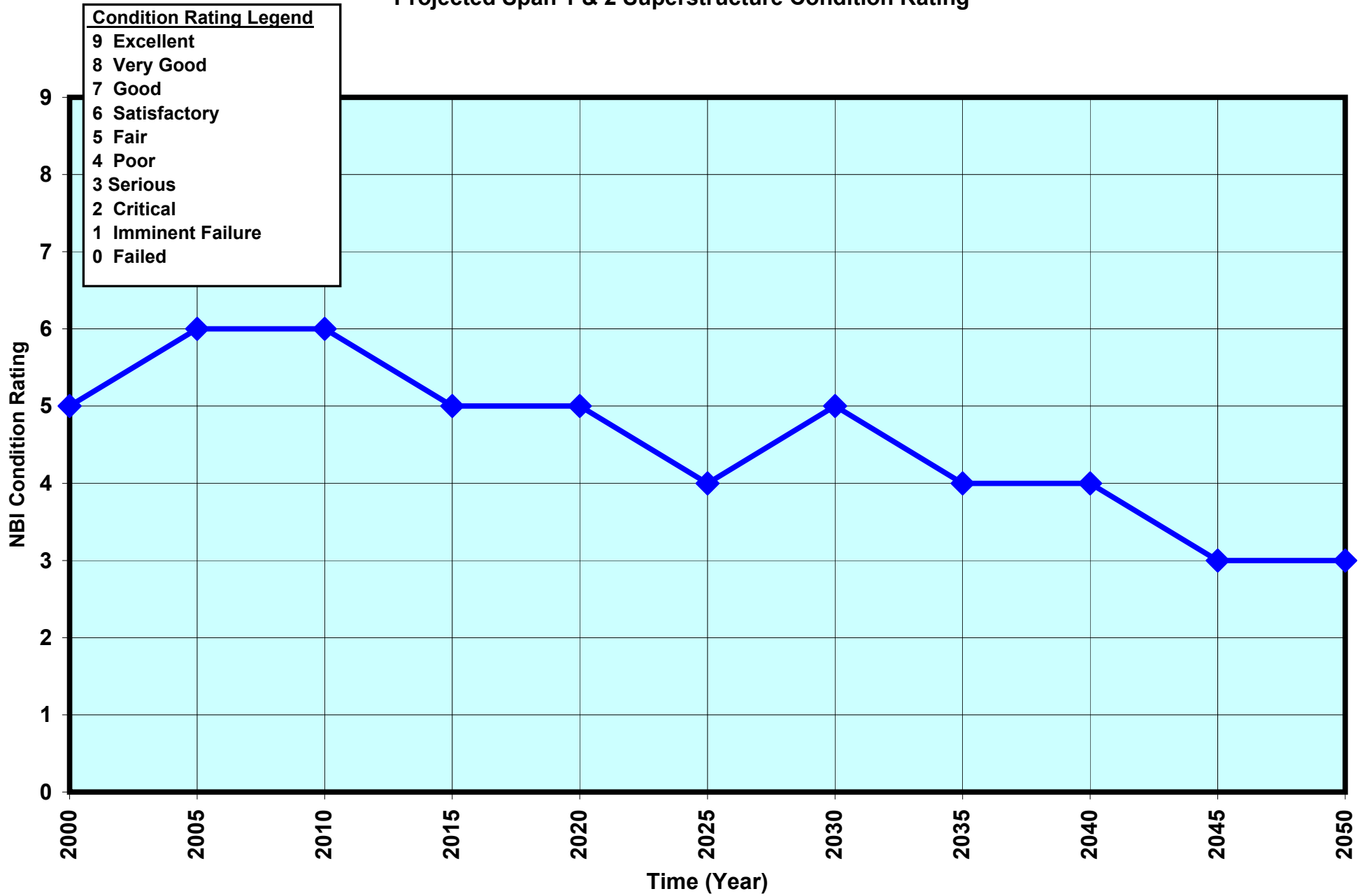
## **Appendix C Projected System Condition Rating Graphs**

The graphics on the following pages represent projected system condition ratings based on the assumption that maintenance and preservation will be applied to the bridge as described within the report and that the lift bridge will carry only pedestrian traffic from 2011 and beyond.

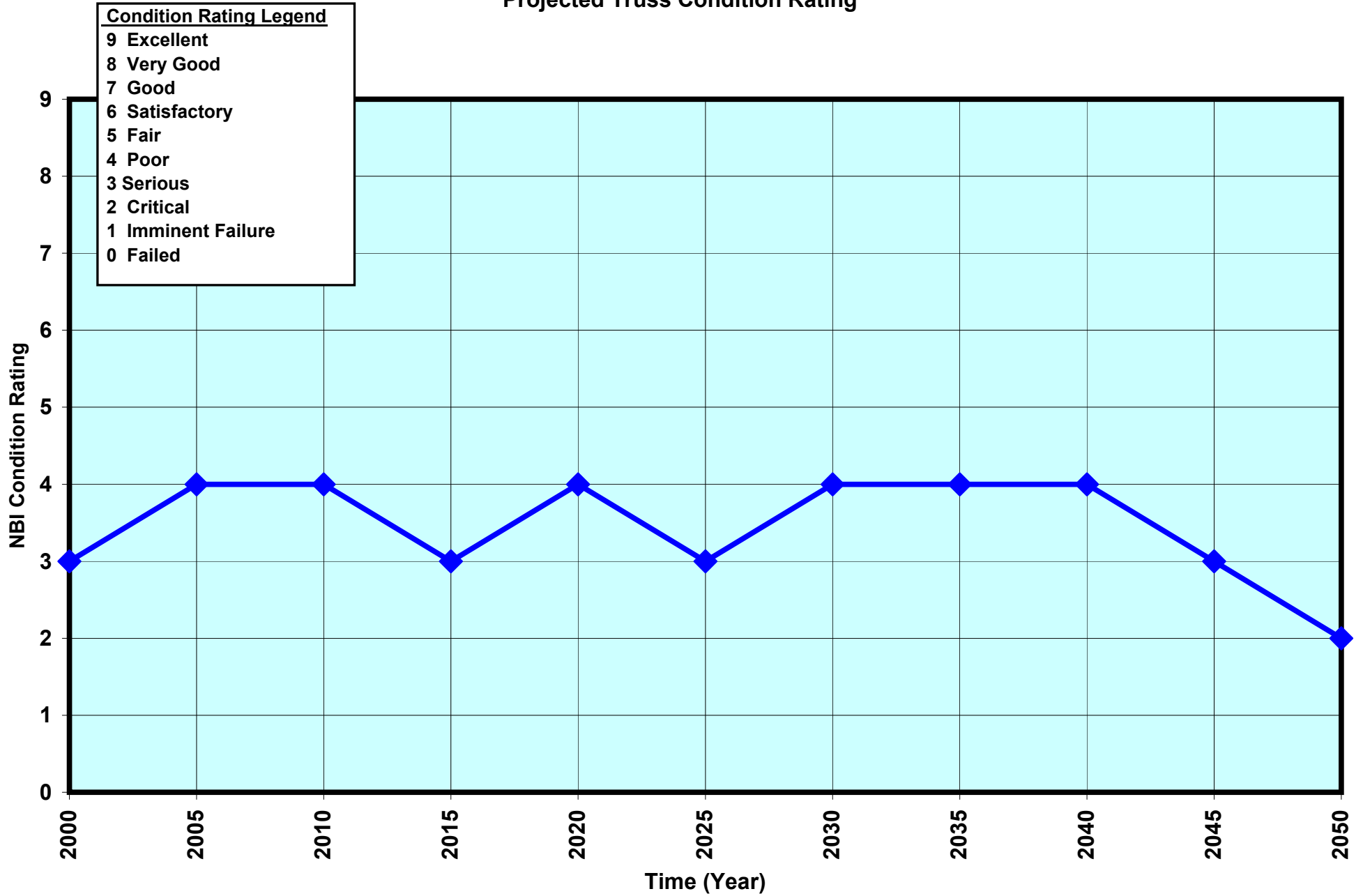
Projected Substructure Condition Rating



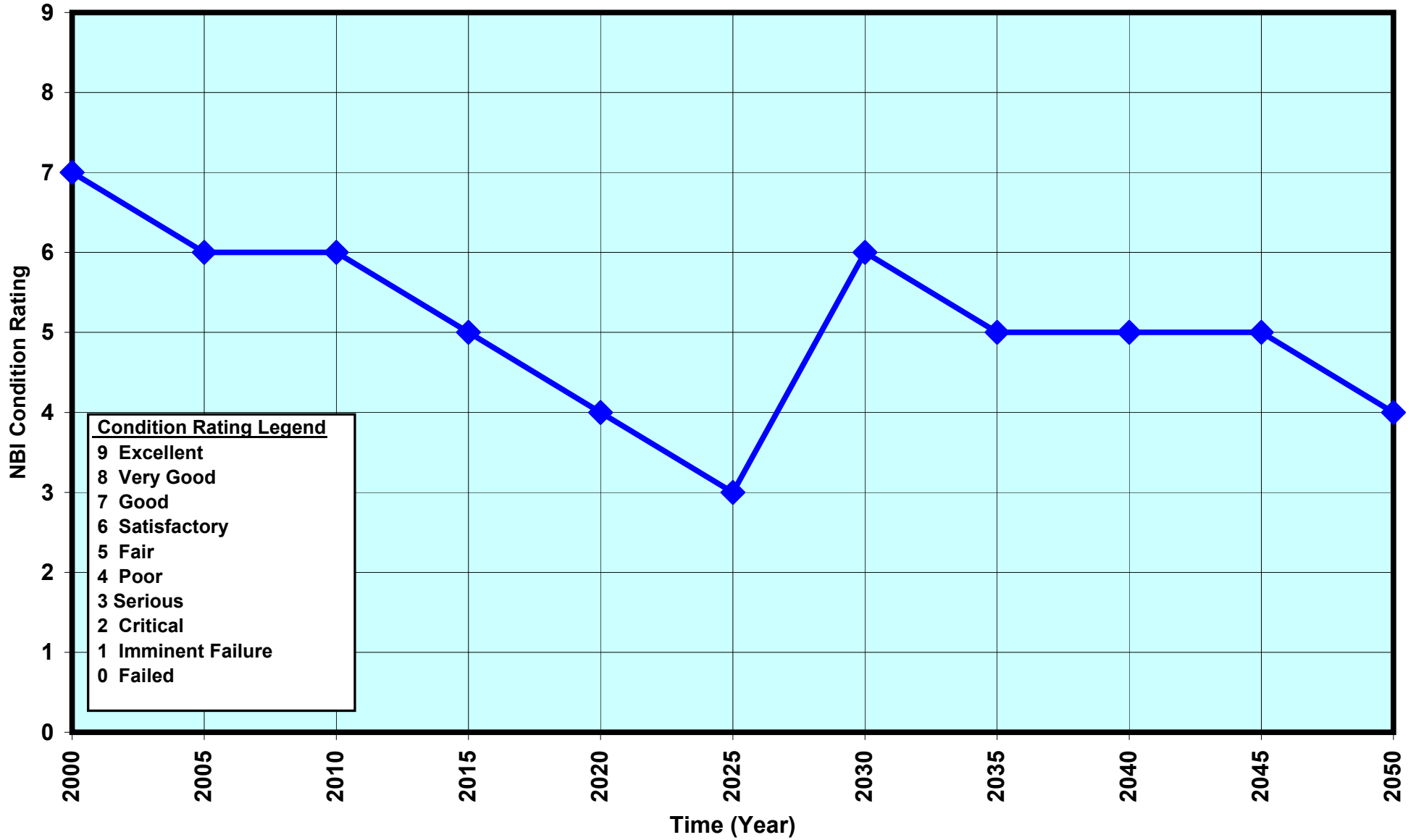
Projected Span 1 & 2 Superstructure Condition Rating



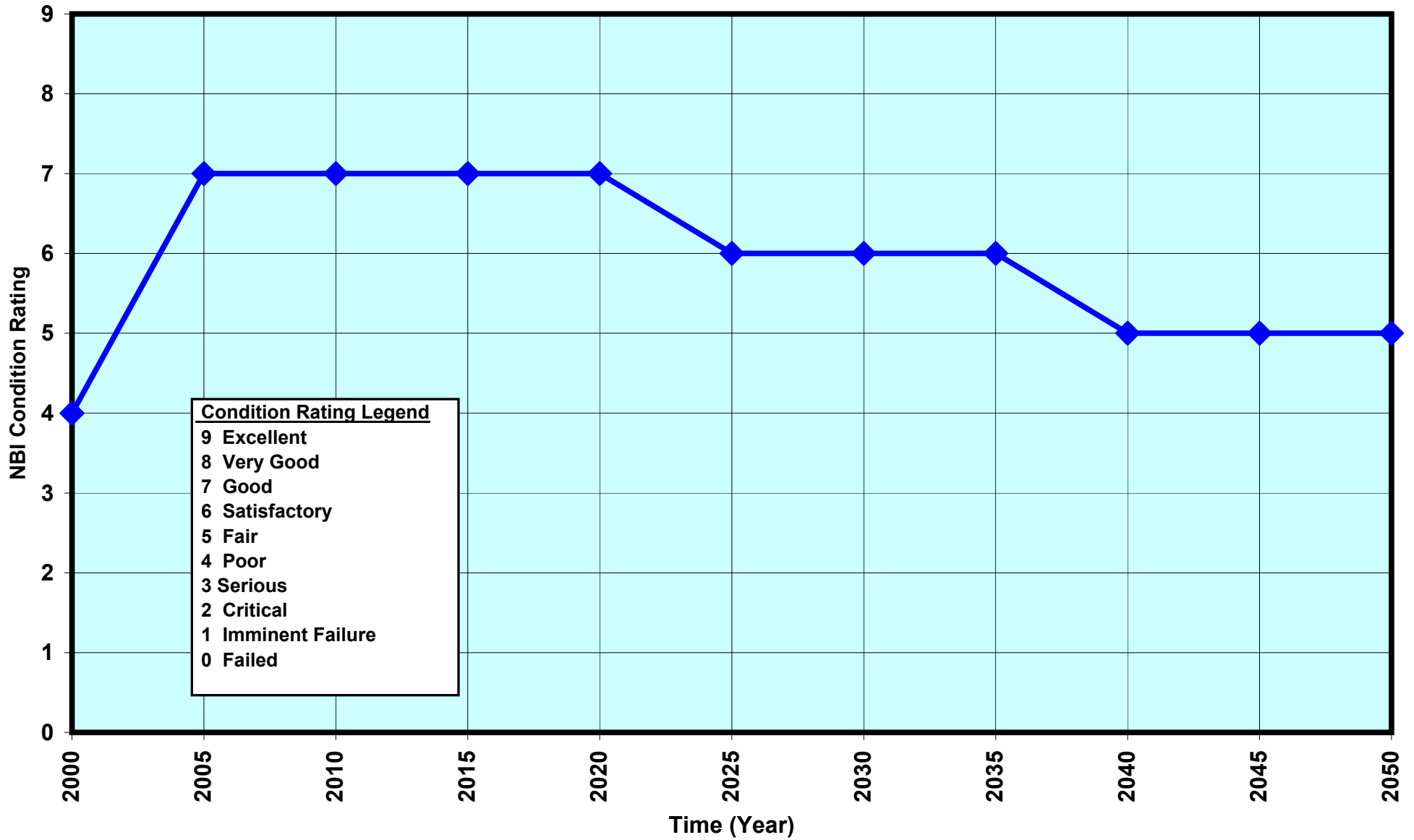
Projected Truss Condition Rating



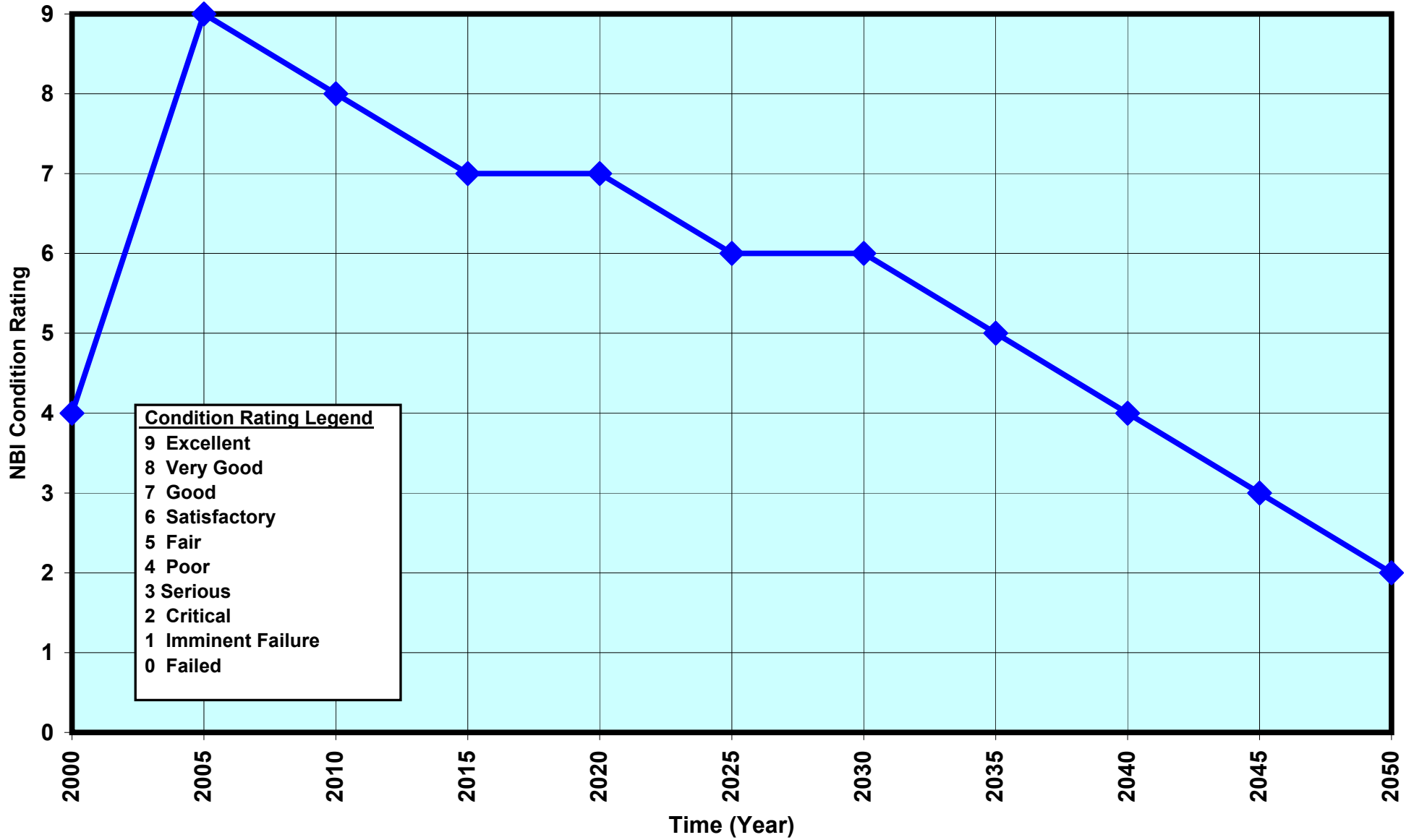
Projected Span 10 Condition Rating



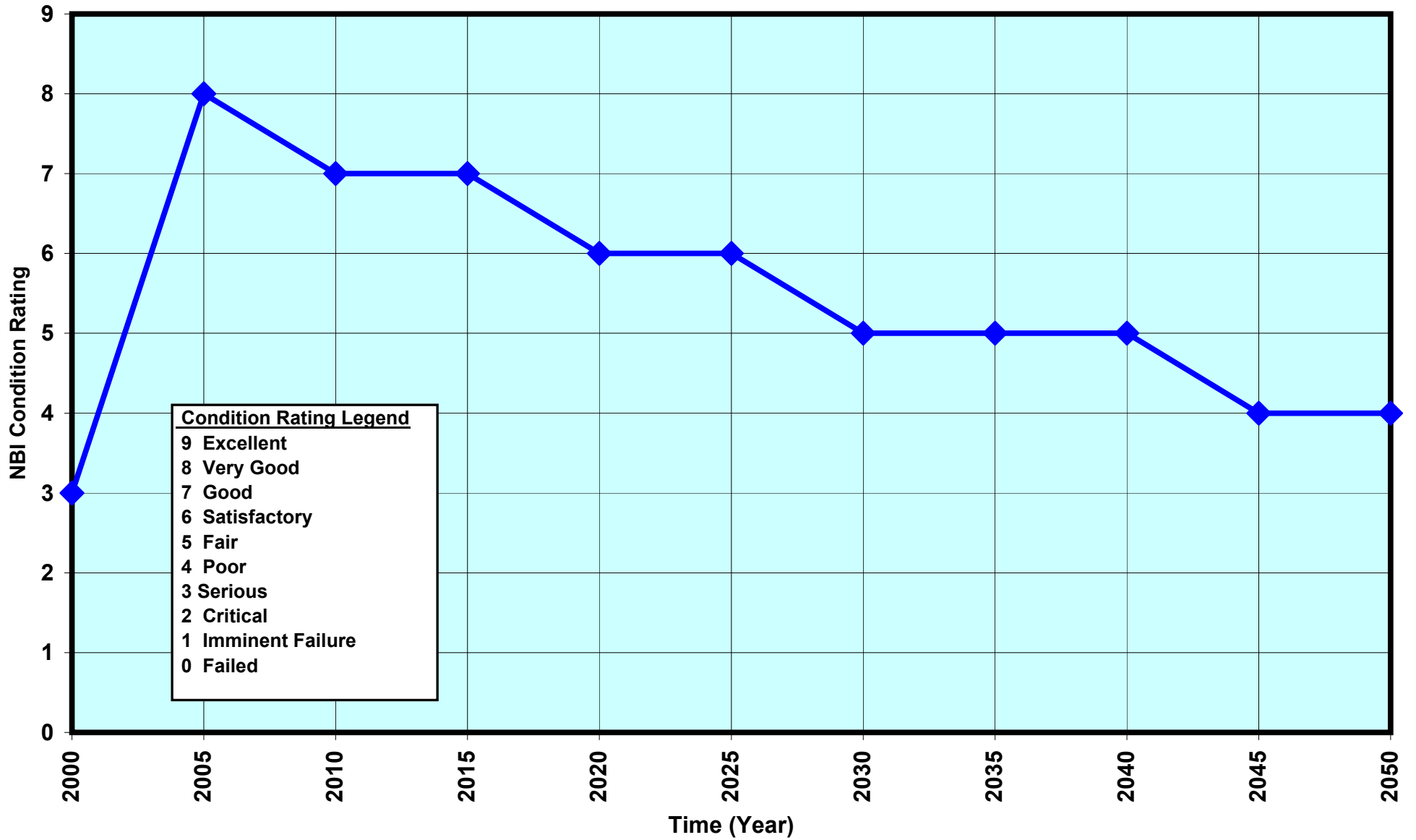
Projected Sidewalk Support System Condition Rating



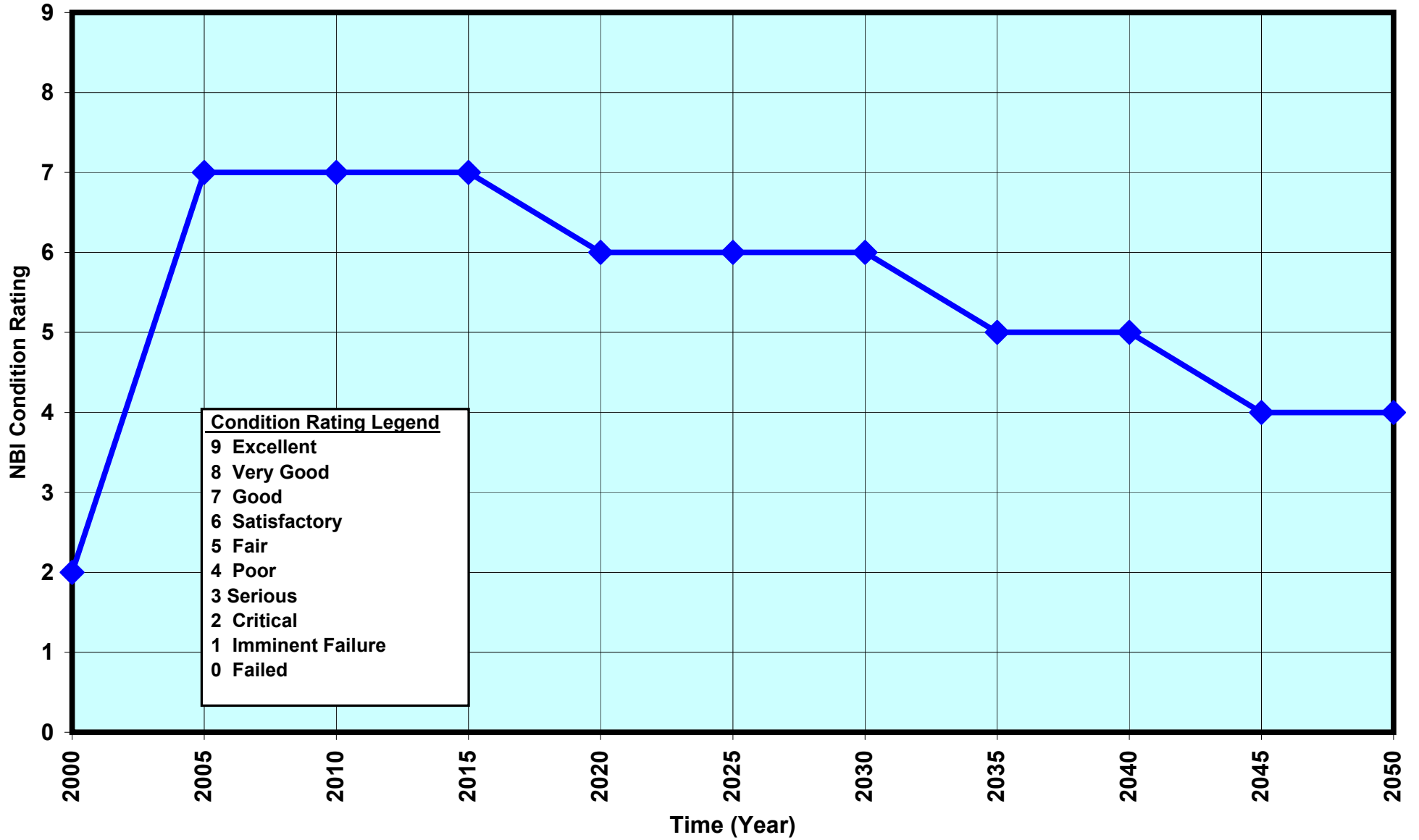
Projected Deck Condition Rating



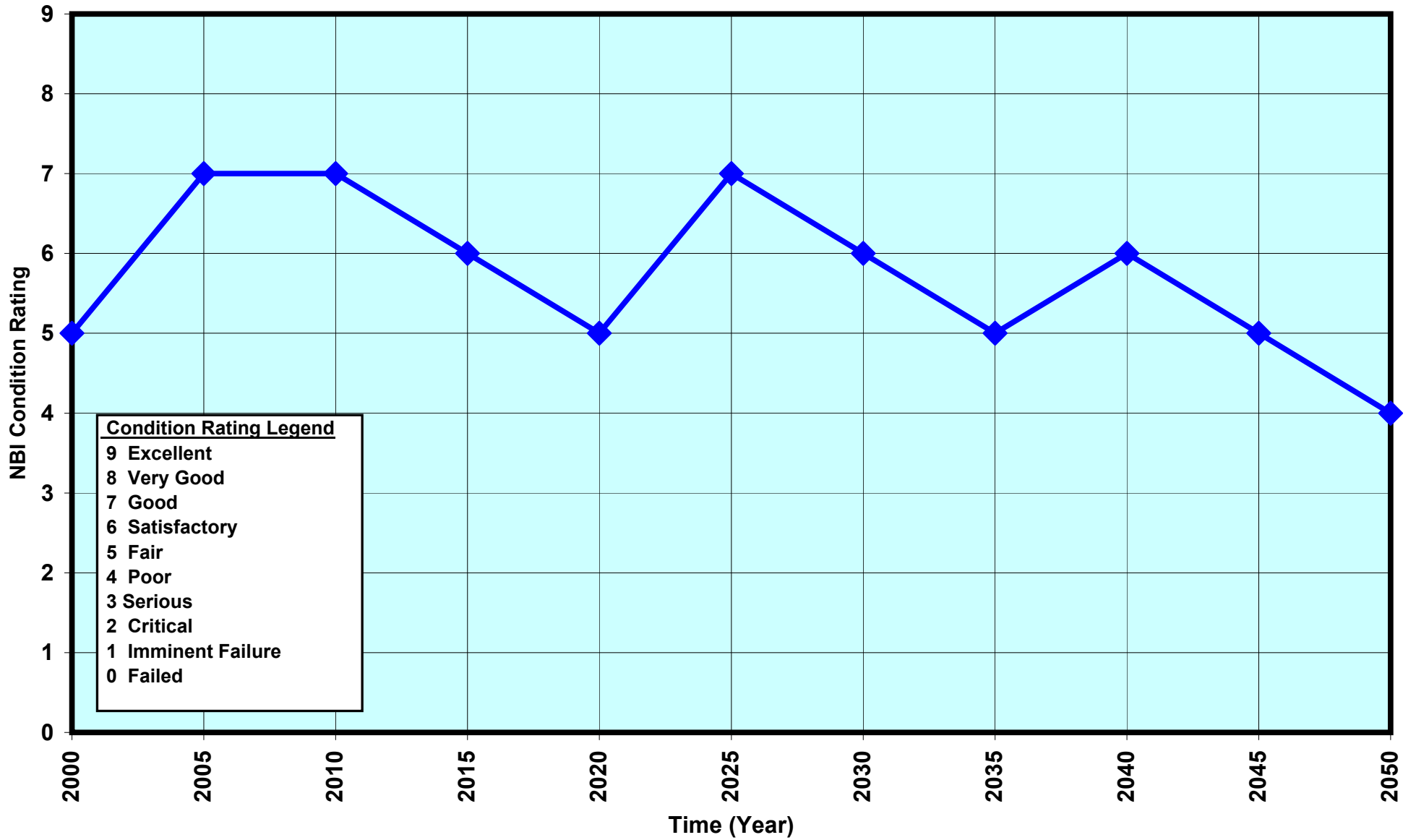
Projected Railing Condition Rating



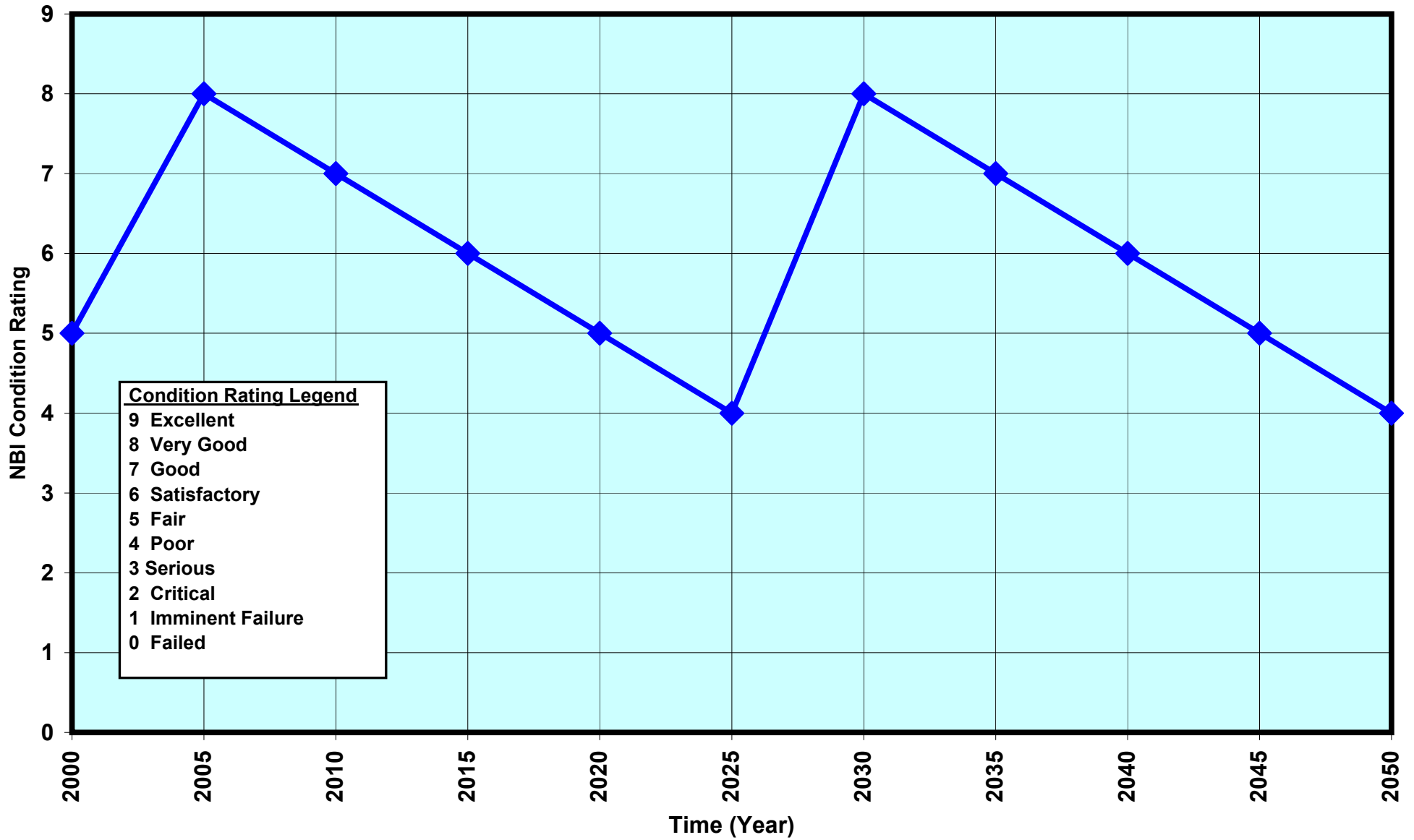
Projected Machinery/Tender's House Condition Rating



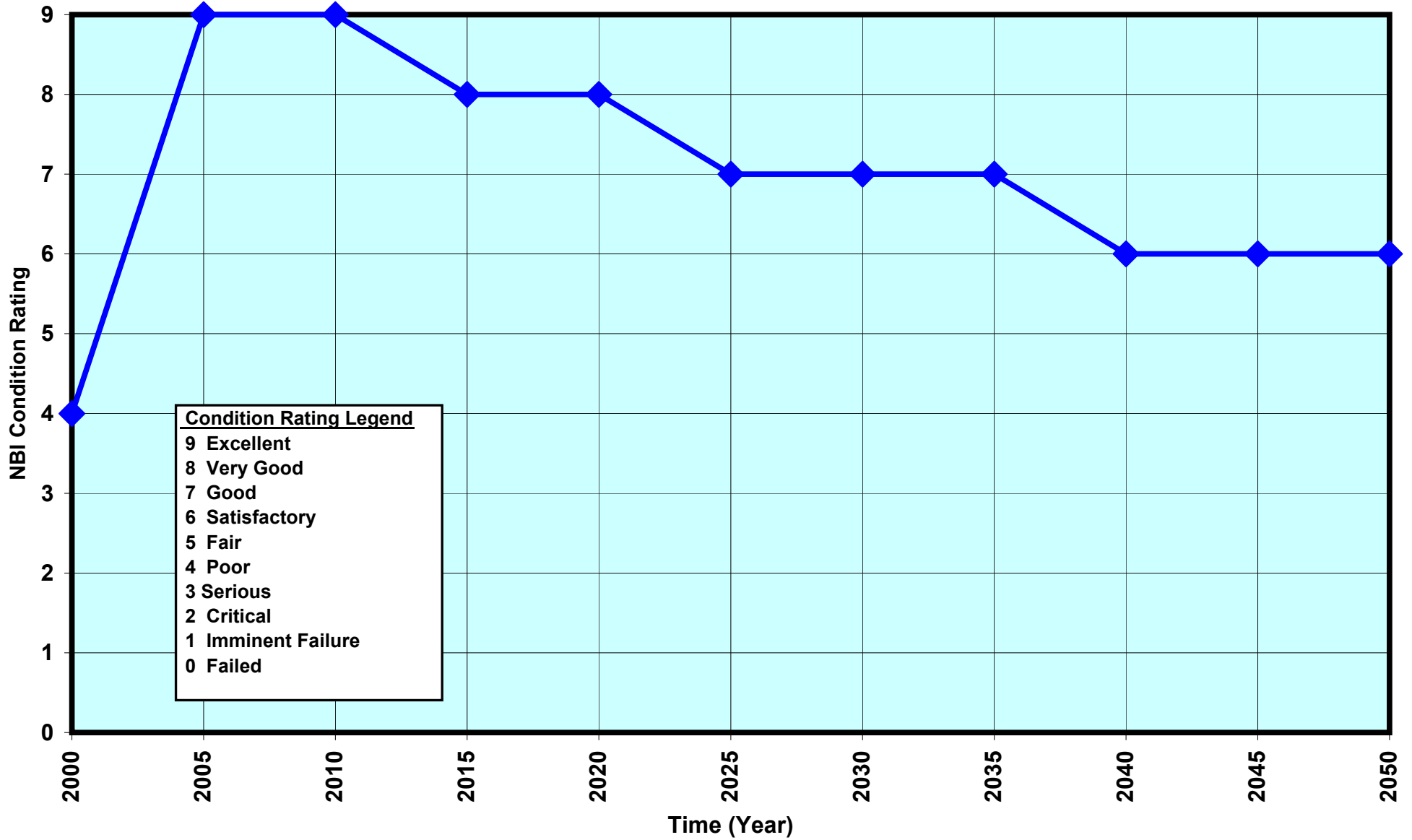
Projected Support System Condition Rating



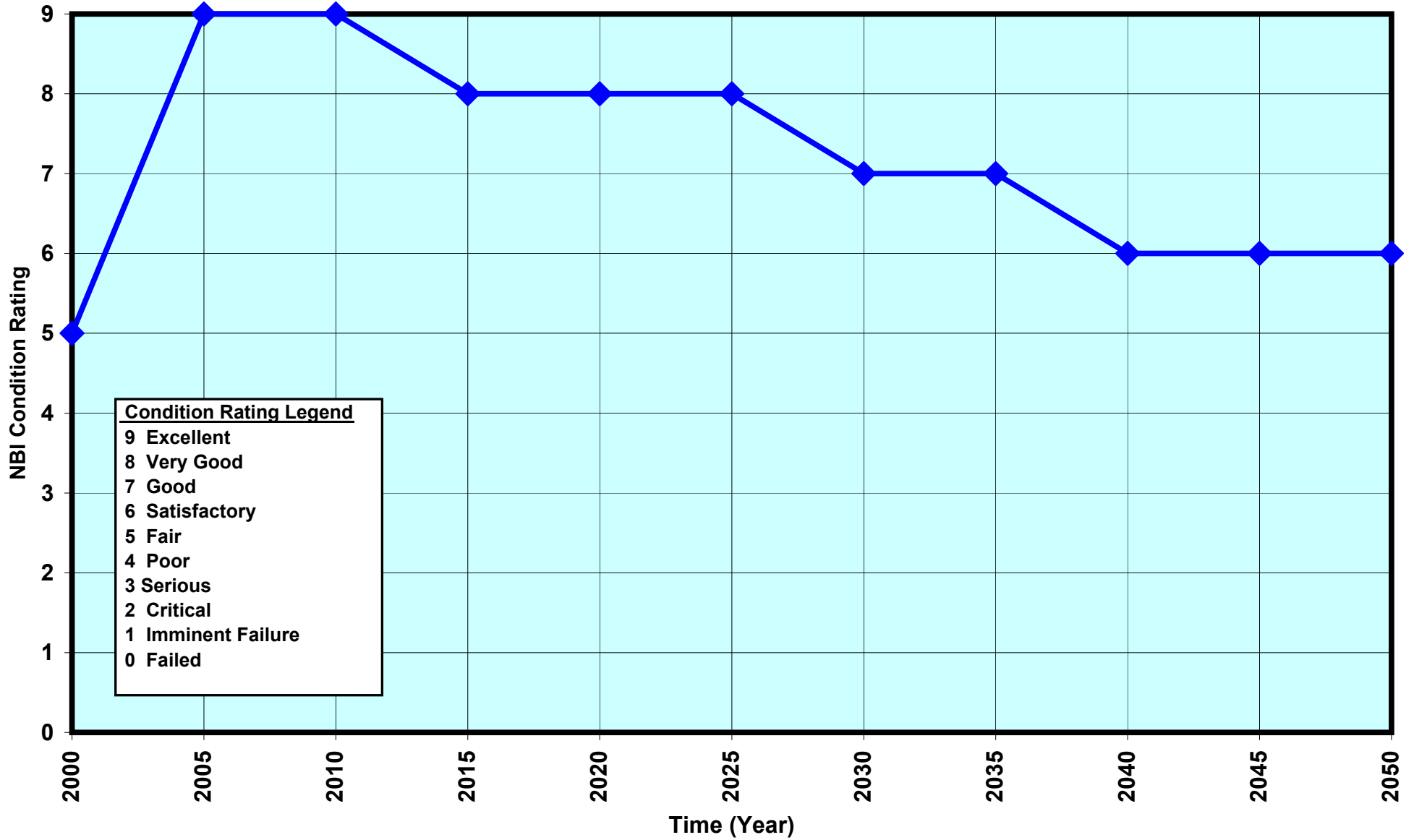
Projected Balance System Condition Rating



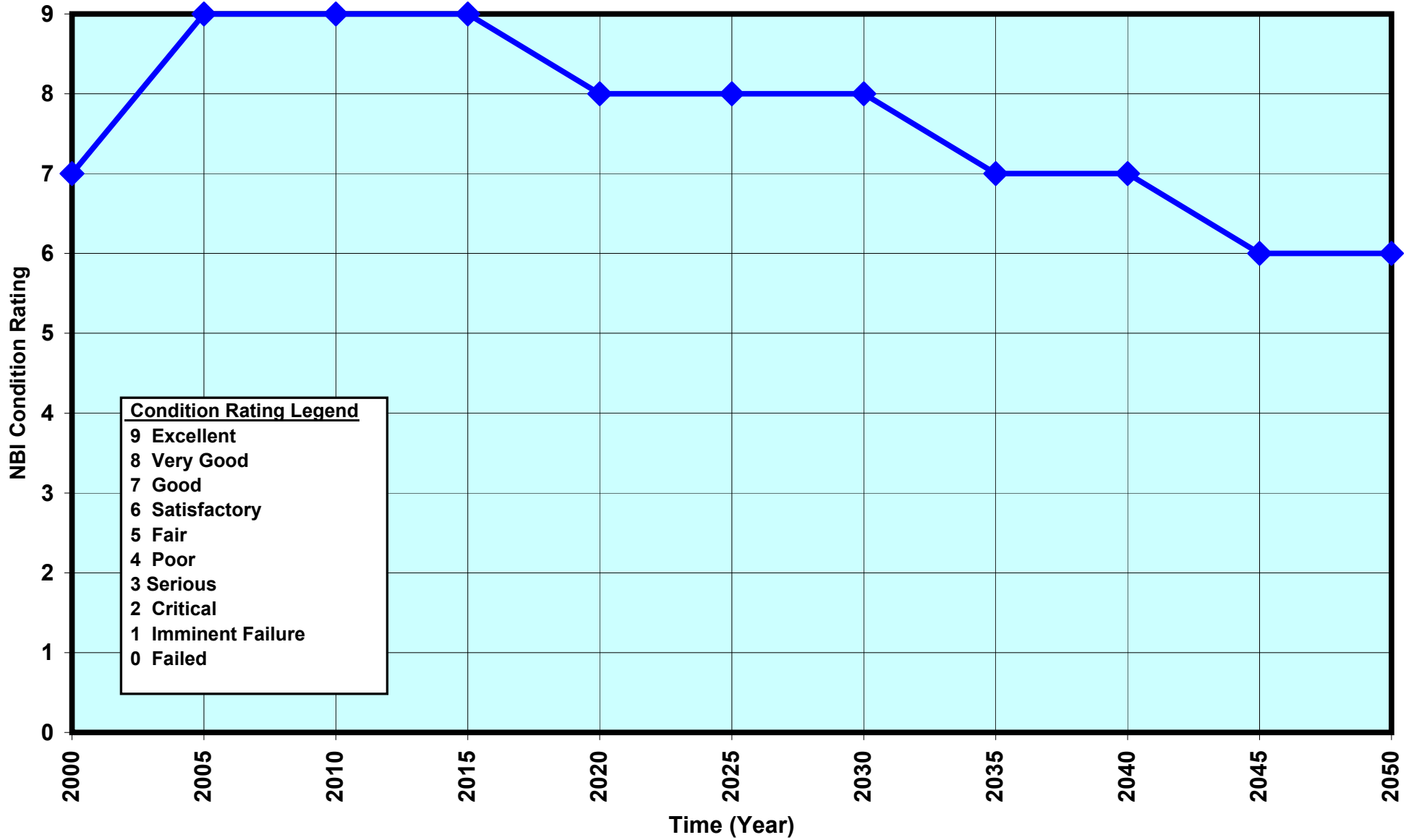
Projected Drive System Condition Rating



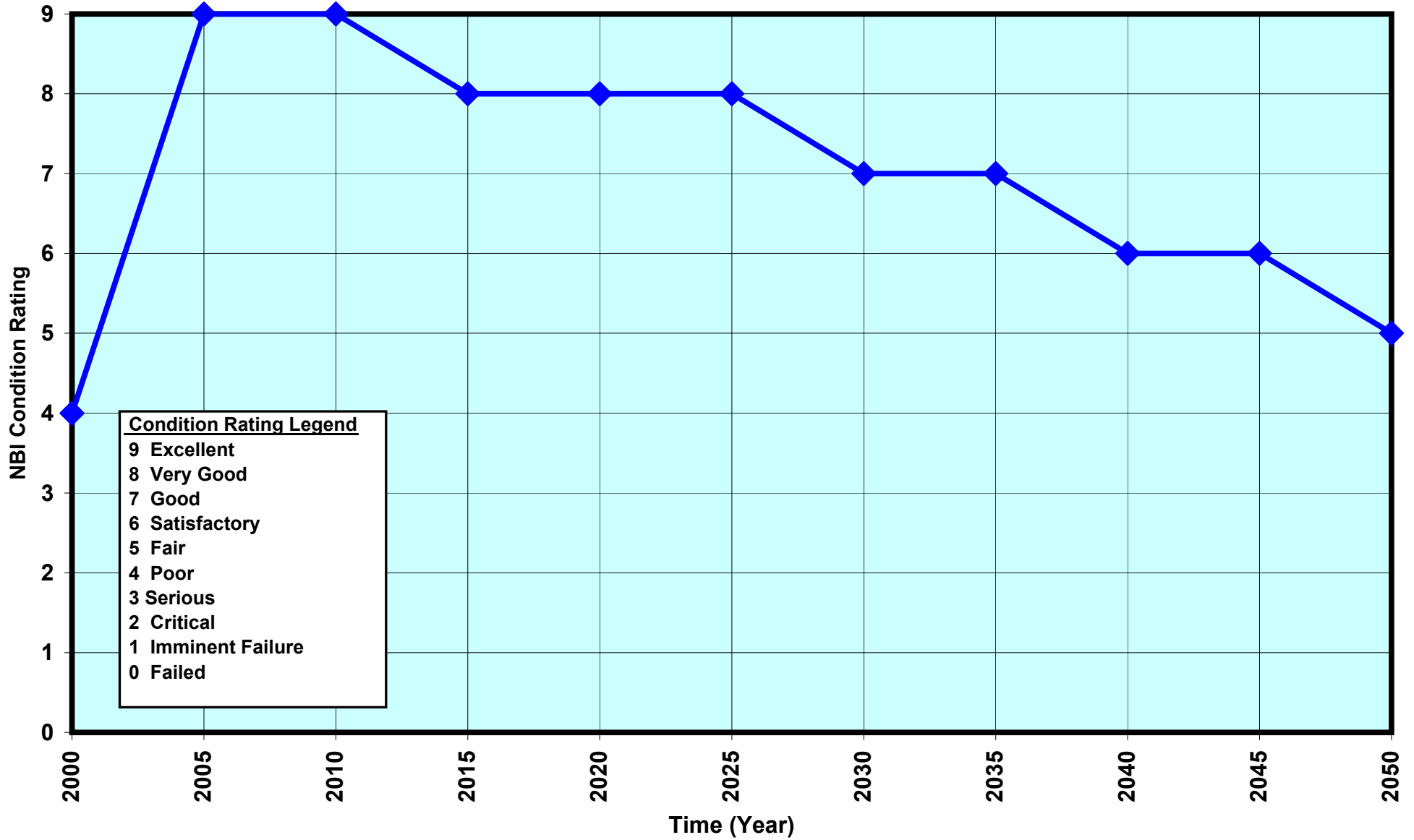
Projected Distribution & Control System Condition Rating



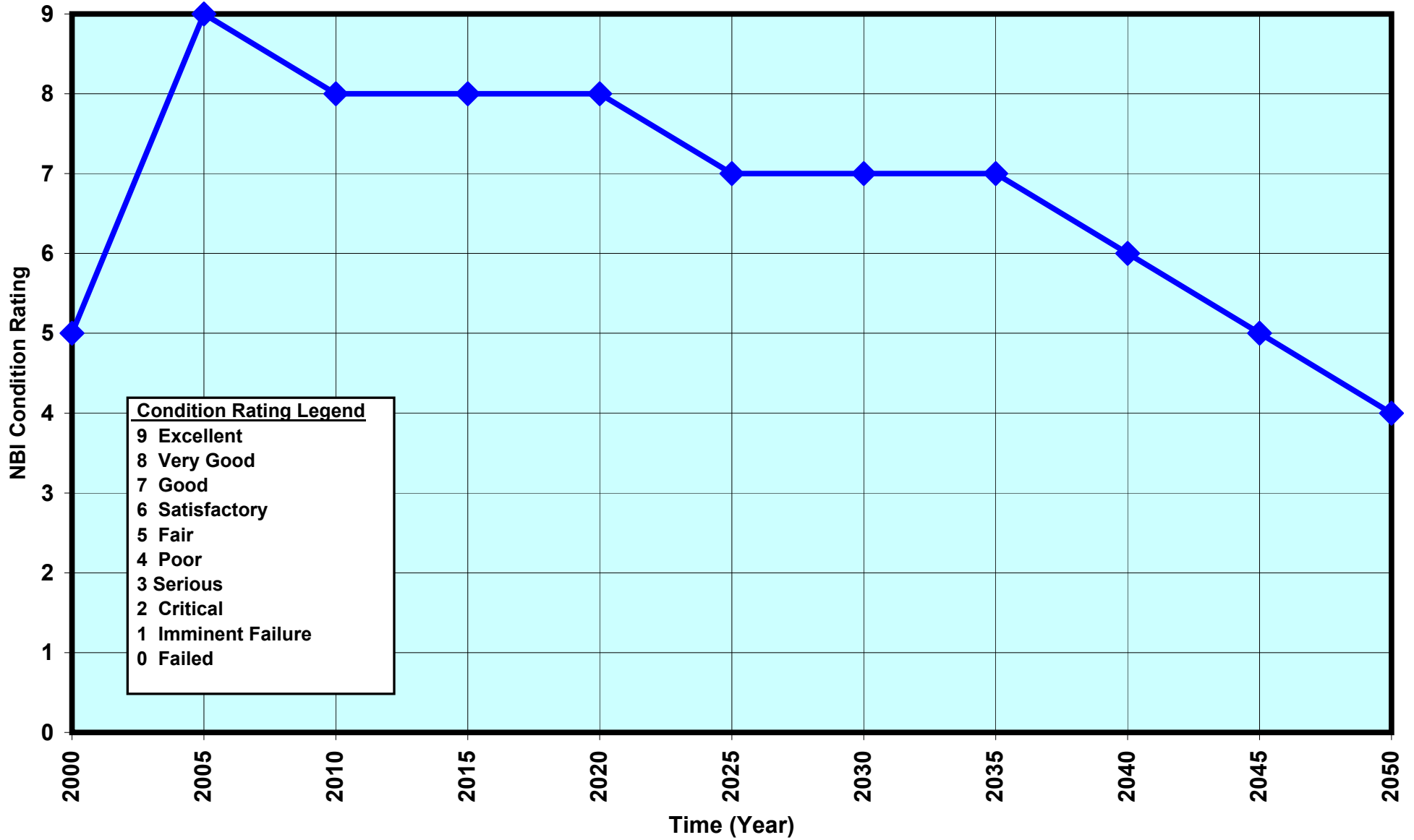
Projected Interlock System Condition Rating



Projected Navigation Guidance System Condition Rating



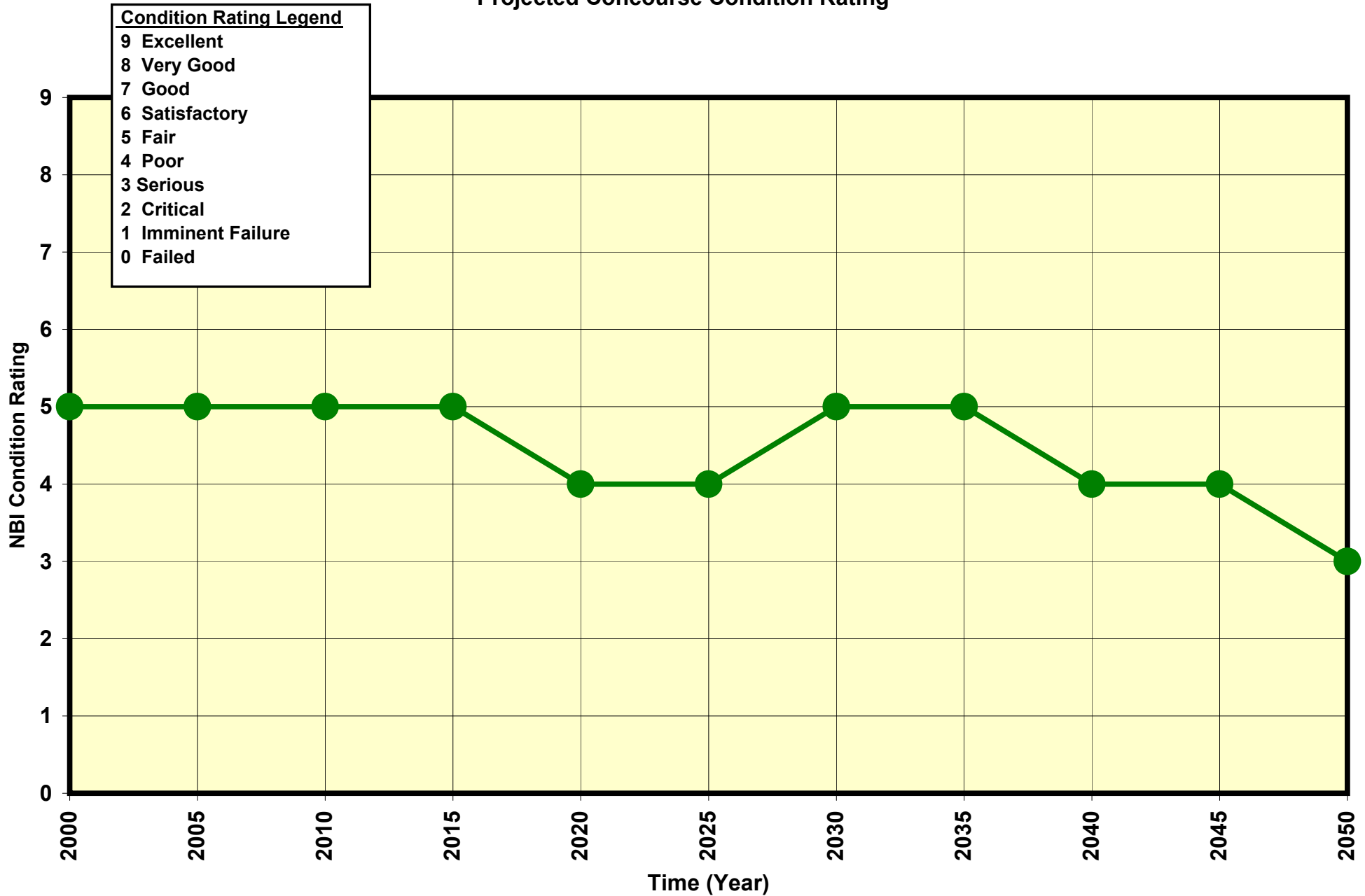
Projected Traffic Control System Condition Rating



## **Appendix D Projected Component (Selected) Condition Rating Graphs**

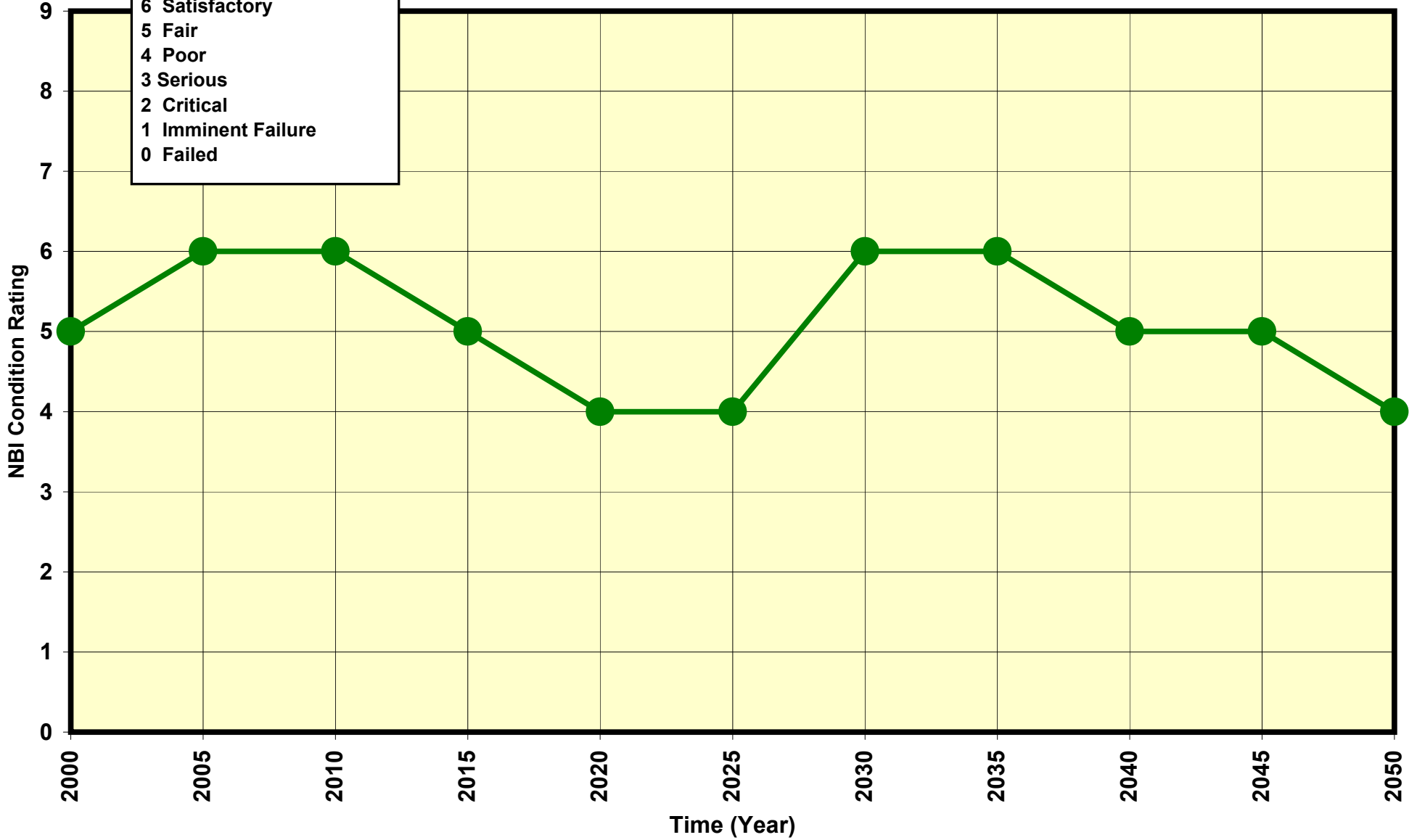
The graphics on the following pages represent projected component condition ratings based on the assumption that maintenance and preservation will be applied to the bridge as described within the report and that the lift bridge will carry only pedestrian traffic from 2011 and beyond.

Projected Concourse Condition Rating

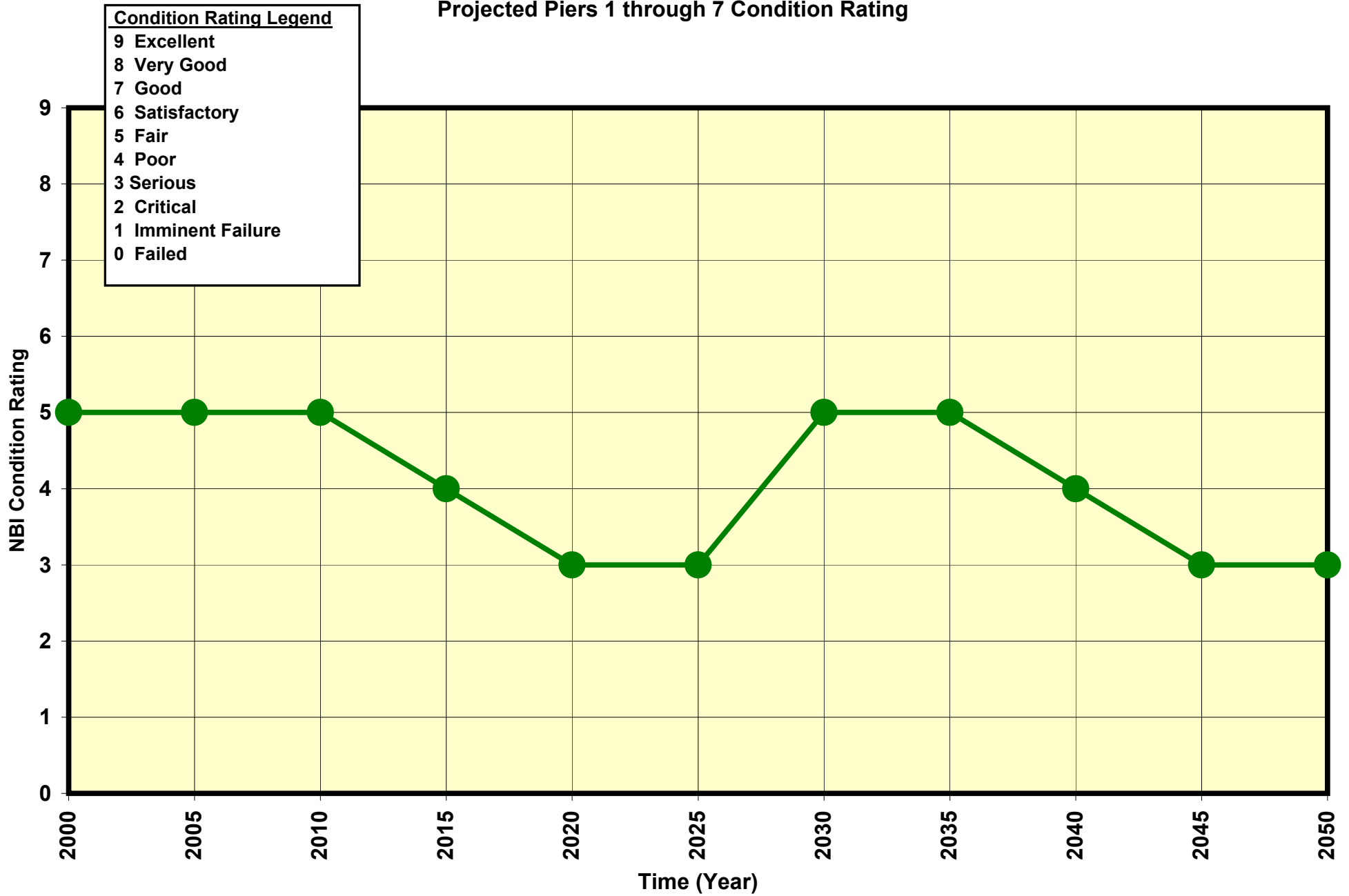


Projected West Abutment Condition Rating

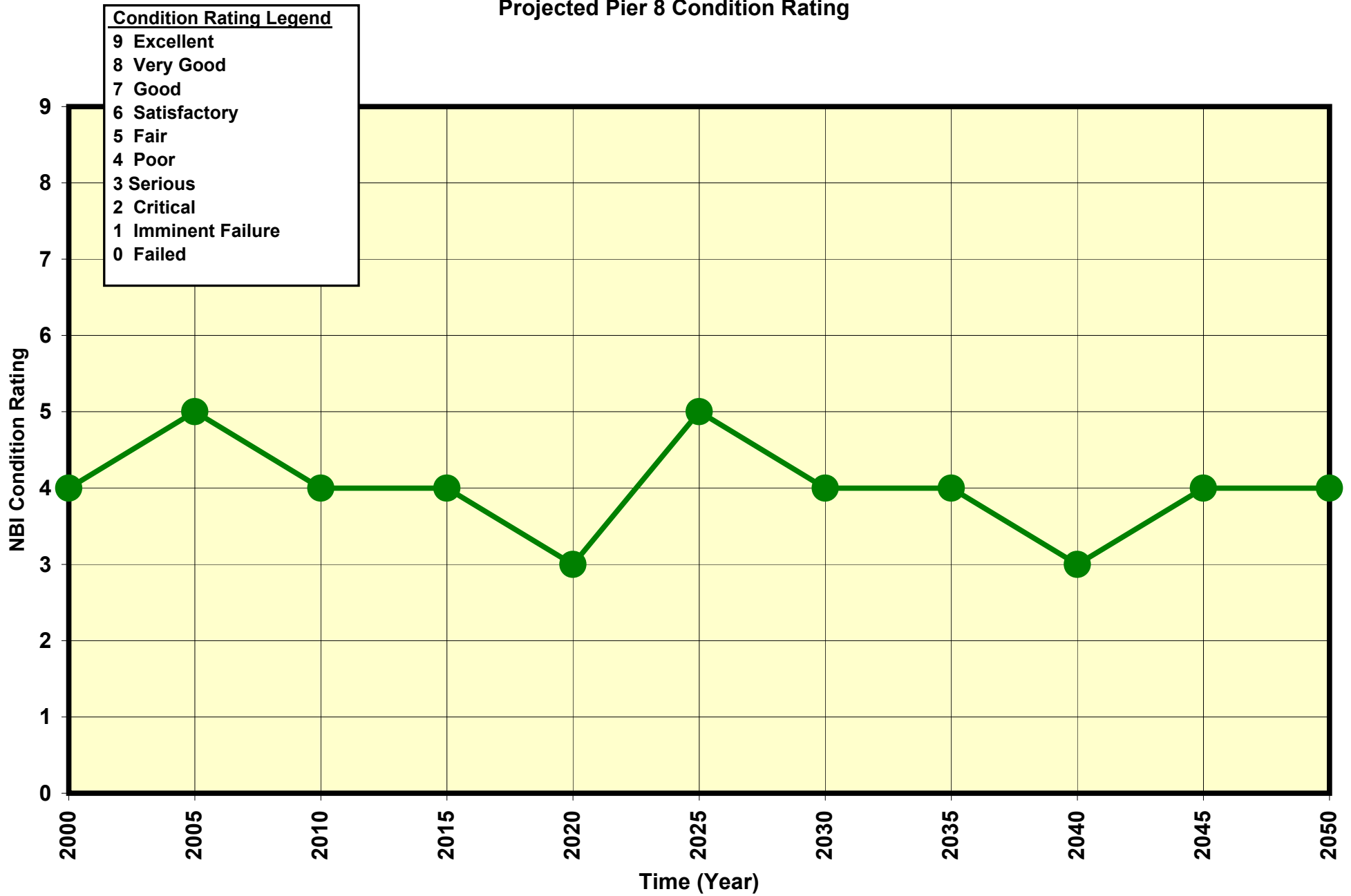
9	Excellent
8	Very Good
7	Good
6	Satisfactory
5	Fair
4	Poor
3	Serious
2	Critical
1	Imminent Failure
0	Failed



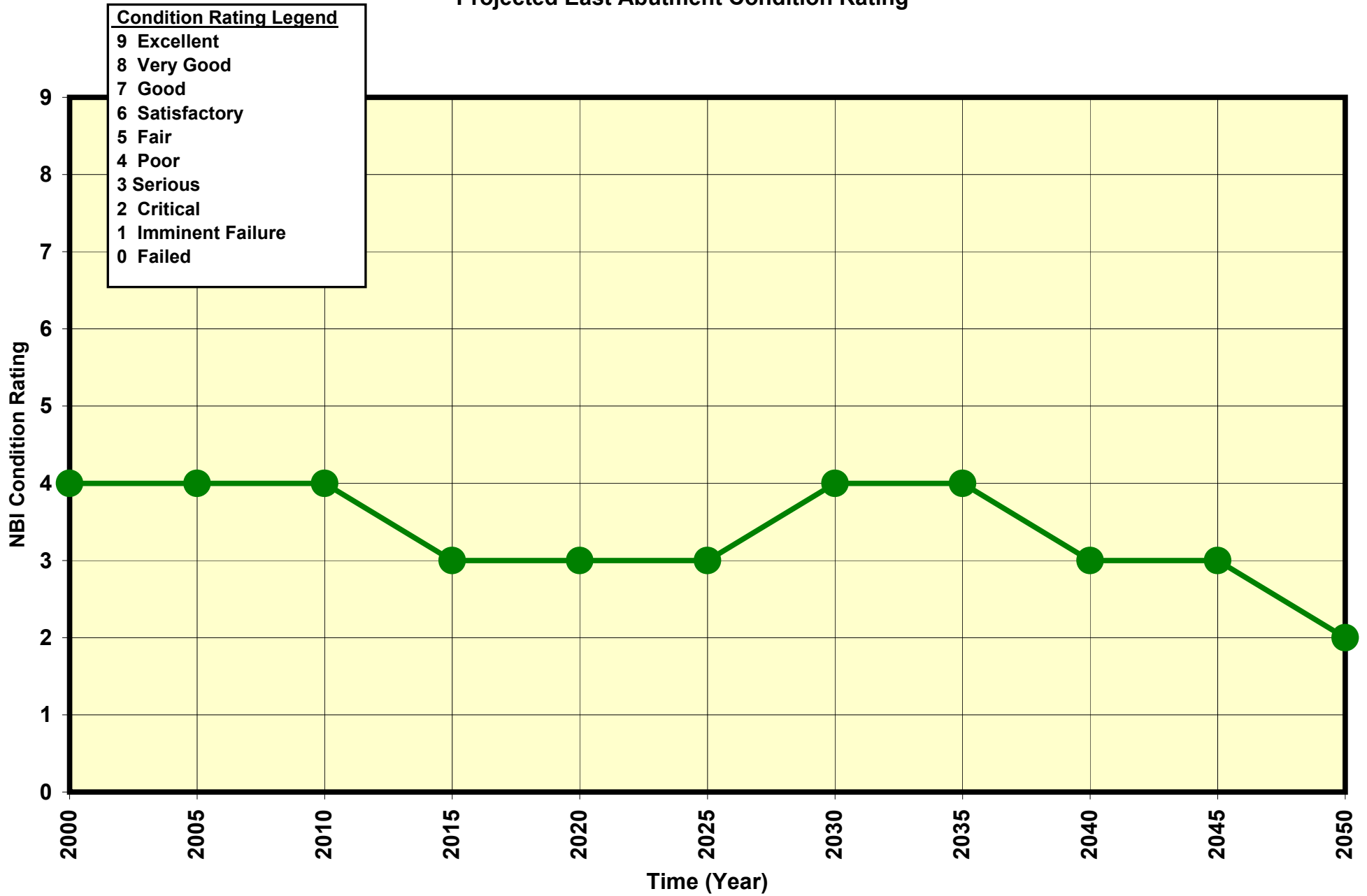
Projected Piers 1 through 7 Condition Rating



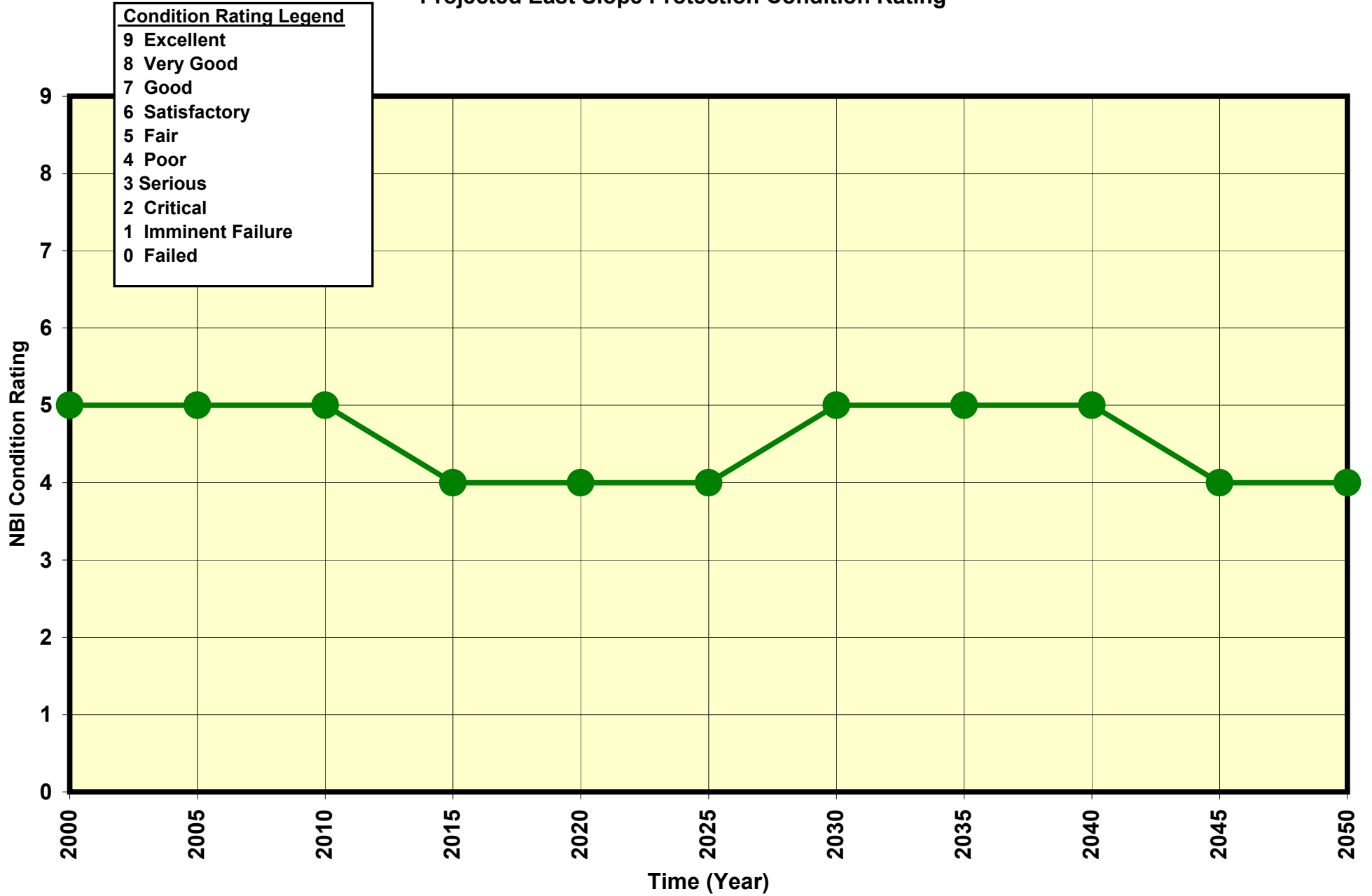
Projected Pier 8 Condition Rating



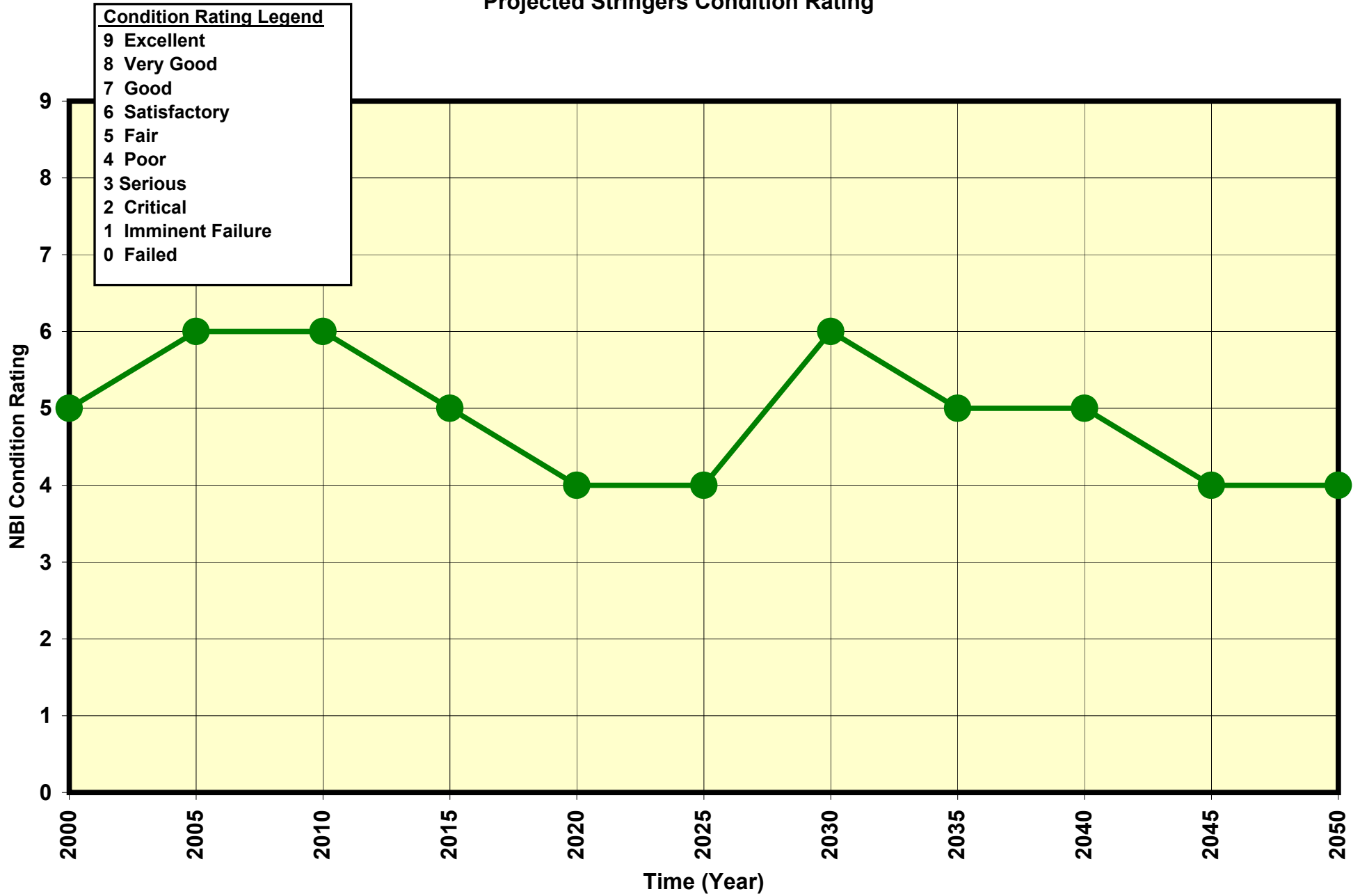
Projected East Abutment Condition Rating



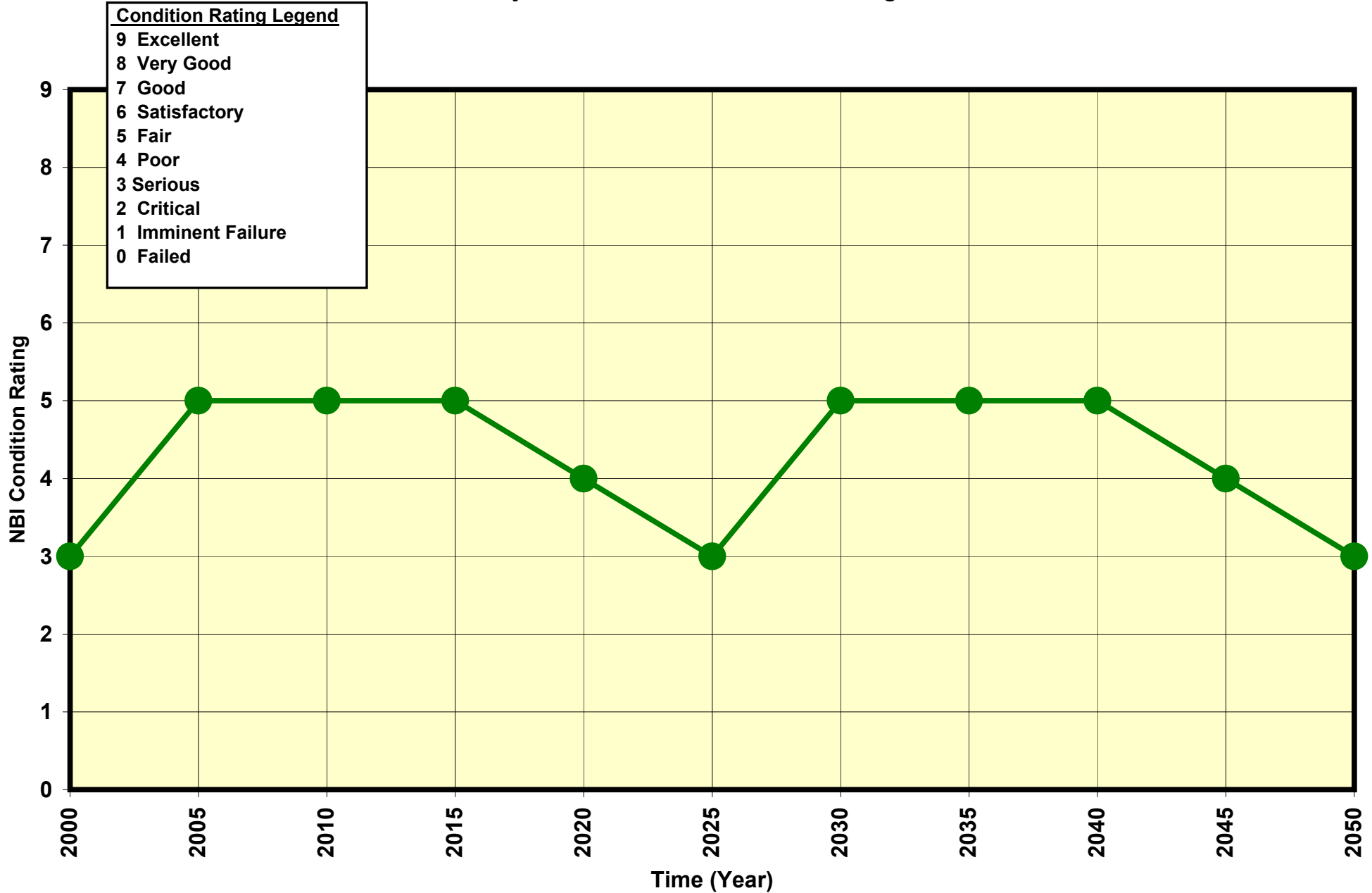
Projected East Slope Protection Condition Rating



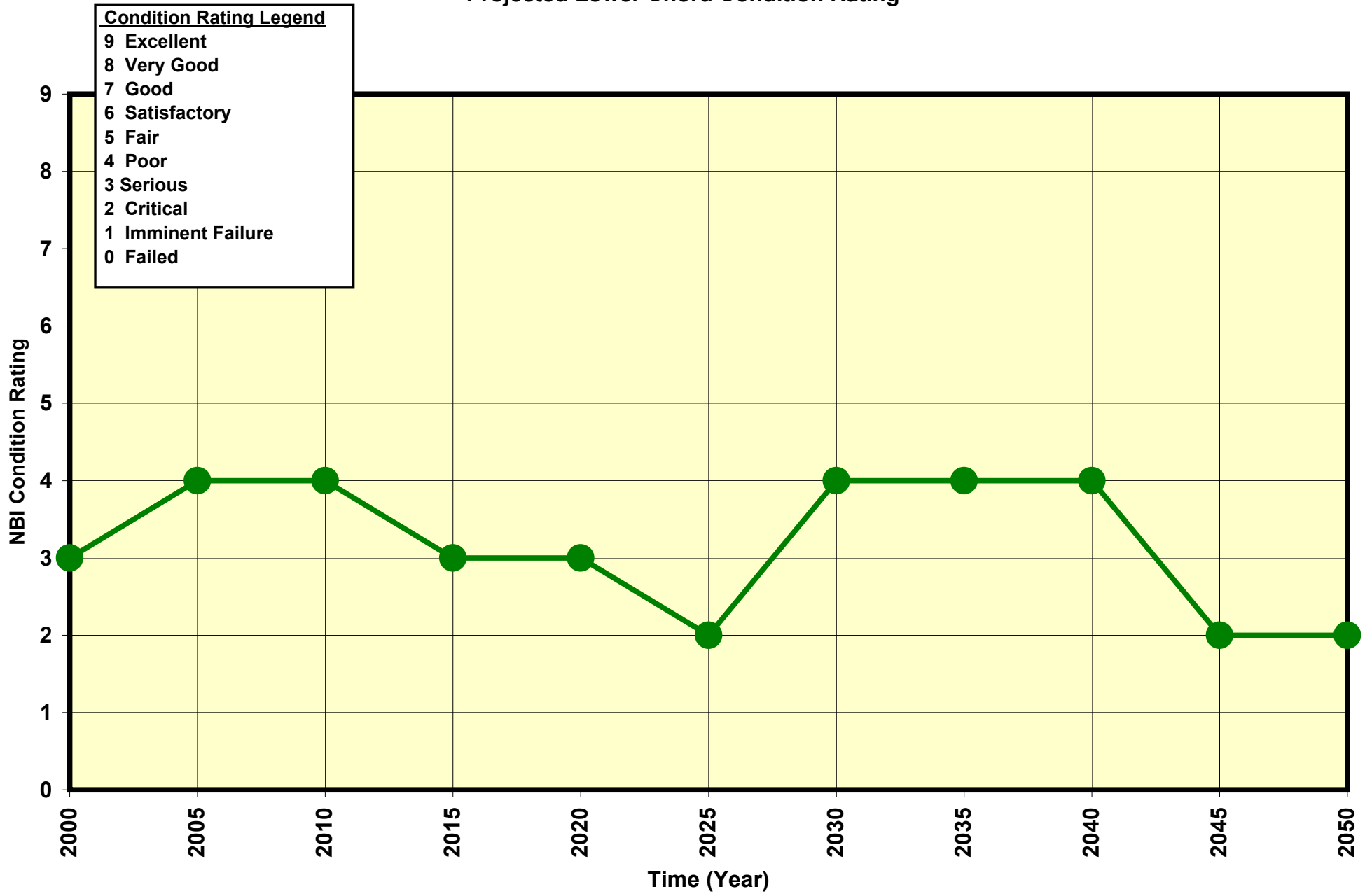
Projected Stringers Condition Rating



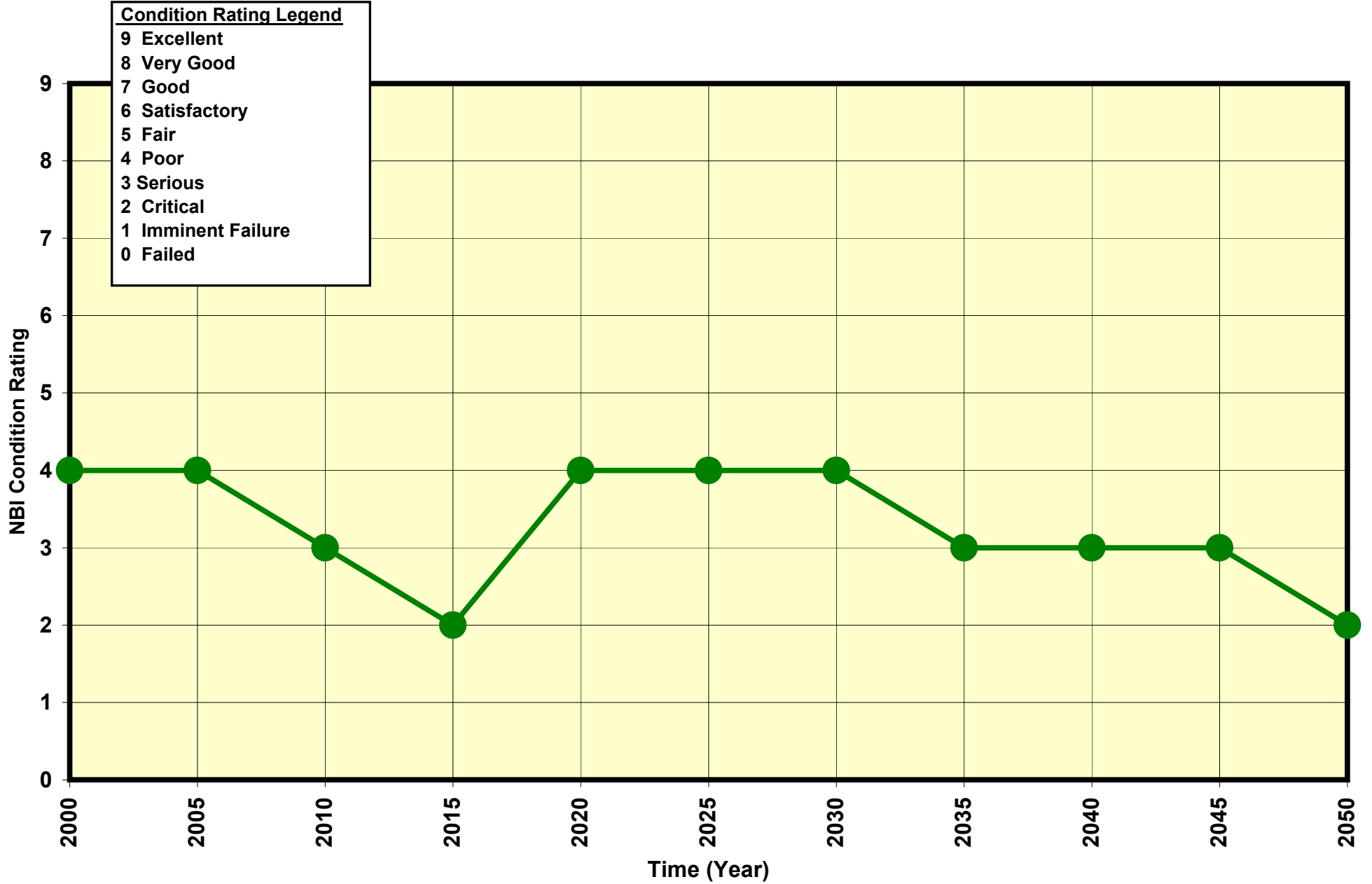
Projected Floor Beam Condition Rating



Projected Lower Chord Condition Rating



Projected Truss Web Members Condition Rating



Projected Lower Connection Condition Rating

