Rhode Island Department of Transportation

Operations Division

Bridge Inspection / Washing Program

Bridge Drainage Program

Rhode Island Department of Transportation
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Two Capitol Hill
Providence, Rhode Island 02903

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February 2002

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Preface

The Rhode Island Department of Transportation, Operations Division is responsible for operation of the State Highway System. This system includes 1079 miles of State Highway, throughout Rhode Island's thirty-nine cities and towns. The Operations Division includes seven functional areas: Construction, Final Review, Highway Maintenance, Materials, Health & Safety, Survey and the Transportation Management Center.

The Maintenance Division is responsible for maintaining 1,079 miles of state highways and 836 bridges. It is also responsible for winter snow removal, safety and civil defense, maintenance of highway lighting, traffic signals, signs, the motorist-aid communications system, litter control, sweeping, mowing, roadside repairs, drainage cleaning / repair, weed control, and bridge inspections.

This document presents information concerning existing and proposed activities related to the bridge program. The focus is washing, as an integral part of inspection and preventive maintenance, and a program to devoted to scupper repairs. Joseph Boardman, Managing Engineer, John E. Brownell, Chief Civil Engineer and John D. Nickelson, Deputy Chief Engineer of the Operations Division wrote this report. Nicole Thomson, GIS Specialist, prepared graphics.

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Introduction

The Rhode Island Department of Transportation, Operations Division is responsible for operation of the State Highway System. This system includes 1079 miles of State Highway, throughout Rhode Island's thirty-nine cities and towns. The Division is responsible for operation and maintenance of roads and bridges, and construction of highway and multi-modal projects to improve the transportation system of our state.

Maintenance is one of the major sections of the Operations Division. This section maintains 1,079 miles of state highways and 836 bridges. It is responsible for winter snow removal, safety and civil defense, maintenance of highway lighting, traffic signals, signs, the motorist-aid communications system, litter control, sweeping, mowing, roadside repairs, drainage cleaning / repair, weed control, and bridge inspections.

One of the major functions is the bridge program, which includes: inspection, maintenance and repair. This program includes 1027 bridges. The state maintains 858 of these bridges. The state also inspects 173 bridges, which are maintained by others.

RIDOT Bridge Program

	State Maintained	***Maintained by Others***	***Total***
Highway Bridges			
Over 20 feet (NBIS)	604	147	751
Under 20 feet	232	Not included	232
Total Highway Bridges	836	147	983
Other Bridges			
Bike/Ped. (over 20 feet)	18	8	26
Railroad	4	14	18
Total Other Bridges	22	26	44
Total Bridges	***858***	***173***	***1027***

This report considers two actions related to the bridge program. First, washing bridges to improve occupational safety of RIDOT Bridge Inspectors, allow thorough inspection of bridges and to reduce corrosion due to salt application. Then a second project devoted to drainage of water off bridges, through scuppers and downspouts, is presented. Based upon this report, RIDOT will request federal-aid funding for these efforts from the Federal Highway Administration.

State Policy

State Guide Plan

The State Planning Council is the *Metropolitan Planning Organization* for the entire State of Rhode Island. The State Planning Council adopted the *Transportation 2020 – Ground Transportation Plan* on November 12, 1998 (revised August, 2001), as part of the *State Guide Plan*. This Plan sets state policy for the transportation system. State agencies are to follow the goals, policies and recommendations of this Plan, several of which are directly related to RIDOT bridge activities. Goals and recommendations from *Part 611-7: Recommendations* of the *Ground Transportation Plan*[1] are reprinted below:

PART 611-7: RECOMMENDATIONS

Goal: **7-3** **GIVE PRIORITY TO PRESERVING AND MANAGING THE TRANSPORTATION SYSTEM**

Rec: 3-1 *Follow regularly scheduled programs of pavement and bridge management*

a. Establish a regularly funded program to preserve the condition and safety of existing roads and bridges, drainage systems, and culverts, both state and local.

g. Continue RIDOT's bridge washing program to reduce bridge corrosion and maintain bridge life.

Transportation Improvement Program

The State Planning Council is also responsible for development of the Transportation Improvement Program. An activity for Preventive Bridge Maintenance is an eligible project included in Rhode Island's *Statewide Transportation Improvement Program* (STIP) for FY2001-2002. The State Planning Council adopted the STIP on August 10, 2000. The Federal Highway Administration and The Federal Transit Administration jointly approved this STIP on October 31, 2000.

Preventive Bridge Maintenance, as defined in the STIP, includes:

Bridge Inspection
Bridge Painting
Bridge Repairs
Bridge ITS Equipment
Bridge Washing, and Non-Corrosive De-icing

[1] Transportation 2020: Ground Transportation Plan, RIDOT, November 1998

Bridge Inspection and Washing Program

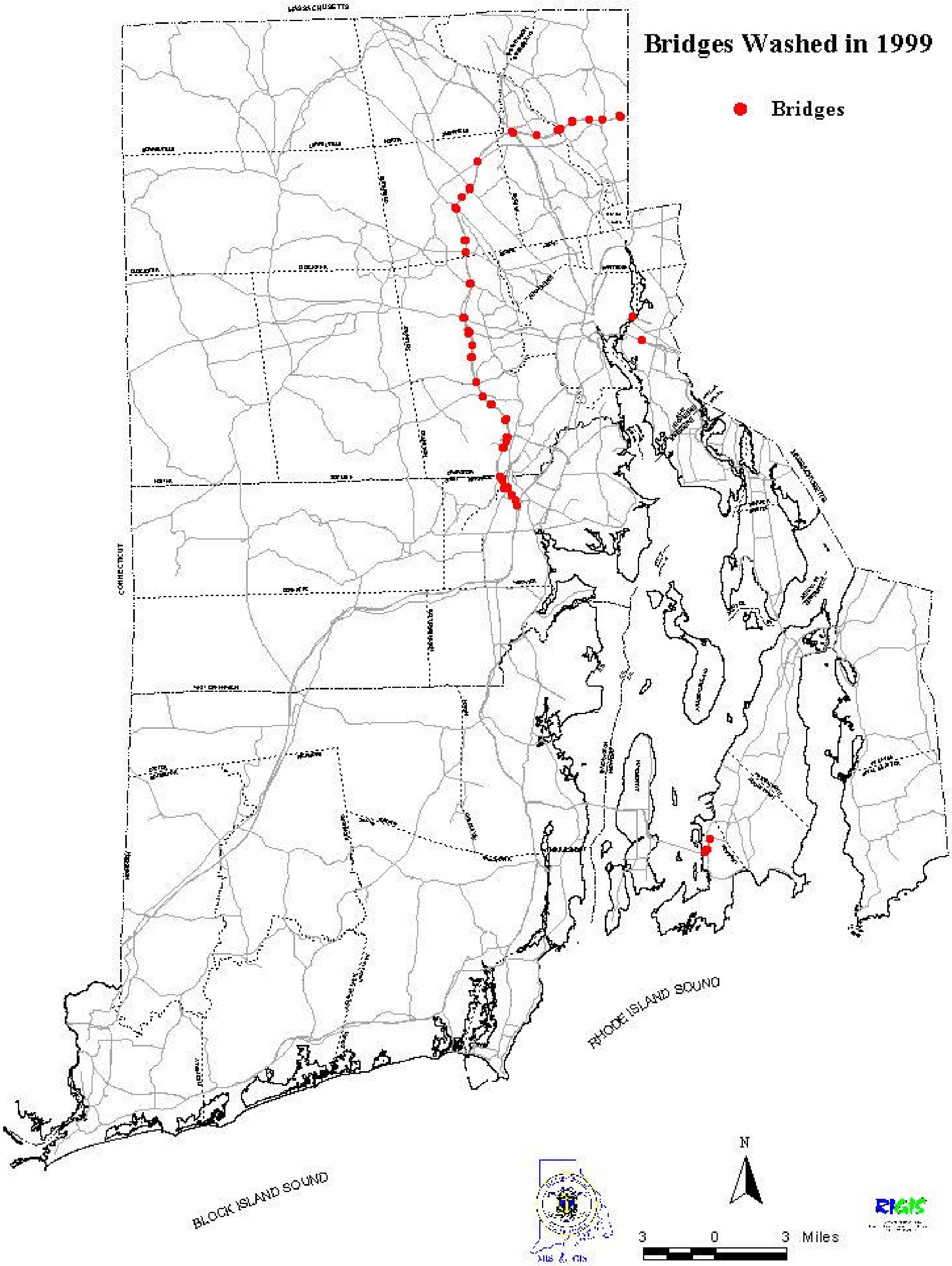
It is recognized that washing bridges is an integral part of an effective bridge inspection program. Inspection of a bridge without sand, mud, salt, bird droppings, bird nests and other debris is much more effective. Washing also addresses a major health and occupational safety concern, as bird droppings and nests can present a health hazard to bridge inspectors. In many cases, inspectors must move bird droppings and nests in order to see steel and concrete below. Washing eliminates major accumulations of this animal waste.

It is also recognized that applying salt to bridge decks increases rusting and degradation of concrete. Washing bridges after the winter season can significantly extend bridge life.

Bridge Washing 1999

RIDOT initiated a bridge washing program in 1999. This initial project included 65 bridges. State funds were used for this initial project. Figure 1 shows the bridges washed in 1999. Inspection during washing indicated a significant structural problem in the Blackstone Viaduct. Two lanes of this four-lane bridge were immediately closed and rehabilitation of this bridge was advanced. Without this washing/inspection effort this bridge could well have failed, possibly resulting in injury to motorists. At minimum replacement cost and detour costs to the motorists would have far exceeded the cost of repair to the bridge.

Figure 1


Bridges Washed in 1999
Bridges
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
N
3 0 3 Miles
RIGIS

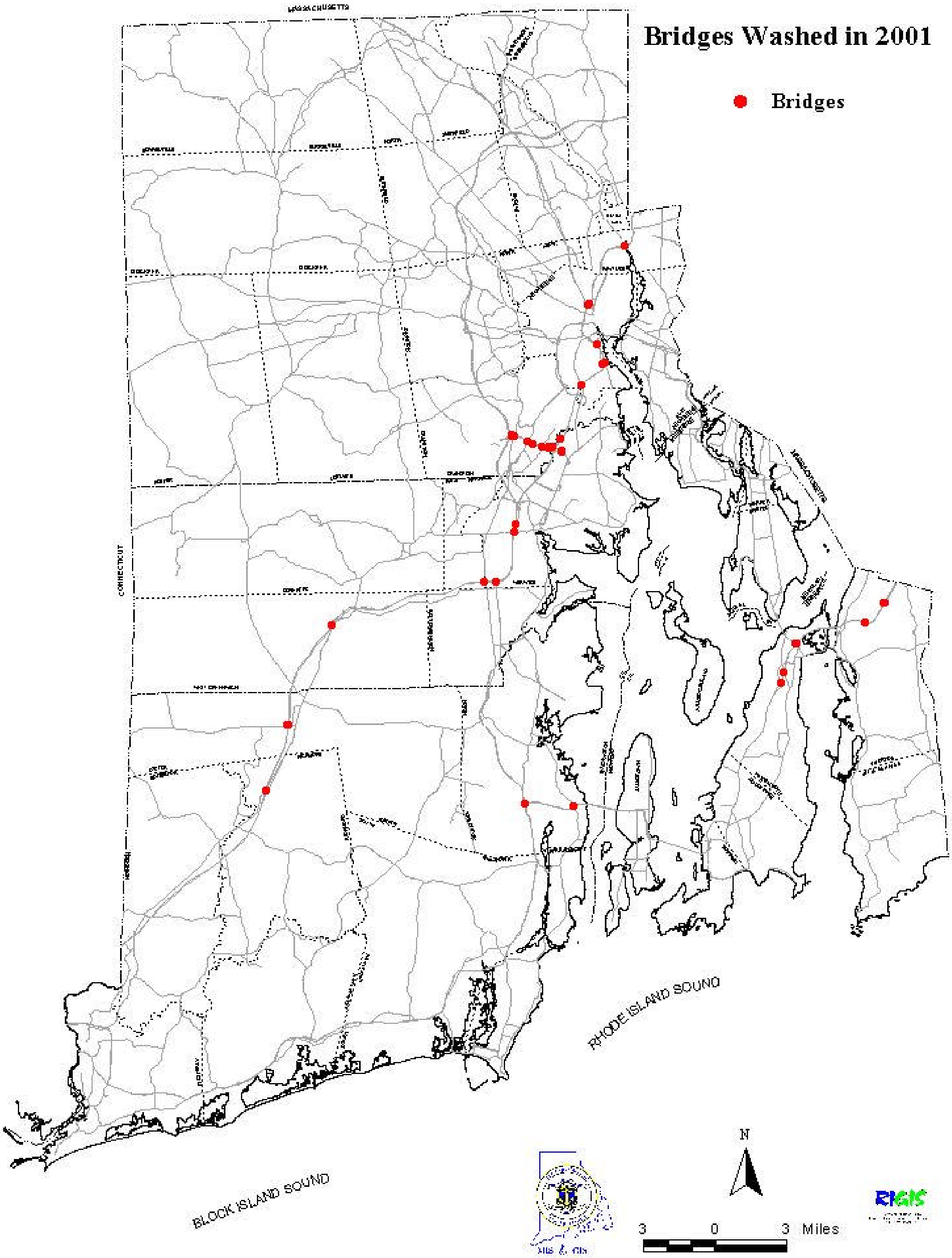
Bridge Washing 2001

The most recent RIDOT bridge washing effort occurred in 2001. As part of this effort, 43 bridges were washed. Figure 2 shows the bridges washed. FHWA approved *bridge funds* for this washing project. Inspection during washing indicated potential structural problems at the bridges listed below:

- Turnpike Avenue Bridge (064501/064521): Deteriorated east abutment bearing pad.
- Weaver Hill Road Bridges (058601/058621): Deterioration on back wall, abutments, piers and bearings.
- Quaker Lane Bridge (051801): Deteriorated pier caps, pier and bridge deck.
- Charles Street Bridge (07081): Deteriorated back walls, bearing plates and deck.
- Pontiac Avenue Bridge (062701): Deteriorated back walls and deck.
- Ten Rod Road Bridge (059101): Deteriorated back walls.
- Pawtucket River Bridge (055001): Deteriorated outer girder.

At the first bridge listed, Turnpike Avenue Bridge in Portsmouth, a bearing pad was repaired on the east abutment before failure, avoiding significant costs and traffic disruption. For the remaining bridges, washing project inspectors took pictures to document problems and advised bridges inspectors. Bridge inspectors reviewed this information, both in the field and with respect to bridge inspection records. It should be noted that many of this problems would not have been nearly as visible if the bridge had not been cleaned.

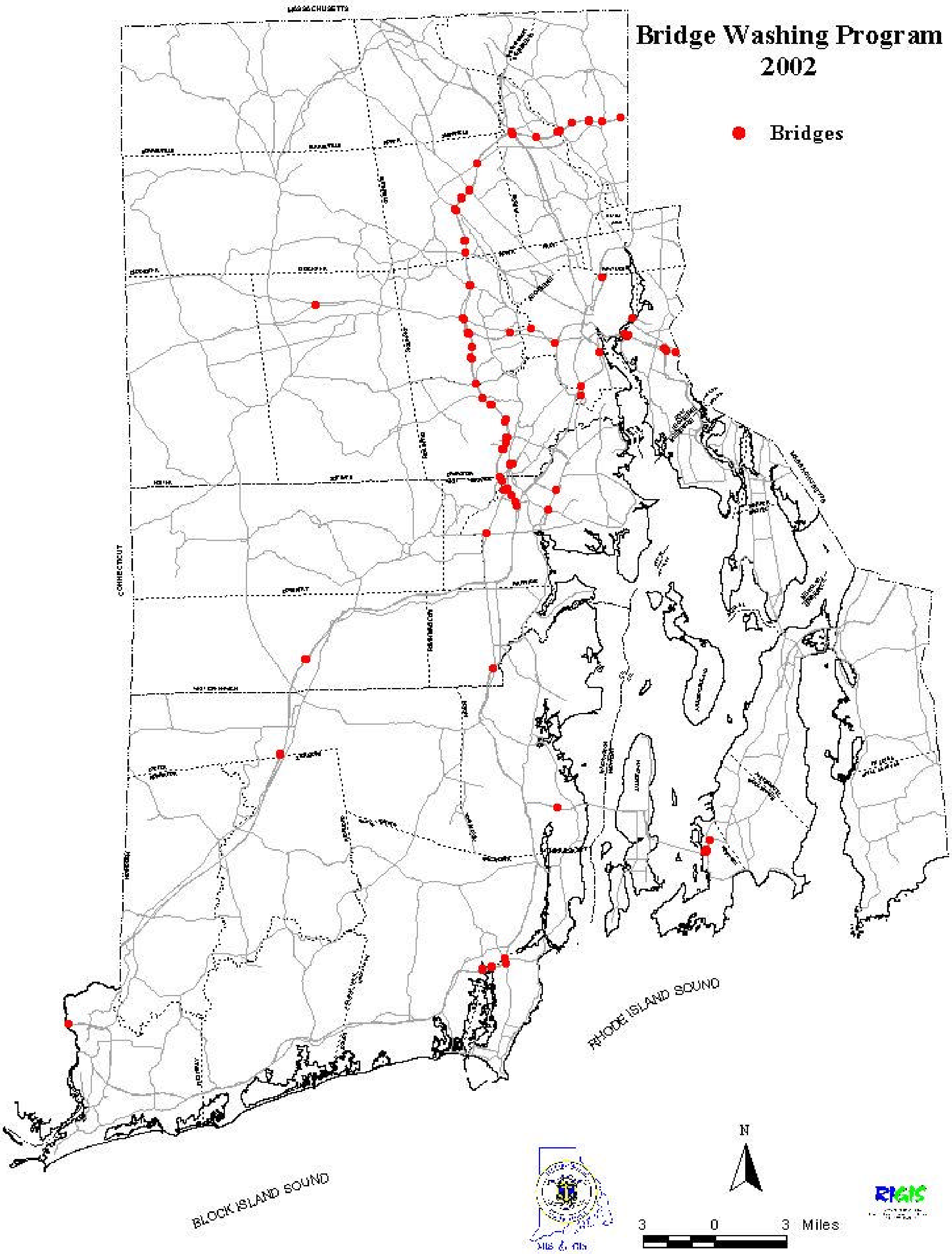
Figure 2


Bridges Washed in 2001
Bridges
BLOCK ISLAND SOUND
RHODE ISLAND SOUND
N
3 0 3 Miles
RIGIS

Bridge Washing Program 2002

The next bridge washing effort is scheduled for this year, 2002. The number of bridges scheduled for washing totals 99. Figure 3 shows these bridges. Again, inspection during washing activity will be considered important. RIDOT will request FHWA funding for this project, as 100 percent state funding is not available.

Figure 3


Bridge Washing Program
2002
Bridges
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
CONNECTICUT
N
3 0 3 Miles

Bridge Washing Benefits

Washing bridges has three major benefits. The most immediate and critical are providing a healthy environment for RIDOT workers and allowing quality bridge inspection. The long-term benefit is reducing degradation of the bridge structure.

- ***Bridge Inspection Quality:*** *RIDOT* considers bridge washing an integral part of the bridge inspection program. Inspection of a bridge without sand, mud, salt, bird droppings, bird nests and other debris is much more effective. A visual inspection is performed immediately after washing using washing personnel and the RIDOT personnel assigned to project supervision. Washing project inspectors take pictures to document problems and advise bridge inspectors. Bridge inspectors review this information, both in the field and with respect to bridge inspection records. It should be noted that many problems would not be nearly as visible if the bridges had not first been cleaned. RIDOT's goal is to perform the detailed *NBIS* inspection as soon as practicable after washing, within the bridge inspection schedule. When the bridge-washing program is fully implemented and bridges are washed repeatedly on a regular schedule, NBIS inspection will be scheduled immediately after washing.

- ***Bridge Inspector Safety:*** Washing also addresses a major health and occupational safety concern, as bird droppings and nests can present a health hazard to bridge inspectors. In many cases, inspectors must move bird droppings and nests in order to see steel and concrete below. Washing eliminates major accumulations of this animal waste.

- ***Structural Benefits:*** The long term benefit relates to degradation of paint and steel as a result of salt and debris remaining on bridges that are never cleaned. Applying a corrosive such as salt to bridge decks decreases paint life and increases rusting. Sand, bird nests and bird droppings hold moisture against structural steel and concrete. The effect is the same as packing areas of the bridge with mud. Periodic washing removes debris, allowing water to drain away and moisture to evaporate. Paint and bridge life is significantly extended.

  While this concept is easily understood, an analysis of washing Interstate highway bridges has been performed. This analysis is presented in the Appendix of this report. This analysis is based upon the FHWA PONTIS program. This analysis clearly shows that cleaning and washing bridges is beneficial and cost effective.

Bridge Drainage Project

The primary incentive for addressing this particular item of work is not specifically whether or not the scuppers/down spouts themselves are in effective condition, but the cause/effect upon contiguous structural elements, if they are not functionally performing.

Scuppers are designed to carry run-off from bridge deck surfaces. This accumulation of excess run-off can be a result of roadway profiles (Sags) and/or bridges with long spans. In addition, past policy was to install scuppers, prior to sliding roadway metal expansion plates, to intercept run-off before reaching the bridge joints. Many, if not most of these roadway sliding plate expansion joints have been and will be replaced by preformed elastomeric roadway expansion joints. The aforementioned joint is designed to function as a leak proof seal.

Scuppers/deck joints are normally located over concrete substructures (piers, abutments) and also with the need for down spout support, are usually in close proximity to the bridge beams and bearings.

There are approximately 102 bridges maintained by the State that have deficient scuppers. It is assumed for this presentation that 50 percent of these bridges are on the Interstate System.

Interstate I-95:	62 bridges x 0.50 = 31 bridges
Interstate I-195:	21 bridges x 0.50 = 10 bridges
Interstate I-295:	48 bridges x 0.50 = 24 bridges

Total number of interstate bridges with deficient scuppers = 65 bridges

The use of de-icers (sodium chloride) both accelerates and intensifies the problems associated with dysfunctional drainage structures.

Previous assessments of deferred maintenance consequences on steel bridges, dealt with a presumed element environment classed as “moderate”. Introducing a chloride agent directly onto the steel beam surfaces would change this element environment to be classed as “Severe”. It is apparent that the deterioration transition probabilities would increase, and therefore, in direct relationship, so would the cost, scope, and frequency of needed repair work.

It is suggested that unnecessary scuppers and their down spouts be removed and those that are necessary, be repaired to perform as designed. This aforementioned work effort can readily be translated into a cost-effective program when compared to the alternative consequences of the inevitable structural element repair cost.

Appendix: Bridge Washing Analysis

Introduction

As an introduction to this presentation, it is essential that the program, *PONTIS*; developed and sponsored by FHWA, be recognized as a viable methodology for determining the rates of element degradation and the consequences and acceptability of the program's recommended actions. The *PONTIS* program will be the future primary action-generating tool, for developing the State's Bridge Management System.

It should be acknowledged that individual bridge element/bridge evaluation as presented here is basically out of context with the *PONTIS* network program concept. However, the program's intrinsic workings are a useful insight for planning. The prediction models consist of mathematical formulas or probability estimates, which predict future bridge conditions based on known current or historical conditions and hypothetical actions. The estimated probability that a given instance of a bridge element will change from its current condition state to a given state at some point during a specific time period is referred to as its transition probability. The time period used here is a transition probability for the occurrence of a given transition at some point during a two-year period.

Analysis

A review of the inventory and the subsequent assessment of the paint condition of those steel bridges maintained by State were made. Only those bridges identified as carrying interstate traffic are subjects of this cost-benefit exercise.

The initial determination of the existing paint condition on each bridge was gleaned from specific paint ratings determined from inspection forms designed for this purpose. Those ratings in turn were equated to appropriate beam lengths and then converted to unit values and thence to appropriate *PONTIS* condition states.

The *PONTIS* element No. 107: "Painted Steel Open Girder" is identified and utilized as being appropriate for this discussion. For each condition state, the *PONTIS* program recommends a specific action. Common to all condition states, is the action: Do Nothing (DN). There is no immediate direct cost in DN, however a subsequent belated cost related to inevitable element condition degradation will occur and that cost will be increased, in direct relationship, to the degree of degradation. Note the following *PONTIS* condition states and their suggested correction action alternatives. For comparative cost relationships, dollar values per linear foot (LF) have been assigned for this presentation.

PONTIS Element 107: Painted Steel Open Girder

Condition States descriptions

1. There is no evidence of active corrosion and the paint system is sound and functioning as intended to protect the metal surface,

   Feasible actions: DN Surface clean -

2. There is little or no active corrosion. The paint system may be chalking, pooling, curling or showing other early evidence of paint system distress but there is no exposure of metal.

   Feasible actions: DN Surface clean Surface clean and restore top coat

3. Surface or freckled rust has formed or is forming. The paint system is no longer effective. There may be exposed metal but there is no active corrosion that is causing loss of section.

   Feasible actions: DN Spot blast, clean & paint -

4. The paint system has failed. Surface pitting may be present but any section loss due to active corrosion does not yet warrant structural analysis of either the element or the bridge.

5. Feasible actions: DN Spot blast, clean & paint Replace paint system

6. Corrosion has caused section loss and is sufficient to warrant structural analysis to ascertain the impact on the ultimate strength and/or serviceability of either the element or the bridge.

   Feasible actions: DN Major rehab unit Replace unit

INTERSTATE I-95	***PONTIS* RATING**
Total steel bridges: 49	
Bridges rated condition 1	3*
Bridges rated condition 2	24*
Bridges rated condition 3	13
Bridges rated condition 4	8
Bridges rated condition 5	1

**Wash and Clean: 27*

INTERSTATE 1-295

Total steel bridges: 31	
Bridges rated condition 1	10*
Bridges rated condition 2	7*
Bridges rated condition 3	5
Bridges rated condition 4	8
Bridges rated condition 5	1

**Wash and Clean: 17*

INTERSTATE 1-195

Total steel bridges: 16	
Bridges rated condition 1	0
Bridges rated condition 2	1
Bridges rated condition 3	4
Bridges rated condition 4	9
Bridges rated condition 5	2

**Wash and Clean: 1*

SUMMATION - INTERSTATE BRIDGES

Total steel bridges = 96	
Bridges rated condition 1	13
Bridges rated condition 2	32
Bridges rated condition 3	22
Bridges rated condition 4	25
Bridges rated condition 5	4

**Wash and Clean: 45*

For *PONTIS* condition 1 & 2, the recommended primary action is *wash and clean*. Therefore, only those bridges in that classification will be evaluated for a period of eight (8) years (arbitrary) and the consequences of either doing nothing (DN) or washing and cleaning.

Bridges now in Condition 1:

Steel beam condition evaluation: 4 - 2 year periods totaling 8 years.

Action: Do nothing (DN); Bridges: 13; Condition: C1

- End of 1st, 2 year period: C1 = 13 x 0.76* = 10 bridges
  C2 = 13 x 0.24* = 3 bridges

- End of 2nd, 2 year period: C1 = 10 x 0.76* = 8 bridges
  C2 = 10 x 0.24* = 2 bridges
  C2 = 3 x 0.76* = 2 bridges
  C3 = 2 x 0.24* = 1 bridges

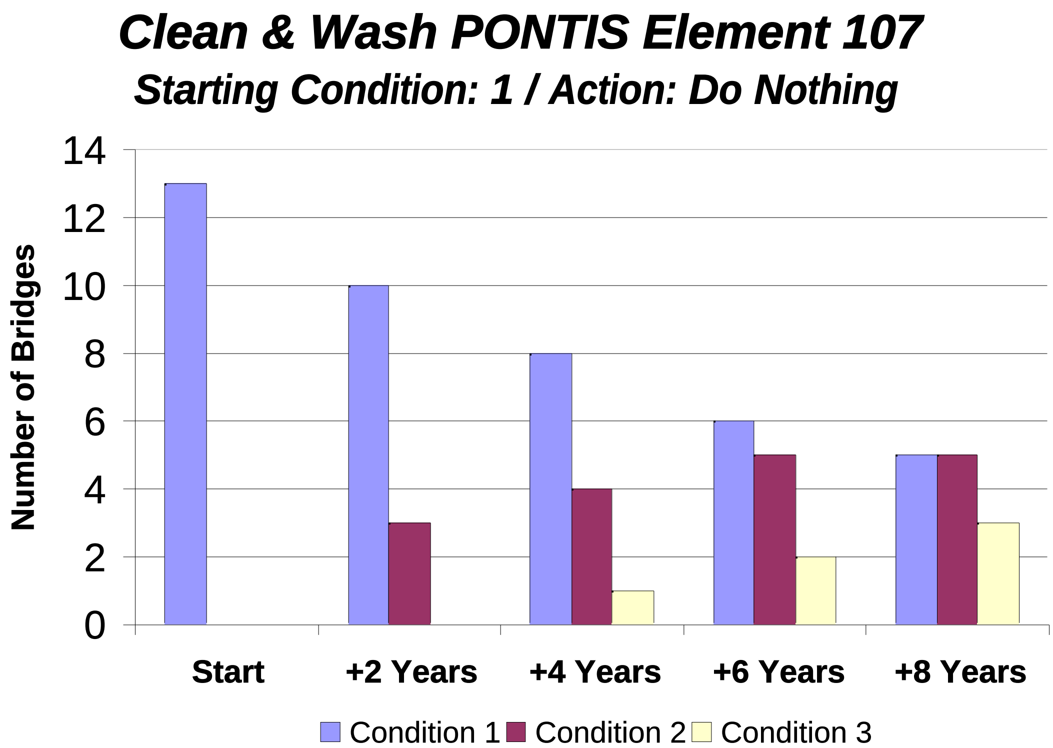
- End of 3rd, 2 year period: C1 = 8 x 0.76* = 6 bridges
  C2 = 8 x 0.24* = 2 bridges
  C2 = 4 x 0.76* = 3 bridges
  C3 = 4 x 0.24* = 1 bridges
  C3 = 1 x 0.76* = 1 bridges
  C4 = none = 0 bridges

- End of 4th, 2 year period: C1 = 6 x 0.76* = 5 bridges
  C2 = 6 x 0.24* = 1 bridges
  C2 = 5 x 0.76* = 4 bridges
  C3 = 5 x 0.24* = 1 bridges
  C3 = 2 x 0.76* = 1 bridges
  C4 = none = 0 bridges

*Note: (.xx) Transitional probability from expert elicitation.

Therefore at end of four, 2 year periods or 8 years, the deterioration as a result of no action (DN) will end with the 13 bridges, originally all in condition state one (1), in the following condition states:

Condition 1: 5 bridges
Condition 2: 5 bridges
Condition 3: 3 bridges
Condition 4: None



Bridges now in Condition 2:

Steel beam condition evaluation: 4 - 2 year periods totaling 8 years.

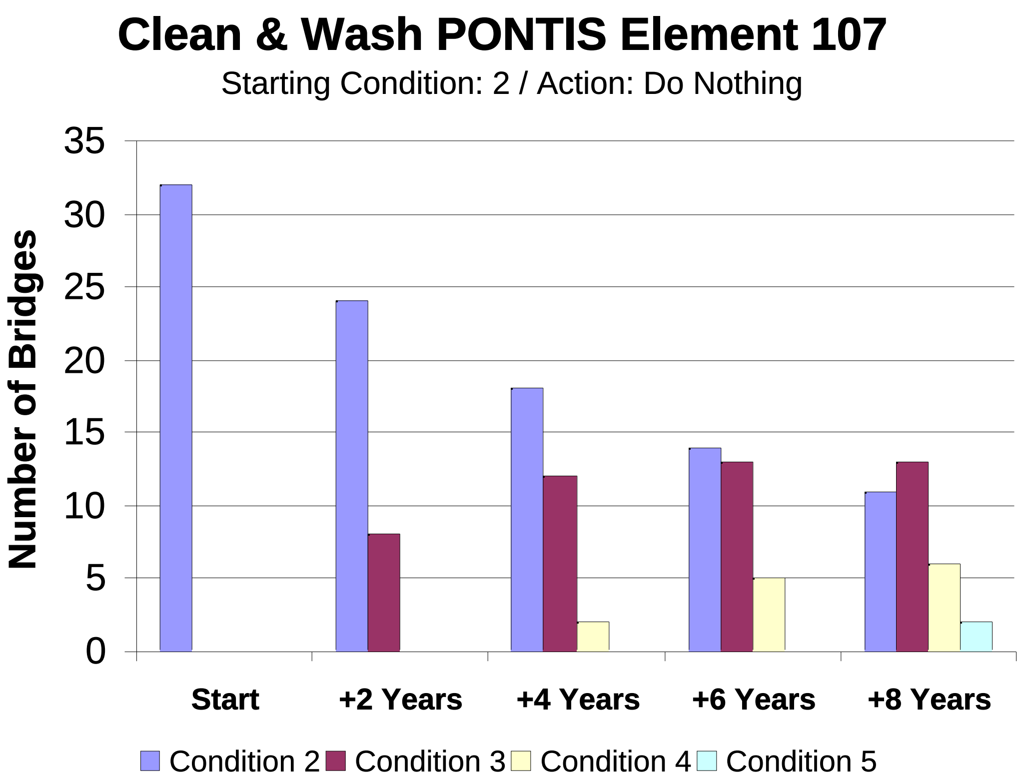
Action: Do nothing (DN); Bridges: 32; Condition: C2

- End of 1st, 2 year period:
  - C2 = 32 x 0.76* = 24 bridges
  - C3 = 32 x 0.24* = 8 bridges
- End of 2nd, 2 year period:
  - C2 = 24 x 0.76* = 18 bridges
  - C3 = 24 x 0.24* = 6 bridges
  - C3 = 8 x 0.76* = 6 bridges
  - C4 = 8 x 0.24* = 2 bridges
- End of 3rd, 2 year period:
  - C2 = 18 x 0.76* = 14 bridges
  - C3 = 18 x 0.24* = 4 bridges
  - C3 = 12 x 0.76* = 9 bridges
  - C4 = 12 x 0.24* = 3 bridges
  - C4 = 2 x 0.63* = 2 bridges
  - C5 = 5 x 0.37* = 0 bridges
- End of 4th, 2 year period:
  - C2 = 14 x 0.76* = 11 bridges

C3 = 14 x 0.24* = 3 bridges
C3 = 13 x 0.76* = 10 bridges
C4 = 13 x 0.24* = 3 bridges
C4 = 5 x 0.76* = 3 bridges
C5 = 5 x 0.37* = 2 bridges

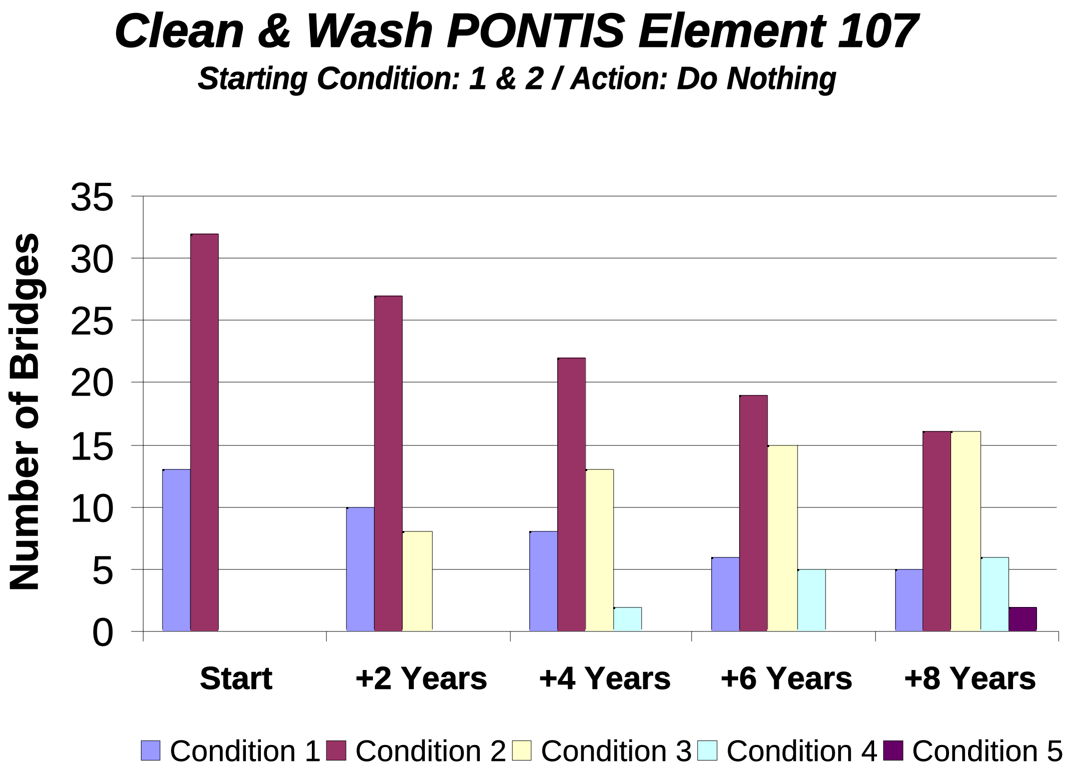
Therefore at end of four, 2 year periods or 8 years the deterioration as a result of no action (DN) will end with the 32 bridges, originally all in condition state two (2), in the following condition states.

Condition 2: 11 bridges
Condition 3: 13 bridges
Condition 4: 6 bridges
Condition 5: 2 bridges



Summing lists of condition 1 & 2 bridges, the results of doing nothing for 8 years for 45 bridges are:

Condition 1: 5 bridges
Condition 2: 16 bridges
Condition 3: 16 bridges
Condition 4: 6 bridges
Condition 5: 2 bridges



It should be noted that now after 8 years, it is cost effective to wash and clean only 21 bridges of the original 45 bridges if a no action program is followed.

To compare the inaction of *doing nothing* as to *following a clean and wash program*, the same 45 bridges are now evaluated.

Bridges now in Condition 1:

Steel beam condition evaluation: 4 - 2 year periods totaling 8 years.

Action: Wash and surface clean (SC); bridges:13

- End of 1st, 2 year period: (Immediately after action) — C1 = 13 x 1.0 = 13 bridges; C2 =.13 x 0.0 = 0 bridges
- End of 2nd, 2 year period: (Immediately after action) — C1 = 13 x 1.0 = 13 bridges; C2 = 13 x 0.0 = 0 bridges
- End of 3rd and 4th, 2 year periods, theoretically all original 13 bridges will remain in condition 1, if washed and cleaned.

Bridges now in Condition 2: (See previous Condition 1)**:**

Steel beam condition evaluation: 4 - 2 year periods totaling 8 years.

Action: Wash and surface clean (SC); bridges: 32

> At end of 8 years, theoretically all original 32 bridges will remain in condition 2, if washed and cleaned.

It should be noted that now after 8 years, it is still cost-effective to wash and clean all the original 45 bridges studied.

<u>COST</u>: Related to recommended actions per condition states:

<u>State</u>	**<u>Action</u>**	**<u>Cost</u>**
	Do Nothing	No cost
C1,C2	Wash and Clean Steel	$0.10 per SF: say $2,000 per br.
C3	Spot blast, clean & paint	$2.00 per SF: say $40,000 per br.
C4	Spot blast, clean and paint	$3.00 per SF: say $60,000 per br.
C5	Major rehab unit	$5.00 per SF: say $100,000 per br.

Scenario One:

Action: Wash and clean 45 bridges every 2 years.

Total Cost: 45 x $2,000 x 4 = $360,000

Results: All bridges remain in relatively good condition after 8 years.

Scenario Two:

Action: Do nothing to 45 bridges for an 8 year period.

Total cost: End of 8.years to address action recommended per condition.

Condition 1:	5 bridges	@	$2,000	=	$10,000
Condition 2:	16 bridges	@	$2,000	=	$32,000
Condition 3:	16 bridges	@	$40,000	=	$640,000
Condition 4:	6 bridges	@	$60,000	=	$360,000
Condition 5:	2 bridges	@	$100,000	=	$200,000
Total					*= $1,242,000*

Cost difference between actions: *8 year period: $882,000*

From these computations, it would suggest that an average savings of $20,000 per bridge would be realized every eight years, if only they were washed and cleaned, on a regular basis. Precise savings realized can be argued up and down, however, the trend of increased cost related to deferred maintenance is apparent. Federal monies have been, and in the future probably will be, authorized for steel beam painting, repair and replacement; it would therefore, certainly appear to be a cost-effective action to prevent/mitigate those circumstances wherein this substandard condition state would evolve.