PAVEMENT RIDE QUALITY

Narinder S. Kohli, P.E.
Supervising Engineer
Pavement & Drainage Management
November 1, 2019

Outline

- **What is Pavement Smoothness?**
- Why Pavement Smoothness Specifications is required?
- History / Background
- What is IRI?
- How Smoothness is measured?
- NJDOT Specification
- Pay Adjustment
- Ride Quality for Local-Aid Projects

What is Pavement Smoothness?

- Smoothness is a measure of the level of comfort experienced by the traveling public while riding over a pavement surface.

- Smoothness is used interchangeably with roughness as an expression of the deviation of a surface from a true planar surface (as defined by ASTM E867) . *Ref. Tech Brief FHWA-HIF-16-032*

Outline

- What is Pavement Smoothness?
- **Why Pavement Smoothness Specifications is required?**
- History / Background
- What is IRI?
- How Smoothness is measured?
- NJDOT Specification
- Pay Adjustment
- Ride Quality for Local-Aid Projects

Why Pavement Smoothness Specifications?

- **Moving Ahead for Progress in the 21st Century (MAP 21)**

  For NHS, ride quality is in performance matrix.

- **Pavement smoothness is important to the user (taxpayer).**

  AASHO Road Test studies have found that **road users judge a road primarily by its ride quality.**

  National Highway User Survey conducted in 1995 and the Federal Highway Administration (FHWA) Infrastructure Survey conducted in 2000, found that the traveling public considers pavement conditions, which includes ride quality, to be **third most important improvement needed for highways, behind only traffic flow and safety.**

Why Pavement Smoothness Specifications?

- **Smoother roads last longer.**

Numerous studies from the Federal Highway Administration, National Cooperative Highway Research Program (NCHRP), and National Asphalt Pavement Association (NAPA) have found **pavements built smoother tend to last longer.**

Average Percent Increase in Performance Life			
Reduction in roughness	10%	25%	50%
Alabama PCC	11	28	55
Arizona PCC	7	18	36
Illinois CRC	5	11	22
Minnesota PCC	6	15	30
Illinois AC/PCC	4	9	18
Alabama AC	8	20	39
Arizona AC	3	9	18
Minnesota AC	5	11	23

Enhancing Pavement Smoothness

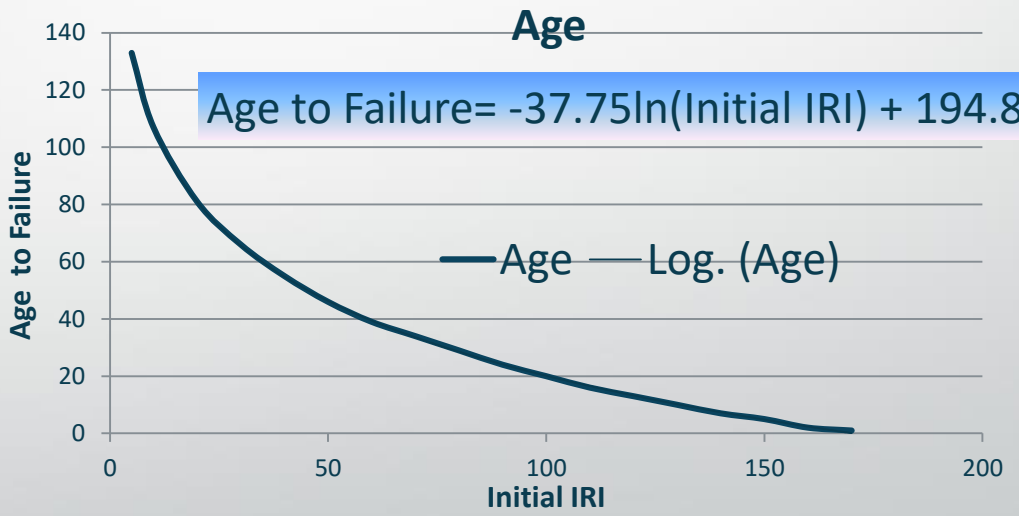
by Mark Swanlund

Issue No: *Vol. 64 No. 2* ***Date:*** *Sept/Oct 2000*

Source: https://www.fhwa.dot.gov/publications/publicroads/ooseptoct/smooth.cfm

Initial IRI vs. Age to Failure Relationship

(Failure only due to roughness of pavement was considered)



Source: Rational Method for Developing Ride Quality Pay Adjustments from PMS IRI Data by Dr. Nicholas Vitillo, PhD , CAIT

Why Pavement Smoothness Specifications?

- **Smoother roads stay smoother longer.**

Evidence from studies of smoothness progression over time shows that pavements built smoother will **stay smoother longer** when designed and constructed properly.

- **Smoother roads are safer.**

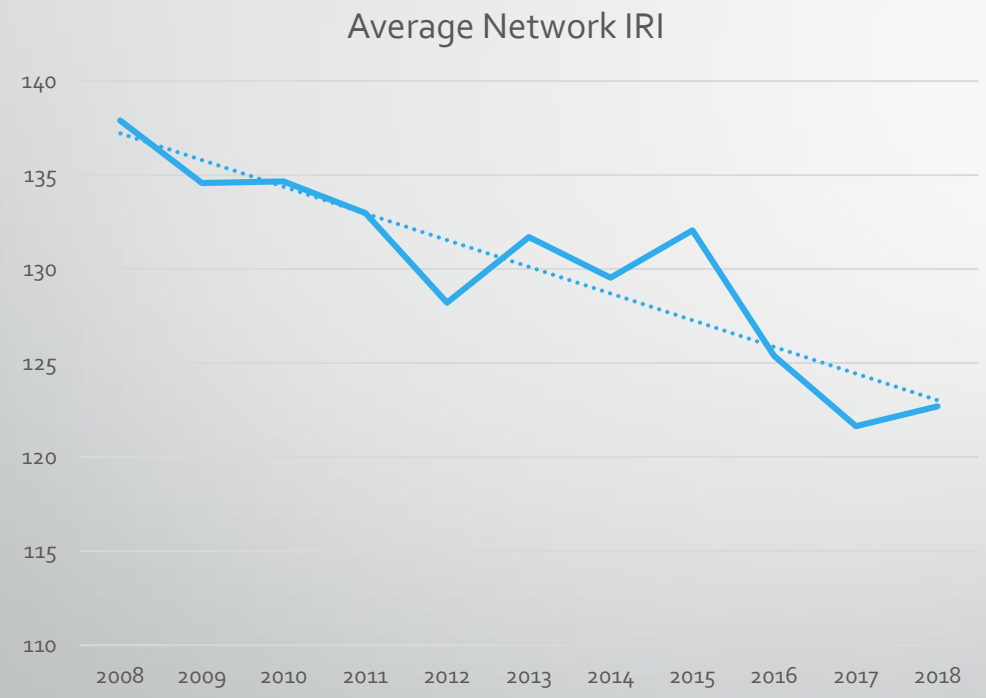
Rough roads can result in a loss of vehicle control, Reduction in a person's ability to perform motor tasks, Driver fatigue, and an increased frequency of accidents

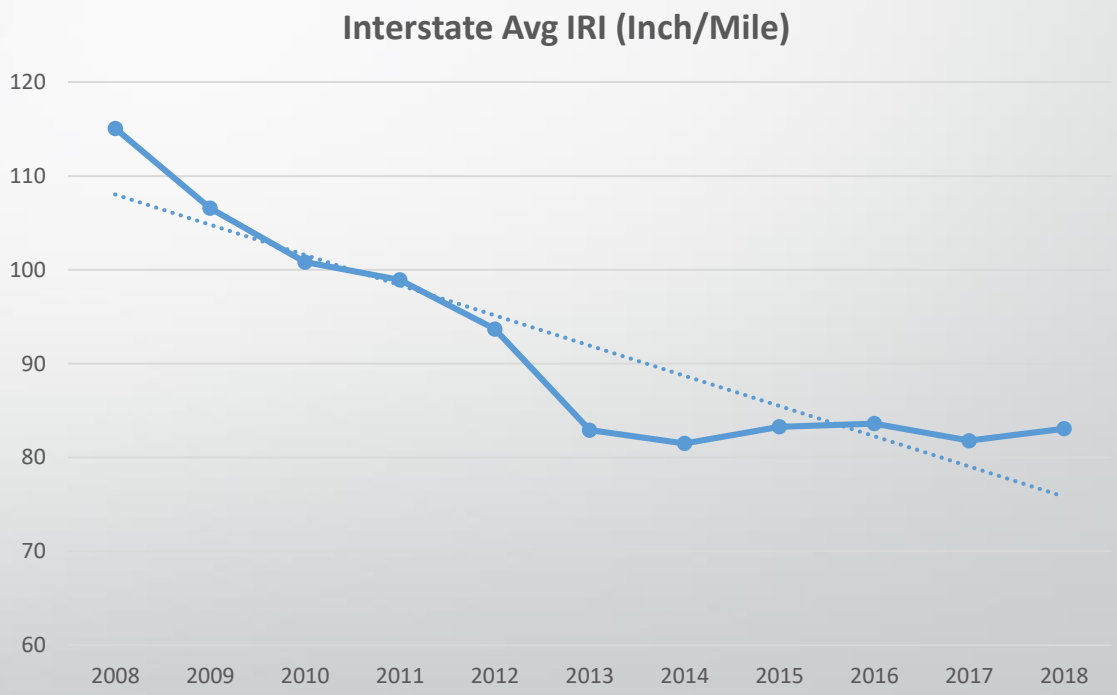
- **Smoother roads save money.**

Save both the user and the owner-agency money.

Studies have found that pavements build smoother initially, require less maintenance over the life of the pavement. Additionally, studies such as WesTrack have shown that smoother pavements **decrease both fuel consumption and vehicle maintenance, which is a savings for roadway users.**

NJDOT NETWORK RIDE QUALITY





Source: NJDOT PMS Data

Outline

- What is Pavement Smoothness?
- Why Pavement Smoothness Specifications is required?
- **History / Background**
- What is IRI?
- How Smoothness is measured?
- NJDOT Specification
- Pay Adjustment
- Ride Quality for Local-Aid Projects

History / Background

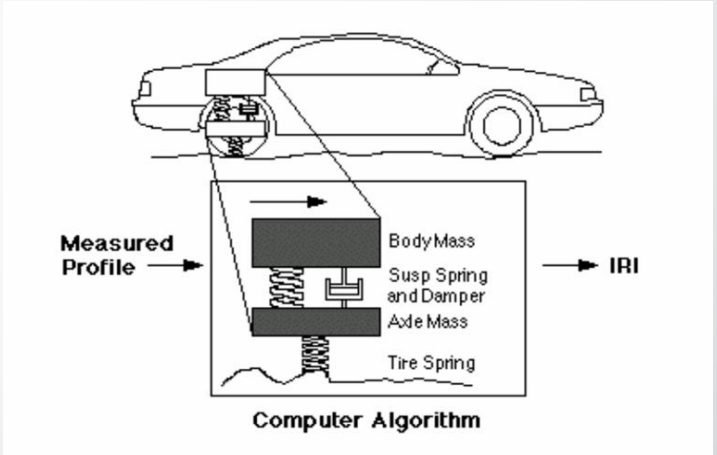
- In the early 1980s the highway engineering community identified road roughness as the primary indicator of the utility of a highway network to road users.
- US National Cooperative Highway Research Program (NCHRP) initiated a research project to help state agencies improve their use of roughness measuring equipment.[
- Continued by The World Bank
- Findings from the **World Bank testing showed that most equipment in use could produce useful roughness measures on a single scale if methods were standardized**. The roughness scale that was defined and tested was eventually named the **International Roughness Index (IRI).**

Outline

- What is Pavement Smoothness?
- Why Pavement Smoothness Specifications is required?
- History / Background
- **What is IRI?**
- How Smoothness is measured?
- NJDOT Specification
- Pay Adjustment
- Ride Quality for Local-Aid Projects

What is IRI

- IRI is calculated using a quarter-car vehicle math model, whose response is accumulated to yield a roughness index with units of slope (in/mi, m/km, etc.). **NJDOT calculate in Inch/Mile**.
- Quarter-car math model
  - Replicates roughness measurements from vibrations
  - Response Type Road Roughness Measuring System
- IRI is obtained from measured longitudinal road profiles.
- AASHTO/ASTM References: *ASTM E1926-Standard Practice for Computing IRI of Roads from Longitudinal Profile Measurements , AASHTO R-56 certification of Inertial Profiling Systems, AASHTO R-57 Operating Inertial Profiling Systems, AASHTO R-54 Accepting Pavement Ride Quality When Measured Using Inertial Profiling Systems.*



Outline

- What is Pavement Smoothness?
- Why Pavement Smoothness Specifications is required?
- History / Background
- What is IRI?
- **How Smoothness is measured?**
- NJDOT Specification
- Pay Adjustment
- Ride Quality for Local-Aid Projects

Dynatest Profiler

LWP Laser

RWP Laser

The longitudinal pavement profile measured using an inertial profiler which include:

1) An accelerometer to measure the movement of the vehicle frame,

2) Noncontact sensors (commonly lasers) to measure the relative displacement between the vehicle frame and the road surface at fixed intervals along the pavement, and

3) A distance measuring device to record the distance along the roadway.

Dynatest Profiler Images

Outline

- What is Pavement Smoothness?
- Why Pavement Smoothness Specifications is required?
- History / Background
- What is IRI?
- How Smoothness is measured?
- **NJDOT Specification**
- Pay Adjustment
- Ride Quality for Local-Aid Projects

What type of NJDOT projects have Ride Quality Requirements?

- All Paving Projects
- All treatments (HMA, SMA, OGFC, HPTO, UTFC, Micro surfacing, Slurry Seal, Diamond Grinding)
- All type of pavements (Flexible, Rigid and Composite –HMA over Concrete)
- For projects paving on mainline travel lanes equal to or greater than 2,500 feet length and any lane within the project of at least 1,000 feet length, the Department will evaluate the ride quality.
- The Department evaluate the ride quality for projects paving on mainline travel lanes of less than 2,500 feet length, if the RE determines that the work may not conform to the ride quality requirements.

Table 401.03.03-8 Target IRI for Resurfacing or Reconstruction (T)[3]

Roadway Type	Current average IRI (C)	New Construction or Reconstruction	Number of Operation for other than New Construction or Reconstruction[5]			
			One[4]	Two[4]	Three[4]	Four or More[4]
			Target IRI (T)			
Freeways or Limited Access Highways	≤ 60	50	50	50	50	50
	61 to ≤95		53	50	50	50
	96 to ≤170		55	53	50	50
	171 to≤200			55	53	50
	201 to ≤285		0.64C[7]	58	55	50
	>286[8]			60	58	53
Other than Freeways or Limited Access Highways with speed limit > 35 MPH	≤ 60	60	60	60	60	60
	61 to ≤95		63	60	60	60
	96 to ≤170		66	63	60	60
	171 to≤200			66	63	60
	201 to ≤285		0.64C[7]	69	66	60
	>286[8]			72	69	63
Other than Freeways or Limited Access Highways with speed limit ≤ 35 MPH	≤ 60	70	70	70	70	70
	61 to ≤95		74	70	70	70
	96 to ≤170		77	74	70	70
	171 to≤200			77	74	70
	201 to ≤285		0.64C[7]	81	77	70
	>286[8]			84	81	74

1. The Department will determine target IRI (T) of roadways containing multiple speed limits of greater than 3 MPH and less than or equal to 35 MPH based on the following equation:

$$\text{Target IRI of a roadway consists of N Roadway type (T)} = \frac{T_1L_1 + T_2L_2 + \cdots \ldots T_NL_N}{L_{1+}L_{2+}L_{3+} \ldots . L_N}$$

   Where TN is the Target IRI of N section and LN is the length of N section in miles to the nearest 0.01 mile
2. Current average IRI (C) is the average of the latest available preconstruction network level IRI data of right mo travel lane from PDMT.
3. Target IRI (T) is the lowest of Current average IRI (C) and T determined from the table.
4. Multiply T with 1.05 for HMA over Concrete, if total HMA after proposed treatment is less than 8 inch thick.
5. Milling is one operation. Paving each layer of asphalt mix is an individual operation unless plans specify pavin a mix in two lifts. In such case, each lift is considered as an operation.
6. Construction or reconstruction of full pavement box on subgrade is new construction or reconstruction.
7. Use Pay Equation as below:

   IRI≤T PA=0

   IRI>T PA=PAE

8. For paving over rubblized concrete, use C >286 to determine target IRI, then multiply T with 1.05 if total HM after proposed treatment is less than 8-inch thick.

How Exclusions Will Now Be Shown

Table 401.03.03-9 –EXCLUSIONS FOR RESURFACING OR RECONSTRUCTION		
Roadway	**Lane Number**	**Exclusions**
Rt-33 NB	Lane 1	5
Rt-33 SB	Lane 1	7

Lane designation is by increasing numbers from left to right in the direction of traffic with left lane being Lane 1.

b. Corrective Action. If the average IRI is greater than the 170 inches per mile after testing is performed, the Department may require corrective action or assess the maximum negative pay adjustment as computed in Table 401.03.03-7. If the Department requires corrective action, the Contractor must submit a plan for corrective action. If the Contractor's plan for corrective action is approved and the lot is corrected, the Department will retest and evaluate the corrected area as a new lot that must meet the same requirements as the initial work. If the Contractor's plan for corrective action is not approved, the Department may require removal and replacement. The replacement work is subject to the same requirements as the initial work.

https://www.state.nj.us/transportation/eng/pavement/ridequality.shtm

Outline

- What is Pavement Smoothness?
- Why Pavement Smoothness Specifications is required?
- History / Background
- What is IRI?
- How Smoothness is measured?
- NJDOT Specification
- **Pay Adjustment**
- Ride Quality for Local-Aid Projects

IRI Pay Adjustment

NEW JERSEY DEPARTMENT OF TRANSPORTATION

Pavement & Drainage Management & Technology

Summary of Ride Quality Pay Adjustment

$ Incentive

($) Disincentive

Benefits of Ride Quality PA

- Ensures contractor quality of work
- Allows DOT to retain damages for poor work

Benefits of Ride Quality Specification

- Compliance with MAP21 requirements
- Ensures contractor quality of work
- Better roads for the public –Users satisfaction (decrease in frequency of accidents, decrease in vehicle maintenance and improve fuel efficiency
- Reduces deficient roads, improve performance and last longer

Outline

- What is Pavement Smoothness?
- Why Pavement Smoothness Specifications is required?
- History / Background
- What is IRI?
- How Smoothness is measured?
- NJDOT Specification
- Pay Adjustment
- **Ride Quality for Local-Aid Projects**

Ride Quality for Local-Aid Projects

- Use latest Updated Specs
- Ride Quality is required for **all NHS and State Owned Roads**
- Paving Length as specified in the spec
- Following information are required to define project specific ride quality requirements:
  - Preconstruction IRI –Network Data
  - Exclusion Calculations
  - Post Construction QA Testing
  - Pay Adjustment Calculation

- RQR Software (zip 2.3m - macro enabled excel file)
  - Examples (pdf 69k)
  - Instructions (pdf 1.2m)
- PA Estimator (xls 1.6m)

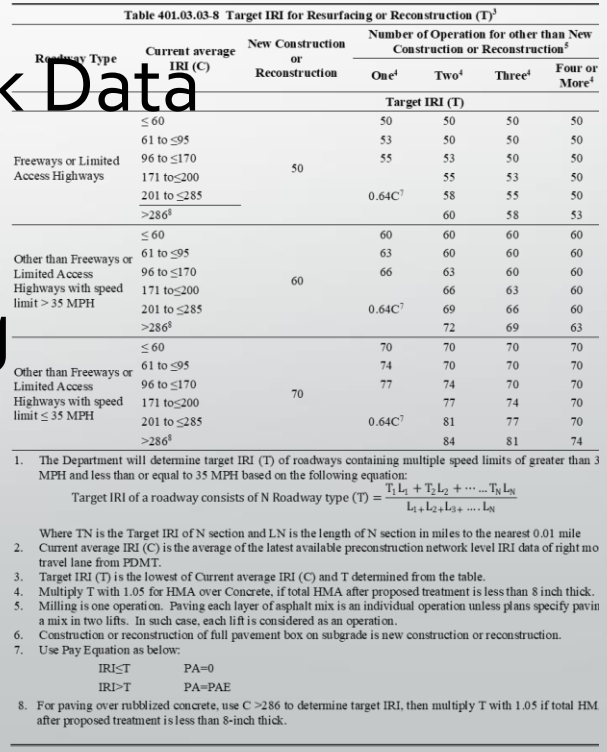


Table 401.03.03-8 Target IRI for Resurfacing or Reconstruction (T)[3]

Roadway Type	Current average IRI (C)	New Construction or Reconstruction	Number of Operation for other than New Construction or Reconstruction[5]			
			One[4]	Two[4]	Three[4]	Four or More[4]
			Target IRI (T)			
Freeways or Limited Access Highways	≤ 60	50	50	50	50	50
	61 to ≤95		53	50	50	50
	96 to ≤170		55	53	50	50
	171 to≤200			55	53	50
	201 to ≤285		0.64C[7]	58	55	50
	>286[8]			60	58	53
Other than Freeways or Limited Access Highways with speed limit > 35 MPH	≤ 60	60	60	60	60	60
	61 to ≤95		63	60	60	60
	96 to ≤170		66	63	60	60
	171 to≤200			66	63	60
	201 to ≤285		0.64C[7]	69	66	60
	>286[8]			72	69	63
Other than Freeways or Limited Access Highways with speed limit ≤ 35 MPH	≤ 60	70	70	70	70	70
	61 to ≤95		74	70	70	70
	96 to ≤170		77	74	70	70
	171 to≤200			77	74	70
	201 to ≤285		0.64C[7]	81	77	70
	>286[8]			84	81	74

1. The Department will determine target IRI (T) of roadways containing multiple speed limits of greater than 3 MPH and less than or equal to 35 MPH based on the following equation:

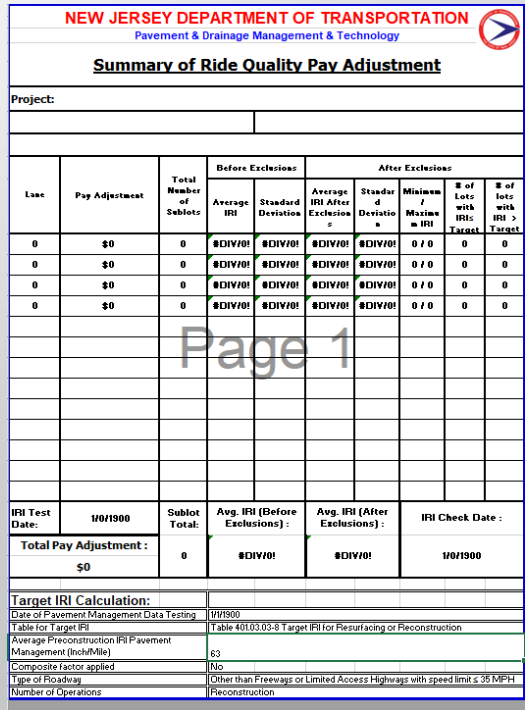
   Target IRI of a roadway consists of N Roadway type (T) = $\frac{T_1L_1 + T_2L_2 + \cdots \ldots T_NL_N}{L_1+L_2+L_3+ \ldots . L_N}$

   Where TN is the Target IRI of N section and LN is the length of N section in miles to the nearest 0.01 mile
2. Current average IRI (C) is the average of the latest available preconstruction network level IRI data of right mo travel lane from PDMT.
3. Target IRI (T) is the lowest of Current average IRI (C) and T determined from the table.
4. Multiply T with 1.05 for HMA over Concrete, if total HMA after proposed treatment is less than 8 inch thick.
5. Milling is one operation. Paving each layer of asphalt mix is an individual operation unless plans specify pavin a mix in two lifts. In such case, each lift is considered as an operation.
6. Construction or reconstruction of full pavement box on subgrade is new construction or reconstruction.
7. Use Pay Equation as below:

   IRI≤T PA=0

   IRI>T PA=PAE

8. For paving over rubblized concrete, use C >286 to determine target IRI, then multiply T with 1.05 if total HM after proposed treatment is less than 8-inch thick.



NEW JERSEY DEPARTMENT OF TRANSPORTATION

Pavement & Drainage Management & Technology

Summary of Ride Quality Pay Adjustment

Project:

Lane	Pay Adjustment	Total Number of Sublots	Before Exclusions		After Exclusions				
			Average IRI	Standard Deviation	Average IRI After Exclusions	Standard Deviation	Minimum / Maximum IRI	# of Lots with IRI< Target	# of lots with IRI > Target
0	$0	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0 / 0	0	0
0	$0	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0 / 0	0	0
0	$0	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0 / 0	0	0
0	$0	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0 / 0	0	0

Page 1

IRI Test Date:	1/0/1900	Sublot Total:	Avg. IRI (Before Exclusions) :	Avg. IRI (After Exclusions) :	IRI Check Date :
Total Pay Adjustment :		0	#DIV/0!	#DIV/0!	1/0/1900
$0					

Target IRI Calculation:	
Date of Pavement Management Data Testing	1/1/1900
Table for Target IRI	Table 401.03.03-8 Target IRI for Resurfacing or Reconstruction
Average Preconstruction IRI Pavement Management (Inch/Mile)	63
Composite factor applied	No
Type of Roadway	Other than Freeways or Limited Access Highways with speed limit ≤ 35 MPH
Number of Operations	Reconstruction

Narinder S. Kohli, P.E.

Narinder.Kohli@dot.nj.gov

609 963 1714