# Iowa Pavement Analysis Techniques (IPAT) Tool

User Guide June 2021





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Institute for Transportation

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Techniques (IPAT) automation tool th performance and RSL. To address this models were developed using paveme obtained from the Iowa Department of	el macro and Visual Basic for Applications at Iowa county engineers can use to estima a aim, statistics and artificial neural network nt structural features, traffic, construction h f Transportation (DOT) Pavement Manager cy of the models was evaluated using the r	tte the project- and net k (ANN)-based pavem nistory, and pavement ment Information Syst	work-level pavement ent performance and RSL performance records em (PMIS) and the Iowa
concrete pavement (JPCP), asphalt con	tions for four pavement types representing nerete (AC) pavement, AC over JPCP, and aches based on various conditions and distr	portland cement conc	rete (PCC) overlay-to
	as part of performance-based pavement mance and rehabilitation decisions for better p		
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# IOWA PAVEMENT ANALYSIS TECHNIQUES (IPAT) TOOL

User Guide June 2021

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#### USING THE IPAT TOOL

The Iowa Pavement Analysis Techniques (IPAT) tool is a Microsoft Excel, macro, and Visual Basic for Applications (VBA)-based automation tool that is comprised of a navigation panel (main tool) and sub-tools. Depending on the version of the operating system, various security warning messages may appear, or the tool may appear in a different font when the tool is first run. The system requirements to run this tool are Excel 2016 and VBA.

#### **Document Scope**

This user guide describes a systematic procedure on how to use the IPAT tool that helps local agencies and engineers in their decision-making process by estimating various pavement performance and pavement remaining service life (RSL) under different pavement management levels of service.

#### **Interface of Main Tool**

#### Select Predictive Model Types

The main tool provides users with selections for predictive model types, pavement type, and pavement performance indicators. The main page of the main tool gives users two options to select predictive model types, statistics-based model and artificial intelligence (AI)-based models, as shown in Figure 1.



Figure 1. Predictive model type selection (main) page of IPAT main tool

Note that the authors recommend the statistics-based model to predict pavement performance and RSL at the project level and AI-based models at the network level, although both approaches can be used for both pavement management levels.

#### Select Pavement Type

S		<b>nent Type</b> predict pavement performa	nce
JPCP (Concrete)	AC (Asphalt)	AC over JPCP (Composite)	PCC Overla (Composite

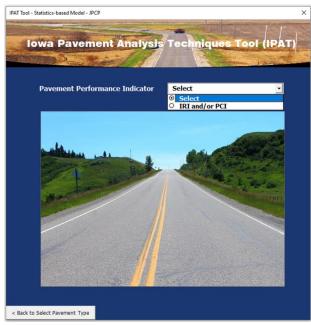
Figure 2 shows the interface of the selection page for pavement type for both statistics- and AI-based approaches.

Figure 2. Pavement type selection page of IPAT main tool

The pavement types include jointed plain concrete pavement (JPCP), asphalt concrete (AC), AC over JPCP, and portland cement concrete (PCC) overlay.

#### Select Pavement Performance Indicator

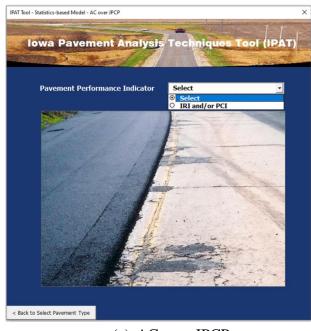
Figure 3 shows sample pages of the statistics-based models for selecting pavement performance indicator for (a) JPCP, (b) AC, (c) AC over JPCP, and (d) PCC overlay.



(a) JPCP



(b) AC



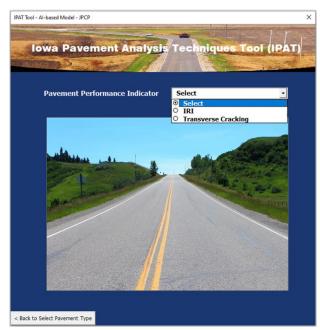
(c) AC over JPCP



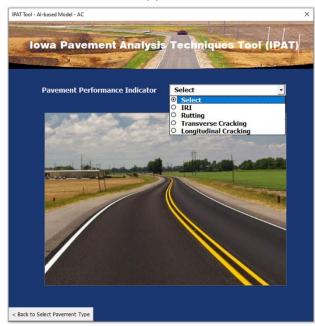
(d) PCC overlay

# Figure 3. Pavement performance indicator selection page for statistics-based models for various pavement types

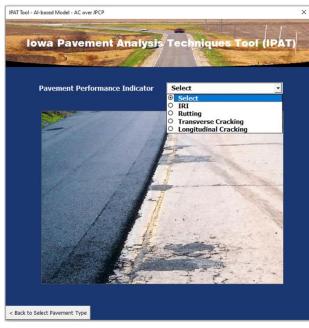
The performance indicators for the statistics-based models are the international roughness index (IRI) and pavement condition index (PCI). Figure 4 shows sample pages of the AI-based models for selecting pavement performance indicator for (a) JPCP, (b) AC, (c) AC over JPCP, and (d) PCC overlay.



(a) JPCP



(b) AC



(c) AC over JPCP



(d) PCC overlay

## Figure 4. Pavement performance indicator selection page for AI-based models for various pavement types

The performance indicators for AI-based models vary for each pavement type. For JPCP, they are IRI and transverse cracking; for AC and AC over JPCP, they are IRI, rutting, transverse and longitudinal cracking; for PCC overlay, it is IRI. Selecting any pavement performance indicator at each pavement type navigates the user to different questions to check the availability of the required data to launch the sub-tools.

Figure 5 and Figure 6 show sample interfaces for the checking process of the required data to predict IRI before launching the sub-tool for the AC pavement type using statistics- and AI-based models, respectively.

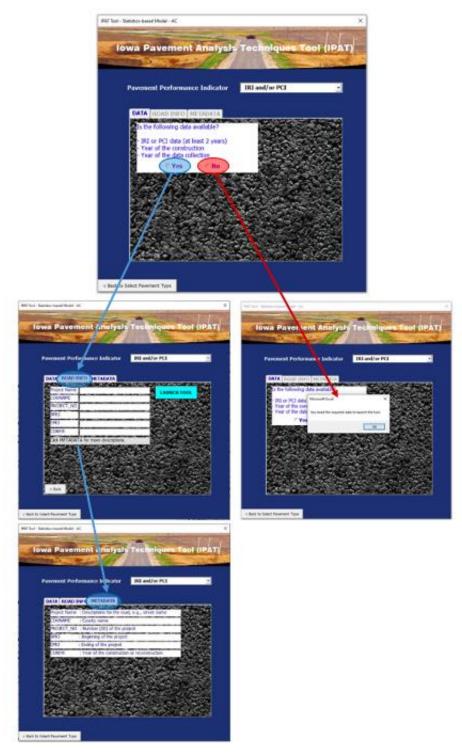
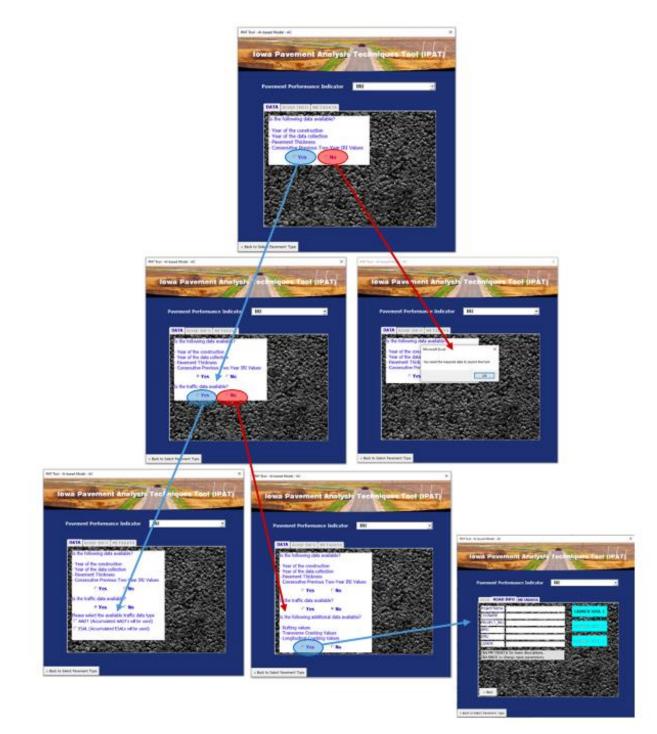


Figure 5. Required data check to launch sub-tool for IRI for statistics-based model for AC pavement type



# Figure 6. Required data check to launch sub-tool for IRI for AI-based model for AC pavement type

A detailed process for each pavement performance indicator and pavement type is indicated as a flowchart in Figure 7 through Figure 15.

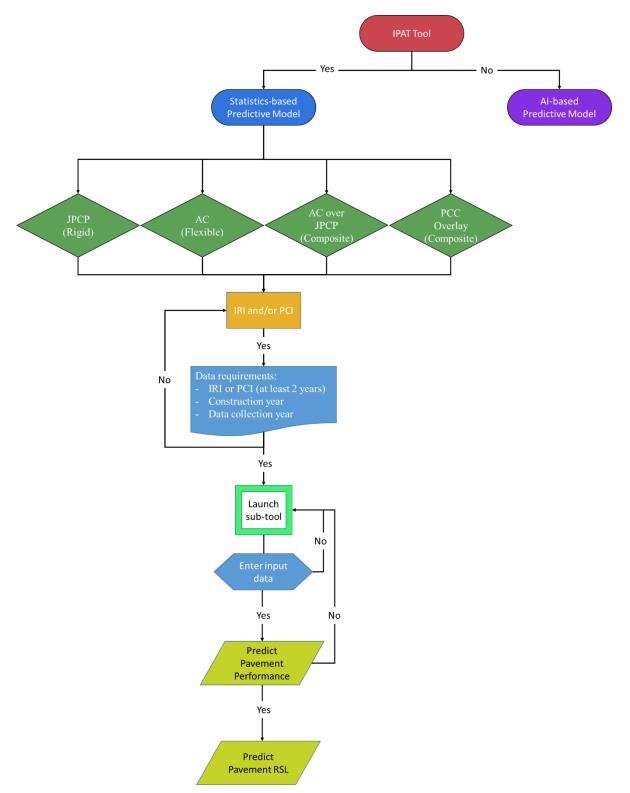


Figure 7. Flowchart of IPAT tool using statistics-based models for all pavement types

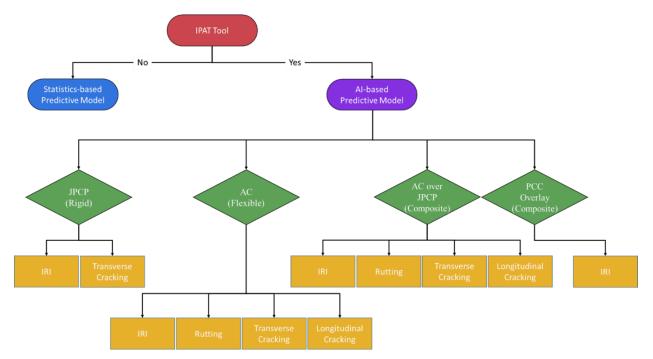


Figure 8. Flowchart of IPAT tool using AI-based models for all pavement types

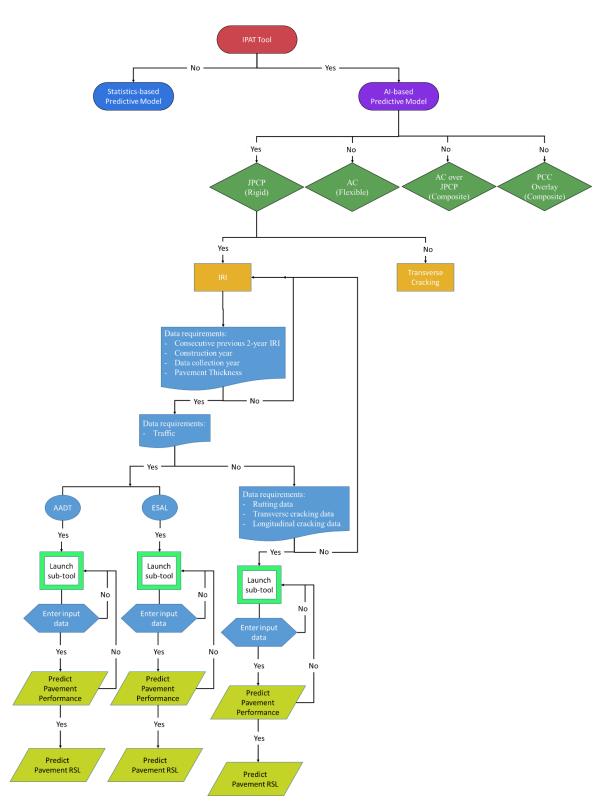


Figure 9. Flowchart of IPAT tool using AI-based IRI model for JPCP

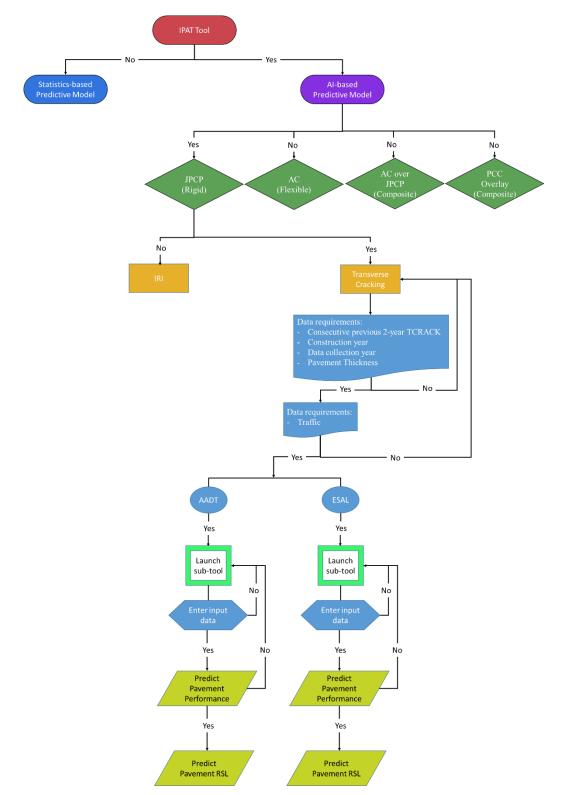


Figure 10. Flowchart of IPAT tool using AI-based TCRACK model for JPCP

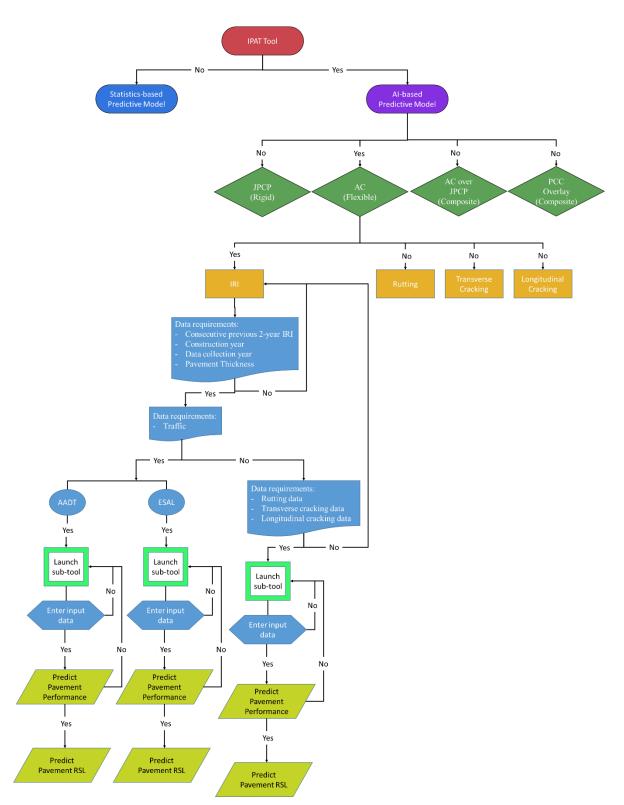


Figure 11. Flowchart of IPAT tool using AI-based IRI model for AC

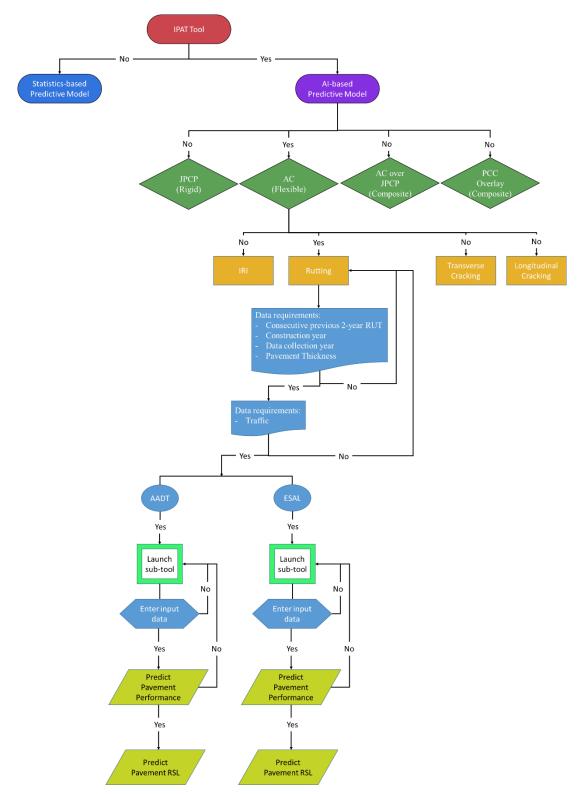


Figure 12. Flowchart of IPAT tool using AI-based RUT model for AC

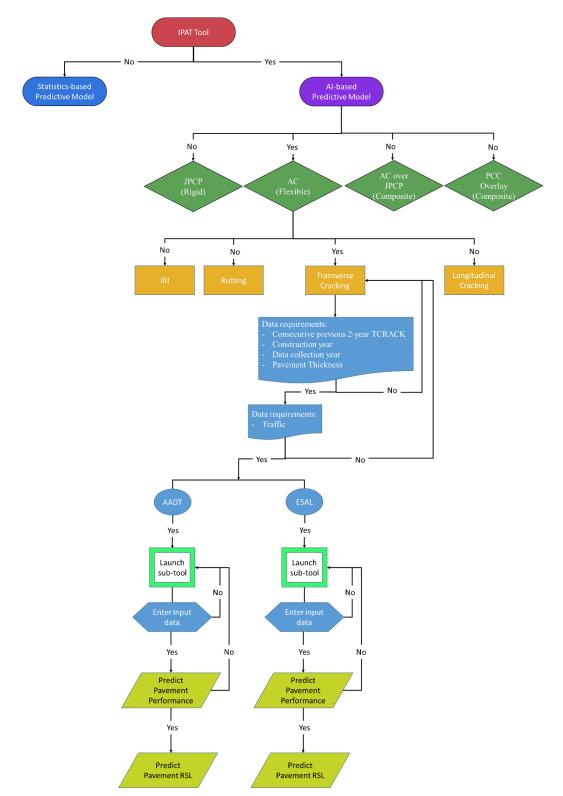


Figure 13. Flowchart of IPAT tool using AI-based TCRACK model for AC

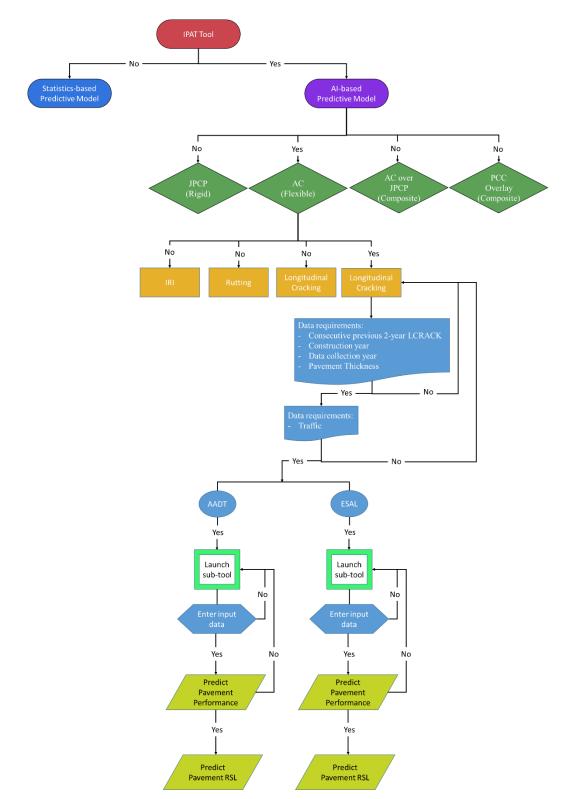


Figure 14. Flowchart of IPAT tool using AI-based LCRACK model for AC

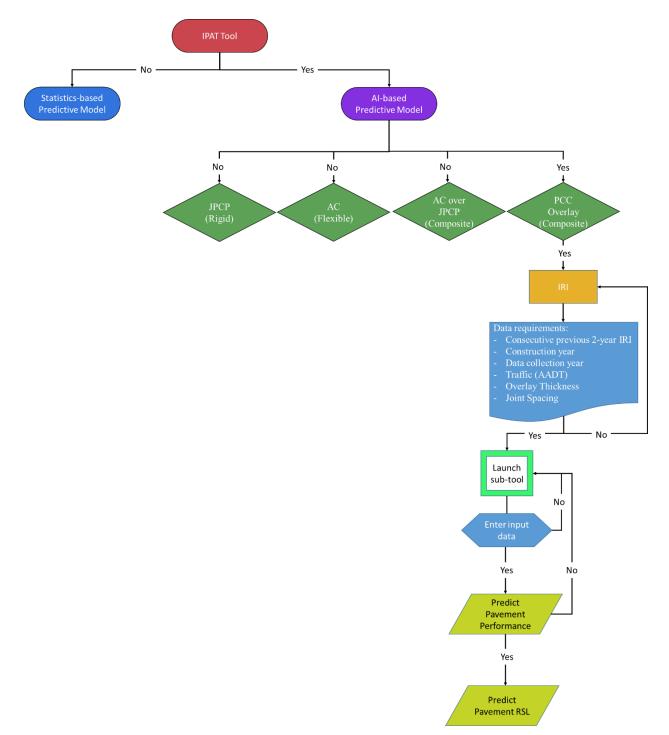


Figure 15. Flowchart of IPAT tool using AI-based IRI model for PCC overlay

#### **Interface of Sub-Tools**

#### Enter Inputs

The IPAT sub-tools for each pavement performance indicator and pavement type are launched

by clicking the launch tool in the IPAT main tool. The sub-tool interfaces, which were developed based on the Excel format that includes macros, have the option of statistics- and AI-based models, developed by using the Iowa Department of Transportation's (DOT's) Pavement Management Information System (PMIS) database (e.g., PMIS model) and improved by using data from a database from counties (e.g., county model), and are shown in Figure 16–Figure 37.

roject Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	IRI, (in/mile)	PCI (%)	Age (years)	Predicted IRI (in/mile)	Predicted PCI (%)
Calculate Fu	uture IRI Calculate Future		ire PCI								
View IRI I	Model		Vie	w PCI M	odel						
Calculate RSL B	ased on IRI		Calculat	e RSL Bas	ed on PCI						
		DECET	-								
	RESET nit for IRI (in/m	iile)				Coeff.	Of Detern		highligted cell		
	Threshold Lin Design Life Present Year	nit for PCI (%)							to. Green-i		

Figure 16. Sub-tool to predict IRI using statistics-based model



Figure 17. Sub-tool to predict IRI using AI-based IRI approach 1 county model for JPCPs (launch tool 1 in main tool)

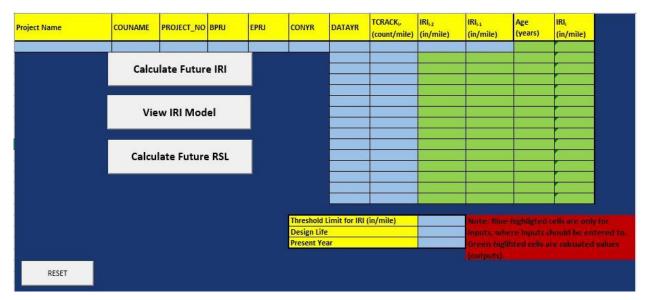


Figure 18. Sub-tool to predict IRI using AI-based IRI approach 2 county model for JPCPs (launch tool 2 in main tool)

Project Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated ESALs	PCC Thickness (in.)		IRI <sub>i-1</sub> (in/mile)	Age (years)	IRI; (in/mile)
	Calc	culate Future I	RI									
				-								
	N	iew IRI Model										
	, i	iew na wodei	8									
	Calc	ulate Future R	SL									
				-								
					Threshol	d Limit for	IRI (in/mile)		1	Note: Blue		cells are only fo
				Design L			inputs, where inputs should be entered to					
					Present	Year	b I	Greenin ginted cells are calcuated value. (outputs)				
					Traffic In	icrement p	oer year (%)	-	l l			
RESET					22							

Figure 19. Sub-tool to predict IRI using AI-based IRI approach 1 PMIS model for JPCPs (launch tool 3 in main tool)

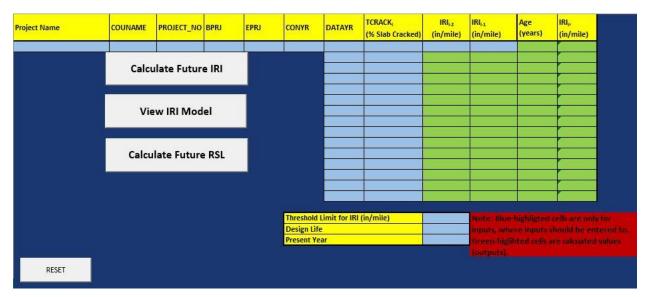


Figure 20. Sub-tool to predict IRI using AI-based IRI approach 2 PMIS model for JPCPs (launch tool 4 in main tool)

roject Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated AADTs	PCC Thickness (in.)	TCRACK <sub>i-2</sub> (count/mile)	TCRACK <sub>i-1</sub> (count/mile)	Age (years)	TCRACK <sub>i</sub> (count/mile)		
	Calculat	e Future T												
	Calculat	Calculate Future TCRACK												
	10													
	View	TCRACK M	امامه											
	view	I CRACK IVI	odel											
		2.12		ĺ										
	Calcu	late Future	RSL											
	al.													
					Threshold I	Limit for TCR	ACK (% slab cracked)							
							ACK (count/mile)	0				ells are only for in		
					Design Life							entered to. Gree		
					Present Ye	ar				higlihted cells are calcuated values (c				
					Traffic Incre	ement per ye	ear (%)	1						
RESET						purju	e e denie							

Figure 21. Sub-tool to predict TCRACK using AI-based county model for JPCPs (launch tool 1 in main tool)



Figure 22. Sub-tool to predict TCRACK using AI-based PMIS model for JPCPs (launch tool 2 in main tool)



Figure 23. Sub-tool to predict IRI using AI-based IRI approach 1 county model for AC (launch tool 1 in main tool)



Figure 24. Sub-tool to predict IRI using AI-based IRI approach 2 PMIS model for AC (launch tool 2 in main tool)



Figure 25. Sub-tool to predict IRI using AI-based IRI approach 1 PMIS model for AC (launch tool 3 in main tool)



Figure 26. Sub-tool to predict RUT using AI-based county model for AC (launch tool 1 in main tool)



Figure 27. Sub-tool to predict RUT using AI-based PMIS model for AC (launch tool 2 in main tool)

roject Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated AADTs	HMA Thickness (in.)	TCRACK <sub>i-2</sub> (ft/mile)	TCRACK <sub>i-1</sub> (ft/mile)	Age (years)	TCRACK; (ft/mile)	
	Calculat	e Future T	CRACK										
	Calculat	e ruture i	CRACK										
												4	
	View	TCRACK M	odel			_							
							20						
	-		-				-			1			
	Calcu	late Future	RSL					1					
			anne e da e										
								8					
											-		
					Threshold I	Limit for TCR	ACK (% cracking)						
					Threshold I	Limit for TCR	ACK (ft/mile)	0.00		inputs, where inputs should be enter			for
					Design Life (years)								
				Present Year		ar				Green-higlihted cells are calcuated values			
					Traffic Iner	ement per ye		1	1				
RESET					Tranic incre	ement per ye	ai (70)	1					

Figure 28. Sub-tool to predict TCRACK using AI-based county model for AC (launch tool 1 in main tool)

roject Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated ESALs	HMA Thickness (in.)	TCRACK <sub>i-2</sub> (ft/mile)	TCRACK <sub>i-1</sub> (ft/mile)	Age (years)	TCRACK <sub>i</sub> (ft/mile)	
							2		-				
	Calcula	te Future T	CRACK										
	View	TCRACK M	odel										
	8# 1									2			
	Calcu	late Future	e RSL										
										2			
					Threshold	Limit for TCR	ACK (% cracking)						
							ACK (ft/mile)	0.00		Note: Blue		d cells are only	for
					Design Life							should be ent	
					Present Y	ear			J	Green-higi (outputs).		are calcuated	
RESET					Traffic Inc	rement per y	ear (%)		1				

Figure 29. Sub-tool to predict TCRACK using AI-based PMIS model for AC (launch tool 2 in main tool)

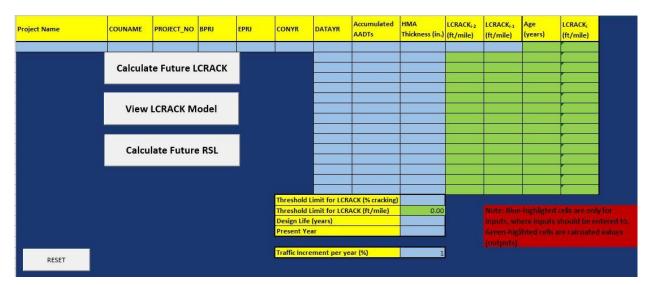


Figure 30. Sub-tool to predict LCRACK using AI-based county model for AC (launch tool 1 in main tool)

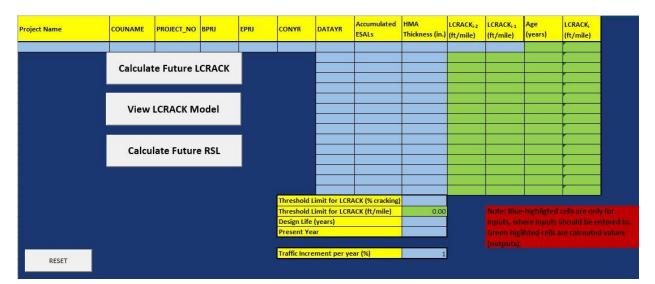


Figure 31. Sub-tool to predict LCRACK using AI-based PMIS model for AC (launch tool 2 in main tool)



Figure 32. Sub-tool to predict IRI using AI-based IRI approach 1 PMIS model for AC over JPCP (launch tool 1 in main tool)

			BPRJ	EPRJ	CONYR	DATAYR	RUT <sub>i</sub> (in)	LCRACK <sub>i</sub> (ft/mile)	TCRACK <sub>i</sub> (ft/mi)	IRI <sub>i-2</sub> (in/mile)	IRI <sub>i-1</sub> (in/mile)	Age (years)	IRI <sub>i</sub> (in/mile)
										i i i i i i i i i i i i i i i i i i i			
	Calcul	late Futur	e IRI			-							
						_					8		
	Viev	w IRI Mod	el			-							
										5	8		
	Calcul	ate Future	e RSL										
0				-									
						Limit for IRI	(in/mile)						t cells are only fo
					Design Life Present Ye								should be enter are calcuated va
											(outputs)		

Figure 33. Sub-tool to predict IRI using AI-based IRI approach 2 PMIS model for AC over JPCP (launch tool 2 in main tool)



Figure 34. Sub-tool to predict RUT using AI-based PMIS model for AC over JPCP

oject Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated ESALs	HMA Thickness (in.)	TCRACK <sub>i-2</sub> (ft/mile)	TCRACK <sub>i-1</sub> (ft/mile)	Age (years)	TCRACK; (ft/mile)
									8		1.2	
	Calcula	te Future T	CRACK									
	View	TCRACK M	lodel									
	Calcu	late Future	o DCI									
	Calcu	nate i uturi	e NJL									
					Threshold	Limit for TCR	ACK (% cracking)					
					Threshold Design Life		ACK (ft/mile)	0.00				t cells are only fo should be enter
					Present Ye				5	Green-hig	inted cells	are calcuated va
					Traffic Incr	ement per y	ear (%)	1	18			

Figure 35. Sub-tool to predict TCRACK using AI-based PMIS model for AC over JPCP



Figure 36. Sub-tool to predict LCRACK using AI-based PMIS model for AC over JPCP



Figure 37. Sub-tool to predict IRI using AI-based county model for PCC overlay

Within all sub-tool interfaces, the yellow cells indicate titles for inputs and outputs, light blue cells indicate that users should enter inputs, green cells indicate predicted outputs, and gray boxes indicate buttons that users should click based on their selections. The user is required to enter and/or edit data for only light blue cells and is not allowed to change yellow and green cells.

The common input parameters for all sub-tools are listed below. The user has the option to enter this road information in the IPAT main tool that will be automatically transferred to the IPAT sub-tools. In the case of not entering the road information in the main tool, the user may enter and/or edit it in sub-tool. The input parameters are as follows:

- Project Name: Descriptions for the road, e.g., street name
- COUNAME: County name
- PROJECT\_NO: Number (ID) of the project
- BPRJ: Beginning of the project
- EPRJ: Ending of the project
- CONYR: Year of the construction or reconstruction

The following parameters are the required inputs and the predicted outputs in IPAT sub-tools:

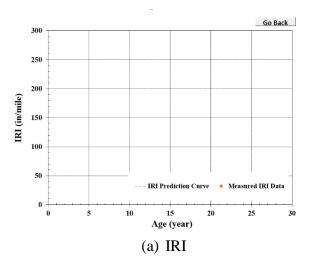
- DATAYR: Year of data collection
- Accumulated AADT: Accumulated annual average daily traffic data that are calculated by adding up current year AADT and previous year AADT
- Accumulated ESAL: Accumulated equivalent single axle load data that are calculated by adding up current year ESAL and previous year ESAL
- Age: Pavement age calculated by subtracting CONYR from DATAYR, in years
- PCC Thickness (in.): Portland cement concrete slab thickness, inch
- HMA Thickness (in.): Hot-mix asphalt concrete slab thickness, inch

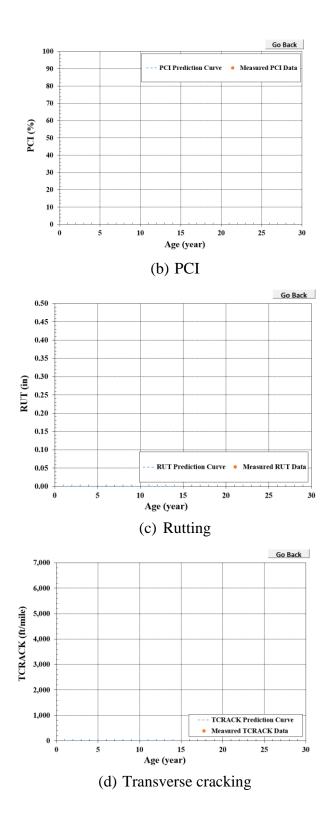
- Overlay Thickness (in.): Portland cement concrete overlay thickness, inch
- PCI (%): Pavement condition index, 0–100 %
- Predicted PCI (%): PCI predicted by statistics-based model, in percentage
- IRI<sub>i-2</sub> (in./mi): International roughness index two years ago, inch per mile
- IRI<sub>i-1</sub> (in./mi): International roughness index one year ago, inch per mile
- IRI<sub>i</sub> (in./mi): International roughness index at current year, inch per mile
- Predicted IRI (in./mi): IRI predicted by statistics-based model, inch per mile
- RUT<sub>i-2</sub> (in.): Rutting depth two years ago, inch
- RUT<sub>i-1</sub> (in.): Rutting depth one year ago, inch
- RUT<sub>i</sub> (in.): Rutting depth at current year, inch
- TCRACK<sub>i-2</sub> (count/mi): Number of transverse cracks/mile two years ago, count per mile
- TCRACK<sub>i-1</sub> (count/mi): Number of transverse cracks/mile one year ago, count per mile
- TCRACK<sub>i</sub> (count/mi): Number of transverse cracks/mile at current year, count per mile
- TCRACK<sub>i-2</sub> (% slab cracked): Transverse cracking two years ago, percent of slab cracked
- TCRACK<sub>i-1</sub> (% slab cracked): Transverse cracking one year ago, percent of slab cracked
- TCRACK<sub>i</sub> (% slab cracked): Transverse cracking at current year, percent of slab cracked
- TCRACK<sub>i-2</sub> (ft/mi): Transverse cracking two years ago, foot per mile
- TCRACK<sub>i-1</sub> (ft/mi): Transverse cracking one year ago, foot per mile
- TCRACK<sub>i</sub> (ft/mi): Transverse cracking at current year, foot per mile
- LCRACK<sub>i-2</sub> (ft/mi): Longitudinal cracking two years ago, foot per mile
- LCRACK<sub>i-1</sub> (ft/mi): Longitudinal cracking one year ago, foot per mile
- LCRACK<sub>i</sub> (ft/mi): Longitudinal cracking at current year, foot per mile
- Joint spacing (ft): Distance between transverse joints on concrete pavements, foot
- Threshold Limit for PCI (%): Threshold PCI value representing pavement in poor condition, inch per mile (e.g., 40%)
- Threshold Limit for IRI (in./mi): Threshold IRI value representing pavement in poor condition, inch per mile (e.g., 170 in./mi)
- Threshold Limit for RUT (in.): Threshold RUT value representing pavement in poor condition, inch
- Threshold Limit for TCRACK (% slab cracked) for JPCP: Threshold TCRACK value representing pavement in poor condition, in percentage
- Threshold Limit for TCRACK (count/mi) for JPCP: Threshold TCRACK value representing pavement in poor condition, count per mile, calculated using the following equation: (% slab cracked/100) × (10 ft of lane width/2 ft of crack width) × (5,280 ft/mi) × (1/10 ft of lane width) width)
- Threshold Limit for TCRACK (% cracking) for AC and AC over JPCP: Threshold TCRACK value representing pavement in poor condition, in percentage
- Threshold Limit for TCRACK (ft/mi) for AC and AC over JPCP: Threshold TCRACK value representing pavement in poor condition, foot per mile, calculated using the following equation: (% cracking area/100) × (10 ft of lane width/2 ft of crack width) × (5,280 ft/mi)
- Threshold Limit for LCRACK (% cracking) for AC and AC over JPCP: Threshold LCRACK value representing pavement in poor condition, in percentage

- Threshold Limit for LCRACK (ft/mi) for AC and AC over JPCP: Threshold LCRACK value representing pavement in poor condition, foot per mile, calculated using the following equation: (% cracking area/100) × (10 ft of lane width/2 ft of crack width) × (5,280 ft/mi)
- Design Life: Design life of pavement (e.g., 40 years)
- Present Year: Current year (e.g., 2010)
- Traffic Increment per Year (%): Traffic increment assumption per year to calculate future accumulated traffic data and then to predict future performance, in percentage (e.g., 1%)
- Coefficient Of Determination (R<sup>2</sup>): Calculated coefficient of determination value (R<sup>2</sup>) based on comparison of IRI<sub>i</sub> and Predicted IRI, 0 to 1 indicating high accuracy in results
- Calculate Future IRI (or PCI, RUT, TCRACK, LCRACK): Button to click to predict future pavement performance indicator
- View IRI (or PCI, RUT, TCRACK, LCRACK) Model: Button to click to view deterioration curve in time by plotting pavement performance indicator versus age
- Calculate RSL Based on IRI (or PCI, RUT, TCRACK, LCRACK): Button to click to calculate RSL based on pavement performance indicator and the following parameters if asked:
  - Threshold Limit for IRI (or PCI, RUT, TCRACK, LCRACK)
  - Design Life
  - o Present Year
- Reset: Button to click to reset the analysis and clean the spreadsheet for the next analysis

#### Predict Pavement Performance

IPAT sub-tools predict pavement performance indicators based on the entered input data, indicate them in numeric value, and plot them in a graph. All green cells indicate the pavement performance predictions. The deterioration model is plotted based on a comparison of the entered field condition and distress data and predicted ones by clicking the View IRI (or PCI, RUT, TCRACK, LCRACK) Model button in the IPAT sub-tool sheets; sample empty graphs are shown in Figure 38. The Go Back button at the top right corner of the graphs should be clicked to return to the input and output sheet.





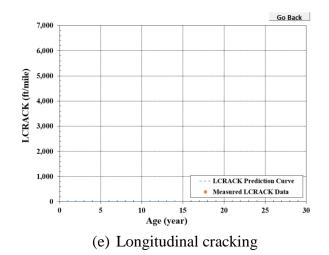


Figure 38. Sample deterioration model graphs (without data) when clicking various view options in IPAT sub-tools

#### Predict Pavement RSL

IPAT sub-tools predict RSL of pavement sections based on current and future predicted performance indicators. The RSL cannot be estimated without entering inputs and having pavement performance predictions. Clicking the Calculate Future RSL button estimates the RSL of a pavement section based on the following:

- Predicted pavement performance indicator (IRI, PCI, RUT, TCRACK, or LCRACK)
- Threshold limit for IRI (or PCI, RUT, TCRACK, or LCRACK)
- Design life
- Present year

Based on different scenarios with predicted performance and entered threshold values, a large green cell appears under the Calculate Future RSL button. The number seen at the top of the green cell is the RSL year of pavement (e.g., 10 years) and the text seen under the number describes the RSL (e.g., RSL is calculated based on design life). Figure 39 indicates a variety of sample RSL results based on the predicted and given information. Note that these results are for illustration purposes; thus, RSL numbers may not represent real values.

Calculate Future RSL

RSL could not be calculated. Please enter more information!

(a)

**Calculate Future RSL** 

IRI predictions do not reach the threshold limit! Thus, RSL could not be calculated. Please enter more information!

(b)

Calculate Future RSL Please enter smaller 'present year' value!

(c)



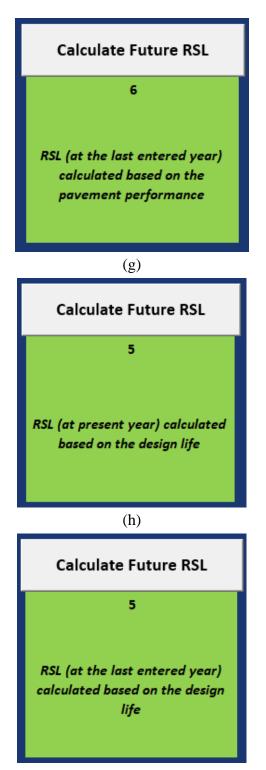
(d)

Calculate Future RSL Entered age already exceeded design service life!

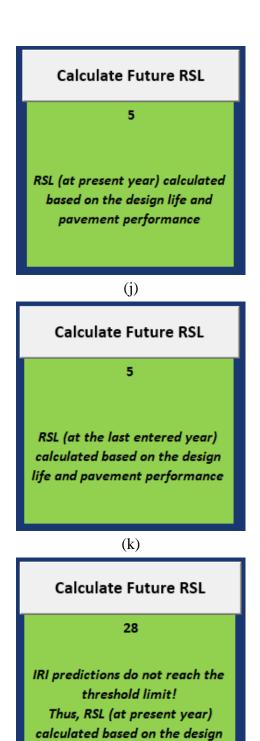


calculated based on the pavement performance

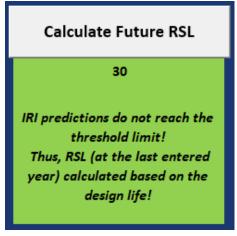
(f)



(i)



life!



(m)

# Figure 39. Sample RSL results when clicking the Calculate Future RSL button in sub-tools

The RSL results that might be obtained based on various scenarios are as follows:

- *RSL could not be calculated. Please enter more information:* If the user does not enter any threshold limit, design life, and present year data, RSL cannot be calculated (Figure 39a).
- *IRI predictions do not reach the threshold limit! Thus, RSL could not be calculated. Please enter more information!:* If the user enters only threshold limit and the performance predictions never reach the threshold limit, RSL cannot be calculated, and the user needs to enter more data such as design life (Figure 39b).
- *Please enter smaller 'present year' value!:* If the user enters all data and the age calculated at the entered present year is larger than the entered design life, RSL cannot be calculated, and the user needs to enter a smaller value for the present year (Figure 39c).
- *Entered IRI already exceeded threshold limit!:* When the user enters threshold limit for pavement condition and distress data that are smaller than the current pavement condition and distress data, pavement performance already exceeds the threshold limit (Figure 39d).
- *Entered age already exceeded design service life!:* When the user enters a design life that is smaller than the current pavement age, the pavement age already exceeds the design life (Figure 39e).
- *RSL (at present year) calculated based on the pavement performance:* When the user enters all data or only threshold limit and present year, RSL is calculated based on the entered present year if the performance predictions reach the threshold limit within the design life (Figure 39f).
- *RSL (at the last entered year) calculated based on the pavement performance:* When the user enters a threshold limit but not the present year, RSL is calculated based on the last entered year in the DATAYR column if the performance predictions reach the threshold limit within the design life (Figure 39g).
- *RSL (at present year) calculated based on the design life:* When the user enters all data or only design life and present year, RSL is calculated based on the entered present year if the pavement age exceeds the design life earlier than the age that the performance predictions reach the threshold limit (Figure 39h).

- *RSL (at the last entered year) calculated based on the design life:* When the user enters design life but not present year, RSL is calculated based on the last entered year in the DATAYR column if the pavement age exceeds the design life earlier than the age that the performance predictions reach the threshold limit (Figure 39i).
- *RSL (at present year) calculated based on the design life and the pavement performance:* When the user enters all data, RSL is calculated based on the entered present year if the pavement age exceeds the design life and the performance predictions reach the threshold limit at the same time (Figure 39j).
- *RSL (at the last entered year) calculated based on the design life and the pavement performance:* When the user enters all data but not present year, RSL is calculated based on the last entered year in the DATAYR column if the pavement age exceeds the design life and the performance predictions reach the threshold limit at the same time (Figure 39k).
- *IRI predictions do not reach the threshold limit! Thus, RSL (at present year) calculated based on the design life!:* When the user enters all data, RSL is calculated based on the entered present year if the pavement age exceeds the design life and the performance predictions never reach the threshold limit within the design life (Figure 391).
- *IRI predictions do not reach the threshold limit! Thus, RSL (at the last entered year) calculated based on the design life!:* When the user enters all data but not present year, RSL is calculated based on the last entered year in the DATAYR column if the pavement age exceeds the design life and the performance predictions never reach the threshold limit within the design life (Figure 39m).

# ILLUSTRATIVE EXAMPLES: PAVEMENT ANALYSIS USING THE IPAT TOOL

Examples of predicting IRI and RSL for each JPCP and AC pavement type using both statisticsbased and AI-based models are examined in the following sections.

#### JPCP Case: Statistics-Based Model

#### Select Predictive Model Type

The statistics-based model was selected as shown in Figure 40.



Figure 40. Select predictive model type: statistics-based model

#### Select Pavement Type

JPCP (concrete) pavement type was selected as shown in Figure 41.

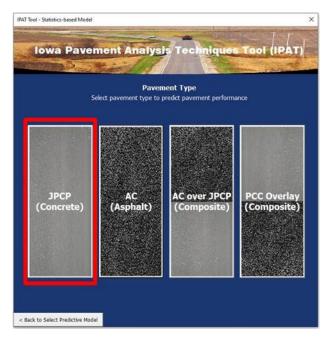


Figure 41. Select pavement type: JPCP (concrete)

# Select Pavement Performance Indicator

IRI, as a pavement performance indicator, was selected, questions are answered (Figure 42) and required road information is entered (Figure 43). Then, the launch tool button is clicked to launch the sub-tool.



Figure 42. Select pavement performance indicator and prepare data: IRI (statistics-based model)

TTA ROAD INFO METADATA Project Name Wrtz Ln
LAUNCH
COUNAME Lee
PROJECT_NO L94-L-273-56
BPRJ N/A
EPRJ N/A
CONYR 1995
Click METADATA for more descriptions.

Figure 43. Enter required data information: county JPCP (statistics-based model)

# Enter Inputs

The entered data information in the IPAT main tool were transferred into the IPAT sub-tool as shown in Figure 44.

Project Name Wirtz In	COUNAME Ler	PROJECT_NO		EPRI	CONYR 1995	D. CAYR	IRI, (in/mile)	PCI (%)	Age (years)	Predicted IRI (in/mile)	Predicted PCI (%)
			in the second se	indus.					<b>*</b>		
									,		
Calculate Futu	ure IRI		Calcu	late Futur	e PCI						
						<u> </u>					
									-		
View IRI Mo	odel		Vie	w PCI Mo	del				ļ —		
								-	<b></b>		
Calculate RSL Bas	ed on IRI		Calculate	e RSL Base	d on PCI						
									;		
									,		
									-		
			_						-		
		RESET									
	three bold the	nit for IBI (in/m	ile)		1		Conth	Of Determin	nation (E <sup>1</sup> )		
	Design Life	and the last of th					coen.	or over mit			
	Present Year									highligted cells are inputs sho	are only for uld be entered
		nit for PCI (%)			]				to, Green-h	iglifited cells a	re the
	Design Life Present Year								calculated	values (output	s).

Figure 44. Transfer data information into IPAT sub-tool: JPCP (statistics-based model)



The columns of DATAYR and  $IRI_i$  were filled based on available data as shown in Figure 45.

Figure 45. Enter input parameters: JPCP (statistics-based model)

#### Predict Pavement Performance

The Calculate Future IRI button was clicked, and future IRI was predicted (Figure 46).

Project Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	IRI;	PCI	Age		Predicted PCI
							(in/mile)	(%)	(years)	(in/mile)	(%)
Wirtz Ln	Lee	L94-L-273-5	N/A	N/A	1995	2013			18		
						2014			19		
						2015			20		
						2016			21	121.26	
Calculate F	uture IRI		Calcu	late Futur	e PCI	2017			22	124.70	
						2018	128.0341		23	128.04	
									24		
									25		
									26		
View IRI	Model		Vie	w PCI Mo	del				27	135.22	
			•10						28		
									30		
			_						31		
									32		
Calculate RSL	Reced on IRI		Calculate	e RSL Base	d on PCI				33	136.47	
calculate KSL	based on IKI		Calculate	e NSL Dase	u on PCI				34		
									35		
		-							36		
									37	136.51	
									38	136.51	
									39	136.51	
									40	136.51	
									41	136.51	
									42	136.51	
									43	136.51	
									44	136.51	
	_								45	136.51	
		RESET							46		
		NEVE 1							47	136.52	
					1						
		nit for IRI (in/m	nile)				Coeff.	Of Determin	ation (R <sup>2</sup> )	1.000	
	Design Life										
	Present Year			_						ighligted cells	
					1						uld be entered
		nit for PCI (%)								glihted cells a	
	Design Life				_				calculated v	alues (output	s).
	Present Year										

Figure 46. Calculate future IRI: JPCP (statistics-based model)

Then, the View IRI Model button was clicked, which shows the plotted deterioration curve based on the field and predicted IRI data (Figure 47).

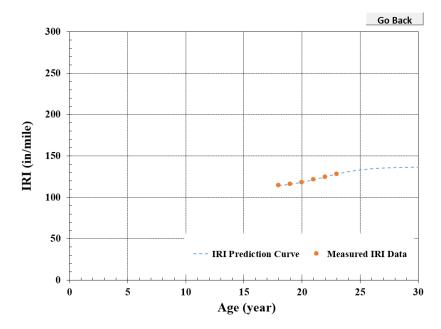


Figure 47. IRI model view: JPCP (statistics-based model)

# Predict Pavement RSL

The threshold limit for IRI, design life, and present year parameters were defined, and then the Calculate RSL Based on IRI button was clicked to predict future IRI. The RSL results and descriptions appear under the Calculate RSL Based on IRI button when different scenarios were applied as follows:

• All parameters (170 in./mi, 40 years, 2021) were defined (Figure 48)

Project Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	IRI	PCI	Age		Predicted PCI
							(in/mile)	(%)	(years)	(in/mile)	(%)
Virtz Ln	Lee	L94-L-273-5	N/A	N/A	1995		114.1822		18		
							116.0963		19		
						2015			20		
						2016	121.3516 124.6929		21	121.26 124.70	
Calculate F	uture IRI		Calcu	late Futur	e PCI		124.6929		22	124.70	
						2018	128.0341		23		
									24	130.85	
									26		
									27	135.22	
View IRI	Model		Vie	w PCI Mo	del				28		
									29		
									30		
									31	136.37	
									32	136.43	
Calculate RSL	Based on IRI		Calculate	RSL Base	d on PCI				33	136.47	
									34	136.49	
									35	136.50	
14									36	136.51	
	·								37	136.51	
									38	136.51	
IRI predictions do	o not reach the								39	136.51	
threshold	l limit!								40		
Thus, RSL (at p	vecent year)								41	136.51	
calculated basea									42	136.51	
									43	136.51	
life	!								44	136.51	
									45	136.51	
		RESET							46	136.51	
									47	136.52	
		le farme il al			1				- 2-		
		nit for IRI (in/m	nile)	170			Coeff.	Of Determin	ation (R*)	1.000	
	Design Life			40					the second second		
	Present Year			2021						ighligted cells	
					1						uld be entered
		mit for PCI (%)								glihted cells a	
	Design Life								calculated v	alues (output:	s].
	Present Year										

Figure 48. Threshold limit for IRI (170 in./mi), design life (40 years), and present year (2021): JPCP (statistics-based model)

• Threshold limit for IRI (170 in./mi) and design life (40 years) were defined (Figure 49)

Project Name	COUNAME	PROJECT NO	BPRJ	EPRJ	CONYR	DATAYR	IRI <sub>i</sub>	PCI	Age		Predicted PCI
		-					(in/mile)	(%)	(years)	(in/mile)	(%)
Virtz Ln	Lee	L94-L-273-5	N/A	N/A	1995		114.1822		18		
						2014	116.0963		19		
						2015			20		
						2016			21	121.26	
Calculate F	uture IRI		Calcu	late Futur	e PCI	2017	124.6929		22		
						2018	128.0341		23	128.04	
									24		
									25		
									26		
View IRI	Model		Vie	w PCI Mo	lah				27	135.22	
view ind	mouer		vie	WPCINO	uei				28		
									29		
									30		
									31	136.37	
									32		
Calculate RSL	Based on IRI		Calculate	e RSL Base	d on PCI				33	136.47 136.49	
									34	136.49	
									36		
17									30	136.51	
									37	136.51	
									39	136.51	
IRI predictions do									40	136.51	
threshold									40	136.51	
Thus, RSL (at th	e last entered 👘								42	136.51	
year) calculated	based on the								43	136.51	
design	life!								44		
									45		
									45		
		RESET							40	136.52	
										100.52	
					1						
		nit for IRI (in/m	iile)	170			Coeff.	Of Determin	ation (R*)	1.000	
	Design Life			40							
	Present Year				-					ighligted cells	
	_				1						uld be entered
		nit for PCI (%)								glihted cells a	
	Design Life								calculated va	ilues (output	5].
	Present Year										

Figure 49. Threshold limit for IRI (170 in./mi) and design life (40 years): JPCP (statisticsbased model)

• Different threshold limit for IRI (130 in./mi) and design life (40 years) were defined (Figure 50)



Figure 50. Threshold limit for IRI (130 in./mi) and design life (40 years): JPCP (statisticsbased model)

# JPCP Case: AI-Based Model

Select Predictive Model Types

The AI-based model was selected as shown in Figure 51.



Figure 51. Select predictive model type: AI-based model

Select Pavement Type

JPCP (concrete) pavement type was selected as shown in Figure 52.

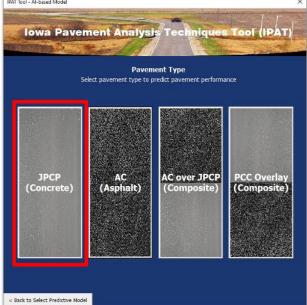


Figure 52. Select pavement type: JPCP (concrete)

#### Select Pavement Performance Indicator

IRI, as a pavement performance indicator, was selected, questions are answered (Figure 53) and required road information is entered (Figure 54). Then, the launch tool button is clicked to launch the sub-tool.



Figure 53. Select pavement performance indicator and prepare data: IRI (AI-based model)

avement Per	formance Indicator	IRI		
DATA ROAD	INFO METADATA			
Project Name	Wirtz Ln		LAUNCH TOO	
COUNAME	Lee	1	Laonchitot	
PROJECT_NO	L94-L-273-56		LAUNCHITOR	
BPRJ	N/A		DADINGATION	<u>, 12</u>
EPRJ	N/A			
CONYR	1995		LAUNCH TOO	JL 3
	TA for more descriptions. change input parameters.		LAUNCH TOO	DL 4

Figure 54. Enter required data information: county JPCP (AI-based model)

#### Enter Inputs

The entered data information in the IPAT main tool was transferred into the IPAT sub-tool as shown in Figure 55.

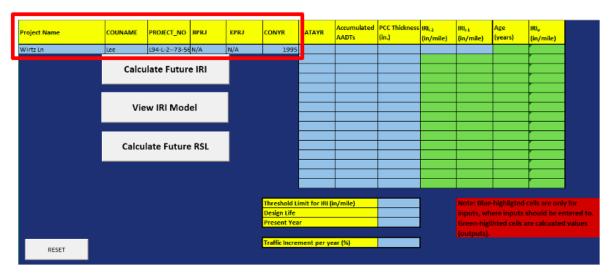


Figure 55. Transfer data information into IPAT sub-tool: JPCP (AI-based model)

The columns of DATAYR, Accumulated AADT, PCC Thickness, IRI<sub>i-2</sub>, and IRI<sub>i-1</sub> were filled based on available data as shown in Figure 56 and Figure 57.



Figure 56. Option 1: Enter existing input parameters and traffic increment per year: JPCP (AI-based model)



# Figure 57. Option 2: Enter existing and prepared input parameters without defining traffic increment per year: JPCP (AI-based model)

Here, there are two options to enter future input parameters: (1) the existing input parameters and defining traffic increment per year (%) to calculate future input parameters (Figure 56), and (2) the existing and prepared future input parameters without defining traffic increment per year (%) (Figure 57).

#### Predict Pavement Performance

The Calculate Future IRI button was clicked and future IRI was predicted (Figure 58 and Figure 59).

Project Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated AADTs	PCC Thickness (in.)	IRI⊷₂ (in/mile)	IRI <sub>FI</sub> (in/mile)		IRI» (in/mile)
Wirtz Ln	Lee	L94-L-273-56	N/A	N/A	1995	2015	505	9	114.18222	116.0963	20	118.28796
						2016	665	9	116.0963	118.28796	21	120.57228
	Calcu	late Futur	e IRI			2017	820			120.57228		122.79682
						2018	970	9	120.57223	122.79682	23	124.84878
									122.79682		24	
									124.84878			128.18369
	Vie	w IRI Mod	el							128.18369		129.43063
										129.43063	27	
									129.43063			131.17541
										131.17541		131.74439
	Calcu	late Future	e RSL							131.74439		132.16069
										132.16069		132.45711
										132.45711		132.66107
										132.66107		132.79468
									132.66107	132.79468	34	132.87555
					Threshold L Design Life Present Yea	imit for IRI (ii Ir	n/mile)			inputs, wh	ere inputs s	ells are only f hould be ente re calcuated v
										(outputs).		
RESET					Traffic Incre	ment per ye	ar (%)	1				

Figure 58. Option 1: Calculate future IRI: JPCP (AI-based model)

Project Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated AADTs	PCC Thickness (in.)	IRI <sub>I-2</sub> (in/mile)	IRI⊨1 (in/mile)	Age (years)	IRI <sub>v</sub> (in/mile)	
Wirtz Ln	Lee	L94-L-273-56	N/A	N/A	1995	2015	505	9	114.18222	116.0963	20	118.28796	
						2016	665	9	116.0963	118.28796	21	120.57223	
	Calcu	late Futur	e IRI			2017	820	9	118.28796	120.57223	22	122.79682	
						2018	970	9	120.57223	122.79682	23	124.84878	
						2019	1115	9	122.79682	124.84878	24	126.6564	
						2020	1255	9	124.84878	126.6564	25	128.18636	
	Vie	w IRI Mod	el			2021	1390	9	126.6564	128.18636	26	129.43694	
						2022	1520	9	128.18636	129.43694	27	130.42875	
						2023	1645	9	129.43694	130.42875	28	131.19529	
						2024	1765	9	130.42875	131.19529	29	131.77483	
	Calcu	late Future	RSL			2025	1880	9	131.19529	131.77483	30	132.20478	
						2026	1990	9	131.77483	132.20478	31	132.51856	
						2027	2095	9	132.20478	132.51856	32	132.74442	
						2028	2195	9	132.51856	132.74442	33	132.9056	
						2029	2290	9	132.74442	132.9056	34	133.02118	
					Threshold Li Design Life Present Yea	imit for IRI (i	n/mile)			inputs, wh	ere inputs s	ells are only hould be entre re calcuated	tered
					resent rea						inteo cens ai	ecalcuated	<b>VOIL</b>
RESET					Traffic Incre	ment per ye	ar (%)			(outputs).			

Figure 59. Option 2: Calculate future IRI: JPCP (AI-based model)

Then, the View IRI Model button is clicked, which shows the plotted deterioration curve based on the field and predicted IRI data (Figure 60).

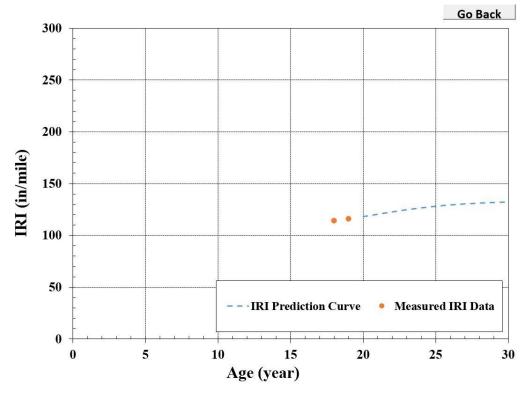


Figure 60. View IRI model (option 1): JPCP (AI-based model)

#### Predict Pavement RSL

The threshold limit for IRI, design life, and present year parameters were defined, and then the Calculate RSL Based on IRI button was clicked to predict future IRI. The RSL results and descriptions appear under the Calculate RSL Based on IRI button when different scenarios were applied as follows:

• All parameters (170 in./mi, 40 years, 2021) were defined (Figure 61)

roject Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated AADTs	PCC Thickness (in.)		IRI <sub>F1</sub> (in/mile)	Age (years)	IRI <sub>u</sub> (in/mile)
/irtz Ln	Lee	L94-L-273-56	N/A	N/A	1995	2015	505	9	114.18222	116.0963	20	118.28796
						2016	665	9	116.0963	118.28796	21	120.57223
	Calcu	late Futur	e IRI			2017	820	9	118.28796	120.57223	22	122.79682
						2018	970	9	120.57223	122.79682	23	124.84878
									122.79682			
									124.84878			128.18369
	Vie	w IRI Mod	el						126.6557	128.18369		The second s
									128.18369		27	
				_					129.43063			131.17541
		_							130.4168			131.74439
	Calcu	late Future	e RSL						131.17541			132.16069
									131.74439			132.45711
		14							132.16069			132.66107
										132.66107		132.79468
									132.66107	132.79468	34	132.87555
	IRI predict	ions do not r	each the		The second second second			170		Note: Dive	bightigted of	alls are only for
	th	reshold limit	1		Design Life	imit for IRI (i	n/milej	170				ells are only for
	Thus, RS	SL (at presen	t year)		Present Yes			2021				hould be entered
	calculated	based on th	e desian		Present rea			2021	l		inted cells al	e calcuated valu
		life!			Tester		100			(outputs).		
RESET		1.901			Traffic Incre	ment per ye	ar (%)	1				

Figure 61. Threshold limit for IRI (170 in./mi), design life (40 years), and present year (2021): JPCP (AI-based model)

• Threshold limit for IRI (170 in./mi) and design life (40 years) were defined (Figure 62)



Figure 62. Threshold limit for IRI (170 in./mi) and design life (40 years): JPCP (AI-based model)

• Different threshold limit for IRI (140 in./mi), design life (40 years), and present year (2021) were defined (Figure 63)



Figure 63. Threshold limit for IRI (130 in./mi), design life (40 years), and present year (2021): JPCP (AI-based model)

#### AC Case: Statistics-Based Model

Select Predictive Model Types

The statistics-based model was selected as seen in Figure 64.



Figure 64. Select predictive model type: statistics-based model

Select Pavement Type

<complex-block><section-header><complex-block><section-header>

AC (asphalt) pavement type was selected as shown in Figure 65.

Figure 65. Select pavement type: AC (asphalt)

#### Select Pavement Performance Indicator

IRI, as a pavement performance indicator, was selected, questions are answered (Figure 66) and required road information is entered (Figure 67). Then, the launch tool button is clicked to launch the sub-tool.



Figure 66. Select pavement performance indicator and preparation of data: IRI (statisticsbased model)

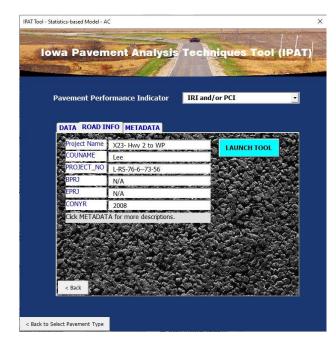


Figure 67. Enter required data information: county AC (statistics-based model)

# Enter Inputs

The entered data information in IPAT main tool was transferred into the IPAT sub-tool as shown in Figure 68.



Figure 68. Transfer data information into IPAT sub-tool: AC (statistics-based model)

The columns of DATAYR and IRI<sub>i</sub> were filled based on available data as shown in Figure 69.

Project Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	IRI; (in/mile)	PCI (%)	Age (years)	Predicted IRI (in/mile)	Predicted PCI (%)
(23- Hwy 2 to WP	Lee	L-RS-76-673	N/A	N/A	2008	2013		-			
						2014	67.93				
						2015					
				2016							
Calculate Future IRI		Calcu	late Futur	2017							
					2018	71.4					
	a										
View IRI N	lodel		Vie	w PCI Mo							
Calculate RSL B			Calculat	e RSL Base	d on PCI						
calculate KSL B	ased off IKI		Calculate	e KSL base	uoneci						
	_										
		RESET									
								_			
					1						
		mit for IRI (in/m	niie)				Coeff.	Of Determin	iation (R*)		
	Design Life Present Year								Note: Plus	highligted cells	are only for
	Present Year				_						uld be entered
	Threshold Lin	mit for PCI (%)			1					iglihted cells a	
	Design Life									values (output	
	Present Year										

Figure 69. Calculate future IRI: AC (statistics-based model)

# Predict Pavement Performance

The Calculate Future IRI button was clicked and future IRI was predicted (Figure 70).



Figure 70. Calculate future IRI: AC (statistics-based model)

Then, the View IRI Model button is clicked, which shows the plotted deterioration curve based on the field and predicted IRI data (

Figure 71).

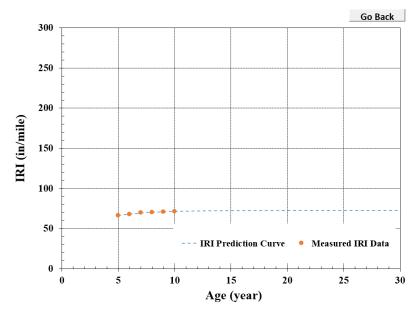


Figure 71. View IRI model: AC (statistics-based model)

Predict Pavement RSL

The threshold limit for IRI, design life, and present year parameters were defined, and then the Calculate RSL Based on IRI button was clicked to predict future IRI. The RSL results and descriptions appear under the Calculate RSL Based on IRI button when different scenarios were applied as follows:

• All parameters (170 in./mi, 40 years, 2021) were defined (Figure 72)



Figure 72. Threshold limit for IRI (170 in./mi), design life (40 years), and present year (2021): AC (statistics-based model)

• Threshold limit for IRI (170 in./mi) and design life (40 years) were defined (Figure 73)

Project Name	COUNAME	PROJECT_NO	BPRJ EPRJ		CONYR	DATAYR	IRI;	PCI	Age		Predicted PCI
							1.1	(%)	(years)	(in/mile)	(%)
(23 - Hwy 2 to WP	Lee	L-RS-76-673	N/A	N/A	2008	2013	66.34		5		
						2014	67.93		6		
		]				2015	69.51		7	69.31	
Calculate Future IRI						2016	70.14		8	70.22	
			Calcu	late Futur	e PCI	2017	70.77		9		
						2018	71.4		10		
									11	71.64	
									12	71.86	
								13	72.01		
View IRI M	lodel		Vie	w PCI Mod	اما				14	72.11	
Alem IVI Monel			10						15		
									16	72.23	
									17		
									10		
Calculate RSL Based on IRI			Calaulata	RSL Base	d an DCI				20		
			Calculate	e KSL Base					20	72.31	
								22	72.32		
									23		
30									24		
									25		
IRI predictions do n	ot reach the								26		
threshold lin									27	72.33	
									28	72.33	
Thus, RSL (at the la									29	72.33	
year) calculated bo									30	72.33	
design life	el 🛛								31	72.33	
									32	72.33	
		RESET							33	72.33	
		RESET							34	72.33	
	Threshold Lin	nit for IRI (in/m	ile)	170	1		Coeff	Of Determin	ation (P <sup>2</sup> )	1.000	
	Design Life		,	40			coeff.	or beterinin	outin (K /	1.000	
	Present Year			40					Note: Blue b	ighligted cells	are only for
	resent rear										uld be entered
	Threshold Us	nit for PCI (%)			1					glihted cells a	
	Design Life									alues (output	
	Present Year								calculated vi	aues jourput	
	rresent real										

Figure 73. Threshold limit for IRI (170 in./mi) and design life (40 years): AC (statisticsbased model)

# AC Case: AI-Based Model

Select Predictive Model Types

The AI-based model was selected as shown in Figure 74.

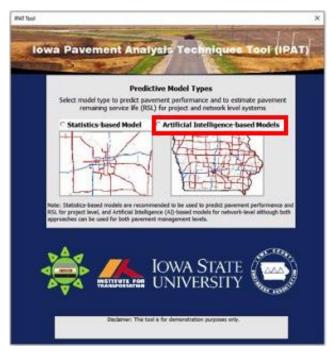


Figure 74. Select predictive model type: AI-based model

Select Pavement Type

AC (asphalt) pavement type was selected as seen in Figure 75.

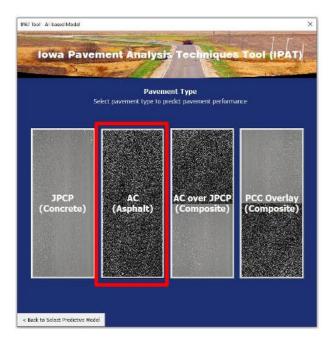


Figure 75. Select pavement type: AC (asphalt)

#### Select Pavement Performance Indicator

IRI, as a pavement performance indicator, was selected, questions are answered (Figure 76), and required road information is entered (Figure 77). Then, the launch tool button is clicked to launch the sub-tool.

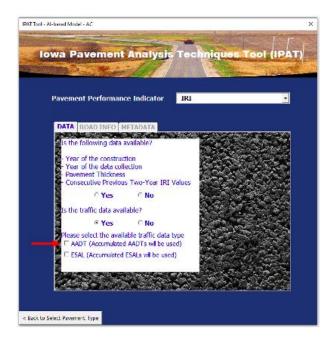


Figure 76. Select pavement performance indicator and preparation of data: IRI (AI-based model)

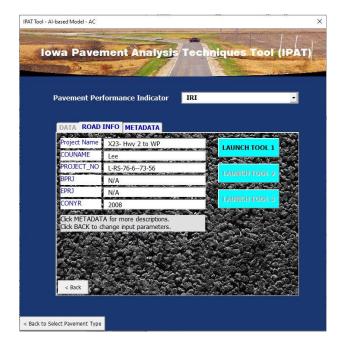


Figure 77. Enter required data information: county AC (AI-based model)

#### Enter Inputs

The entered data information in the IPAT main tool was transferred into the IPAT sub-tool as shown in Figure 78.



Figure 78. Transfer data information into IPAT sub-tool: AC (AI-based model)

The columns of DATAYR, Accumulated AADT, HMA Thickness, IRI<sub>i-2</sub>, and IRI<sub>i-1</sub> were filled based on available data as shown in Figure 79 and Figure 80.



Figure 79. Option 1: Enter existing input parameters and traffic increment per year: AC (AI-based model)

Project Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated AADTs	HMA Thickness (in.)		IRI <sub>i 1</sub> in/mile	Age	IRI; in/mile
23 - Hwy 2 to WP	Lee	L-RS-76-673-	N/A	N/A	2008	2015	4690	14	66.34	67.93		
						2016	6270	14				
	Calcu	late Futur	e IRI			2017	7860	14				
						2018	9460	14				
						2019	11070	14				
						2020	12690	14				
	Vie	w IRI Mod	el			2021	14320	14				
						2022	15960	14				
						2023	17610	14				
						2024	19270	14				
	Calcu	late Future	e RSL			2025	20940					
						2026	22620	14				
				_		2027	24310					
						2028	26010					
						2029	27720	14				
						imit for IRI (ii	n/mile)				e-highligte	
					Design Life						inputs, whe	
					Present Yea	r				should b	e entered t	o. Green-
										higlihte	d cells are c	alcuated
RESET					Traffic Incre	ment per ye	ar (%)	1				< Back to Mai

# Figure 80. Option 2: Enter existing and prepared input parameters without defining traffic increment per year: AC (AI-based model)

Here, there are two options to enter future input parameters: (1) the existing input parameters and defining traffic increment per year (%) to calculate future input parameters (Figure 81), and (2) the existing and prepared future input parameters without defining traffic increment per year (%) (Figure 80).

# Predict Pavement Performance

The Calculate Future IRI button was clicked and future IRI was predicted (Figure 81 and Figure 82).

oject Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated AADTs	HMA Thickness (in.)	IRI <sub>i-2</sub> (in/mile)	IRI <sub>i-1</sub> (in/mile)	Age (years)	IRI <sub>i</sub> , (in/mile)
3- Hwy 2 to WP	Lee	L-RS-76-673-	N/A	N/A	2008	2015	4690	14	66.34	67.93	7	69.30857
						2016	6270	14	67.93	69.30857	8	70.252533
	Calcu	ilate Futur	e IRI			2017	7860	14	69.30857	70.252533	9	70.949883
						2018	9460	14	70.252588	70.949883	10	71.987029
				_					70.949883	71.987029	11	74.387744
								71.987029				
	Vie	w IRI Mod	el						74.39616			87.570116
									79.334279			98.426257
									87.612394			110.02387
									98.507899			122.05552
	Calcu	late Future	e RSL						110.16297			
									122.25386			
						<u> </u>			135.84368			166.59407
									152.8251 166.8008			174.47131
							(		100.0008			177.7099
						imit for IRI (i	n/mile}					ells are only for
					Design Life							hould be entere
					Present Yea	11					inteo cells ai	re calcuated valu
							10.0			(outputs).		
RESET					Traffic Incre	ment per ye	ar (%)	1				

Figure 81. Option 1: Calculate future IRI: AC (AI-based model)

Project Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated AADTs	HMA Thickness (in.)	IRI <sub>i-2</sub> in/mile	IRI⊨1 in/mile	Age	IRI; in/mile
23 - Hwy 2 to WP	Lee	L-RS-76-673-	N/A	N/A	2008	2015	4690	14	66.34	67.93	7	69.30857
						2016	6270	14	67.93	69.30857	8	70.252588
	Calcu	late Futur	e IRI			2017	7860	14	69.30857	70.252533	9	70.949883
						2018	9460	14	70.252533	70.949883	10	71.987029
						2019	11070					74.255526
						2020	12690	14	71.987029	74.255526		78.762754
	Vie	w IRI Mod	el			2021	14320		74.255526			86.166979
						2022	15960			86.166979		95.651256
						2023	17610			95.651256		105.18378
						2024	19270			105.18378		114.10018
	Calcu	late Future	RSL			2025	20940			114.10018		123.66965
						2026	22620					136.36981
						2027	24310		123.66965			149.35397
						2028	26010		136.36981			160.56868
						2029	27720	14	149.35397	160.56868	21	168.27637
					Threshold L	imit for IRI (i	n/mile)			Note: Blu	.e-highligted	i cells are
					Design Life					only for	inputs, whe	re inputs
					Present Yea	ır				should b	e entered t	o. Green-
										higlihte	d cells are c	alcuated
RESET					Traffic Incre	ment per ye	ar (%)					< Back to Mai

Figure 82. Option 2: Calculate future IRI: AC (AI-based model)

Then, the View IRI Model button was clicked, which shows the plotted deterioration curve based on the field and predicted IRI data (Figure 83).

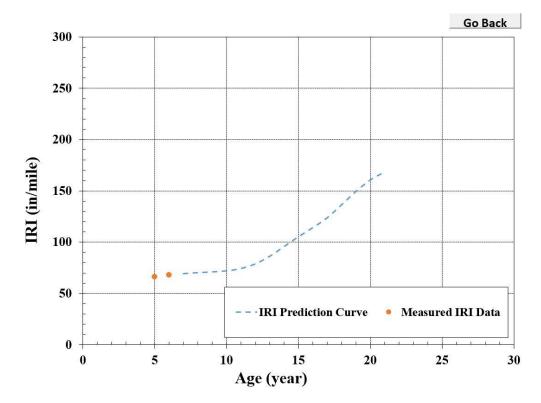


Figure 83. View IRI model (option 1): AC (AI-based model)

#### Predict Pavement RSL

The threshold limit for IRI, design life, and present year parameters were defined, and then the Calculate RSL Based on IRI button was clicked to predict future IRI. The RSL results and descriptions appear under the Calculate RSL Based on IRI button when different scenarios were applied as follows:

• All parameters (170 in./mi, 40 years, 2021) were defined (Figure 84)

roject Name	COUNAME	PROJECT_NO	BPRJ	EPRJ	CONYR	DATAYR	Accumulated AADTs	HMA Thickness (in.)	IRI <sub>i-2</sub> (in/mile)	IRI⊦ı (in/mile)	Ag <del>e</del> (years)	IRI <sub>v</sub> (in/mile)
23- Hwy 2 to WP	Lee	L-RS-76-673-	N/A	N/A	2008	2015	4690	14	66.34	67.93	7	69.30857
						2016	6270	14	67.93	69.30857	8	70.252533
	Calcu	ilate Future	e IRI			2017	7860	14	69.30857	70.252533	9	70.949883
						2018	9460	14	70.252533	70.949883	10	71.987029
									70.949883	71.987029	11	
									71.987029	74.39616		
	Vie	w IRI Mod						74.39616			87.570116	
									79.334279			98.426257
									87.612394			110.02387
								98.507899			122.05552	
	Calcu	late Future						110.16297	122.25386			
									122.25386			
		7							135.84368	152.8251		166.59407
									152.8251	166.8008		174.47131
									166.8008	174.6276	21	177.7099
	DCI /	RSL (at present year) calculated based on the			Threshold L	imit for IRI (i	n/mile)	170		Note: Blue	-highligted c	ells are only fo
					Design Life			40		inputs, wh	ere inputs s	hould be ente
				Present Yea	ar			Green-higli	ihted cells a	re calcuated va		
	pavem	nent perform							(outputs).			
RESET					Traffic Incre	ment per ye	ar (%)	1				

Figure 84. Threshold limit for IRI (170 in./mi), design life (40 years), and present year (2021): AC (AI-based model)

• Threshold limit for IRI (170 in./mi) and design life (40 years) were defined (Figure 85)



Figure 85. Threshold limit for IRI (170 in./mi) and design life (40 years): AC (AI-based model)

• Different threshold limit for IRI (125 in./mi), design life (40 years), and present year (2021) were defined (Figure 86)



Figure 86. Threshold limit for IRI (125 in./mi), design life (40 years), and present year (2021): AC (AI-based model)

• Different threshold limit for IRI (200 in./mi), design life (40 years), and present year (2021) were defined (Figure 87)



Figure 87. Threshold limit for IRI (200 in./mi), design life (40 years), and present year (2021): AC (AI-based model)

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