NETC Project 21-1: Quality Review and Assessment of Pavement Condition Survey Vehicle Data Across New England

Pavement Data Quality Guidelines July 2023

NEW ENGLAND TRANSPORTATION CONSORTIUM

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1. Introduction

The New England Transportation Consortium (NETC) members consist of Maine (ME), Connecticut (CT), Massachusetts (MA), New Hampshire (NH), Rhode Island (RI), and Vermont (VT) transportation agencies. The member agencies spend a considerable amount of time and resources on pavement surface data collection. The data collected are used for a wide range of reporting and decision-making functions within these agencies, including (but not limited to):

- Evaluating the condition of the network.
- Reporting the pavement asset register, life-cycle planning, and investment strategies for the federally required Transportation Asset Management Plans (TAMPs) and Performance Management Rule 2 (PM2).
- Selecting sections for preservation, maintenance, and rehabilitation plans.
- Optimizing the expenditure of funds on the network through use of a Pavement Management System (PMS).
- Developing and updating pavement performance models.
- Utilizing the right-of-way (ROW) images for quantity take-offs for construction projects and to document site condition for asset inventories.

Because the pavement network for each NETC state represents a large-scale asset, and the associated maintenance and rehabilitation (M&R) budget is significant, data quality is critical to ensure that decisions being made based on the collected data are effective and reliable.

Pavement data quality management plans (DQMPs)—mandated by Congress in 23 CFR 490.319(c) of the final rule for national performance management measure regulations published by the Federal Highway Administration (FHWA)—provide a means to assist in quality control (QC) and quality assurance (QA) over the entire data collection life cycle, including methods to check quality of data before, during, and after the pavement data collection cycle. Figure 1 shows a timeline of typical DQMP activities carried out throughout the data collection cycle.

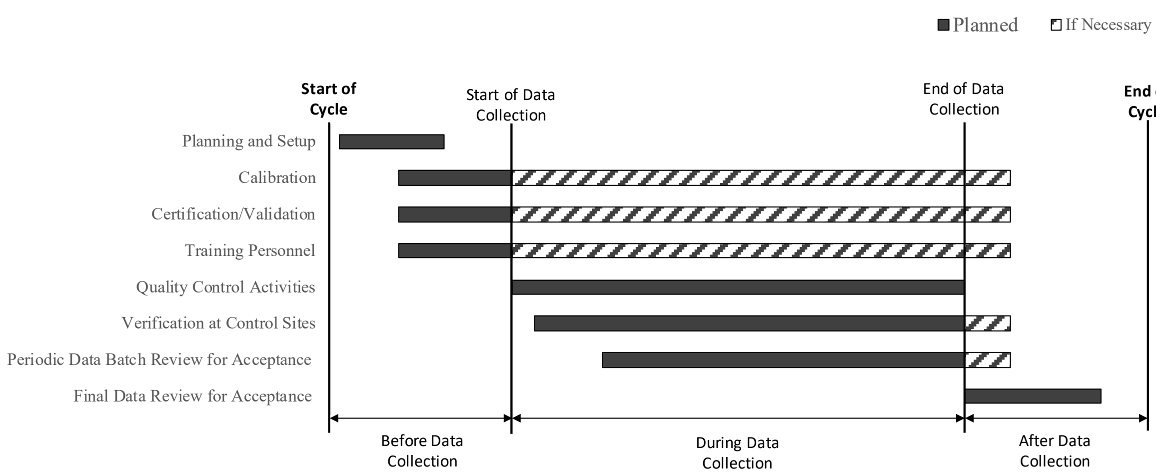


Figure 1. Timeline of typical DQMP activities throughout data collection cycle.

Although FHWA provides guidance, the specific data quality steps that must be taken are not clear. In turn, this has resulted in the NETC member agencies having plans which vary in the level and sophistication of QC/QA conducted. Consequently, NETC Project 21-1 "Quality Review and Assessment of Pavement Condition Survey Vehicle Data Across New England" was undertaken to produce needed pavement surface condition data collection quality guidance, which is captured in these guidelines.

The guidelines begin with the definition of common terminology critical to ensure clear and concise data-quality-related communications between the NETC member agencies. More specifically, seven key terms are defined, with each term representing important practices or concepts for data quality management.

The guidelines then focus on the identification and selection of control sites (for certification, validation, or verification) to produce the reference data needed for establishing the quality—accuracy and precision—of the pavement condition data being collected. The major elements considered include the control site requirements and characteristics. In addition, an accompanying software tool was developed to help NETC member agencies with the control site identification and selection process.

The establishment of control sites and the actual certification, validation, or verification of the pavement data collection equipment and operators at those sites is resource intensive. Consequently, these guidelines also consider control site sharing options for the NETC member agencies, including the possibility of annual rotating rodeos. This is especially meaningful because the life of control sites is limited since pavement conditions change over time due to the environmental and traffic loading impacts. In addition, successful practices found in the literature concerning control sites are incorporated into these guidelines.

Lastly, these guidelines address other considerations (not covered by terminology and control sites) derived from successful practices identified in the literature. Most of these best practices come from ongoing or recent studies and include certification/validation/verification frequency, accuracy and repeatability acceptance, error resolution, and process improvement.

2. Terminology

To provide standard terminology and facilitate communications between the NETC member agencies, seven key terms are defined in these guidelines. As shown in Table 1, they include calibration, certification, validation, verification, quality control, quality assurance, and control sites. Each term represents important practices or concepts for data quality management. Also, as summarized in Figure 1, many of these terms refer to processes that occur at specific times throughout data collection. For example, while certification and validation typically occur prior to annual data collection, verification occurs during frequent or at regular intervals throughout the data collection season.

3. Control Site Selection

Control sites are critical to the NETC state data collection quality management plans, as they are needed for carrying out the required certification, validation, or verification of pavement surface condition equipment and operators—they provide the reference data required for these processes.

In general, a small set of control sites is desirable to minimize the required resources; however, those control sites must address the control site requirements and characteristics.

Table 1. Standard terminology.

Term	Definition
Calibration	A procedure to compare data collected by the equipment against a known standard that is used to adjust the equipment, or a factor applied to the collected data to reach an expected level of accuracy. Calibration of equipment is conducted prior to the start of the data collection effort, periodically during the data collection effort, and as required. Calibration is typically performed by the equipment manufacturer.
Certification	A procedure to evaluate the data collected by the equipment and operators in accordance with a nationally recognized standard or test procedure to check the accuracy and precision of the collected data with respect to reference measurements. Certification of the equipment and operators is conducted prior to the start of the data collection program.
Validation	A procedure performed to evaluate the data collected by the equipment or operators in comparison with reference measurements under representative conditions. Validation is conducted prior to the start of the data collection program.
Verification	A procedure performed at regular intervals throughout the data collection schedule to check that the equipment is functioning as expected.
Quality Control	Actions taken to measure the quality of the data to identify its compliance with the required quality standard. QC refers to the product and can be part of the calibration, validation, or verification review.
Quality Assurance	Actions taken to assure that the data collection processes are being followed as required, such that the resulting data will meet the specified quality standard. QA refers to the testing performed on the production processes and can be part of the calibration, validation, or verification review.
Control Site	Also known as "certification sites" or "verification sites," locations with known length and condition values used to calibrate, validate, or verify the equipment and operators.

Requirements

AASHTO protocols and successful practices were used in NETC Project 21-1 to develop a matrix of requirement factors recommended for control site selection. As shown in Appendix A, the matrix addresses the following three key elements:

- Metric type – NETC members select the metrics for which the guidelines will apply—IRI, DMI, rutting, or cracking.

- Test type – based on the metric type selected, NETC members can select the type of testing they would like to conduct. Testing types include certification (IRI and DMI only), validation, or verification.
- Guidance type – NETC member agencies can select the type of guidance for which the testing type will adhere to. This includes established standards (i.e., AASHTO R56) or other guidance developed based on NETC state practices.

The matrix also provides an overview of the equipment needed, test type, protocol/field testing that applies, site requirements (surface type, distress level, section length, section width, and macrotexture), test requirements (traffic control, whether it takes place in the field or a garage, number of passes/representative measures needed for collection, test speed, and reference data type), and the NETC states for which the different tests are applicable.

In total, if each of the recommended test types for certification, validation, and verification of IRI, rutting, cracking, and faulting were conducted on separate control sites, more than 20 individual control sites would be needed. However, the number of control sites can be reduced by finding locations that cover varying types and severities of performance metrics.

Desired Characteristics

The list of recommended control site desired characteristics resulting from NETC Project 21-1 is provided in Table 2. Safety was considered the primary factor when selecting control sites; characteristics related to this factor include average annual daily traffic (AADT), number of lanes, and extent to which traffic control is necessary. Pavement performance was also considered an important factor by the NETC member agencies; control sites with multiple distress types and severity levels are desirable. Other factors include pavement geometry, access/collection efficiency, equipment, and requirements.

Table 2. Desired control site characteristics.

Factor	Characteristics Considered
Pavement Performance	• Contains multiple severity levels—e.g., all low, medium, and high cracking severity on one section • Contains multiple distress types –e.g., not only high cracking but also high rutting • Variable distresses at sections before and after sections • Representative of network
Safety	• Low impact of traffic control • Rural area • Low AADT (e.g., <2,000) • Multilane preferred • Good sight distance

Factor	Characteristics Considered
Geometry	• Not on a curve • Minimal grade changes • Not near an intersection • Not on a ramp, bridge, or tunnel • Consistent speed
Access/Collection Efficiency	• Limited turn-around time—i.e., the data collector does not need to travel significantly to turn around and recollect a site • Close to agency's garage where survey vehicle is stored
Equipment Requirements	• Not tree covered, open and clear of debris • Ability to reach speed required for test (low and high speed)
Other	• Will not be paved within the next few years/not on 3-year work plan list • State-owned and maintained

Selection Tool

To help NETC member agencies with the control site identification and selection process, a control site selection tool was developed. The primary outcome from this tool is a map and associated table summarizing the potential control sites in the NETC member state; these are illustrated in Figure 2 and Figure 3, respectively. Each candidate site is given a score based on how well it meets the control site requirements and characteristics.

The tool enables NETC members to identify and rank pavement sections for use as control sites based on State data availability and needs. To do so, the tool imports available NETC state data and utilizes available attributes to determine the best potential locations for control sites—it helps NETC member agencies identify the number and characteristics of control sites based on State-defined needs. Additionally, the tool provides recommended acceptance criteria for the metrics of interest. The resulting tool is included as a standalone attachment to this report, while the tool's user guide is provided in Appendix B.

Sharing

An outcome from NETC Project 21-1 was a better understanding of each member's willingness to share control sites and travel. While the preference was to limit travel, NETC member agencies generally agreed there was benefit in sharing control sites even if it meant traveling throughout New England. Considering these findings, three options for control site selection were identified and recommended:

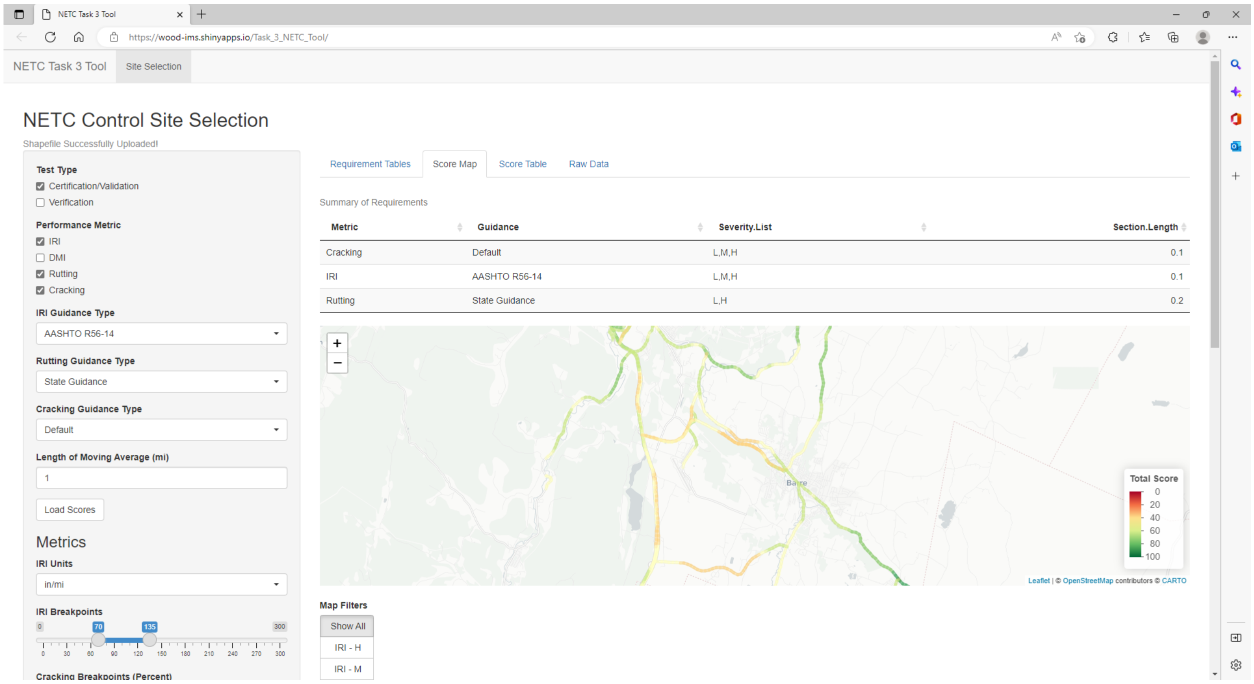


Figure 2. Control site selection tool map.

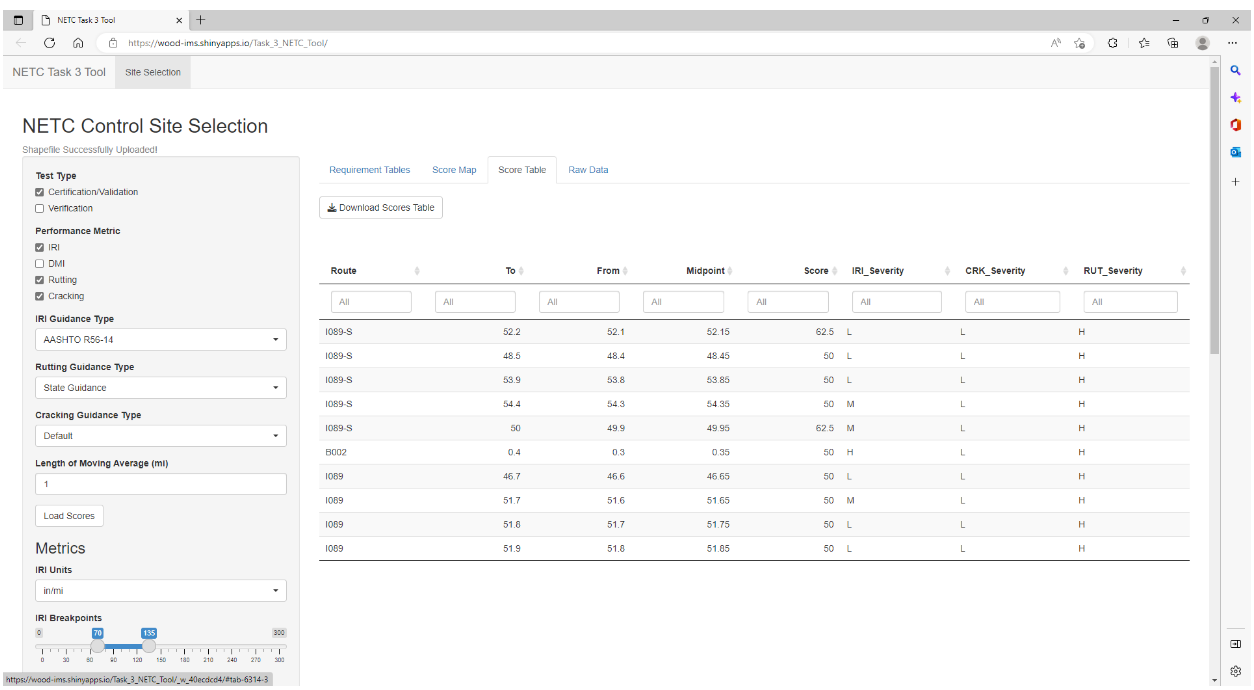


Figure 3. Control site selection tool table.

- Have one host agency manage locations, markings, and the collection of reference data, while the other NETC member agencies participate in a "rodeo." The rodeo would rotate between the NETC states to distribute the work required to select and set up control sites each year.
- Have each agency perform its own quality testing, independent of the other five agencies.
- Combination of Option 1 and Option 2; some of the NETC states would work together to carry out a rodeo while other states would work independently. This option would cover the scenario in which the three northern NETC states and the three southern NETC states would hold concurrent rodeos.

A summary of the three proposed options is provided in Table 3. The NETC member agencies generally agreed that Option 1 or Option 3 would help maximize the benefits for certification and validation testing of pavement condition data.

Table 3. Control site sharing options.

Option	Advantages	Disadvantages
Option 1: Annual rodeos where host agency establishes locations, marking, and collection of reference data, while other NETC member agencies participate in rodeo	• Equally distributed workload between NETC States • Shared efficiency and lessons learned	• Requires a lot of upfront resources (until rodeo becomes more established) • May require higher amounts of travel
Option 2: Each agency performs all activities by itself, independent from other five agencies	• More control over timing and location of testing • Continuation of existing practices • No travel involved for State agency	• No gained efficiencies in control site selection or setup • Requires control sites to be selected each year
Option 3: Combination of Options 1 and 2—i.e., a group of agencies agree to work together and carry out rodeo, while remaining agencies may carry out work independently	• Shared efficiency and lessons learned • More of an equally distributed workload between NETC States than Option 2	• Requires a lot of upfront resources (until the rodeo becomes more established) • May require higher amounts of travel but likely less overall than Option 1

Other Considerations

Additional information concerning control sites is also available in the literature. The *FHWA Practical Guide for Quality Management of Pavement Condition Data Collection*, for example, provides relevant information relating to control sites; these guidelines are summarized in Table

4. The referenced FHWA guide also provides recommendations on how to best categorize control sites according to the testing type and primary use of control sites.

Table 4. Successful quality management practices.

Guidance Area	Successful Practices
Control Sites	• Reasonably represent pavement types in the network • Include a range and variety of ride quality and distresses that are typically encountered in the network • Include all data metrics that are collected and used during DOT decision-making processes • Are of sufficient length to gather enough data for certification processes • Have adequate ground reference data established so that the accuracy of the data being collected can be checked
Ground reference data	• Are established during similar environmental conditions to certification of data collection equipment
Data collection procedures	• Allow for enough repeat runs • Performed at the same speeds that data is collected at in the field • Verify calibrations of sensors and other associate systems
Acceptance criteria	• Have been established so that data collection equipment can be rated as pass or fail

Specifically, the guide outlines three tiers of control site types, which are used to inform the reference data, environmental controls, and acceptance criteria. The three tiers described include:

- Top tier – control sites that are used for the highest level of data quality testing (i.e., certification). Control sites for the top tier adhere to strictest environmental controls, ground reference data (e.g., a walking profiler for IRI testing), and tolerances for acceptance criteria.
- Middle tier – control sites that follow some successful practices for data quality testing, but do not adhere to the strictest level of controls for environmental, ground reference data, and tolerances for acceptance criteria. Middle Tier control sites are most appropriate for validation testing.
- Bottom tier – control sites used to compare data quality but that do not adhere to specific controls for environmental conditions, reference data, or tolerances for acceptance criteria. Typically, control sites in this category reference historical or previous collection data and would therefore be most appropriate for verification testing.

These guidelines should lead to improved control site selection, which in turn should lead to improved pavement condition data collection and better compliance with FHWA-approved DQMPs. The guidelines should also yield efficiencies in the collection and analysis of pavement condition data for each of the NETC states.

4. Certification/Validation/Verification Frequency

Certification and validation are typically performed on an annual basis. This frequency allows for equipment updates or changes in data collection vendors. Equipment should be re-certified prior to further data collection after major repairs that impact vehicle suspension or repairs or changes in the data collection equipment.

Verification testing is typically performed at routine intervals throughout the data collection. The frequency of these tests should be no less than every two weeks throughout the data collection cycle and may be required as frequently as once a week.

5. Accuracy and Repeatability

The recommended requirements for repeatability and accuracy for the certification and validation of each condition metric are provided in Table 5.

Table 5. Recommended requirements for accuracy and repeatability.

Condition Metric	Certification / Validation		Verification
	Accuracy	Repeatability	Repeatability
IRI	Cross-Correlation ≥ 90%	Cross-Correlation ≥ 92%	Coefficient of Variation of IRI < 5%
DMI	Average Absolute Difference < 0.15%	Average Absolute Difference < 0.15%	Average Absolute Difference < 0.15%
Rutting	±0.08 inches	Values within ±0.08 inches at 90% confidence	Average Absolute Difference < 0.04 inches
Cracking	±30%	Values within ±30% at 90% confidence	Coefficient of Variation < 15%

6. Error Resolution

If the equipment or personnel do not pass the certification/validation on the first attempt, provide a second attempt to meet the requirements. If the criteria are not met after the second attempt, the operator should discuss the appropriate actions prior to further action. At this stage, it may be necessary for the agency to perform some in-depth data review along with review of the equipment to assess the potential cause for the results.

For the verification testing, the operator should discuss appropriate actions with the agency to identify potential causes for the higher variability. No further data collection should be performed until any potential issues are resolved. Once the issue is identified it may be necessary to repeat data collection performed since last successful verification test.

7. Process Improvement

Data Sharing

In instances where sharing a control site is not possible, sharing data for a particular vendor between agencies may assist in the evaluation of a particular vendor. If the vendor intends to use the same equipment and operators for the data collection process, these data may be sufficient. However, if the vendor intends to use separate equipment or operators, the agency will need to perform certification of the equipment to be used within their jurisdiction. However, sharing data related to a particular vendor may allow the agencies to identify successful practices or problems with a particular vendor.

Feedback Loop

A feedback loop is an important final step with implementation of the recommended guidelines. Review of the guidelines on a routine basis to identify elements that were particularly successful and elements that may require improvement will assist each agency in improving the overall quality of data collected and subsequent decisions made from these data.

Appendix A. Control Site Requirements Matrix

					Site/Section Requirements								Test Requirements			Applicable to					
Metric	**Equipment**	**Test Type**	**Protocol/ Field Testing**	**Section #**	**Surface Type**	**Distress Level**	**Section Length**	**Section Width**	**Geometry**	**Surface Macrotexture**	**Traffic Control**	**Field/ Garage**	**Nr Passes/ Rep Meas**	**Test Speeds**	**Reference Data**	**CT**	**MA**	**ME**	**NH**	**RI**	**VT**
IRI	Inertial Profiler	Certification	AASHTO R56	1	AC/ Composite	Smooth (30-75 in/mile)	≥ 528' with lead-in & stopping distance	N/A	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network. Coarse preferred	Yes	Field	5 per speed	2 speeds: maximum operation speed and minimum operation speed	SurPRO profiler	X	X	X	X	X	X
IRI	Inertial Profiler	Certification	AASHTO R56	2	AC/ Composite	Medium-Smooth (95-135 in/mile)	≥ 528' with lead-in & stopping distance	N/A	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network. Coarse preferred	Yes	Field	5 per speed	2 speeds: maximum operation speed and minimum operation speed	SurPRO profiler	X	X	X	X	X	X
IRI	Inertial Profiler	Certification	AASHTO R56	3	AC/ Composite	Medium-Rough (<200 in/mile)	≥ 528' with lead-in & stopping distance	N/A	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network. Coarse preferred	Yes	Field	5 per speed	2 speeds: maximum operation speed and minimum operation speed	SurPRO profiler	X	X	X	X	X	X
Section Length (part of IRI test)	DMI	Certification	AASHTO R56	1	AC/ Composite	N/A	≥ 1,000' with lead-in & stopping distance	N/A	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	N/A	No	Field	at least 3 per speed	2 speeds: maximum operation speed and minimum operation speed	Measuring Tape	X	X	X	X	X	X
IRI	Inertial Profiler	Certification	AASHTO R56	1	JCP/CRCP	Smooth (30-75 in/mile)	≥ 528' with lead-in & stopping distance	N/A	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	5 per speed	2 speeds: maximum operation speed and minimum operation speed	SurPRO profiler	X	X				
IRI	Inertial Profiler	Certification	AASHTO R56	2	JCP/CRCP	Medium-Smooth (95-135 in/mile)	≥ 528' with lead-in & stopping distance	N/A	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	5 per speed	2 speeds: maximum operation speed and minimum operation speed	SurPRO profiler	X	X				
IRI	Inertial Profiler	Certification	AASHTO R56	3	JCP/CRCP	Medium-Rough (<200 in/mile)	≥ 528' with lead-in & stopping distance	N/A	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	5 per speed	2 speeds: maximum operation speed and minimum operation speed	SurPRO profiler	X	X				

Metric	Equipment	Test Type	Protocol/ Field Testing	Section #	Surface Type	Distress Level	Section Length	Section Width	Geometry	Surface Macrotexture	Traffic Control	Field/ Garage	Nr Passes/ Rep Meas	Test Speeds	Reference Data	CT	MA	ME	NH	RI	VT
Section Length (part of IRI test)	DMI	Certification	AASHTO R56	1	JCP/CRCP	N/A	≥ 1,000' with lead-in & stopping distance	N/A	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	N/A	No	Field	at least 3 per speed	2 speeds: maximum operation speed and minimum operation speed	Measuring Tape	X	X	X	X	X	X
Rutting	Transverse Profiler	Certification	AASHTO PP106 - Static	1	N/A	N/A	N/A	≥ 13.5 ft	mini ramps and jack stands	N/A	N/A	Garage ?	10 scans	NA	13' Straightedge & block	X	X	X	X	X	X
Rutting	Transverse Profiler	Certification	AASHTO PP107 - Body Motion	1	AC	N/A	8' section 0.25 mile lead-in + stopping distance	≥ 14 ft	Unknown	Unknown	Yes	Field	2 per speed	3 speeds 5, 8, 12 mph	Flat Plates & Excitation Boards	X	X	X	X	X	X
Rutting	Transverse Profiler	Certification	AASHTO PP108 - Navigation Drift	1	AC	N/A	178'	79'	Unknown	Unknown	Yes	Field	5	8 mph	Global position survey	X	X	X	X	X	X
Rutting	Transverse Profiler	Certification	AASHTO PP109- Highway Performance AASHTO PP110- GRE	1	AC	Low Rutting	12' section 0.25 mile lead-in + stopping distance	≥ 13.5 ft	Unknown	Unknown	Yes	Field	3 per speed	7 speeds 15 to 105, every 15 mph	Hand-held Scanner	X	X	X	X	X	X
Rutting	Transverse Profiler	Certification	AASHTO PP109- Highway Performance & AASHTO PP110- GRE	2	AC	High Rutting	12' section 0.25 mile lead-in + stopping distance	≥ 13.5 ft	Unknown	Unknown	Yes	Field	3 per speed	7 speeds 15 to 105, every 15	Hand-held Scanner	X	X	X	X	X	X
HPMS Cracking	Distress Measuring System	Validation	Field Testing	1	AC/ Composite	Low Cracking	≥ 528' with lead-in & stopping distance	9'-13'	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	10 per speed	2 speeds 30, 55 mph	Consensus Survey of Raters	X	X	X	X	X	X
HPMS Cracking	Distress Measuring System	Validation	Field Testing	2	AC/ Composite	Medium Cracking	≥ 528' with lead-in & stopping distance	9'-13'	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	10 per speed	2 speeds 30, 55 mph	Consensus Survey of Raters	X	X	X	X	X	X

Metric	Equipment	Test Type	Protocol/ Field Testing	Section #	Surface Type	Distress Level	Section Length	Section Width	Geometry	Surface Macrotexture	Traffic Control	Field/ Garage	Nr Passes/ Rep Meas	Test Speeds	Reference Data	CT	MA	ME	NH	RI	VT
HPMS Cracking	Distress Measuring System	Validation	Field Testing	3	AC/ Composite	High Cracking	≥ 528' with lead-in & stopping distance	9'-13'	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	10 per speed	2 speeds 30, 55 mph	Consensus Survey of Raters	X	X	X	X	X	X
HPMS Cracking & Faulting	Distress Measuring System	Validation	Field Testing	1	JCP	Low Cracking, Low Faulting	≥ 528' with lead-in & stopping distance	9'-13'	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	10 per speed	2 speeds 30, 55 mph	Consensus Survey of Raters	X	X				
HPMS Cracking & Faulting	Distress Measuring System	Validation	Field Testing	2	JCP	High Cracking, Low Faulting	≥ 528' with lead-in & stopping distance	9'-13'	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	10 per speed	2 speeds 30, 55 mph	Consensus Survey of Raters	X	X				
HPMS Cracking & Faulting	Distress Measuring System	Validation	Field Testing	3	JCP	Low Cracking, High Faulting	≥ 528' with lead-in & stopping distance	9'-13'	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	10 per speed	2 speeds 30, 55 mph	Consensus Survey of Raters	X	X				
HPMS Cracking & Faulting	Distress Measuring System	Validation	Field Testing	4	JCP	High Cracking, High Faulting	≥ 528' with lead-in & stopping distance	9'-13'	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	10 per speed	2 speeds 30, 55 mph	Consensus Survey of Raters	X	X				
HPMS Cracking	Distress Measuring System	Validation	Field Testing	1	CRCP	Low Cracking	≥ 528' with lead-in & stopping distance	9'-13'	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	10 per speed	2 speeds 30, 55 mph	Consensus Survey of Raters	X	X				
HPMS Cracking	Distress Measuring System	Validation	Field Testing	2	CRCP	High Cracking	≥ 528' with lead-in & stopping distance	9'-13'	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative of pavements in States' highways network	Yes	Field	10 per speed	2 speeds 30, 55 mph	Consensus Survey of Raters	X	X				
AC HPMS Distresses		Verification	Field Testing		AC, open-graded surface preferred	Medium levels of roughness and distress	≥ 1,000' with lead-in & stopping distance	9'-13'	avoid: (1) significant grade or grade change; (2) significant horizontal curvature or superelevation	Representative but coarse preferred	No	Field	5 per speed	≥ 1 every X miles or 2 weeks during peak data collection	Based on historical data	X	X	X	X	X	X
JCP/ CRCP HPMS Distresses		Verification	Field Testing											≥ 1 every X miles or X weeks	Based on historical data						

Metric	Equipment	Test Type	Protocol/ Field Testing	Section #	Surface Type	Distress Level	Section Length	Section Width	Geometry	Surface Macrotexture	Traffic Control	Field/ Garage	Nr Passes/ Rep Meas	Test Speeds	Reference Data	CT	MA	ME	NH	RI	VT
DMI		Verification	Field Testing											≥ 1 every X miles or X weeks	Based on historical data	X	X	X	X	X	X

Appendix B. Control Site Selection Tool User's Guide

Overview

This tool is intended to assist the NETC member agencies with control site selection in support of their pavement data collection efforts. Given testing requirements for certification, validation, and verification, the user can upload a shapefile with relevant distress information and the tool will quantify how effective a given site would be as a control site based on the number of testing requirements satisfied by that site. The tool breaks each condition metric down into three groups: Low, Medium, and High levels, which are set by the user. These classifications are then compared to the testing requirements to determine the score. The testing requirements are those requirements related to the overall site conditions such as level of traffic, grade, presence of curves, speed limit, or other generic site conditions. Scores are calculated by taking the proportion of testing requirements that are satisfied. The requirements are weighted the same so, for example, if a site satisfies 1 of 3 IRI requirements, 1 of 3 cracking requirements, and 1 of 2 rutting requirements, the score would be 100*(1+1+1)/(3+3+2) = 37.5. The resulting information is displayed on a filterable map as well as a downloadable data table. The data being input in support of the control site selection process must conform with the data specifications listed in Attachment A, and must contain all required fields, as the tool is set up to only work with specific field names. Because of this, the tool will be effective with both new and old data (assuming it follows the criteria) and will not require an update each year.

Uploading a Shapefile

When a user opens the application, there will be a button at the top where he or she can upload the required shapefile. To upload, click "Browse" and navigate to the folder with the desired shapefile. User must upload ALL files in the shapefile by highlighting them in the folder and clicking "Open." Figure 4 shows screen capture of these steps.

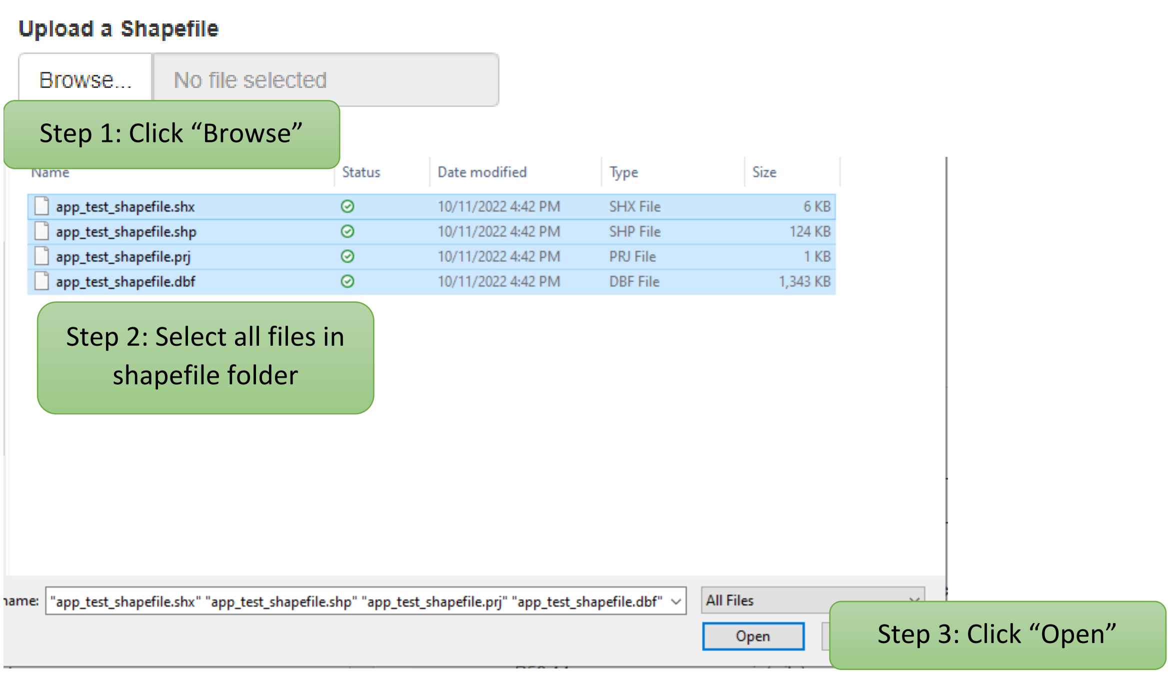


Figure 4. Process for uploading a shapefile.

Once a shapefile has been properly loaded, the tool will show “Shapefile Successfully Uploaded!” in place of the box. If user would like to upload a different shapefile, the tool will need to be either refreshed or restarted.

Field Mapping Tab

Once a shapefile has been uploaded, a series of dropdown menus will appear in the “Field Mapping” tab with each dropdown populated by the fieldnames in the dataset; see Figure 5. Fields that match the field names in the file specifications in Attachment A will automatically be mapped, while fields that do not match will need to be manually mapped. If an optional field is not present in the shapefile, the field mapping should stay as the default dropdown selection, “NA.” These fields will be added to the data in the tool with a default value, but this will not affect the scoring. This field mapping will need to be done each time a shapefile is uploaded. Please also note that some of the field names in the dropdown menu may be truncated or shortened.

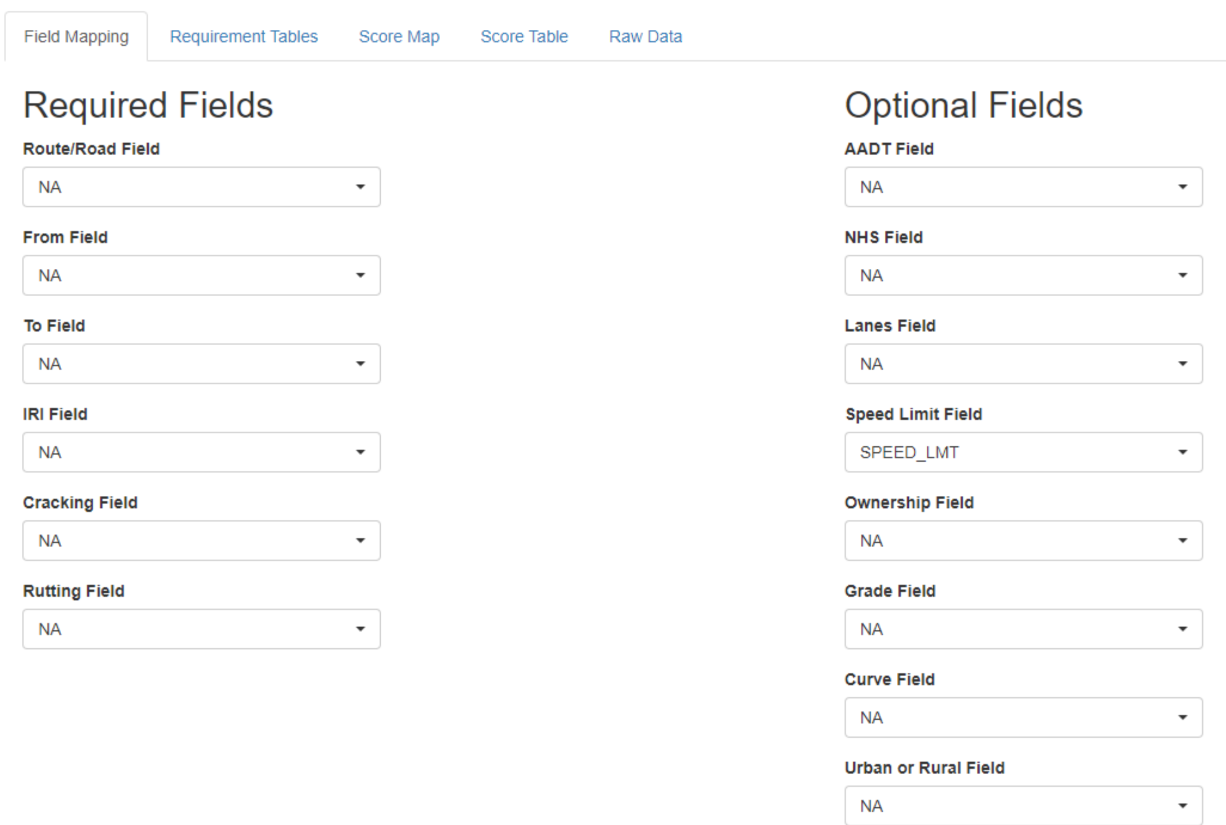


Figure 5. Overview of field mapping dropdown menus.

Requirement Tables Tab

The next tab the user will encounter is “the Requirement Tables” tab. On the left, the user will be able to select the requirements he or she would like to consider; see Figure 3. First, the user chooses test types he or she would like to review. By default, the Certification/Validation type is selected. After choosing one or both test types, the user will then choose which metrics he or she would like to view; see Figure 6. For each metric chosen, a dropdown menu will appear where the user can select the guidance type. Note that if the user updates a choice that is above the others in the list on the right, it will set all choices below that selection to the default option (e.g., if the user updates Test Type, it will reset Performance and Guidance to their respective defaults).

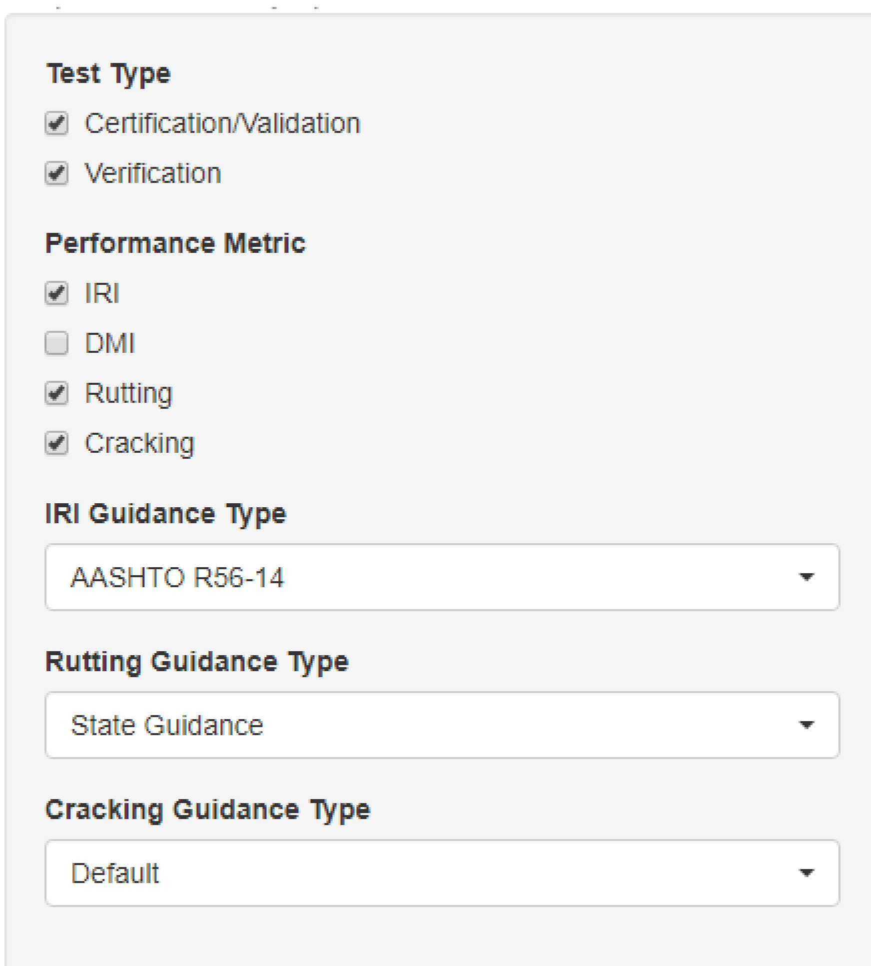


Figure 6. Overview of requirement selection options.

As the user updates his or her choices, the tables on the right will automatically update. These tables are broken down according to Test Type (certification/validation and Verification) as well as their respective Site Requirements and Test Requirements. At the top, a quick summary of the certification/validation requirements is shown to make it easier to keep track of the control site requirements; this is illustrated in Figure 7.

Summary of Requirements

Metric	Guidance	Severity.List	Section.Length
Cracking	Default	L,M,H	0.1
IRI	AASHTO R56-14	L,M,H	0.1
Rutting	State Guidance	L,H	0.2

Figure 7. Certification and validation requirements.

Score Map Tab

This tab, along with the “Score Table” and “Raw Data” tabs, requires a shapefile to be properly uploaded. On the left side, the map parameters can be set. First, the user chooses which test types, metrics, and guidance types he or she would like the control sites to match the requirements; see Figure 8. Certification/validation must be selected for the map to load. Choosing verification in addition will add whether or not a site satisfies the verification requirements in the map popup, but it will not affect the score of a site. Next, the length of the moving average can be changed. This length affects how many sections will be considered as potential control sites. For a 1-mile moving average length, each section from ½ mile before to ½ mile after the location in question will be included in the moving average of a given section.

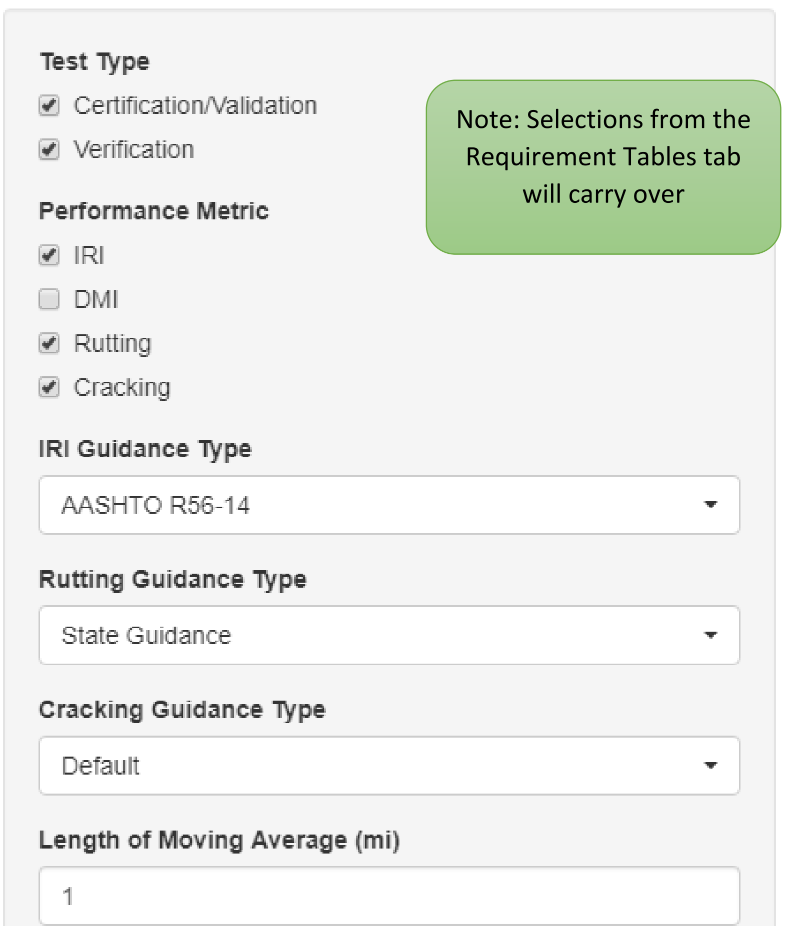


Figure 8. Overview of map requirement selections.

After specifying the requirements and moving average length, the next step is to consider the performance metrics. Adjusting the sliders will affect what is considered high, medium, and low. Values below the number on the left (in blue) will be considered Low, values in the middle will be considered Medium, and values higher than the number on the right (in blue) will be considered High; see Figure 9. User must make sure to select the units based on the units of the uploaded data. The tool will not convert units between selections.

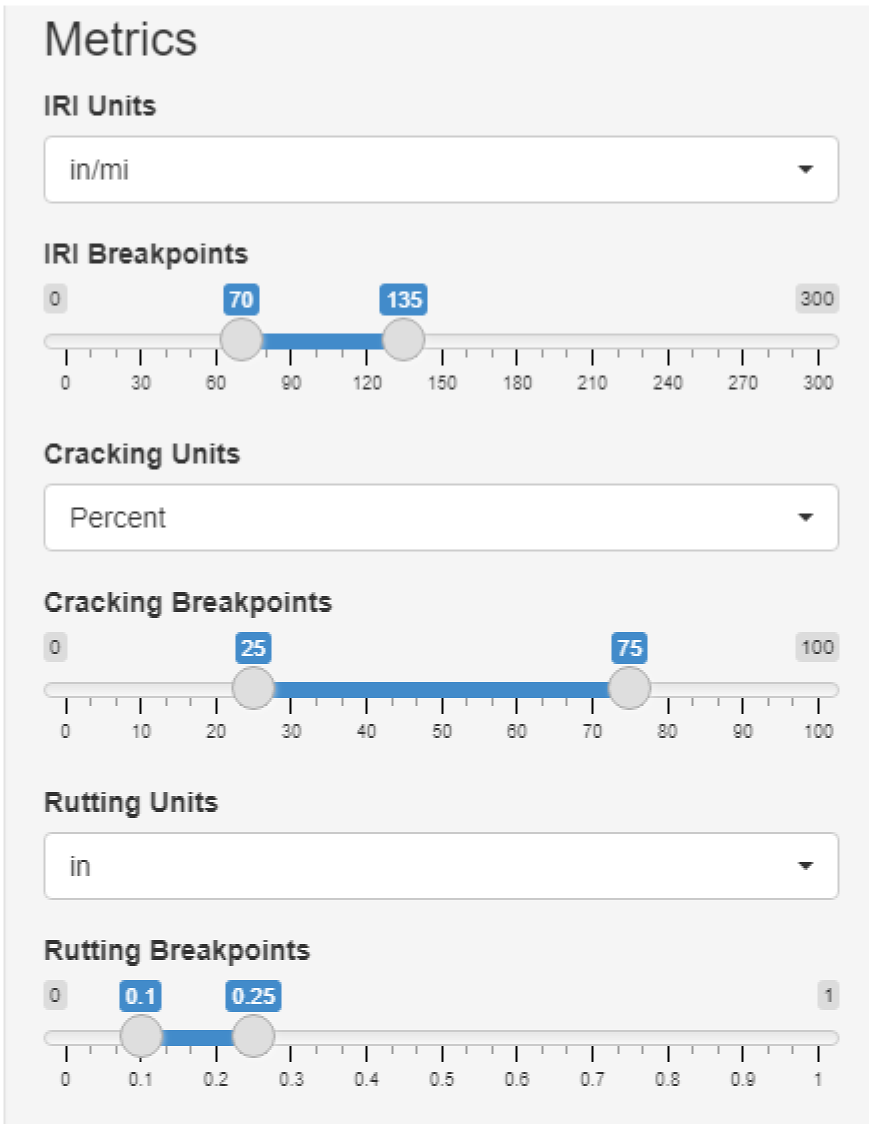


Figure 9. Overview of metric breakpoint selections.

Next, the user can filter for site characteristics that are included in the uploaded data; this is illustrated in Figure 10 (Note: there may be more characteristics in the tool than there are depicted in this figure). If a characteristic is filtered and is not in the data, then the map will fail to show potential control sites. Data filtering is optional and works as an "and," meaning that a site will have to fulfil all characteristic filters, not just one. The site characteristics that are available for filtering (if present in the data) are:

- AADT
- Number of Lanes
- Speed Limit
- Ownership
- Curve
- Grade
- Urban or Rural
- NHS
- Intersections (does not need to be included with the data; this selection will filter out sections that are at the end of routes)

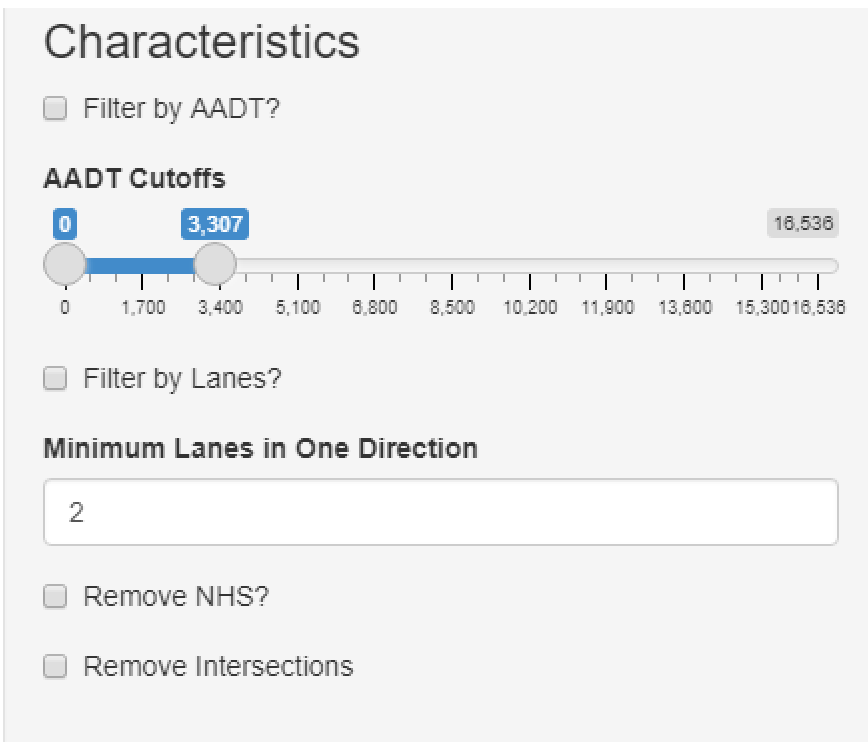


Figure 10. Example characteristics filtering.

Once the user has selected the desired requirements, metric breakpoints, and site characteristics, he or she needs to click the "Load Scores" button underneath the "Length of Moving Average" field; see Figure 11. As shown, a loading box will pop-up at the bottom right side of the screen. Depending on the size of the map in question, it may take a while for the map to load.

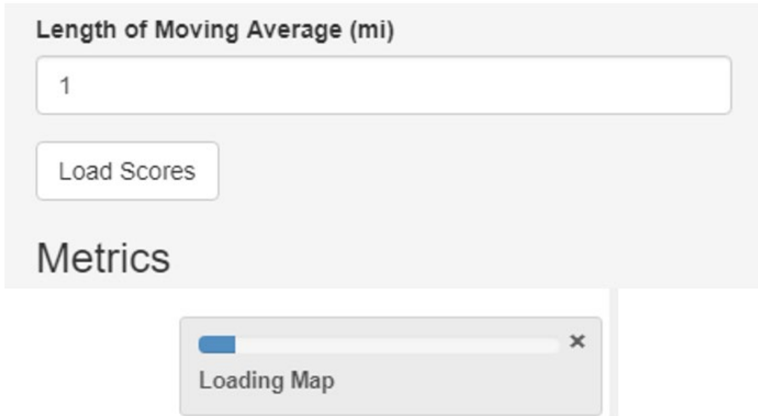


Figure 11. Location of "Load Scores" button as the resulting loading box.

Once the map loads, it will be color-coded by score. The score is the percentage of requirement that the site fulfills. To see which requirements a site fulfills, the user can click on the site and a pop-up will appear; this is illustrated in Figure 12. On this pop-up, the user will see the route, mile marker of the midpoint, the score, and the requirements that are satisfied by the chosen site.

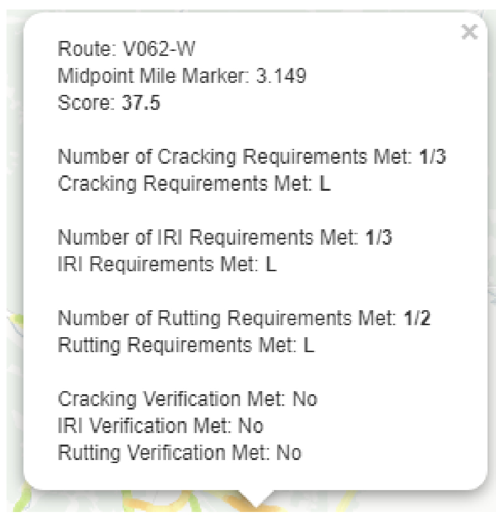


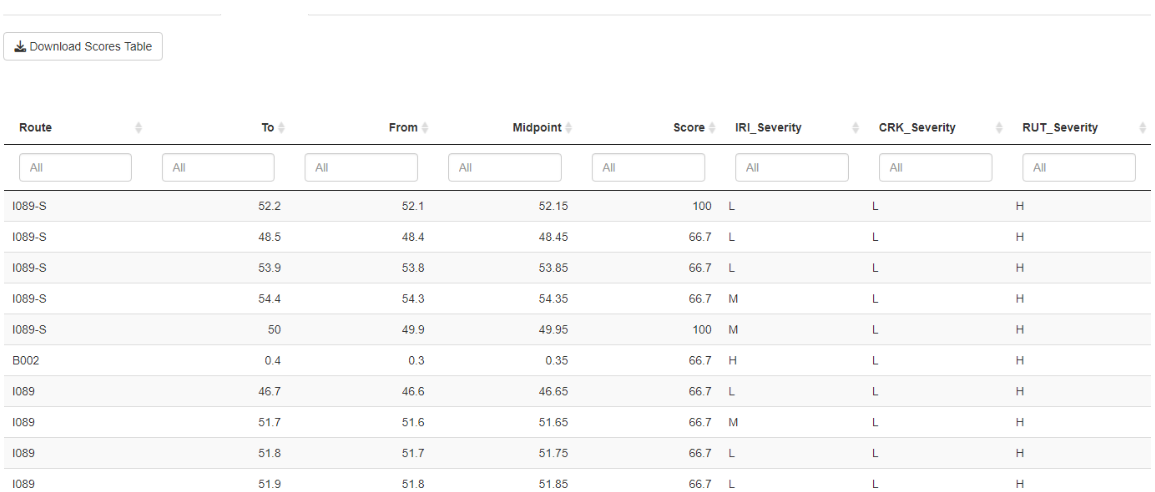
Figure 12. Example of map popup once scores are loaded.

If the user decides he or she would like to edit the requirements, metrics, or characteristics, he or she can do so and then click "Load Scores" again to reload the map with the new parameters. If the user would like to see control sites that only fulfill certain requirements, then below the map there will be buttons that he or she can click; see Figure 13 – these may be selected, and scores re-loaded to filter for desired sections. If "Show All" is NOT selected, then it will only show the sites with the selected criteria. Once the user determines what requirements to filter for, click "Load Scores." This can be helpful if the user finds a site that satisfies all but one or two requirements. Please note that this will not update the requirements, but rather just filter which sites are shown in the map.

Figure 13. Example of selection boxes once map is loaded.

Score Table Tab

This tab shows the contents of the map summarized in tabular format; see Figure 14. It will be generated when the map is generated. The table can be arranged and searched to find particular sites, scores, etc. Above the table there is a button to download the score table for the entire map (not just what is displayed). The file will be named according to date. The level listed in this table are for the section, not the entire site.



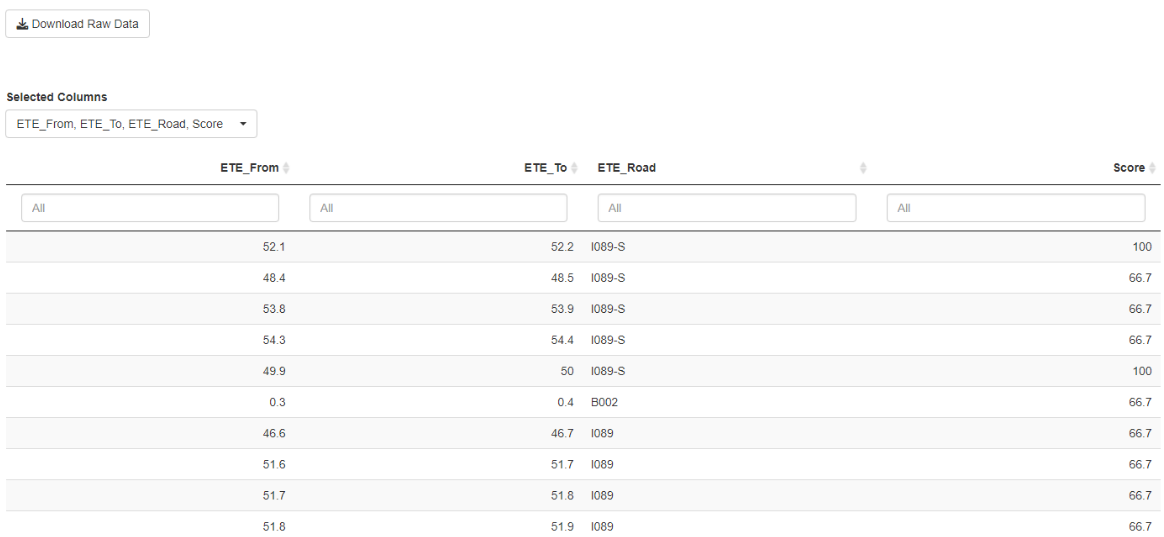
Download Scores Table

Route	To	From	Midpoint	Score	IRI_Severity	CRK_Severity	RUT_Severity
All	All	All	All	All	All	All	All
I089-S	52.2	52.1	52.15	100	L	L	H
I089-S	48.5	48.4	48.45	66.7	L	L	H
I089-S	53.9	53.8	53.85	66.7	L	L	H
I089-S	54.4	54.3	54.35	66.7	M	L	H
I089-S	50	49.9	49.95	100	M	L	H
B002	0.4	0.3	0.35	66.7	H	L	H
I089	46.7	46.6	46.65	66.7	L	L	H
I089	51.7	51.6	51.65	66.7	M	L	H
I089	51.8	51.7	51.75	66.7	L	L	H
I089	51.9	51.8	51.85	66.7	L	L	H

Figure 14. Layout of the Scores Table.

Raw Data Tab

Like the Score Table tab, this tab will also be generated when the map is generated. In addition to the information shown in the Score Table, the entirety of the uploaded datafile with the score information will be available. Different columns can be selected, or all columns can be selected using the drop-down menu, allowing for easy comparison. The datafile can be downloaded using the Download Raw Data button and will include only the selected columns; see Figure 15.


Download Raw Data

Selected Columns

ETE_From, ETE_To, ETE_Road, Score

ETE_From	ETE_To	ETE_Road	Score
All	All	All	All
52.1	52.2	I089-S	100
48.4	48.5	I089-S	66.7
53.8	53.9	I089-S	66.7
54.3	54.4	I089-S	66.7
49.9	50	I089-S	100
0.3	0.4	B002	66.7
46.6	46.7	I089	66.7
51.6	51.7	I089	66.7
51.7	51.8	I089	66.7
51.8	51.9	I089	66.7

Figure 15. Layout of the Raw Data Table with default columns selected.

Attachment A. NETC Control Site Selection Tool File Specifications

Required Format

The data must be a shapefile consisting of one file of each of the following four formats:

- .shx
- .shp
- .prj
- .dbf

Example:

app_test_shapefile.shx
app_test_shapefile.shp
app_test_shapefile.prj
app_test_shapefile.dbf

Optional/Non-Optional Fields

Table 6 lists the optional and non-optional fields for shapefiles uploaded to the tool. The names of the fields in the shapefile DO NOT need to match the names of the fields in the tables below; however, the fields that match will automatically be mapped. The tool will not work if any of the non-optional fields are missing or if ANY of the fields present in the shapefile are of a different type than listed below.

Table 6. List of optional and non-optional fields.

Field Name	Description	Type	Optional
ETE_Road	Route ID	Character	No
ETE_To	Beginning Mile Post – Preferably in 0.1-mile segments	Numeric	No
ETE_From	End Mile Post – Preferably in 0.1-mile segments	Numeric	No
IRI_AVG	IRI Value (in/mi)	Numeric	No
CRK_AVG	Cracking Percent Value (0-100%)	Numeric	No
RUT_AVG	Rutting Value (in)	Numeric	No
AADT	Traffic Volume	Numeric	Yes
NHS	Whether or not the section is on NHS. 0 = Not on NHS and 1 = on NHS	Integer (0 or 1)	Yes

Lanes	Number of Lanes in One Dir.	Integer	Yes
SPEED_LIMIT*	Speed Limit (mph)	Integer	Yes
OWNERSHIP	Ownership of Section (coded number)	Integer	Yes
GRADE	Grade Categorization (A, B, C, …)	Character	Yes
CURVE	Curve Categorization (A, B, C, …)	Character	Yes
URBAN_OR_RURAL*	Either URBAN or RURAL	Character	Yes

* Some shapefile formats require the field names to be 10 or less characters. In this case, these can be renamed to SPEED_LMT and UBN_OR_RRL, respectively. However, this is not required.