IDAHO TRANSPORTATION DEPARTMENT

RESEARCH REPORT

RP 211A

Road Map for Implementing The AASHTO Pavement ME Design Software for the Idaho Transportation Department

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16. Abstract

This report provides a Road Map for implementing the *AASHTOWare Pavement ME* Design software for the Idaho Transportation Department (ITD). The Road Map calls for a series of three stages: Stage 1 - Immediate, Stage 2 - Near Term, and Stage 3 - Future or Long Range. Within each stage are various specific steps to achieve the required objectives for implementation. The general implementation plan is to develop for ITD the *Idaho AASHTOWare Pavement ME Design User's Guide, Version 1.1* under Stage 1 for use by designers and others for preliminary design and training purposes. Specific deficiencies in inputs and calibrations are identified in the draft guide for further improvement under the next stage. Stage 2 represents a major work effort over several years to fill the deficiencies for inputs, to conduct local Idaho calibration of distress and IRI models, and to provide training. Stage 3 represents future long-term work to improve various inputs and to maintain unbiased models.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4		mm
ft	feet	0.3048		m
yd	yards	0.914		m
mi	Miles (statute)	1.61		km
		AREA		
in^2	square inches	645.2	millimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.4046	hectares	ha
		MASS (weight)		
oz	Ounces (avdp)	28.35	grams	g
lb	Pounds (avdp)	0.454	kilograms	kg
T	Short tons (2000 lb)	0.907	megagrams	mg
		VOLUME		
fl oz	fluid ounces (US)	29.57	milliliters	mL
gal	Gallons (liq)	3.785	liters	liters
ft^3	cubic feet	0.0283	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

Note: Volumes greater than 1000 L shall be shown in m^3

Symbol	When You Know	Multiply By	To Find	Symbol
		TEMPERATURE (exact)		
^oF	Fahrenheit temperature	5/9 (^oF-32)	Celsius temperature	^oC
		ILLUMINATION		
fc	Foot-candles	10.76	lux	lx
fl	foot-lamberts	3.426	candela/m^2	cd/cm^2
		FORCE and PRESSURE or STRESS		
lbf	pound-force	4.45	newtons	N
psi	pound-force per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	Miles (statute)	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
km^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.471	acres	ac
		MASS (weight)		
g	grams	0.0353	Ounces (avdp)	oz
kg	kilograms	2.205	Pounds (avdp)	lb
mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	milliliters	0.034	fluid ounces (US)	fl oz
liters	liters	0.264	Gallons (liq)	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		TEMPERATURE (exact)		
^oC	Celsius temperature	9/5 ^oC+32	Fahrenheit temperature	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/cm^2	candela/m^2	0.2919	foot-lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	pound-force	lbf
kPa	kilopascals	0.145	pound-force per square inch	psi

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The Applied Research Associates, Inc. staff that assisted with the *Road Ma*p includes: Jagannath Mallela, Harold L. Von Quintus, Michael I. Darter, and Biplab B. Bhattacharya.

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List of Acronyms

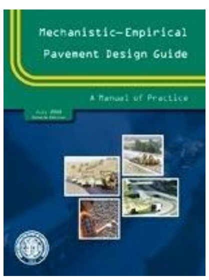
AASHO	American Association of State Highway Officials (predecessor to AASHTO)
AASHTO	American Association of State Highway and Transportation Officials
AMPT	Asphalt Mixture Performance Tester
ARA	Applied Research Associates, Inc.
CIR	Cold-In-Place Recycle
CPR	Concrete Pavement Restoration
CTE	Coefficient of Thermal Expansion
DCP	Dynamic Cone Penetrometer
DOT	Department of Transportation
DSR	Dynamic Shear Rheometer
FDR	Full-Depth Reclamation
FHWA	Federal Highway Administration
FWD	Falling Weight Deflectometer
ITD	Idaho Transportation Department
JPCP	Jointed Plain Concrete Pavement
LTPP	Long Term Pavement Performance
ME	Mechanistic Empirical
MEPDG	Mechanistic Empirical Pavement Design Guide
ME Design	AASHTO Pavement ME Design
M_r	Resilient Modulus
NALS	Normalized Axle Load Spectra
NCDC	National Climatic Data Center
NCHRP	National Cooperative Highway Research Program
PCC	Portland Cement Concrete
PRS	Performance-Related Specifications
QC	Quality Control
USGS	U. S. Geological Survey
WIM	Weigh-in-Motion

Chapter 1
Introduction

Background

Many highway agencies, including the Idaho Transportation Department (ITD), are transitioning from the 1993 American Association of State Highway and Transportation Officials (AASHTO), or a State specific design procedure (such as the Idaho R-value method), to the *AASHTO Mechanistic-Empirical Pavement Design Guide* (MEPDG) for designing new and rehabilitated pavements. The new design procedure is recently programmed into the *AASHTOWare Pavement ME Design* software.

One of the biggest criticisms of the AASHTO 1993 procedure is its empirical basis that makes it less accurate when considering newer materials, rehabilitation alternatives, and number of traffic loadings without expanding the original American Association of State Highway Officials (AASHO) Road Test experiment from which it was developed. Its simplistic approach to design - such as lack of in-depth treatment of climate factors and interactions between climate, materials, and traffic loadings - has resulted in designs of pavement structures that have either under-performed or over-performed (e.g., the Idaho R-value method in that it predicts thicker base sections than necessary).



In the late 1990s, the highway community, under a national initiative sponsored by the AASHTO Joint Task Force on Pavements (now the Joint Technical Committee on Pavements), embarked on the development of a design methodology that characterizes in-service pavements more realistically and provides uniform guidelines for designing flexible, rigid, and composite pavements in different climates and under different traffic loadings. The MEPDG procedure was developed under National Cooperative Highway Research Program (NCHRP) Project 1-37A. The MEPDG transfer functions were calibrated and validated, using data from the Long Term Pavement Performance (LTPP) program, under NCHRP Projects 1-37A and 1-40D. The *MEPDG Manual of Practice* was prepared under NCHRP Project 1-40B, and it became the AASHTO approved interim *Mechanistic-Empirical (M-E) Design Standard* in 2008. A second manual, also prepared under NCHRP Project 1-40B, became *AASHTO's Manual of Practice for Local Calibration of the MEPDG* in 2010.

AASHTOWare Pavement ME Design - the production grade, pavement design software that supports MEPDG, was released in spring 2011. ME Design can be used to:

- Designing pavement.
- Evaluate the impact of material properties and some construction practices on pavement performance.
- Aid in implementing performance-related specifications (PRS) or warranties.
- Analyze some truck size and weight configurations.
- Provide tools for use in a comprehensive pavement management system.

To maximize the benefits and accuracy of the design procedures, however, it is essential to properly select inputs and calibrate the transfer functions to an agency's operational policies, material and construction specifications, and traffic.

As stated in AASHTO's *Guide for the Local Calibration of the MEPDG*, the goals of any calibration-validation process are to:

1. Confirm that the transfer functions can predict pavement distress and smoothness without bias.
2. Determine the standard error associated with the transfer functions.

All transfer functions in the MEPDG were globally calibrated using data from pavement test sites around North America. Most of these test sites were a part of the LTPP program. The *Local Calibration Guide* can be used to determine if the data obtained from non-LTPP pavement sections that state DOTs maintained using local policies and practices result in a significant bias in the distress and performance predictions. The *Local Calibration Guide* also provides procedures to recalibrate the MEPDG to eliminate bias and decrease the standard error of the estimate.

The experience of agencies that have completed local calibration suggests following/using the work flow depicted in Figure 1 to obtain successful implementation. While this figure does not show all the details of implementation, it does indicate the overall work flow and key activities required at a minimum. Key activities include:

- Defining the scope of the implementation (what pavement applications are of interest to the agency).
- Identifying pavement sections with adequate data to enable local calibration.
- Defining many aspects related to the design inputs through a carefully crafted laboratory and field testing program.
- Validating distress and International Roughness Index (IRI) models and recalibrating the models if necessary.
- A number of technology transfer activities.

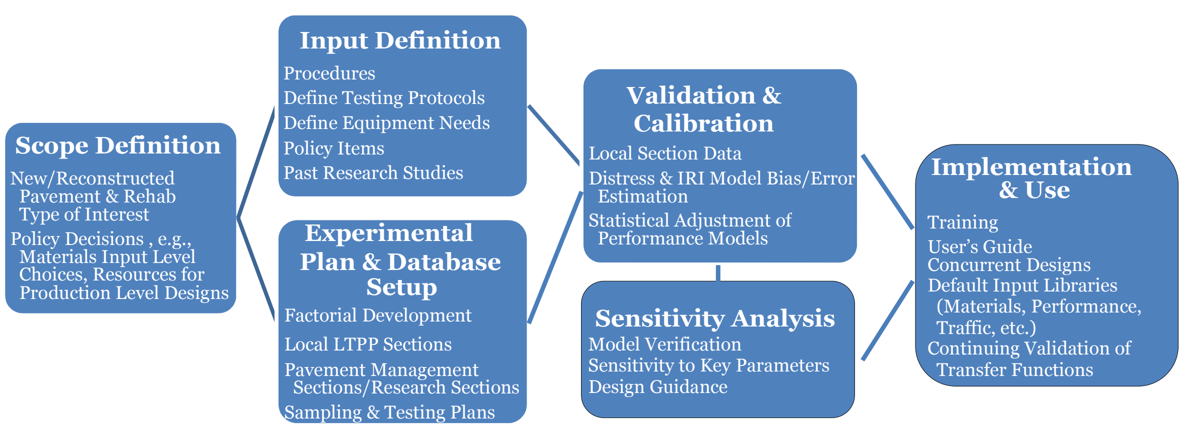


Figure 1. Work Flow of Activities for Implementing MEPDG

ITD has recognized the advantages and importance of adopting M-E principles for the design of new and rehabilitated pavements. ITD has been preparing for the implementation of the MEPDG for several years through participation in the MEPDG-related implementation activities and through its own research initiatives.

As part of the preparatory work to implement the MEPDG, ITD is looking into:

- Reviewing its implementation efforts to date.
- Assessing agency needs and resources required for a full-scale implementation.
- Developing a practical road map to guide future implementation efforts.

Thus, ITD initiated an implementation process to ensure that all of the input procedures are acceptable and practical and that the distress and smoothness transfer functions accurately represent the performance of ITD roadway pavements. The purpose of this document is to present ITD's *Road Map* for that transition and implementation of the MEPDG procedure.

Objective of the Road Map

To facilitate a transition from ITD's current pavement design methodology to the MEPDG procedure as outlined in *AASHTO ME Design Manual of Practice* and the *AASHTOWare Pavement ME Design* software, it is important that ITD assess its needs in terms of the new and rehabilitation design inputs (traffic, materials, and environment). The *AASHTOWare Pavement ME Design* software allows the user to determine a design thickness for different layers, one layer at a time using the optimization tool for typical inputs used in Idaho. Equally important, however, is the verification and/or calibration of the transfer functions with local input data. The objectives of this *Road Map* are:

- Identify the activities needed to verify and/or calibrate the transfer functions to ITD's policies and materials.
- Streamline a design process enabling ITD personnel to use ME Design to determine layer thicknesses with confidence for routine pavement design.

Scope of the Implementation Effort

ITD's reason for using the MEPDG procedure is to achieve more accurate and cost-effective pavement designs, which can be directly tied back to ITD's pavement management policies. In other words, the predicted distresses and smoothness values can be used in pavement scheduling some preservation and maintenance activities. Furthermore, the MEPDG procedure and accompanying software can be useful for other purposes, such as estimating the impact of specification changes without long-term distress data, determining the appropriateness of price adjustments during construction, evaluating the impact of construction anomalies, and other like factors.

In terms of the scope of implementation efforts, the *AASHTOWare Pavement ME Design* software is expected to be used for all service levels of roadways: interstates, freeways, major arterials, and collectors. The scope of ITD's implementation is defined through the design strategies (new construction and rehabilitation) and materials that are commonly used in Idaho. Infrequently used design strategies or materials are also included, but laboratory studies were relied upon to create materials libraries used in the MEPDG process. Both of these are identified and addressed in the *Road Map*.

End Products

As part of the overall scope of the implementation effort, it is important to establish a vision of the end products and how those products will be used at the end of the implementation effort. The result of the implementation effort outlined herein will result in the following products in support of MEPDG's use in Idaho:

- *Idaho AASHTOWare Pavement ME Design User's Guide, Version 1.1 was* prepared at the beginning of the implementation effort. While recognizing that this *User's Guide Version 1.1* will have a lack of Idaho-specific input data and distress prediction model coefficients, it will nevertheless be important to facilitate initial training and use of MEPDG procedures and the accompanying software within ITD. The "Final" *User's Guide* needs to include, when available: Idaho-specific default values and data. Any gaps in Idaho-specific data should be filled with suitable regional or national defaults will be filled in by ITD.

- Idaho-specific truck traffic, climate, pavement material, soils and other data that are representative of the conditions and site features in Idaho.

- Local calibration factors of the transfer functions for predicting pavement distress and performance in Idaho.

- The "Final" *User's Guide* will essentially be an updated version of the *User's Guide Version 1.1* with the data from Stages 2 and 3. It should be updated upon the completion of local calibration efforts.

- A training program to ensure proper and consistent use of the *AASHTOWare Pavement ME Design* software.

Chapter 2
Stages to Implementation

The *Road Map* for ITD's implementation of the ME Design procedure has been divided into three stages consisting of seven steps:

- Stage 1: Develop *ITD's User's Guide Version 1.1* and assemble an initial set of inputs for immediate use of the software. Stage 1 is primarily based on work already completed for ITD by the University of Idaho (RP193) in preparation of using the MEPDG procedure plus ARA experience in other States. Stage 1 will be completed when the "Final" *User's Guide* will be completed when local calibration efforts are finished.

- Stage 2: Will started at completion of Stage 1 in 2014. The major work efforts will focus on: filling in the missing input data gaps identified in Stage 1, conduct the local calibration effort, and provide training.

- Stage 3: Consists of continued long-term data collection and future updates of Idaho-specific ME Design related inputs and calibration coefficients.

Table 1 lists the specific steps within each Stage, while Figures 2 through 4 illustrate how they relate to one another. These flow charts are intended to show the interaction and interrelationship between the different steps in terms of a building process towards using ME Design on a production basis.

ITD has already initiated some activities in preparing to implement the MEPDG procedure and ME Design. These initial initiatives include sponsoring studies to evaluate data to determine default values for traffic, conducting laboratory tests of selected materials, and hosting initial training on the MEPDG procedure and software.

Step 1. Familiarization and Data Availability

Review of Experience and Lessons Learned by Other Agencies

ITD staff will continue to familiarize themselves with *AASHTO's ME Design Manual of Practice*, the *AASHTOWare Pavement ME Design* software and its inputs, and on-going implementation and local calibration studies of other state departments of transportation (DOTs) such as: Arizona, Colorado, Georgia, Indiana, Mississippi, Montana, Mississippi, Missouri, Utah, Wisconsin, Wyoming and others as the product is implemented. The state implementation reports mentioned above are listed in the reference section of this report. ARA Inc. (ARA) will provide ITD staff with most of these reports (a few are still under final review). This will greatly assist ITD in making decisions needed for some of the implementation activities proposed in this work plan and absorb the lessons learned by other agencies. This work plan does however draw from ARA's experiences of being involved in or studying these implementation work efforts.

Decisions of Relevance to ITD

ITD will need to make decisions of relevance for collecting data needed for various activities. The decisions of relevance will form the basis and determine the level of effort for full implementation of the MEPDG software. The items should include the following, at a minimum, and the results used in developing the experiment sampling matrix under Step 4 (a preliminary sampling matrix is provided under Step 4 for each pavement type):

- Pavement types and rehabilitation methods commonly used in Idaho.
- Design features typically used by ITD (thick non-frost susceptible layers, rock fills, polymer modified asphalt, dowels in jointed plain concrete pavement (JPCP), widened concrete pavement slabs, etc.).
- Typical site conditions (subgrade, traffic, climate, existing pavement condition).
- Typical maintenance activities and/or pavement preservation techniques applied to pavements.
- Inputs commonly used in the current design procedure for new and rehabilitation design and how they differ from those required for *AASHTOWare Pavement ME Design.*

Table 1. Steps Within Each Stage for Implementing MEPDG and Using the *AASHTOWare Pavement ME Design* Software in Idaho

Steps	Stage 1 - Immediate	Stage 2 - Near Term	Stage 3 - Future or Long Term
1. Familiarization of Software & Prepare *User's Guide Version 1.1*	Complete Within Stage 1		
2. Complete Concurrent Project Designs (ME Design vs current ITD designs, on same project)	Initiate at End of Stage 1.	Continue into Stage 2 for Use in Training Program.	
3. Establish Inputs for ME Design	Initial Library of Inputs from Available Data & Experience.	Laboratory & Field Test Programs to Fill Data Gaps for Climate, Traffic, & Materials.	Continued Under Step 7
Climate	Sufficient Weather Stations Available.	None	Clean Weather Station Data; Add Additional Weather Stations to Library.
Traffic	Use Defaults Generated by RP193 & Develop Data Collection Plan.	Data Collection & Evaluation of Other Road Classes.	Continued in Step 7.
Materials	Use Defaults Measured by University of Idaho (RP193) & Develop Data Collection Plan.	Measure Properties for Materials not included in Current Studies & Add to Materials Library.	Continued in Step 7.
Calibration Coefficients	Based on Other Agency Calibration Studies.	See Step 4.	See Step 7.
4. Calibration-Validation of Transfer Functions		Complete Within Stage 2. This is the Main Focus of the RP 235 *Calibration of the MEPDG Performance Models for Flexible Pavements in Idaho*, an ITD/UI Research Project Beginning in 2014.	
5. Prepare "Final" *User's Guide* will incorporate data from calibration efforts.		Product from Stage 2.	
6. Establish & Execute Training Program		Preliminary Training at Beginning of Stage 2 & Final Program at End of Stage 2.	
7. Future/Periodic Updates to Input Libraries & Local Calibration Coefficients			Continuation of Data Collection Activities to Fill Gaps & Update Calibration Coefficients.
These work items will be worked on as funding or resources become available. The goal is to get up and running as soon as possible and then fine tune.			

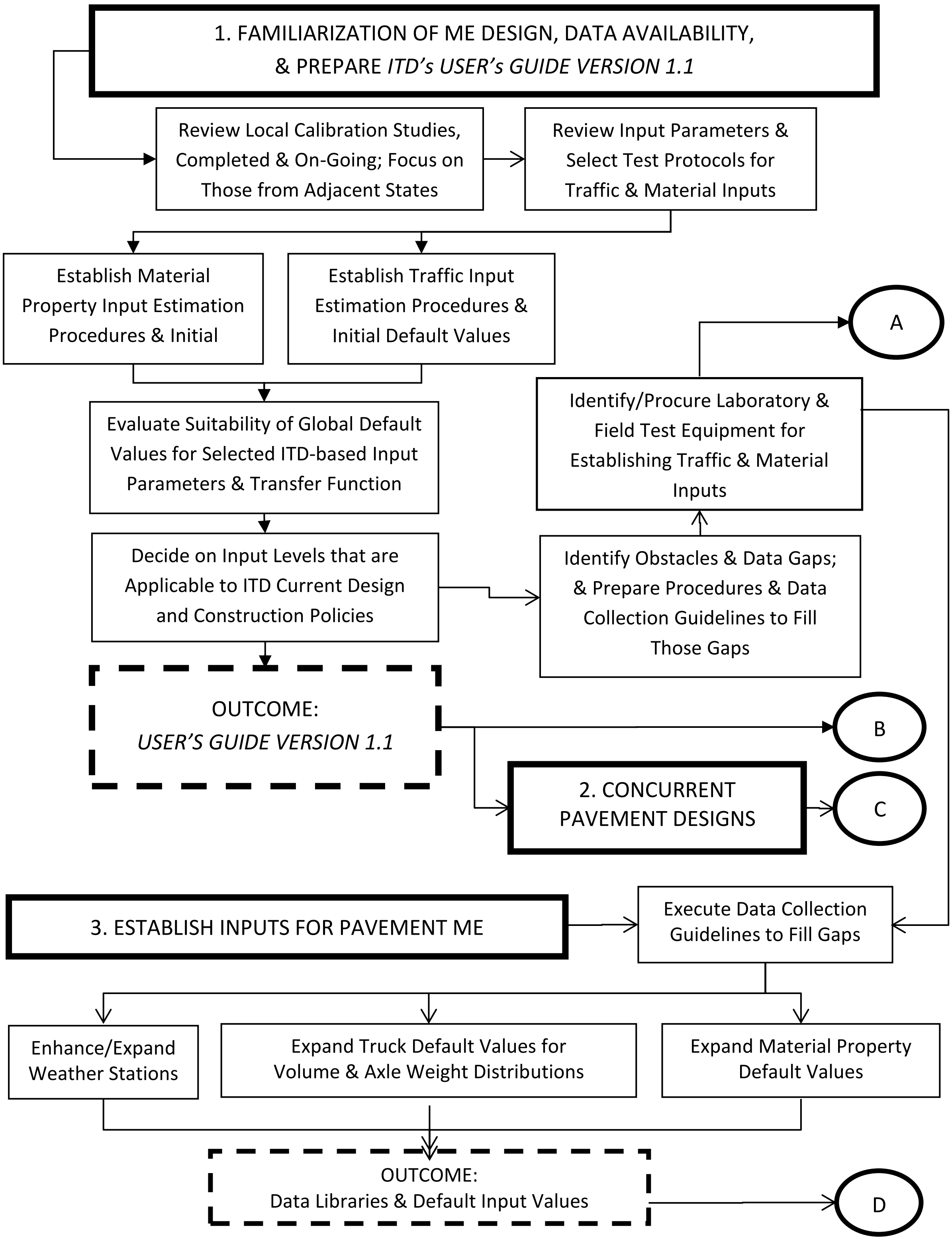


Figure 2. Flow Chart Showing the Initial Familiarization and Data Collection Activities to Implement M-E Design for ITD and to Establish Concurrent Designs

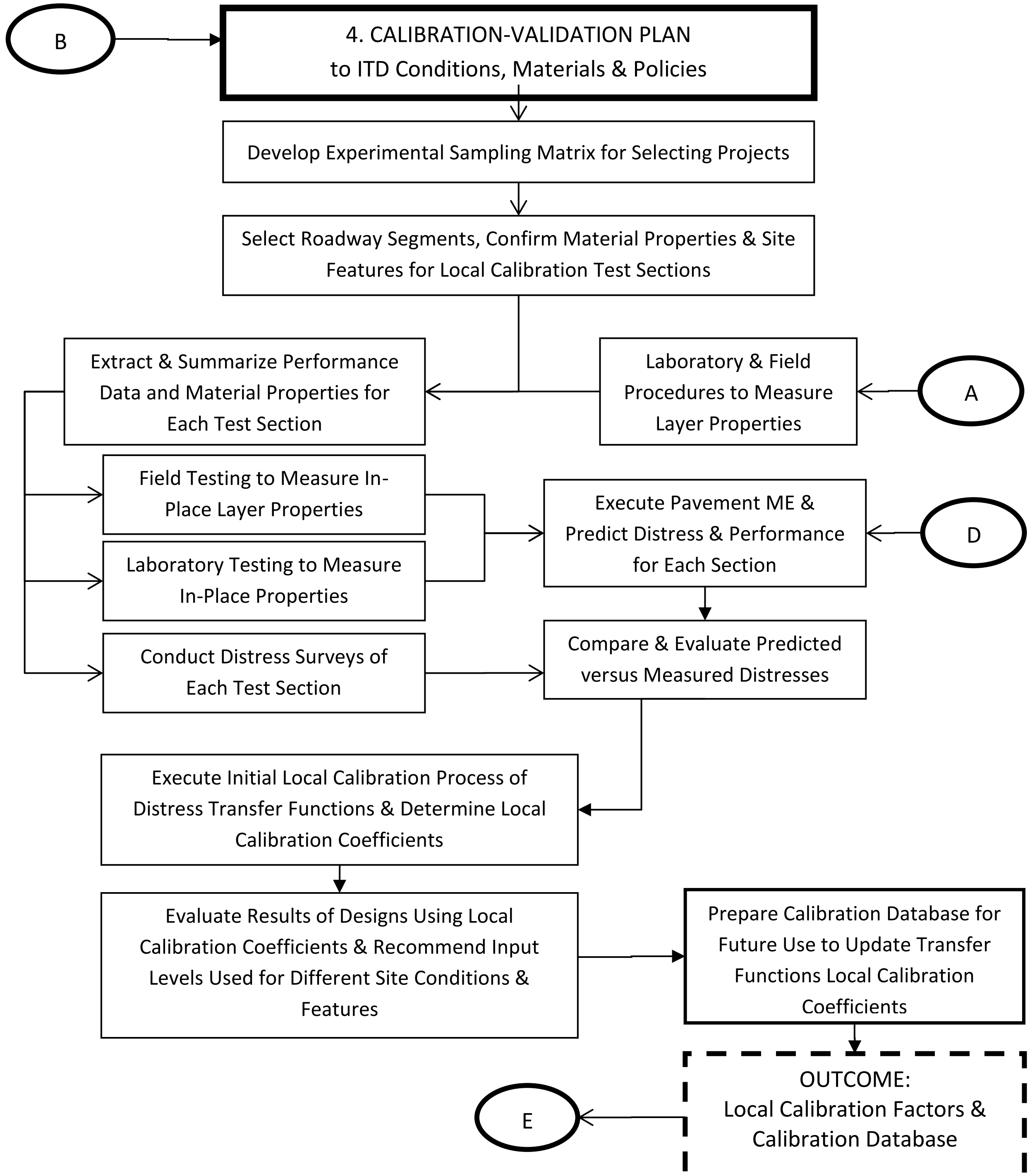


Figure 3. Flow Chart Showing All of the Calibration Steps and Activities That Are Suggested to Implement ME Design for ITD

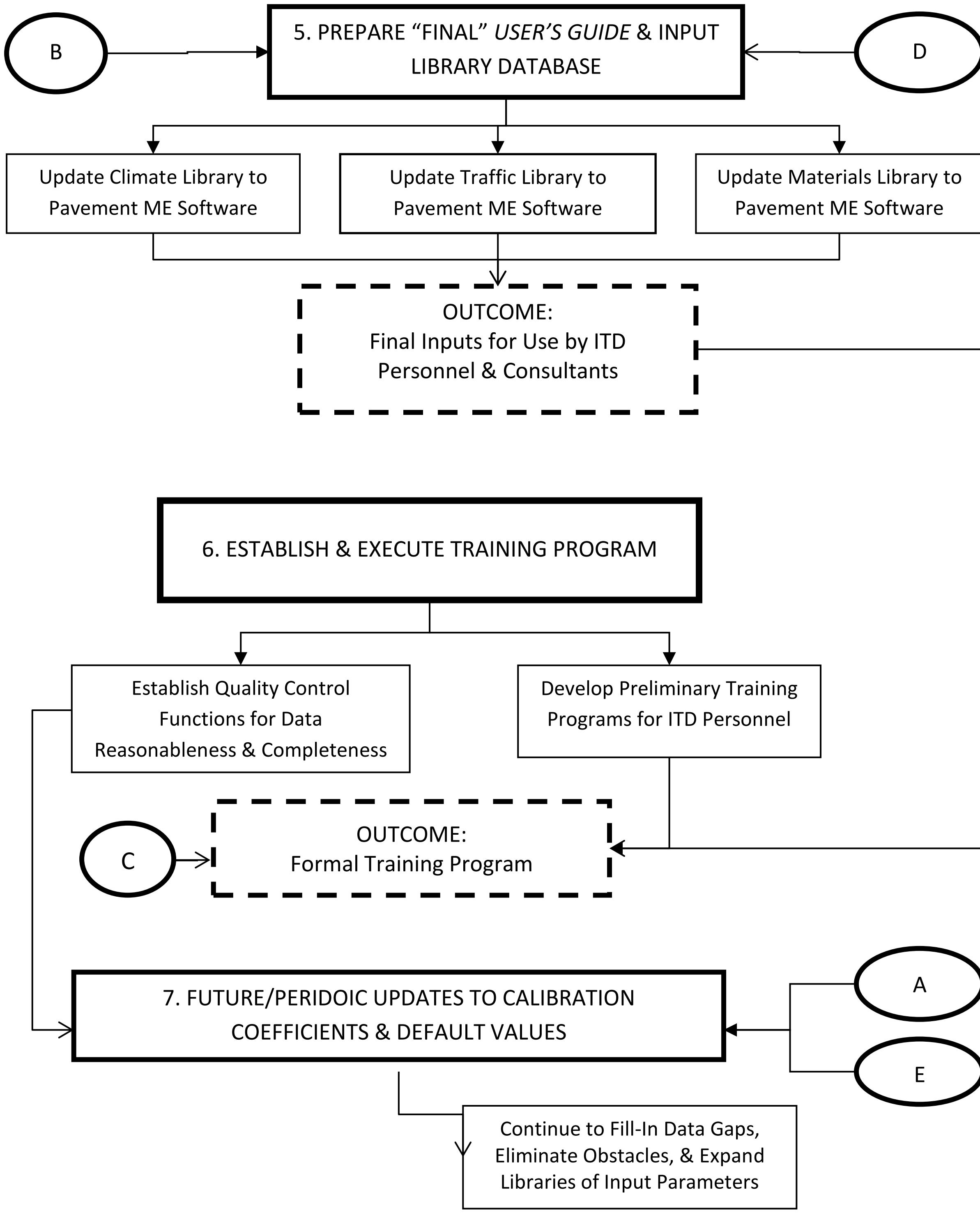


Figure 4. Flow Chart Showing the Training and Future Update Steps and Activities That are Suggested to Implement ME Design for ITD

Another set of relevant decisions needs to focus on determining the ME Design inputs for new and rehabilitation designs, which are based on:

- Appropriate input levels for use in design (Input Levels 1, 2, or 3), which are usually policy driven based on preferences and resources available to the agency during production level design work.
- Appropriate default values and ranges for Input Level 3.
- Design performance criteria and design reliability levels. This is determined from or based on ITD's Pavement Management data a portion of ITD's TAMS System and can be facility dependent.
- Pavement preservation and maintenance schedules, as they relate to the design criteria, if applicable.

Identify Missing Data and Obstacles

Following the decisions of relevance, a critical activity of the implementation process is to identify missing data, information gaps, and obstacles for using *AASHTOWare Pavement ME Design* software in accordance with the appropriate input levels to be used in design. ITD has completed laboratory testing through research project (University of Idaho's project RP193 for ITD) of selected asphalt mixtures and soils to establish the initial default values. In addition, ITD has also evaluated the Idaho traffic data to ascertain statewide defaults for this input. Therefore, in terms of these inputs, the immediate implementation and use of ME Design should take a minimal level of effort and time. However, many other inputs such as concrete materials, rehabilitation inputs and others will need considerable guidance development prior to adoption.

Step 3 provides a brief discussion on the more important inputs for which gaps are known to exist. These data and information gaps, and the methods proposed to fill those gaps, need to be confirmed within this first step. These methods and procedures are used in the later steps for continued data collection activities and efforts. Much of the information from this activity will be based on the results from the decisions of relevance from the previous activity.

Prepare *ITD's User's Guide Version 1.1*

Using the decisions made and data reviewed in the earlier activities of this step, prepare *ITD's User's Guide Version 1.1* based on existing ITD practices, policies, and construction data for new design and rehabilitation projects. The *ITD's User's Guide Version 1.1* will help the implementation process to stay focused on key issues and input variables different from those used in the national calibration effort.

Step 2. Complete Concurrent Pavement Designs

After the *ITD's User's Guide Version 1.1* has been prepared, it is beneficial to compare designs based on the current ITD design procedure to those generated using the *AASHTOWare Pavement ME Design* software for the same projects. Concurrent designs are completed using the "best available" input data in accordance with the *User's Guide* to accomplish the following:

1. Assist ITD staff to become proficient in using the software.

2. Provide ITD staff with an understanding of the differences between ITD's current design procedure and the *AASHTOWare Pavement ME Design* software.

3. Identify issues for determining the inputs or with the prediction of distresses for some design strategies. Help refine the Stage 2 *Work Plan*.

4. Provide a valuable source of examples for the training program suggested under Step 6.

Indiana and Mississippi completed concurrent designs early in the implementation process to determine the expected difference in construction costs, as well as to identify input parameters that are more difficult to obtain. They found this process to be very beneficial in streamlining their *User's Guide* development.

Step 3. Establish Inputs

Step 1 identified specific challenges to obtain selected input parameters, while this step provides potential solutions to those challenges, as well as confirming the Input Level 3 default values. Specifically, Step 1 consists of establishing default values to aid in the uniform application of ME Design within ITD. For example, soils and materials libraries should be created along with the recommended default values, traffic libraries should be established to select default traffic inputs (including volumes, weights, and adjustments) based on the roadway's service class or broad traffic stream descriptions, and so forth. ITD will need to maintain and update these input libraries continually, so it is a continuing activity but at a much reduced level of effort. *ITD's User's Guide Version 1.1* includes many specific references to inputs that require improved estimates and/or measurement.

Another set of inputs are the calibration factors or coefficients and standard deviations of the transfer functions. An initial set of calibration coefficients and standard deviations will be established in Step 1 based on calibrations performed by other state DOTs since ITD has not completed a local calibration study of its own. The final set of calibration coefficients and standard deviations will be determined in Step 4 based on Idaho-specific pavement sections and data. These will be included in the "Final" *ITD's User's Guide* prepared under Step 5. The following lists the activities to establish Idaho-specific ME Design inputs.

Enhance/Expand Weather Stations

A total of 11 weather stations in Idaho are included in the MEPDG software. In addition, there are a number of stations in States that border Idaho which can be utilized by ITD to define historical weather at a given design project location (see Figure 5). They represent a reasonable number and distribution of stations for the geographical climate differences across Idaho. The data from these 11 stations along with data from neighboring states is considered sufficient for immediate use of ME Design under Stage 1 (see Table 1). This Step 3 activity consists of enhancing and expanding the number of weather stations across Idaho to be accomplished under Stage 3.

This activity starts with updating the *AASHTOWare Pavement ME Design* software's Idaho climatic data to match the currently available information from the National Climatic Data Center (NCDC). The *AASHTOWare Pavement ME Design* weather files currently contain information up to December 2006 for the Idaho weather stations which was when the *AASHTOWare Pavement ME Design* software's climate database was last updated. However, NCDC accumulates and posts information on a monthly basis and these data are publicly available. These data will need to be downloaded, quality checked and newer *.icm files created. Quality checking of climate data is a very crucial aspect of the local calibration exercise since climate data controls certain key aspects of performance.

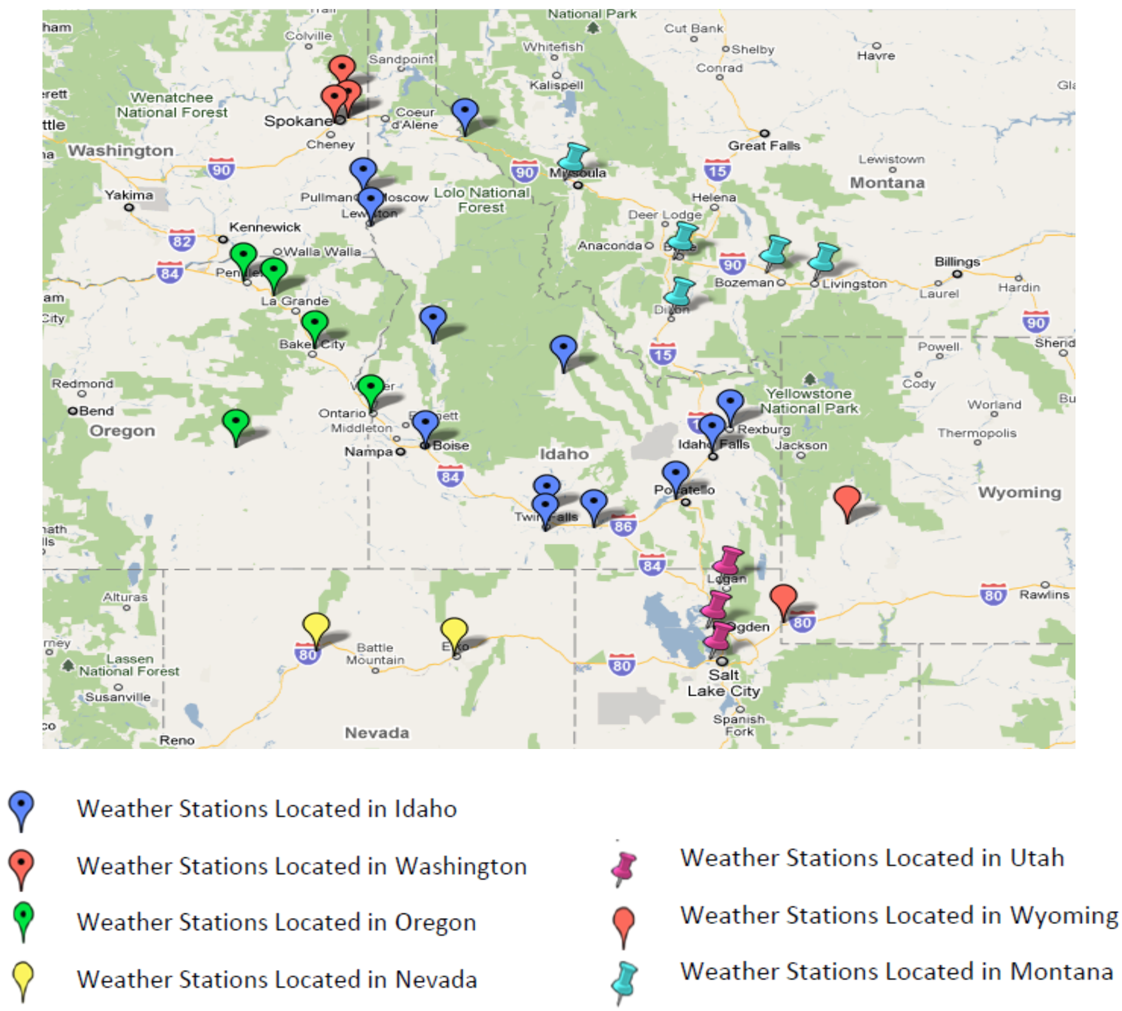


Figure 5. Weather Stations in Idaho and Neighboring States for Which Hourly Climatic Data is Included in the MEPDG Software

Another enhancement activity with regard to climate data is to improve the geospatial coverage of climate data by identifying other weather stations located in Idaho but not included in the *AASHTOWare Pavement ME Design* software. Sources for such data include Idaho meteorological or water survey authorities who keep track of historical weather information at various locations within Idaho that are not coincident with the Idaho-specific first-order weather data included in the NCDC database. The additional coverage should specifically target areas in Idaho where the ME Design climate stations do no provide adequate coverage. Quality checking this type of data is paramount and is a rigorous activity particularly to fill gaps in data records for a given location. It is highly recommended that the services of a climate scientist be retained to perform this task.

Establish Groundwater Table Depths

A data element required by the ME Design software which is unavailable from existing files in Idaho is the depth to the groundwater table. For Stage 1, a default depth to water table needs to be established, when it is unavailable from boring logs. The following sources of information for groundwater table depths can be utilized in Stage 3.

1. Detailed deep boring logs established by the ITD Materials/Geotechnical Section along all highway alignments translated to a map format. There may be data available from projects that have been previously constructed. This is a data intensive effort but has a potential for higher accuracy.

2. Estimates obtained by interpolating groundwater table depth information obtained from the United States Geological Survey (USGS). Mississippi DOT has used this approach to determine the average depth to a water table for all areas of that State. The Idaho Department of Water Resources website should be able to provide data for this activity. (http://www.idwr.idaho.gov/hydro.online/gwl/default.html)

Establish Traffic Input Estimation Procedures and Default Values

Traffic information is a key factor for any pavement design procedure. Data from a total of 25 weigh-in-motion (WIM) sites are available in Idaho. However, RP193 a University of Idaho study commissioned by ITD, concluded that only 14 of the sites had sufficient weight data that complied with the Federal Highway Administration (FHWA) recommended procedure. These 14 WIM sites however represent a reasonable number of sites for generating the normalized axle load spectra (NALS) and other input parameters. FHWA recommends a minimum of three WIM sites for determining an average NALS for a specific road class.

The RP193 study completed an initial evaluation of the WIM data and developed three NALS, along with other truck input parameters, for use in design which can be used immediately under Stage 1 (see Table 1). The other truck traffic inputs include monthly and hourly truck volume distributions, average axle spacing, average number of axles per truck class, et al.

The 3 NALS reported by RP193 resulted in significantly higher amounts of cracking than the global default NALS. Most of these WIM sites, however, are located on specific classes of roadways:

interstates and primary arterials. Thus, additional WIM data will need to be collected under Stages 2 and 3. As such, this activity is a two-part effort:

1. Develop a truck traffic data collection plan, which should be completed at the end of Stage 1. This plan should include short-term, mid-term, and long-term goals for truck traffic data collection.

2. Implement the truck traffic data collection plan: short, mid, and long-term goals of the plan in Stages 2 and 3 (see Table 1).

    a. The short-term goal is to collect data using portable WIM devices at sites for roadway classes not currently represented by the existing 14 WIM sites with sufficient or adequate data. See Table 63 in RP193 *Implementation of MEPDG for Flexible Pavements in Idaho*. These additional data should be collected over different seasons for evaluating the NALS for these lower volume roadway classes. These additional data are evaluated at the end of Stage 2, to develop additional NALS and other truck traffic default values, if needed, for use in design and in local calibration under Step 4. Overloaded trucks, although infrequent, have a disproportionate effect on pavement performance, so an accurate count of overloaded trucks from WIM stations is desirable.

    b. The mid-term goal is to continue to collect data at the existing WIM sites into Stage 3 for confirming the default NALS and other truck traffic inputs in Idaho. Data should be collected at the existing permanent WIM sites of sufficient quality to accurately measure the axle weights and truck volumes. This is simply a continuation of the existing data collection efforts through Stage 2 and into Stage 3.

    c. The long-term goal is to install additional permanent WIM sites at strategic locations for developing additional NALS or confirming the 3 NALS and other truck traffic default values that were determined from the initial RP193 study. This activity starts in Stage 2 but continues into Stage 3. The sites for installing the additional permanent WIM equipment are selected based on an evaluation of the existing WIM data to fill in the data gaps identified from Stage 1. For planning purposes of this *Road Map*, four to six additional WIM sites should be sufficient.

Establish Material Property Default Values

Materials information is a key input parameter for most pavement design procedures. The purpose of this activity is to establish default material property inputs for new construction or reconstruction and rehabilitation design strategies. This includes physical properties for materials included in the original or national MEPDG calibration work for the materials typically used by ITD. As an example, some of the materials excluded from the national calibration study but used by ITD in their pavement and rehabilitation design projects include:

- Rock fills or embankments.
- Cold-in-place recycled layers, with and without additive(s).

- Full-depth reclamation (FDR).
- Soil-cement and other additives like lime and fly ash for soil stabilization.
- Polymer modified asphalt mixtures.

To establish default values of typical material properties requires a review of mix design and construction records for a range of projects. The range of default material properties should be tied back to the quality of construction and types of specification used to construct projects. Similar to the truck traffic inputs, this activity is a two-part effort:

1. Develop a materials characterization data collection plan which should be completed at the end of Stage 1. This plan should be grouped by material type: asphalt concrete mixtures/materials, portland cement concrete (PCC) mixtures/materials, and unbound aggregate base and subgrade soils.

2. Implement the materials characterization data collection plan for each material in Stages 2 and 3 (see Table 1). As such, the plan needs to consider how the testing will be completed, what ME-Design specific inputs will be developed, what format will the data be supplied, and whether ITD will purchase the equipment or use external contractors to characterize the material properties.

The following briefly addresses these plans and data collection efforts for creating or enhancing the material libraries on a material type basis. These activities will be considered as funds become available.

Asphalt Concrete Mixtures/Materials

Under the Research Project RP193, the University of Idaho completed some testing of selected asphalt concrete materials: dynamic shear rheometer tests (DSR) for the binder and dynamic modulus testing for the mixtures. Indirect tensile creep compliance and strength tests have not been performed on any asphalt concrete mixture in Idaho. Thus, creep compliance and tensile strength tests need to be measured on the more common mixtures produced and placed by ITD.

The test results completed by RP193 can be used in Stage 1. ITD should also plan to expand the mixture properties database under Stage 2 using either internal resources or external testing labs. If internal resources are used the ITD should plan on purchasing a DSR and an Asphalt Mixture Performance Tester (AMPT) to perform research grade binder, dynamic modulus and repeated load testing. Furthermore, low-temperature creep compliance and strength testing should also be conducted as part of Stage 2. Typically, creep compliance and indirect tensile strength testing services are procured from contracted laboratories due to the more advanced nature of these tests.

The number of mixtures included in the testing plan for Stage 2 should be carefully planned and should include the common mixtures and binders used for the base layer, intermediate layers and the wearing course. An “Experimental Laboratory Test Plan” should be developed prior to executing the work to ensure that the work products are directly in line with ITD’s ME Design implementation efforts. For planning purposes, 4 binders and 12 mixtures should cover the more common mixtures placed along ITD roadways.

Portland Cement Concrete Mixtures/Materials

No formal testing program has been initiated for the PCC materials. ITD has the capability to measure the elastic modulus, compressive strength, and flexural strength of PCC materials; however, it is possible that some of these properties are not frequently tested. The test not conducted by ITD is the PCC linear coefficient of thermal expansion (CTE). Similar to the asphalt concrete materials, it is recommended that ITD either perform the full suite of concrete testing (strength, modulus, and CTE) using internal resources or make use of a specialized contractor to measure the concrete properties for typical PCC mixtures under Stage 2. If internal resources are planned, ITD should plan to purchase the equipment necessary to perform the CTE testing. The equipment can be used in both Stage 2 and 3. However, if only CTE testing is done by outside agencies, ITD should make available concrete samples, co-batched with the remainder of the samples for other strength and modulus tests, to its contractor. A carefully crafted work plan should be put in place prior to any testing being performed to ensure that work products of the testing program and in line with ITD's ME Design implementation efforts.

Unbound Aggregate Base Materials/Subgrade Soils

No formal testing for resilient modulus testing (M_r) has been completed for the unbound aggregate base materials or soils in support of implementing the MEPDG. However, Idaho has an established M_r and R-value correlation developed through a contract with the University of Idaho RP193. This correlation is different from the one in the *AASHTOWare Pavement ME Design* software and needs to be verified in the local calibration done in Stage 2 for new designs. However, it can be used immediately in Stage 1 for subgrades and embankment soils. As ITD is confident in use of the R-value and its correlation to M_r, no M_r testing is planned as part of Stages 1, 2, or 3. The testing plan for the unbound aggregate base materials and subgrade soils should include the major soil types in Idaho, as well as the predominant crushed aggregate base types used in Idaho. This testing should include one full set of inputs for each material/soil type: Atterberg limits, maximum dry unit weight/optimum water content, R-value, and gradation. Most of this testing will be for the aggregate base materials, as sufficient testing has been completed on most of the predominant soils encountered in Idaho.

For rehabilitation designs, ITD uses back-calculated elastic layer modulus values from the deflection basin data and plans to continue with this process. However, a careful procedure for testing pavements, estimating in situ moduli, and correcting them for use with the *AASHTOWare Pavement ME Design* software should be developed under Stage 2. Initial recommendations are provided in the ITD *User's Guide Version 1.1.*

Step 4: Calibration-Validation of Distress and Smoothness Transfer Functions

The MEPDG transfer functions used to predict the performance indicators were calibrated and validated using the LTPP test sections throughout North America. However, this national calibration-validation effort did have some gaps and limitations. It did not consider all potential factors that can influence pavement performance, e.g., such as maintenance strategies, construction specifications, polymer modified binders, and material specifications which can result in differences in performance, all other factors being equal. In fact, small differences in some of these factors can cause large differences in performance. As such, a key activity during the implementation phase of any new design procedure is the verification and/or local calibration-validation of the distress and smoothness models used in design.

The purpose of the calibration-validation process is to determine whether the MEPDG computational methodology and global transfer functions as well as standard deviations are a reasonable representation of pavement performance in Idaho and if the desired accuracy exists between the model simulations and real-world conditions. This step should be completed in accordance with the *2010 AASHTO MEPDG Local Calibration Guide*. The success of this process is gauged based on biases of the predicted values and the standard error of the estimate. The following provides a brief discussion on the critical activities of the calibration-validation effort.

Design an Experimental Sampling Matrix

One of the first activities of this step is to prepare a sampling matrix of factors representative of ITD's operational policies. A sampling matrix considers the site conditions, design features, materials, and design strategies commonly used by ITD (see Step 1). The sampling matrix defines the number of roadway segments needed for the local calibration and validation effort.

Within practical limitations of any experimental plan, it is impossible to account for all potential factors in developing a national performance model. The experimental plan and sampling matrix is designed to identify potential differences between the national calibration factors and those applicable to ITD conditions, materials, specifications, and operational policies. The experimental sampling matrix is developed around the following hypothesis:

- **Null Hypothesis – Confirmation of National Calibration Factors**: There is no significant error and no bias (i.e., reasonable correlation and accuracy) between the predicted and measured values for each performance indicator.

The calibration-validation experimental design or sampling matrix should concentrate on common site conditions and design features from Step 1. Tables 2 and 3 are the preliminary sampling matrix for the asphalt concrete and PCC pavements, respectively. These preliminary sampling matrices are provided as examples and starting points. The sampling matrix should be designed at the end of Stage 1, in planning for Stage 2.

To eliminate bias of the transfer functions, sufficient test sections for each primary tier of the sampling matrix are selected such that they are consistent with other tiers of the sampling matrix. A full factorial is not needed for the local calibration of the distress transfer functions, but replication within some cells is needed when a partial or fractional factorial is used. The probable number of projects for the partial factorial is discussed in the next section of the road map.

Using the results from previous studies (such as LTPP) allows ITD to reduce the number of test sections required to calibrate the distress transfer functions to its policies, materials, and climate. It is recommended that fewer than half of the calibration sites be from LTPP, because of potential differences between the roadway segments within the LTPP program and ITD's operational policies.

Table 2. Preliminary Experimental Sampling Matrix for Asphalt Concrete Pavements

Mix Type	Volume of Truck Traffic	Soil Type	Pavement Structure				
			New Design	Rehabilitation			
			Unbound Aggregate Base	HMA Overlay		CIR	FDR Stabilized with Cement
				Flexible	Rigid		
Neat Mixtures	Low	Coarse - Grained					
		Low Plasticity					
		High Plasticity					
	High	Coarse - Grained					
		Low Plasticity					
		High Plasticity					
Polymer Modified Asphalt	High	Coarse - Grained					
		Low Plasticity					
		High Plasticity					

CIR - Cold-in-Place Recycle

Table 3. Preliminary Experimental Sampling Matrix for PCC Pavements

JPCP Joints	Volume of Truck Traffic	Soil Type	Structure				
			New Design		Rehabilitation		
			Unbound Base	Stabilized Base	PCC Overlay		CPR
					Flexible	Rigid	
With Dowels	Low	Coarse - Grained					
		Low Plasticity					
		High Plasticity					
	High	Coarse - Grained					
		Low Plasticity					
		High Plasticity					
Without Dowels	Low	Coarse - Grained					
		Low Plasticity					
		High Plasticity					

Based on findings from other agencies verifying or calibrating the MEPDG procedure, the null hypothesis may be rejected for rutting, bottom-up fatigue cracking, and thermal cracking for asphalt concrete pavements and cracking and faulting for PCC pavements. If the null hypothesis is rejected, adjustments need to be made to the calibration factors and the models re-evaluated. If significant differences are found between the predicted and measured performance indicators, then it will be necessary to determine what factors are causing these differences so that adjustments can be made to the calibration factors. Because several State local calibrations have shown bias, Stage 1 recommends that the following calibration coefficients and standard deviations be used initially in Idaho (these recommendations are provided in the *ITD's User's Guide Version 1.1*:

- Rutting calibration coefficients and standard deviations for asphalt pavement.
- Transverse cracking and faulting calibration coefficients and standard deviations.

Select Test Sections for Verifying ME Design Transfer Functions

Define the specific cells of the sampling matrix that were not included in any of the earlier work related to calibration and validation. It is expected that a minimum of 30 sites will be needed for verification. The following summarizes the information needed for the test sections to be used in the verification process:

- To assess the experimental hypothesis, a comprehensive pavement performance database is essential. The projects selected should include at least two distress data points from ITD pavement management records in the Pavement Management portion of TAMS database. Approximately 20 pavement management segments are needed to cover the different tiers of the sampling matrix. The actual number of roadway segments will be determined after the sampling matrix has been finalized.

- Extract the performance history of each roadway segment and physical properties from construction records. Data to be used for this activity will come from ITD's Pavement Management portion of TAMS database and construction files. The roadway segments selected for the verification of the performance models should exhibit distresses that approach the failure criteria to be used in pavement design.

- A testing plan to establish the initial material properties and condition of each test section included in the calibration process should be developed in accordance with the requirements identified in the *ITD's User's Guide Version 1.1* (see Step 1). This plan should include deflection, ride quality, rutting, and distress surveys to identify the surface condition and structural response characteristics of each test section. All information needed to execute the *AASHTOWare Pavement ME Design* software needs to be accumulated.

ITD roadways may have different traffic (lower traffic volumes and unique traffic mix) and climate (altitude differences, proximity to coastal regions) from some of these LTPP and State sections, so data from these other sections should be evaluated carefully to ensure they represent conditions similar to ITD projects before inclusion in the calibration process and sampling matrix.

Summarize Performance Data and Material Properties for Each Test Section

After the test sections have been selected, the historical information on these projects is accumulated. This information should include: basic material properties/structural characteristics, previous deflection tests, ride quality, and condition surveys. This activity should also include the creation of a database in which all information is stored for future analysis work.

Laboratory and Field Testing Programs in Support of ME Design

Laboratory and field testing programs are used to determine pavement and foundation layer properties over a range of mixes, materials, and site conditions in Idaho. All testing should be performed as specified in the *ITD's User's Guide Version 1.1* prepared under in Step 1.

Laboratory Test Program

The *Laboratory Testing Plan* is used to determine the in-place volumetric properties of each layer. The testing plan should define the types of tests to be completed and test equipment needed, as well as the number of tests to be performed. If data are unavailable from construction records or files, the following should be included in the laboratory tests, as a minimum (the test protocols are included and identified in the *MEPDG Manual of Practice* for all materials):

- Unbound Aggregate Layers and Soils.
    a. Tests to classify the unbound layers.
    b. ITD uses the R-value test. Most pavement designs are based on the R-value but the volumetric properties of the test specimens are not always available. All of the calibration sites should have the R-value or M_r from historical records or existing databases (for example, LTPP database).
    c. In-place water content of unbound layers. The *Road Map* assumes that densities of the unbound layers will be available from construction records.

- Asphalt Concrete Materials.
    a. Bulk and maximum specific gravities of hot mix asphalt structural layers.
    b. Asphalt content of the hot mix asphalt structural layers. The road map assumes that the performance grade of the asphalt binder will be available from construction records.

- Portland Cement Concrete Materials.
    a. Coefficient of thermal expansion.
    b. Compressive strength and elastic modulus.

Field Test Program

A *Field Testing Plan* is used to define and determine the in-place material properties and pavement cross section. The *Field Testing Plan* should consist of deflection basin measurements and the use of cores and borings to define the material types and layer thicknesses. The *Field Testing Plan* should also consist of the following activities:

- ITD has both the Falling Weight Deflectometer (FWD) and Dynamic Cone Penetrometer (DCP) but uses the DCP only in limited situations. FWD deflection basins should be measured on each site selected for the calibration-validation process. The elastic modulus should be back-calculated from the deflection basins measured along a representative segment of the roadway. EVERCALC can be used for back-calculating the elastic layer pavement modulus values.

- Conduct limited coring along each representative roadway segment. Two types of cores should be drilled: one set through any cracks within the roadway segment to determine where the cracks initiated and one set for measuring the physical properties of the hot mix asphalt layer, if unavailable from construction records. Both sets of cores can be used to confirm the pavement layer thickness recovered from construction records.

- Conduct current distress surveys at these sites to define the extent and severity of the distresses.

Execute ME Design

Run *AASHTOWare Pavement ME Design* to predict performance and distress. The predicted values should be compared to the observed or measured values to determine the standard error of the estimate and if any of the transfer functions exhibit significant bias. These results are used to confirm or reject the experimental hypothesis. If the hypothesis is rejected, the results from the calibration runs are used in revising the coefficients of the distress transfer functions until the bias is eliminated. If the hypothesis is accepted, no further runs are needed.

Step 5: Finalize ME Design Guide

The *ITD's AASHTOWare MEPDG Design User's Guide, Version 1.1* should be updated and revised using the results from the calibration and validation process from Step 4 and based on ITD operational policies and design criteria. This manual is the primary document used as part of the training program developed under Step 6.

The *"Final" ITD's AASHTOWare MEPDG Design User's Guide* should include the following major sections or topics and refer to the recommended default values for Input Level 3, test protocols for determining Input Levels 1 and 2, and example problems, as a minimum:

- Overview and Software Installation.
- General Information.

- Performance Criteria.
- Design Reliability.
- Traffic Inputs.
- Climate Inputs.
- Structure and Materials Inputs.
- Rehabilitation Inputs and Designs.
- Performance Outputs.
- Performing a Pavement or Overlay Design.
- Example Designs:
    - Conventional Flexible Pavement.
    - JPCP Rigid Pavement.
    - Asphalt Concrete Overlay of Flexible Pavements.
    - Cold-in-Place Recycling.
    - FDR.

Step 6: Establish a Formal Training/Technology Transfer Program

Training of ITD personnel should begin immediately after Stage 1 has been completed. ITD personnel and consultants have already participated in some initial training on the use of the software. In addition, various training courses and webinars are available nationally, but these are not agency-specific.

The full implementation of ME Design into daily usage requires a number of activities in addition to those related to obtaining inputs, validation, and calibration. These include training of staff, preparation of the *"Final" ITD's AASHTOWare MEPDG Design User's Guide* (Step 5), conducting concurrent designs (Step 2), preparation of default input libraries for designers (Step 3), and the continuing validation of the transfer functions or extension to other materials (Steps 3 and 7). Most of the validation and calibration activities feed information directly into all of these activities.

The main objective of the training program is to help ITD staff become comfortable and proficient with using the *AASHTOWare Pavement ME Design* software. The training program includes presentations, workshops, and short courses that should be held throughout the period of implementation to accomplish this goal. Training should not be thought of as a one-time activity. It should be virtually continuous throughout the period of implementation and beyond, and given as new personnel join ITD.

Key topic areas of the training program include the following, as a minimum:

1. General background on the MEPDG methodology and software - coverage of fundamental concepts of mechanistic design and an introduction to the mechanistic analysis tools included in ME Design.

2. Overview of the assumptions, theory, and methods embedded in MEPDG, as well as the output from the program and how that output is used.

3. Detailed information on each of the input parameters and how they are determined, which includes the local calibration coefficients of the transfer functions.

4. Example designs using the *AASHTOWare Pavement ME Design* software - a hands-on workshop on how to use the software to accomplish pavement designs.

These training activities should be conducted between the end of Stage 1 and the beginning of Stage 2, so that the ITD staff could more actively participate in the calibration-validation study. The study itself could be used as a training tool.

Establish Quality Control Functions

A data quality control (QC) program should be initiated at the beginning of the Stage 2 and formalized at the end to minimize variability in the data collected for establishing inputs to ME Design. The QC program should ensure that data are collected and used consistently over time.

In addition, the program should include training for all personnel so that consistent distress definitions and measurement techniques are maintained. Some of the difficulties in calibrating various distress transfer functions and analyzing pavement structures are differences in distress interpretation and the use of different equipment to measure a specific pavement response and/or performance over time. Some of these discrepancies can result in significant bias in the calibration factors.

Develop Training Programs

Training of ITD personnel should be an integral part of the overall implementation program. Training materials should be structured to address needs at all levels, including: high-level managers, engineers, and field/laboratory technical personnel.

Step 7: Future Updates and Enhancements to ME Design

ITD should continue periodic monitoring of test sections and data analysis to confirm the calibration factors for the expected service life of the new pavements and overlays. As part of the performance monitoring plan, periodic visual condition surveys, deflection testing, and longitudinal profiling should be conducted. Some pavement sections may need to be instrumented to define the traffic characteristics, as discussed in Step 3.

The periodic monitoring program should be consistent with the LTPP program, except that a higher frequency of data collection should be implemented. The monitoring program should include deflection tests, condition surveys to identify and measure the types and extents of distress at the site, ride quality, and rut depths (determined from the transverse profiles). Traffic counts should be made over selected time periods at each test section, if those values do not already exist.

There might be a need to survey some sections more frequently than established at the beginning of calibration. Specifically, as sections begin to fail (or develop significant amounts of distress) they will have to be surveyed more frequently to define the failure curve. Each year these sections should be identified and the testing frequency determined for that year. In addition, measurements should be taken on a section that is scheduled for rehabilitation or significant maintenance prior to these activities.

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