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RESEARCH REPORT

2023 Implementation Plan for the AASHTOWare Pavement ME Design Software

RP 305

By

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Applied Research Associates, Inc.

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16. Abstract

This report provides an updated implementation plan or Road Map for implementing the AASHTO Pavement ME Design (PMED) software for the Idaho Transportation Department (ITD). The initial Road Map to implement the PMED software was published in 2014. This document is an update and continuation of ITD's plan based on the completed activities between 2014 and 2023.

The updated Road Map continues the series of three implementation stages: Immediate, Near Term, and Future or Long Range. Within each stage are various steps to achieve the required objectives for implementation. Stage 1 is considered immediate activities that can be completed in less than 2 years. Stage 2 represents a longer work effort over several years to fill the deficiencies for inputs, to update the local Idaho calibration of distress and IRI models, and continued training. These activities can be completed in less than 5 years. Stage 3 represents long-term work or reoccurring activities to improve selected inputs and to maintain unbiased models and transfer functions. These activities are initiated and/or completed in 5 or more years.

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The Applied Research Associates, Inc. staff that assisted with the 2023 Implementation Plan includes: Abu Sufian and Harold L. Von Quintus.

Technical Advisory Committee

Each research project is overseen by a Technical Advisory Committee (TAC), which is led by an ITD project sponsor and project manager. The TAC is responsible for monitoring project progress, reviewing deliverables, ensuring that study objectives are met, and facilitating implementation of research recommendations, as appropriate. ITD's Research Program Manager appreciates the work of the following TAC members in guiding this research study.

- Project Sponsor:
- Project Manager: John Arambarri
- TAC Members: Braydan DuRee, Lucas Marsh, Greg Fisher, Riley Bender, Seung Baek, Tyler Coy, Stan Crawforth, Zach Lootens, Margaret Pridmore
- FHWA-Idaho Advisor: [Name]

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List of Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
CRCP	Continuously Reinforced Concrete Pavement
CTE	Coefficient of Thermal Expansion
DOT	Department of Transportation
EICM	Enhanced Integrated Climatic Model
FHWA	Federal Highway Administration
HMA	Hot Mix Asphalt
IRI	International Roughness Index
ITD	Idaho Transportation Department
JPCP	Jointed Plain Concrete Pavement
LTPP	Long Term Pavement Performance
MEPDG	Mechanistic-Empirical Pavement Design Guide
NALS	Normalized Axle Load Spectra
NCHRP	National Cooperative Highway Research Program
PCC	Portland Cement Concrete
PMED	Pavement ME Design
SMA	Stone Matrix Asphalt
TAC	Technical Advisory Committee
WIM	Weigh-in-Motion

Executive Summary

This report provides an updated implementation plan or Road Map for implementing the AASHTO Pavement ME Design (PMED) software for the Idaho Transportation Department (ITD). The initial Road Map to implement the PMED software was published in 2014. This document is an update and continuation of ITD's initial plan based on the completed activities between 2014 and 2023.

The updated Road Map calls for a series of three implementation stages: Immediate, Near Term, and Future or Long Range. Within each stage are various specific steps to achieve the required objectives for implementation. Stage 1 is considered immediate activities, that are relatively easy to do requiring a low level of effort and can be completed in less than 2 years. Stage 2 represents a major work effort over several years to fill the deficiencies for inputs, to conduct local Idaho calibration of distress and International Roughness Index (IRI) models, and to provide training. These activities can be completed in less than 5 years and require a higher level of effort. Stage 3 represents future long-term work to improve selected inputs and to maintain unbiased models and transfer functions. These activities are initiated and/or completed in 5 or more years.

1. Introduction

Background

Idaho Transportation Department (ITD) is transitioning from their Idaho R-Value procedure which is an empirical based (Gravel Equivalency and R value of subgrade) design procedure to the AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG) for designing new and rehabilitated pavements.

One of the biggest criticisms of the Idaho R-Value 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 Caltrans and AASHTO 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. Few agencies have quantified this impact on design and predicting performance using the AASHTO 1993 procedure, while the MEPDG quantifies the impact through statistical parameters that are directly considered in the design strategies for flexible, semi-rigid, and rigid pavements. Just about all agencies, including ITD, that began using the MEPDG have quantified the accuracy through their local calibration efforts.

The experience of agencies that have completed local calibration suggests the flow of work depicted in Figure 1.1 for successful implementation. While figure 1.1 does not show all the details of implementation, it does indicate the overall workflow and key activities required, as 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, validation of the distress and IRI models, a recalibration of the models as necessary, and several technology transfer activities.

ITD has recognized the advantages and importance of adopting mechanistic-empirical principles for the design of new and rehabilitated pavements, and formally began the implementation process in 2014 with the publication of its implementation plan or Road Map (Mallela et al., 2014). ITD initiated the use of the MEPDG sooner than 2014 through different research studies with universities and training sessions that introduced earlier versions of the software to ITD. ITD has continued its implementation process of the MEPDG through participation in the MEPDG-related implementation activities and through its own research initiatives.

As part of continuing and streamlining the implementation process of the MEPDG, ITD is updating the 2014 Road Map. Thus, ITD initiated a review process to ensure the input procedures are acceptable and practical and that the distress transfer and smoothness degradation functions accurately represent the performance of ITD roadway pavements.

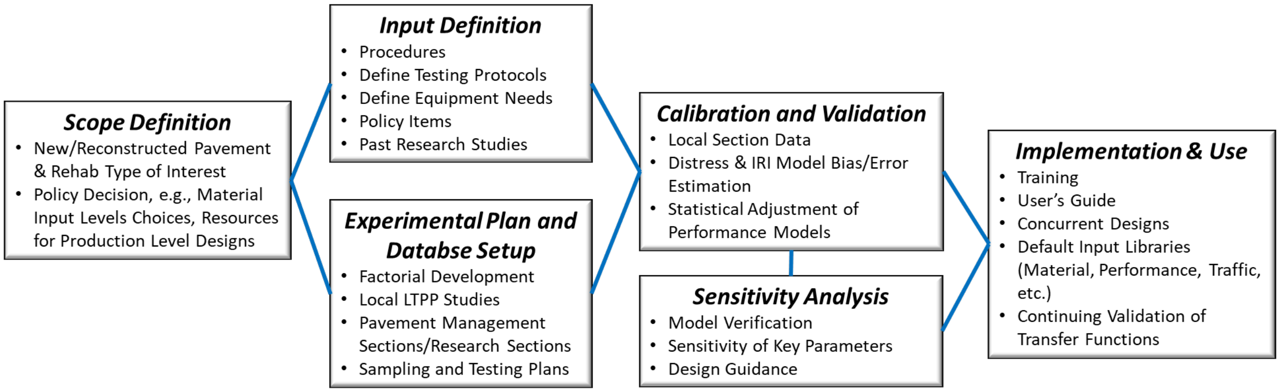

Figure 1.1 Workflow of activities for implementing the MEPDG (Mallela et al., 2014)

The purpose of this document is to update ITD's 2014 Road Map for the continued implementation of the MEPDG procedure. The completed and ongoing activities referred to in ITD's 2014 Road Map are included in Chapter 2 of this Implementation Plan for completeness. Two examples of ITD MEPDG implementation activities that have been completed are: (1) an analysis of Weigh in Motion (WIM) data, the initial development of a WIM and traffic data collection plan including short-, medium-, and long-term activities, and (2) materials testing for building the materials libraries for asphalt mixture dynamic modulus, aggregate base and soil resilient modulus, and concrete thermal expansion (CTE) values.

Objective of the Updated Implementation Plan/Road Map

The objective of the updated implementation plan remains the same as for the 2014 Road Map:

> *To facilitate use of the MEPDG procedure as outlined in AASHTO MEPDG Manual of Practice and the Pavement ME Design (PMED) software in Idaho.*

The PMED software allows the user to determine a design thickness for different layers using the optimization tool for project specific inputs. Equally important, however, is the verification and/or calibration of the transfer functions with local input data. Thus, the goals of the updated implementation plan remain the same, as in the 2014 Road Map:

1. Establish and expand input libraries to simplify the use of the PMED software.
2. Streamline a design process enabling Pavement Designers to use the PMED software to determine layer thicknesses with confidence for routine pavement design.
3. To continually update the activities needed to verify and/or calibrate the transfer functions to ITD's policies and materials.

Scope of PMED Software Implementation and Use

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.*

The design criteria and/or threshold values should be representative and come from ITD’s pavement operational policies for rehabilitation. The predicted distresses and smoothness values can also be used in pavement preservation and maintenance scheduling. This reason remains the key driving force for using the PMED software by ITD.

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 factors.

In terms of scope or use of the PMED software:

> *The PMED 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 through laboratory studies to measure the properties required by the MEPDG procedure for creating the material libraries.

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 2014 Road Map resulted in the following products in support of the MEPDG’s use in Idaho. The status of the end products stated in the 2014 Road Map along with some appropriate notes or comments are listed below in Table 1.1.

Table 1.1 Status of the End Products Stated in the 2014 Road Map

Product Identified in the 2014 Road Map Document	Status	Notes/Comments
1. A preliminary user's guide or design manual prepared at the beginning of the implementation effort. While recognizing that this preliminary user's guide 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 the MEPDG procedure and the accompanying software within the Department. The user's guide needs to include, in as much as available, Idaho-specific default values and data. Any gaps in Idaho-specific data should be filled with suitable regional or national defaults.	Completed	None.
2. Idaho-specific truck traffic, climate, pavement material, soils and other data that are representative of the conditions and site features in Idaho.	Completed	As new materials, different traffic features are exhibited along ITD's roadways, these should be included in ITD's input libraries.
3. Local calibration factors of the transfer functions for predicting pavement distress and performance in Idaho.	Completed	The calibration coefficients should be periodically checked or verified. The time interval being considered by the PMED task force is 5 years.
4. A final user's guide that essentially is an updated version of the preliminary user's guide with the data from products 2 and 3.	Completed	ITD integrated the 2014 User's Guide into their Materials Manual, Section 520 regarding pavement design.
5. A training program to ensure proper and consistent use of the AASHTO Pavement ME Design software.	Completed	The training program should be a continuous and on-going effort to train new staff and consultants.

The following lists the end products of the Implementation Plan or the continuation of the implementation process.

1. *Adoption and routine use of the PMED software for pavement design.*
2. *Update of ITD's Materials Manual Section 520 to be consistent with and provide inputs to the PMED software.*
3. *Expanded input libraries for traffic and materials commonly used in Idaho to reduce the level of effort required for routine or day-to-day pavement design.*

2. History, Overview, and Status of 2014 Road Map

The 2014 Road Map for ITD's implementation of the MEPDG was grouped into three stages defined as:

- Stage 1 included activities to develop a preliminary ITD User's Guide and assemble an initial set of inputs for immediate use of the PMED software. Stage 1 is primarily based on work completed by the University of Idaho in preparation of using the MEPDG procedure plus ARA experience in other States. Stage 1 was essentially completed in 2014 when the "final" user's guide was submitted and published.

- Stage 2 started at completion of Stage 1 beginning in 2014. The major work efforts were to fill in the input data gaps identified from stage 1, conduct the local calibration effort, and provide training. Many of the activities in stage 2 have been completed.

- Stage 3 consisted of continued long-term data collection and future updates of Idaho-specific MEPDG related inputs and calibration coefficients.

Table 2.1 lists the specific steps or activities within each stage, while Figures 2.1 through 2.3 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 the PMED software on a production basis or practical day-to-day use.

ITD initiated and completed many of the activities identified in the 2014 Road Map in preparing to use the MEPDG procedure and PMED software. These initial initiatives included 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 PMED software. The following paragraphs of Chapter 2 summarize the seven steps and whether the step has been completed. Chapter 3 suggests the steps and activities to be continued – the 2023 Implementation Plan.

Step 1: Familiarization and Data Availability

Review of Experience and Lessons Learned by Other Agencies – COMPLETED

ITD staff should continue to familiarize themselves with AASHTO's MEPDG Manual of Practice, the PMED 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, Missouri, Utah, Wisconsin, Wyoming, and others. Applied Research Associates Inc. (ARA) provided ITD staff with most of these reports to assist ITD in making decisions needed for continued implementation and absorb the lessons learned from other agencies.

Table 2.1 Steps within each Stage for Implementing the MEPDG and Using the PMED Software in Idaho

Steps	Stage 1 – Immediate	Stage 2 – Near or Short Term	Stage 3 – Future or Long Term
1. Familiarization of Software and Prepare Draft User's Guide	Complete within stage 1	NA*	NA
2. Complete Concurrent Project Designs (ME Design Vs current ITD designs, same project)	Initiate at end of stage 1.	Continue into stage 2 for use in training program.	NA
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, and materials.	Continued under step 7
3.1 Climate	Sufficient weather stations available.	None	Clean weather station data; add additional weather stations to library.
3.2 Traffic	Use defaults generated by Univ. of Idaho & develop data collection plan.	Data collection and evaluation of other road classes.	Continued in step 7.
3.3 Materials	Use defaults measured by Univ. of Idaho & develop data collection plan.	Measure properties for materials not included in current studies and add to materials library.	Continued in step 7.
3.4 Calibration Coefficients	Based on other agency calibration studies.	See step 4.	See step 7.
4. Calibration-Validation of Transfer Functions	NA	Complete within stage 2. This is the main focus of the ITD/UI research program that began in 2014.	NA
5. Prepare Final User's Guide or Design Manual	NA	Product from stage 2.	NA
6. Establish and Execute Training Program	NA	Preliminary training at beginning of stage 2 and final program at end of stage 2.	NA
7. Future/Periodic Update to Input Libraries & Local Calibration Coefficients	NA	NA	Continuation of data collection activities to fill gaps & update calibration coefficients.

*NA – Not applicable or nothing additional.

(NOTE: These steps were worked on as funding or resources became available. The goal was to get up and running as soon as possible and then fine tune.)

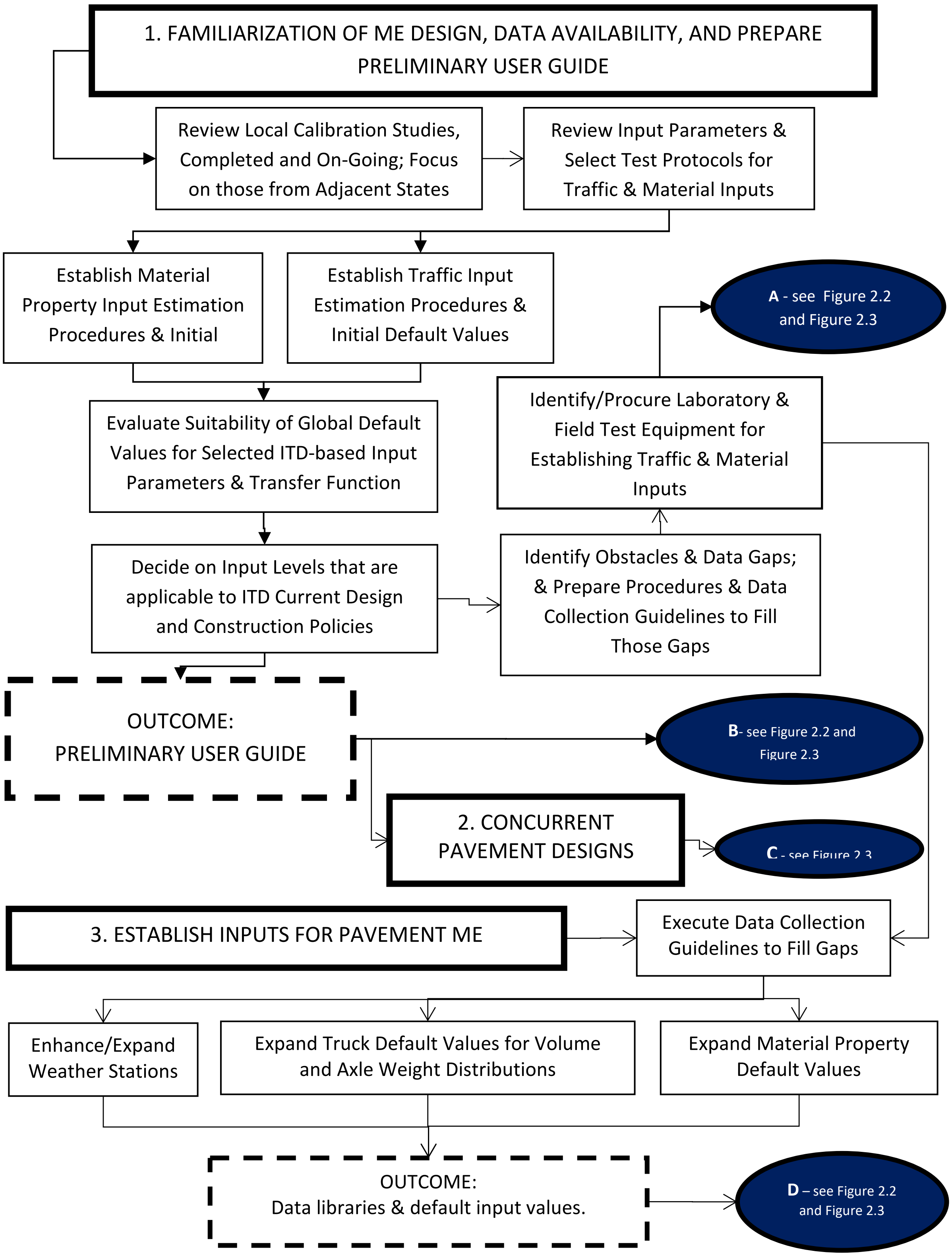

Figure 2.1 Flow chart displaying the initial familiarization and data collection activities to implement the MEPDG for ITD and to establish concurrent designs

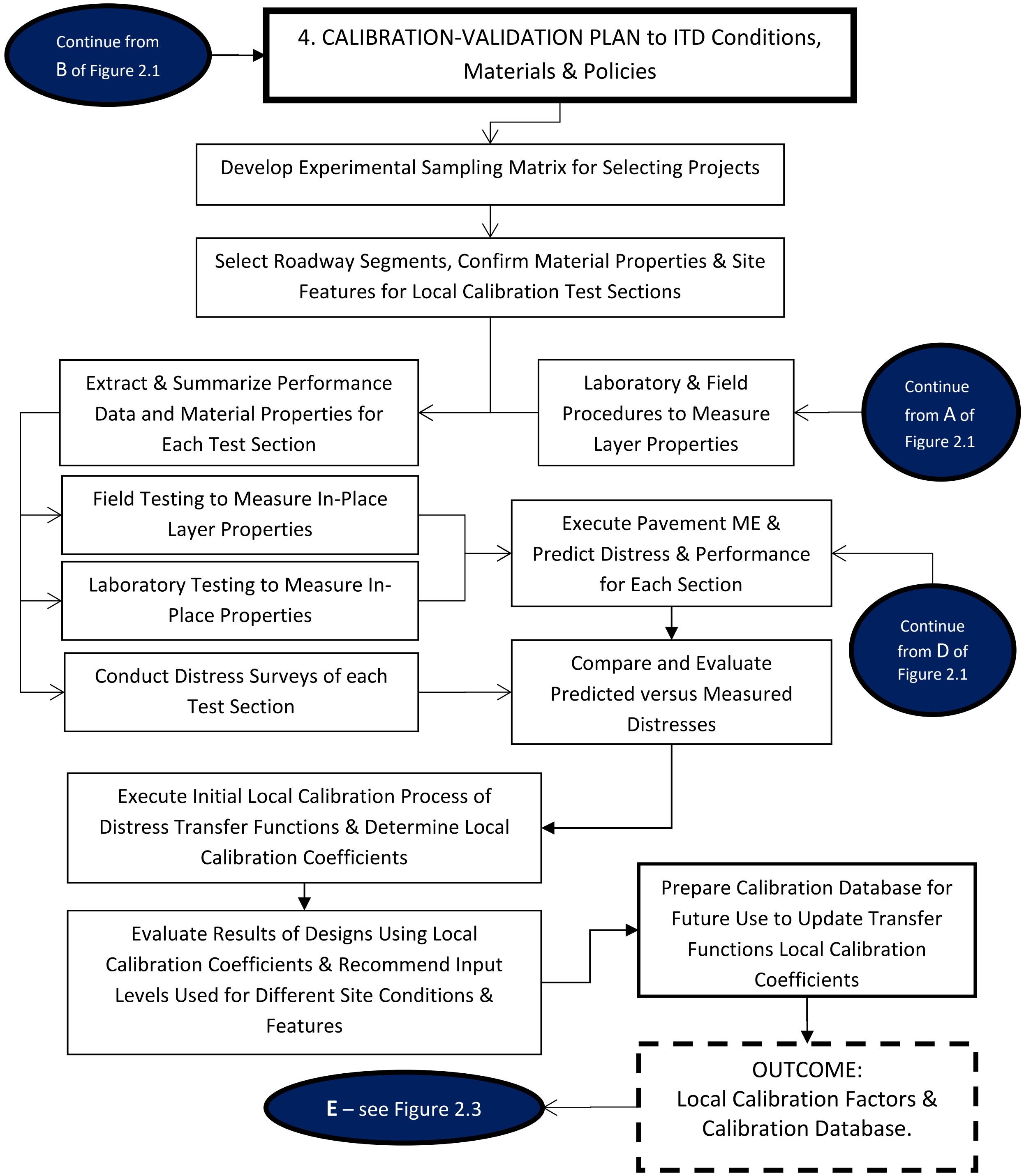

Figure 2.2 Flow chart displaying the calibration steps and activities suggested to implement the MEPDG and PMED Software for ITD.

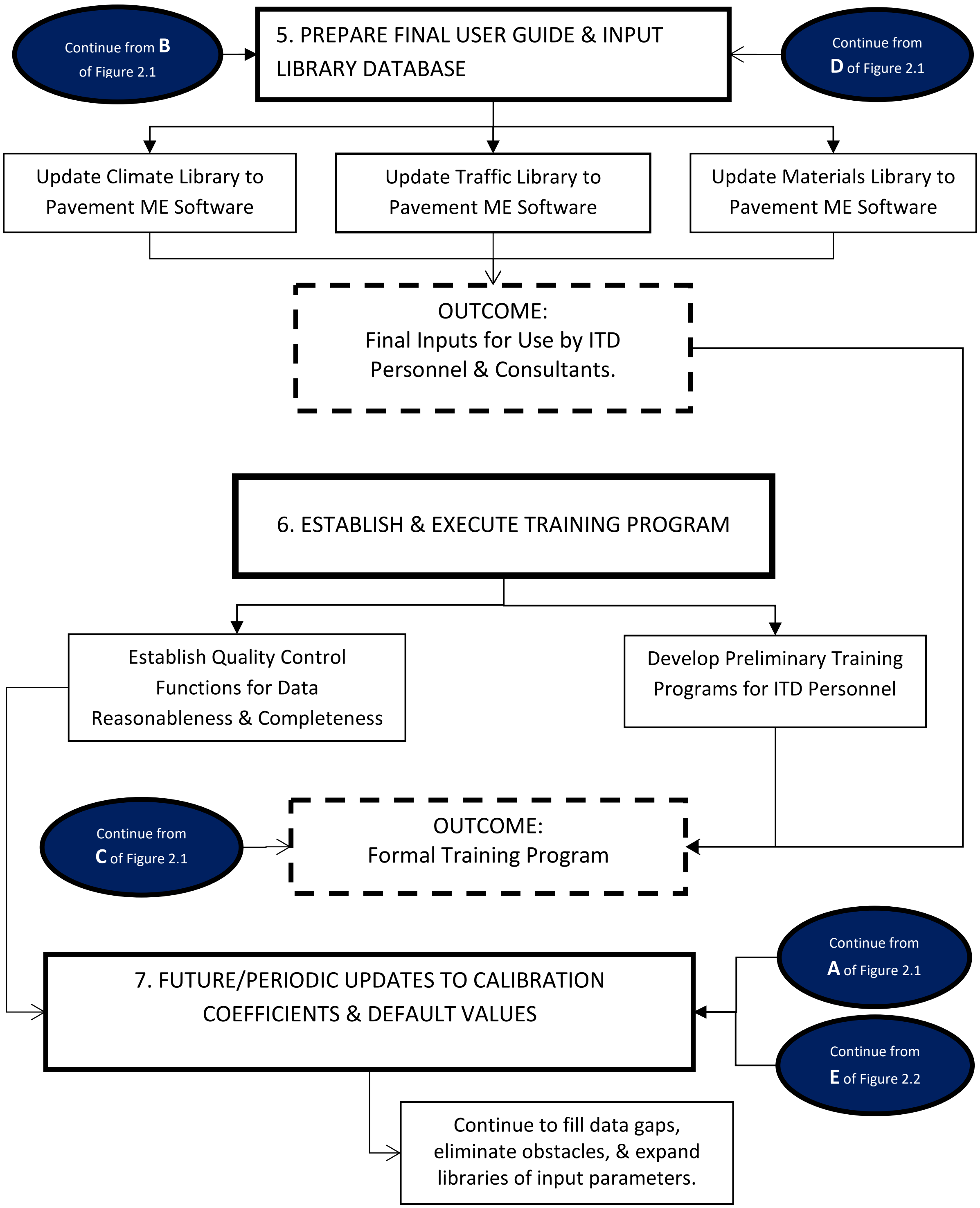

Figure 2.3 Flow chart displaying the training and future update steps and activities suggested to implement the MEPDG for ITD

Decisions of Relevance to ITD – COMPLETED

ITD should make decisions of relevance for collecting data needed for various activities. The decisions of relevance form the basis and determines the level of effort for full implementation of the PMED software. The items include the following, as a minimum, and the results were used in developing the experiment sampling matrix under step 4:

- 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, 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 the PMED software.

Another set of relevant decisions needs to focus on determining the PMED 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 policy driven based on preferences and resources available to ITD 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 and can be facility dependent.
- Pavement preservation and maintenance schedules, as they relate to the design criteria, if applicable.

The decisions of relevance were used in preparing ITD's 2014 PMED User's Guide and later incorporated into ITD's Materials Manual Section 520 (Layered Analysis Thickness Design Using AASHTOWare Pavement ME Version 2.5.5).

Identify Missing Data and Obstacles – COMPLETED

Following the decisions of relevance, an activity of the implementation process was to identify missing data, information gaps, and obstacles for using PMED software in accordance with the appropriate input levels to be used in design. Work was completed prior to and after 2014 to fill-in missing data gaps and information for the initial use of the PMED software. As examples:

- ITD completed laboratory testing through outsourced contracts (University of Idaho was the contractor) of selected asphalt and Portland cement concrete (PCC) mixtures, aggregate bases, and soils to establish initial default values.
- ITD evaluated their traffic data to ascertain statewide defaults for this input.

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

Prepare Preliminary Design Manual - COMPLETED

Using the decisions made and data reviewed in the earlier activities of this step, a preliminary user's guide or design manual was prepared based on existing ITD practices, policies, and construction data for new pavement and rehabilitation design projects. The preliminary user's guide helped the implementation process to stay focused on key issues and input variables different from those used in the global calibration effort.

Step 2: Complete Concurrent Pavement Designs – COMPLETED FOR INITIAL USE

After the preliminary user's guide was prepared, designs based on the previous ITD design procedure were compared to those generated using the PMED software for selected projects. Concurrent designs were completed using the "best available" input data in accordance with the user's guide to accomplish the following:

1. To help 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 ME Design software.
3. Identify issues for determining the inputs and prediction of distresses for some design strategies to help refine the stage 2 activities.
4. Provide a valuable source of examples for the training program suggested under step 6.

Arizona, Colorado, Indiana, Mississippi, and other agencies 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. Agencies found this process to be very beneficial in streamlining their documentation for use and implementation of the MEPDG.

Step 3: Establish Inputs

Step 1 identified specific challenges to obtain selected input parameters, while this step provided potential solutions to those challenges, as well as confirming the input level 3 default values. Specially, this step's focus was to establish default values to aid in the uniform application of PMED software within ITD. For example, materials libraries were created along with the recommended default values, traffic libraries 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 should maintain and update these input libraries over time, so it is a continuing activity but at a much-reduced level of effort. The 2014 PMED User's Guide included references to inputs that require improved estimates and/or measurement (ARA, 2014).

Enhance/Expand Weather Stations – NOT COMPLETED, BUT NOT NECESSARY USING V3.0 OF THE PMED SOFTWARE

A total of 11 weather stations in Idaho were included in the earlier versions of the PMED software. In addition, there were several stations in States that border Idaho which were utilized by ITD to define historical weather at a given design project location. 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 were considered sufficient for immediate use of PMED software under stage 1 (see Table 1). This step 3 activity was to enhance and expand the number of weather stations across Idaho and was a stage 3 activity.

A different climate dataset is used by version 3.0 of the PMED software which is referred to as the MERRA2 climate data. The MERRA2 dataset is applicable for use in design of flexible, semi-rigid, and rigid pavements. The MERRA2 dataset is available from the InfoPave website which is directly connected to the PMED software. Thus, no additional effort is necessary in using the PMED software on a day-to-day basis for routine pavement design.

Establish Ground Water Table Depths – COMPLETED

A data element required by the PMED software is the depth to the ground water table. The depth to water table was unavailable from existing files in Idaho. For stage 1, a default depth to water table needed to be established when unavailable from boring logs. The following sources of information for ground water table depths were utilized in Stage 3.

1. Detailed deep boring logs established by the geotechnical section along all highway alignments translated to a map format. Data were available from projects that have been constructed, which improved the accuracy of this input parameter.

2. Estimates obtained by interpolating ground water 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. There is an Idaho Department of Water Resources website inches data used for this activity. (https://www.idwr.idaho.gov)

The other PMED software tool that is available for use in referred to as MAP-ME. MAP-ME contains the different soil strata and water table depths on a state-wide level and can be assessed through the PMED website. MAP-ME contains the data included in the USGS water table depth information.

Establish Traffic Input Estimation Procedures and Default Values – PARTIALLY COMPLETED

Traffic information is a site factor for any pavement design procedure. Data from a total of 25 weigh-in-motion (WIM) sites were available in Idaho. 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. The 14 WIM sites, however, represents 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 University of Idaho study completed an initial evaluation of the WIM data and developed three NALS, along with other truck input parameters, for use in design which were used immediately under stage 1 (see Table 1.1). The other truck traffic inputs include monthly and hourly truck volume distributions, average axle spacing, average number of axles per truck class, and others.

The three NALS were reported by the University of Idaho to result in significantly higher amounts of cracking than the global default NALS. Most of these WIM sites, however, are located on two classes of roadways—interstates and primary arterials. Thus, additional WIM data needs to be collected under stages 2 and 3. The additional WIM data have yet to be evaluated to determine whether additional NALS are needed for use in design.

Establish Material Property Default Values – PARTIALLY COMPLETED

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

- Rock fills or embankments.
- Cold-in-place recycled asphalt base layers, with and without some additive, or chemically stabilized soils base layer defined as CRABS.

- 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 required a review of mixture design and construction records for a range of projects. The range of default material properties were tied back to the quality of construction and types of specification used to construct the projects. This activity was a two-part effort:

1. The first activity was to develop a materials characterization data collection plan which was to be completed at the end of stage 1. The plan was grouped by material type: asphalt mixtures/materials, (PCC) mixtures/materials, and unbound aggregate base and subgrade soils.
2. The second activity was to implement the materials characterization data collection plan for each material in stages 2 and 3 (see Table 1). The plan considered how the testing will be completed, what PMED 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 the data collection efforts for creating or enhancing the material libraries on a material type basis. The University of Idaho created a materials library or database of material properties to be used with the PMED software for design and initial calibration of the MEPDG transfer functions.

Asphalt Materials/Mixtures

The University of Idaho completed testing of selected asphalt materials and mixtures: dynamic shear rheometer tests for the binder and dynamic modulus testing, indirect tensile creep compliance and strength tests for the mixtures. Unfortunately, dynamic modulus and creep compliance tests were completed but not on the same asphalt mixtures. Separate mixtures were used to measure the dynamic modulus and creep compliance values.

The test results completed by the University of Idaho were used in stage 1. ITD should expand the mixture properties database under stage 2 using either internal resources, academia, or commercial testing labs.

Portland Cement Concrete Mixtures/Materials

ITD has the capability to measure the elastic modulus, compressive strength, and flexural strength of PCC materials. The test not conducted by ITD is the PCC linear coefficient of thermal expansion (CTE). It was recommended that ITD either perform the full suite of concrete testing (strength, modulus, and

CTE) using internal resources or make use of an external specialized contractor to measure the concrete properties for typical PCC mixtures under stage 2. The University of Idaho established a PCC library (Nassiri et al.,2017) to be used with the PMED software.

Unbound Aggregate Base Materials/Subgrade Soils

ITD has an established resilient modulus (M_r) and Idaho R-value correlation equation that was developed by the University of Idaho (Bayomy et al. 2012). Resilient modulus testing of different aggregate base materials and soils are available from that study. This correlation is different from the one in the PMED software and was used in the local calibration in Stage 2 for new designs. It was used in Stage 1 for subgrades and embankment soils.

ITD has included the R-Value to resilient modulus regression equation in its materials manual and all of ITD's pavement design personnel and consultants are familiar with it use (ITD Materials Manual, 2019). Thus, no resilient modulus testing was planned as part of stages 1, 2, or 3.

Determine/Establish Local Calibration Coefficients – COMPLETED

Another set of inputs are the calibration factors or coefficients and standard deviation of the residual errors for the transfer functions. The residual error is the difference between the predicted and measured or observed distress values.

An initial set of calibration coefficients and standard deviation of the residual errors were suggested in step 1 based on calibrations performed by the Wyoming DOT because ITD had yet to complete a local calibration study of its own. These were included in the final user's guide prepared and published in 2014.

The final set of calibration coefficients and standard deviation of residual errors were determined in step 4 by the University of Idaho using version 2.5.3 (Bayomy et al. 2018 and 2019) and Idaho-specific pavement sections and data. The Idaho local calibration coefficients are included in the ITD's Materials Manual Section 520.

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 Long-Term Pavement Performance (LTPP) test sections throughout North America. However, the global calibration-validation effort did have some gaps and limitations as 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, an activity during the implementation phase of any new design procedure was the verification and/or local calibration-validation of the distress and smoothness models used in design.

The purpose of the calibration-validation process was to determine whether the MEPDG computational methodology and global transfer functions as well as standard deviation of the residual errors 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 was completed in accordance with the MEPDG Local Calibration Guide that AASHTO published in 2010. The University of Idaho completed the first round of local calibration of the MEPDG transfer functions using PMED version 2.5.3 (Bayomy et al. 2018 and 2019). The Idaho local calibration coefficients for each transfer function are included in ITD's Materials Manual Section 520 (ITD Materials Manual Section 520, 2021).

Design an Experimental Sampling Matrix – COMPLETED

One of the first activities of this step was 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. The University of Idaho created the sampling matrix to be used in the local calibration process (Bayomy et al. 2018 and 2019).

Select Test Sections for Verifying ME Design Transfer Functions – COMPLETED

This activity included selecting roadway segments of the sampling matrix for both flexible and rigid pavements. The type of roadway segments included the Idaho LTPP test sections and non-LTPP sections. Using the Idaho LTPP sections and results from previous studies allowed ITD to reduce the number of test sections required to calibrate the distress transfer functions to its policies, materials, and climate.

It was recommended that fewer than half of the calibration sites come from LTPP, because of potential differences between the roadway segments within the LTPP program and ITD's operational policies. A minimum of 30 additional sites was suggested for verification, calibration, and validation for flexible and rigid pavements. The University of Idaho identified the roadway segments to be used in the local calibration process (Bayomy et al. 2018 and 2019).

Summarize Performance Data and Material Properties for Each Test Section – COMPLETED

After the test sections were selected, the historical information and performance data on these projects were assembled. This information included basic material properties and structural characteristics, previous deflection tests, ride quality, and condition surveys. This activity resulted in the creation of a database in which all information is stored for future analysis work. The University of Idaho created the database (Nassiri et al.,2017; Bayomy et al., 2018 and Mishra et al., 2019).

Laboratory and Field-Testing Programs in Support of PMED – COMPLETED FOR INITIAL USE

Laboratory and field-testing programs are used to determine pavement and foundation layer properties over a range of mixtures, materials, and site conditions. All testing on the Idaho test sections was performed as specified in the preliminary user's guide prepared under in step 1. The determination of layer properties was based on laboratory tests. A field-test program was not completed, other than the field test data available through the LTPP program.

Execute PMED – COMPLETED

The PMED version 2.5.3 was used to predict performance and distress. The predicted values were 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 were 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.

The University of Idaho completed the 2018 local calibration for flexible pavements and 2019 calibration for rigid pavements in Idaho (Bayomy et al. 2018 and 2019). The hypothesis was rejected for some of the transfer functions and the local calibration coefficients were derived by the University of Idaho for those transfer functions. The local calibration coefficients are included in ITD's Materials Manual, Section 520.

Step 5: Finalize ITD's PMED Users Guide – COMPLETED

The preliminary ITD PMED users guide was updated and revised using information from steps 1 through 4 in 2013. The ITD PMED Users Guide was published in 2014. The ITD Users Guide was the primary document used as part of the training program developed under step 6, until the ITD Materials Manual Section 520 was adopted and published in 2020. The 2014 PMED Users Guide included the Wyoming DOT's local calibration coefficients.

The University of Idaho completed ITD's local calibration study under step 4 which was based on ITD's operational policies and design criteria. The results from the local calibration were included in a modified version of the ITD Materials Manual Section 520 (October 2020).

Step 6: Establish a Formal Training/Technology Transfer Program – NOT COMPLETED, CONTINUING

Training of ITD personnel was an integral part of the overall implementation program. Training materials were structured to address needs at all levels, including high-level managers, engineers, and field/laboratory technical personnel. The main objective of the training program was to help ITD staff become comfortable and proficient with using the PMED software.

Training of ITD personnel began before and continued after stage 1 had been completed. ITD staff and consultants participated in multiple sessions on the initial use of the PMED software. The training program included presentations and workshops delivered throughout the period of implementation to accomplish this goal. In addition, various training courses and webinars were available nationally, but these are not agency specific. Topic areas of the training program included:

1. General background on the MEPDG methodology and software—coverage of fundamental concepts of mechanistic design and introduction to the mechanistic analysis tools included in PMED.
2. Overview of the assumptions, theory, and methods embedded in the 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 PMED software—a hands-on workshop on how to use the software to accomplish pavement designs.

Training should not be thought of as a one-time activity but should be virtually continuous throughout the period of implementation and beyond, as new personnel join ITD.

Step 7: Future Updates and Enhancements to PMED – ONGOING

The 2014 Road Map suggested ITD 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.

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.

3. Moving Forward – The 2023 Implementation Plan

ITD has been preparing for the implementation of the MEPDG for several years through its sponsorship of MEPDG-related implementation activities. The PMED software was calibrated by the University of Idaho using version 2.5.3 in 2019. Many improvements of enhancements have been made to the software since version 2.5.3 was released in 2019. The following tabulates and summarizes the enhancements and/or changes made to the PMED software since version 2.5.3 was released.

Table 3.1 Enhancements and Updates done on Different Versions of PMED

PMED Version	Date of Release	Updates/Enhancements/Changes
2.6.0	July 2020	1. The manual of practice or MOP was integrated with the PMED software. 2. General Updates: • Enhanced Integrated Climatic Model (EICM) performance enhancements • Asphalt Pavement Analysis and Design System (APADS) performance enhancements o No changes were made to the bottom-up fatigue cracking and permanent deformation models. o APADS includes the following models: ▪ JULEA layered elastic analysis procedure. ▪ Bottom-up fatigue damage and cracking models ▪ Cement treated base (CTB) fatigue damage and cracking models for semi-rigid pavements. ▪ Permanent deformation models for asphalt and unbound materials • Top Down Cracking Integration (Top-Down Cracking Enhancement (me-design.com)) • Climate map is updated for educational users to show all the climate station by default
2.6.1	July 2021	1. The fracture mechanics-based top-down fatigue cracking for asphalt pavements was updated and correcting some errors in the initial integration. 2. General Updates: • The absolute minimum or maximum input value limits were adjusted for the selected inputs: dual tire spacing and saturated hydraulic conductivity. • Fixed or limited the predicted amount of PCC cracking to 100 percent for the design reliability.
3.0	July 2022	1. The web-based application was released for all design strategies. 2. Integrate the National Cooperative Highway Research Program (NCHRP) 1-51 product on PCC slab – aggregate base friction degradation for rigid pavements. 3. Application and use of the MERRA2 climate dataset for designing rigid pavements. All pavement design strategies now use the MERRA2 climate dataset.

Three major enhancements were made to the PMED software since version 2.5.3 was released in 2019 that impact the calibration coefficients of selected distresses: (1) the top-down cracking model for asphalt pavement, (2) the integration of the new aggregate base friction degradation for rigid pavements, and (3) use of the MERRA2 climate dataset for rigid pavement design.

This chapter includes the activities for moving forward with implementation and day-to-day use of the PMED software in accordance with Table 2.1 and Figures 2.1 through 2.3. The steps identified in Chapter 2 but not discussed in Chapter 3 are considered fully complete.

The focus of the 2023 Implementation Plan is for ITD to start using version 3.0 or the web-based application of the PMED software. The following sections list the suggested activities for accomplishing the goals of the 2023 Implementation Plan.

Step 1: Establish/Update Organizational Structure

ITD includes a technical advisory committee (TAC) for each of the major outsourced projects for implementing the MEPDG. The use of the TACs should be continued. Chapter 5, Organizational Structure for PMED Implementation and Use, provides additional discussion to formalize the implementation process.

Step 2: Verify/Update ITD Calibration Coefficients for PMED Version 3

During the previous training session hosted by ITD, an issue with the asphalt fatigue cracking calibration coefficients was identified. There is a concern that the 2020 ITD calibration coefficients using version 2.5.3 are not representing asphalt pavement performance in Idaho. The cause of the concern was not identified, but comparison of the predicted and measured amounts of cracking are of a concern. Thus, one of the first activities of the 2023 Implementation Plan is to resolve and recalibrate the asphalt transfer functions.

Since version 3.0 includes improvements to the software use, which was recently released, it is suggested that all pavement design strategies (flexible and rigid) be recalibrated using version 3.0.

1. Use the test sections established by the University of Idaho to verify and/or recalibrate the coefficients of the transfer functions for rigid and flexible pavements. Table 3.2 and Table 3.3 represent the preliminary experimental sampling matrix for asphalt and rigid pavements, respectively, and include the Idaho LTPP test sections. The non-LTPP sites are not included in the sampling matrices because details for the site features and materials were unavailable. A total of 32 flexible pavement sections were used to calibration the flexible pavement transfer functions, and a total of 40 sections were used for the calibration of the rigid pavement transfer functions.

a. Many of the non-LTPP PMED calibration files/runs, however, were unavailable for review in preparing the 2023 Implementation Plan. Designating the PMED calibration files/runs should be a priority. So, first collect, review, and store the PMED calibration files/runs used with version 2.5.3. The calibration files will then need to be converted to version 3.0. The calibration sites (LTPP and non-LTPP sites) should be included in the sampling matrices (see Table 3.2 and Table 3.3, which include the designated Idaho LTPP test sections).

Table 3.2 Experimental sampling matrix for asphalt or flexible pavements.

Mix Type	Truck Volume	Soil Type	New Design, Aggregate Base	Asphalt Overlay of Flexible Pavement	Asphalt Overlay of JPCP	Asphalt Overlay of CRCP	Asphalt Overlay of CRABS
Neat Mix	Low	Coarse-Grained	1001; 105; 1007; 1010; 1021; 6027; 9034; B320; B330; B350; C320; C330; C350	1001; 1007; A310; B310; C310		5025	
Neat Mix	Low	Low Plasticity	1020; 9032; A320; A330; A350	1020			
Neat Mix	Low	High Plasticity					
Neat Mix	High	Coarse-Grained					
Neat Mix	High	Low Plasticity	1009	1009			
Neat Mix	High	High Plasticity					
PMA*	High	Coarse-Grained					
PMA	High	Low Plasticity					
PMA	High	High Plasticity					

*-Polymer modified asphalt.

Table 3.3 Experimental sampling matrix for rigid pavements.

Joints	Truck Volume	Soil Type	JPCP* with Aggregate Base	JPCP with Asphalt Base	CRCP** with CTB	PCC Overlay of JPCP	CPR***
With Dowels	Low	Coarse-Grained					
With Dowels	Low	Low Plasticity					
With Dowels	Low	High Plasticity					
With Dowels	High	Coarse-Grained	3023				3023
With Dowels	High	Low Plasticity		3017			
With Dowels	High	High Plasticity					
No Dowels	Low	Coarse-Grained			5025		
No Dowels	Low	Low Plasticity					
No Dowels	Low	High Plasticity					

*-Jointed plain concrete pavement
**- Continuously reinforced concrete pavement
***-Concrete pavement restoration

b. Prior to the recalibration or verification of the calibration coefficients, the non-LTPP sites selected and used by the University of Idaho should be reviewed and the distress/performance data evaluated to determine if anomalies and/or errors are present in the dataset.

c. The LTPP and non-LTPP test sections or roadway segments can be used to verify the accuracy of the ITD local calibration coefficients.

d. Additional performance observations (distress data) for the LTPP and non-LTPP test sections should be included in the database.

e. Use of the original test sections will only require the determination of two additional inputs for the flexible and rigid pavement sections. The two inputs are the total asphalt content by weight for the wearing surface mixtures and the PCC slab-subbase interface degradation coefficient for jointed plain concrete pavements (JPCP).

2. The recalibration effort should be minimal because:

   a. The MERRA2 climate dataset and the new PCC slab-base interface degradation function were found to have minimal impacts on the predicted cracking and faulting.

   b. The top-down cracking model and transfer function requires the total asphalt content by weight as a new input. This variable, however, should be readily available for all non-LTPP sections from construction records.

   c. If some of the original calibration files are unavailable and must be recreated, the level of effort for recalibration will be higher.

3. The results from the verification study will determine if any of the transfer functions need to be recalibrated using version 3.0. ITD should plan on having to recalibrate the asphalt fatigue cracking transfer functions (top-down and bottom-up cracking), and the faulting and mid-slab cracking for rigid pavements – JPCP.

4. Results from the recalibration process should be included in ITD's Materials Manual Section 520.

Step 3: Expand Catalog of Designs

ITD should continue to maintain and expand a catalog or library of runs. The purpose of the catalog of designs is for use in training purposes and for checking any changes or enhancements made to the PMED software over time to determine the impact of an enhancement using Idaho materials, site conditions, and design criteria.

The catalog should use a formalized naming convention so that information from historical projects can be recorded over time. These runs can be uploaded and saved in the PMED database for future reference or stored separately in a different venue. The use of a consistent naming convention is important for these files be used so that they can be retrieved in the future.

The catalog of designs should be prepared by ITD design staff under the guidance of the ITD steering committee or Technical Advisory Committee (TAC) (see Chapter 5, Organization Structure for MEPDG Implementation and Use). The catalog of designs should be completed for typical new pavement design and rehabilitation strategies (refer to Table 2.1 and Figure 2.1) and include the following:

1. The concurrent designs completed in the early stages of implementation (see Figure 2.1) should be included in the catalog. The concurrent designs and the previous library of runs, however, should be updated or converted to version 3.0.

2. The catalog of designs and design features should be expanded to include more complex design strategies, as defined by the steering committee or TAC.

Step 4: Expand Default XML Input Libraries

A set of initial input libraries were established and used for the ITD local calibration. The input libraries provide a readily available set of input information to the designers, materials engineers, and others involved in pavements. The default input libraries should be available to all ITD designers and to pavement design consultants using the software to ensure consistency in the inputs.

The input libraries should be expanded over time. The appropriate committees (traffic and materials) should provide the oversight for expanding the truck traffic and materials input libraries.

Climate and Weather Data

As noted under Chapter 2, a different climate dataset is used by version 3.0 of the PMED software which is referred to as the MERRA2 climate data. The MERRA2 dataset is applicable for use in design of flexible, semi-rigid, and rigid pavements. A different climate dataset is not needed for the different pavement design strategies. Importing climate data for all pavement design strategies is simple and does not require any additional steps or creation of climate files for a specific location.

The MERRA2 dataset is available from the LTPP InfoPave website which is directly connected to the PMED software. Thus, no additional effort is necessary in using the PMED software version 3.0 on a day-to-day basis for routine pavement design.

Truck Traffic Input Libraries

ITD sponsored a WIM study with the goal of creating XML files in support of the PMED software (Bayomy and El-Badawy, 2011). The WIM study and the results from the local calibration study provided necessary truck traffic data. Three default NALS and three normalized truck volume distributions were created and are being used.

A study should be sponsored to analyze WIM and volume data to decide whether the default input values (especially the normalized axle load spectra or distribution) need to be revised or additional default values be added to the truck traffic library (refer to figure 2.1). ITD should plan on outsourcing the analysis of the WIM data, as the analysis can be time consuming and requires extensive data manipulation to determine the quality of the data. As such, this activity is a two-part effort:

1. The first activity is to develop a truck traffic data collection plan. This plan should include short-term, mid-term, and long-term goals for truck traffic data collection. The traffic data collection plan should be prepared based on the experience and knowledge from the traffic subject matter experts. As an example, the Georgia DOT created a short and long-term traffic data collection plan. The document describing their data collection plan was previously provided to ITD (Traffic Load Spectra for Implementing and Using the Mechanistic-Empirical Pavement Design Guide in Georgia, Contract Number GDOT RP10-09, February 2014).

2. The second activity is to implement the truck traffic data collection plan: short, mid, and long-term goals (see Table 2.1).

a. The short-term goal is to collect data using portable WIM and automated vehicle classification devices at sites for roadway classes not currently represented by the existing 14 WIM sites with sufficient or adequate data. These additional data should be collected over different seasons for evaluating the NALS and seasonal volume distributions for lower volume roadway classes. The seasonal volume distributions are to verify the default monthly adjustment factors. Overloaded trucks, although infrequent, should be captured because they exhibit a disproportionate effect on pavement performance, so an accurate count of overloaded trucks from WIM stations is important. These additional data are evaluated to develop additional NALS and other truck traffic default values, if needed.

b. The mid-term goal is to continue to collect data at the existing WIM sites 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.

c. The long-term goal is to install additional permanent WIM sites at strategic locations for developing additional NALS or confirming the three NALS and other truck traffic default values that were determined from the initial University of Idaho study. The sites for installing the additional permanent WIM equipment are selected based on an evaluation of the existing WIM data to fill in data gaps. For planning purposes, six to ten additional WIM sites should be sufficient.

The analysis of the added WIM and volume data should be used to determine if the existing traffic inputs need to be revised and/or expanded to cover the range of ITD roadway classifications. It is expected that the truck traffic default inputs will be used for at least two years. The additional WIM data should be used to confirm the default values.

Material/Layer Input Libraries

Expansion of the materials library should be planned over 2 years and outsourced. Information for the individual materials is discussed below.

General Mixture Properties: Asphalt and PCC

The appropriate subject matter experts on the technical committee should recommend if any changes should be made to the default input values that are measured on a day-to-day basis on construction projects. The default volumetric input values should be revised and updated to determine if any changes need to be made at the end of each construction season. The construction default values include the initial IRI measured after construction.
The average volumetric and strength data are tabulated for different mixtures. These values need to be reviewed to determine if the default values need to be revised. In accordance with the recalibration schedule, review construction data to determine if any revisions need to be made to the default values.

Any recommended changes will need to be reflected in ITD's Materials Manual Section 520 and in the training documents as well as in any design/policy documents.

Asphalt Materials/Mixtures

ITD has sponsored projects (Bayomy et al. 2012) for testing dynamic modulus and creep compliance of multiple asphalt mixtures. These results have been incorporated into the ITD asphalt materials library.

The dynamic modulus (AASHTO T 342 or 378) and creep compliance (AASHTO T 322) of the mixture and dynamic shear modulus (AASHTO 315) of the binder input files should be expanded to include a wider range of binders and mixtures commonly specified and used by ITD. Unfortunately, the dynamic modulus and creep compliance were not measured on the same mixture. It is suggested that dynamic modulus and creep compliance be measured on the same asphalt mixture for the wearing surface mixtures.

The mixtures and binders to be included in the materials library should be defined by the Asphalt subject matter experts on the Technical Committee. The number of mixtures included in the asphalt library should be expanded to include common mixtures and binders used for the base layer, intermediate layers and the wearing course for the properties not routinely measured by ITD. ITD is starting to use other mixtures like warm mix asphalt (WMA) that can exhibit significantly different mixture properties. These mixtures should be added to the asphalt materials library in the long term.

At present, the transfer function coefficients for rutting and fatigue cracking represent general conditions that are not mixture specific. The asphalt subject matter experts on the technical committee should consider the benefits and difficulties in measuring these properties for specific mixtures. Materials testing projects should be outsourced to measure the following mixture parameters for ITD's commonly used or specified mixtures.

- Laboratory derived plastic deformation coefficients from repeated load plastic deformation tests. Repeated load plastic deformation tests should be run in accordance with the procedure in NCHRP Report 719. The laboratory derived plastic deformation coefficients are used to determine the field derived, mixture specific plastic deformation coefficients that are entered into the Pavement ME Design software. A draft standard method of test was prepared for AASHTO but has yet to be balloted at the time of the 2023 Implementation Plan. This standard method of test is similar to AASHTO T 378. In addition, a Standard Practice was prepared for AASHTO to derive the plastic strain or asphalt layer rutting coefficients from the repeated load plastic strain test.

- Laboratory derived fatigue cracking coefficients from flexural bending beam fatigue tests or the indirect tensile strength test. The flexural bending beam fatigue test should be performed in accordance with AASHTO T 321, and the indirect tensile test in accordance with ASTM D6931. The laboratory derived fatigue cracking coefficients are used to determine the field-derived, mixture specific fracture coefficients that are entered into the PMED software. A standard practice for deriving the fatigue strength coefficients from the flexural beam fatigue test

(AASHTO T 321) or the indirect tensile strain at failure test (ASTM D6931) and dynamic modulus test (AASHTO T 378) was prepared for AASHTO.

The number of mixtures included in the testing plan 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 to ensure the XML files are directly in line with ITD's MEPDG implementation efforts. Table 3.4 provides a preliminary testing plan for asphalt mixtures, which should include SMA (Stone Matrix Asphalt) and polymer modified asphalt mixtures.

Table 3.4 Suggested Asphalt Mixture Testing Plan

Measured Property	Dense-Graded Asphalt Wearing Surfaces	Dense-Graded Intermediate Layer Mixes	Dense-Graded Lower Asphalt or Base Layer
Estimated Number of Mixtures	10	5	8
Dynamic Modulus, AASHTO T 378	✓	✓	✓
Indirect Tensile Creep Compliance and Strength, AASHTO T 322	✓	NA	NA
Repeated Load Plastic Strain, Rut Depth Coefficients	✓	✓	✓
Fatigue Strength Coefficients	NA*	NA	✓

*NA – Not applicable.

A clustered analysis should be completed to determine whether some of the individual mixtures can be combined into a specific mixture category to reduce the number of asphalt material input libraries.

Portland Cement Concrete Mixtures/Materials

PCC compressive strength and elastic modulus were measured on PCC mixtures by the University of Idaho (Nassiri et al.,2017). Coefficient of thermal expansion (CTE) values were provided for common aggregate types in Idaho (AASHTO T 336). These CTE and strength tests were included in the ITD local calibration study. The PCC materials subject matter experts on the technical committee or TAC should review this information and default input values and recommend if any updates need to be made for the PCC mixtures commonly used and specified by ITD. It is suggested that 8 PCC mixtures be included in the PCC test plan.

A clustered analysis should be completed to determine whether some of the individual PCC mixtures can be combined into a specific mixture category to reduce the number of PCC material input libraries. The strength-elastic modulus relationship of ITD's PCC mixtures should be compared to the regression equation between strength and elastic modulus in the PMED software. The clustered analysis should include a statistical comparison of the relationships between the flexural or compressive strength and elastic modulus of the PCC mixtures.

Unbound Aggregate Base Materials

The testing of aggregate base materials should include a full set of inputs for different aggregate sources approved in Idaho: Atterberg limits (AASHTO T 89 and T 90), maximum dry unit weight and optimum water content (AASHTO T 180 or T 99), gradation (AASHTO T 88), and design resilient modulus (AASHTO T 307). The physical property tests typically measured on construction projects can be completed by ITD, but the resilient modulus tests in accordance with AASHTO T 307 should be outsourced. The materials included in the test program should be defined by the subject matter experts on the technical committee. A standard practice to determine the design resilient modulus for any unbound aggregate and soil layer was prepared for AASHTO.

It is estimated that six aggregate base sources be included in the test program for determining the ITD default volumetric properties and design resilient modulus for different pavement design strategies.

Other Pavement Materials

XML files should be prepared for other types of materials being used for rehabilitation and reconstruction and included in ITD's specifications. These other materials include cold in place recycled material, full-depth reclamation, soil cement, and chemically stabilized soil base material (termed CRABS). The default layer properties should be determined from a combination of laboratory and field tests. One concern of ITD is how to model CRABS (unbound aggregate or chemically stabilized layer). It is recommended that deflection data should be collected from this pavement surfaces and modulus should be backcalculated from the deflection data.

Step 5: Update Idaho's Materials Manual Section 520

A comprehensive PMED Users Guide are essential for designers, materials engineers, and others involved using the MEPDG. As noted above, ITD Users Guide was published in 2014, and incorporated into the ITD Materials Manual Section 520 in 2020. Section 520 is being updated in 2023 but should be periodically updated as new versions of the PMED software are released and ITD's input libraries are expanded.

It is expected that a 5-year update cycle should be sufficient unless major changes of the software require more frequent updates. Attendance at the AASHTO sponsored webinars after each annual release will provide ITD staff with information about whether the changes to the software are technical or cosmetic.

Step 6: Periodically Update Calibration Coefficients of the Distress Transfer Functions

Calibration is required in a ME based design procedure to establish relationships between computed structural responses, accumulated damage, and observed pavement distress. Global calibration of the transfer functions was completed under NCHRP Projects 1-37A and 1-40, primarily using data extracted from the LTPP database over a wide range of pavement sections from across the United States, including some in Canada. The global calibration was updated by AASHTO in 2018, because of the enhancements made to the software after the NCHRP project.

Limitations in the LTPP database and no forensic investigations were allowed as part of the MEPDG model development, State DOTs should validate the global coefficients of the transfer functions to agency specific materials, climate, specifications, and operational policies to ensure their accuracy and unbiasedness. The success of the implementation process has been based or gauged on biases of the predicted values and the standard error of the estimate.

As noted above, the MEPDG transfer functions were verified and calibrated using performance data from ITD LTPP and non-LTPP roadway segments with current design and materials and construction standards, as part of the early MEPDG implementation process in Idaho. The PMED version 2.5.3 was used for the local calibration. This verification-calibration effort, however, is not a one-time activity. Verifying the accuracy and unbiased transfer function should be periodically evaluated as ITD considers the use of new materials, techniques, and design strategies. Thus, ITD should continue to monitor the non-LTPP and LTPP test sections for future verification and local validation of the MEPDG transfer functions.

The update and continued monitoring should be completed in accordance and under the guidance of the Verification, Calibration, and Validation subject matter experts as part of the educational committee. Updating the local calibration coefficients of the transfer function should be consistent with updating ITD’s Materials Manual Section 520. Results from calibration should be stored in ITD’s MEPDG database that was established by the University of Idaho for future use.

The PMED software is released by AASHTO at the end of June on an annual basis. Version 3.15.0.0 was released in July 2023. ITD should attend the webinars scheduled near the end of July after the release to determine if any change to the software will have an impact on the design strategies being used. If the change influences the local calibration coefficient, ITD should verify their calibration coefficients. The verification and re-calibration, if required, should be outsourced.

The LTPP and special ITD sections used in the local validation and calibration process should be used in the future to provide an ongoing validation of the transfer functions used to predict performance. More importantly, sections with newer mixtures, design strategies, and materials should be established and monitored to provide long term performance data to ensure the transfer functions are producing reliable results.

To expand the data set used to verify the ITD local calibration coefficients, the existing roadway segments (LTPP and non-LTPP sections) as well as for additional test sections should be continually monitored. The sampling matrices (see Table 3.2 and Table 3.3) should be periodically updated and add more calibration sections over time, as sections are taken out of service and/or reconstructed to ensure the calibration is representative of ITD's design practices. Many of the roadway segments for new construction should also be monitored when they are rehabilitated because the added monitoring cost for these sections would be minimal in relation to the added performance data to be used for future verification-validation efforts.

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. An analysis of variance (ANOVA) should be performed to identify and determine what input variables have a significant impact on the residual error between the measured and predicted distresses. The calibration coefficients can be determined using the Calibration Assistance Tool (CAT) that was developed by AASHTO in 2021 to assist State DOTs and local agencies in calibrating the transfer functions.

Step 7: Attend Annual MEPDG Meetings

It is suggested ITD staff attend the annual PMED User Group meeting and webinars sponsored by AASHTOWare. The enhancement and changes made to the PMED software are presented and discussed at the annual User Group Meeting and webinars after a new version of the software is released. ITD staff can then provide a summary of the enhancements and changes and what impact they have on the final results or predicted distresses at their annual asphalt and concrete pavement associations meetings.

Step 8: Periodic Training

As noted under Chapter 2 and Step 6, training should not be thought of as a one-time activity but should be continuous over time as new ITD staff are hired. This step is an important step so Chapter 4 focuses on the training and technology transfer activities.

Schedule of ITD'S MEPDG 2023 Implementation Plan

This section of the Implementation Plan provides a schedule of completion and timing of the implementation activities. Figure 3.1 shows the schedule of activities for the next five years.

In terms of executing the plan, it is assumed that ITD will conduct the administrative type activities of the plan, while the technical activities will be conducted by outside agencies either through AASHTO or ITD's standard consultant services contracts.

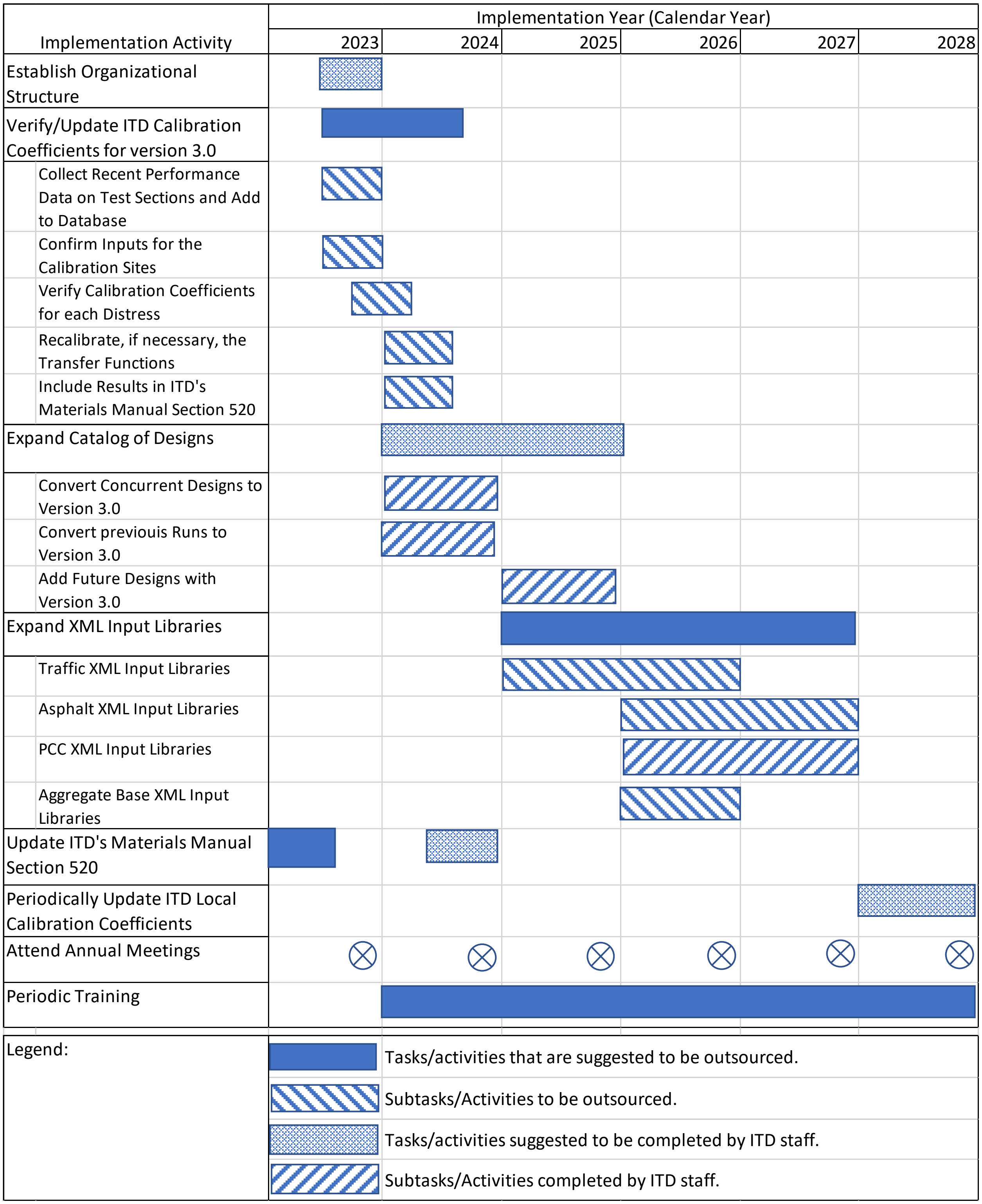

Figure 3.1 Schedule of the 2023 Implementation Plan Steps and Activities

4. Training/Technology Transfer and Certification of Designers

The main objective of the training program is to help ITD staff and its consultants understand the inputs and their importance, as well as how to determine the inputs, in using the MEPDG. The training includes presentations, workshops, and short courses to accomplish this goal that should be held throughout the period of implementation and beyond.

As listed above, some of this information has already been prepared and used in the preliminary training program for ITD staff. These preliminary training products are listed below and have been used in preparation of multiple workshops.

- PowerPoint presentations as an introduction to the MEPDG methodology and principles.
- Webinars delivered by FHWA that can serve as basic information on using the MEPDG software.
- Workshop problems: some of the examples are included in a separate volume to the 2014 Users Guide.

Training should not be thought of as a one-time activity but should be virtually continuous throughout the period of implementation and beyond. The training programs should focus on two items: training in terms of using the PMED software and certification of users. The training plan includes presentations, workshops, and short courses to cover various topics, including the following:

1. General background on mechanistic design—coverage of fundamental concepts of mechanistic design and introduction to mechanistic analysis tools; this course was developed through FHWA and NHI and is already available for agencies to use.
2. Overview of MEPDG design methodology—coverage of the assumptions, theory, and methods behind the MEPDG. Another course developed by AASHTO in 2015 is available. AASHTO updated the course on the introduction and fundamentals of the MEPDG in 2023. The materials for this course are available to ITD.
3. Design using MEPDG software—a hands-on workshop on how to use the PMED software to accomplish pavement designs. Two preliminary training courses that are ITD specific have been developed. One is for the general ITD staff and consultants, while the other workshop is a train-the-trainer tool for ITD staff that is leading the MEPDG implementation effort in Idaho.

During the initial implementation of the MEPDG, it was recommended that an annual meeting (one-day in length should be sufficient) be planned and hosted by ITD with its staff and industry, as a minimum (refer to Figure 2.3). The purpose of the annual MEPDG meetings is to communicate information on changes to the software and inputs specific to Idaho. Currently, the annual PMED User Group meeting hosted by AASHTO and the webinars delivered by AASHTO after each software release summarize the enhancements and changes made to the software, as listed below.

1. **MEPDG Webinars**: AASHTO delivers webinars to communicate changes after each annual release of the software, near the end of July. ITD should attend these webinars to understand any change to the software and what impact the change has on flexible and rigid pavement design. The webinars are advertised by AASHTO.

2. **MEPDG User Group Meetings**: The user group meetings have been sponsored by FHWA for the past 10+ years but are now being sponsored by AASHTO. The user group meetings will continue to support agencies in all stages of the implementation process. ITD should plan to actively participate in the user group meetings. The annual meeting addresses concerns with the PMED software and procedures, as well as communicate any enhancements that are planned by AASHTO.

As noted above, some initial training and workshops have been completed. Training, however, should be on an annual basis in terms of refresher courses and certification of new staff and consultants. It is suggested that the ITD staff and consultants go through an internal certification process like the materials testing certification process. This certification process, however, has yet to be established. ITD should consider the establishment of a certification program prior to ITD accepting consultant designs using the AASHTO PMED software.

Two training topics are included or addressed in the implementation plan – one is for the general training on the use of the MEPDG and the PMED software and a future one is for the certification of users of the MEPDG in Idaho.

1. General training workshops – one workshop per year should be planned, as a minimum. Each workshop should be about 2.5 days in length and follow the format used for the “train-the-trainer” workshop given as part of the initial implementation process.

2. Certification of training for consultants and ITD personnel. Certification is the more important and a critical element because the procedure represents a significant divergence in the pavement design concepts. The certification program can be established and administered through the University of Idaho and ITD. A technical committee should be established that focuses specifically on the certification process in setting it up and tracking its users that have been certified. The certification process should ensure that the designers understand the MEPDG concepts, and the inputs needed to use the procedure. The certification process should be focused on consultant designs. The following provides recommendations for each type of training session.

    a. Establish certification program. This should be established like any testing certification program. It is suggested that the pavement designers be certified or confirmed on a 10-year cycle. Indiana is the only known agency at present that requires the pavement designer to attend a workshop hosted by the Indiana DOT. However, other agencies are considering certification because of the complexities in determining the inputs to the PMED software.

b. AASHTO developed a course on the Principles of ME Design, which was available in July 2023. This course should be the prerequisite to the local training and certification. It is suggested that ITD still require their designers to pass their own course to ensue successful use of the program in Idaho. It is also suggested that ITD consider setting up a regional certification process with the other surrounding states in the Rocky Mountain region.

c. During the next five years, it is suggested that ITD plan on hosting an annual workshop on using the MEPDG software for all pavement designers in Idaho. These annual workshops should be planned with the annual MEPDG user group meetings to reduce the redundancy between the different activities.

5. Organizational Structure for PMED Implementation and Use

Meeting the implementation plan objective on training discussed in Chapter 4 is challenging and requires diverse talents and cooperation among several groups and individuals within ITD. This is in addition to the support of upper management in ITD. A simple organizational structure to oversee the implementation process and use of the PMED software is shown in Figure 5.1 and includes a Steering Committee, several Technical Committees, and an Educational Committee through the TAC.

Various committees should be formed during the next year. ITD initially set up multiple TACs focused on implementation. The committee structure should be maintained throughout the next 5-year cycle of the implementation plan. Three different committees should be formed or reactivated: a steering committee, input specific technical committees, and an educational committee. These committees are briefly defined below.

- The steering committee should be composed of ITD management and the chairpersons of the technical and educational committees. The steering committee should meet at least once a quarter.
- The technical committees should be established for each of the major input categories, including traffic and materials. Materials should be further grouped into subject matter experts (SMEs) within ITD, including asphalt materials, PCC materials, and unbound aggregate base and subgrade soils.
- The educational committee should be formed to focus on training, certification, and calibration of the transfer functions.

These committees are to provide guidance and direction over the next 5 years as the MEPDG implementation process nears completion. The steering and technical committees can be sunset after the MEPDG is incorporated into day-to-day practice. The educational committee, however, should be continued for monitoring the certification process and the accuracy of the MEPDG transfer functions. If the educational committee is ended, then those long-term responsibilities should be included under Pavement Design.

The technical committees are composed of subject matter experts and tied to the different input categories for the MEPDG with the exception for the educational committee. The educational committee is led by the pavement management subject matter expert in terms of distress and other parameters used in managing ITD's roadway network.

This organizational structure is suggested to encourage ownership of the final design process using the PMED software because it gets all ITD offices involved.

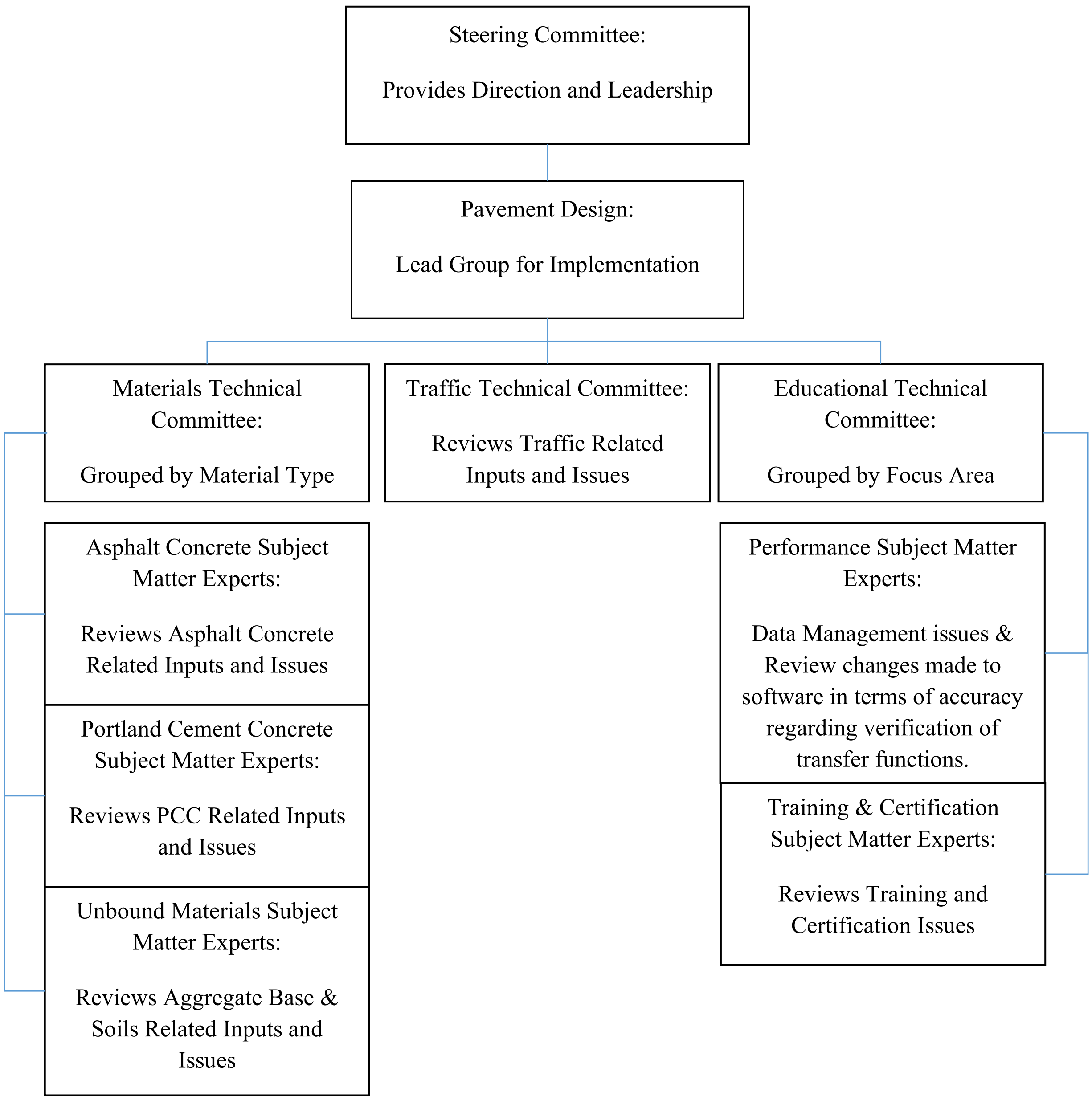

Figure 5.1 Suggested Organizational Structure for Implementing and Using the PMED Software in Idaho

Steering Committee

The steering committee provides vision, guidance, monitoring the plan progress, and giving feedback to the technical committees. Members of the steering committee should be composed of areas of ITD that are involved in pavement design and the pavement design inputs. Members of industry should also be included to facilitate communication.

Technical Committees

The technical committees oversee executing or providing guidance towards inputs to be used for the implementation plan. The technical committees should be small and composed of subject matter experts that direct activities in the specific area which provides inputs to the software. Subject matter experts for the technical committees include traffic and materials characterization or testing by type of material. A liaison member from the technical committees (subject matter experts) should be included or assigned to the steering committee to provide flow of communications and consistency among the committees and avoid duplication of effort.

Traffic Committee of Subject Matter Experts

The Traffic Committee is responsible for load spectra data collection and analysis. This is to include locating and installing WIM sites to ensure state coverage is provided and ensuring the traffic data meets the requirements of the Traffic Monitoring Guide (TMG). Members of the traffic committee should be composed of areas of ITD that are involved in traffic data collection, analysis, and traffic growth projections.

Materials Committee of Subject Matter Experts

Designs using input level 1 require site-specific input data. Since plans or designs are prepared years in advance, it is necessary to make assumptions on the materials that will be used, and the construction methods employed. As such, three committees (one for each type of material: soils and GAB, PCC, and cementitious stabilized material; and asphalt) should be established for making those decisions and recommendations. The following paragraphs provide specific responsibilities of each material specific technical committee.

Soils and Aggregate:

The Soils and Aggregate Committee of subject matter experts is responsible for characterizing and establishing a representative state-wide data base for the resilient modulus of soils and aggregates. An important role for the committee is providing guidance in performing the soils and aggregate testing, quality control (QC) and analysis of the collected data and setting procedures for selecting the proper soils and aggregate input parameters for input level 1, 2 and 3 with values matching the stress level at the subgrade and subbase, respectively. Members of the soils and aggregates committee should be composed of areas within ITD that are involved in geotechnical pavement design and the pavement design inputs.

Concrete and Stabilized Base Materials:

The Concrete and Stabilized Materials Committee of subject matter experts is responsible for characterizing the properties of current ITD paving PCC mixes by performing laboratory tests for the elastic modulus, compressive strength, and CTE. Additionally, the committee performs QC on the collected data, and establishing the PCC properties database for use as input Levels 2 & 3. The committee also is responsible for characterizing elastic modulus of stabilized materials such as; cement treated aggregate, soil cement, and lime stabilized soils. Members of this committee should be composed of areas of ITD that are involved in concrete pavement and the pavement design inputs.

Asphalt Mixtures:

The Asphalt Mixture Committee of subject matter experts is responsible for characterizing ITD asphalt mixes (all layers) for their stiffness (dynamic modulus), plastic deformation, and creep compliance properties. This is to include laboratory testing, QC of the collected data, and establishing a materials database for use as input levels 2 & 3 in the analysis procedure. Properties stored in the database should include dynamic modulus, plastic deformation parameters, creep compliance, and tensile strength, as well as typical volumetric properties for mixtures typically used in Idaho. Members of this committee should be composed of areas within ITD that are involved in asphalt and the pavement design inputs.

Educational Committee

The educational committee is grouped into two functions or responsibilities: one for the verification of and maintaining the accuracy of the transfer functions and the second is for the training and certification of users of the software. Both should remain in place and not be sunset after the implementation has been completed. As such, the champion of the MEPDG implementation process should lead both committees which are discussed below.

Verification, Calibration, and Validation Subject Matter Experts

The responsibility of this committee of subject matter experts is to determine the validity of the analysis and the local calibration coefficients for Idaho conditions and materials. In addition, it will be the responsibility of this committee to monitor changes made to the software by AASHTO to decide whether the local calibration coefficients need to be verified.

The committee will oversee the verification and re-calibration, if necessary, of the MEPDG which is the process of making adjustments to the theoretical models to account for model simplification and limitations in simulating actual pavement behavior. Additionally, the committee should evaluate the MEPDG accuracy to determine whether the model provides a reasonable prediction of actual performance. Members of this committee should be composed of areas within ITD that are involved in the data management area and have a statistical background, as well as be knowledgeable of the performance characteristics of typical pavement strategies constructed in Idaho.

Performance specifications seem to lend themselves well to the goal for implementing the MEPDG. Data can be utilized as part of ITD specifications. Also, FHWA has made available their Mobile Testing Laboratories (trailers). Those can be requested by ITD to perform on-site materials testing and characterization to establish input level 1 values, which is recommended especially for the Interstate rehabilitation and widening projects.

Training and Certification Subject Matter Experts

The responsibility of this committee of subject matter experts is to plan the training and maintain a database of the certified users of the PMED software within and beyond the implementation process or plan. Maintaining the database of certified user can be like ITD's database of certified materials suppliers. Members of this committee should be composed of areas within ITD that are involved in the technical nature of materials, pavements, and construction. As such, the training and certification committee should be composed of one individual from each of the other technical committees, at least throughout the implementation period.

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