

Database Preparation for MEPDG PrepME

For the 2009 Southeastern Pavement Conference, New Orleans

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Key Contributors and the Team

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Introduction

- Need to Develop Database & Software to Support Mechanistic-Empirical Techniques for Pavement Design
 - ❑ Better evaluation of new load levels
 - ❑ Better use of available materials
 - ❑ Minimize premature failures
 - ❑ Better characterization of seasonal effects
 - ❑ Improve rehabilitation design
 - ❑ Daily, seasonal and yearly changes in materials, climate and traffic into design process

Research Objectives

- Study the Required Inputs & Data
 - Design the Supporting Database Tables
 - Locate Possible Data Sources
 - Develop a 3rd Party Software for MEPDG
 - Import the Huge Amount of Raw Data
 - Check the Data Quality and Filter Them
 - Generate Files for MEPDG Software Inputs
 - Integrate the Related Research Data
 - Result: **PrepME**
-

Required Data for MEPDG

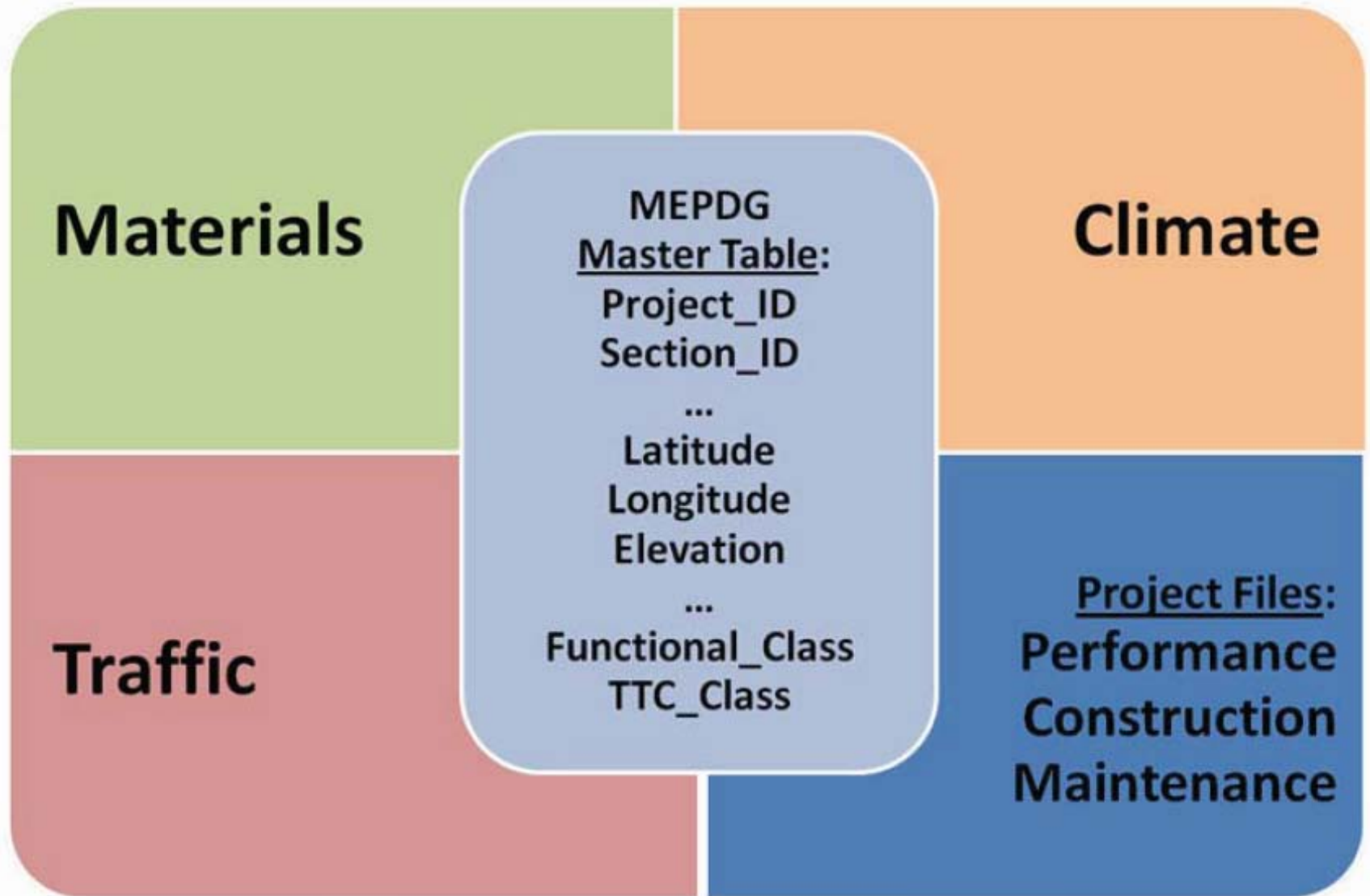
- General
- Climate
- Traffic
- Structure & Material

Design Inputs

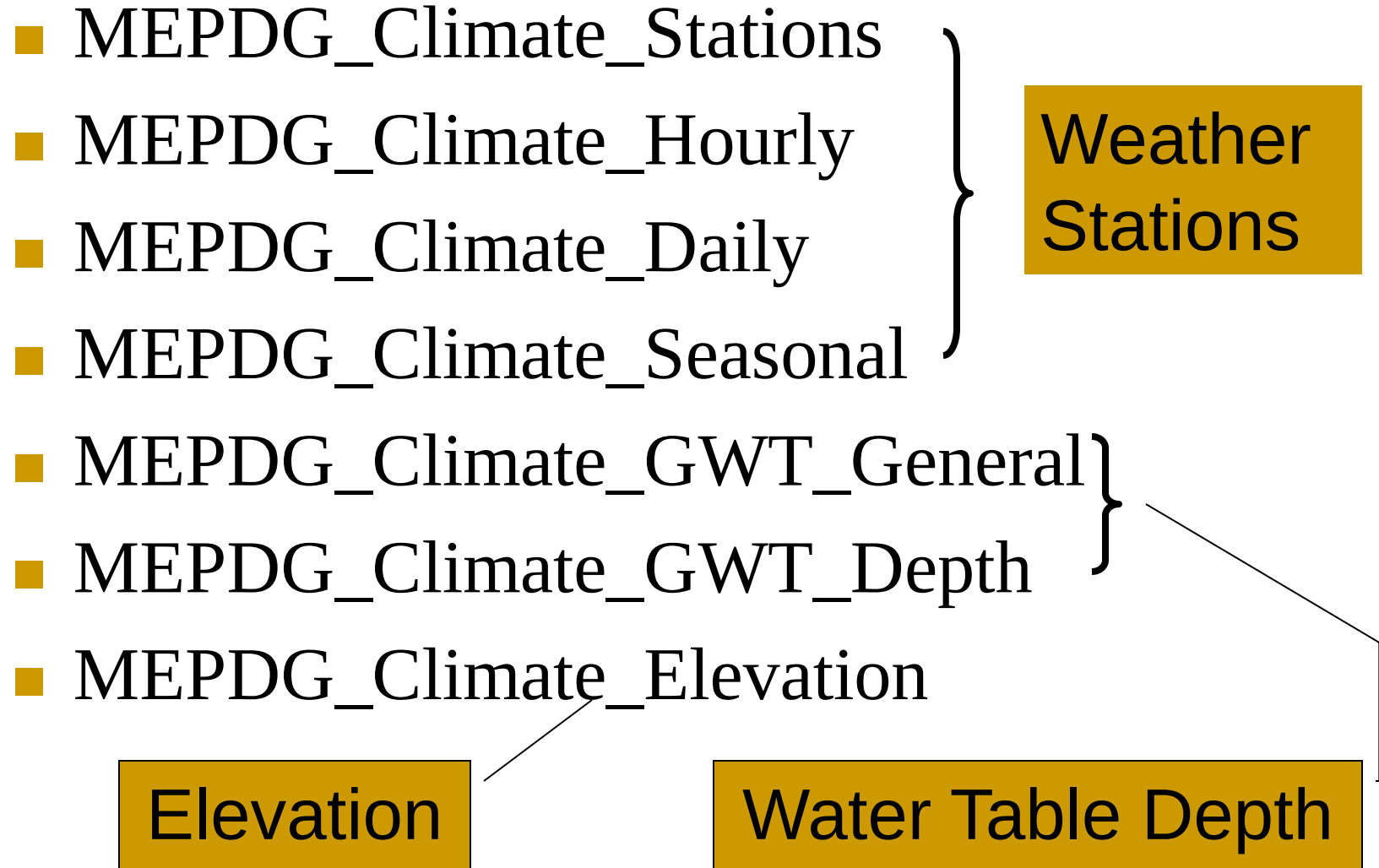
- Performance
- Construction & Related Testing Data
- Maintenance
- Research

Calibration

Database Structures



Climate Module



Climate Data Sources

- Climatic Data
 - ❑ “icm” files instead of “hcd” files
 - Water Table Depth
 - ❑ USGS Online Database
 - ❑ Unevenly Distributed Testing Locations
 - Elevation
 - ❑ From Google Map
 - ❑ GPS Coordinates: Two Decimal Points (Same as MEPDG)
-

Traffic Module

■ General Tables

- ❑ MEPDG_Traffic_Stations_Yearly
- ❑ MEPDG_Traffic_Stations_TTC_Classification

■ Tables for QC

- ❑ MEPDG_Traffic_QC_Vehicle_Class_Available_Month
- ❑ MEPDG_Traffic_QC_Vehicle_Class_Result
- ❑ MEPDG_Traffic_QC_Weight_Available_Month
- ❑ MEPDG_Traffic_QC_Weight_Average_Front_Axle_Weight
- ❑ MEPDG_Traffic_QC_Weight_Average_Tandem_Axle_Weight
- ❑ MEPDG_Traffic_QC_Weight_Front_Axle_Weight_Monthly_Data
- ❑ MEPDG_Traffic_QC_Weight_Gross_Monthly_Data
- ❑ MEPDG_Traffic_QC_Weight_Result

Four Weight Data Check Criteria

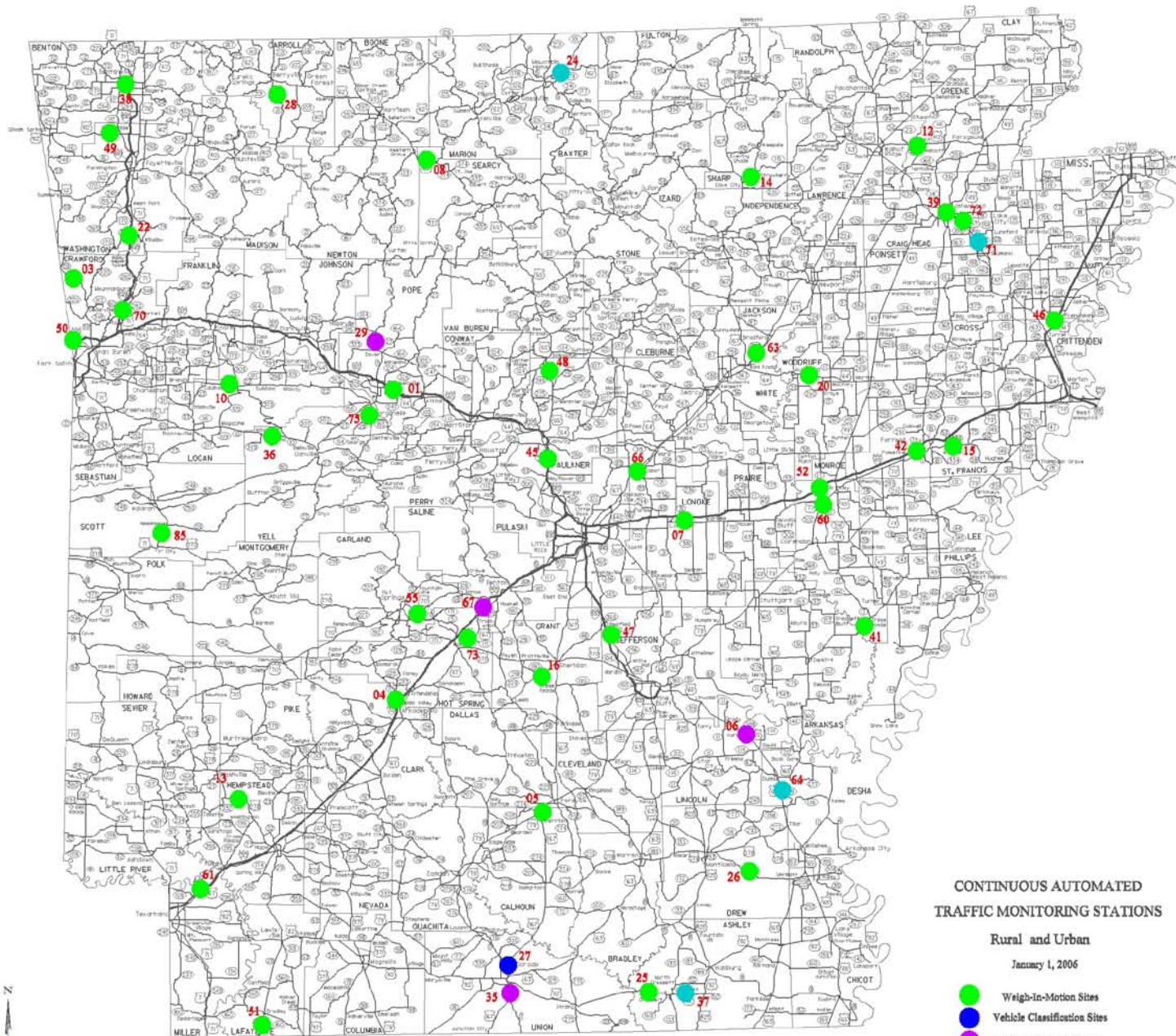
Traffic Module (Cont.)

- Tables for Vehicle classification Data
 - ❑ MEPDG_Traffic_Vehicle_Class_Hourly
 - ❑ MEPDG_Traffic_Vehicle_Class_Monthly
 - ❑ MEPDG_Traffic_Vehicle_Class_Average_Monthly
 - ❑ MEPDG_Traffic_Vehicle_Class_Modified_Monthly

Traffic Module (Cont.)

■ Tables for Weight Data

- ❑ MEPDG_Traffic_Weight_Single_Monthly
- ❑ MEPDG_Traffic_Weight_Average_Single_Monthly
- ❑ MEPDG_Traffic_Weight_Tandem_Monthly
- ❑ MEPDG_Traffic_Weight_Average_Tandem_Monthly
- ❑ MEPDG_Traffic_Weight_Tridem_Monthly
- ❑ MEPDG_Traffic_Weight_Average_Tridem_Monthly
- ❑ MEPDG_Traffic_Weight_Quad_Monthly
- ❑ MEPDG_Traffic_Weight_Average_Quad_Monthly

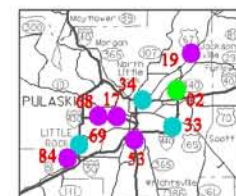


CONTINUOUS AUTOMATED TRAFFIC MONITORING STATIONS

Rural and Urban

January 1, 2006

- Weigh-In-Motion Sites
- Vehicle Classification Sites
- Volume Count Only Sites
- Non-Operational Sites



Material Module

- AC
- PCC
- Stabilized Base
- Unbound
- Subgrade
- Bedrock

Material Module (Cont.)

■ General Tables

- Admix
- Gradation
- Shoulder
- M_R

■ AC Tables

- Conventional Binder Testing
- Brookfield
- DSR

- Mixture
- Dynamic Modulus
- Creep Compliance
- Indirect Tension Strength

□ PCC Tables

- Joint
- Mixture
- Steel
- Strength
- Thermal

Material Module (Cont.)

- Others
 - ❑ Stabilized Base (1)
 - ❑ Subgrade (1)
 - ❑ Unbound (1)
 - ❑ Bedrock (1)
-

Construction and Related Testing Module

- As Built Construction Data
 - Field Materials Sampling
 - AC Construction Related Testing
 - PCC Construction Related Testing
 - Stabilized Materials Construction Related Testing
 - Unbound Materials and Subgrade Construction Related Testing
-

Performance Module

■ AC

- Distress
- Rutting
- IRI

■ CRCP

- Distress
- IRI

■ JPCP

- Distress
- Faulting
- IRI

■ Others

- FWD
- GPR
- Friction

Performance Module (Cont.)

- Distress (MEPDG Required)
 - ❑ Based on LTPP Survey Manual
- FWD
 - ❑ FWD Equipment Information
 - ❑ Point to Point Dropping Data
- GPR
 - ❑ GPR Equipment Information
 - ❑ GPR Point Data
 - ❑ GPR Section Data
- Friction

Maintenance Module

■ PCC Pavement

- ❑ Crack Seal
- ❑ Full Depth Repair
- ❑ Partial-Depth Patching
- ❑ Joint Reseal

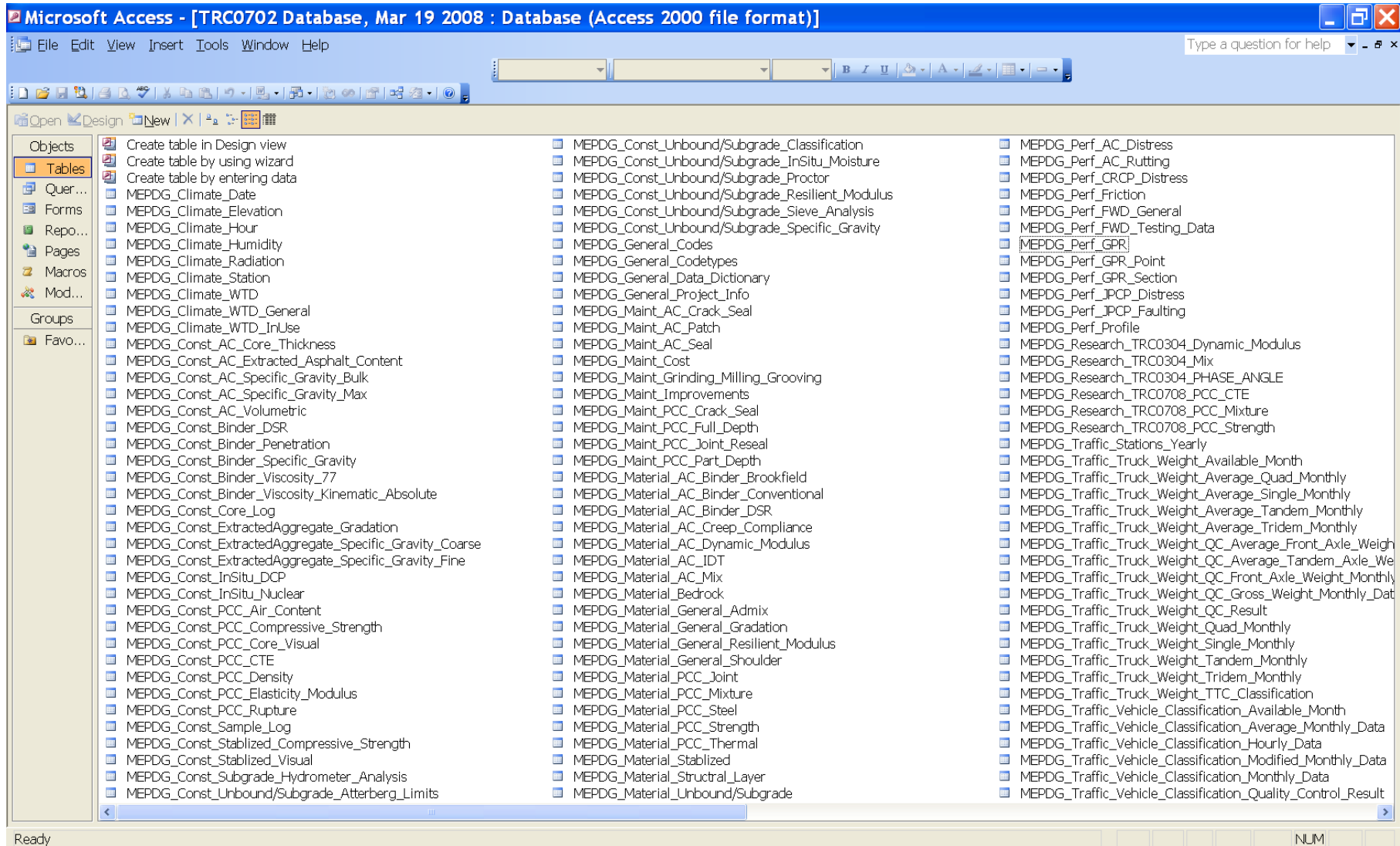
■ AC Pavement

- ❑ Crack Seal
- ❑ Patching
- ❑ Seal Coat

■ Others

- ❑ Grinding, Milling, Grooving
- ❑ Costs
- ❑ Improvements

Database Tables



Consensus from Database Work

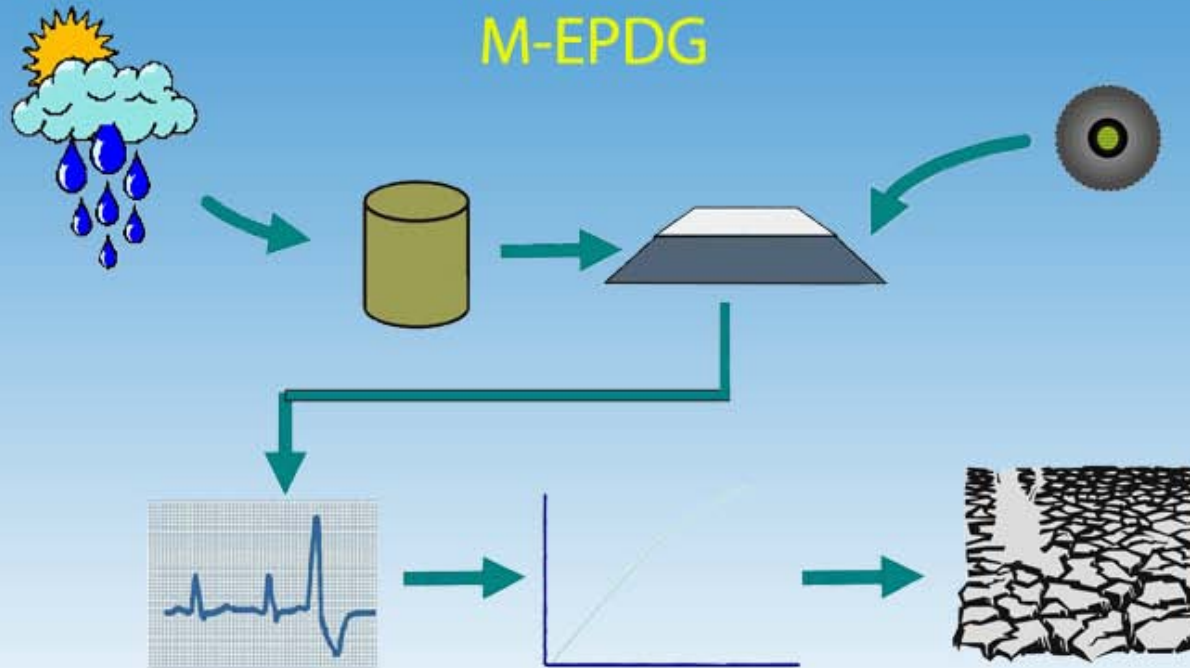
- MEPDG and PMS
 - Share Large Amount of Data
- Golden Opportunity
 - Advance Both Pavement Design and Pavement Management with the Same Database Backbone
- Support of Underlying Technologies
 - Computer Network, Database Engine
 - Data Collection and Analysis

PrepME Software Capabilities

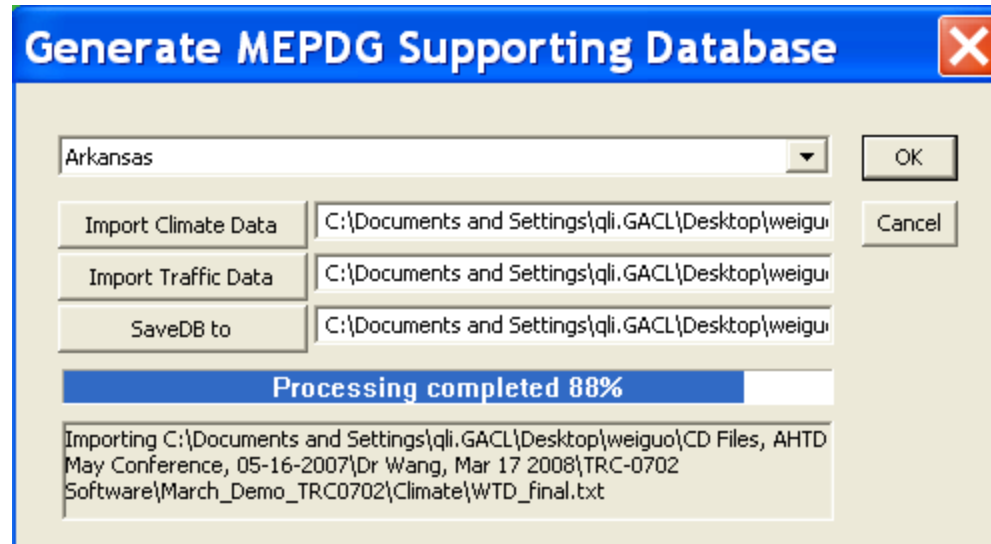
- Import Raw Data Sets
- Traffic Data Check
- Interpolate Climate and Traffic Data
- Retrieve Material Data

PrepME

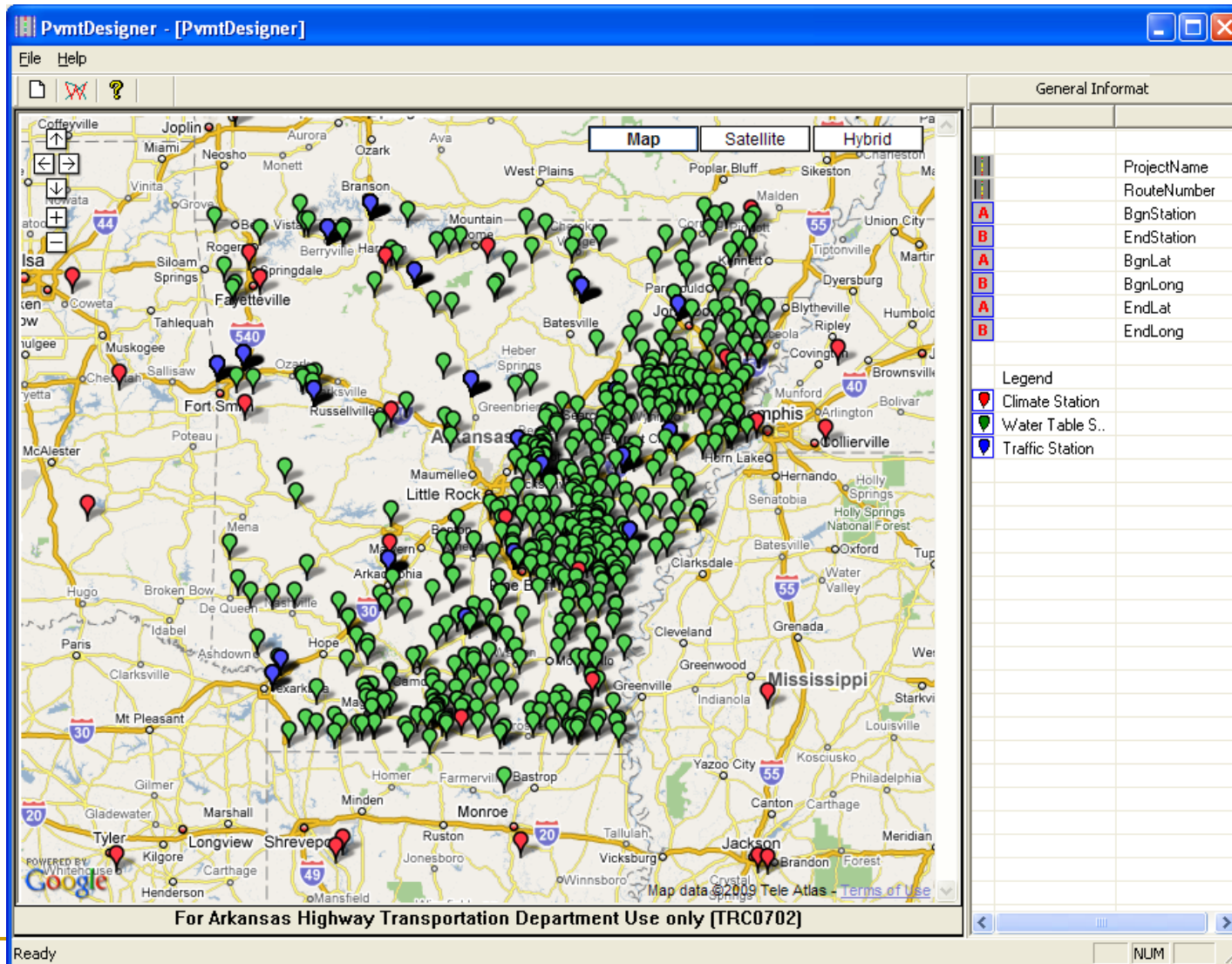
For the Mechanistic Empirical Pavement Design Guide
M-EPDG



Import Raw Data



Geo-Mapping Utility



Weight Data Check --Algorithms

- Class 9 Truck
- Check the Weight of Front Axle (Btw 8,000 and 12,000 lb)
- Check the Weight of Drive Tandem Axle (Btw 30,000 and 36,000 lb)
- Check the Gross Vehicle Weights (two peaks: one btw 28,000 and 36,000 lb, the other btw 72,000 and 80,000 lb)
- Over-Weight Vehicles (<5%)

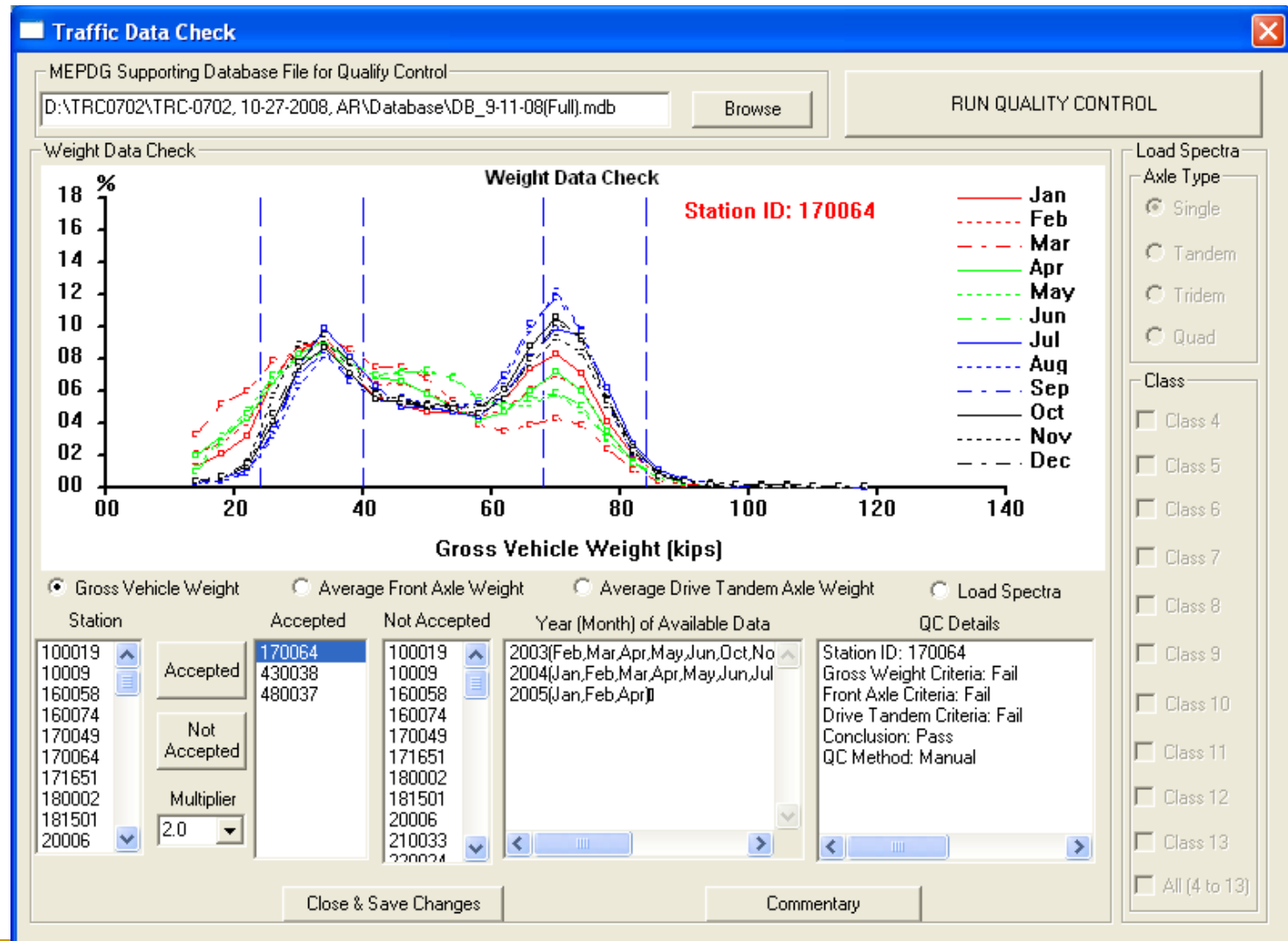
Weight Data Check--Implementation

- To Check the Gross Vehicle Weights
 - Plot a histogram of the gross vehicle weights using a 4,000-lb. increment
 - The plot should have two peaks (one btw 32,000 $\pm$ 4,000 lb -- unloaded Class 9 trucks, the other btw 76,000 $\pm$ 4,000 lb -- loaded vehicle)
 - Fluctuated Data: scale failed
 - Both peaks shifted: out of calibration
 - One peak shifted: should be reviewed using additional information
- Over-Weight Vehicles (<5%)

Weight Data Check--Multipliers

- ❑ If No Multiplier: Few Stations Passed the Weight Data Check
- ❑ Need to Relax Requirements—Multipliers
- ❑ If multiplier=1.0, LTPP Weight Range, e.g.. $10,000 \pm 2,000$ lb;
- ❑ If Multiplier=2.0, For Example, the Range for Front Axle $10,000 \pm (2,000 \times 2.0)$ lb.

Weight Data Check--



Classification Data Check--Algorithms

■ Data Check Algorithm

- ❑ Compare with Manual Counts Data (N/A)
- ❑ Check the # of Class 1 (Motorcycles) (<5%)
- ❑ Check the # of Unclassified Vehicles (<5%)
- ❑ Data W/O Significant Change (see Multiplier)

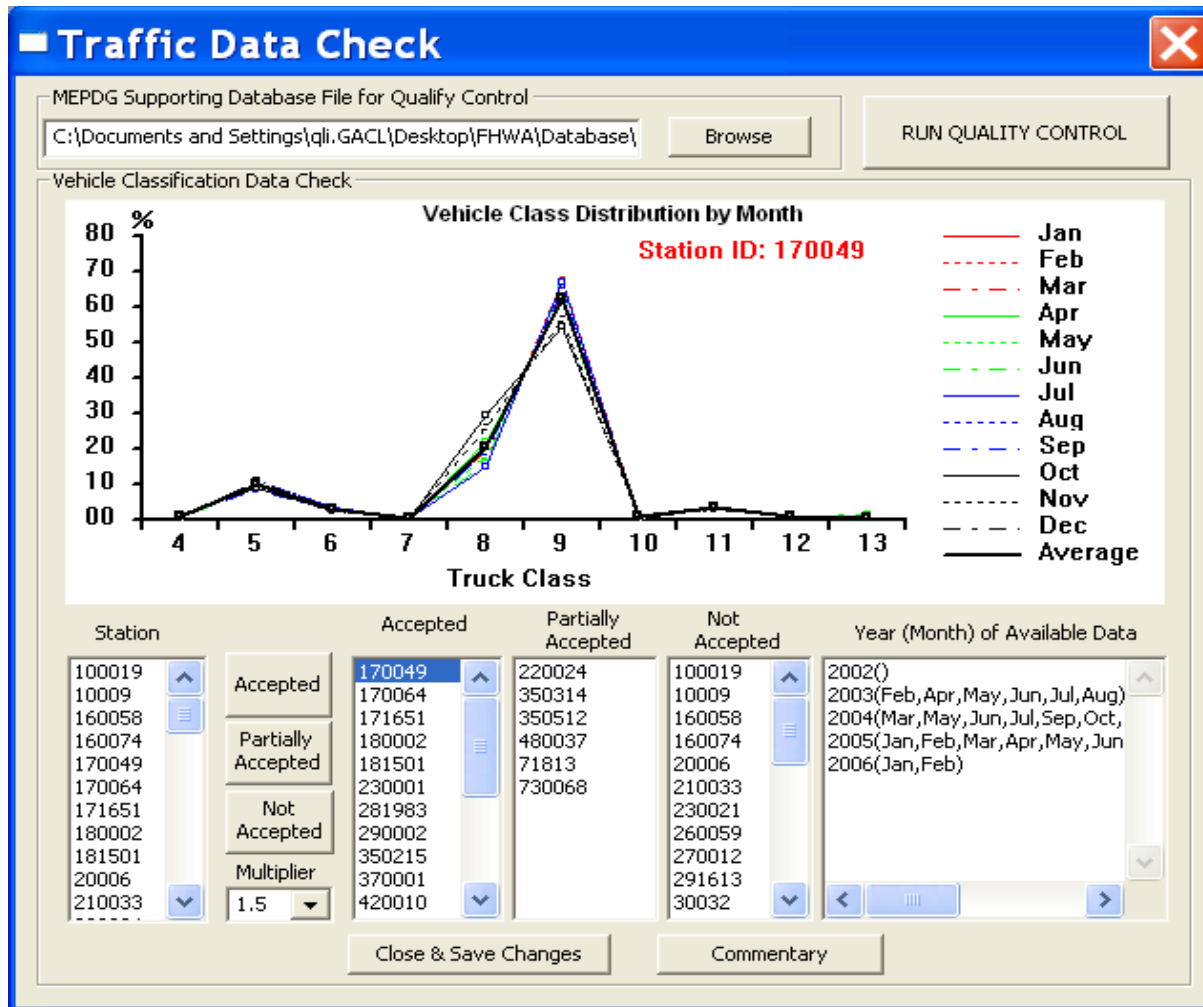
■ Multiplier

- ❑ Use Standard Deviation to Identify the Consistence of the Data
- ❑ If Multiplier=1.0, then 2 Standard Deviation. If Multiplier=1.2, then 2.4 Standard Deviation

Classification Data Check--Implementation

- The first to the third steps are straightforward
- The fourth step
 - ❑ Determine the number of trucks by class for each month
 - ❑ Calculate the normalized class distribution for each month
 - ❑ Compare the normalized class distribution for each month to determine if unexpected changes in vehicle mix had occurred (statistical procedure)

Classification Data Check--



Data Files Generation

Interpolation

MEPDG Supporting Database File
D:\TRC0702\TRC-0702, 10-27-2008, AR\Dal Browse

Export to MEPDG Input Files
D:\TRC0702\TRC-0702, 10-27-2008, AR\Int SaveTo

General Information

Project ID: 540 Section ID: 01

Start at: End at:

Latitude: 36.00 36.50 (range from 33 to 37)

Longitude: -94.15 -93.15 (range from -89 to -95)

Station: 01 10

Climate

☐ Interpolate Based on Radius

Radius (mi) Click to Choose Stations within Radius

☒ Interpolate Based on Adjacent Six Stations

Water Table Depth

From Database

☒ Annual ☐ Seasonal

From User Input

☐ Annual (ft)

☐ Seasonal

Spring (ft) Summer (ft) Fall (ft) Winter (ft)

RUN CLIMATE INTERPOLATION

Traffic Parameters

Initial Two-Way AADTT: 10000

Number of Lanes in Design Direction: 2

Percent Trucks in Design Direction (%): 50

Percent Trucks in Design Lane (%): 95

Operational Speed (mph): 60

Traffic Growth: Linear, 3.00%

TTC (Truck Traffic Classification): TTC6:Intermediate Light and Single Trailer Truck Route (Typ)

Classification Stations

170049
171651
180002
181501
220024

Weight Stations

170064
430038
480037

Stations of Selected TTC

170064
290002
350314
40432
460286

Source for Interpolation

Classification

290002
350314
40432
460286
480037

Weight

170064
480037

RUN TRAFFIC INTERPOLATION

This process shows 11 files to be generated which can be imported to the MEPDG software

Retrieving Material Data

Retrieve Material Parameters

MEPDG Supporting Database File

C:\Documents and Settings\qli.GACL\Desktop\weiguo\C

Browse

Export to MEPDG Input Files

C:\Documents and Settings\qli.GACL\Desktop\weiguo\C

Save To

☐ Rigid Pavement

☒ Flexible Pavement

Retrieving Coefficient of Thermal Expansion Data Based On

Coarse Aggregate Type

Age

Cementitious Paste Type

Retrieving Dynamic Modulus & Dynamic Shear Rheometer Based On

Binder Grade

PG76-22

Design Air Void Level

High (7.0%)

Nominal Max Aggregate Size

12.5 mm

Coarse Aggregate Type

Limestone

☐ VMA

☐ Asphalt Content

☐ Aggregate Gradation

Show Report

Close & Export Report and Material Files

Materials E*

Dynamic Modulus Report

Retrieved Parameters

Binder Grade PG76-22
 Design Air Void Level (%) High (7.0%)
 Nominal Aggregate Size (mm) 12.5 mm
 Aggregate Type Limestone

Material Gradation

Sieve Size	Job Mix
37.5 - 1-1/2"	
25.0 - 1"	
19.0 - 3/4"	100
12.5 - 1/2"	
9.5 - 3/8"	75
4.75 - #4	43
2.36 - #8	
1.18 - #16	
0.6 - #30	
0.3 - #50	
0.15 - #100	
0.075 - #200	4

Mix Design Summary

Mix ID 414
 Aggregate Type Limestone
 Aggregate Source MCA
 Aggregate Location McCliton Anchor, Lowell
 Nominal Aggregate Size 12.5 mm
 Binder Grade PG76-22
 Designed Air Void High (7.0%)
 Max Theoretical Specific Gravity
 Void Mineral Aggregate (VMA)
 Bulk Specific Gravity (Gsb)
 Effective Specific Gravity (Gse)
 Asphalt Specific Gravity (Gb)

Close

Dynamic Modulus E* (ksi)

Temperature (F degree)	Frequency					
	0.1	0.5	1.0	5.0	10.0	25.0
14	1835.77	2185.92	2336.96	2669.61	2776.7	3038.62
40	1298.9	1670.79	1771.18	2230.07	2429.92	2691.75
70	270.58	430.58	520.74	780.28	924.71	1114.98
100	72.99	113.63	141.69	249.06	318.81	432.42
130	30.29	40.13	47.03	76.35	98.34	141.85

Phase Angle (degree)

Temperature (F degree)	Frequency					
	0.1	0.5	1.0	5.0	10.0	25.0
14	11.47	9.49	9	6.61	9.56	13.37
40	15.19	11.55	10.88	10	10.7	13.18
70	26.43	25.37	24.61	22.4	22.26	23.91
100	24.44	29.06	30.7	32.73	33.04	35.87
130	18.62	23.59	26.26	32.45	35.75	41.2

Dynamic Shear Rheometer (DSR) with Angular Frequency = 10 rad/sec

Temperature (F degree)	G* (Pa)	Delta (degree)
68	1596873.58	55.25
95	159902.52	67.28
122	20226.94	67.13
149	3765.7	68.34

Materials CTE

Coefficient of Thermal Expansion Report



Retrieved Parameters

Coarse Aggregate Type

Age

Cementitious Paste Type

Coefficient of Thermal Expansion (per F degree x 10⁻⁶)

Strength & Poisson's Ratio

Time	Elastic Modulus (ksi)	Compressive Strength (ksi)	Poisson's Ratio
3 days		4320	
7 days	5.026	4976	0.227
28 days	5.241	5334	0.222
90 days	5.307	5536	0.231

Mix Properties

Cement (lb/yd³)

Fly Ash (lb/yd³)

Slag (lb/yd³)

Coarse Aggregate (lb/yd³)

Coarse Aggregate Type

Coarse Aggregate Size (in)

Fine Aggregate (lb/yd³)

Water (lb/yd³)

Water/Cement

Daravair (fl oz/cwt)

Temperature (F degree)

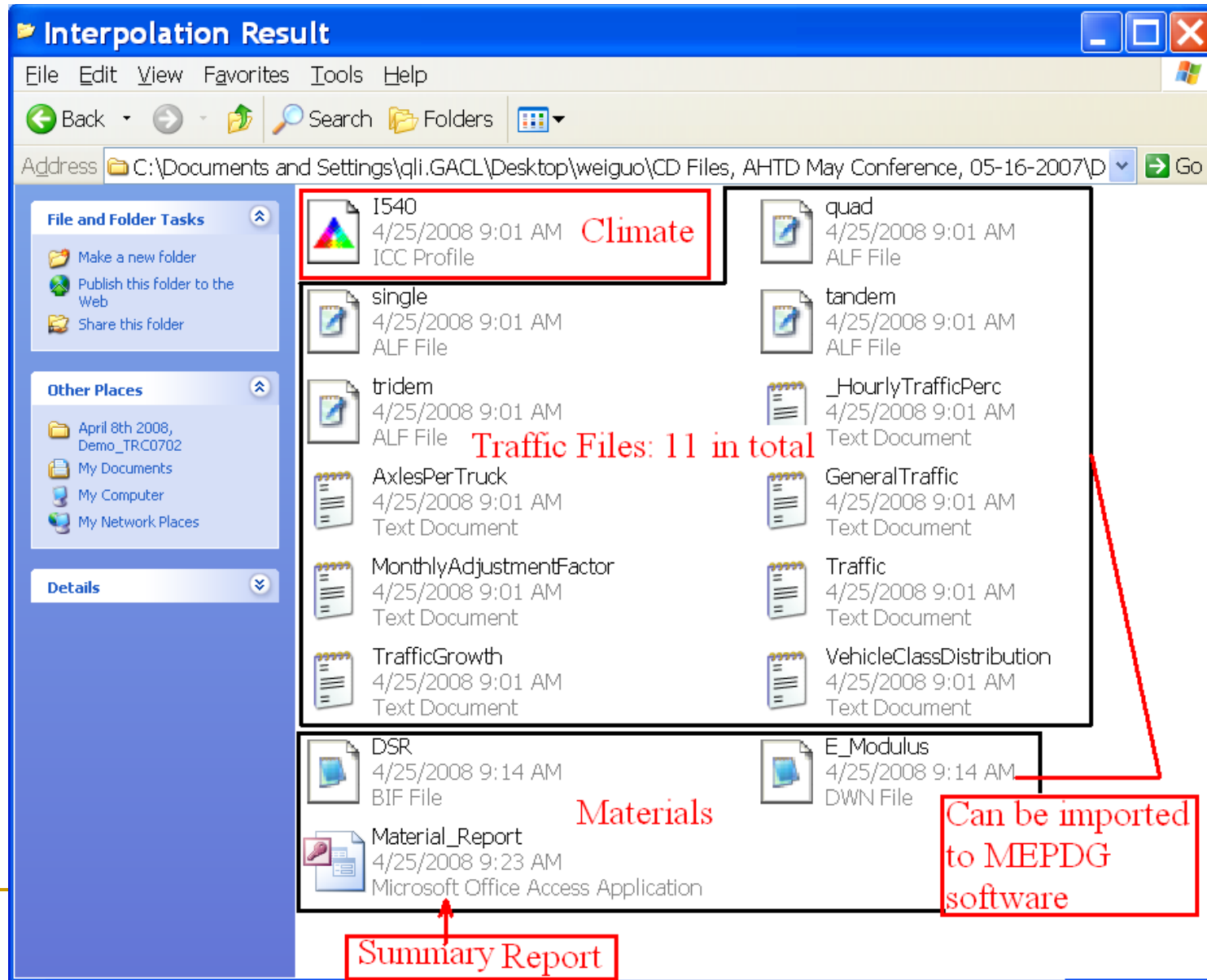
Slump (in)

Air Content (%)

Unit Weight (pcf)

Close

Generated Files



Climate File Import (MEPDG)

Environment/Climatic [?] [X]

Current climatic data file: C:\Documents and Settings\qli.GACL\Desktop\weiguo\CD Files, AHTD May Conference,

(1)

(2) Latitude (degrees.minutes): 36.25
Longitude (degrees.minutes): -93.65
Elevation (ft): 403
☒ Seasonal

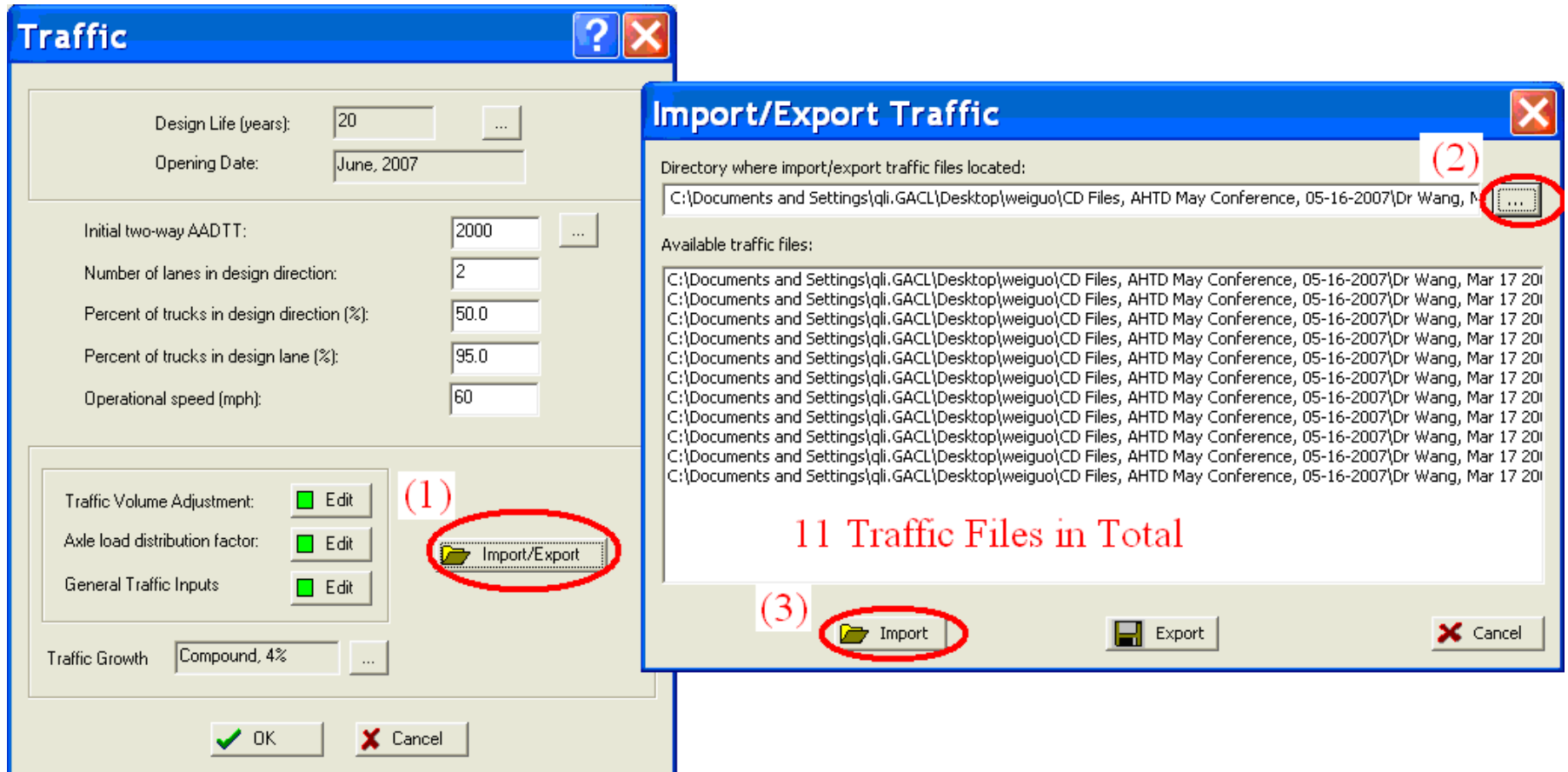
Spring (April)	223.1526
Summer (July)	225.9512
Fall (October)	245.1275
Winter (January)	222.5977

Note: Ground water table depth is a positive number measured from the pavement surface.

(3)

Months of available data: 105

Traffic Files Import (MEPDG)



E* Data Import (MEPDG)

Asphalt Material Properties

(1) Level: 1

Asphalt material type: Asphalt concrete

Layer thickness (in): 6

(2) ☒ Asphalt Mix ☐ Asphalt Binder ☐ Asphalt General

Dynamic Modulus Table

Number of temperatures: 5 Number of frequencies: 4

Temperature (°F)	Mixture E* (psi)			
	0.1	1	10	25
10				
40				
70				
100				
130				

(3) ☒ Import ☐ Export

OK Cancel View HMA Plots

Open (4)

Look in: Interpolation Result

E_Modulus

File name: E_Modulus

Files of type: Dynamic Modulus Files (*.dwn)

Open Cancel

Asphalt Material Properties

Level: 1

Asphalt material type: Asphalt concrete

Layer thickness (in): 6

☒ Asphalt Mix ☐ Asphalt Binder ☐ Asphalt General

Dynamic Modulus Table

Number of temperatures: 5 Number of frequencies: 6

Temperature (°F)	Mixture E* (psi)					
	0.1	0.5	1	5	10	25
10	1835770	2185920	2336960	2669610	2230070	2230070
40	1298900	1670790	1771180	2230070	780280	780280
70	270580	430580	520740	249060	76350	76350
100	72990	113630	141690	249060	76350	76350
130	30290	40130	47030	76350	76350	76350

(5) ☒ Import ☐ Export

OK Cancel View HMA Plots

Import Dynamic Shear Rheometer DSR Data

Asphalt Material Properties

Level: 1

Asphalt material type: Asphalt concrete

Layer thickness (in): 6

(1) ☒ Asphalt Mix ☒ Asphalt Binder ☐ Asphalt General

(3) **Import** (2) ☒ Superpave binder test data ☐ Conventional binder test data

Options - At Short Term Aging - RTFO

Number of temperatures: 8

Temperature (°F)	Angular frequency = 10 rad/sec	
	G' (Pa)	Delta (°)

OK Cancel View HMA Plots

Open (4)

Look in: Interpolation Result

DSR

File name: DSR

Files of type: Binder Information File (*.bif)

Open Cancel

Asphalt Material Properties

Level: 1

Asphalt material type: Asphalt concrete

Layer thickness (in): 6

☒ Asphalt Mix ☒ Asphalt Binder ☐ Asphalt General

Import ☒ Superpave binder test data ☐ Conventional binder test data

Options - At Short Term Aging - RTFO

Number of temperatures: 4

Temperature (°F)	Angular frequency = 10 rad/sec	
	G' (Pa)	Delta (°)
68	1596873.58	55.25
95	159902.52	67.28
122	20226.94	67.13
149	3765.7	68.34

OK Cancel View HMA Plots

(5)

Conclusions

- MEPDG: an analysis suite that happens to be a design software
 - The Study & Implementation of MEPDG
 - Research Efforts for Pavement Engineering
 - High Quality Data Needs: Data Collection
 - Driving the Industry with Better Data & Tools
 - **PrepME**: Data Preparation Tool for MEPDG & other Pavement Engineering Tasks (PMS et al)
-

Thank You !