Colorado's Development of the MEPDG

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Pavement Design Program Manager

Arizona Pavement / Materials Conference

November 16th, 2011

Taking Care To Get You There

DOT

DEPARTMENT OF TRANSPORTATION

Pavement Design Timeline and MEPDG Implementation in Colorado

1999: NCHRP 1-37A Launches
2001: CDOT Prepares Implementation Roadmaps

2007: CDOT Updates Roadmaps

Late 1950's
AASHO
Road Test

1972,
1986, 1993
AASHTO
Guides

2004
NCHRP
Develops
MEPDG

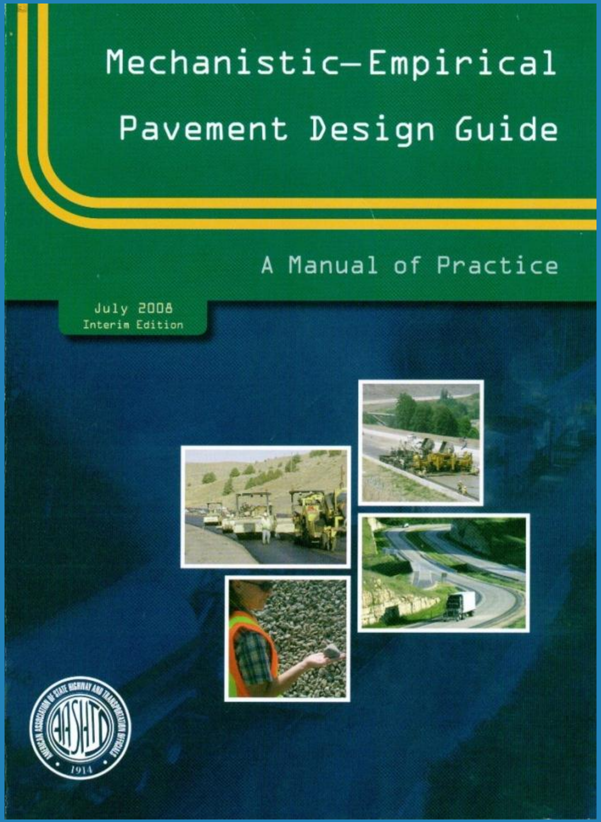
2008
MEPDG is an
AASHTO
Standard

2009 CDOT Begins
Calibration/Validation
Efforts with ARA

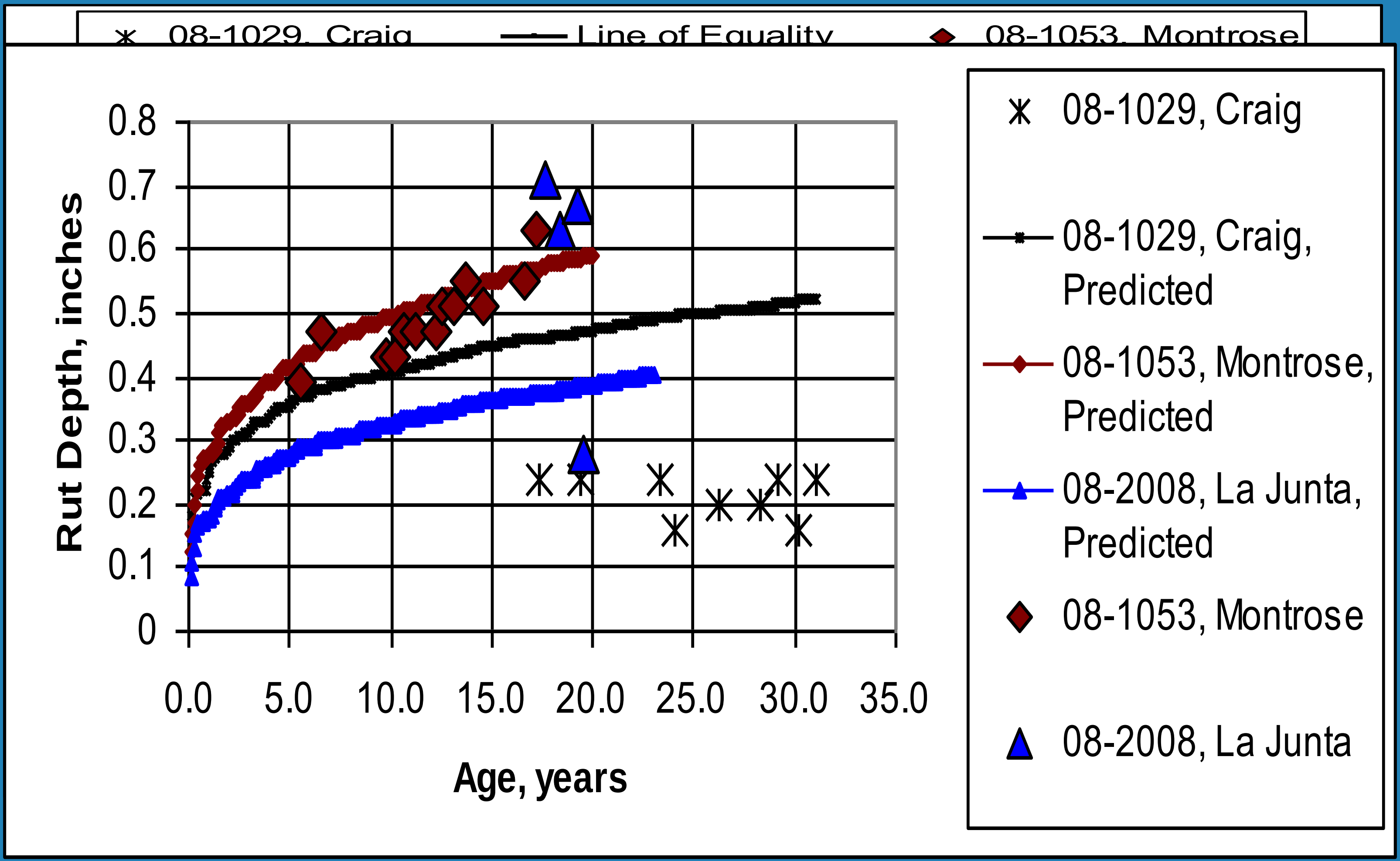
2012 CDOT
Adopts
DARWin - ME

Objectives of CDOT's MEPDG Implementation Project

- Identify resources needed to implement the MEPDG
- Confirm or adjust default values
- Confirm or adjust the calibration coefficients
- Recommend any changes in policy and procedure that will be needed
- Provide design document that can be used by CDOT designers



HMA Rut Depth in Colorado



Colorado's MEPDG—The Plan

- **2009 to 2010: Data collection and input determination, 121 test sections**
  - **Materials Testing and Characterization**
  - **Traffic Analyses**
  - **Performance Analyses**

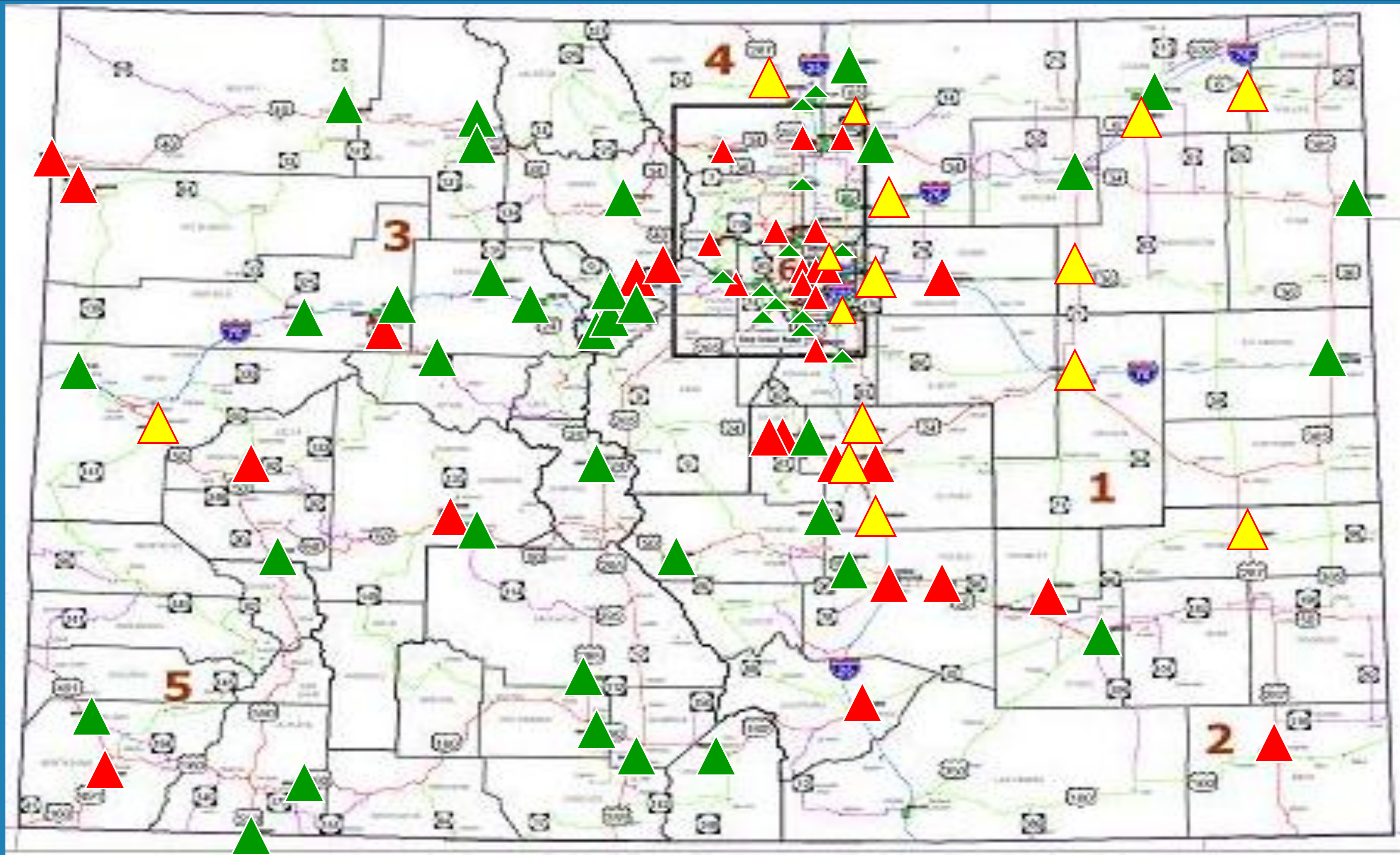
- **2010 to 2011: Data analysis and calibration/validation**
  - **Create Input libraries**
  - **Determine local calibration values**
- **2011: Documentation and Design Manual**
- **2012: Adopt MEPDG for use on all CDOT Projects**
- **Continuous Training**

MEPDG Traffic Analysis

MEPDG Traffic Input Parameter	Need to Compute CDOT Defaults?	MEPDG Default Available?
Monthly adjustment factors	Needed	Yes
Hourly distribution factors	Needed	Yes
Vehicle class distribution	Needed	Yes
Axle load distribution factors	Needed	Yes
Number of axles per truck	Needed	Yes
Mean wheel load location and lateral traffic wander	Needed	Yes
Axle configuration	Needed	Yes
Wheelbase	Needed	Yes

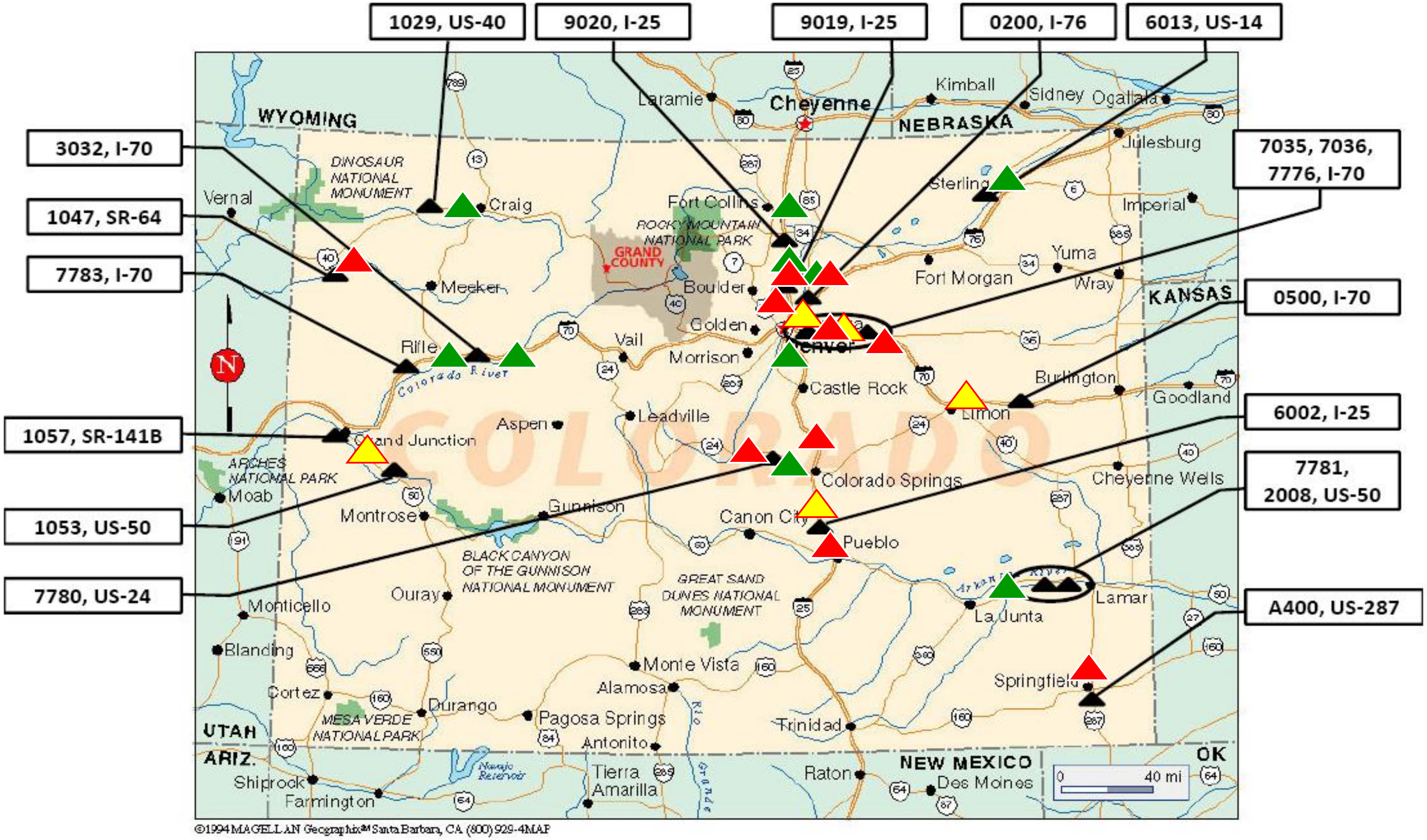
Traffic Data

Continuous Length Classification
Continuous Axle Classification
Weigh-in-Motion Station

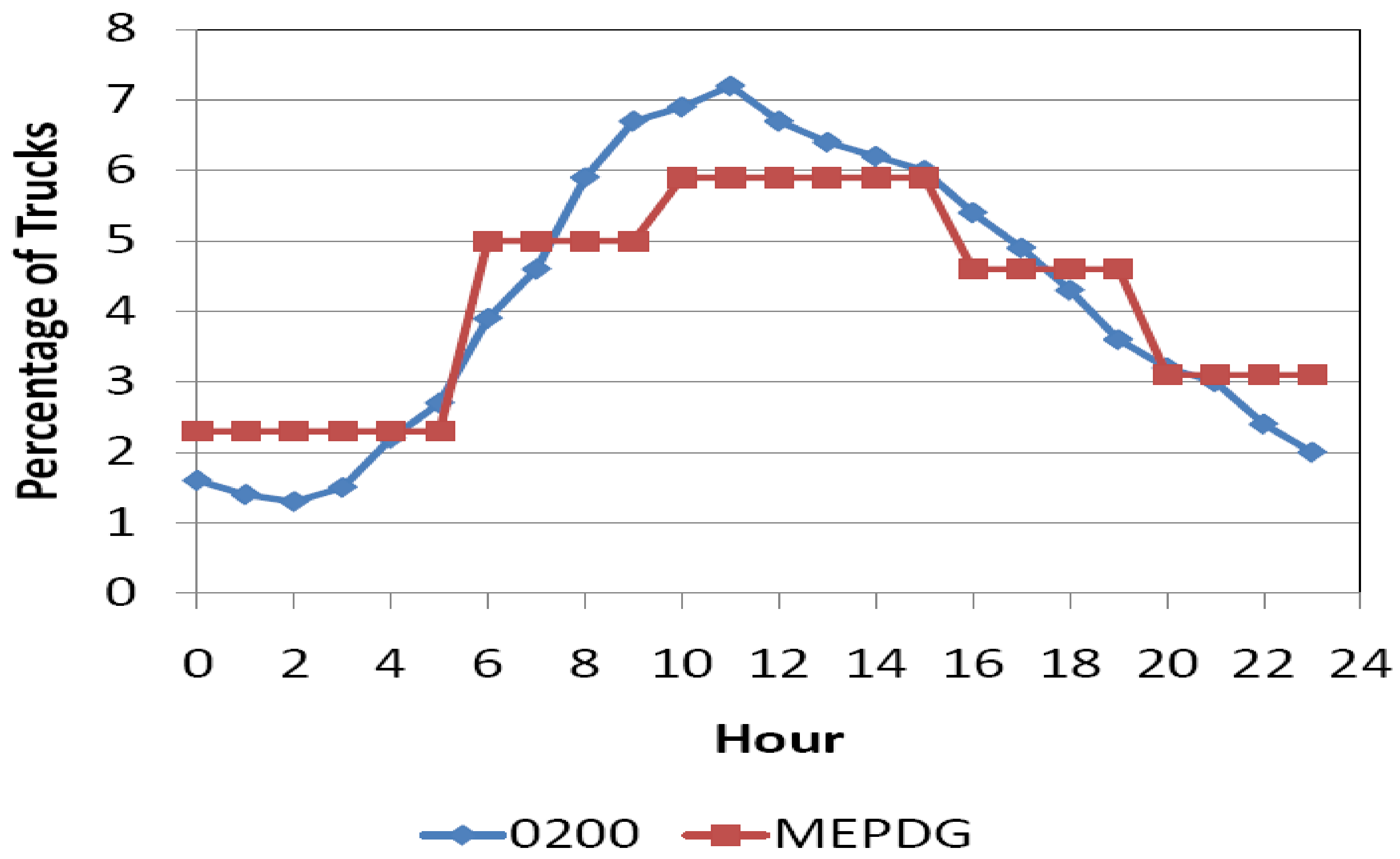


LTPP Sites with Traffic Data

Continuous Length Classification   Continuous Axle Classification   Weigh-in-Motion Station

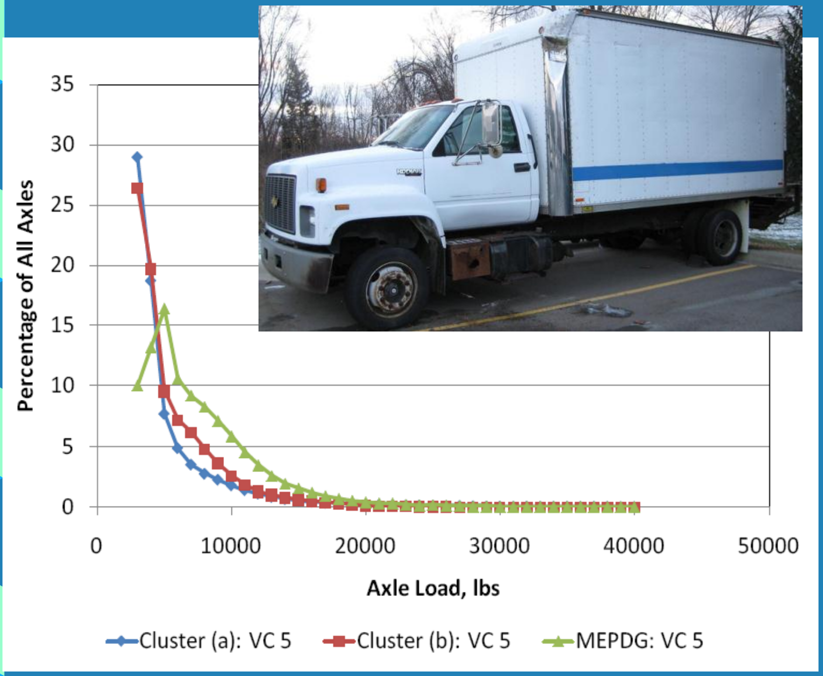


Traffic Data

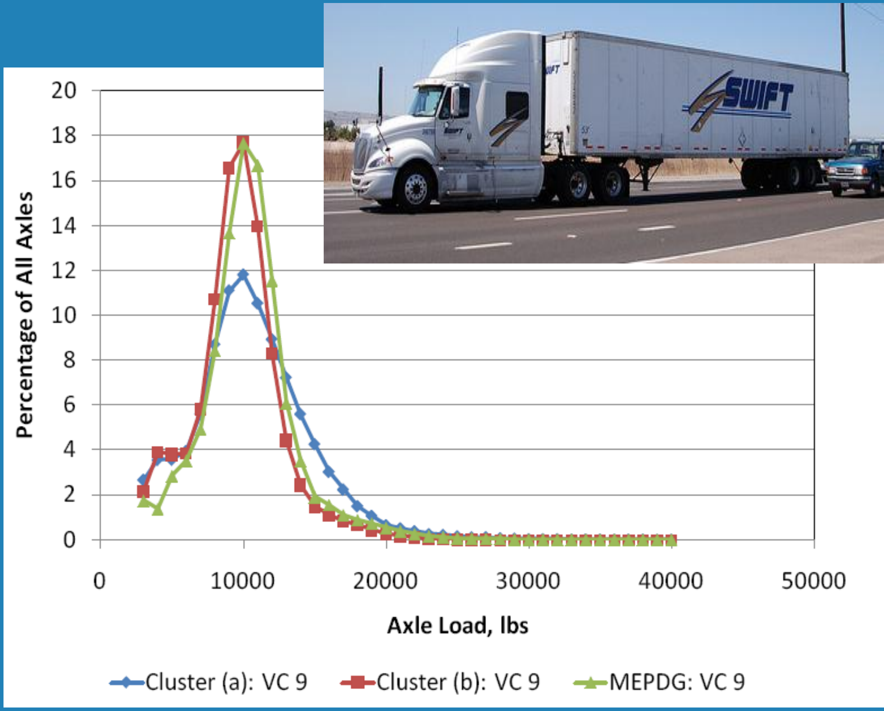


Axle Load Spectra

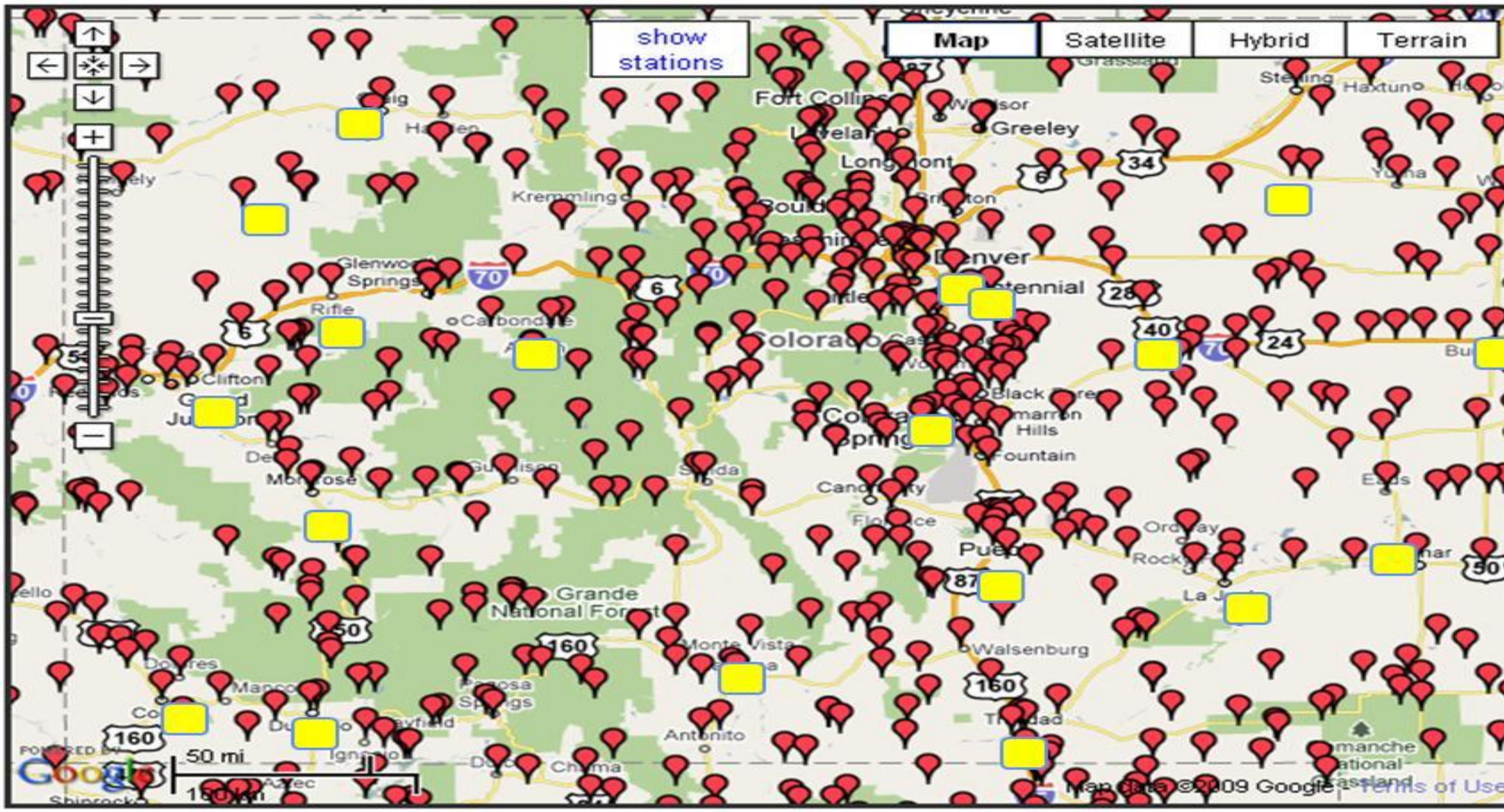
Class 5 Trucks



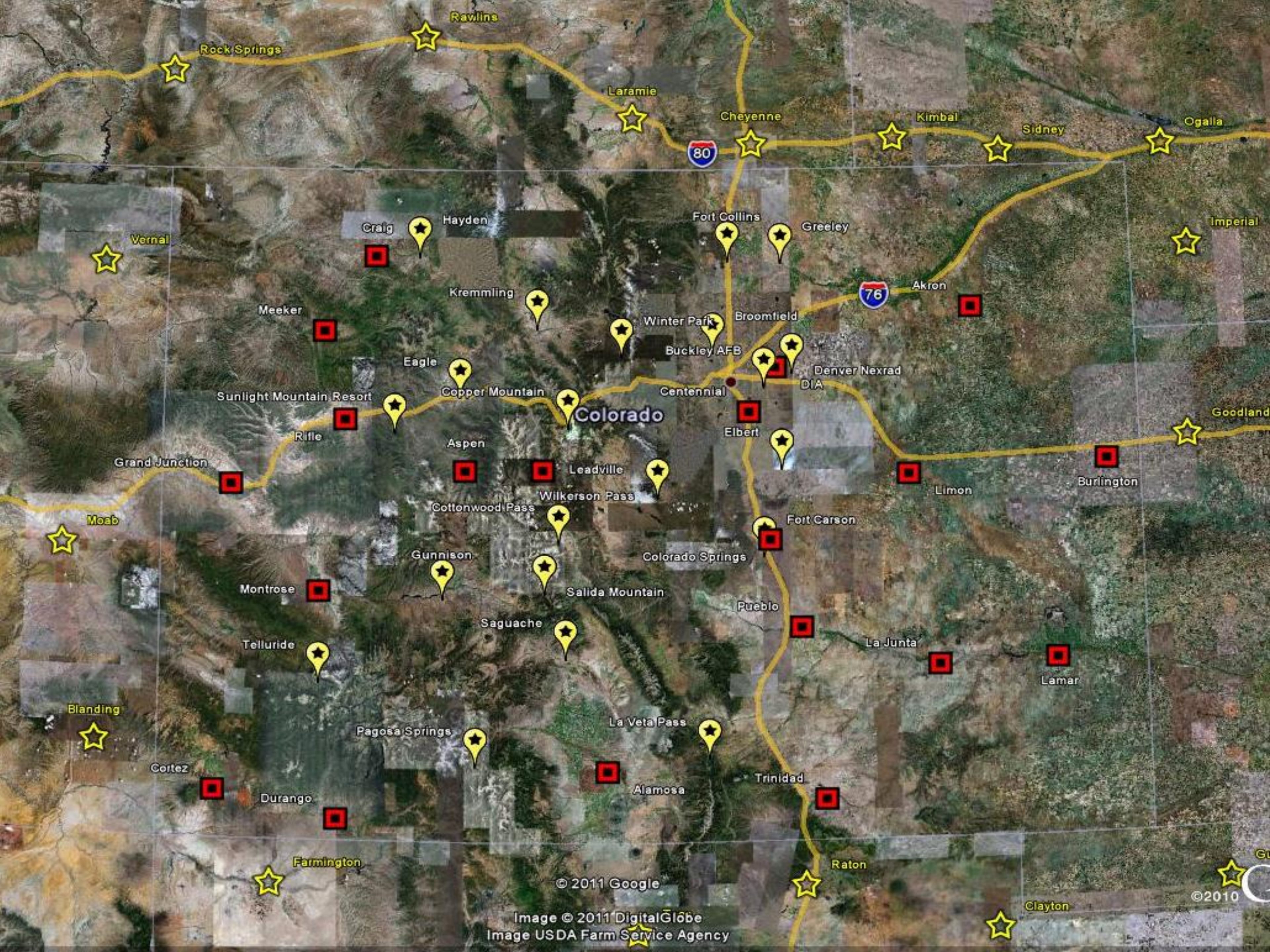
Class 9 Trucks



Climate Data



= Cooperative Weather Station = MEPDG Station


Rawlins
Rock Springs
Laramie
Cheyenne
80
Kimbal
Sidney
Ogalla
Vernal
Craig
Hayden
Fort Collins
Greeley
Imperial
Akron
76
Kremmling
Meeker
Winter Park
Broomfield
Buckley AFB
Eagle
Denver Nexrad
DIA
Sunlight Mountain Resort
Copper Mountain
Centennial
Colorado
Goodland
Rifle
Elbert
Aspen
Grand Junction
Leadville
Burlington
Limon
Wilkerson Pass
Moab
Cottonwood Pass
Fort Carson
Gunnison
Colorado Springs
Montrose
Salida Mountain
Pueblo
Saguache
Telluride
La Junta
Lamar
Blanding
La Veta Pass
Pagosa Springs
Cortez
Alamosa
Trinidad
Durango
Farmington
Raton
© 2011 Google
Clayton
©2010
Image © 2011 DigitalGlobe
Image USDA Farm Service Agency

HMA Experimental Factorials:

1. Conventional (HMA over ABC)Pavements
2. Full-Depth HMA Pavements
3. HMA Overlay
    - Straight overlay
    - Mill and fill
    - Full depth reclamation
    - Hot in-place recycled
    - Cold in-place recycled
    - SMA
4. HMA Overlay of PCC Pavements
    - Intact
    - Fractured

HMA Experimental Factorials (Continued):

A. HMA Thickness
  - Less than 4 inches
  - 4 to 8 inches
  - Greater than 8 inches

B. Base Course
  - Class 6
  - Class 7

C. Soil Foundation
  - Stabilized
  - Non-expansive
    - i. Course grained
    - ii. Fine grained

D. Climate Based on Elevation
  - Less than 6,500 feet
  - 6,500 to 8,000 feet
  - Greater than 8,000 feet

LTPP test sections, pavement management sections, adjacent DOTs.

Secondary Factors:
Neat and PMA mixes; with and w/o RAP; etc.

PCC Experimental Factorials:

1. Conventional (PCC over ABC) Pavements
2. Full-Depth PCC Pavements
3. PCC Overlay of PCC Pavements
   - Intact
   - Fractured
4. PCC Overlay of HMA Pavements
   - 5 to 7 inch thickness
   - Less than 8 inches
   - Greater than 8 inches

PCC Experimental Factorials (Continued):

A. PCC Thickness
- Less than 9 inches
- 9 to 11 inches
- Greater than 11 inches

B. Aggregate Base Course
- Class 6
- Class 7
- Asphalt Treated

C. Soil Foundation
- Cement or Lime Stabilized
- Non-expansive

LTPP test sections, pavement management sections, adjacent DOTs.

Secondary Factors:
Dowels and Nondoweled
Standard and Widened Slabs
AC and PCC Shoulders

Populating the Experimental Factorials

Long-Term Pavement Performance Data

- 60 sections in CO, 10 sections outside CO; 30 GPS and 40 SPS
- New Flexible and Rigid Pavements
- HMA or PCC overlay of Flexible and Rigid Pavements

CDOT PMS Section Selection Criteria

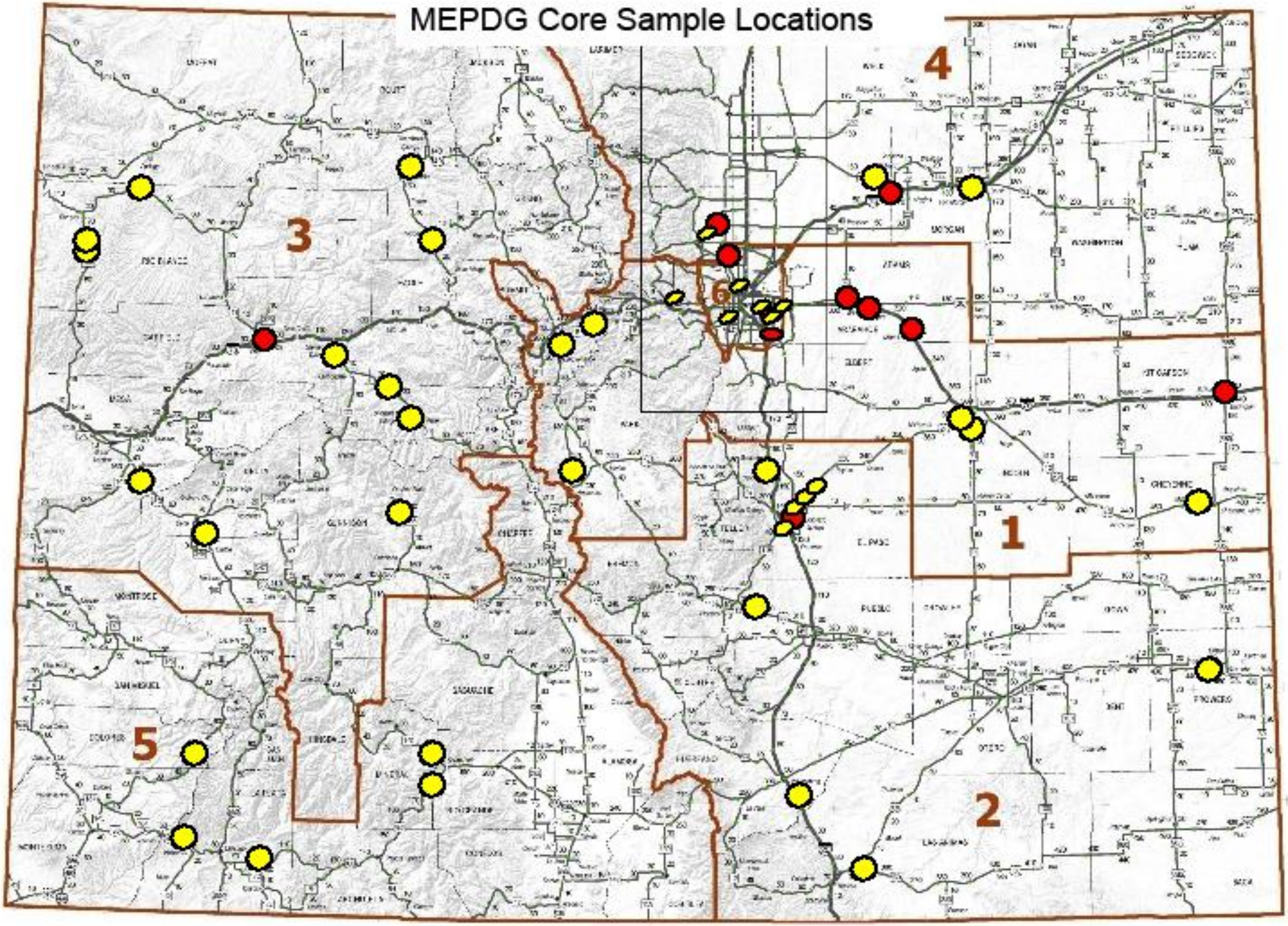
- Representative roadway sections
- Availability of 3 condition surveys within 7-10 yr period (min)
- Consistency of distress measurements
- Availability of construction history data
- Availability of well-defined traffic data
- Availability of material properties from construction/ project records

CDOT Sections

- 40 Hot Mix Asphalt Sections
  - 11 New Pavements
  - 19 Simple AC Overlays of HMA Pavements
  - 6 AC Overlays with Hot In-Place Recycling
  - 2 AC Overlays with Cold In-Place Recycling
  - 2 AC Overlays of Rigid Pavements
- 11 Portland Cement Concrete Pavements
  - 5 New Pavements
  - 4 Conventional Overlays of HMA
  - 2 Thin Whitetopping Overlays of HMA


BEGIN
MEPDG
TEST
SECTION

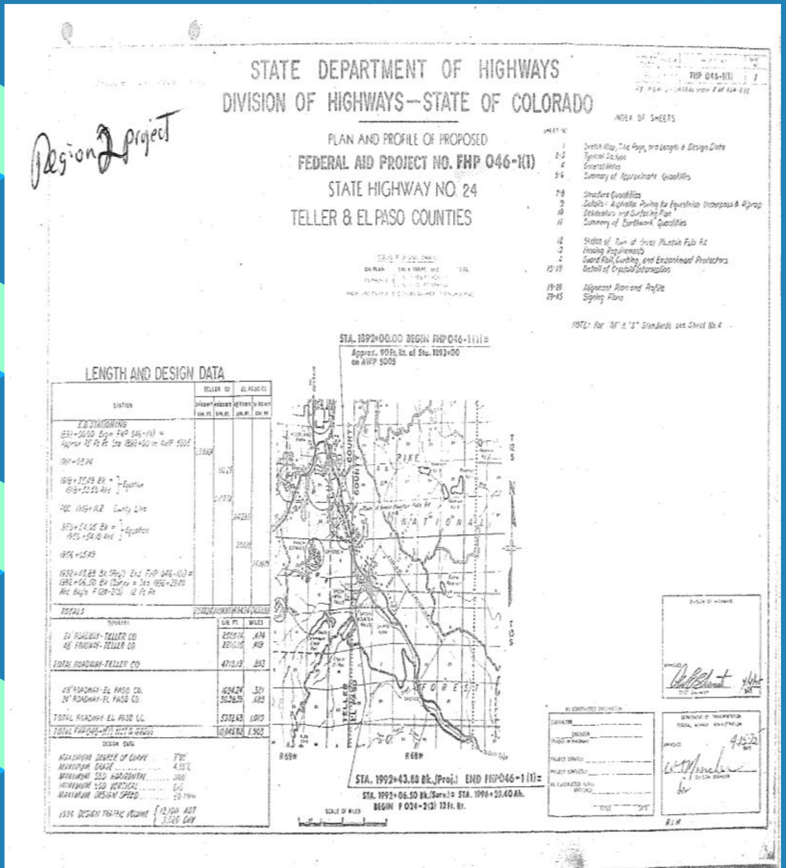
MEPDG Core Sample Locations



Data Collection – Forensic Investigations

PMS Historical Information

1975 Original Construction Project



STATE DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS—STATE OF COLORADO

Region 2 project

PLAN AND PROFILE OF PROPOSED
FEDERAL AID PROJECT NO. FHP 046-1(1)
STATE HIGHWAY NO. 24
TELLER & EL PASO COUNTIES

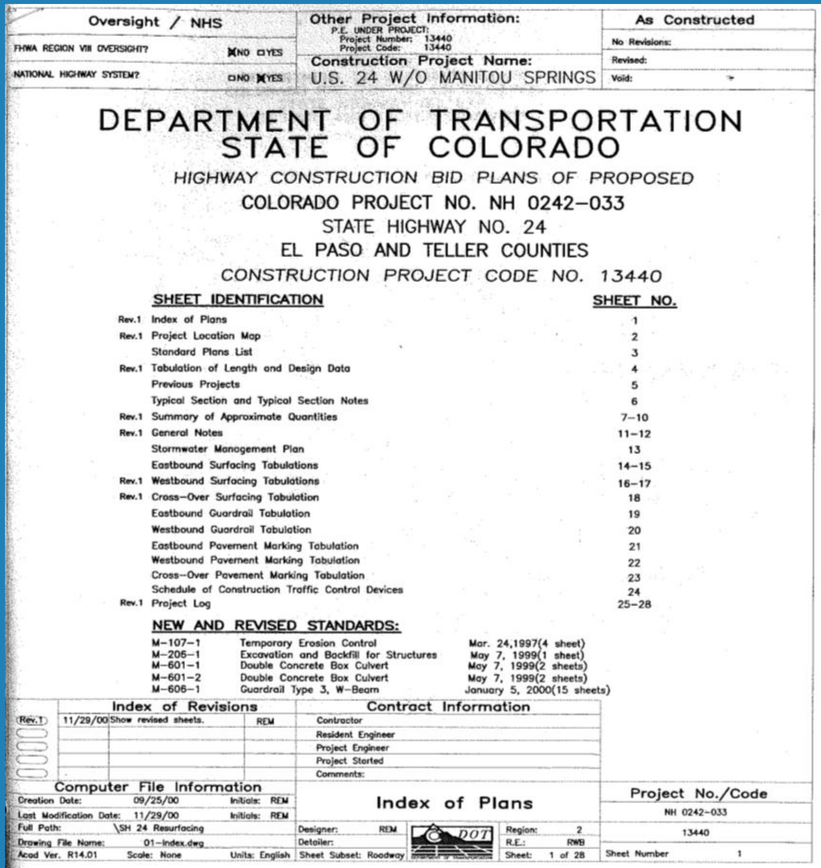
INDEX OF SHEETS

LENGTH AND DESIGN DATA

STA. 1392+00.00 BEGIN FHP 046-1(1)

STA. 1992+43.88 Bk.(Proj.) END FHP046-1(1)=

2000 Resurfacing Project



Oversight / NHS

FHWA REGION VIII OVERSIGHT? ☒NO ☐YES

NATIONAL HIGHWAY SYSTEM? ☐NO ☒YES

Other Project Information:
P.E. UNDER PROJECT:
Project Number: 13440
Project Code: 13440

Construction Project Name:
U.S. 24 W/O MANITOU SPRINGS

As Constructed
No Revisions:
Revised:
Void:

DEPARTMENT OF TRANSPORTATION
STATE OF COLORADO

HIGHWAY CONSTRUCTION BID PLANS OF PROPOSED
COLORADO PROJECT NO. NH 0242-033
STATE HIGHWAY NO. 24
EL PASO AND TELLER COUNTIES
CONSTRUCTION PROJECT CODE NO. 13440

	SHEET IDENTIFICATION	SHEET NO.
Rev.1	Index of Plans	1
Rev.1	Project Location Map	2
	Standard Plans List	3
Rev.1	Tabulation of Length and Design Data	4
	Previous Projects	5
	Typical Section and Typical Section Notes	6
Rev.1	Summary of Approximate Quantities	7–10
Rev.1	General Notes	11–12
	Stormwater Management Plan	13
	Eastbound Surfacing Tabulations	14–15
Rev.1	Westbound Surfacing Tabulations	16–17
Rev.1	Cross-Over Surfacing Tabulation	18
	Eastbound Guardrail Tabulation	19
	Westbound Guardrail Tabulation	20
	Eastbound Pavement Marking Tabulation	21
	Westbound Pavement Marking Tabulation	22
	Cross-Over Pavement Marking Tabulation	23
	Schedule of Construction Traffic Control Devices	24
Rev.1	Project Log	25–28

NEW AND REVISED STANDARDS:

M-107-1	Temporary Erosion Control	Mar. 24,1997(4 sheet)
M-206-1	Excavation and Backfill for Structures	May 7, 1999(1 sheet)
M-601-1	Double Concrete Box Culvert	May 7, 1999(2 sheets)
M-601-2	Double Concrete Box Culvert	May 7, 1999(2 sheets)
M-606-1	Guardrail Type 3, W-Beam	January 5, 2000(15 sheets)

Index of Revisions

(Rev.1) 11/29/00 Show revised sheets. REM

Contract Information
Contractor
Resident Engineer
Project Engineer
Project Started
Comments:

Computer File Information
Creation Date: 09/25/00 Initials: REM
Last Modification Date: 11/29/00 Initials: REM
Full Path: \SH 24 Resurfacing
Drawing File Name: 01-Index.dwg
Acad Ver. R14.01 Scale: None Units: English

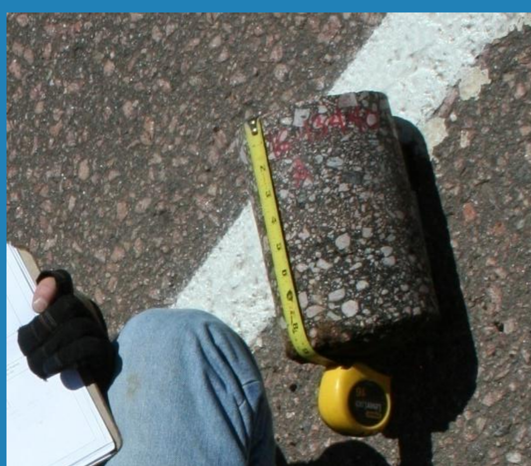
Index of Plans

Designer: REM
Detailer:
Sheet Subset: Roadway

Region: 2
R.E.: RWB
Sheet: 1 of 28

Project No./Code
NH 0242-033
13440
Sheet Number 1

Site Specific Data



Other Testing as Needed

HMA Material Properties Needed for the MEPDG Procedure

Material Property	Input Level		
	1	2	3
HMA Dynamic Modulus	✓	-	-
HMA Repeated Load Permanent Deformation	✓	✓	✓
HMA Indirect Tensile Creep Compliance	✓	✓	-
HMA Indirect Tensile Strength	✓	✓	-
HMA Maximum Specific Gravity	✓	✓	✓
Bulk Specific Gravity of Cores	✓	✓	✓
HMA Mixture Design Sheets	-	✓	✓
Asphalt Specific Gravity	✓	✓	✓
Asphalt Content of HMA Mixture	✓	✓	✓
Asphalt Performance Grade	-	✓	✓
Asphalt Penetration @ 25 °C	✓	-	-
Asphalt Viscosity @ 140 °C	✓	-	-
Asphalt Viscosity @ 275 °C	✓	-	-
Asphalt Viscosity	✓	-	-
Asphalt Softening Point	✓	-	-
Fine aggregate specific gravity & absorption	✓	✓	✓
Coarse aggregate specific gravity & absorption	✓	✓	✓
Sieve analysis of fine & coarse aggregate	-	✓	✓

PCC Material Properties Needed for the MEPDG Procedure

Material Property	Input Level		
	1	2	3
Elastic Modulus	✓	-	-
Poisson's Ratio	✓	✓	✓
Flexural Strength	✓	-	-
Compressive Strength	-	✓	✓
Unit Weight	✓	✓	✓
Coefficient of Thermal Expansion	✓	✓	✓
Thermal Conductivity	✓	✓	✓
Heat Capacity	✓	✓	✓
Surface Shortwave Absorptivity	-	-	-
PCC Zero-Stress Temperature	✓	✓	✓
Cement Type	✓	✓	✓
Cementitious Material Content	✓	✓	✓
Water to Cement Ratio	✓	✓	✓
Aggregate Type	✓	✓	✓
Curing Method	✓	-	-
Ultimate Shrinkage	✓	✓	✓
Reversible Shrinkage	✓	✓	✓
Time to Develop 50 % of Ultimate Shrinkage	✓	✓	✓

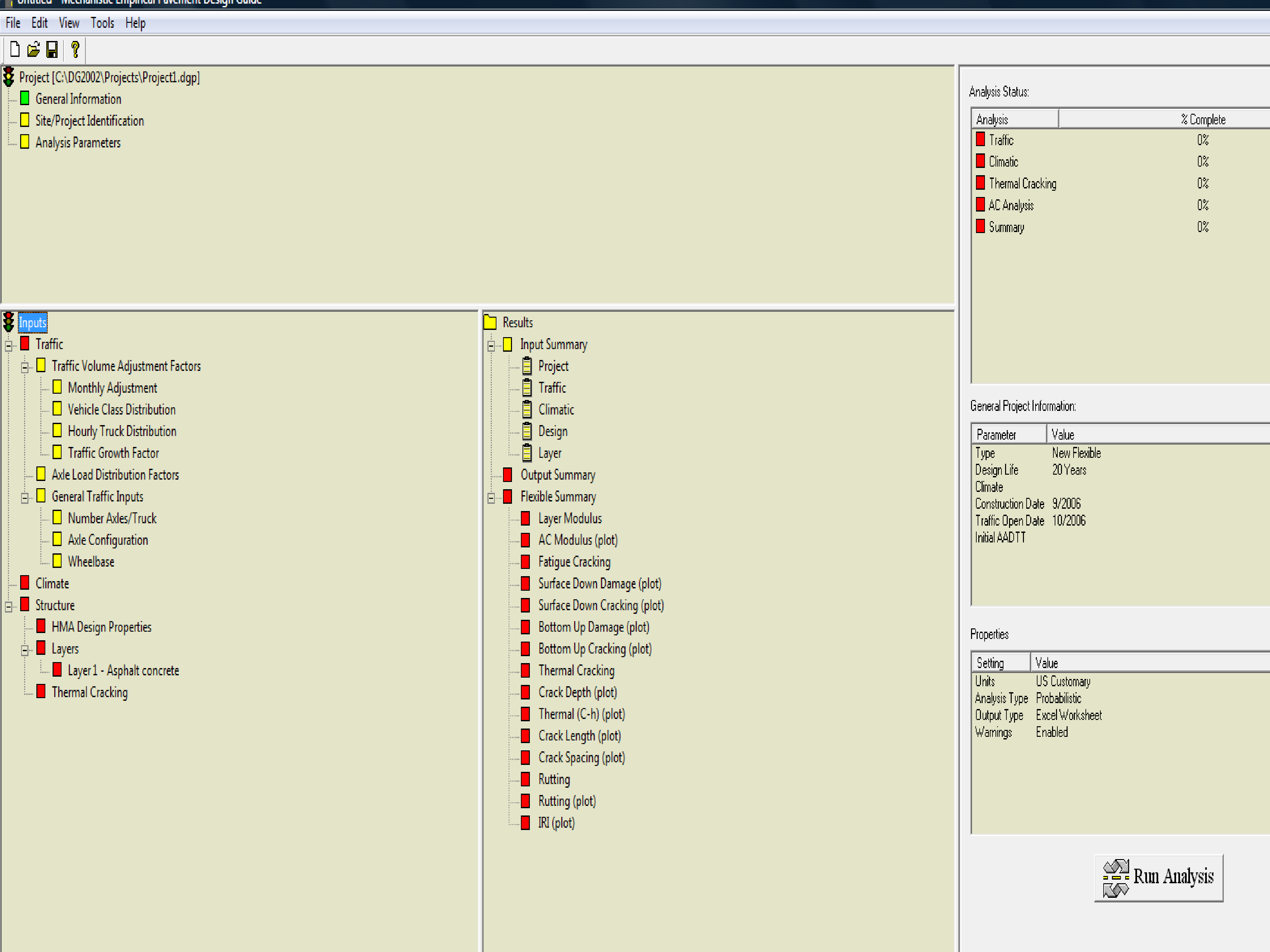
Framework for Model Validation and Recalibration

- **Statistical Approach for Model Validation**
  - Determine Model Prediction Capability
    - Using coefficient of Variation, R^2
  - Estimate Model Accuracy
    - Using standard error estimate (SEE)
  - Determine Bias
    - Hypothesis testing of model intercept and slope for linear model fitting predicted and measured data
      - Slope = 1; Intercept = 0
    - Paired t-test for measured and predicted distress/IRI
- **Non-Statistical Approach for Model Validation**
  - Used when measured distress/IRI was mostly zero
  - Computation of diagnostic statistics not possible or meaningless

Current Status

- ☑ Task 0: Project Kick-Off Meeting and Coordination
- ☑ Task 1: Database Development
- ☑ Task 2: Field Investigations and Lab Materials Testing
- ☑ Task 3: Verification of Current MEPDG
- ☑ Task 4: Local Calibration & Validation of MEPDG Models
- Task 5: Development of CDOT MEPDG Design Manual
- Task 6: Deployment of Concurrent Designs
- ☑ Task 7: Development of Default Input Libraries
- Task 8: Training Program Delivery
- Task 9: Preparation and Submittal of Reports

User Friendly Software


File Edit View Tools Help
Project [C:\DG2002\Projects\Project1.dgp]
General Information
Site/Project Identification
Analysis Parameters
Inputs
Traffic
Traffic Volume Adjustment Factors
Monthly Adjustment
Vehicle Class Distribution
Hourly Truck Distribution
Traffic Growth Factor
Axle Load Distribution Factors
General Traffic Inputs
Number Axles/Truck
Axle Configuration
Wheelbase
Climate
Structure
HMA Design Properties
Layers
Layer 1 - Asphalt concrete
Thermal Cracking
Results
Input Summary
Project
Traffic
Climatic
Design
Layer
Output Summary
Flexible Summary
Layer Modulus
AC Modulus (plot)
Fatigue Cracking
Surface Down Damage (plot)
Surface Down Cracking (plot)
Bottom Up Damage (plot)
Bottom Up Cracking (plot)
Thermal Cracking
Crack Depth (plot)
Thermal (C-h) (plot)
Crack Length (plot)
Crack Spacing (plot)
Rutting
Rutting (plot)
IRI (plot)
Analysis Status:
Analysis
% Complete
Traffic 0%
Climatic 0%
Thermal Cracking 0%
AC Analysis 0%
Summary 0%
General Project Information:
Parameter
Value
Type New Flexible
Design Life 20 Years
Climate
Construction Date 9/2006
Traffic Open Date 10/2006
Initial AADTT
Properties
Setting
Value
Units US Customary
Analysis Type Probabilistic
Output Type Excel Worksheet
Warnings Enabled
Run Analysis

Oh, by the Way…..

- $930,000 – Consultant Contract
- $150,000 – Resilient Modulus for Soils
- $100,000 – Asphalt Mix Performance Tester, Pine Compactor, Incubators and Saws
- $24,000 – Upgrade to FWD
- $15,000 – Coefficient of Thermal Expansion Device
- $15,000 – Flexural Strength Tester
- $40,000 – DARWin ME Annual License fee to AASHTO

Benefit to Colorado

Estimated savings is about 9 % of our resurfacing budget = $14 million per year

- ✓ Cost effective typical sections
- ✓ Higher reliability in designs
- ✓ Improved accuracy of long-term budget
- ✓ Increased ability to model distresses
- ✓ Better assessment of contractor materials

Summary: Colorado's MEPDG

- ☑ Comprehensive tool for pavement design and analyses.
- ☑ Excellent forensic tool!
- ☑ Optimize on design features – not just increase pavement thickness!
- ☑ Accuracy can be quantified.

QUESTIONS?