

# TECHNICAL BRIEF



U.S. Department of Transportation  
**Federal Highway Administration**

## DEFINITION OF PRE-MAPPING

Pre-mapping is defined as measuring base line stiffness of existing support materials using an IC roller. The IC measurement value (ICMV) system is used to estimate stiffness based on acceleration signals caused by roller drum rebound.

The pre-mapping ICMV and its measurement depths—typically 3 to 5 feet—depend on the roller type, weight, drum dimension, vibration frequency and amplitude, speed, direction of travel, and the stiffness of the mapped materials.

Candidate support materials for pre-mapping include granular full-depth reclamation materials or their equivalent. Typically, the IC machines used to pre-map existing pavement subsurface structural support are the same as those used to construct subsequent layers. In order to prevent “double jump” during pre-mapping, the IC machine settings (including speed, vibration frequency, and amplitude.) must be carefully selected.

With IC, teams can identify soft spots during construction and make corrective actions. If the soft spot was caused by excess moisture in the soil, the materials can be disked and aired out before recompaction. If the soft spot occurred due to insufficient moisture, water can be added to the materials before recompaction.

# INTELLIGENT COMPACTION FOR PRE-MAPPING

## TECHNICAL BRIEF



*A double drum IC roller pre-mapping the granular base at Route 4, MN under the TPF-FHWA IC study.*

## BACKGROUND

Intelligent compaction (IC) is an equipment-based technology to improve quality control of compaction. IC vibratory rollers are equipped with a high precision global positioning system (GPS), infrared temperature sensors, an accelerometer-based measurement system, and an onboard color-coded display. IC has been used to improve compaction control for various pavement materials including granular and clayey soils, subbase materials, and asphalt materials.

Pre-mapping originated as a research activity on the 2008 FHWA TPF IC project in Minnesota. The project team used a Sakai double-drum IC roller to measure the baseline support condition by mapping subbase materials at low vibration frequency and amplitude prior to the asphalt layer construction at Route 4. Later during paving, construction traffic caused the asphalt layer to fail prematurely. A soft spot had occurred—and the team later realized they could identify the soft spot in the pre-mapping data. Due to this discovery, the industry now recognizes the value of pre-mapping: the data collected by pre-mapping can help construction team identify potential soft spots before pavement failure.

As of today, several state department of transportation (DOT) IC specifications include pre-mapping as an option or requirement. This tech brief intends to provide the best available technical information regarding pre-mapping in order to clarify its advantages and limitations.

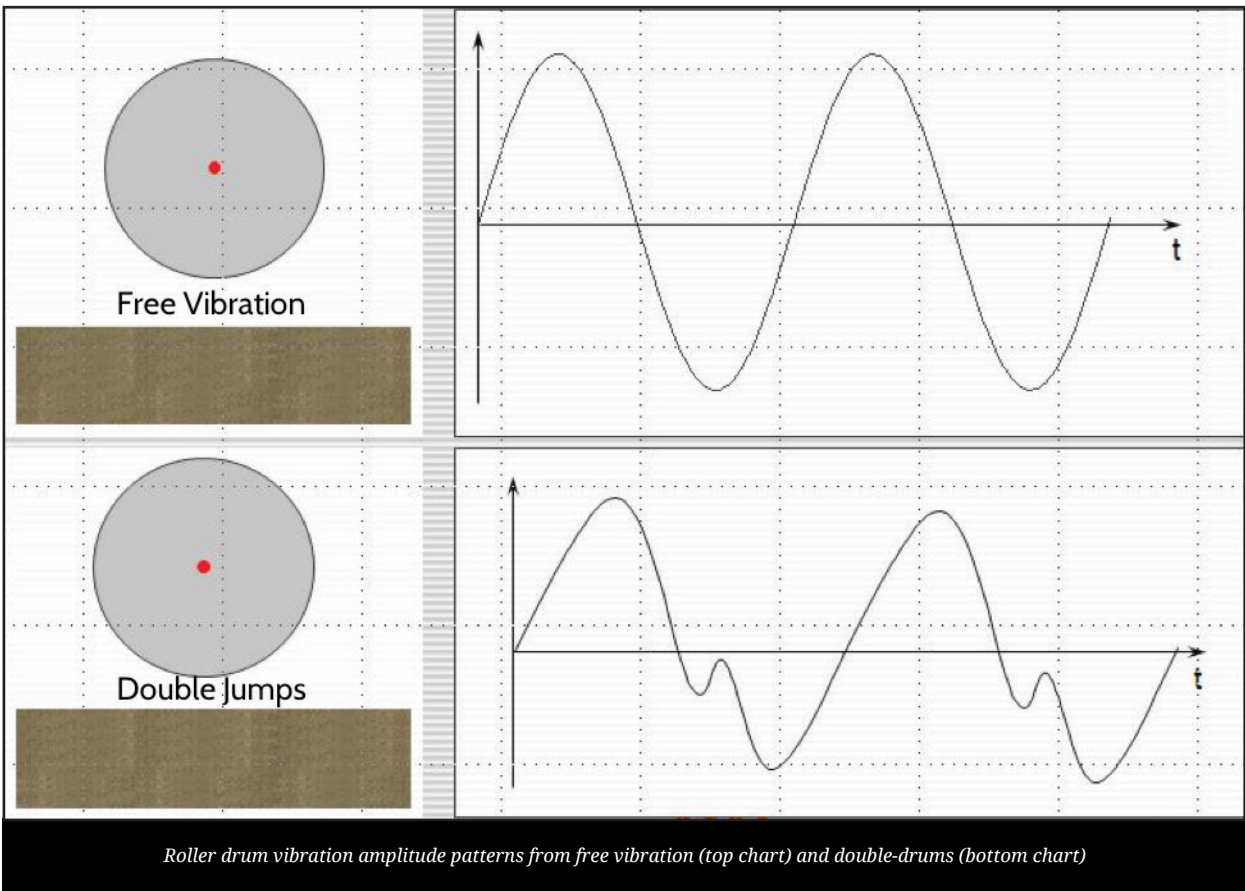
# DOUBLE JUMP RESPONSE

The IC roller is designed to compact relatively loose materials to a stiffer and denser state. However, if the compacted materials become too stiff, the harsh rebound of the drum can cause the IC roller to vibrate in the air before hitting the ground.

This motion is called a “double jump,” and it can lead to machine instability, damages to the machine, damage to the IC components, and other concerns.

During double jump conditions, the IC roller applies force to the compacted materials and the materials’ stiffness causes the drum to bounce off the hard surface and skip the next amplitude wave directing the drum back towards the surface. Double jumping can occur during both pre-mapping and during normal compaction operations.

Double jumping can also damage the underlying materials layer, as a heavy machine is literally “bouncing” down the road. What may have been a sound layer may now be damaged by pre-mapping.



## DOUBLE JUMP WARNING AND WARRANTIES



*A double drum IC roller conducting pre-mapping under the FHWA-TXDOT IC Retrofit study.*

When the roller is experiencing double jumping, the ICMV system does not register reliable readings due to the amplitude wave anomaly received by the accelerometer. In light of this issue, some vendors provide warning systems.

One of these systems, Active Bouncing Control, alerts roller operators to double jumping and will automatically turn off the roller vibration if the operator ignores the alert.

Some aftermarket systems also alert the operator by displaying a “decoupling” alarm on the display and stops recording a ICMV value when this condition is present.

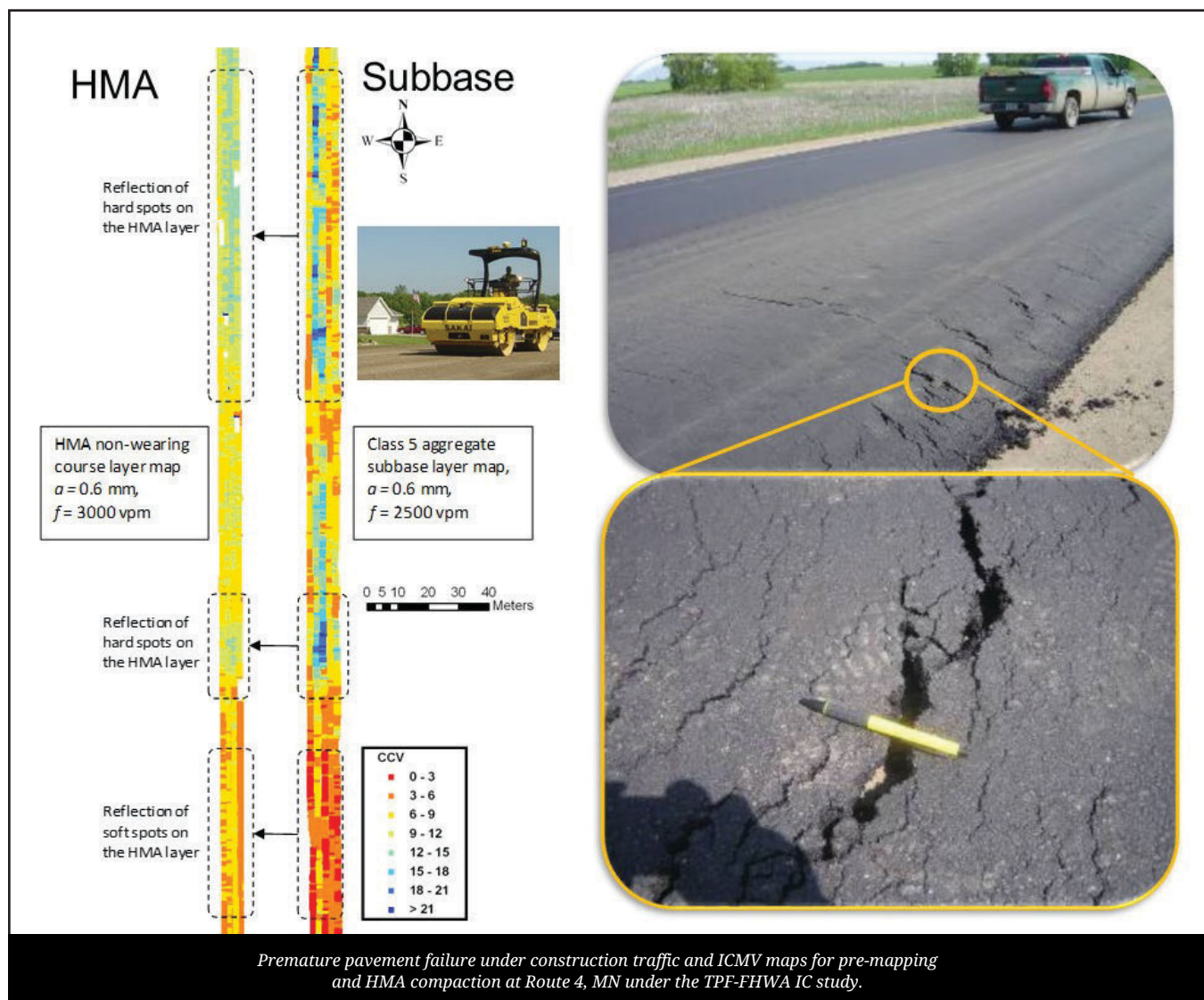
If a roller is damaged during pre-mapping, most manufacturers’ warranties will be voided and the vendors will not be held liable for repair, replacement, or any damages resulting from such use.

## ADVANTAGES AND BENEFITS OF PRE-MAPPING

By implementing pre-mapping, the construction team can find weak areas in otherwise unknown materials. Pre-mapping allows the contractor to focus on those weak areas and reinforce their confidence in areas of higher stiffness.

With this added knowledge, the construction team can conduct additional testing to verify the weak areas and plan and perform corrective actions—such as replacing materials or additional compaction (e.g., after drying out materials or adding moisture, whatever is suitable)—within a reasonable time span.

When pre-mapping allows weaker support areas to be spotted and corrected before subsequent layer construction, the practice significantly benefits long-term pavement performance.

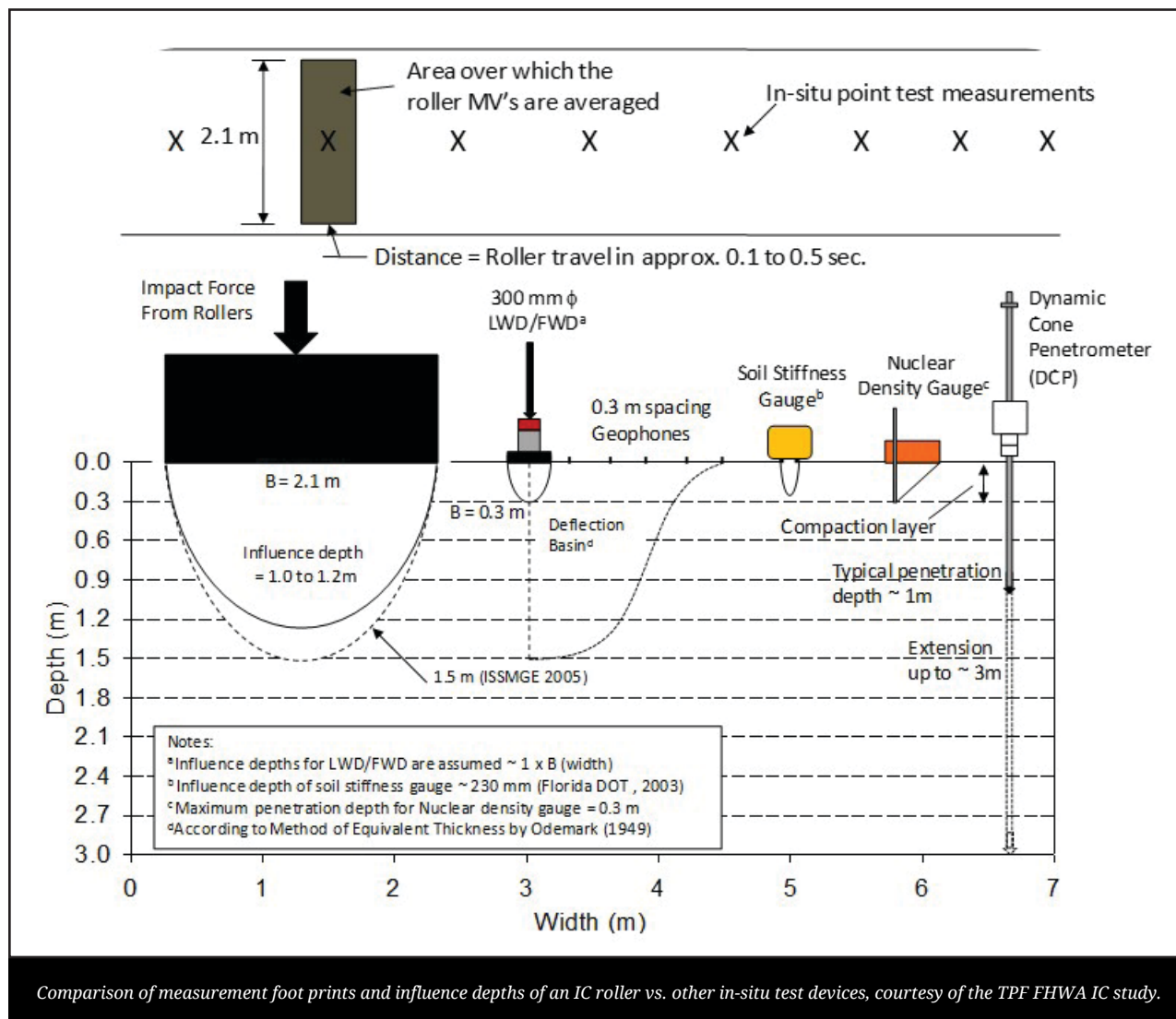


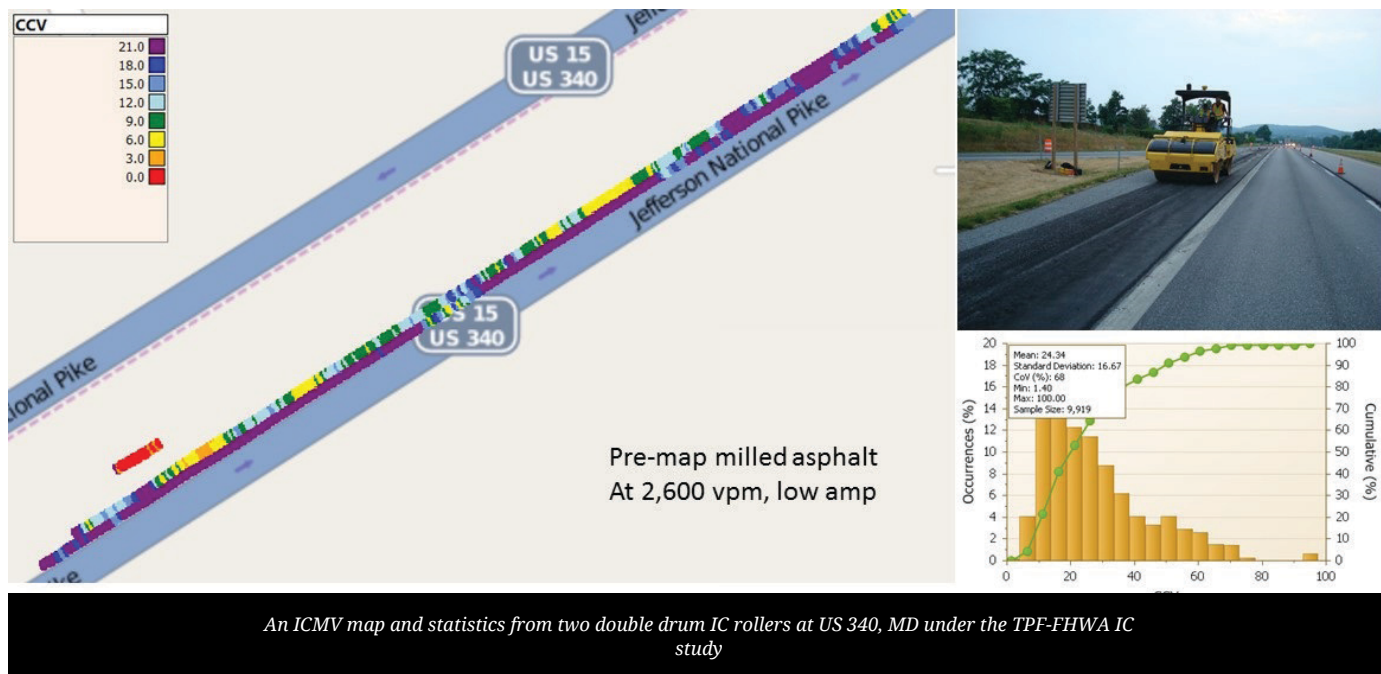
## LIMITATIONS OF PRE-MAPPING

Pre-mapping is limited by the unknown depth of actual soft layer(s) of identified weak spots using the current ICMV technologies. However, ICMV is still evolving and may measure layer-specific mechanical properties in the future (e.g., on-going NCHRP 24-45 research).

Additionally, further research is needed to define the range of ICMV values for weak spots based on the influence factors of ICMV that were stated above. The question of “how weak is too weak” does not yet have a definitive answer.

When pre-mapping stiffer materials, roller frequency and amplitude need to be lowered to prevent double jumps. However, using lower frequency/amplitude settings may limit the measurement depth and thus usefulness of pre-mapping.





## POTENTIAL DAMAGES CAUSED BY DOUBLE-JUMPING

IC vendors report several types of potential damage caused by rollers double jumping during pre-mapping stiff materials such as milled existing asphalt pavement. According to a vendor's recent study, double jumping can cause the following damages:

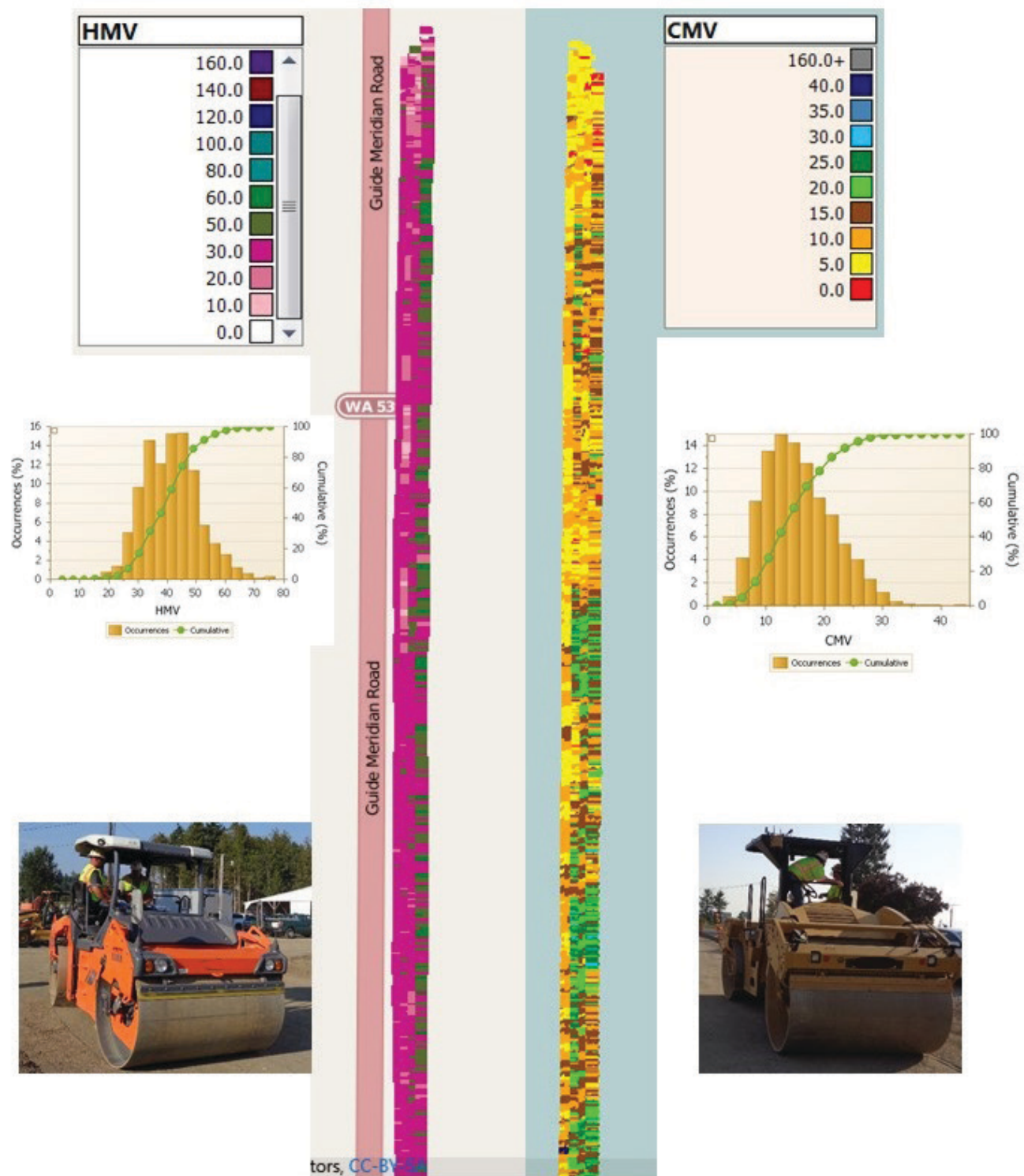
### 1. Damage to drums

- Cracks and damages on the drum main body and welding
- Excessive wearing of drum steel plates
- Damage to the bearing of the vibratory eccentric shaft
- Loosened bolts located on the drum axles, hydraulic motors, etc.

### 2. Damage to machine frame and structure

- Cracks on welding between side plates and cross members
- Loosened bolts between frames, isolator brackets, sprinkler systems, etc.

### 3. Damage to or deterioration of the existing pavement



A comparison of ICMV maps from double drum IC rollers pre-mapping the granular base at SR 539, WA under FHWA IC HMA In-Place Density Study.

## CONTACT

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**FHWA-HIF-13-049**

## RECOMMENDATIONS

FHWA recommends the following based on currently available technical information regarding pre-mapping:

- Further research on benefits and limitations of pre-mapping is warranted.
- Pre-mapping is recommended on granular soils materials or similar.
- Pre-mapping stiff materials such as existing or milled asphalt pavements, or concrete pavements is highly not recommended.
- Double jumps should be prevented during pre-mapping or common compaction operations.

