# INVENTORY BASED RATING SYSTEM: A STABLE AND IMPLEMENTABLE METHOD OF CONDITION ASSESSMENT FOR UNPAVED ROADS

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**ABSTRACT**

The current rating systems for unpaved roads lack stability and reliability and, therefore, provide little benefit as a project- or network-level metric. Since many of these systems are derived from paved road assessment systems, they focus heavily on surface distresses rather than road width, drainage, and other features. Because unpaved roads can change rapidly, measuring surface distresses is an unreliable rating factor. The Inventory-Based Rating (IBR) system assesses unpaved roads on Surface Width, Drainage Adequacy and Structural Adequacy. These features impact road users and have significant costs associated with creation and maintenance. The system defines a baseline condition for each inventory feature with its tiered *good-fair-poor* rating. Five counties, selected based on their road network classification, participated in a pilot IBR data collection. User feedback was also collected from participants. The study showed very high repeatability and reliability of the IBR system. It also provided productivity benchmarking, which can forecast the time commitment for data collection. User feedback resulted in modifications to the system.

*Keywords:* unpaved roads, gravel roads, condition assessment, inventory based rating, asset management, pavement management

## INTRODUCTION

Road-owning agencies in Michigan use the Pavement Surface Evaluation and Rating (PASER) (*1,2,3*) system to assess and report paved road (e.g., asphalt, concrete, and sealcoat) conditions. The PASER system has been used since the early 1990s as a cost-effective, network-level metric for reporting to the Michigan Legislature. Since 2002, the Michigan Transportation Asset Management Council (TAMC) has been collecting and reporting PASER data on paved roads to the Legislature (*4*). The TAMC also reports the condition of public bridges in the state using the National Bridge Inventory (NBI) rating system. However, the TAMC has not identified a condition assessment system for unpaved roads that satisfactorily provides a cost-effective and stable network-level measure that benefits local road managers. Therefore, Michigan Technological University's Center for Technology & Training (CTT) developed the Inventory Based Rating (IBR) System. Colling and Kueber-Watkins detail the genesis of this assessment system in the research report *Inventory Based Assessment System for Unpaved Roads*, submitted to TAMC (*5*). This report outlines the testing and implementation of the IBR system for possible statewide implementation.

### Limitations of Existing Unpaved Road Assessment Systems

Condition assessment systems serve two purposes: providing project-level guidance that infers the necessary treatment for a given asset and providing a network-level metric to evaluate overall system performance. The PASER system, for example, offers project-level guidance through condition ratings that help road owners determine appropriate treatments (*1,2,3*) on paved roads; it also offers network-level measures that enable efficient, easy determination of the necessary investment for maintaining or working toward a condition target. The best assessment systems serve both purposes.

Many condition assessment systems exist for unpaved roads (*6*). Most unpaved road condition assessment systems evolved from paved road assessment systems and, thus, rely heavily on the extent and severity of surface distresses. For paved road networks, surface condition significantly impacts road use by motorists; it is a quality of the most expensive pavement layer—the surfacing—and its decline typically drives improvement work. Surface distress works well for measuring the quality of paved roads because surface distresses change slowly, remaining relatively static over the course of a year (*1,2,3*), and require significant effort to repair. Because of this slow rate of change, a condition rating every one to two years provides sufficient data for managing paved roads.

Unlike paved roads, unpaved roads can have rapid surface condition changes (over weeks or even days), making surface condition data quickly outdated (*7*) and yielding a highly variable network-level metric. In addition, poor unpaved road surface condition does not always reflect loss in road value or the surfacing's life, and may be rectified by low-cost grading. Furthermore, the quality of other inventory elements—such as adequate ditches and culverts, minimum lane widths, shoulders, and sufficient structural gravel to support loads—can adversely influence road use. Many road users, for example, consider potholes or ruts on an unpaved road as a secondary inconvenience compared to a narrow surface width that precludes the operation of two-way vehicle traffic at any significant speed. Finally, many unpaved roads do not contain basic inventory elements that are common to paved roads and fluctuate greatly in design, construction, use, and upkeep. Thus, an exclusive focus on surface condition is problematic for unpaved roads.

### Premise of Inventory-Based Rating System

The IBR system (*5*) assesses conditions for three characteristic elements of unpaved road. These elements—Surface Width, Drainage Adequacy and Structural Adequacy—were selected for use in the IBR based on their impact on road use and based on the level of investment required to create them. Since these IBR elements do not change rapidly, a rating only requires updates when construction activities occur or when lack of maintenance leads to loss or degradation of a road feature; but, when these features do degrade, they require significant construction or maintenance efforts to improve. Monitoring the IBR inventory features over time at a network level provides measures that illustrate the impact of investments on the unpaved road network.

Defining a baseline or *good* condition for each of the IBR elements creates a reference for road comparison; each element's baseline is determined by characteristics that are considered acceptable for the majority of road users with guidance from design standards. Not meeting the baseline condition results in a lower rating. Each of the three IBR elements have three ranges of classification—*good*, *fair*, and *poor*—based on ranges of physical characteristics. IBR elements are apparent enough to be evaluated from a moving vehicle and do not typically require hand measurement. More information on the genesis of the specific criteria and bin ranges for each rating factor can be found Colling and Kueber-Watkins' report (*5*).

The *good*, *fair*, and *poor* ratings for each IBR elements (detailed below) are used to accrue rating points in the IBR's nine-point system, while a rating point of ten is reserved for newly constructed pavements. For the element being rated on a road segment, criteria that meet the baseline condition (*good* rating) generate more points. The points system used for IBR approximates the PASER scale. More detail on the derivation of IBR points can be found in the report by Colling and Kueber-Watkins (*5*).

The IBR system uses the following criteria:

*Surface Width*

Surface width is assessed by estimating the width of the traveled portion of the road, including travel lanes and any travel-suitable shoulder.

- Good – Surface width of 22 feet (6.7 meters) or greater
- Fair – Surface width between 16 to 21 feet (4.9 to 6.4 meters)
- Poor – Surface width of 15 feet (4.6 meters) or less

*Drainage Adequacy*

Drainage adequacy is assessed by, first, estimating the difference in elevation between the ditch's flow line or level of standing water (if present) and the top edge of the shoulder and, second, determining the presence or absence of secondary ditches (high shoulder) that are able to retain surface water.

- Good – Two feet (61 centimeters) or more of difference in elevation; no secondary ditches are present
- Fair – Between 0.5 and 2 feet (15 and 61 centimeters) of difference in elevation; or, 2 feet (61 centimeters) or more difference in elevation where secondary ditches are present
- Poor – Less than 0.5 feet (15 centimeters) of difference in elevation; secondary ditches may or may not be present

*Structural Adequacy*

Structural adequacy is assessed by the presence or lack of structural distresses (rutting or large potholes) during the previous year that required emergency maintenance for serviceability. If data are unknown, an estimate of the thickness of good quality gravel (crushed and dense graded) can be used. Ratings should be based on local institutional knowledge and should not require involved testing or probing of existing conditions.

- Good – No structural rutting (1 inch [2.54 centimeters] or more) or major potholes (3 feet [0.9 meters] or larger); or, 8 inches (20 centimeters) or more of good gravel.
- Fair –Limited structural rutting and/or some major potholes during the spring or wet periods requiring emergency maintenance grading; or, gravel thickness is 4 to 7 inches (10 to 18 centimeters), so additional gravel material could be added (e.g., placement of 1 to 4 inches (10 centimeters) of good quality gravel).
- Poor – Structural rutting and/or major potholes are apparent during much of the year requiring frequent emergency maintenance grading or pothole filling; or, gravel thickness is less than 4 inches (10 centimeters), so significant additional gravel material should be added (e.g., placement of 5 to 8 inches (13 to 20 centimeters) of good quality gravel).

## OBJECTIVE AND SCOPE

This study aimed to estimate the scope, cost, and other planning factors necessary for potential statewide IBR collection. The study gathered data on various types of unpaved roads in Michigan—with differences in users and network types—under real world conditions to determine the repeatability and accuracy of the IBR system. The study also benchmarked data collection speeds, determined training and guidance needs, and secured direct feedback from transportation professionals who would collect and use IBR data. This study sought to define the type of information necessary for implementing full-scale collection and provided a means for assessing the value of these data as a local agency road-management tool through direct user feedback.

## METHODS

### Selection of Data Collection Locations

Michigan's unpaved roads vary greatly from county to county in their use, construction, distribution and maintenance. Based on overall function, management, and maintenance, the project team defined three classifications of unpaved road networks (see Figure 1):

*Low Volume Terminal Branch Networks*

These unpaved roads provide access to only a few properties, are primarily the "ends" of the road system, and are often seasonal roads. They experience low traffic volumes. Counties in the Upper Peninsula and northern Lower Michigan generally fall into this category.

*Agricultural Grid Networks*

These unpaved roads support the local agricultural economy by providing regular access to farm fields. They experience seasonally higher volumes of traffic and larger truck loads. Generally, these networks are maintained all year because they serve both residents and agriculture.

*Suburban Residential Networks*

These unpaved roads enable year-round local access to rural residential properties located near urban centers. These roads serve predominantly passenger vehicle traffic. These road networks are near urban centers and are typically located in the population belt between Grand Rapids and Detroit.

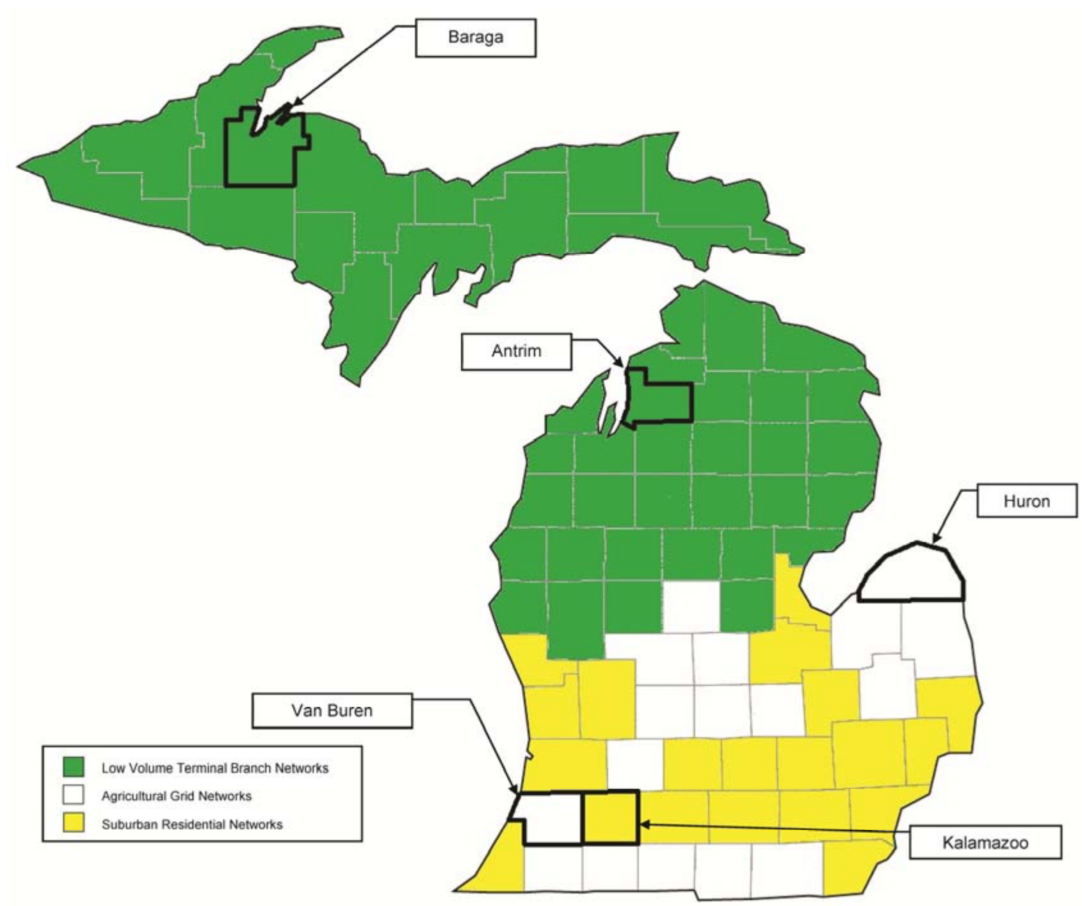



**FIGURE 1 Qualitative classification of counties based on unpaved road network type. Volunteer pilot counties outlined in bold.**

The study sought to collect 1,000 miles of unpaved road rating data using the IBR system in a minimum of four counties, at least one from each type of network classification spread throughout the state. This sample size could enable accurate predictions for statewide data collection rates, determination of the validity of the system, and necessary improvements to the training materials. Cooperation was voluntary: county road commission and regional planning staff participated in the study at their own expense.

## Pre-Field Work Training

Prior to rating unpaved roads, engineers from the CTT trained participating agency employees and planning agency representatives. First, participants received the *Inventory Based Assessment Systems for Unpaved Roads* report for their review. Then, participants took part in a two-hour training presentation and in-class rating exercises that provided experience using the IBR system. They also received a two-page quick reference handout that detailed the IBR criteria (Figure 2).

PILOT

# INVENTORY-BASED RATING FOR UNPAVED ROADS

PILOT

| | GOOD | FAIR | POOR |
|---|---|---|---|
| **Width** | 22 feet or greater in surface width<br><br>Vehicles have sufficient room to pass by each other when approaching in the opposite direction. Reduction of speed is unnecessary.<br><br>**Remedy/Action:** None | 16 to 21 feet in surface width<br><br>Vehicles should reduce speed to pass by each other when traveling in the opposite direction.<br><br>**Remedy/Action:** 1' to 6' of widening | 15 feet or less in surface width<br><br>One vehicle should slow down and pull over and the other should reduce speed to pass by when traveling in the opposite direction.<br><br>**Remedy/Action:** 7' to 15' of widening |

**Width Rating Guide:** Include any shoulder in the width that is suitable for travel.
- Quick Tip: When driving at 20 mph, does the driver feel they need to slow down when approaching another vehicle in the opposite lane?

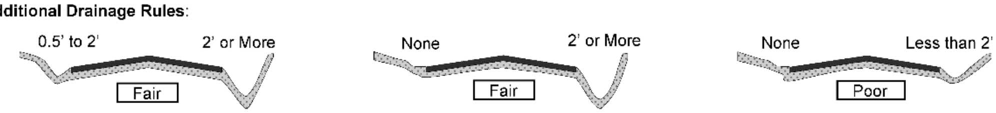
**Drainage Adequacy**

**Distance X** is the difference in elevation from the ditch flow line (or any standing water, whichever is less) to the top edge of the shoulder.


| | GOOD | FAIR | POOR |
|---|---|---|---|
| **Drainage Adequacy** | **Distance X is 2 feet or more,** and:<br><br>No secondary ditches are present. | **Distance X is 2 to 0.5 feet** (if secondary ditches are present or not), or:<br><br>**Distance X is two feet or more,** where:<br><br>Secondary ditches are present. | **Distance X is less than 0.5 feet,** and:<br><br>Secondary ditches may or may not be present. |
| | **Remedy/Action:** None | **Remedy/Action:** Ditches or swales are present but they need to be cleaned out and/or remove secondary ditches. | **Remedy/Action:** Ditches need to be created. |

**Drainage Rating Guides:**
- Rate the condition that is typical of the entire segment.
- Beware of being influenced by conditions that would not warrant ditching i.e., ditches are usually not needed on the top of hills.
- If driveway culverts are needed, then the drainage is most likely poor.

**Additional Drainage Rules:**




| **Structural Adequacy** | ***Historical Measure*** | GOOD | FAIR | POOR |
|---|---|---|---|---|
| | **1 inch ruts or 3 foot potholes** | Did not develop throughout the year | Developed during the spring or very wet periods | Developed during much of the year |
| | **Emergency maintenance to make road passable was** | Not required leaving the road passable throughout the year (when plowed) | Necessary to make the road passable during wet periods | Required to make the road passable throughout the year |
| | **Alternately, existing gravel thickness of** | 8 inches thick or more | 4 to 7 inches | Less than 4 inches |
| | **Remedy/Action:** | None | Placement of 4 inches of good quality gravel would be recommended as a fix (assuming drainage is good*) | Placement of 5 to 8 inches of good quality gravel would be recommended as a fix (assuming drainage is good*) |

**Structural Rating Guides:**
- Rate by *Historical Measure*, if you don't know the history of a segment ask someone who does, otherwise:
  Are potholes present? *or* Is gravel not present on surface?
    Yes: rate it Poor, monitor it for a year and re-rate next year by *Historical Measure*.
    No: rate it Fair, monitor it for a year and re-rate next year by *Historical Measure*.

*Look into what is causing structural problems because more gravel is not a good remedy for bad cross slope drainage.

2015 Pilot V5



**FIGURE 2 Front page of the IBR system's quick-reference guide.**

## Data Collection Methodology

This study had three discrete data collection events. The first event gathered IBR data (i.e., Surface Width, Drainage Adequacy, and Structural Adequacy) and productivity benchmarks (i.e., time spent rating and miles rated) in each county over one to two days per county. Each roadway segment received an IBR of *good*, *fair*, or *poor* according to the IBR system for each of the three inventory elements. Team consensus determined IBR data for each road, and every individual team member generated "blind" IBR data for random road segments.

The second data collection event verified gravel thickness at randomly selected locations. The CTT project team measured gravel depth on a sample of the rated roads in each county. These gravel depth measurements determined the accuracy of local agency staff knowledge about road structure. The third data collection event is addressed in the section *Combined PASER and IBR Data Collection*, below.

## Inventory Based Rating Data Collection

In order to gather IBR data quickly and accurately, collection tools included Roadsoft and the Laptop Data Collector (LDC) software programs, which would likely be used in full-scale collection. Roadsoft is a GIS-based asset management program used by agencies in Michigan for storing, managing, and analyzing roadway assets and associated data. The LDC facilitates field collection of data for Roadsoft by connecting with a recreational-grade GPS to associate spatial locations with the data. Roadsoft and the LDC use a statewide unified Framework base map for Michigan, allowing data stored in Roadsoft to be related to other regional and state-level agencies.

Prior to the data collection event, each county provided the project team with a copy of their Roadsoft database. From this initial inventory of each county's unpaved roads network, the project team planned the routing and size of collection areas with each agency's management, engineering staff, and foremen. Selected portions of the unpaved road networks were to be representative of the county and were to generate useful data for agency management. Subdividing data collection areas by township yielded meaningful reporting blocks and reflected individual township policy for constructing and maintaining unpaved roads.

During field collection, collection teams entered IBR data into the LDC, which minimized transcription or location errors. For safety reasons, field collection involved a minimum of three raters, with duties being driving, data entry, or navigating. To minimize their influence on raw data collection, the CTT staff entered data into their own LDC and did not direct or guide ratings from the collection team. Data collection occurred on a continuous basis from a moving vehicle except when stops were necessary to investigate hard-to-see or hidden features. To orient collection teams to field conditions, initial data collection efforts involved physical checks of road width and ditch depth using a tape measure. Each team member determined an IBR, and all members agreed upon a rating. When they lacked a consensus, raters and the project team employed physical checks to determine a rating.

At random intervals (every 20 to 60 minutes) during data collection, teams made blind ratings of road segments. For blind ratings, raters individually ascertained, rated, and recorded a rating based on observing IBR elements from the vehicle; team members were not permitted to exchange information or talk. After all team members submitted a rating, the group discussed the ratings until they reached a consensus. Raters then verified the accuracy of the Surface Width and Drainage Adequacy consensus ratings using physical checks; the local agency representative verified the Structural Adequacy consensus rating since gravel thickness could not be measured during field data collection. The CTT project team recorded consensus ratings in the LDC.

Assessing productivity involved tracking start/end times (including time travelling to/from data collection areas, but not time spent driving to meet the rating team) and break times (excluding lunch breaks) as well as vehicle miles traveled and miles of road rated. The LDC's tools supplied the rated road mileage data. Rating productivity data represents the teams' overall average collection rate for IBR data without collecting paved road condition or other data.

### Gravel Thickness Data Collection

Following IBR data collection, the CTT project team made at least nine gravel depth measurements (using a core drill or demolition hammer) in each pilot county on random county roads that had been rated during collection events. Gravel thickness was measured at the center of the travel lane on one randomly selected side of the road. These thickness measurements determined the accuracy of Structural Adequacy estimates by the local agency representative, who solely used local knowledge. The CTT project team verified with local agency maintenance staff that no significant additions or removal of gravel occurred between initial ratings and this collection.

### Combined PASER and IBR Collection

The third data collection event occurred only in Baraga County. The rating team collected IBR data for unpaved roads and PASER data for paved roads in a combined collection, and the project team gathered productivity benchmarks for PASER as well as IBR to determine the impact of combined data collection efforts. On the first day, the rating team collected both IBR data on unpaved roads and PASER data on paved roads. On the second day, they collected only PASER data.

### User Feedback

The CTT project team gathered user feedback on the IBR system from the study participants. They collected comments at the training, during rating, and during a post-collection conference call. These comments served to refine the rating system, correct training deficiencies, and identify training areas needing more explanation.

## RESULTS

### Network Classification and IBR Collection Results of Participating Counties

The participating counties were Antrim, Baraga, Kalamazoo, Huron, and Van Buren (refer to Figure 1).

*Antrim County*

Antrim County classifies as a Low Volume Terminal Branch Network because its population was less than 100,000 people (*8*) and more than 40 percent of the land area was covered by forests (*9*). Efficient travel was difficult due to lakes and streams dividing the county. The rated road network predominantly consisted of short-length, low-volume, seasonal, dead-end roads.

Antrim County's rated unpaved roads exhibited narrow widths with both minimal drainage and structural gravel layer, leading to overall low IBR scores. Several unpaved roads in the Framework base map terminated early or were non-existent; thus, data collection verified and documented corrections to the Framework base map, thereby better defining Michigan's road system.

*Baraga County*

Baraga County classifies as a Low Volume Terminal Branch Network because its population was less than 100,000 people (*8*) and more than 40 percent of the land area was covered by forests (*9*). The unpaved roads provide mostly seasonal or very low-volume access to recreational and forest properties. They are often ends of the road network; thus, rating road segments required more total miles (kilometers) of travel. The height of roadside vegetation further complicated productivity by requiring the rating team to exit the vehicle to assess ditch presence/absence and depth.

Baraga County's rated unpaved roads generally had narrow widths (slightly wider than one lane), minimal drainage, and little or no structural gravel layer; this lead to overall low IBR scores. While these characteristics are conventional for very low-volume unpaved roads that enable access to a few rural properties, many of Baraga County's rated non-seasonal, unpaved roads would provide more reliable service to users if they had adequate ditches and gravel.

*Huron County*

Huron County classifies as an Agricultural Grid Network because its population was less than 100,000 people (*8*), its land area has less than 40 percent forests coverage (*9*), and its road network follows one-mile-long-section-line grid patterns. Generally speaking, IBR data collection for Agricultural Grid Networks like Huron County is efficient because the interconnected grid pattern of their unpaved roads permits increased collection speeds. These roads accommodate higher speed, volume, and travel loads, and are reliable for connecting two locations (e.g., farm to market roads).

Huron County's rated unpaved roads were generally wide, fully ditched, and contained significant structural gravel layers; this led to high IBR scores. Notably, all of the townships used for data collection had significantly more unpaved miles (kilometers) of road than paved miles (kilometers).

*Kalamazoo County*

Kalamazoo County classifies as a Suburban Residential Network because its population was over 100,000 (*8*). Kalamazoo County's unpaved network was concentrated along county borders and away from the city of Kalamazoo; the network serves agricultural and rural residential needs. Data for the entire 103.1-mile (106.0-kilometer) network were collected in one day. Kalamazoo County's rated unpaved roads exhibited moderately-poor IBR scores.

*Van Buren County*

Van Buren County classifies as an Agricultural Grid Network because its population was less than 100,000 people (*8*) and its land area has less than 40 percent forest coverage (*9*). Most land use was rural residential and agricultural. The unpaved network interconnects with paved roads, increasing the efficiency of data collection. But, since Van Buren County had more paved roads than Huron County, collecting data required more travel between unpaved segments. As with Baraga County, unpaved roads often had high grass along the shoulders, making Drainage Adequacy assessment difficult. Van Buren County's rated unpaved roads had fair surface widths, fair drainage adequacy, and good structural adequacy leading to moderately good IBR scores.

**Benchmarking Rating Productivity**

Productivity benchmarking can help forecast the time commitment for collecting IBR data for Michigan's gravel roads. Therefore, the CTT project team recorded and calculated IBR data collection speeds to account for the unique geographic and road network features of each county. The main factors that influenced IBR data collection speed were the network classification (which related to the connectivity of the unpaved roads) and the condition of the road being rated (which dictated travel speed). Recorded collection times represent the time actively rating roads or transiting to and from rating segments; however, the collection time does not account for breaks for lunch and switching of rating crews. Table 1 summarizes the productivity benchmarking data for the IBR system. Antrim County's IBR data collection was the slowest. Huron County had the most productive collection.

**TABLE 1 IBR data collection statistics by county. Statistics are indicative of collecting only IBR data on unpaved roads.**

| County | Collection Time (Hr) | Gravel Miles (km) Rated | Rating Productivity in Miles/Hr (km/hr) | Total Miles (km) Driven | Travel Speed in Miles/Hr (km/hr) | Percentage of Total Driven Miles (km) that were Rated |
|---|---|---|---|---|---|---|
| Antrim | 11.50 | 71.976 (115.834) | 6.3 (10.1) | 234.5 (377.4) | 20.4 (32.8) | 31% |
| Baraga | 11.33 | 99.205 (159.655) | 8.8 (14.2) | 238.0 (383.0) | 21.0 (33.8) | 42% |
| Huron | 8.67 | 245.185 (394.587) | 28.3 (45.5) | 289.0 (465.1) | 33.3 (53.6) | 85% |
| Kalamazoo | 9.92 | 103.163 (166.025) | 10.4 (16.7) | 314.0 (505.3) | 31.7 (51.0) | 33% |
| Van Buren | 12.42 | 141.524 (227.761) | 11.4 (18.3) | 318.0 (511.8) | 25.6 (41.2) | 45% |
| **Total** | **53.83** | **661.053 (1063.862)** | **12.3 (19.8)** | **1393.5 (2242.6)** | **25.9 (41.7)** | **47%** |

The time of year likely influences IBR data collection speed as well. Collecting data later in the growing season is increasingly difficult and less reliable since Drainage Adequacy features can become hidden by roadside vegetative growth.

**Combined PASER/IBR Collection Benchmarking**

In Baraga County, two days of IBR-only collection gathered 99.2 miles (159.6 kilometers) of data at 8.8 miles (14.2 kilometers) rated per hour. An additional day of combined IBR and PASER data collection yielded 40.9 miles (65.8 kilometers) of gravel IBR data and 110.4 miles (177.7 kilometers) of paved PASER data for a total of 151.3 miles (243.5 kilometers) of data collected at 20.9 miles (33.6 kilometers) rated per hour. Another additional day of PASER-only data collection resulted in 81.6 miles (131.3 kilometers) of paved PASER data at 14.8 miles (23.8 kilometers) rated per hour. The rate of collecting IBR data and PASER data together was higher than collecting PASER data only or collecting IBR data only due to minimizing the time traveled without rating.

**System Wide IBR Collection Estimates**

This study's overall average rate for using the IBR system on unpaved roads was 12.3 miles (19.8 kilometers) per hour. Thus, to capture the estimated 40,000 centerline miles (64,374 kilometers) of unpaved roads in Michigan requires roughly 3,200 hours of data collection. This averages just under 40 hours of IBR data collection per county.

If one assumes that this study experienced average collection rates and that unpaved roads were evenly distributed in each county, then segregating counties by their road network classification can also provide an adjusted average of the hours needed to collect IBR data. Classifying Michigan's counties by network (refer to Figure 1) yields:

- **46 Low Volume Terminal Branch Networks (Antrim and Baraga Counties):**
  (6.3 mph + 8.8 mph) / 2 = 7.55 mph average collection speed
  *or:* (10.1 kph + 14.2 kph)/2 = 12.2 kph average collection speed
  46 counties X 481 miles (774.1 kilometers) per county / 7.55 mph (12.2 kph) = 2,930 hours
- **17 Agricultural Grid Networks (Huron and Van Buren Counties):**
  (28.3 mph + 11.4 mph) / 2 = 19.85 mph average collection speed
  *or:* (45.5 kph + 18.3 kph)/2 = 31.9 kph average collection speed

17 counties X 481 miles (774.1 kilometers) per county / 19.85 mph (31.9 kph) = 411 hours

- **20 Suburban Residential Networks (Kalamazoo County):**

20 counties X 481 miles (774.1 kilometers) per county / 10.4 mph (16.7 kph) = 925 hours

where mph = miles per hour, kph = kilometers per hour, and 48 miles (774.1 kilometers) is the average per Michigan county based on the estimated 40,000 centerline miles (64,374 kilometers). Therefore, the time to collect unpaved road condition data is approximately 4,300 hours—or roughly 52 hours per county—for IBR-only data collection in Michigan:

**Total Hours**

2930 hours + 411 hours + 925 hours = 4,260 hours total.

The combined PASER and IBR data collection was significantly more productive than IBR or PASER collection alone. Baraga County's combined data collection was 41 percent more productive than PASER collection alone. While this gain would be rare for other network types, the project team believes that combined collection rates averaging 20 mph (32.2 kph) are likely. This means that collecting 100 percent of the 40,000 center line miles (64,374 kilometers) of unpaved roads would only require an additional 2,000 hours–approximately 24 hours per county– during a combined collection event. Table 2 shows system-wide estimates.

**TABLE 2 System-wide IBR data collection estimates.**

| Collection Method | Rating Productivity Miles/Hr (Km/Hr) | Time to Collect 40k Unpaved Miles in Michigan (Hr) | Average Time per County (Hr) |
|---|---|---|---|
| IBR only (average rate) | 12.3 (19.8) | 3,252 | 39 |
| IBR only (segregated by county type) | 7.55 to 19.85 (12.15 to 31.95) | 4,260 | 52 |
| Combined PASER and IBR | 20 (32.2) | 2,000 | 24 |

**Repeatability of Measurement**

Repeatability relies on the accuracy and consistency for each rating team member's perception of road conditions during rating. Accuracy and consistency can be ascertained and validated by subtracting the point values of periodic blind individual ratings from group consensus ratings—or ground truth—for Surface Width, Drainage Adequacy, and Structural Adequacy as well as the overall combined IBR number (see the report *Inventory Based Assessment Systems for Unpaved Roads* (*5*) for details on point value calculations). High match percentages and low points spread for each element indicates accurate and consistent rating.

The study collected 281 blind rating sets from 58 road segments, divided almost equally between the five counties. Blind ratings matched ground truth with a frequency of 92.2 percent for Surface Width, 85.1 percent for Drainage Adequacy, and 90.7 percent for Structural Adequacy (Figure 3). Comparing aggregate IBR values (all three factors are exact matches) from blind ratings and ground truth showed that 72.2 percent were exact matches and 92.9 percent were within a tolerance of plus/minus one rating point on the nine-point IBR scale.

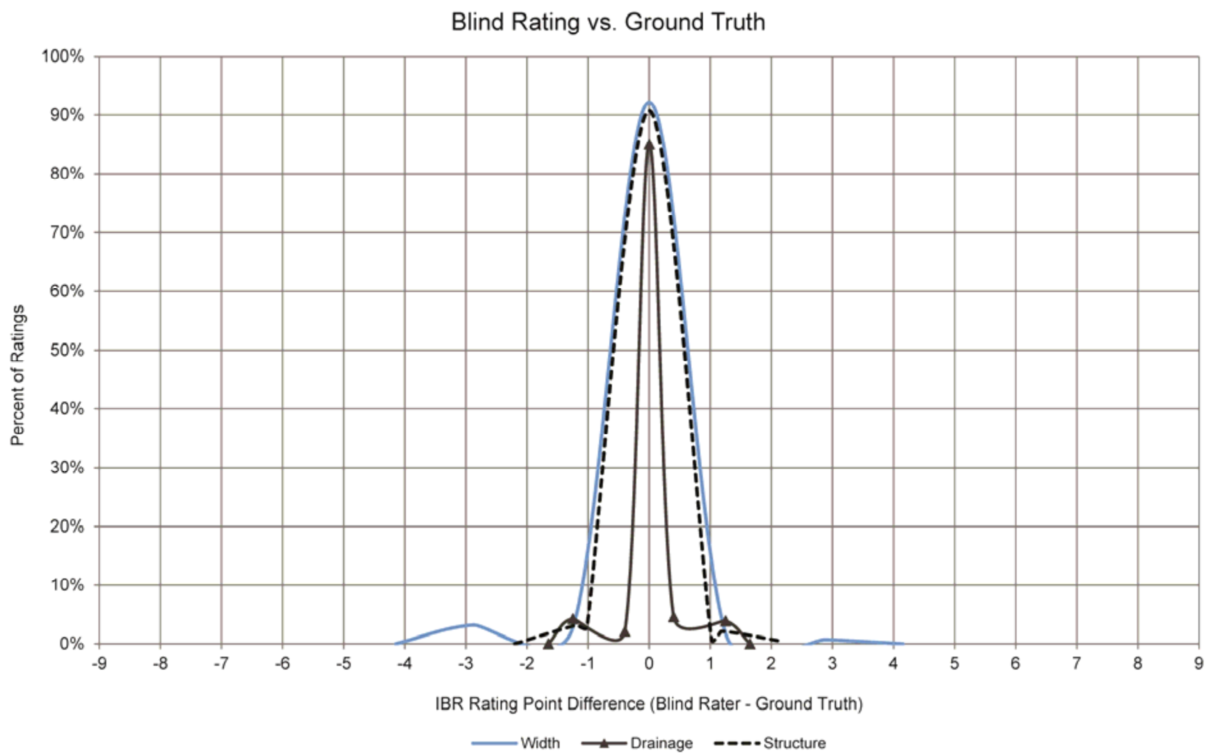



**FIGURE 3 IBR element point difference (rater minus ground truth).**

While ground truth for Surface Width and Drainage Adequacy was verifiable by field measurement, Structural Adequacy required core samples. To determine the accuracy of ratings, the project team compared their field measurements with the assigned Structural Adequacy ratings (which were measurement ranges) that relied on local institutional knowledge. When actual measurements were within the gravel thickness bin range of the consensus rating for Structural Adequacy, they were considered a match. Measurements outside of the bin range were considered errors, with the error amount being calculated as: Actual gravel thickness – Upper/lower bin range = Error amount. Gravel thickness data matched the bin ranges selected by local agency staff 79.6 percent of the time; in the 20.4 percent of thickness measurements that were not exact matches, raters were more likely to overestimate gravel thickness (Figure 4).

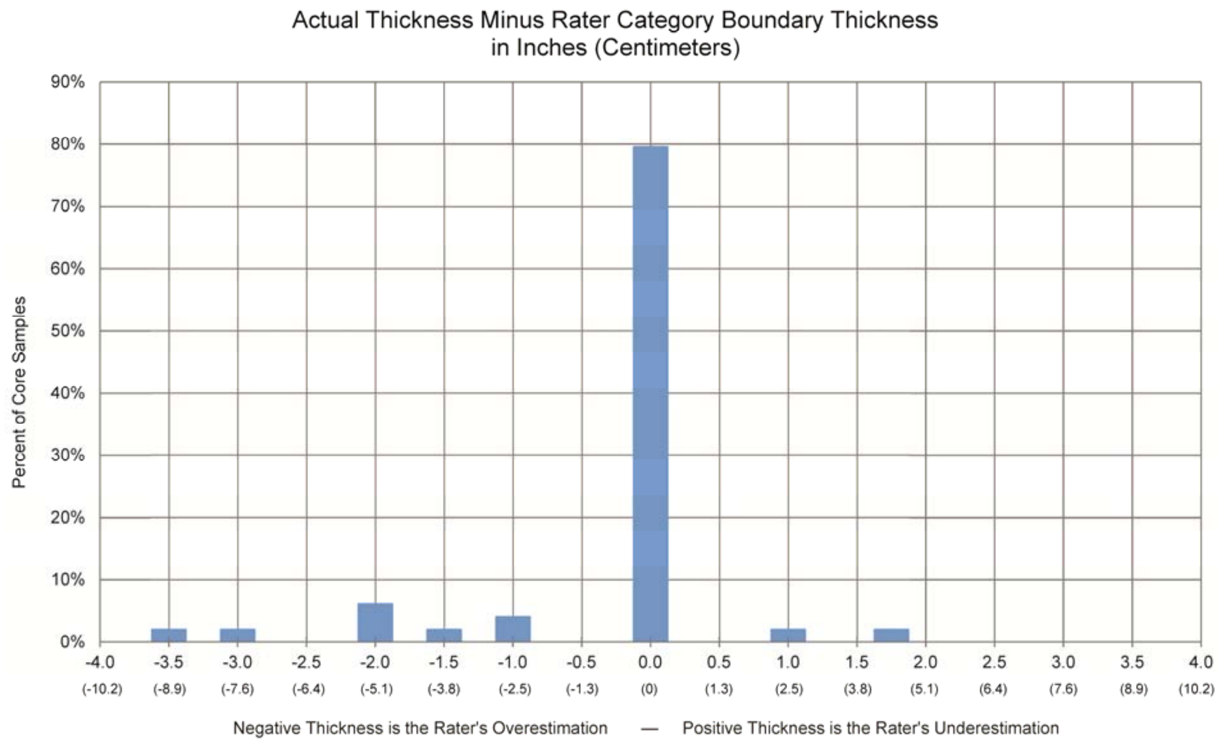



**FIGURE 4 Validation of the institutional knowledge on gravel thickness.**

### Feedback from Users

Participants provided 72 comments during training, data collection, and the post-collection conference call meeting. After removing repeat comments, 63 comments were unique: 13 comments referred to the software tools, 37 comments pertained to the IBR system, three comments involved the training materials, and 10 comments addressed miscellaneous issues.

## CONCLUSIONS

### Recommendation for Modification of the Original System

Overall, user feedback was positive and helpful. Of the 63 unique comments received, 37 comments resulted in modification of the IBR system, training materials, and/or software. Twenty-six comments were not addressable.

### Modifications to the Drainage Adequacy Measurement Rating Guidance

The original IBR system dictated an average rating for Drainage Adequacy, that is, *fair* for a road where one side is *good* and the other is *poor*. Antrim County Engineer Burt Thompson suggested rating only the worst side of the road when conditions on each side differ. The revised IBR system, thus, simplifies Drainage Adequacy to depend upon the rating for the worst side.

### Modifications to the Structural Adequacy Measurement Rating Guidance

The original IBR guidance suggested that roads with *good* Structural Adequacy have 8 inches (20 centimeters) or more of gravel and roads with *fair* Structure Adequacy have 4 to 7 inches (10 to 18 centimeters): this guidance was non-contiguous between the *good* and *fair* category. The revised *good* Structure Adequacy category eliminates this gap by changing the *good* range to greater than 7 inches (18 centimeters).

Several agencies suggested modifying the range of gravel thickness based on their practices. The AASHTO Design Catalogs (*7, 10*) recommend aggregate base thicknesses for unpaved roads that have not had in-depth road design analyses. These recommendations depend on United States Climatic Regions. Since Michigan is in Climatic Region III, the recommended aggregate thickness ranges from 6 to 17 inches (15 to 43 centimeters) depending on traffic volume and subgrade quality. Most of AASHTO's recommendations for aggregate thicknesses are close or exceed the *good* IBR range. Therefore, the *good* Structural Adequacy range for the IBR system was not modified.

### Concerns Over the Intent of *Good-Fair-Poor* Designations

The *good-fair-poor* designations intuitively gauge inventory features relative to a baseline condition. Those designations were neither an indictment nor endorsement of a network's condition. However, local agencies expressed concern over the stigma associated with *good*, *fair*, and *poor* designations. Similarly, when Michigan began PASER collection, agencies perceived a stigma associated with the rating scale, but that dissipated with education and experience. The CTT project team believes that IBR system education will alleviate these perceptions.

### Repeatability/Reliability of the System

Repeatability of the IBR system was very high both on individual inventory features and the aggregate IBR number when comparing consensus ratings (control) to individual ratings (blind). Individual IBR numbers were identical to consensus IBR numbers 72.2 percent of the time and were within a tolerance of plus/minus one rating point 92.9 percent of the time. In comparison, the best year for PASER agreement (2008) had only 48 percent of ratings as exact matches between rating teams and 86.6 percent within a tolerance of plus/minus one point. The Drainage Adequacy element had the lowest exact match percentage for blind ratings versus the control at 85.1 percent. The CTT project team believes that high vegetation on roadway shoulders negatively influenced the agreement on Drainage Adequacy ratings since obscured ditches could not be examined or measured during blind ratings. With regard to Structural Adequacy, the high accuracy for estimating gravel thickness using local knowledge and surface observations—79.6 percent of the time—illustrates that local agencies know the structure of their unpaved roads.

## RECOMMENDATIONS FOR IMPLEMENTATION

Based on this pilot data collection, the following recommendations can be made for agencies considering implementation of the IBR system: First, IBR data should be collected when roadside vegetation is short, which would increase the repeatability of Drainage Adequacy ratings. Second, initially-collected IBR data should be updated after any road project that changes IBR features, such as ditching, widening, addition of gravel, or paving. This method would tie investment reporting to updating the IBR, which is easily recorded in Roadsoft as projects are completed. Third, re-rating the entire network should occur on a three- or four-year cycle to detect changing conditions outside of construction projects, such as changes due to loss of gravel or ditch sedimentation. Fourth, IBR and paved road condition data, such as PASER data, should be collected concurrently to improve efficiency of collection.

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