Western Federal Lands Highway Division

Yale-Kilgore Road Safety and Traffic Assessment

SAFETY DATA CASE STUDY
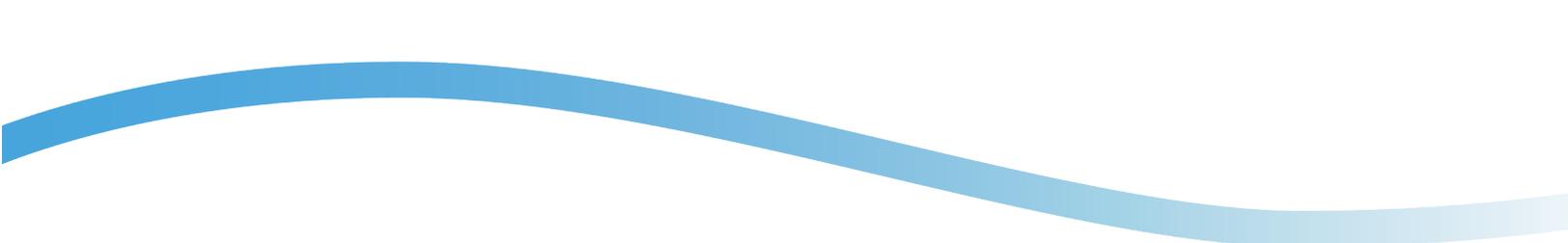
FHWA-SA-21-073

Federal Highway Administration Office of Safety

Roadway Safety Data Program

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U.S. Department of Transportation
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Technical Documentation Page

1. Report No. FHWA-SA-21-073	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Yale-Kilgore Road Safety and Traffic Assessment	5. Report Date May 2021	
	6. Performing Organization Code	
7.Author(s) Ian Hamilton and Dylan Coley	8. Performing Organization Report No.	
9. Performing Organization Name and Address Vanasse Hangen Brustlin, Inc (VHB) 940 Main Campus Drive Raleigh, NC 27606	10. Work Unit No.	
	11. Contract or Grant No. DTFH61-16-D-00052	
12. Sponsoring Agency Name and Address Federal Highway Administration Office of Safety 1200 New Jersey Ave., SE Washington, DC 20590	13. Type of Report and Period Case Study, January 2020-January 2022	
	14. Sponsoring Agency Code FHWA	

16. Abstract
This case study presents a safety analysis by the Federal Highway Administration, Western Federal Lands Highway Division (WFLHD) Highway Safety Team. The WFLHD used the Interactive Highway Safety Design Model (IHSDM) software as part of the design process for the rehabilitation of Yale-Kilgore Road. The Yale-Kilgore Road corridor is a county owned and operated two-lane undivided road located in Clark and Fremont counties in Idaho. The project corridor is an important recreational and commercial artery for the community. As a rural highway in and around a national forest, it has many unique challenges that may not exist in more urban and suburban environments. The Yale-Kilgore Road Safety and Traffic Assessment is a practical example of how the suite of IHSDM modules can support typical project development in an atypical context. Although the corridor is currently a mix of paved and unpaved surfaces, with speed and out-of-town traffic representing major concerns in both the present and the future, IHSDM assisted practitioners with the analysis tradeoffs necessary to make informed design and safety countermeasure decisions. The ability to analyze the corridor from a broad perspective (i.e., not crash prediction alone) allowed WFLHD to assess targeted improvements along the corridor, especially along segments of the corridor where the relative crash risk is highest.

17. Key Words: Rural, 2-lane, Undivided, Safety, IHSDM, Highway Safety Manual	18. Distribution Statement No restrictions.		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 16	22. Price

Acronyms

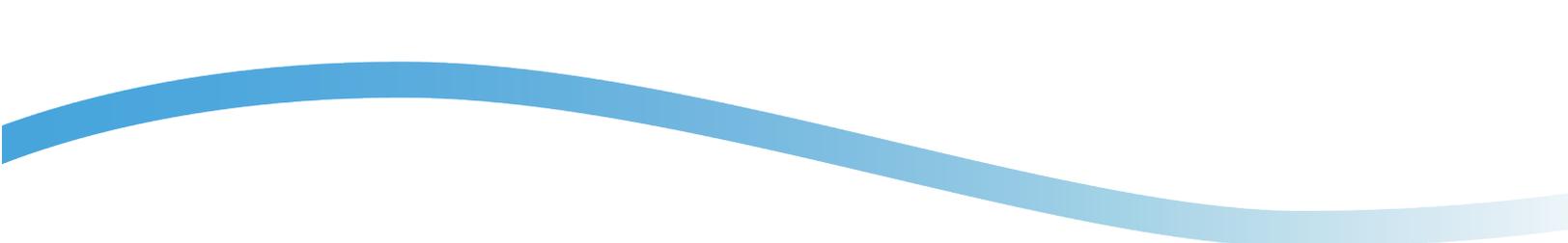| Acronym	Description
AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
CPM	Crash Prediction Module
DCM	Design Consistency Module
DVM	Driver/Vehicle Module
EB	Empirical-Bayes
FHWA	Federal Highway Administration
FI	fatal and injury
HSM	Highway Safety Manual
ID	Idaho
IHSDM	Interactive Highway Safety Design Model
ITD	Idaho Transportation Department
mph	miles per hour
PDO	property damage only
PRM	Policy Review Module
PS&E	Plans, Specifications, and Estimates
TAM	Traffic Analysis Module
WFLHD	Western Federal Lands Highway Division

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Executive Summary

This case study presents a safety analysis by the Federal Highway Administration, Western Federal Lands Highway Division (WFLHD) Highway Safety Team. The WFLHD used the Interactive Highway Safety Design Model (IHSDM) software as part of the design process for the rehabilitation of Yale-Kilgore Road. The Yale-Kilgore Road corridor is a county owned and operated two-lane undivided road located in Clark and Fremont counties in Idaho. The project corridor is an important recreational and commercial artery for the community. As a rural highway in and around a national forest, it has many unique challenges that may not exist in more urban and suburban environments. The Yale-Kilgore Road Safety and Traffic Assessment is a practical example of how the suite of IHSDM modules can support typical project development in an atypical context. Although the corridor is currently a mix of paved and unpaved surfaces, with speed and out-of-town traffic representing major concerns in both the present and the future, IHSDM assisted practitioners with the analysis tradeoffs necessary to make informed design and safety countermeasure decisions. The ability to analyze the corridor from a broad perspective (i.e., not crash prediction alone) allowed WFLHD to assess targeted improvements along the corridor, especially along segments of the corridor where the relative crash risk is highest.

Introduction

The Transportation Research Board's Safety Performance and Analysis (ACS20) User Liaison Subcommittee has an on-going initiative focused on practical application of the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) (i.e., "using the HSM in the real world"). The Federal Highway Administration (FHWA) also administers the HSM Implementation Pooled Fund, which includes 22 States focused on projects to help further HSM implementation. Development of HSM case studies will assist practitioners in performing data-driven safety analysis using the advanced methods described in the HSM. The primary purpose of the HSM case studies is to highlight noteworthy applications of HSM methods, focus on common challenges, and feature agencies that overcame those challenges. These case studies serve as a source of lessons learned and noteworthy practices to help guide practitioners applying the HSM.

Background

This case study presents a safety analysis by the FHWA, Western Federal Lands Highway Division (WFLHD) Highway Safety Team. The WFLHD used the Interactive Highway Safety Design Model (IHSDM) software as part of the design process for the rehabilitation of Yale-Kilgore Road. Yale-Kilgore Road is a county owned and operated two-lane undivided road located in Clark and Fremont counties in Idaho (ID). The western half of the corridor in Clark County is unpaved and transitions to paved asphalt at the county line with Fremont County. Although the road is county owned and operated, a substantial portion of the corridor falls within the Caribou-Targhee National Forest, and the eastern terminus of the corridor is less than 30 miles from an entrance to Yellowstone National Park.

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Note: The white location pins and white dashed line were added by the authors to delineate the project bounds.

Figure 1. Graphic. Yale-Kilgore Road project location.

Purpose and Need

Although the Yale-Kilgore Road project is primarily focused on rehabilitation, the corridor is expected to assume a more regionally important role in the near future. The western, unpaved portion of the corridor will be paved, and the entire corridor will become an increasingly important connection between I-15 near Spencer, ID and US 20 near Island Park, ID. With asphalt paving becoming necessary for future mobility along the corridor, WFLHD applied the IHSDM software to assess anticipated safety needs. The application of the IHSDM software allowed WFLHD to comprehensively analyze the corridor for safety and operational concerns during the project development process. The IHSDM software contains five evaluation modules and an Economic Analysis Tool. WFLHD used the evaluation modules to assess future safety performance and make recommendations based on existing conditions, historical crash trends, and anticipated design changes to the corridor:

1. Crash Prediction Module (CPM).
2. Design Consistency Module (DCM).
3. Policy Review Module (PRM).
4. Traffic Analysis Module (TAM).
5. Driver/Vehicle Module (DVM).

Project Description

- **Sponsoring agency:** WFLHD.
- **Project location:** Clark County and Fremont County, ID.
- **Project bounds and length of project:** Yale-Kilgore Road from milepost 9.0 to milepost 30.8 (21.8 miles).
- **Facility type(s):** 2-lane, undivided major collector.
- **Area type:** Rural, mountainous terrain.
- **Project status (as of January 2021):** Analysis completed based on a 30-percent plans, specifications, and estimate (PS&E) package submittal; begin construction in 2022.

Safety Performance Analysis

This section provides an overview of the safety analysis methods, proposed alternatives, and final results.

Analysis Overview

WFLHD obtained crash data from the Idaho Transportation Department's (ITD's) OpenData portal for all years between 2005 through 2018. The high number of years of crash data reflect the low frequency of crashes on the corridor. (Underreporting is a noted concern on rural, Federal Lands roads, and more years of crash data on low frequency roads better reflect long-term average frequency). The limited number of historical crashes emphasized the need for other modules of the IHSDM software to assess more nuanced risks. The project team linked crash data to the corridor by using associated mileposts and assigning project station equivalences for each location. The PS&E package submission for 30-percent designs provided relevant traffic information. The PS&E package documented a base year (2015) annual average daily traffic (AADT) of 650 vehicles per day (7-percent truck traffic) and a future year

(2035) AADT of 966 vehicles per day (12-percent truck traffic). The project team assumed a linear growth rate between 2015 and 2035 to estimate traffic for the construction year (2021) and design year (2041). For other design and roadside elements, the PS&E package contained normal cross slopes, typical sections provided shoulder widths, and the project team derived driveway density and roadside hazard rating (i.e., a 1-7 rating of roadside objects and the availability of recoverable space; Harwood et al., 2000) from aerial imagery.

To begin the analysis, IHSDM segmented the study corridor based on changes in geometric characteristics (e.g., lane width, shoulder width, cross slope, roadside hazard rating), traffic data, and anticipated driver behavior. This identified 363 unique segments, and WFLHD aggregated these locations into 18 distinct "groups" for easier output analysis and reporting (figure 2).
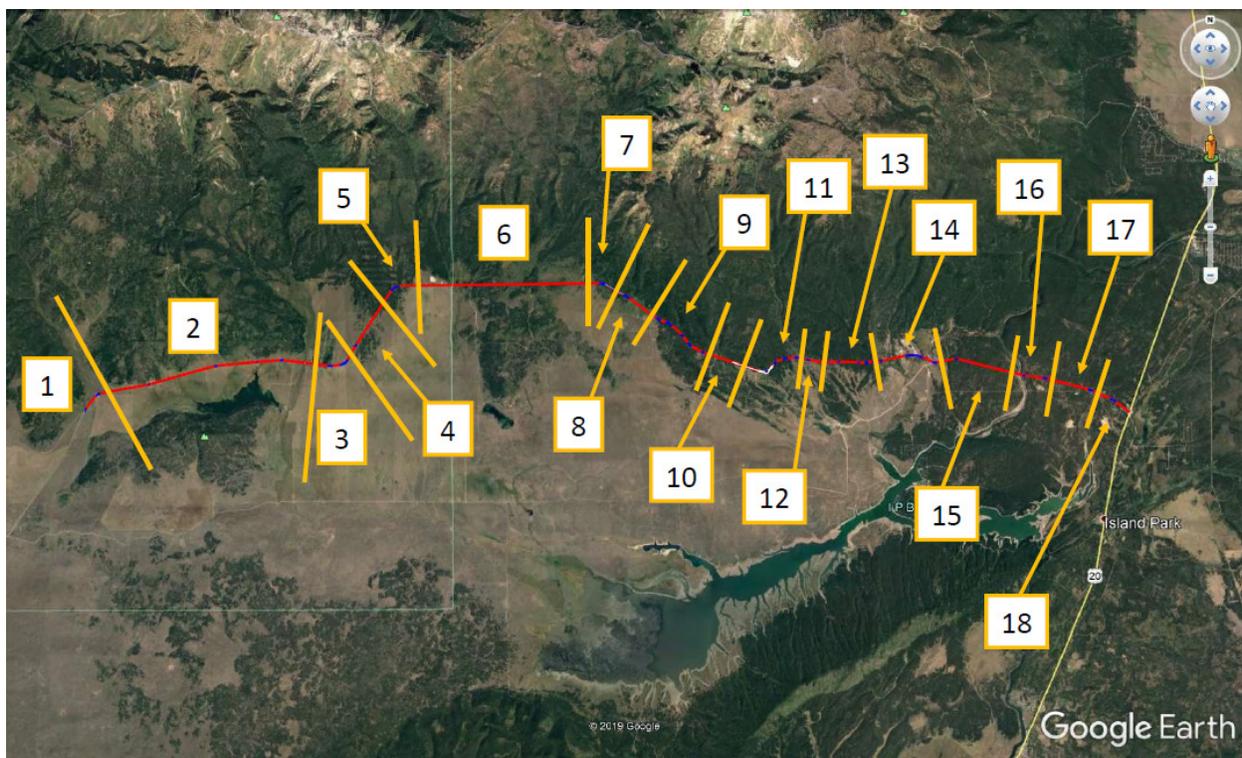
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Note: The yellow arrows and lines, number callout boxes, and red line were added by the WFLHD project team to delineate project extents and sections.

Figure 2. Graphic. Yale-Kilgore Road segment groups.

The defining features of these segments include long tangents or a series of reverse curves. The project team used the TAM and DVM to help identify errors in data inputs, areas of high opposing speed differentials, and higher risk locations within the study area; the project team did not complete the remaining three modules until these two modules were run without error.

The project team used the IHSDM DVM and DCM to examine expected speeds throughout the corridor. These modules use geometric features, horizontal curves, and vertical grades to assess likely

impacts on speed. The WFLHD analysts used a design speed of 45 miles per hour (mph). Since the project team lacked formal speed data, they used a desired free-flow speed of 55 mph due to long tangents and minimal variation in grade. The project team also assumed a "nominal" driver type, a "passenger car" vehicle type, and "long tangent" for driver road familiarity. Discrepancies between the design speed and the expected speed (i.e., predicted as a result of horizontal curvature, vertical grade, or other design elements that lead to large changes in speed) highlight locations where speed countermeasures would be most appropriate.

WFLHD compared each of the 18 groups using the CPM, PRM, DVM, and DCM in IHSDM. The project team developed the following metrics for each group:

- An Empirical-Bayes (EB) analysis using historical crashes; this produced an estimate of expected crashes per group per mile.
- Predicted crashes using the default, uncalibrated CPM in IHSDM.
- A design consistency analysis that flagged differences between the design speed and expected speed based on the results from the TAM.
- A policy review flag for design elements that did not conform to the guidance of the AASHTO *A Policy on Geometric Design of Highways and Streets* or "Green Book" (2011) or deficient stopping-sight distance.
    - WFLHD obtained surveyed horizontal and vertical alignments, used preliminary cross-section designs, and reviewed aerial imagery for vegetation or other fixed obstructions to support this analysis.
- An average lateral vehicle offset for both directions of travel; this DVM analysis assesses the difficulty with which vehicles are able to stay within a travel lane (e.g., side friction demand).

Crash Prediction Analysis & Results

WFLHD developed estimates for predicted crashes, as well as EB-derived expected crashes, based on the HSM's default model values for two-lane, undivided rural roads. For the historical period between 2005 and 2018, the study corridor averaged 3.1 total crashes and 0.6 fatal and injury (FI) crashes per year. WFLHD assumed a future paved condition along the entire corridor for the purposes of this analysis. Table 1 summarizes the results of the CPM analysis for each year in the study period (2021-2041). Over 30 percent of all expected crashes were FI crashes with the remaining crashes being property damage only (PDO); this is the default distribution from the predictive method, and it is constant throughout the study period.

Table 1. Yale-Kilgore Road expected crash frequencies by year.

Year	Total Crashes	FI Crashes	Percent FI (%)	PDO Crashes	Percent PDO (%)
2021	4.33	1.35	31.188	2.98	68.812
2022	4.43	1.38	31.188	3.05	68.812
2023	4.52	1.41	31.188	3.11	68.812
2024	4.62	1.44	31.188	3.18	68.812
2025	4.72	1.47	31.188	3.25	68.812
2026	4.82	1.5	31.188	3.31	68.812
2027	4.92	1.53	31.188	3.38	68.812
2028	5.01	1.56	31.188	3.45	68.812
2029	5.11	1.59	31.188	3.51	68.812
2030	5.21	1.62	31.188	3.58	68.812
2031	5.31	1.66	31.188	3.65	68.812
2032	5.41	1.69	31.188	3.72	68.812
2033	5.5	1.72	31.188	3.78	68.812
2034	5.6	1.75	31.188	3.85	68.812
2035	5.7	1.78	31.188	3.92	68.812
2036	5.8	1.81	31.188	3.99	68.812
2037	5.9	1.84	31.188	4.06	68.812
2038	6	1.87	31.188	4.13	68.812
2039	6.1	1.9	31.188	4.2	68.812
2040	6.2	1.93	31.188	4.27	68.812
2041	6.3	1.97	31.188	4.34	68.812
Total	**111.48**	**34.77**	**31.188**	**76.71**	**68.812**

Table 2 compares the results of the expected and predicted crash analyses. The comparison indicated that more crashes are predicted based on the HSM predictive methodology than are expected based on the available historical crash data and the application of the EB method. Table 3 shows the distribution of expected crash types. The largest expected crash type involved single vehicle, run-off-road crashes.

Table 2. Comparison of expected and predicted crashes for the evaluation period.

Scope	Total Crashes	FI Crashes	Percent FI (%)	PDO Crashes	Percent PDO (%)
Predicted	129.55	41.59	32.10	87.97	67.90
Expected	111.48	34.77	31.19	76.71	68.81
Expected - Predicted	-18.07	-6.82	n/a	-11.25	n/a
Percent Difference	-16.21	-19.61	n/a	-14.67	n/a

Note: n/a = not applicable.

Table 3. Expected crash type distribution.

Crash Type	Single/ Multi- Vehicle	FI Crashes	FI Crashes (%)	PDO Crashes	PDO Crashes (%)	Total Crashes	Total Crashes (%)
Collision with Animal	Single	1.3	1.2	14.1	12.7	13.5	12.1
Collision with Bicycle	Single	0.1	0.1	0.1	0.1	0.22	0.2
Other Single-vehicle Collision	Single	0.2	0.2	2.2	2.0	2.3	2.1
Overturned	Single	1.3	1.2	1.2	1.0	2.8	2.5
Collision with Pedestrian	Single	0.2	0.2	0.1	0.1	0.3	0.3
Run Off Road	Single	19.0	17.0	38.7	34.8	58.1	52.1
Right-Angle Collision	Multi-	3.5	3.1	5.5	5.0	9.5	8.5
Head-on Collision	Multi-	1.2	1.1	0.2	0.2	1.8	1.6
Other Multi-vehicle Collision	Multi-	0.9	0.8	2.3	2.1	3.0	2.7
Rear-end Collision	Multi-	5.7	5.1	9.4	8.4	15.8	14.2
Sideswipe	Multi-	1.3	1.2	2.9	2.6	4.1	3.7
Total Crashes	**n/a**	**34.8**	**31.2**	**76.7**	**68.8**	**111.5**	**100**

Note: n/a = not applicable.

Although the analysis predicts more crashes per year than the number of reported crashes between 2005 and 2018, the project team noted that this annual increase is likely the result of projected traffic growth on the corridor. The project team also noted that increased speeds, as a result of paving currently unpaved roads, could potentially lead to a higher baseline for crash frequency in addition to higher traffic volumes.

It is important to note that WFLHD used the IHSDM CPM results as just one component of its overall assessment of the corridor, and the project team applied the predicted, non-EB crash results as part of the final overall assessment. There are important considerations and trade-offs when using the crash prediction methodology in the HSM, and these are compared with the Yale-Kilgore Road project team's assumptions in the *Challenges* section of this case study.

Documentation and Use of Analysis Results

Using the aforementioned comparison metrics, the project team devised a scoring system to rank the 18 groups. For each metric, the project team assigned:

- One point to groups scoring in the 90th percentile (e.g., a segment group had a predicted and expected per-mile crash rate greater than 90 percent of all groups).
- One-half point to groups scoring between the 75th and 90th percentiles.
- Zero points to groups scoring below the 75th percentile.

This comparison highlighted five groups for closer consideration, Groups 14, 13, 1, 7, and 18 (table 4). Although Group 18 scored lower than the highest four and scored similarly to other groups, the project team included it for its history of recorded crashes.

Table 4. Segment groups ranked by risk score.

Rank	Group	Cumulative Risk Score	Start (Station)	End (Station)
1	14	3	876+63.81	950+00.00
2	13	2.5	825+46.46	876+63.81
3	1	2	10+00.00	36+83.43
3	7	2	570+19.81	581+09.88
5	18	1.5	1126+00.00	1140+89.50
5	2	1.5	36+83.43	259+00.00
5	8	1.5	581+09.88	637+19.92
5	11	1.5	756+85.00	790+00.00
9	4	1	295+00.00	364+77.78
9	5	1	364+77.78	380+00.00
9	9	1	637+19.92	701+00.00
9	15	1	950+00.00	1006+09.77
13	3	0.5	259+00.00	295+00.00
13	6	0.5	380+00.00	570+19.81
13	10	0.5	701+00.00	756+85.00
13	12	0.5	790+00.00	825+46.46
13	16	0.5	1006+09.77	1053+99.78
13	17	0.5	1053+99.78	1126+00.00

WFLHD has an agency-specific Crash Reduction Factor Calculation Spreadsheet that the agency uses to assess potential benefits with respect to specific treatments; this tool mirrors a common crash modification factor application. The project team applied the treatments and crash reduction factors available in the Crash Reduction Factor Calculation Spreadsheet to predicted crashes for the entire corridor, with the top 5 high-risk groups in table 4, (14, 13, 1, 7, and 18) receiving special consideration.

The project team recommended several potential treatments based on the cumulative design flags, crash predictions in IHSDM, and the results of the Crash Reduction Factor Calculation Spreadsheet. The recommendations included:

▸ Replace all existing regulatory and warning signs.
▸ Increase enforcement and increase regulatory signage for speeding concerns.
▸ Convert the roadway surface from dirt/gravel to asphalt (with additional 2-ft paved shoulder).
▸ Use safety edge.
▸ Stripe or restripe all centerlines and edge lines to wet reflective pavement markings.
▸ Add or replace post-mounted delineators where necessary, especially on curves.
▸ Consider typical project clearing limits to remove trees and smaller vegetation within the roadside.
▸ Add guardrail in high-risk groups, especially at bridges and culverts.
▸ Flatten side slopes in combination with other warning signage, delineators, clear zone, and guardrail installations.

Since roadway departure and speed were key concerns during the corridor assessment (table 3), WFLHD noted in the analysis documentation specifically how these countermeasures could potentially reduce crashes, as well as how the existing conditions in each high-risk group could be targeted by the suite of recommended countermeasures. Based on the current design, the WFLHD project team estimated that these countermeasures could reduce crashes over the entire corridor by approximately 35 percent over the project's design life.

Challenges

Although the EB method is a way to account for regression-to-the-mean bias in future crash predictions, there are a few important caveats that could apply to a context similar to the Yale-Kilgore corridor:

1. The HSM predictive methods, and associated EB method, do not necessarily apply to unpaved roads; however, the Yale-Kilgore analysis only applied the predictive methods to an assumed paved condition in the future.
2. As a general rule, practitioners should not apply the EB method to an uncalibrated model; this could lead to significant bias in the results.
3. If a corridor is expected to experience significant operational and geometric changes in the future (e.g., converting an unpaved facility to a paved facility), the EB method should not be used to directly compare a "Build" scenario with a "No-Build" scenario.

Although these are important considerations when applying the predictive method, WFLHD used the CPM results as one component to supplement its more detailed safety assessment. WFLHD noted that the analysis did not compare the Build scenario with a potential No-Build scenario, and the project team did not use the analysis as a justification for the project. The results served to help assess potential risks along the corridor and identify appropriate countermeasures, complementary to the other IHSDM modules. The HSM contains more information regarding the application of predictive methods and the appropriateness of the EB method.
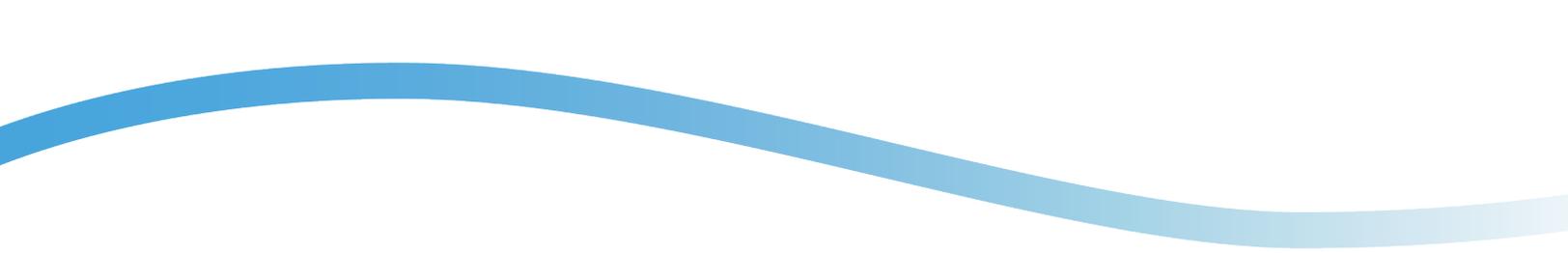
The IHSDM software provides a platform for safety analysts and engineers to assess the cumulative impact of various safety design and policy decisions. However, many of the inputs in the IHSDM modules are subject to engineering judgment, and the software may not be applicable for all circumstances (e.g., unpaved roads). For instance, the practitioner must assess the roadside hazard rating based on input criteria and professional judgment. Furthermore, the software can flag design deficiencies or assist with the tradeoffs associated with various elements, such as sight distances, clear zones, side slopes, and cross slopes, but the optimal solutions may not be feasible at every candidate location. In these circumstances, the practitioner can assess and outline potential improvements where possible. The WFLHD project team noted the order of preferential countermeasures (e.g., install/upgrade guardrail; flatten side slopes; and install curve delineators and warning signage) based on the availability of clear zone. In more extreme circumstances, tree removal to improve sight distance or widen clear zone could destabilize a slope (particularly on the inside of horizontal curves on Group 13). In these circumstances, the project team recommended vegetation trimming alone.

Conclusions and Lessons Learned

The Yale-Kilgore Road project corridor is an important recreational and commercial artery for the community. As a rural highway in and around a national forest, it has many unique challenges that may not exist in more urban and suburban environments. The *Yale-Kilgore Road Safety and Traffic Assessment* is a practical example of how the suite of IHSDM modules can support typical project development in an atypical context (WFLHD, 2020). Although the corridor is currently a mix of paved and unpaved surfaces, with speed and out-of-town traffic representing major concerns in both the present and the future, IHSDM assisted practitioners with the tradeoffs necessary to make informed design and safety countermeasure decisions. The ability to analyze the corridor from a broad perspective (i.e., not crash prediction alone) allowed WFLHD to assess targeted improvements along the corridor, especially along segments of the corridor where the relative crash risk is highest.

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