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FOUNDATION FOR TRAFFIC SAFETY

Uncovering the Spillover Effect from Posted Speed Limit Changes: A Tool to Examine Potential Safety Concerns

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Title

Uncovering the Spillover Effect from Posted Speed Limit Changes: A Tool to Examine Potential Safety Concerns

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AAA Foundation for Traffic Safety

Foreword

The AAA Foundation for Traffic Safety has been examining topics related to posted speed limits and speeding since 2017 and has published several documents thus far that described practices for setting posted speed limits in the U.S.; the impact of speed increases on driver safety from vehicle crash tests; and traffic fatalities in relation to speed limits and speeding. Information presented in this technical report represents AAA Foundation's continued efforts in this body of work, with the goal to bring awareness about the dangers of speeding and potential traffic safety consequences from raising the posted speed limit.

Work presented in this report used a geospatial analysis tool to compare 'before' and 'after' speed-related crashes on local roads, when posted speed limits were increased on nearby Interstate segments. Multiple traffic safety concerns were presented graphically from three case studies examined in this work. This report can be a useful resource for transportation practitioners when considering making changes to posted speed limits – by recognizing potential safety impacts on surrounding roads, proper countermeasures can be planned and implemented.

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President and Executive Director
AAA Foundation for Traffic Safety

About the Sponsor

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Founded in 1947, the AAA Foundation for Traffic Safety in Washington, D.C., is a nonprofit, publicly supported charitable research and educational organization dedicated to saving lives by preventing traffic crashes and reducing injuries when crashes occur. Funding for this report was provided by voluntary contributions from AAA/CAA and their affiliated motor clubs, individual members, AAA-affiliated insurance companies, and other organizations or sources.

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List of Abbreviations and Acronyms

AAAFTS	American Automobile Association Foundation for Traffic Safety
AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
GDOT	Georgia Department of Transportation
HSIP	Highway Safety Improvement Program
HRRR	High-Risk Rural Roads
MPH	Miles per Hour
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety
ODOT	Oregon Department of Transportation
QGIS	Quantum Geographic Information System
SHSP	Strategic Highway Safety Plan
TAZ	Traffic Analysis Zones
MDOT	Michigan Department of Transportation
USDOT	United States Department of Transportation
VMT	Vehicle Miles Traveled

Executive Summary

This study investigates whether raising the posted speed limit on Interstates can lead to a systemic propagation of unsafe behavior that results in additional crashes at nearby locations, a phenomenon known as "spillover effect." The purpose of this research is to encourage transportation agencies to investigate speed-related crash patterns at local and state roadways near Interstates that raised the posted speed limit.

This study purported to: (a) conduct a systematic literature review of spillover effects, including safety interventions and evaluation methods, and construct a set of research themes related to speeding and spillover effects; (b) develop a geospatial analysis tool that facilitates the identification of areas prone to speed-related crashes after raising the posted speed limit on Interstates, and (c) present three case studies using the proposed spatial analysis method to uncover the impact of higher posted speed limits and speeding based on different urban and rural contexts.

The project has two interconnected activities to examine the spillover effect. The first task was a systematic review of relevant literature on the spillover phenomenon. This review also explored related subjects, including general speeding behaviors, speeding countermeasures, and alternative methods for measuring any unanticipated effects of implementing roadway treatments.

The second project task was to understand spillover from a geographic perspective and explore patterns, trends, and relationships among speed-related crashes occurring on adjacent roadways near Interstates that have raised posted speed limits. Hot spot analyses were conducted on roads within a 1-mile radius of Interstates to quantify and visualize differences in speed-related crash clusters in areas surrounding the Interstate segments before and after a regulatory speed increase became effective. The sites selected for the spatial analysis included communities in Georgia, Michigan, and Oregon. Before and after comparisons were performed with QGIS software using available crash data from the adjacent roadways.

Results from the spatial analysis suggest that comparing only 'before' and 'after' crash counts may underestimate the true safety impact across communities when the posted speed limits on Interstates were raised. A preliminary analysis of aggregated crash counts alone did not indicate an increase in speed-related crashes in all locations examined in the study. Some arterials, collectors, and local streets within a 1-mile buffer from ramps of the three Interstates examined in this project, i.e., I-85 (Georgia), I-75 (Michigan), and I-84 (Oregon), had lower speed-related crashes after the posted speed limits were raised. However, a spatial analysis uncovered hidden safety concerns on multiple adjacent roads along these Interstates. Hence, to accurately assess the adverse safety impact from posted speed limit changes, state and local transportation agencies should employ a systemic approach that considers a broader view and evaluates safety across an entire roadway system.

This project demonstrates how raising the posted speed limits on Interstates to accommodate higher operating speeds and increase traffic flow and throughput can inadvertently impact entities or networks of adjacent roads being operated and managed by county, city, and town transportation agencies. All case studies examined in this project showed the emergence of hot spots on roads adjacent to Interstates with new posted speed limits. To minimize unintended traffic safety consequences and better prepare local transportation departments, it is important for state-level departments to coordinate and work closely with other road agency partners when considering making posted speed limit adjustments on Interstates and state highways.

The spatial analysis approach employed in this project also provides a visualization tool to measure the outcomes and identify at what level spillover effects can occur. The hotspot analysis performed in QGIS measures how speed-related crashes are correlated to each other in space across a study area. Figures from the spatial analysis identified hot spots and categorized them as New Hot Spot or Maintained Hot Spot (Intensifying, Persistent, or Diminishing). The categorization of hot spots can be helpful for public transportation agencies to prioritize funding and countermeasure implementation decisions. When spillovers vary across locations, it is important for transportation departments to understand the diverse impact on different stakeholders and develop regional improvement plans and safety programs that target speeding concerns.

Case study results presented in this project clearly demonstrated that one change to the design and management of a road facility (i.e., raising the posted speed limit on the Interstate) can cause adverse effects on other road facilities within a transportation network. To minimize unintended traffic safety consequences from posted speed limit changes on Interstates, transportation departments at the state-level need to proactively work with agencies from counties, cities, and towns to discuss goals and plans, identify potential safety issues and mitigation strategies, and allocate resources to implement countermeasures. Adopting a Safe System approach is an example of how to proactively manage and operate a transportation network. Instead of focusing on adjusting posted speed limits based on operating speeds of vehicles or to increase throughputs on a section of an Interstate, the state transportation agency can work with other state and local partners to educate the public about the dangers of speeding, utilize technology to manage traffic flows and monitor dangerous driving behaviors, and modify roadway designs to promote safe driving behaviors and discourage activities such as speeding.

Introduction

Purpose

"Spillover effect" can be interpreted as a diffusive and pervasive consequence that was not the initial intention. In the context of posted speed limit changes and driving behaviors, spillover effect characterizes unsafe driving practices wherein higher speeds observed on Interstates are propagated to local roads and cause negative safety outcomes on nearby road segments.

This research investigates whether changing to higher posted speed limits on Interstates can cause spillover effects, or a systemic propagation of unsafe behaviors that results in additional crashes at nearby road segments. The goal of this research is to help state and local transportation agencies in identifying locations with potential risks across the transportation network they maintain due to posted speed limit changes on related Interstates. By identifying potential areas with traffic safety concerns, proper countermeasures can be implemented to minimize crash risks.

The current study included the following tasks:

- A systematic literature review of spillover effects, including safety interventions and evaluation methods, and construction of a bibliometric network to understand the relationships between research themes related to speeding and spillover effects.
- Development of a spatial analysis method as a network screening and diagnosis tool to categorize crash trends and patterns associated with speeding.
- Evaluation of case studies using the spatial analysis method and exploring speeding behavior resulting in crashes after raising posted speed limit on a nearby Interstates.

Motivation of this Study

Every day, more than 110 people die on the U.S. roads (Centers for Disease Control and Prevention, 2023). One-third of traffic deaths are speed-related crashes and are disproportionally represented by drivers between the age of 18 and 44 (National Highway Traffic Safety Administration, 2023a). Speeding increases the stopping distance necessary to avoid a collision and shortens drivers' ability to perceive or respond to danger, leading to mistakes that often result in fatal or severe crashes. Speeding has a devastating effect on crash severity outcomes due to the vulnerability of humans to survive crash forces imposed by the kinetic energy released at the time of collision (Kim et al., 2021).

Overall, speeding is not harshly stigmatized in the United States, especially speeding on freeways. A recent survey by the AAA Foundation for Traffic Safety (AAAFTS) revealed that fewer drivers perceived speeding as a dangerous activity versus other risky driving behaviors, such as driving while intoxicated or texting while driving. However, most respondents recognized that speeding 10 mph over the limit on residential streets is very or extremely dangerous (AAA Foundation for Traffic Safety, 2023).

It has been estimated that about 87% of fatal speeding crashes occur on non-Interstate roadways (National Highway Traffic Safety Administration, 2023b). Transportation agencies in U.S. counties and cities carry the responsibility in the planning, designing, operating, and maintaining of local roadways, which encompass more than 75% of the total roadway milage in the United States. When state-level transportation departments decided to raise the posted speed limits to allow drivers operate their vehicles at higher speeds, some may continue to drive at high speeds after transitioning from the Interstates to local roads and create traffic safety concerns in adjacent neighborhoods.

Current methods (e.g., comparison of 'before' and 'after' crash counts on Interstates where posted speed limited were raised) may not clearly reveal all traffic safety concerns on the local transportation network caused by propagation of speeding behaviors from higher posted speed limits on the Interstates. Findings presented in this report, obtained using a spatial analysis method, efficiently revealed the spillover effects on local roads caused by higher posted speed limits on Interstates. When traffic safety concerns, or "hot spots," can be clearly identified, transportation agencies at various levels can then work together and introduce proper countermeasures and strategies to combat safety concerns. Ultimately, traffic crashes, injuries, and fatalities caused by speeding can be drastically reduced.

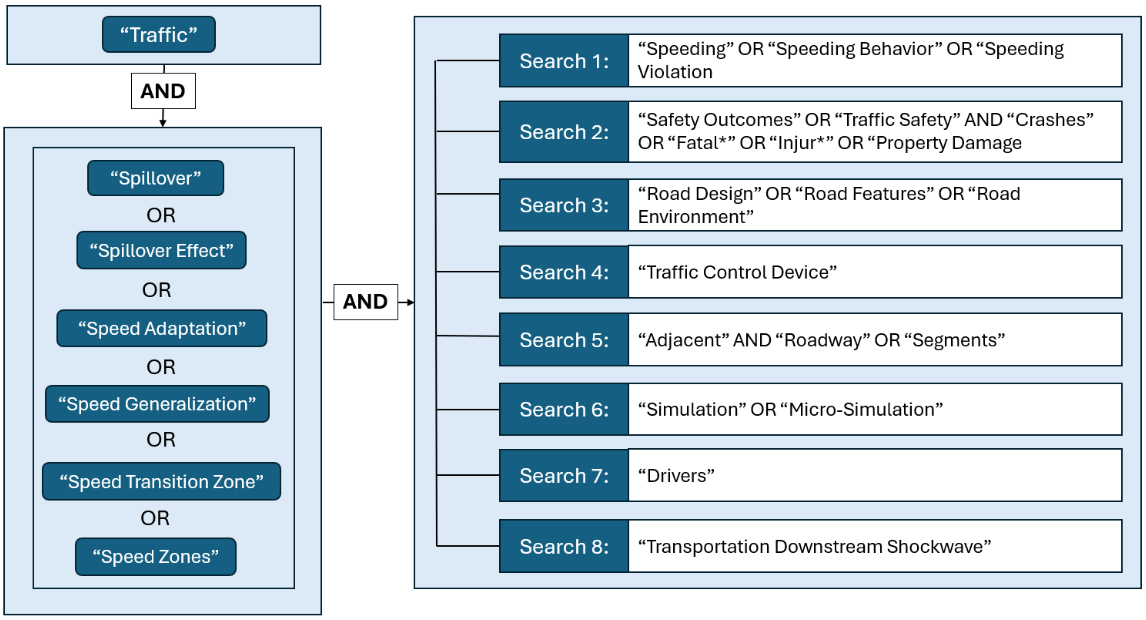
Literature Review

Literature Review Process

The literature review used two primary data sources: the George Mason University online library system and the Transport Research International Documentation (TRID). A preliminary directed search to explore the existing landscape of the spillover effect literature yielded 19 results, indicating that the phenomenon is not well represented in the literature. The limited number of results produced by the initial search prompted a more exhaustive search that used broad search terms and imposed few initial restrictions on results. This comprehensive search process was used to identify any spillover literature not captured by the directed search, as well as identify any emergent themes or sub-topics, applicable methodology to explore, or relevant adjacent literature.

The eight search terms (e.g., Search 7: "Drivers") shown in ***Figure 1*** were used in eight separate keyword searches that yielded 12,450 results in total.

Figure 1. *Literature Review Keyword Search Terms*



Subsequent title and abstract scans of these results reduced the number to 91 articles. Results from the directed search and the comprehensive search were combined for a total of 98 articles selected for full review. These articles were then summarized in a tabular format listing the article's title, author, year, and tags, an overview of the research, the article's conclusions and/or recommendations, the state or country involved, the type of roadway environment, and the method of data collection used. The full summary table of results can be found on the AAA Foundation for Traffic Safety's website at: http://aaafoundation.org/wp-content/uploads/2024/03/202404-AAAFTS-Spillover-Effect-Articles-Summ.xlsx

Literature Review Findings

Keyword scans using the *litsearchr* package (Grames et al., 2019) in R (*R: The R Project for Statistical Computing*, n.d.) were used to explore keywords present in the titles, abstracts, and tags of article results at each stage of review. In addition to the primary topic of interest (the spillover effect), additional recurrent themes included speeding violations and speed compliance, automated enforcement countermeasures, roadway and roadway features, and spatial analysis. Based on the themes identified by the keyword identification process and the full review and synthesis performed by the research team, a brief summary of the key themes and groupings from the literature review are presented below:

The topic of the spillover effect was addressed in some manner by 73 of the collected articles. The effect was the primary research topic for some studies and a secondary topic for others, therefore, some results were categorized under one or more themes. Of these articles, more than half were from the United States (42); international results included articles from Australia, Canada, China, Colombia, Denmark, Finland, France, India, Italy, Israel, and Japan.

The majority of articles that examined the spillover effect found evidence of its existence—that after a change in the posted speed limit, changes in speeds on an initial segment were maintained as changes in speed on surrounding segments with lower or different speed limits (Alhomaidat et al., 2021; Atumo et al., 2023; Casey & Lund, 1987, 1992; Dixon et al., 2022; Friedman et al., 2007; Garber & Grahman, 1990; Matthews, 1978; Megat Johari et al., 2023; Richter et al., 2004; Schmidt & Tiffin, 1969; Wagenaar et al., 1990; Zhai et al., 2022). Additionally, as a consequence of maintained higher speeds, many found a measurable and adverse effect on one or more adjacent areas of a transportation network in the form of increased crashes. For example, Atumo et al. (2023) noted that crashes increase by 1.28 times by raising the posted speed limit of a segment by 5 mph, and that crashes increase by 1.11 times when the posted speed limit of a neighboring segment is raised by 5 mph. Similarly, after a 5-mph posted speed limit increase, Alhomaidat et al. (2021) observed a 13.9% increase in crashes on adjacent arterial roads. Among this increase in crash rates, speed-related crashes were those most affected by the change in the speed limit.

However, several investigations examining the phenomenon found little to no evidence to support potential spillover effect(s) (Gupta et al., 2023; Hunt et al., 2004; Lund, 2007; Mahmud et al., 2021; Pant et al., 1992). For example, after the speed limit was raised by 10 mph on several rural highway segments in Michigan, Mahmud et al. (2021) found limited evidence of spillover effects. In a 2007 study on rural freeways in Iowa, Lund (2007) reported finding no evidence of speed adaptation or speed spillover from Interstates to nearby rural primary highways. The authors do note however that these findings applied to this setting, and that speed adaptation effects could occur on other facility types (such as in urban settings).

Other investigations have produced mixed results (Brown et al., 1989; Brubacher et al., 2018; Srinivasan et al., 2002). For example, Brubacher et al. (2018) saw a 26% increase in insurance claims on nearby road segments after the posted speed limit was raised, but also saw a non-significant decrease in fatal crashes. Roadway type was a relevant distinguishing feature in some studies with mixed results. For example, Brown et al. (1989) saw significant spillover effects from 65-mph Interstates to 55-mph Interstates for property damage only (PDO) crashes; however, on non-Interstate highways adjacent to the 65-mph Interstates, no significant effects were seen.

Several of these studies discussed the expected or observed range to which the spillover effect extends in spatial or temporal terms. In a 1978 study, Matthews described the duration of driver "adaption period" as at least four minutes. Spatially, Alhomaidat et al. (2021) suggest that the spillover effect is most likely to manifest within 3 miles of the freeway or less. In their investigation of crash data from Michigan urban arterial sites, the authors examined the “influence areas” of 0–1 mile, 1–2 miles, and 2–3 miles from the freeway, finding the spillover effect of crashes to be most pronounced in the 0–1-mile range (41.9%) and 1–2-mile range (16.9%) (Alhomaidat et al., 2021). Alternatively, a 2022 study from the National Cooperative Highway Research Program (NCHRP) reports that speed-related crash frequency can begin to decay as early as 0.5 miles from the freeway and last as far as 2 miles from the freeway. In this analysis of Texas facilities, the authors state that the influence of the freeway segment’s posted speed limit “does not extend beyond this window of 10,000 feet in each direction” (Dixon et al., 2022). In a driving simulator study by Alhomaidat et al. (2023), 95% of participants subjectively reported experiencing speed spillover after exiting a freeway segment onto urban arterials, and 70% of the participants reported experiencing this speed spillover within the first mile of the urban arterial.

The reviewed spillover studies included a mix of speed related outcome measures and crash related outcome measures as can be seen in ***Table 1***:

Table 1. *Relevant Studies on Measuring Spillover Effects*

Outcome Measures	Studies by Publication Year
Crash	Garber & Grahman, 1990 Wagenaar et al., 1990 Pant et al., 1992 Richter et al., 2004 Friedman et al., 2007 Brubacher et al., 2018 Alhomaidat et al., 2020, 2021 Zhai et al., 2022 Atumo et al., 2023 Megat Johari et al., 2023
Speed	Matthews, 1978 Casey & Lund, 1987, 1992 Hunt et al., 2004 Mahmud et al., 2021 Gupta et al., 2023
Speed and Crash	Brown et al., 1989 Lund, 2007 Dixon et al., 2022

Other methods, such as driving simulator experiments (Alhomaidat et al., 2023; Schmidt & Tiffin, 1969) and literature reviews (Farmer, 2017; Srinivasan et al., 2002), have also been employed.

Another separate but related effect that was frequently highlighted under the broader topic of spillover, was the occurrence of "positive spillover" effects. In these instances, safety treatments would unintentionally produce positive impacts that extended beyond the initial installation site to surrounding segments (Alhomaidat et al., 2023; Boakye et al., 2015; Li et al., 2015; Shin & Washington, 2007; Zhai et al., 2022). Most commonly, this positive effect was seen when changes in speed limit were accompanied by the installation of red light cameras and speed safety cameras (Jiang et al., 2017; McCartt & Hu, 2014; Sohrabi & Lord, 2019).

Adjacent Literature

Additional results captured in this review considered to be adjacent to the spillover topic were primarily related to speeding behavior (causes and countermeasures) and methodologies that could be pertinent to or extended to further exploration of the effect. Results fell under four general categories: Speeding Violations and Speed Compliance, Automated Enforcement Countermeasures, Roadway and Roadway Features, and Spatial Analysis. Note that these sections should not be considered comprehensive reviews of these emergent topics, given the search strategy depicted in Figure 1.

Speeding Violations and Speed Compliance

Many authors have explored what driver factors are associated with compliance and non-compliance with speed limits, such as demographics (Chevalier et al., 2016; Ghasemzadeh & Ahmed, 2019; Liang & Xiao, 2020; Perez et al., 2021; C. M. Richard et al., 2020; Yadav & Velaga, 2021), driver experience (Liang & Xiao, 2020; Yadav & Velaga, 2021), and speeding intentions (Alizadeh et al., 2023; Ding et al., 2023; Zhu et al., 2011). Attitudes towards speed limits and subjective perceptions, such as the speeds that are seen as "most pleasurable" were also cited as relevant predictors of individual speed choice (Lheureux, 2012). Other articles examined the impacts of punishments and deterrents on speeding behaviors (Mesken et al., 2002; Truelove et al., 2021) Several authors also attempted to characterize and describe common features across speeding events in general, such as prevalence, typical durations, and shared factors (Kong et al., 2020; Perez et al., 2021; C. Richard et al., 2013; C. M. Richard et al., 2020); many of these studies involved analysis of naturalistic driving data. In a study using the Strategic Highway Research Program 2 (SHRP 2) dataset containing trip data from 2,910 drivers, C. M. Richard et al. (2020) noted that 99.8% of drivers had at least one occurrence of a continuous speeding episode within their trip sample. The authors also found that most speeding episodes involve driving 10 mph over the speed limit (C. M. Richard et al., 2020). Kong et al. (2020) report that speeding events lasting longer than 2 minutes are associated with longer trips, while those lasting from 30 seconds to 2 minutes are associated with shorter trips, lower functional class roads, and roads without a median. Additionally, speeding of 1–5 mph over the speed limit is associated with higher functional road classes, short trips, and congestion; speeding of 5 mph over the limit is associated with lower functional classes, congestion, and roads with a median (Kong et al., 2020).

Automated Enforcement Countermeasures

The majority of automated enforcement articles were focused on red light cameras and speed safety cameras. Numerous studies provided evidence that red light cameras can be used as an effective safety countermeasure (Kitali et al., 2021; Ko et al., 2017; McCartt & Hu, 2014; Shin & Washington, 2007; Sohrabi & Lord, 2019). Though, evidence in favor of red light camera effectiveness primarily extended to reductions in red light running and angle crashes. Several investigations found mixed results for other types of crashes, with varying degrees of success based on crash type (Council et al., 2005; Goldenbeld et al., 2019; Martínez-Ruíz et al., 2019; Persaud et al., 2005). In some instances, an increase in rear-end collisions were seen after their installation (Ahmed & Abdel-Aty, 2015; Llau et al., 2015). A 2014 study by Wong found primarily negative safety impacts; while red light–running collisions were reduced as a result of the cameras, collisions overall increased, particularly right angle and injury collisions. Like red light cameras, speed safety cameras appear to primarily be an effective countermeasure, with the literature indicating that are beneficial in both lowering driver speeds (Afghari et al., 2018; Tavolinejad et al., 2021) and reducing crashes (Moore-Ritchie et al., 2023).

Roadway and Roadway Features

Many studies also explored elements of the roadway and built environment that are associated with speeding and driver speed selection. Road geometry, urban–rural classification, and speed limits were frequently explored, as well as roadway characteristics such as lane width and number, shoulder width, and the presence or absence of features such as sidewalks and bike lanes (Afghari et al., 2018; Bassani et al., 2014; Cai et al., 2021; Cheng et al., 2019; Dias et al., 2018; Perez et al., 2021; Wen et al., 2019). While there is agreement that roadway features are relevant influencers of drivers' speed behavior, there is not broad consensus on the impact of specific elements that can be generalized across different contexts.

Spatial Analysis

Several of the studies directly examining the spillover effect included geospatial data in their analyses, primarily by way of crash data. Though, adjacent literature included additional spatial analysis methods that have been applied in other areas of traffic safety research.

To examine the spatial effect between the availability of alcohol and alcohol-related crashes, Wang et al. (2020) extracted population characteristics and the densities of alcohol outlets within given Traffic Analysis Zones (TAZs) and compared them with reported alcohol-related crashes. To explore these spatial effects, they compared the Ordinary Least Squares (OLS) model, Spatial Lag Model (SLM), Spatial Error Model (SEM), and Spatial Durbin Model (SDM) and found the SDM model to be the most optimal to characterize the relationships (Wang et al., 2020). Additionally, they cited 3 km as the most suitable radius for point density or “hot spot” analysis in their investigation, as this threshold produced the most significant spatial autocorrelation value (Wang et al., 2020).

In a traffic analysis zone–based analysis of pedestrian and bicyclist crash frequency, (Cai et al., 2016) speak to the value of considering adjacent TAZs in crash frequency models. The authors discuss some of the concerns involved in macro-level non-motor crash analyses, primarily that crashes within a spatial unit are typically aggregated to find the crash frequency. To counter spatial unit–induced bias and account for spatial dependency, they recommend using a spatial spillover approach, which considers exogenous variables from neighboring zones. They claim this approach provides better understanding of the influence of neighboring zones and allows for the quantification of this influence on crash frequency (Cai et al., 2016). The authors compared models that did and did not consider spatial spillover effects, and found those that included spatial spillover effects outperformed those that did not (Cai et al., 2016).

A 2017 investigation of mapped speed zones by Chevalier et al. (2017) cautions the potential pitfalls of their use in drawing conclusions about real world speeding behavior. The authors’ investigation demonstrated that service provider speed zone data were prone to inaccuracies (false positive identifications of high-range speeding) and that a second set of comparison speed zone data should be used for verification (Chevalier et al., 2017).

Research Gaps

This literature review process identified the known results for examinations of the spillover effect, in addition to an overview of related subjects, including general speeding behaviors, speeding countermeasures, and alternative methods for examining traffic safety outcomes. Although the concept of the spillover effect was first introduced by Schmidt & Tiffin (1969), the body of literature on the topic remains relatively small. Among the limited research, there are mixed findings on the prevalence of the effect and its impact on the safety of areas surrounding higher speed segments. The literature does provide evidence that spillover effects did manifest in many of the conditions in which it has been studied, though results are not consistent across different contexts. There is still a need for additional investigations that can provide data from a wider variety of real-world sites.

The spillover effect is a complex phenomenon encompassing a range of behaviors, and although previous studies have employed methods such as speed spot studies, crash data analysis, and driving simulator experiments, continuing to expand the range of methods used to explore the question will only improve our understanding. The existing body of literature primarily measures the spillover effect with a mix of speed-related and crash-related metrics. Speed metrics are useful in demonstrating the effect itself, while crash metrics provide evidence of the impact of the behavior(s) captured by the speed metrics. Compared to speed data, crash data is typically a more readily available resource that includes geospatial information (X and Y coordinates) and some indication of whether speeding was involved in the accident. Moreover, there can be some concerns with loss of spatial detail when using speed data, as it is often aggregated within a given boundary. In addition to crash and speed data, adjacent literature such as Wang et al. (2020) and Cai et al. (2016) suggest that the incorporation of spatial considerations could reveal important insights that may not be captured by current methods alone.

Overall, there is still a dearth of research on the spillover effect, and the increased use of more holistic spatial approaches may provide meaningful information that is being overlooked in many existing examinations of the impacts of changes in posted speed limits. There is a need to continue developing the depth and breadth of this literature with more investigations in a wider variety of contexts, and with increased consideration of potential spatial effects. In an effort to better understand the potential safety impacts of spillover and to explore evaluation methods that are widely accessible and easily reproducible by a wide range of stakeholders, the scope of the present study focuses on the “crash” spillover effect. In addition to raising awareness of potential spatial impacts of speed changes, such as spillover effects, identification of an accessible method can better enable more interested parties to contribute to this body of knowledge with investigations of their own systems.

Geospatial Analysis Approach

The purpose of this analysis is to provide additional insights to ‘before’ and ‘after’ evaluations of posted speed limit changes that can be a useful reference for transportation agencies in examining potential spillover effects and identify areas prone to crashes or “hot spots.” Consequently, they can develop proactive safety management strategies that promote multi-agency coordination of capital improvement programs within a city, county, or region to identify key areas of concern and implement targeted safety measures.

Conducting a hot spot analysis allows practitioners to understand consequences of posted speed limit changes and speeding from a geographic perspective and explore patterns, trends, and relationships among speed-related crashes occurring on adjacent roadways near high-speed facilities such as state highways and Interstates. This project used QGIS, a free and open-source geographic information system application to measure how speed-related crashes are correlated to each other in space across a study area. Statistical outcomes (i.e., Z-scores and p-values) were computed using an open-source hot spot analysis plug-in.

Using the Getis-Ord Gi* statistic (Getis & Ord, 1992), clusters of highly significant related values, or hot spots (i.e., areas of safety concerns), were identified based on spatial patterns denoted by high Z-scores and small p-values. Cold spots or clusters with low values are estimated by negative Z-scores and small p-values. Z-scores near zero indicate that there is no apparent spatial clustering or spatial autocorrelation. Getis-Ord spatial statistics has been used by transportation agencies to identify high-risk locations and prioritize safety measures using Incident Management Data (Songchitruksa & Zeng, 2010), and has been recommended as an evaluation tool for Highway Safety Improvement Programs (Tsapakis et al., 2019).

Categorical Clusters for Hotspots

To evaluate the impact of raising the posted speed limits, a set of rules were defined to compute differences of the statistical significance between crash rate clusters in the 'before' and 'after' scenarios. Using this analytical framework, it is possible to uncover spillover effects by comparing 'before' and 'after' crash patterns and classifying outcomes into three main categories: (1) New Hot Spots; (2) Maintained Hot Spots; and (3) Historical Hotspots. Descriptions of these categories of hot spots are provided below:

1. <u>New Hot Spots</u>: New areas of safety concern where clusters of speed-related crashes with no statistical significance that became statistically significant after raising the posted speed limit

2. <u>Maintained Hot Spots</u>: three sub-categories of speed-related crash clusters are as follows:

    a. <u>Intensifying Clusters</u>: areas showing stronger significant levels in the 'after' scenario

    b. <u>Persistent Clusters</u>: areas where similar significant levels were maintained in the 'before' and 'after' scenarios

    c. <u>Diminishing Clusters</u>: areas with a weaker statistical significance in the 'after' scenario

3. <u>Historical Hot Spots</u>: areas where significant levels of crash clusters are no longer observed after the speed limit was raised

Using QGIS to reveal the three categories of hot spots listed above after the posted speed limits were raised can help local transportation agencies to develop and implement effective countermeasures and strategies with the goal of improving traffic safety. The spatial analysis also shows areas with no statistically significant clustering of speed-related crashes (i.e., Non-Significant Hot Spots).

Assumptions of the Analysis

A geospatial analysis assumes that speed-related crashes are random and do not exhibit a predictable spatiotemporal dependency. This null hypothesis is accepted or rejected based on the Z-scores and p-values associated with the distribution of speed-related crashes within a specified zone and their proximity to other speed-related crashes. To measure the concentration of high or low values in the study area, a binary weighting assigned a weight of 1 to all neighboring features and 0 to non-neighboring features (ArcGIS Pro, n.d.).

The proposed analytical method eliminates the need for traffic data collection across an entire study area. Corridor analysis requires additional efforts to determine where traffic comes from and goes to (e.g., link analysis) based on the nearest permanent traffic count station, which may not be near a corridor or local street of interest.

In addition, this approach avoids overemphasizing safety assessments on local streets as in the case of crash rates estimated from low traffic exposure. Therefore, crash events are the preferred denominator since the study area comprises different functional classifications, various posted speed limits, and diverse land uses. In its most simple form, speed-related crash rates normalized by the total number of crashes, allows for the representation of unsafe speeding behavior that led to a crash.

The analysis required two crash data attributes: (1) speed as a factor contributing to a crash and (2) geospatial information of the crash location. To quantify the cascading negative effects, the study only examined crashes that reported ***speeding as a contributing factor***. According to the National Highway Traffic Safety Administration (NHTSA), speed-related crashes are those where a police officer charged a driver with a speeding offense or involved racing, driving too fast for conditions, or exceeding the posted speed limit (Kumfer et al., 2023). Data limitations about the accuracy of reporting crash locations or reporting speeding behavior itself by police officers are beyond the scope of this study. The spatial analysis performed in this study is solely based on speeding crashes along neighboring corridors, arterials, collectors, and local streets. The study intentionally excluded crashes on the Interstate where the posted speed limit was raised.

Crashes from the year when the speed limit was raised were excluded from the analysis to avoid introducing exogenous variables from travel patterns during an adoption period. In this manner, the ‘after’ evaluation period accounts for speeding behavior on arterials, collectors, and local streets after new posted speed limits became effective and most drivers were fully adjusted to the new speed on the Interstate.

The statistical significance of spatial crash distributions was computed within a 0.25-by-0.25-mile grid layer imposed on a geographical area comprising all roadways within one mile from an Interstate ramp. A 1-mile buffer was selected under the assumption that speeding eventually decreases under interrupted traffic flow conditions on signalized or stop-controlled arterials. The coverage or buffer area for the study is based on a more conservative and smaller boundary compared to previous studies. A seminal study by Schmidt and Tiffin (1969) reported a 4-mile distance attributed to the 5-to-6-minute-long lasting effect of speed adaptation after exiting a freeway. However, recent work proposes a smaller 2-mile spillover boundary (Dixon, et al., 2022). Crashes outside the 1-mile boundary area were removed and any crash points on the Interstate mainline were removed.

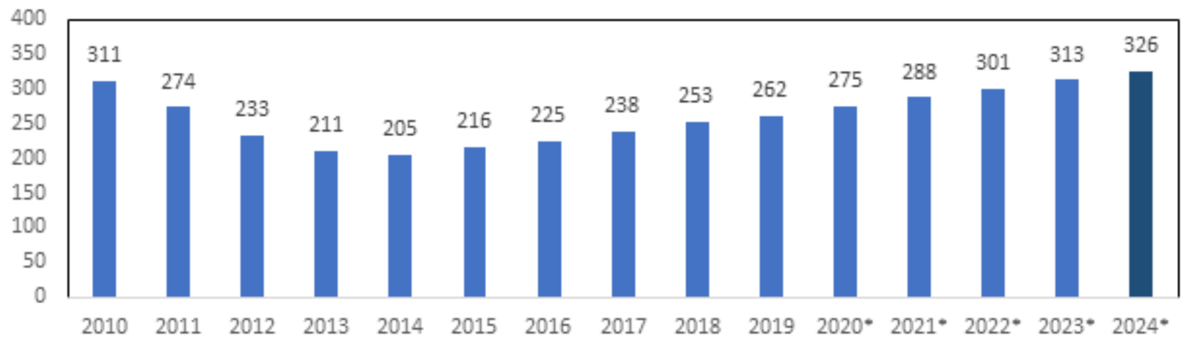
To demonstrate how the proposed spatial analysis approach can be helpful for local transportation agencies in identifying hotspots of speeding-related crashes, three case studies were evaluated and are presented in the next section of this report. These case studies compared 'before' and 'after' historical crash trends in communities in Georgia, Michigan, and Oregon within a mile of Interstates. The study sites were selected based on data availability, to ensure that the research team had access to the necessary crash attributes required for the analysis. Both the spatial resolution of 0.25-by-0.25-mile grids and 1-mile boundary were replicated on all case studies examined in this work to ensure that the results were analyzed consistently and captured the appropriate level of detail.

Case Study 1: Georgia

Site Description

The state of Georgia ranks 4th in the U.S. for number of traffic fatalities (Georgia Governor's Office of Highway Safety, 2021). As can be seen in ***Figure 2***, speed-related crashes have steadily increased since 2015. As a commitment to prevent deaths, the state's strategic safety vision incorporates safer speeds in transportation planning efforts and continues the assessment of safety performance measures including speed-related fatalities. According to 2022–2024 Strategic Highway Safety Plan, speed-related fatalities in the state of Georgia are projected to reach 326 in 2024 based on a projected rolling average as shown in ***Figure 2***.

Figure 2. *Speed-Related Fatalities in the State of Georgia based on a 5-Year Rolling Average*



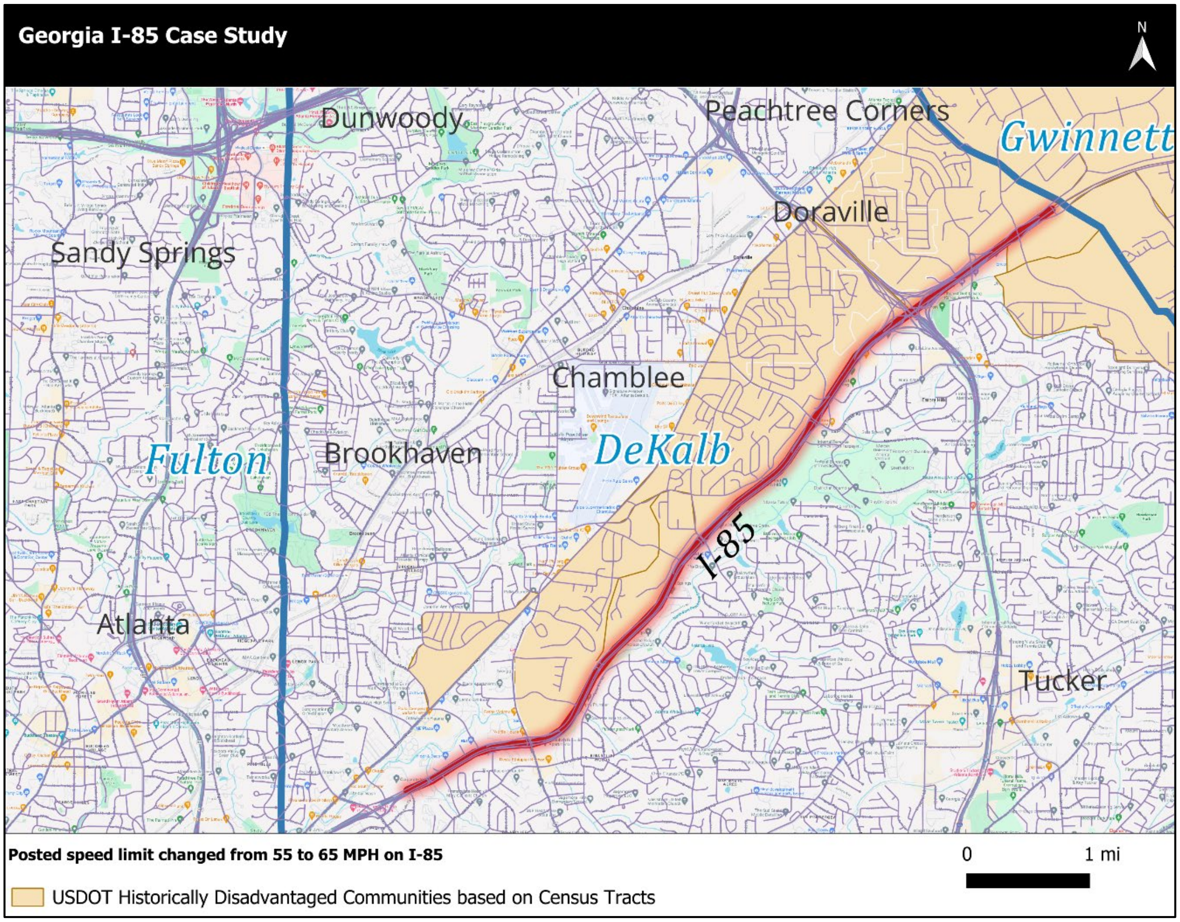
Source: 2022–2024 Georgia Strategic Highway Safety Plan
(Georgia Governor's Office of Highway Safety, 2021)

*Data based on projection analysis presented in Georgia's SHSP

The study area selected for the first case study is based on the roadway segment of the Interstate I-85 in Georgia extending from SR42/North Druid Hills Road to the Gwinnett County Line. This Interstate segment corresponds to District 7 of the Georgia Department of Transportation.

Interstate I-85 is a divided multi-lane highway with five lanes in each direction that currently serves about 236,000 vehicles per day on average (Drakewell, 2024). In 2015, the posted speed limit was raised by 10 mph from 55 mph to 65 mph on this 7.3-mile-long segment that traverses the cities of Brookhaven, Chamblee, Doraville, Tucker, and other communities in the County of Dekalb. Most of these communities are historically disadvantaged as can be seen in ***Figure 3***. The highlighted areas in orange indicate that four out of the six disadvantage theme indicators (Transportation, Health, Economy, Equity, Resilience, and Environmental) exist (United States Department of Transportation, 2024).

Figure 3. *Study Area in DeKalb County including Disadvantaged Communities*



Crash Data Summary

The Georgia Department of Transportation maintains a crash data portal through the alliance between the American Association of State Highway and Transportation Officials Cooperative Computer Software Development Program AASHTOWare and Numetric (Numetric, 2024), a safety platform for mapping and visualization tools for state and local transportation agencies. After creating a free account in Numetric, crashes were downloaded at no cost.

The analysis for the 'before' period was based on crash records from the earliest available year in the database, i.e., 2013 and 2014. The 'after' scenario also consisted of a 2-year period, from 2016 and 2017. Crashes from 2015, when the new 65-mph posted speed limit became effective, were excluded to avoid introducing exogenous variables from travel patterns during an adoption period.

The first step of the analysis was to plot all the crashes, including speed-related crashes, and create a 1-mile buffer from freeway exit and entrance ramps. Crashes outside the

1-mile boundary area were removed and any crash points on the I-85 mainline were excluded. ***Table 2*** describes the total number of records considered for the study.

Overall, all crashes on nearby roadways increased about 20% after the new 65-mph speed limit was implemented on I-85 (see ***Table 2***). At a first glance, it was observed that speed-related crashes on nearby roadways decreased by 16%, which could support the idea that spillover effects did not occur. The next step was to perform geospatial analysis to verify whether there were any safety concerns beyond the speed-related crash counts.

Table 2. 'Before' and 'After' Crash Counts on Arterials, Collectors, and Local Streets within a 1-Mile Buffer from I-85 Ramps

Crash Type	Total Crashes 'Before' Period (2013–2014)	Total Crashes 'After' Period (2016–2017)
All	5,492	6,601
Speed-related	100	84

Results from Geospatial Analysis for Urban Communities nearby I-85

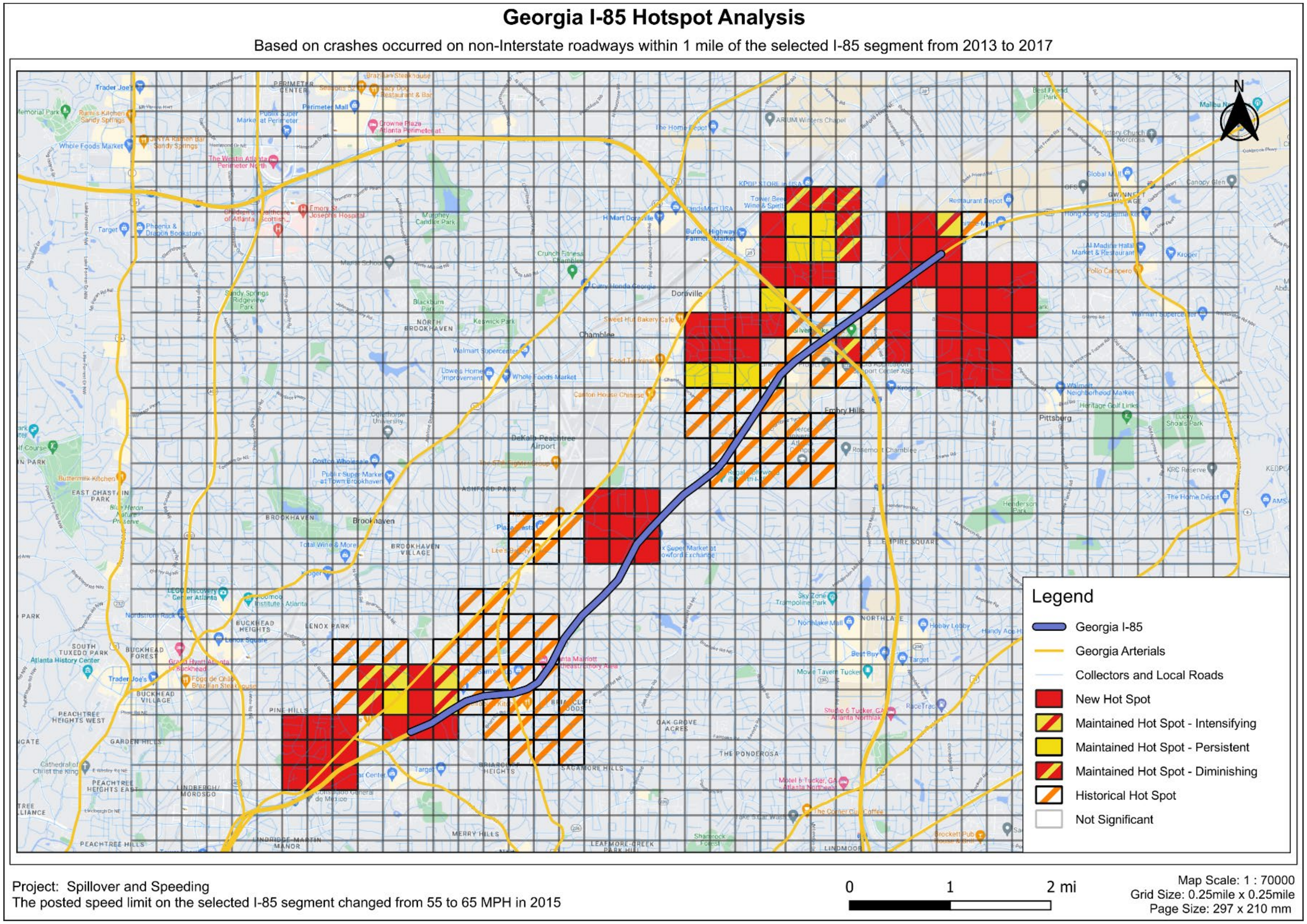
New Hot Spots

New Hot Spots are red color-coded areas where speed-related crashes emerged on adjacent roads after raising the posted speed limit on I-85. These areas could be of special interest to local transportation agencies since they were the most affected by the new posted speed limit on I-85, with more speeding crashes that posed safety concerns for communities in the vicinity of I-85. As can be seen in ***Figure 4***, new hotspots were most prevalent at the beginning and end of the study segment.

Maintained Hot Spots—Intensifying

Based on the 'before' and 'after' comparison, a few 0.25-by-0.25-mile grids are under the 'Intesifying' sub-category, as can be seen in ***Figure 4*** at the beginning and end of the study segment.

Figure 4. *Hot Spots on Adjacent Roadways nearby I-85 in Delkab County, Georgia*



Maintained Hot Spots—Persistent

This sub-category of 'Maintained' Hot Spots is shown in yellow grids in ***Figure 4***, indicating areas in the network where the distribution of speed-related crashes was apparently unaffected by the posted speed limit change on the Interstate I-85. These yellow grids reveal driving behaviors remained similar after raising the posted speed limit. Yellow grids should not be viewed as unimpactful or safer areas. Instead, the density of speeding-related crashes was statistically significant in both the 'before' and 'after' evaluation periods and maintaining this type of aggressive driving will lead to safety concerns.

Maintained Hot Spots—Diminishing

This sub-category of 'Diminishing' Hot Spots is shown in red grids with yellow stripes in ***Figure 4***. The word 'Diminishing' implies that hot spots are still visible in the 'after' evaluation period, but with lesser speeding behaviors because the crash rate difference between the Z-scores remained positive but at a lower value compared to the 'before' period. For this sub-category, the statistical significance was maintained but the spatial autocorrelation of speed-related crash rates became weaker.

Historical Hot Spots

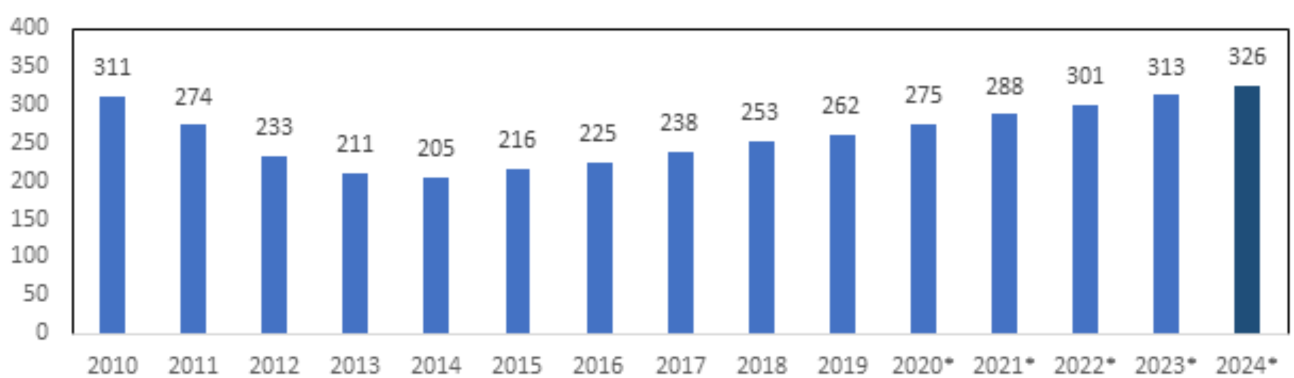
Historical hot spots are presented in ***Figure 4*** as transparent grids with orange stripes. There were several clusters of adjacent roadways along the study area of I-85 with significant speed-related crashes in the 'before' period but not in the 'after' period when posted speed limit changed from 55 mph to 65 mph on I-85.

Case Study 2: Michigan

Site Description

Over the last few years, speed-related fatalities in Michigan have shown a concerning upward trend, as can be seen in ***Figure 5***. Rural highways are a safety priority due to their high fatality and injury rates. The Governor's Traffic Safety Advisory Commission (GTSAC) estimates that 40% of fatalities and 35% of serious injuries occur on rural roadways carrying only 31% of the daily vehicle miles traveled (VMT) and with only 18% of the population living in rural Michigan. Consequently, the State of Michigan is looking for ways to reduce traffic fatalities and improve safety. The 2021 Michigan Highway Safety Improvement Program (HSIP) has a systematic process for funding safety projects at locations of concern per an action item from 2023–2026 Michigan Strategic Highway Safety Plan (SHSP) (Governor's Traffic Safety Advisory Commission, 2023). In addition, Michigan Department of Transportation (MDOT) requires traffic safety initiatives to address emphasis areas: High-Risk Behaviors, At-Risk Road Users, Engineering Infrastructure, and System Administration (Governor's Traffic Safety Advisory Commission, 2023).

Figure 5. *Fatal Motor Vehicle Crashes Involving Speeding in the State of Michigan based on a 5-Year Rolling Average*



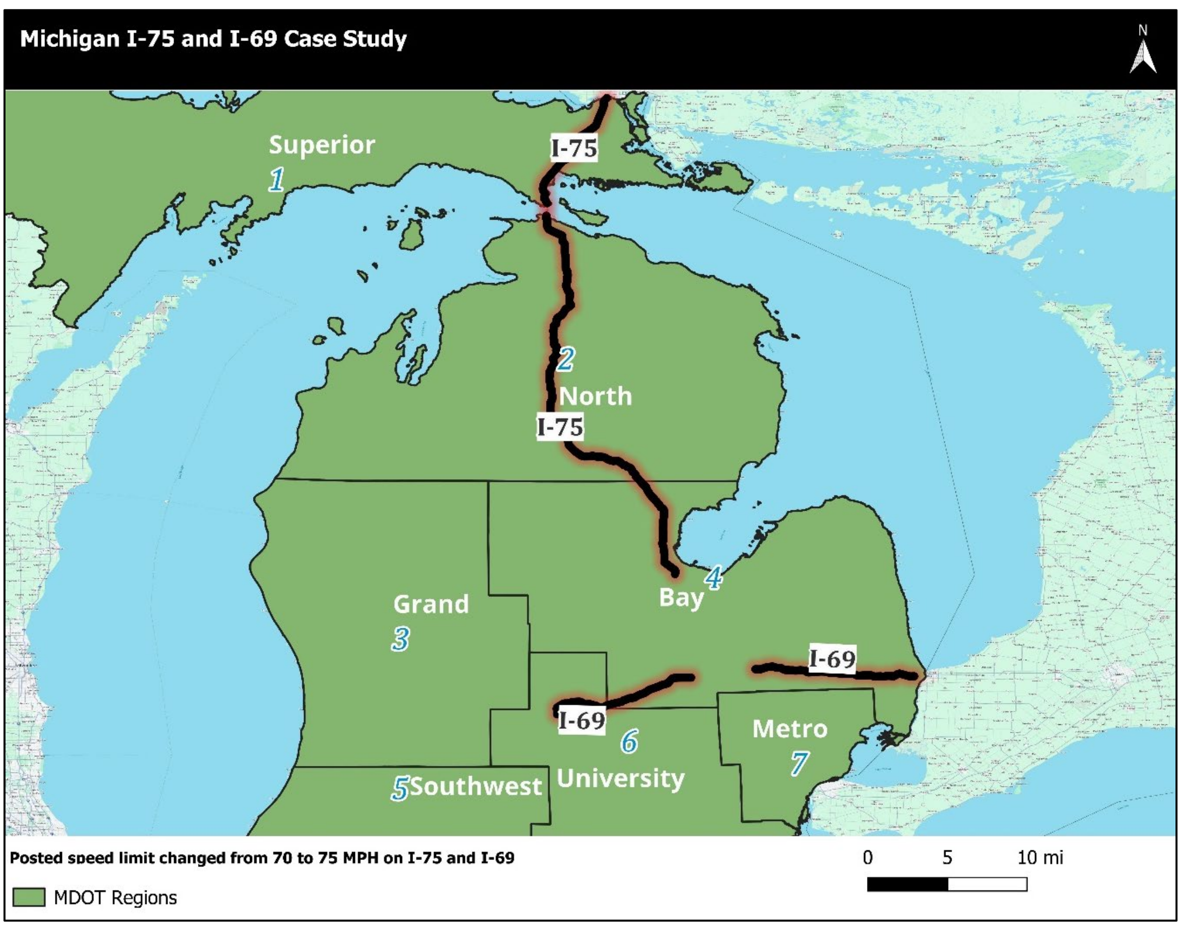
Source: Fatality Analysis Reporting System (National Highway Traffic Safety Administration, 2024)
*Data based on projection analysis presented in Michigan's SHSP

The study area for this case study includes two Interstate segments, I-75 and I-69. In 2017, both I-75 and I-69 raised the posted speed limit from 70 mph to 75 mph. This was in accordance with the Michigan State legislature (Michigan Vehicle Code Section 256.627 Speed Limits, 1949), which allowed MDOT and the state police department to raise speed limits on at least 600 miles of freeways, raising the posted speed limit to 65 mph on state highways if an engineering and safety study proves that 85% of drivers operate their vehicles at the proposed higher posted speed limit under ideal conditions.

Both I-75 and I-69 are divided rural Interstates with two lanes in each direction and an Annual Average Daily Traffic (AADT) ranging from 2,000 in remote areas to 35,500 vehicles per day in denser cities. Interstate 75 is oriented in the North–South direction and encompasses three MDOT regions including: Superior (Region 1), North (Region 2) and Bay (Region 4). Interstate 69, oriented East–West, traverses the Bay (Region 4) and the University district (Region 6).

Combined, there are 16 counties and 59 cities considered in the two Michigan sites analyzed for the case study of this project. Interstate 75 is a continuous segment that is approximately 225 miles long serving 49 cities and towns in 10 different counties. Interstate 69 has two separate segments that measure about 84 miles long. The first 33 miles segment of the highway is west of the outskirts of the City of Flint starting from Eaton County and extending east to Genesee County. The second portion of the segment goes from Lapeer County to St. Clair County. There are six counties and 10 cities with neighboring roadways within 1 mile of I-69. ***Figure 6*** provides an aerial view of the location of these Interstates.

Figure 6. *Study Area in Michigan within MDOT Regions*



Crash Data Summary

Table 3 summarizes the aggregated 3-year count of crashes for each evaluation period: 'before' (2013–2016) and 'after' (2018–2020) raising the posted speed limit. This total count excluded crashes on the Interstates and accounts only for crash events within a 1-mile buffer. As can be seen from ***Table 3***, I-75 had a decrease in total crashes and speed-related crashes. In comparison, I-69 showed a 9% increase of total crashes and a 4% increase in speed-related crashes.

Table 3. 'Before' *and 'After' Crash Counts on Arterials, Collectors, and Local Streets within a 1*-Mile *Buffer from I-75 and I-69 Interstate Ramps*

Crash Type	I-75		I-69	
	Total Crashes 'Before' Period (2013–2016)	Total Crashes 'After' Period (2018–2020)	Total Crashes 'Before' Period (2013–2016)	Total Crashes 'After' Period (2018–2020)
All	3,557	3,407	3,286	3,589
Speed-related	526	407	378	394

Results from Geospatial Analysis for Rural Communities nearby I-75

New Hot Spots: I-75

Red color-coded areas are shown throughout the study area on I-75 (see ***Figure** 7* through ***Figure** 27*). These areas represent communities where speeding-related crashes became statistically significant after Michigan raised the posted speed limit on I-75. These new hot spots appeared on low-volume rural roadways where drivers can easily drive over the posted speed limits with a higher probability of getting involved in fatal crashes. These new hot spots emerged throughout the different local communities along I-75 but some of them were more prominent in the counties of Chippewa (see ***Figure** 7* and ***Figure 8***) and Mackinac (see ***Figure 9*** and ***Figure 10***).

Maintained Hot Spots—Intensifying: I-75

Maintained Hot Spots categorized as 'Intensifying' are shown in yellow grids with red stripes in ***Figure** 7* to ***Figure** 27*. These areas represent nearby communities with a significantly higher concentration of speed-related crashes compared to before the posted speed limit was raised. Examples of hot spots with intensifying speed-related crash frequencies can be found in Otsego County (see ***Figure 14***, ***Figure* 15**, and ***Figure* 16**).

Maintained Hot Spots—Persistent: I-75

Yellow color-coded areas shown in ***Figure 7*** to ***Figure 27*** represent the 'Persistent' sub-category of Maintained Hot Spots, where a higher frequency of speed-related crashes remain similar after raising the posted speed limit. Although not as prominent as new hot spots or intensifying maintained hot spots, these areas can be seen at rural roadways serving communities such as Cheboygan County (see ***Figure 12*** and ***Figure 13***).

Maintained Hot Spots—Diminishing: I-75

The 'Diminishing' sub-category of Maintained Hot Spots are represented as red grids with yellow stripes in ***Figure 7*** to ***Figure 27***. These areas demonstrated a shift to a lower statistical significance level but nonetheless the cluster of speed-related crashes remained significant after the increase in the posted speed limit on I-75. As an example, these types of clusters were observed in Ogemaw County (***Figure 22***).

Historical Hot Spots: I-75

Translucent grids with orange stripes represent low-crash locations where speeding is not a contributing factor on crashes versus before increasing the posted speed limit on I-75. These areas, although less common in this case, appeared in Bay County as shown in ***Figure 26*** and ***Figure 27***.

Figure 7. *Hotspots on Adjacent Roadways nearby I-75 in Chippewa County (North), Michigan*

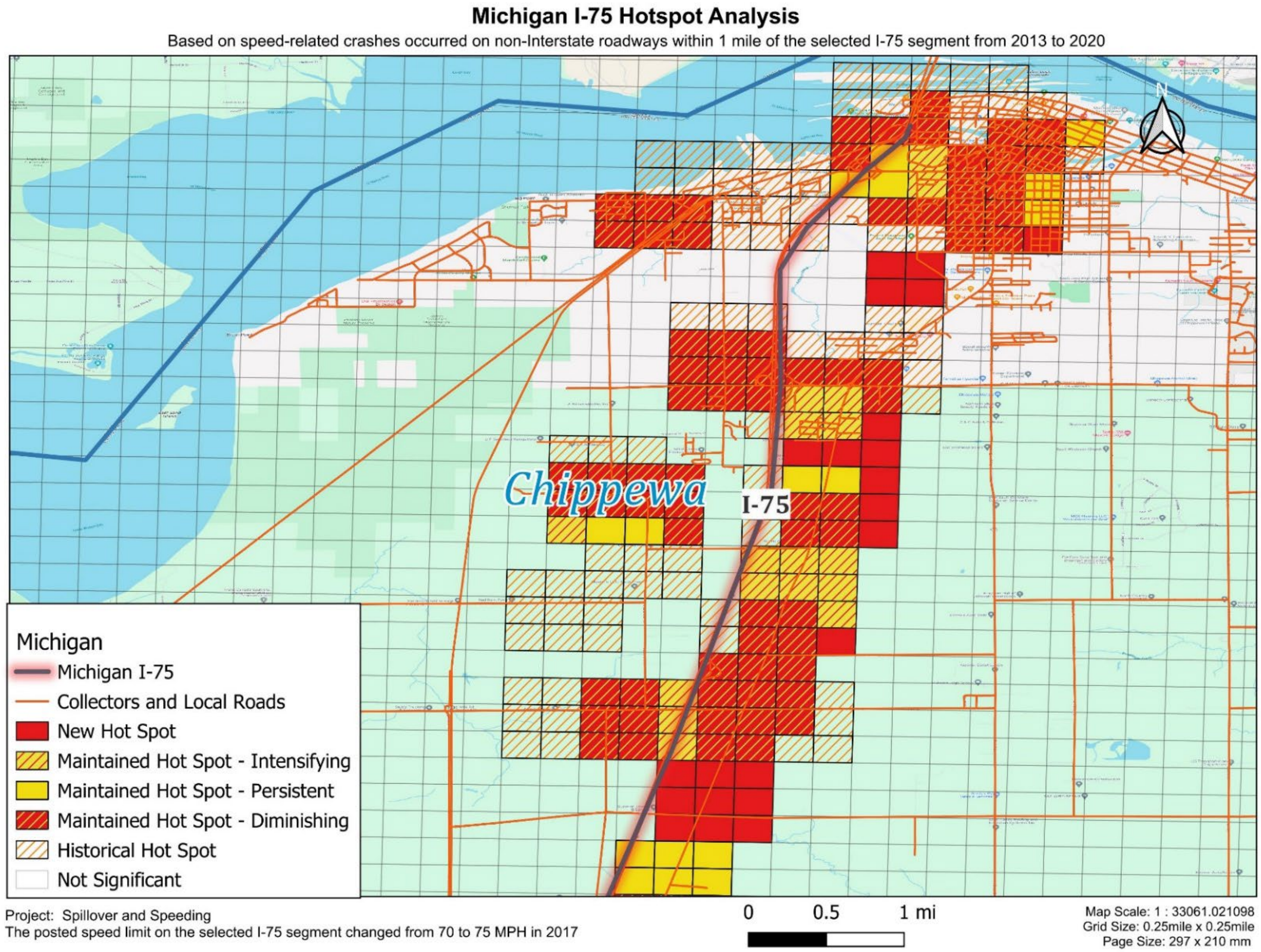


Figure 8. Hotspots on Adjacent Roadways nearby I-75 in Chippewa County (South), Michigan

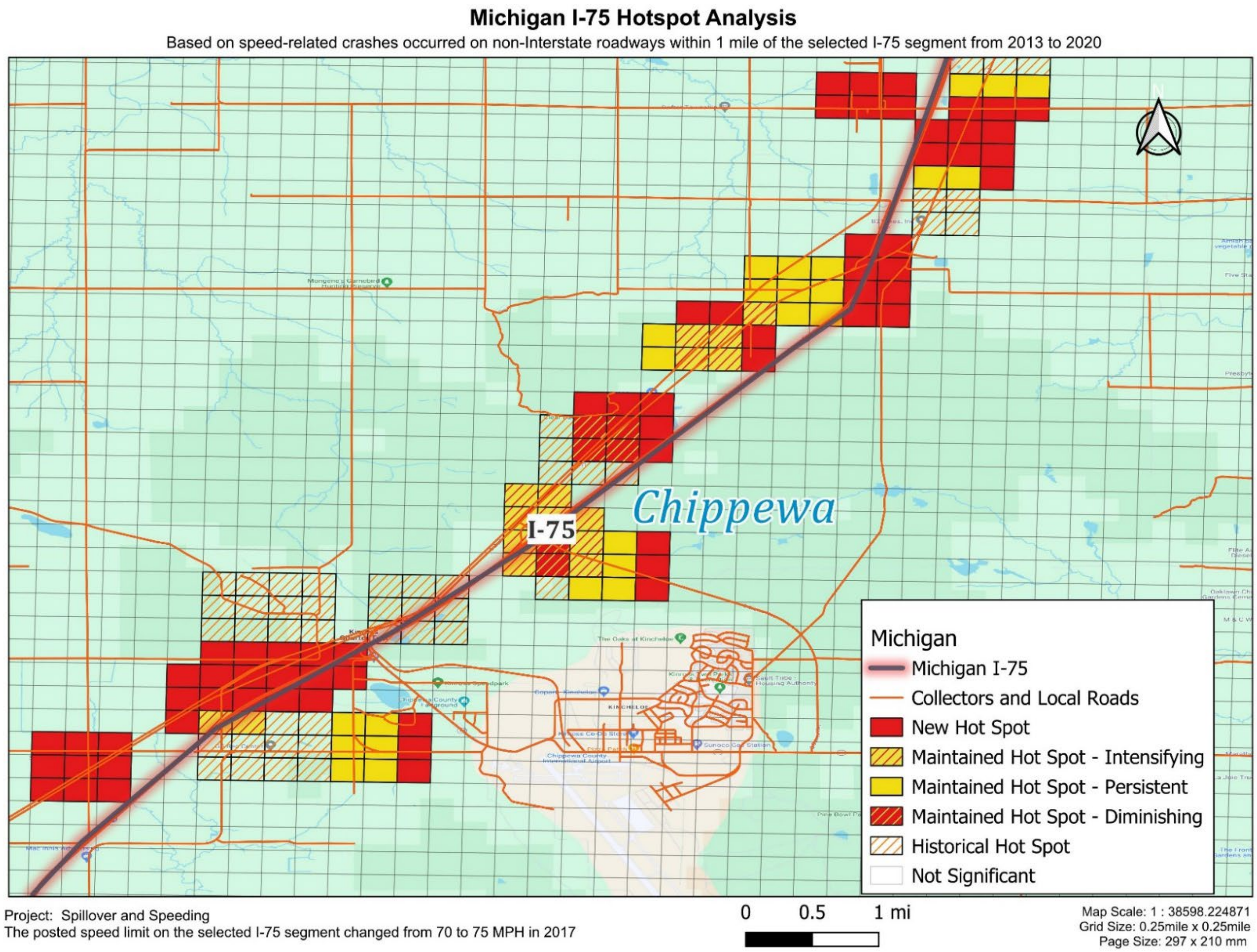


__Figure 9.__ Hotspots on Adjacent Roadways nearby I-75 in Mackinac County (North), Michigan

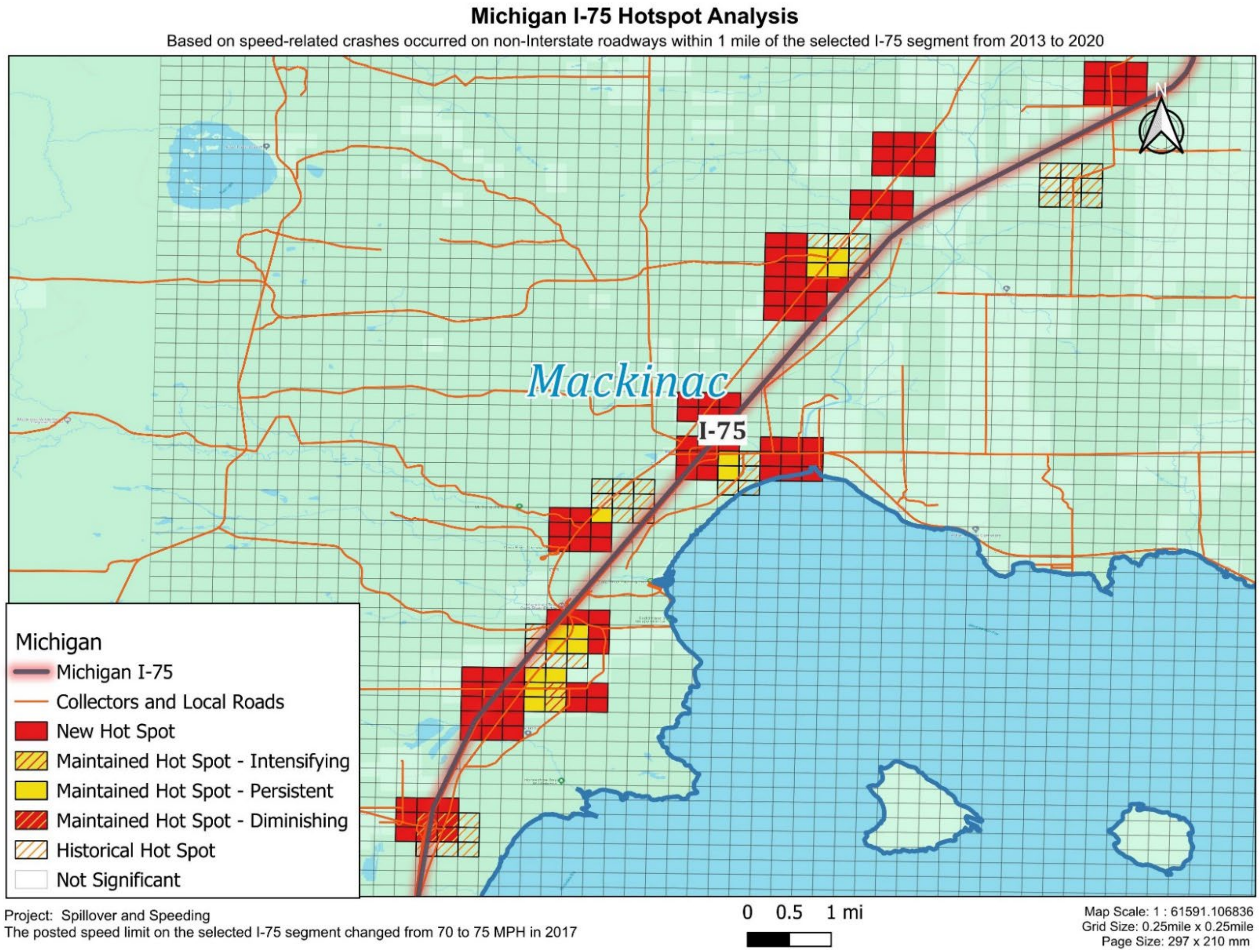


Figure 10. Hotspots on Adjacent Roadways nearby I-75 in Mackinac County (South), Michigan

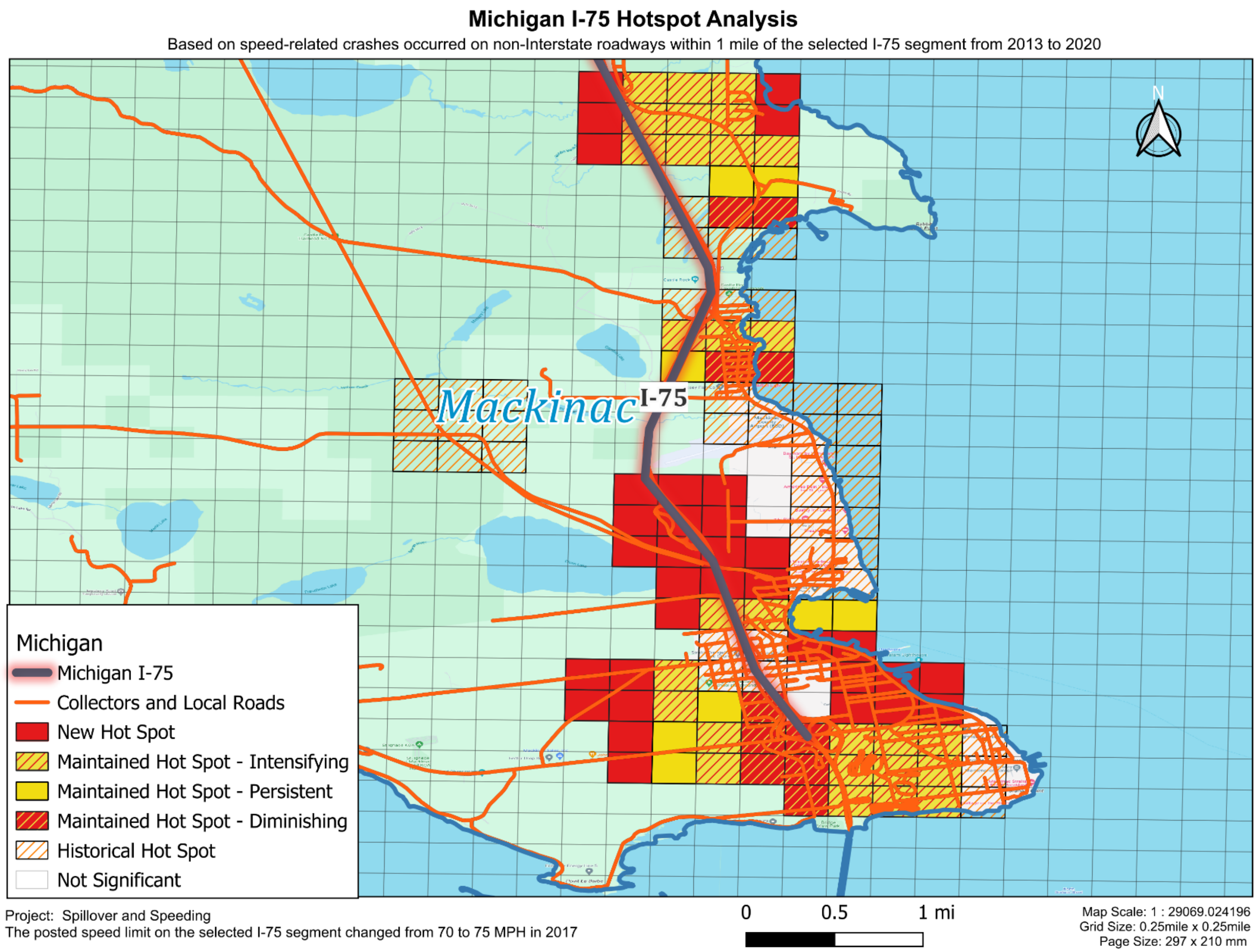


Figure 11. *Hotspots on Adjacent Roadways nearby I-75 in Emmet County and Cheboygan County (North), Michigan*

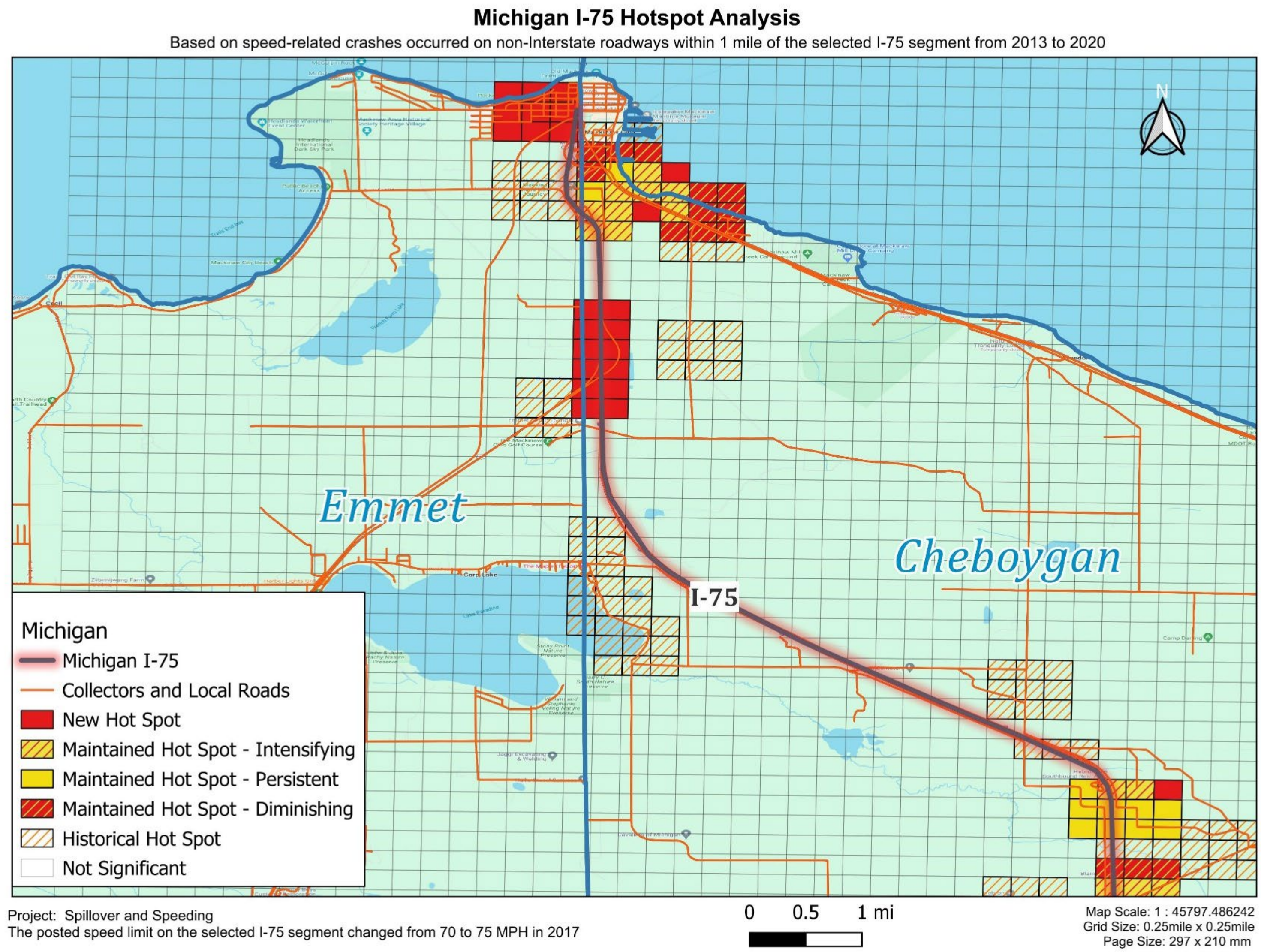


Figure 12. *Hotspots on Adjacent Roadways nearby I-75 in Cheboygan County (Central), Michigan*

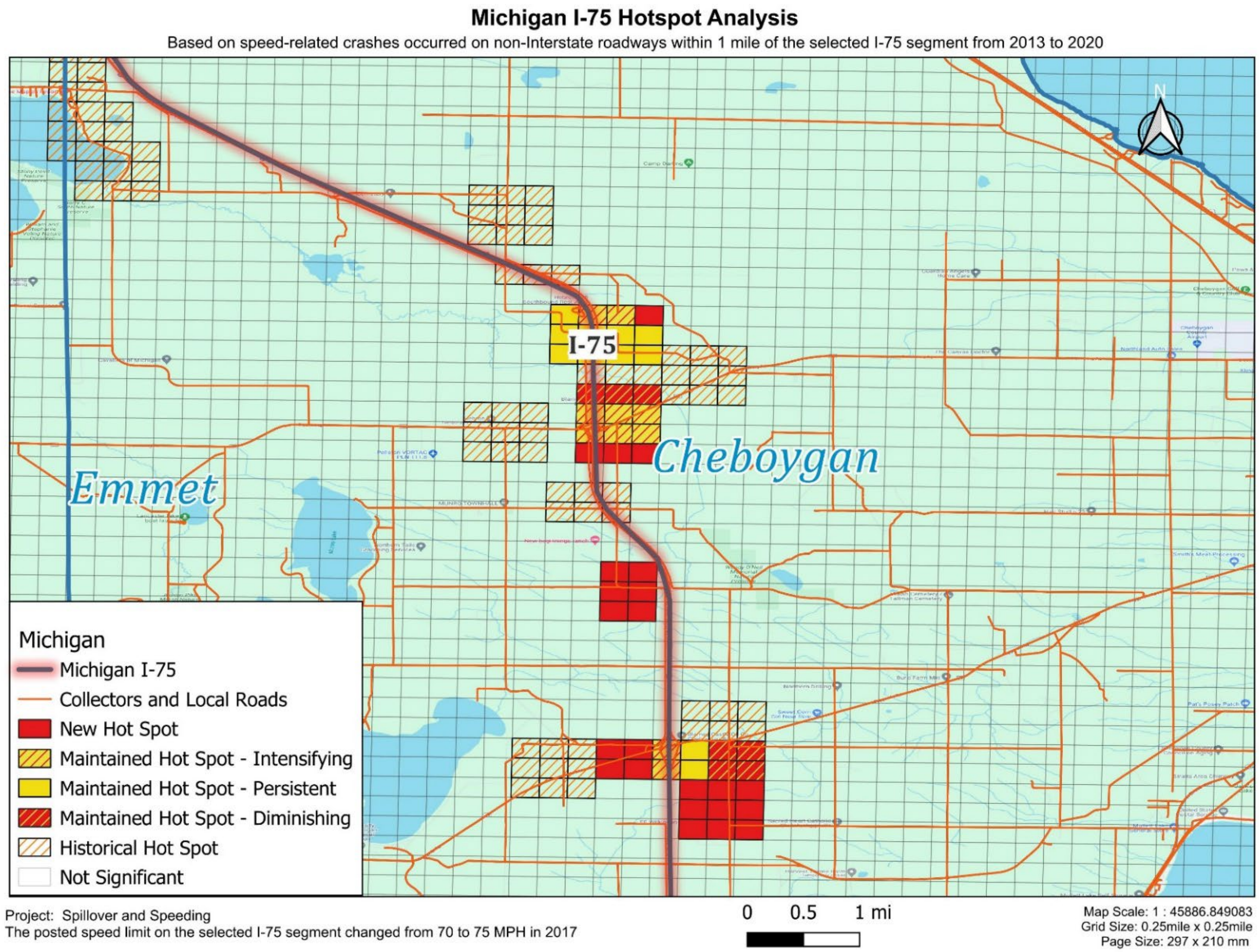


Figure 13. *Hotspots on Adjacent Roadways nearby I-75 in Cheboygan County (South), Michigan*

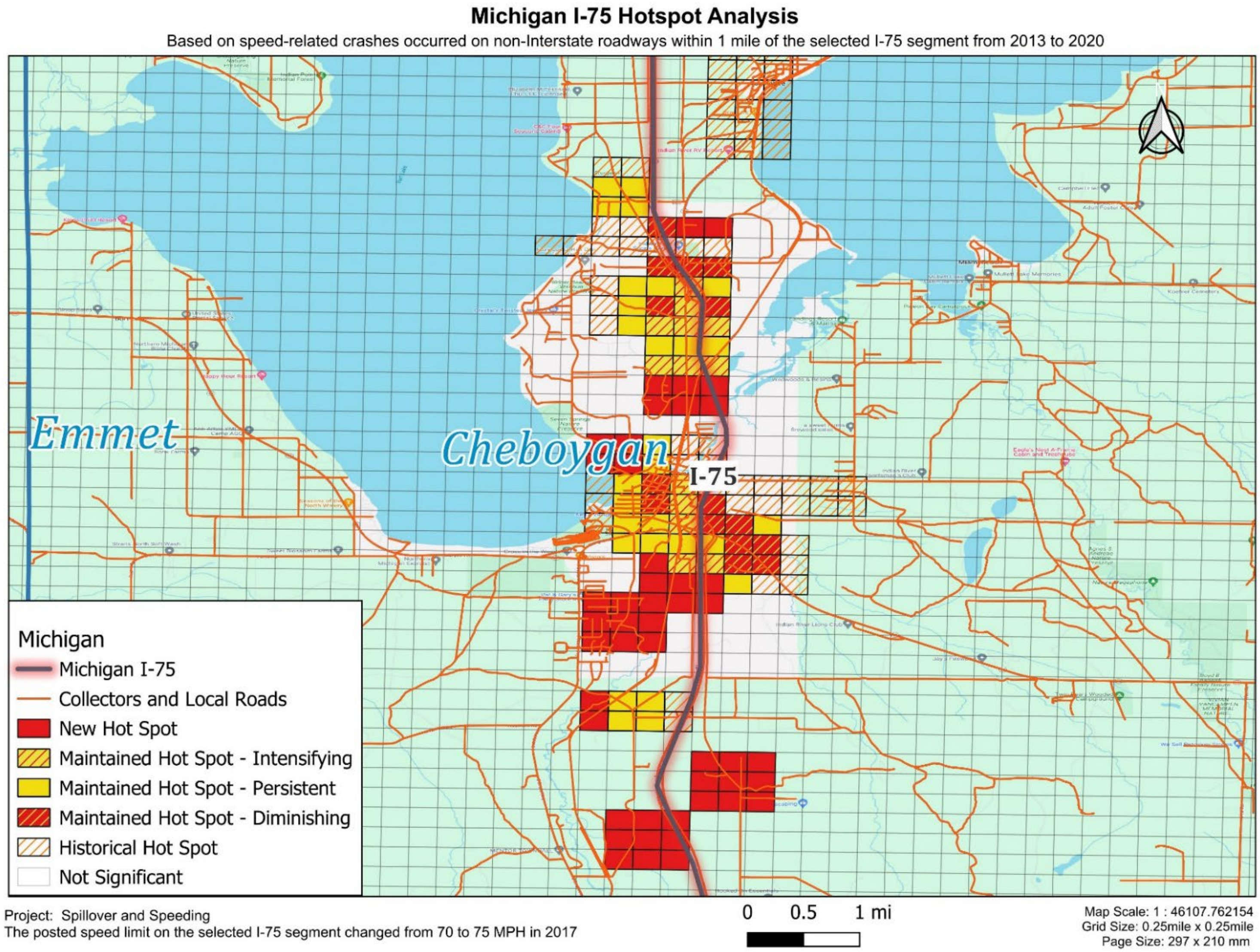


Figure 14. *Hotspots on Adjacent Roadways nearby I-75 in Otsego County (North), Michigan*

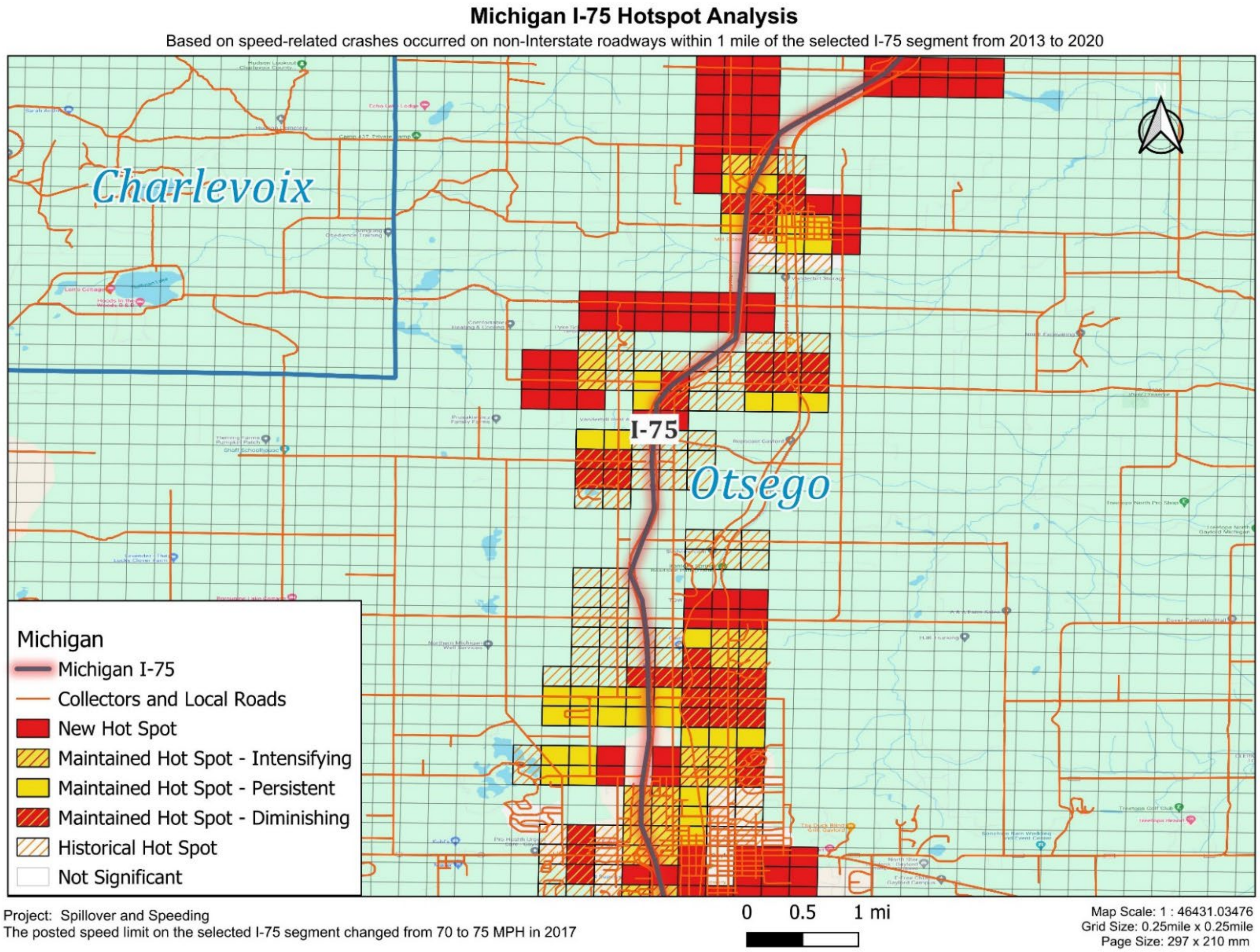


Figure 15. *Hotspots on Adjacent Roadways nearby I-75 in Otsego County (Central), Michigan*

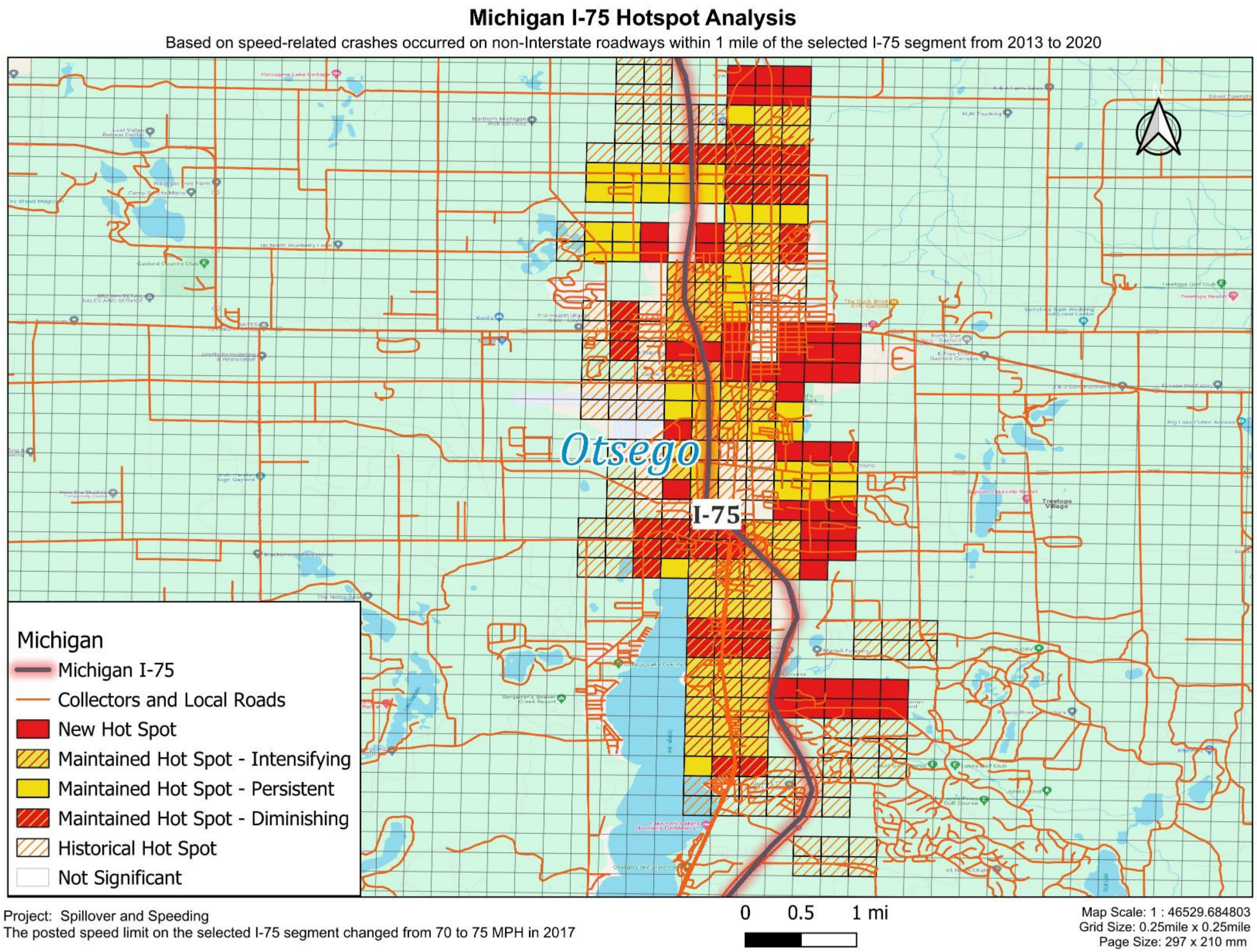


Figure 16. Hotspots on Adjacent Roadways nearby I-75 in Otsego County (South), Michigan

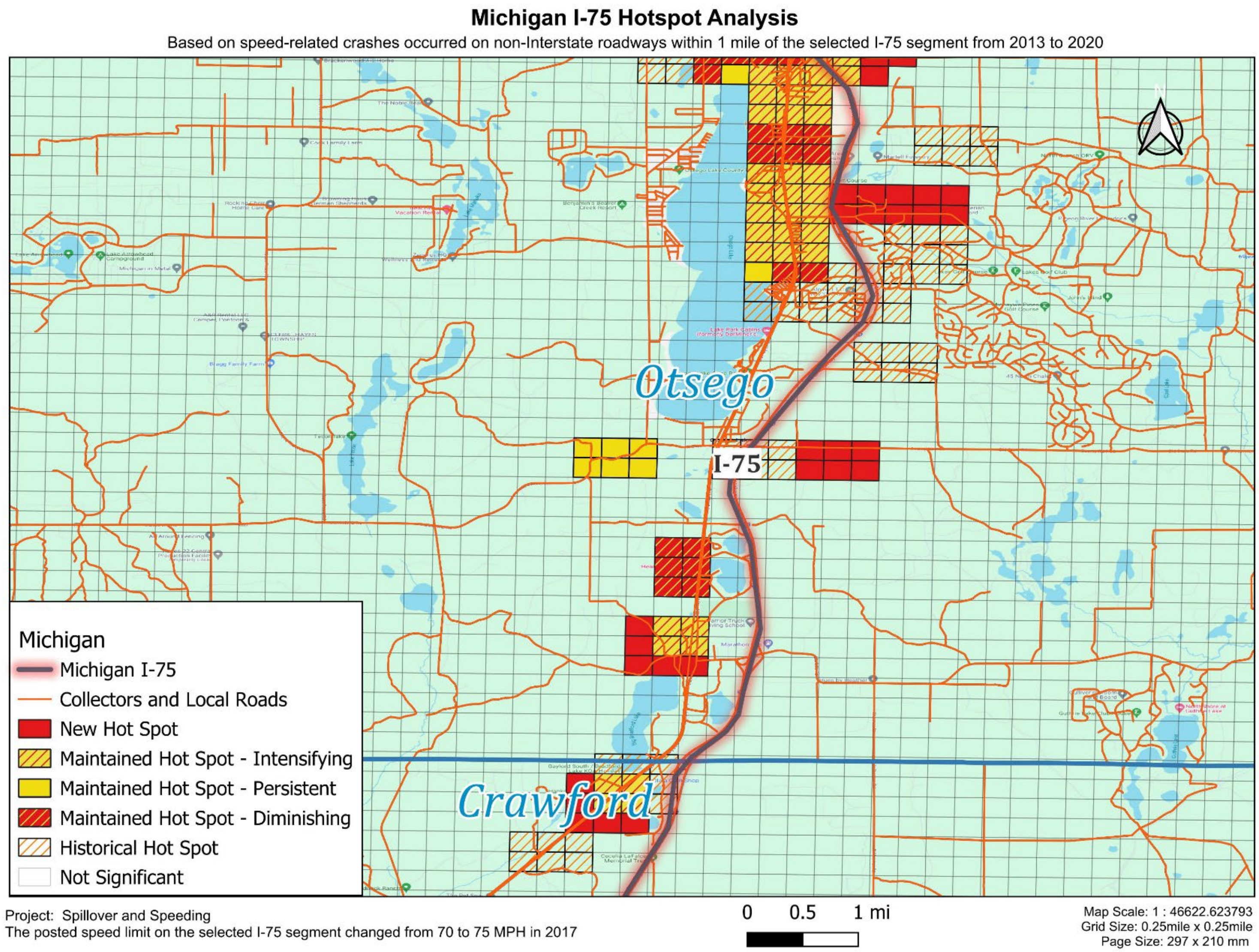


__Figure 17.__ Hotspots on Adjacent Roadways nearby I-75 in Crawford County (North), Michigan

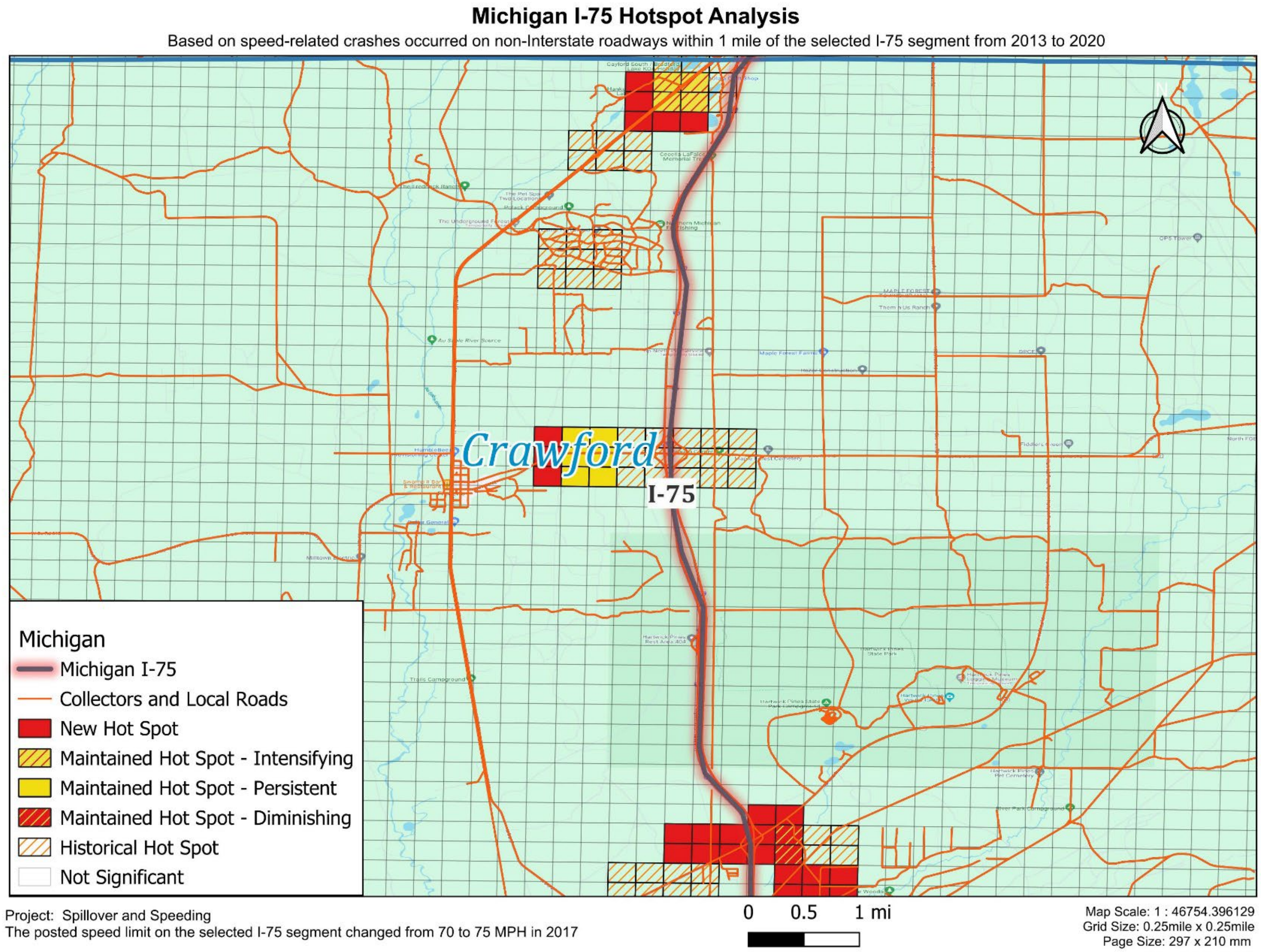


Figure 18. *Hotspots on Adjacent Roadways nearby I-75 in Crawford County (Central), Michigan*

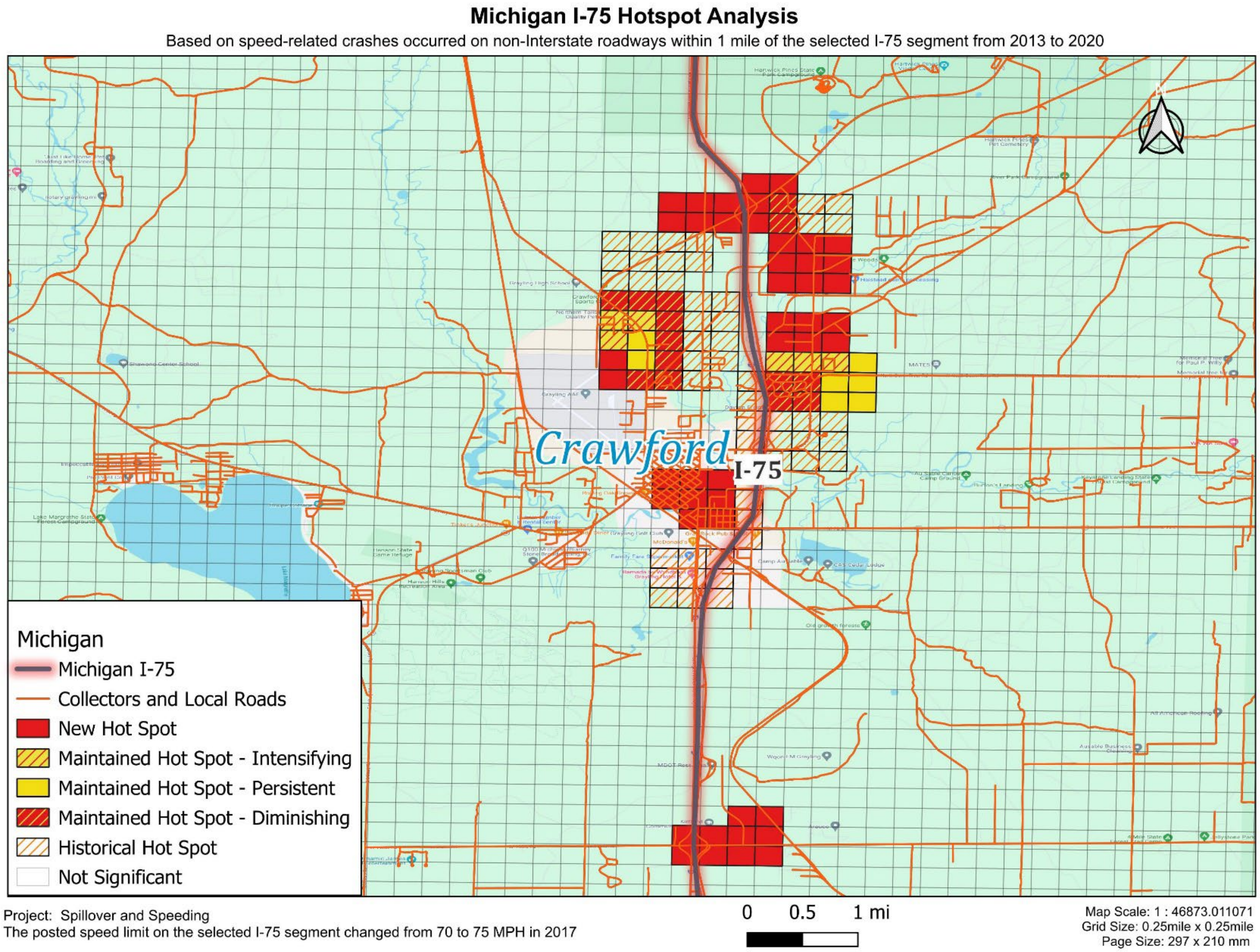


Figure 19. *Hotspots on Adjacent Roadways nearby I-75 in Crawford (South) County and Roscommon (North) County, Michigan*

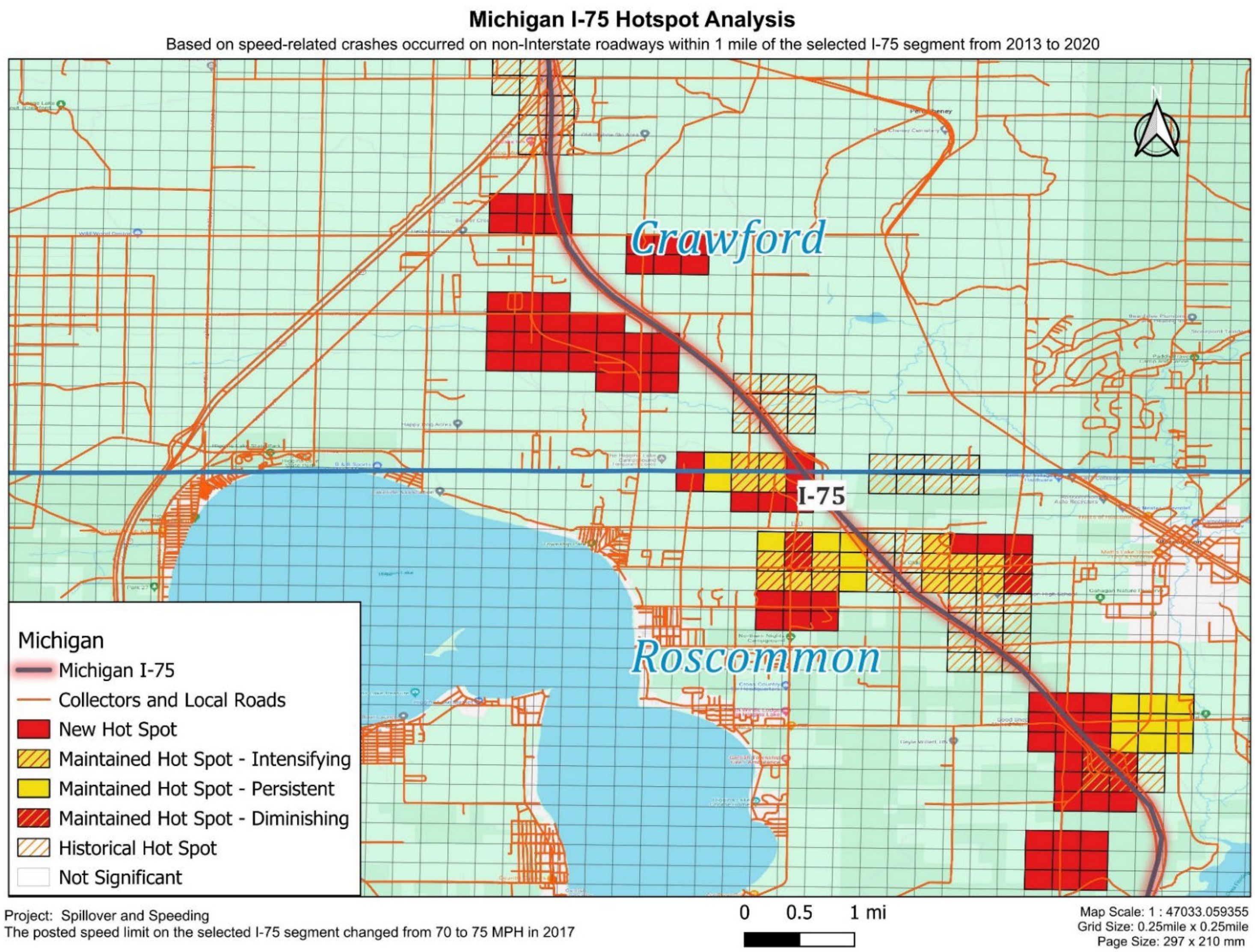


Figure 20. Hotspots on Adjacent Roadways nearby I-75 in Roscommon County (Central), Michigan

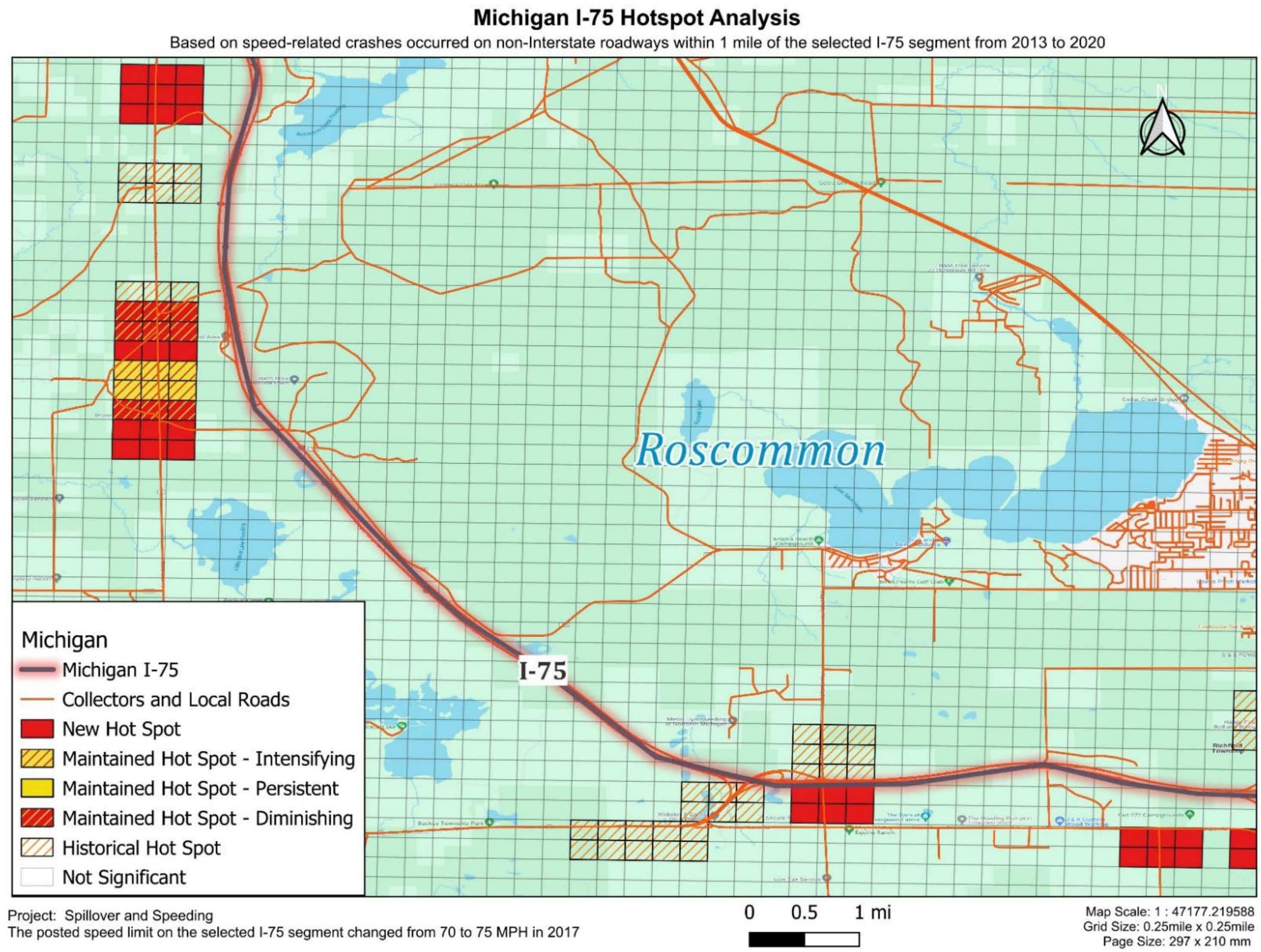


Figure 21. *Hotspots on Adjacent Roadways nearby I-75 in Roscommon County (East) and Ogemaw County (West), Michigan*

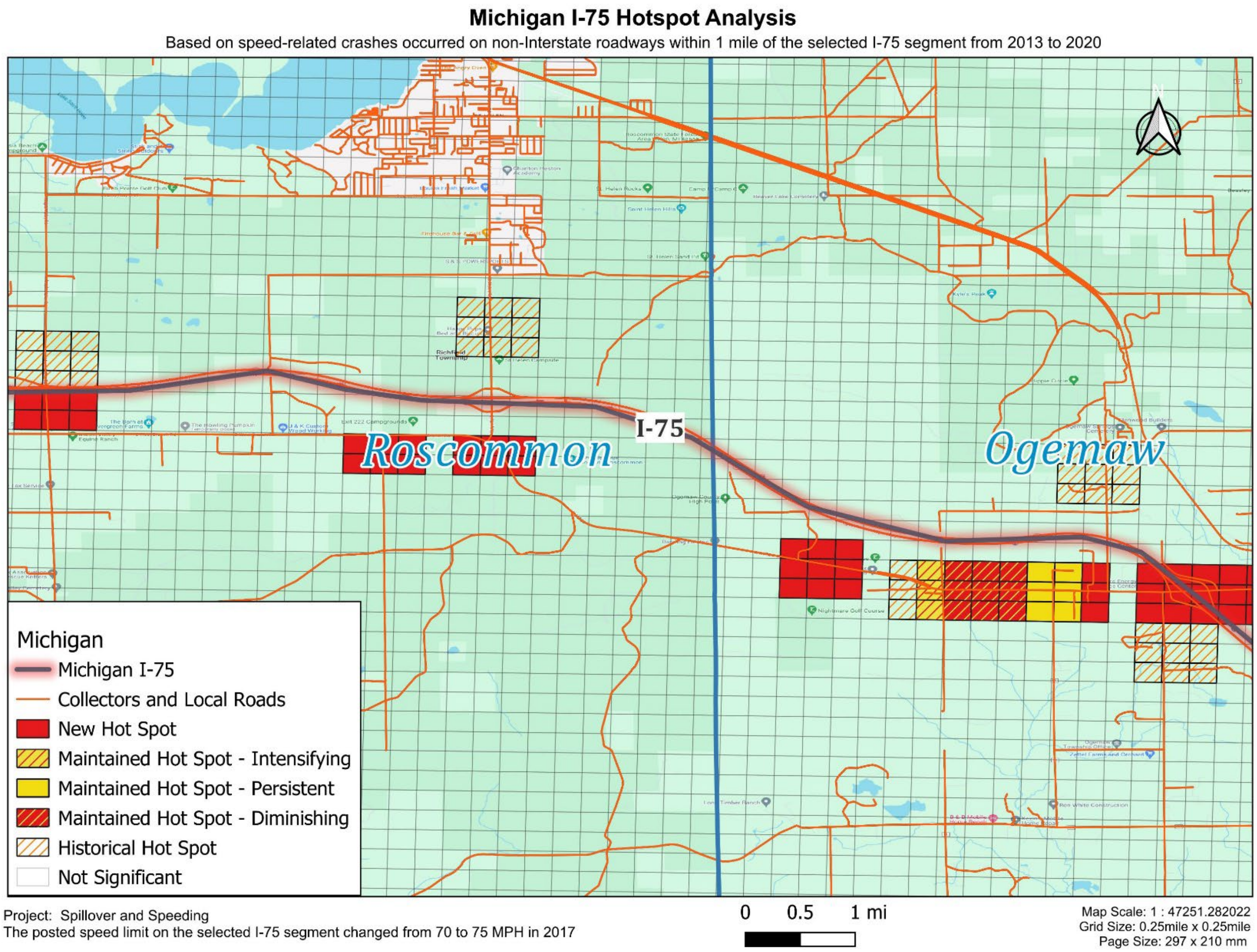


Figure 22. *Hotspots on Adjacent Roadways nearby I-75 in Ogemaw County (East), Michigan*

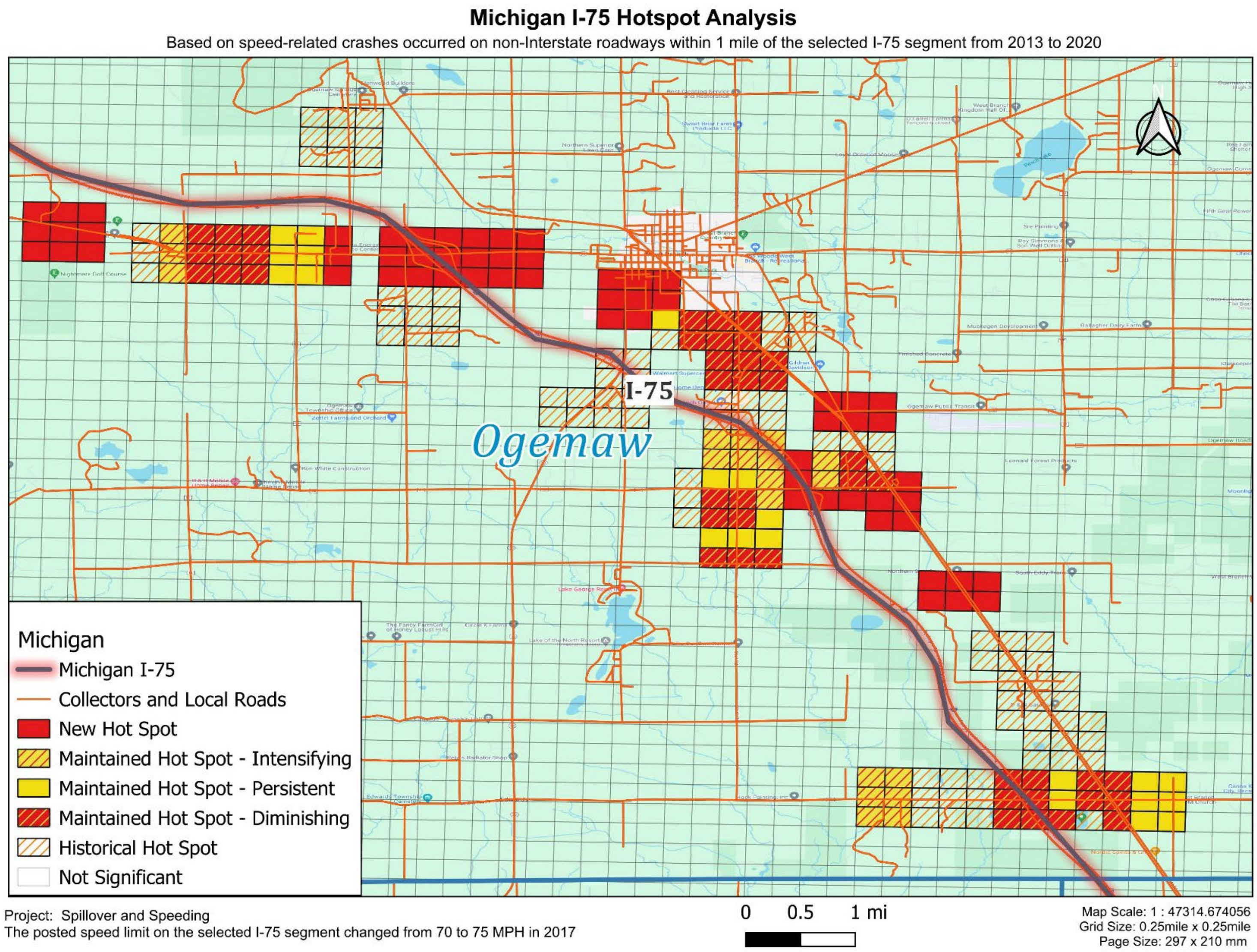


Figure 23. *Hotspots on Adjacent Roadways nearby I-75 in Arenac (North) County, Michigan*

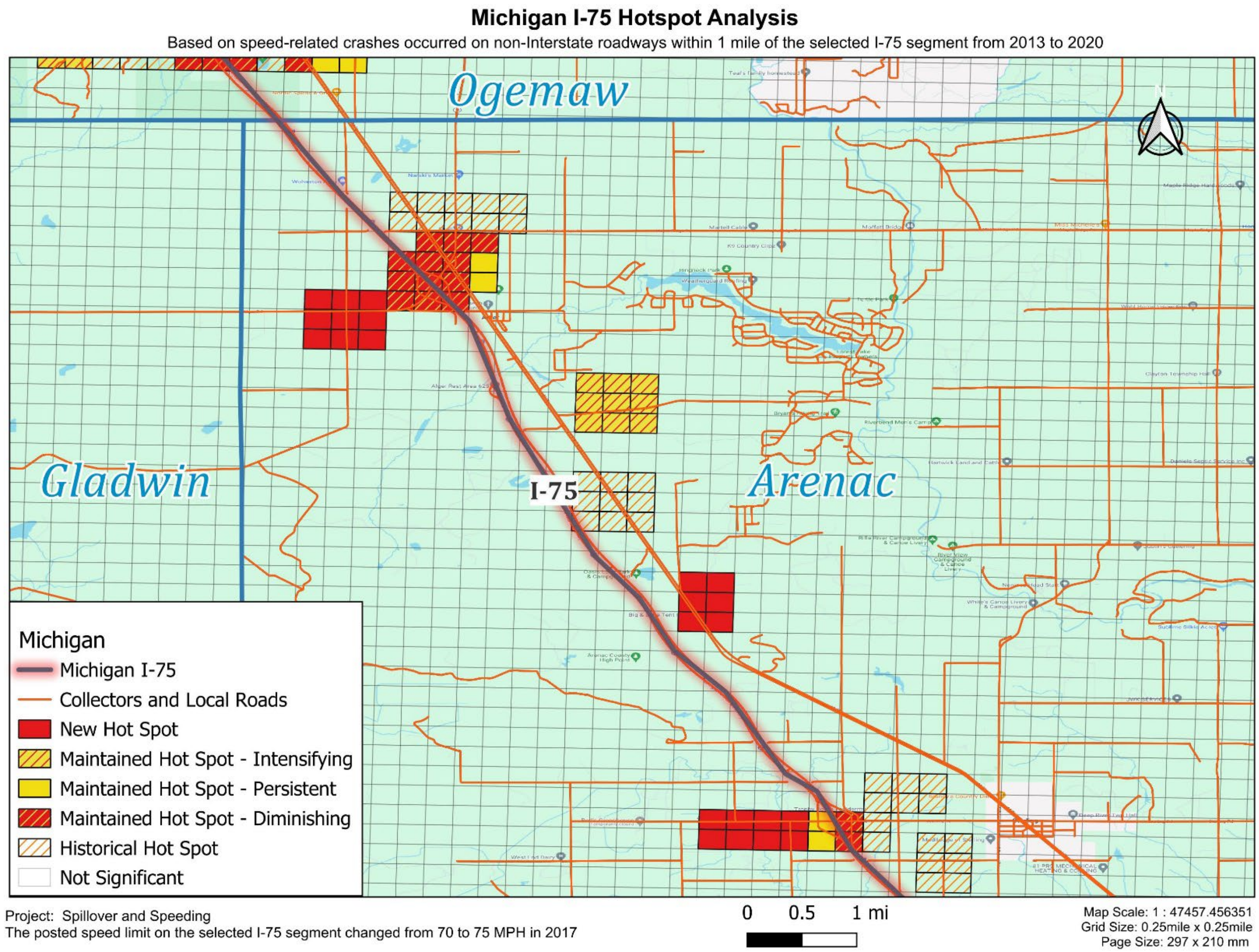


Figure 24. Hotspots on Adjacent Roadways nearby I-75 in Arenac County (Central), Michigan

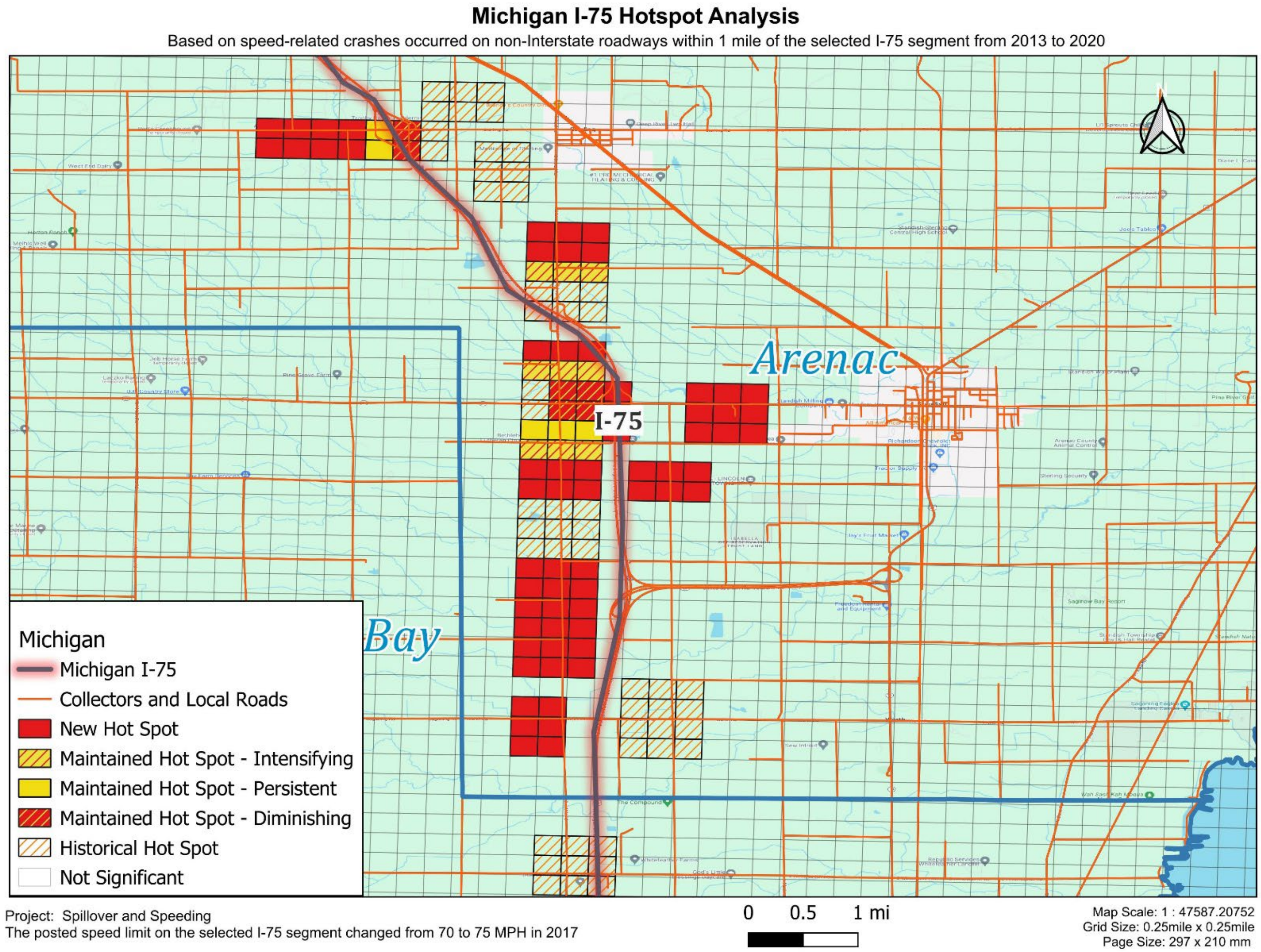


Figure 25. *Hotspots on Adjacent Roadways nearby I-75 in Arenac County (South) and Bay County (North), Michigan*

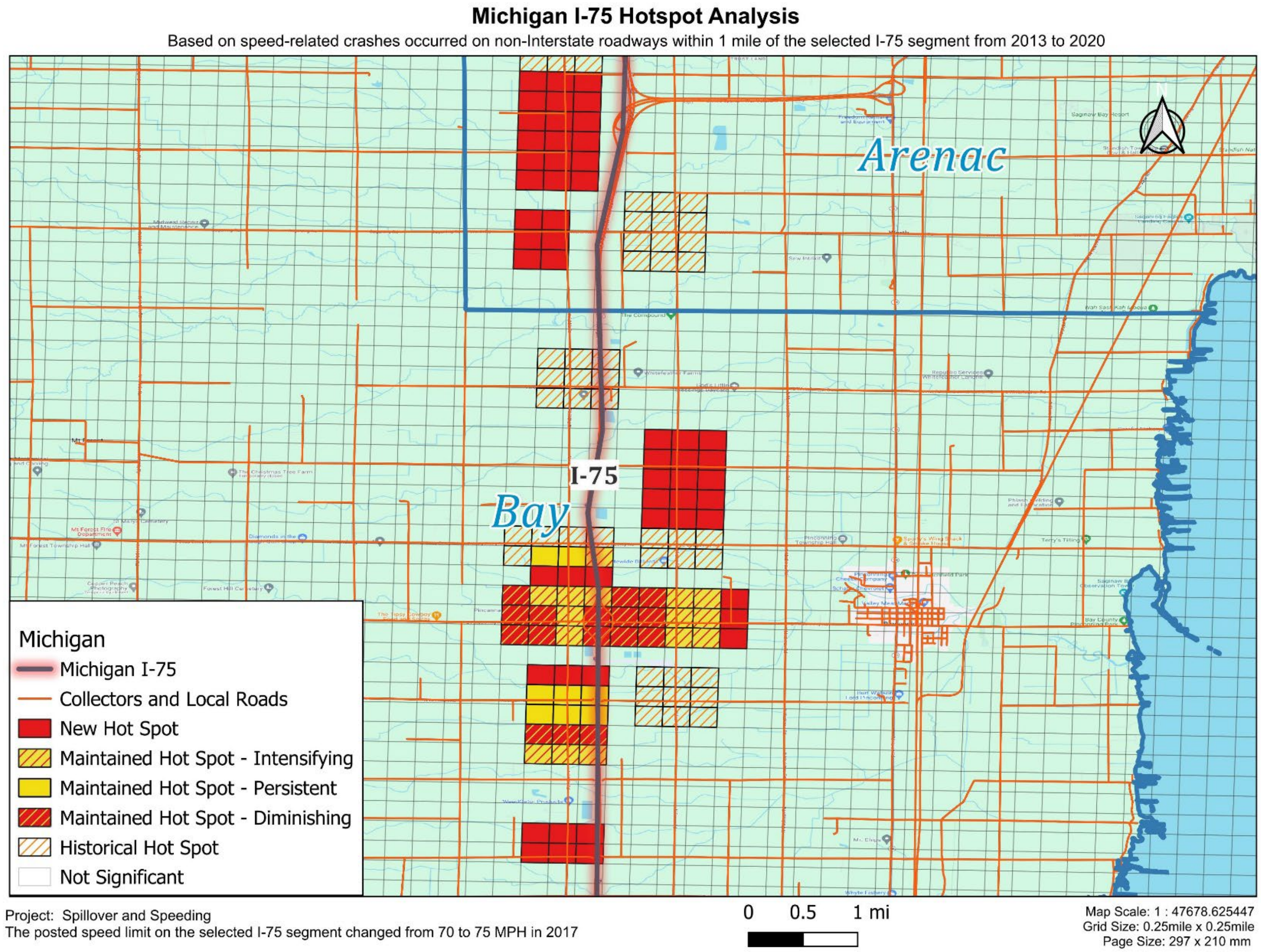


Figure 26. Hotspots on Adjacent Roadways nearby I-75 in Bay County (Central), Michigan

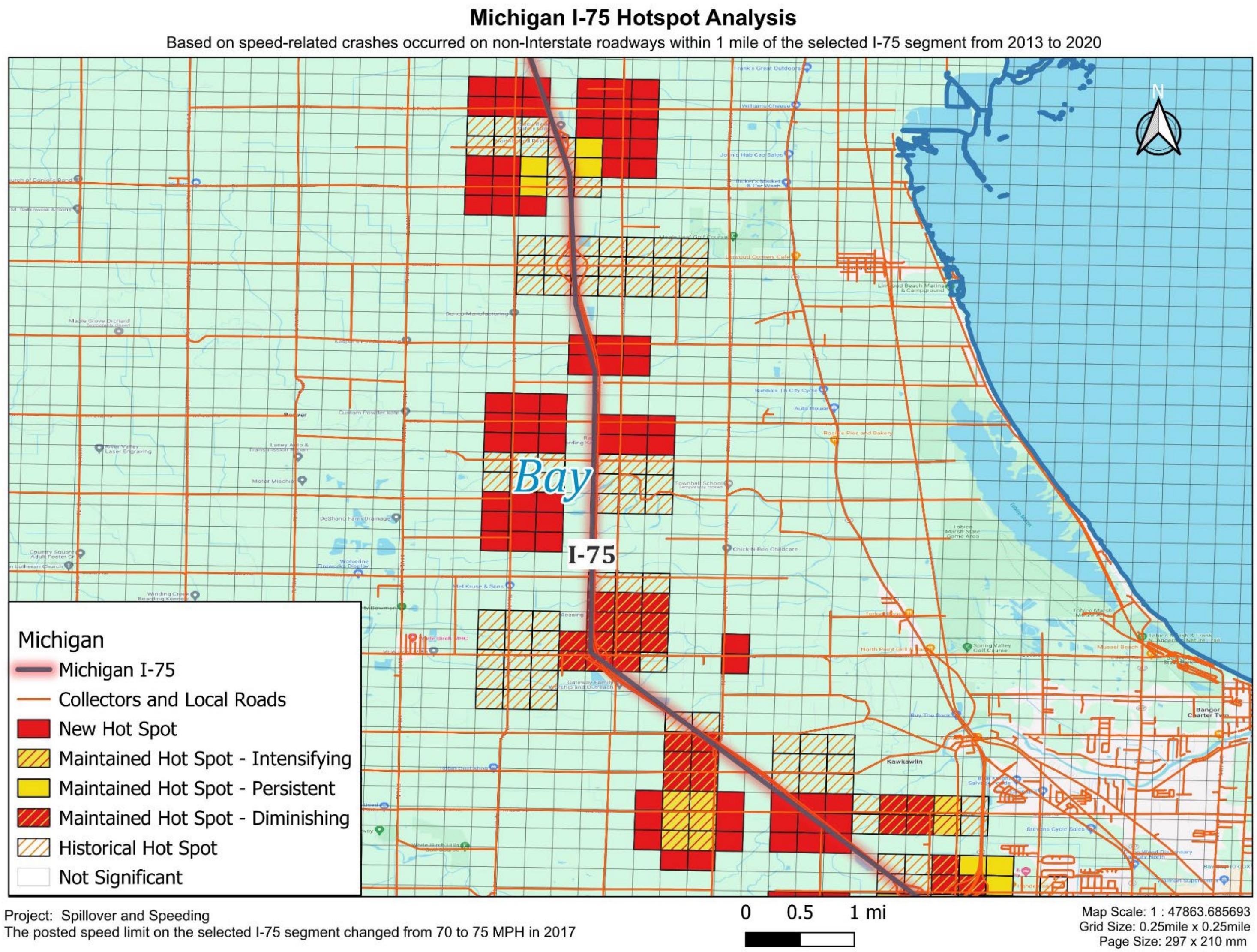
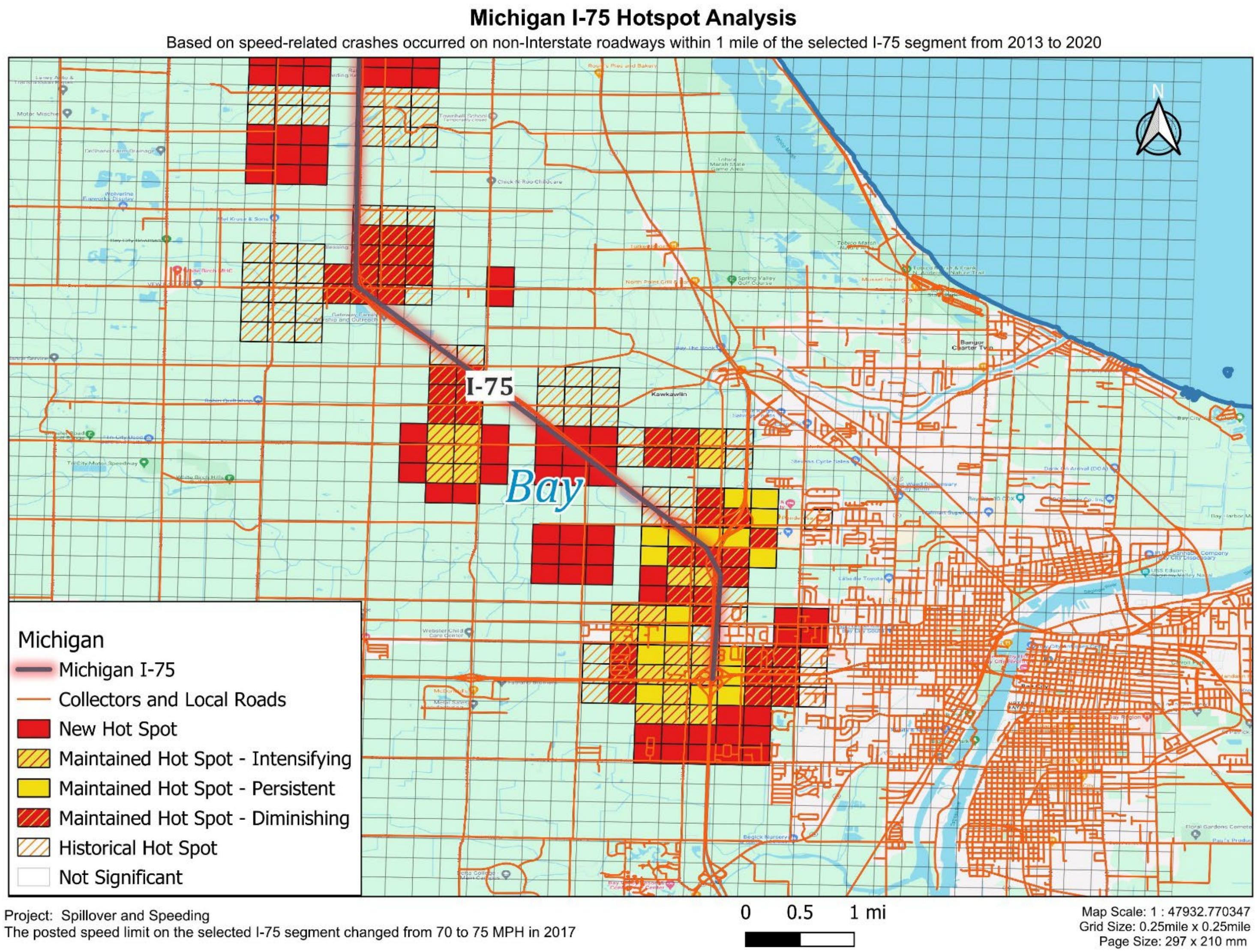


Figure 27. Hotspots on Adjacent Roadways nearby I-75 in Bay County (South), Michigan



Results from Geospatial Analysis for Rural Communities nearby I-69

New Hot Spots: I-69

Rural communities with new and high spatial autocorrelation along I-69 are presented in ***Figure 28*** through ***Figure 34*** in red color-coded areas. Clinton County is an example of unexpected shifts in speed-related crashes. As can be seen from ***Figure 28***, Clinton County had several clusters of new speed-related crashes that were not a significant problem previously. Multiple new hot spots emerged in these communities after the posted speed limit on I-69 was raised from 70 mph to 75 mph.

Maintained Hot Spots—Intensifying: I-69

The sub-category of 'Intensifying' Maintained Hot Spots is shown in yellow grids with red stripes in ***Figure 28*** through ***Figure 34***. These clusters maintained a statistical significance of speed-related crashes after the new posted speed limit took effect, which suggest that there is a higher possibility for these local communities to experience speed-related crashes compared to the 'before' period. For example, both Eaton and Clinton County shown in ***Figure 28*** experienced this sub-category of Maintained Hot Spots.

Maintained Hot Spots—Persistent: I-69

The 'Persistent' sub-category of the Maintained Hot Spots is presented as yellow color-coded grids scattered throughout the study area as shown in ***Figure 28*** through ***Figure 34***. Fewer rural townships along I-69 experienced persistent speed-related crashes compared to other categories. See Lapeer County in ***Figure 31*** and ***Figure 32*** for an illustration of this type of Maintained Hot Spot.

Maintained Hot Spots—Diminishing: I-69

Statistically significant hot spots with a lower spatial autocorrelation in the 'after' evaluation period were considered as 'Diminishing' and this sub-category of Maintained Hot Spots is shown as red grids with yellow stripes in ***Figure 28*** to ***Figure 34***. Interestingly, some of these areas appeared in proximity of new hot spots or intensifying hot spots on I-69, which suggests that speeding behavior leading to crashes was not necessarily less frequent, but crashes shifted or expanded to the next 0.25 to 0.5 miles. Some of this type of hot spot can be observed in St. Clair County (see ***Figure 33*** and ***Figure 34***).

Historical Hot Spots: I-69

Only a few locations revealed a statistically significant autocorrelation among speed-related crashes within a 0.25-by-0.25-mile grid after raising the speed limit in the nearby Interstate. Historical Hot Spots, shown as translucent grids with orange stripes, can be seen in Shiawassee County (see ***Figure 29*** and ***Figure 30***).

Figure 28. Hotspots on Adjacent Roadways nearby I-69 in Eaton County and Clinton County, Michigan

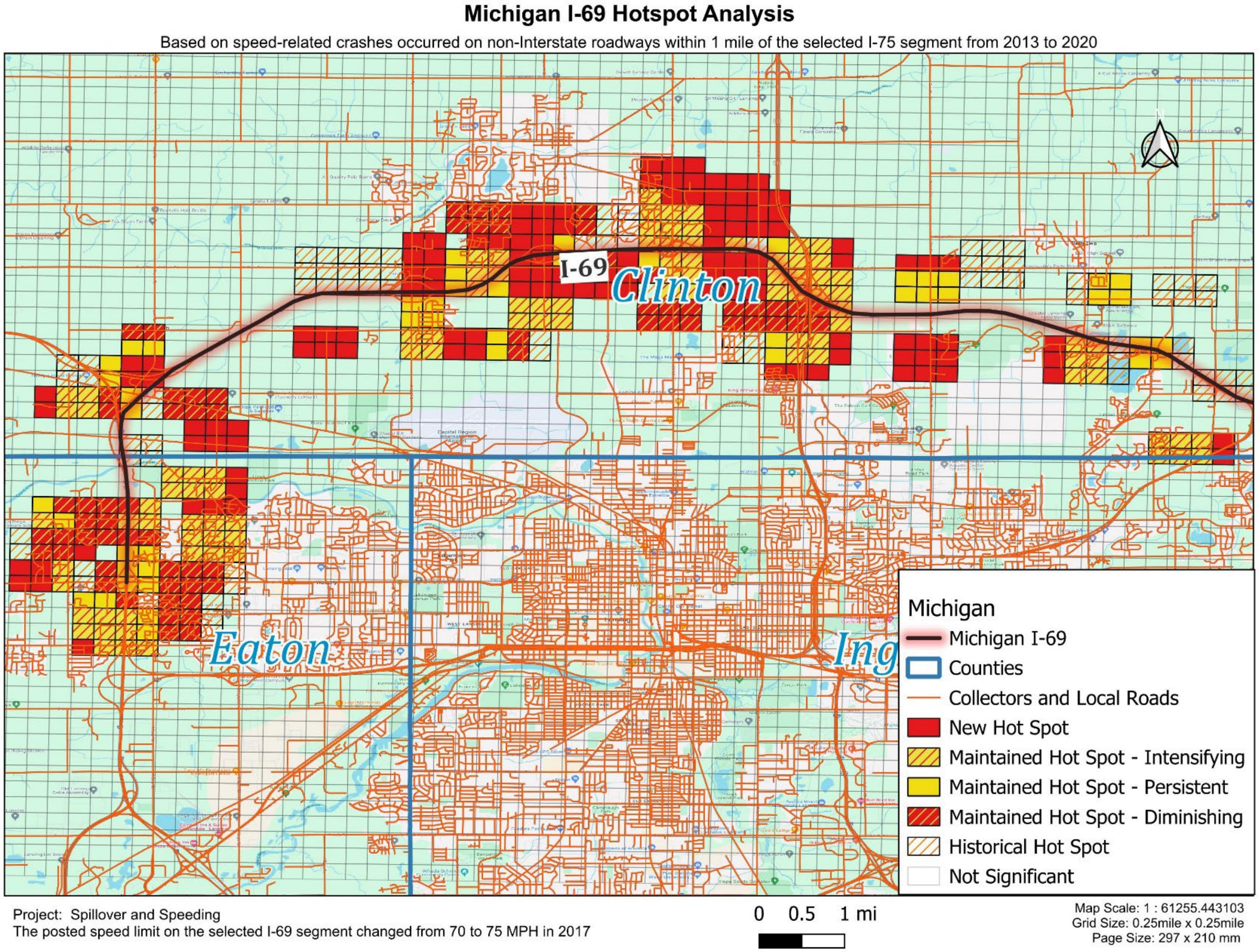


Figure 29. Hotspots on Adjacent Roadways nearby I-69 in Clinton County (East) and Shiawassee County (West), Michigan

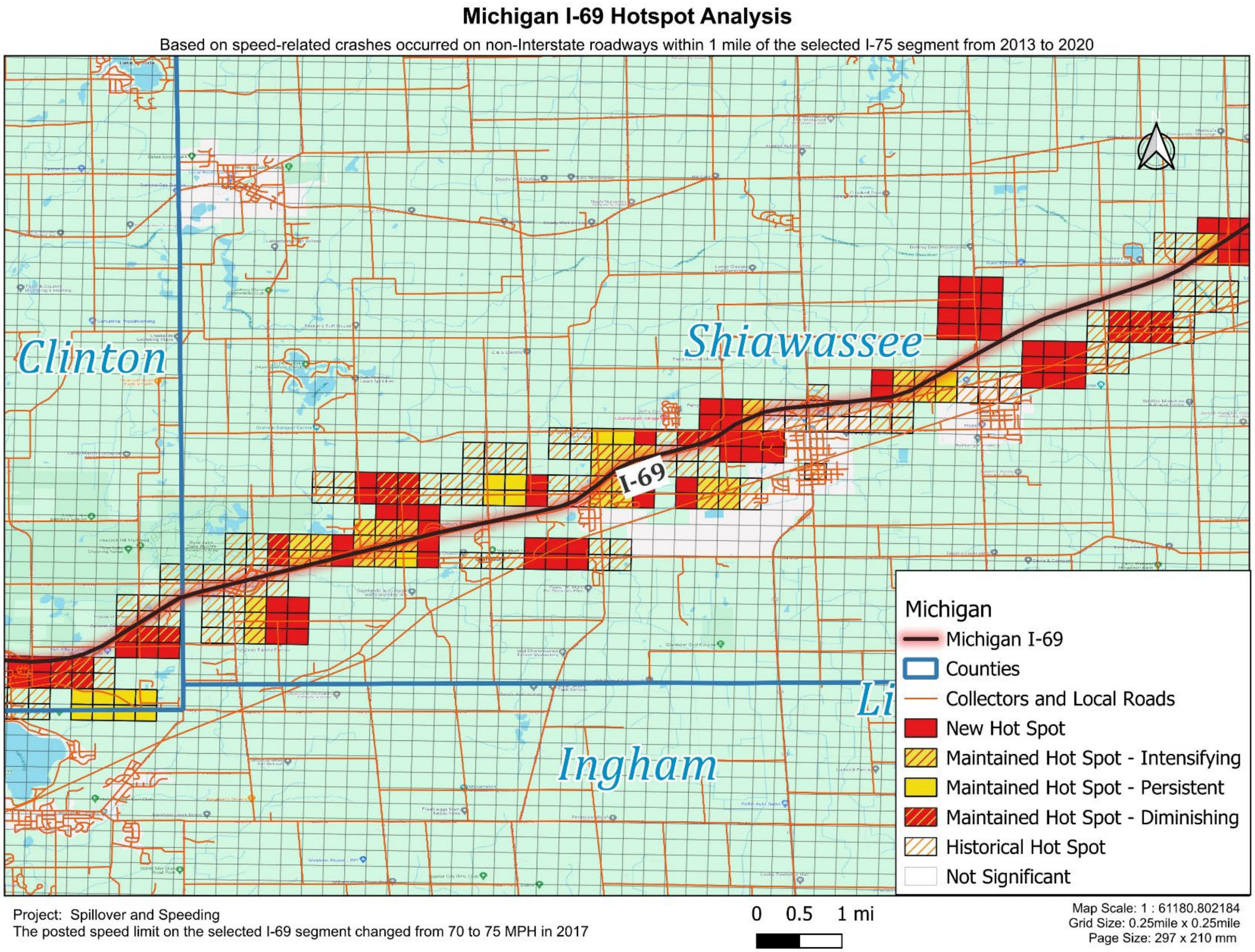


Figure 30. *Hotspots on Adjacent Roadways nearby I-69 in Shiawassee County (East) and Genessee County (West), Michigan*

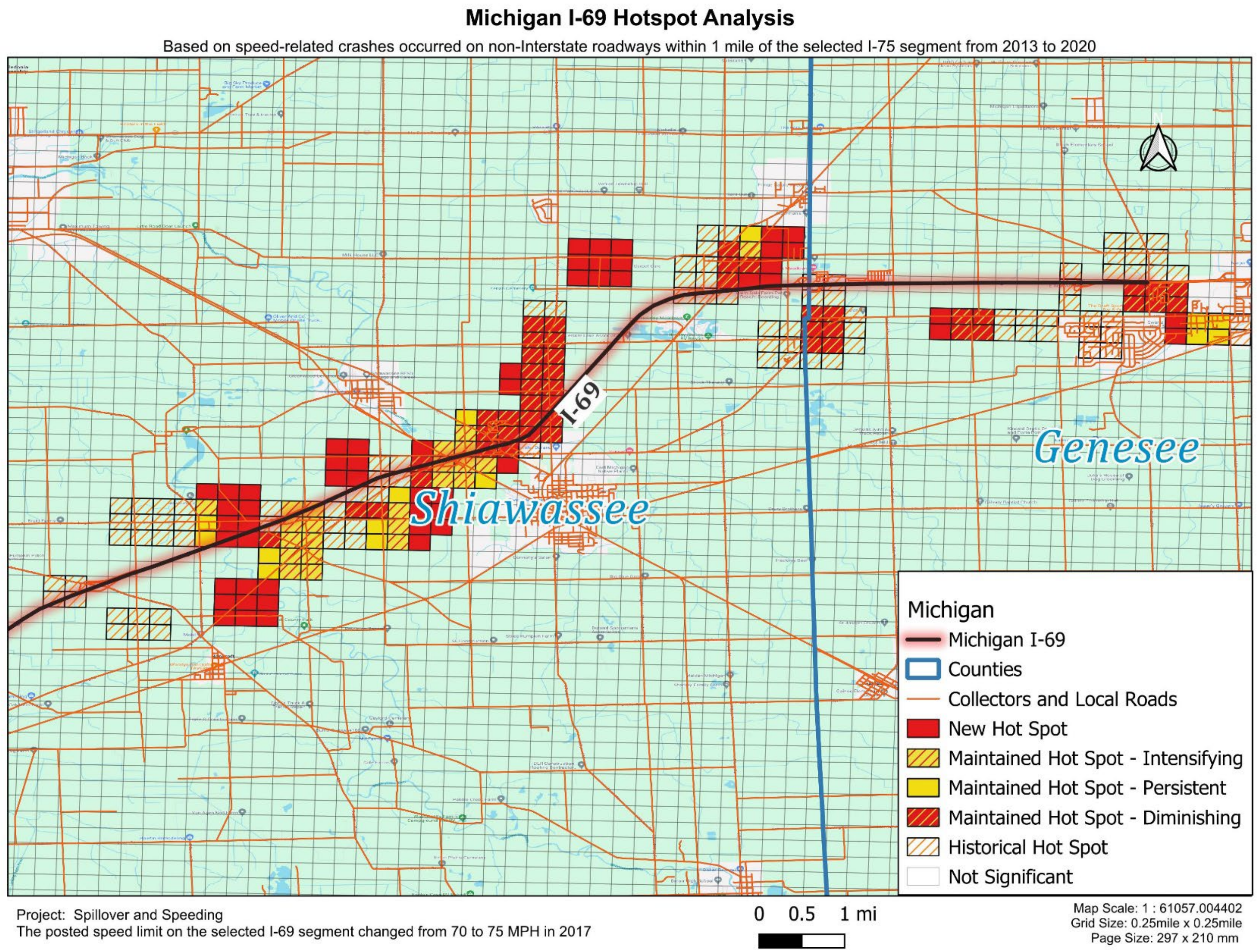


Figure 31. *Hotspots on Adjacent Roadways nearby I-69 in Lapeer County (West), Michigan*

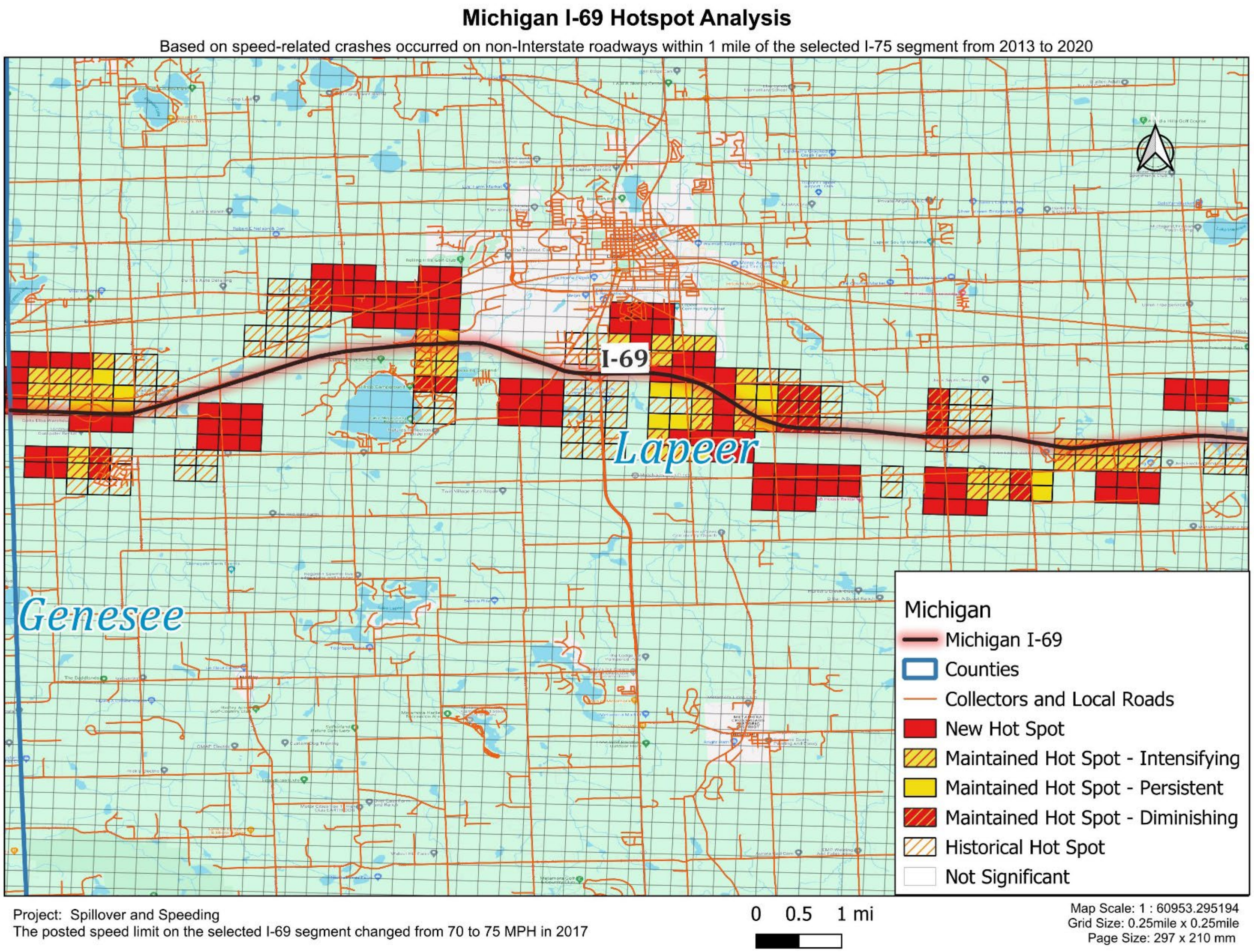


Figure 32. *Hotspots on Adjacent Roadways nearby I-69 in Lapeer County (East) and St. Clair County (West), Michigan*

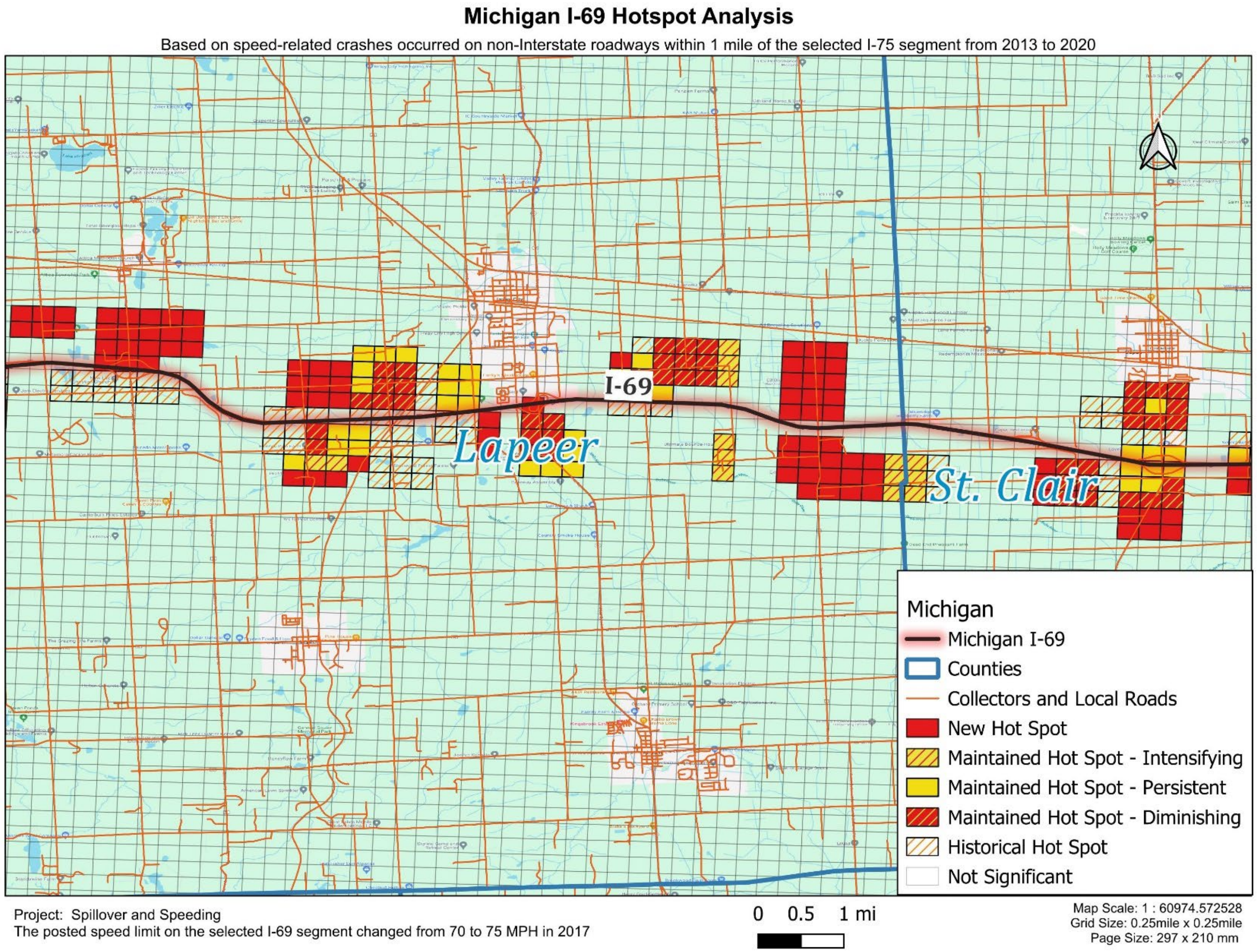


Figure 33. *Hotspots on Adjacent Roadways nearby I-69 in St. Clair County (Central), Michigan*

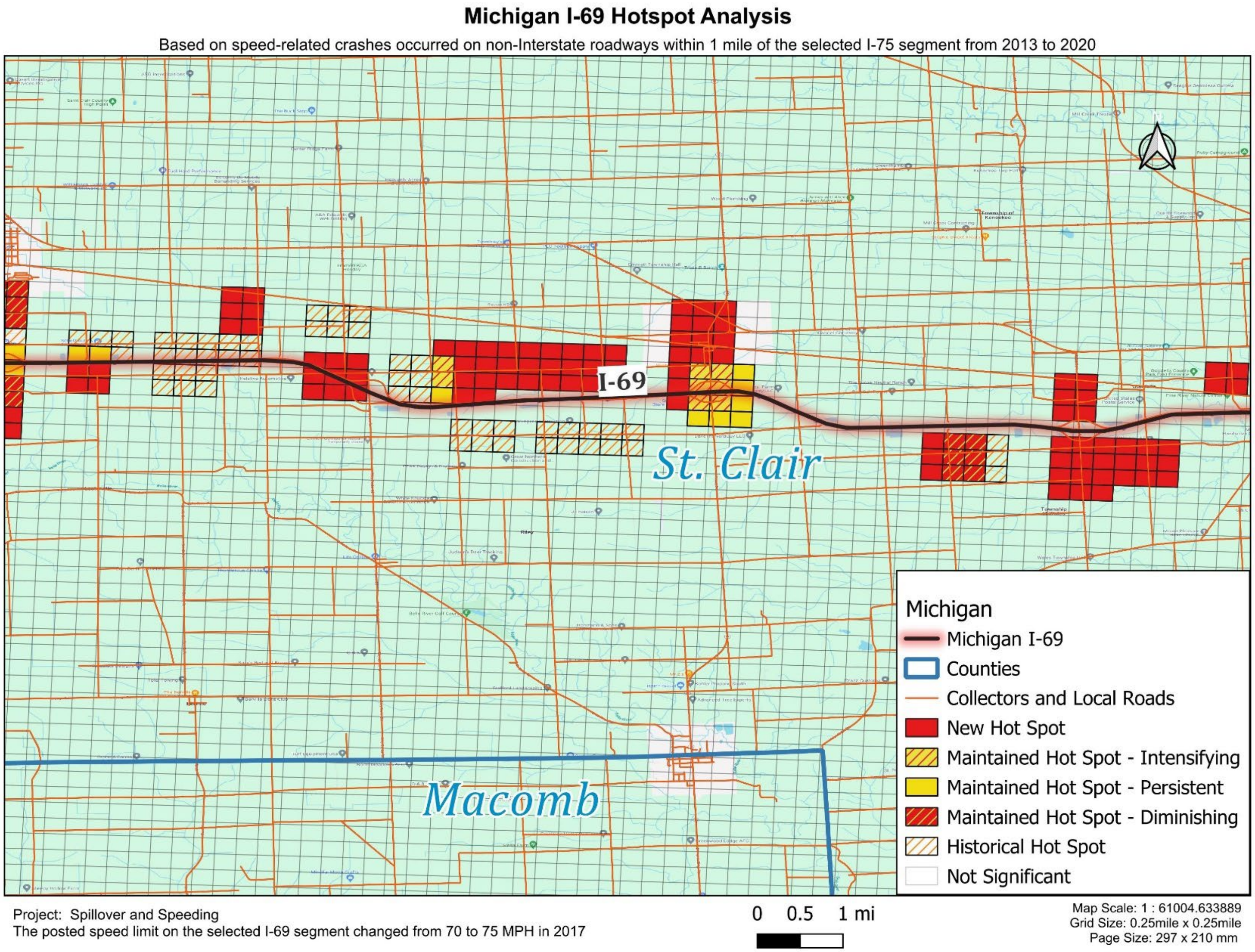
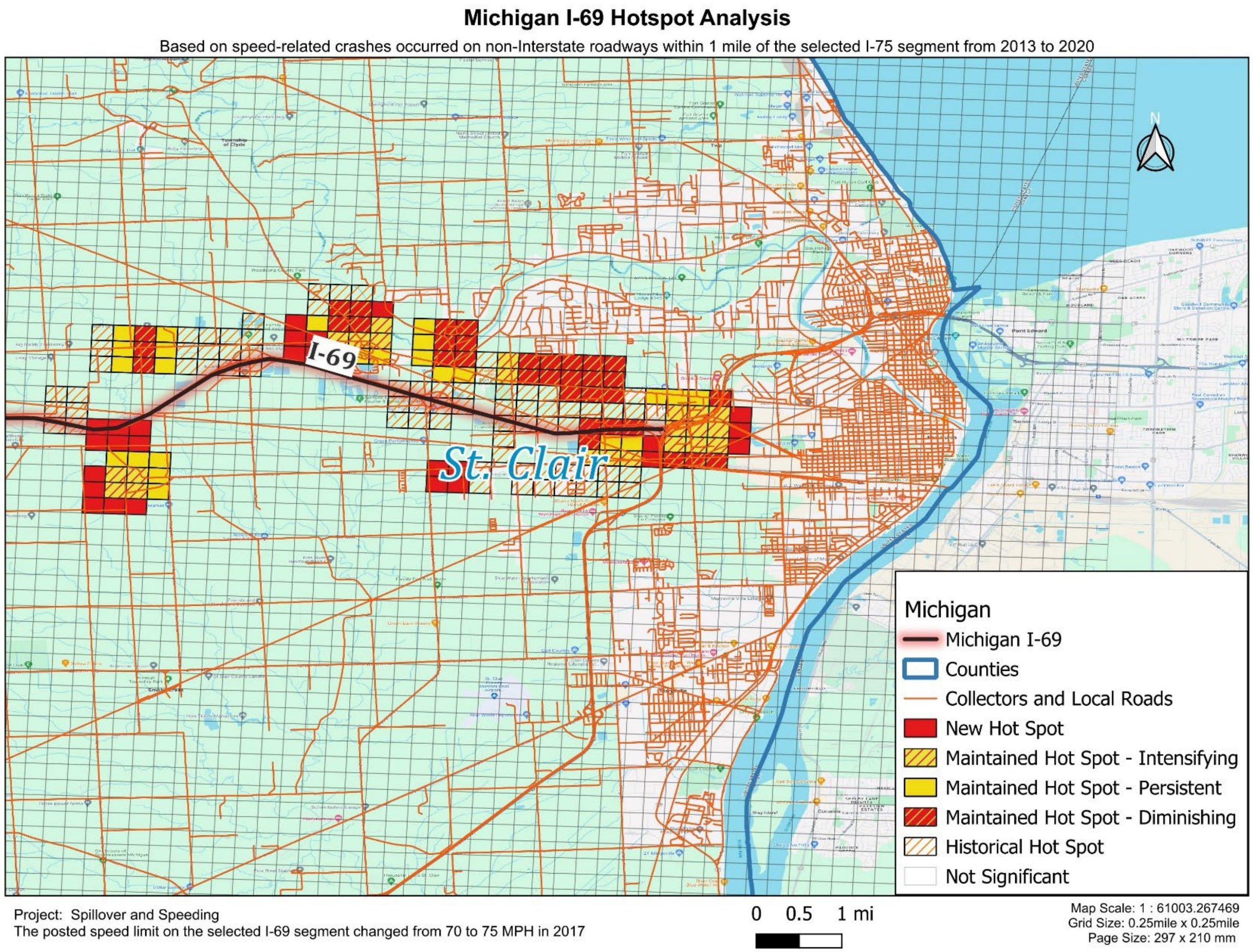


Figure 34. Hotspots on Adjacent Roadways nearby I-69 in St. Clair County (East), Michigan



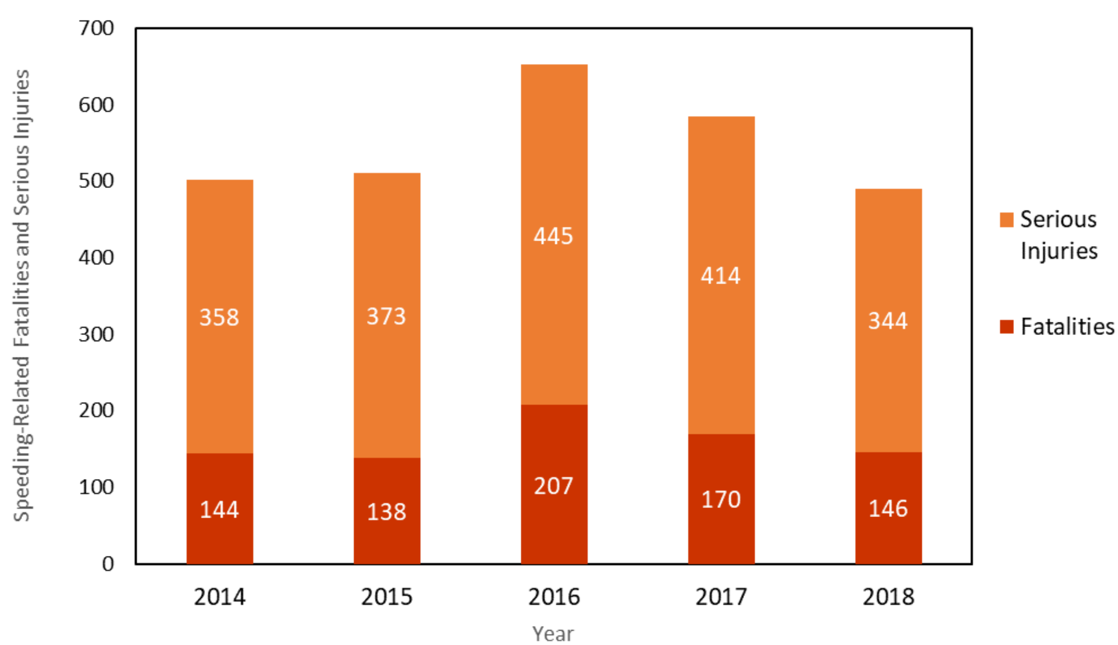
Case Study 3: Oregon

Site Description

Based on the Statewide Transportation Improvement Program (Oregon Department of Transportation, 2024), the Oregon Transportation Commission is responsible for developing a list of critical projects to be proposed for transportation system investment based on the $3.3 billion state and federal funding allocated in the next 3 years. Under this program, local government agencies have an opportunity to find areas of safety concern and apply safety improvements to reduce crashes.

The 2021 Oregon Transportation Safety Action Plan (TSAP) identified speeding as a key risky behavior that needs to be addressed through speed management efforts, regulations, and programs at a state, county, and city level (Oregon Department of Transportation, 2021). The Oregon Department of Transportation (ODOT) estimates that speeding has contributed to 24% of fatal and serious injuries from 2014 to 2018 (see ***Figure 35***). One of the actions proposed in the TSAP is to conduct safety evaluations where posted speed limits have been changed by tracking and assessing crashes over time.

Figure 35. *Speed-Related Fatalities and Serious Injuries in Oregon*

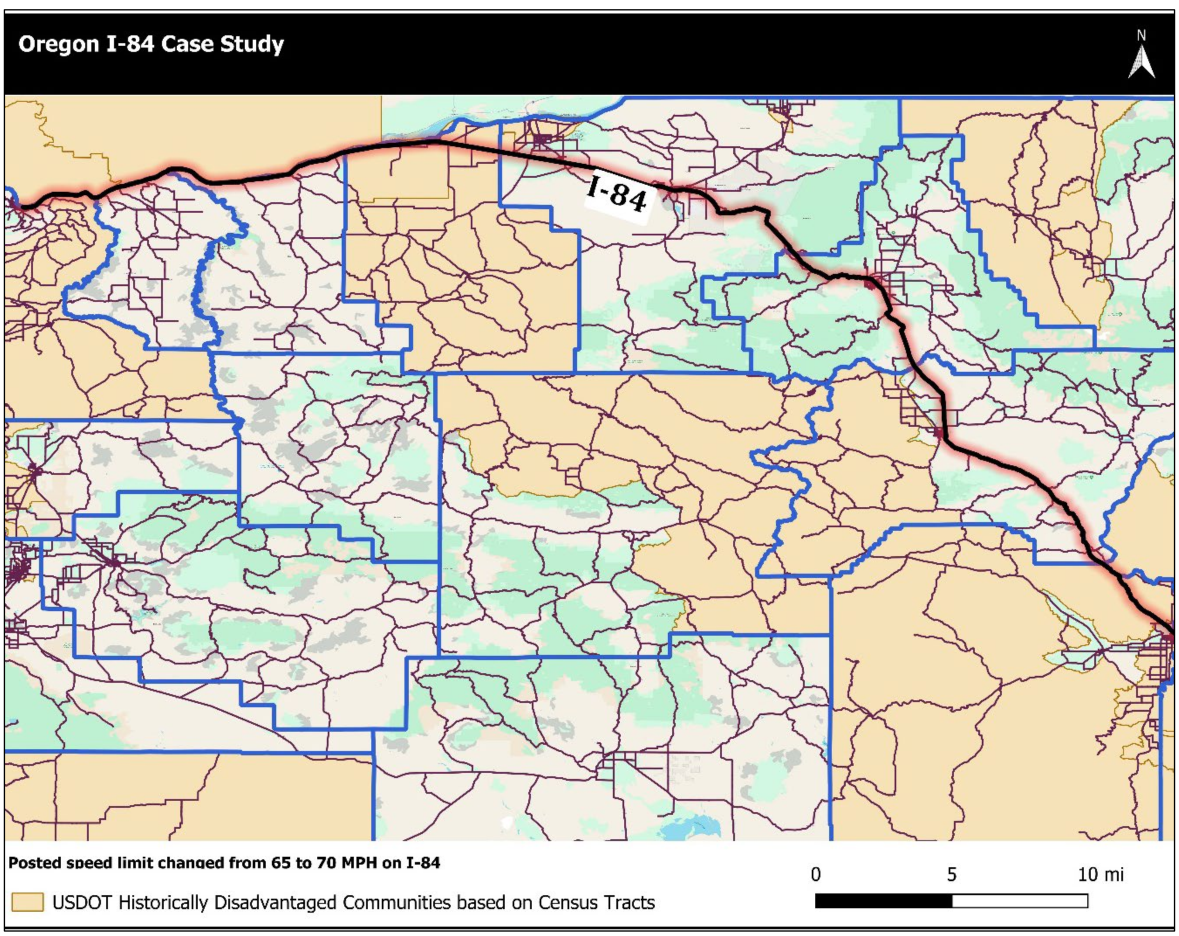


Source: Oregon Transportation Safety Action Plan (Oregon Department of Transportation, 2021)

The study area selected for Oregon covers 291 miles of I-84, mostly in a rural setting, where the posted speed limit changed from 65 mph to 70 mph in 2016. The segment of I-84 examined in this case study traverses eight counties in Oregon, from west to east: Wasco, Sherman, Gilliam, Morrow, Umatilla, Union, Baker, and Malheur. This portion of I-84 includes interchanges at the following cities: The Dalles, Pendleton, La Grande, Baker City, and Ontario.

I-84 is a divided highway with two lanes in each direction carrying a daily traffic volume between 16,000 and 20,000 vehicles per day. A large percentage of the traffic is heavy vehicles since I-84 connects long-distance travel from/to Idaho and Washington State, in addition to providing access to farms, state parks, and military facilities. It is estimated that about 25% to 30% of the total traffic on this Interstate is trucks. ***Figure 36*** provides an aerial view of the roadway network around the study site. Note that the census tracts in orange represent disadvantaged communities based on four out of the six disadvantage theme indicators: Transportation, Health, Economy, Equity, Resilience, and Environmental (United States Department of Transportation, 2024).

Figure 36. *Speed Study Area in Oregon* Including *Disadvantaged Communities*



Crash Data Summary

Crash and traffic volume data was downloaded directly from the Oregon.gov website (State of Oregon, 2024) at no cost. The 3-year 'before' evaluation period consists of crash data from 2013 to 2015. The 'after' evaluation period covers crash data from 2017 to 2019. The study excludes crash data from 2016, the year when the posted speed limit was raised. As with the other case studies, crashes on I-84 mainline were excluded and only crashes within 1-mile from the on and off ramps were included in the analysis.

Comparison of 'before' and 'after' aggregated crashes indicates a minimal 3% decrease in all crashes and a 19% reduction of speed-related crashes (see ***Table 4***). However, as with the case studies presented previously, it is important to examine and verify whether safety concerns have propagated to local roads as a result raising the posted speed limit on I-84. Hence, spatial analysis was carried out to examine potential hot spots.

Table 4. 'Before' *and 'After' Crash Counts on Arterials, Collectors, and Local Streets within a 1-mile Buffer from I-84 Ramps*

Crash Type	Total Crashes 'Before' Period (2013–2015)	Total Crashes 'After' Period (2017–2019)
All Crashes	1,669	1,616
Speed-related	225	183

Results from Geospatial Analysis from Rural Communities near I-84

New Hot Spots

Red color-coded areas throughout the study area shown from ***Figure 37*** to ***Figure 51*** offer visual presentation of new hot spots in the eight Oregon counties considered in this case study. Emerging clusters of new hot spots were prominent in Wasco County (see ***Figure 37***) and Gilliam County (***Figure 39***), among others, where speed-related crashes extended onto roadway facilities beyond interchanges and ramps.

Maintained Hot Spots—Intensifying

Yellow grids with red stripes shown in the study area from ***Figure 37*** to ***Figure 51*** indicate the 'Intensifying' sub-category where speed-related crashes intensified after raising the posted speed limit on I-84. Counties such as Union County (***Figure 44***) and Malheur County (***Figure 51***) have prominent areas of this sub-category of Maintained Hot Spots. Speed-related crash trends in these areas were maintained after the posted speed limit increased on I-84 and they have a greater statistical significance than the 'before' period.

Maintained Hot Spots—Persistent

The 'Persistent' sub-category of Maintained Hot Spots is shown in yellow grids in various areas. Persistent hot spots indicate that the spatial distribution of statistically significant clusters of speed-related crashes was maintained after raising the posted speed limit on I-84. This type of hot spot was not as prominent compared to others. Some of the areas with persistent speed-related crashes are located at the start and end of the study segment, in Wasco County (***Figure 37***) and Malheur County (***Figure 51***).

Maintained Hot Spots—Diminishing

The 'Diminishing' sub-category of Maintained Hot Spots is shown in red grids with yellow lines. Diminishing hot spots can be observed, for example, in Baker County (see ***Figure 48***) where hot spots were maintained after raising the posted speed limit on I-84 but with a lesser statistically significance level.

Historical Hot Spots

Historical hot spots, presented as translucent grids with orange stripes, are areas where speed-related crashes are no longer statistically significant after raising the posted speed limit from 65 mph to 70 mph in I-84. Multiple counties of the study area have examples of historical hot spots such as Umatilla County (***Figure 42***), Union County (***Figure 44***) and Baker County (***Figure 48***).

Figure 37. *Hotspots on Adjacent Roadways nearby I-84 in Wasco County, Oregon*

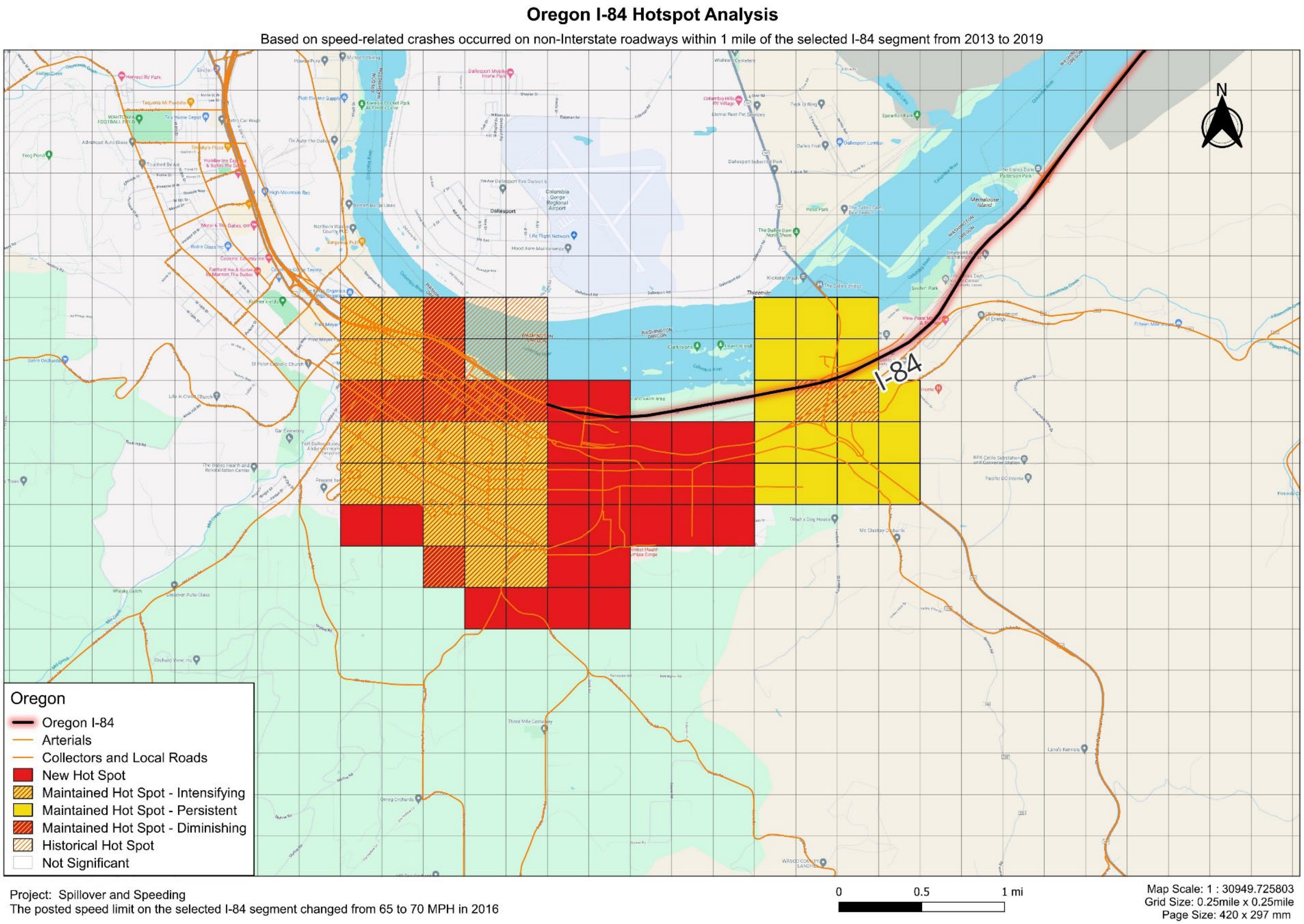


Figure 38. *Hotspots on Adjacent Roadways nearby I-84 in Sherman County, Oregon*

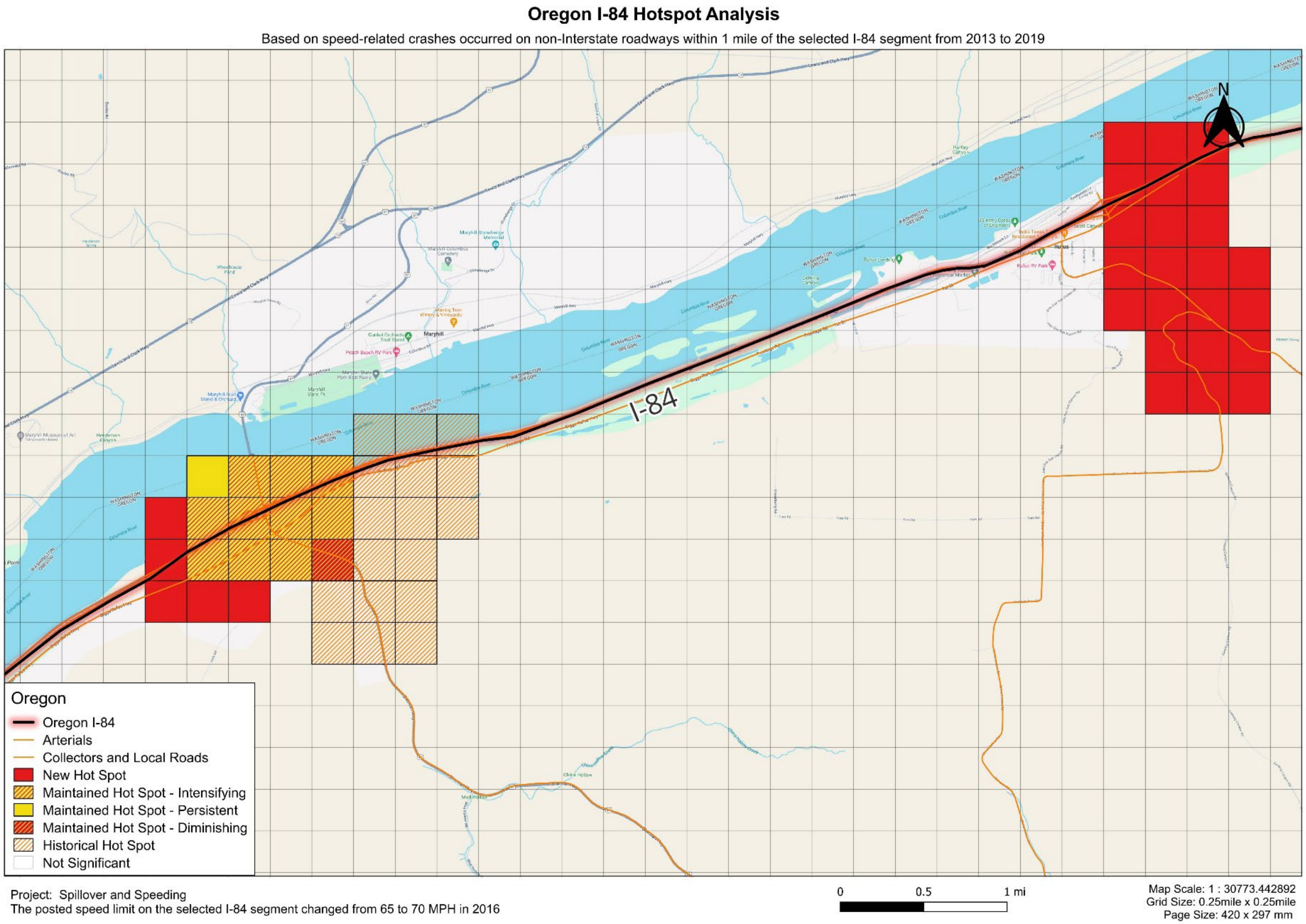


Figure 39. *Hotspots on Adjacent Roadways nearby I-84 in Gilliam County, Oregon*

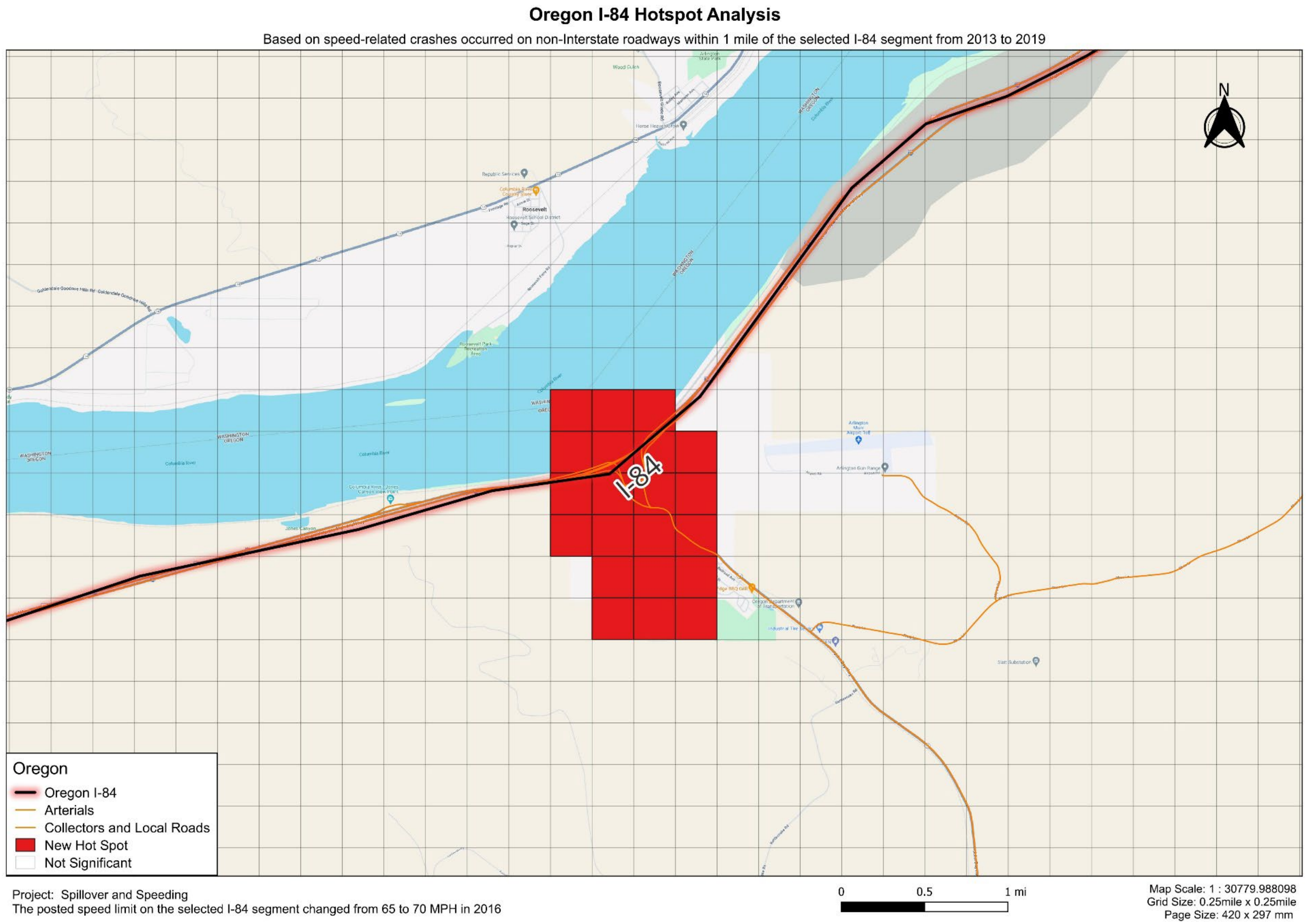


Figure 40. *Hotspots on Adjacent Roadways nearby I-84 in Morrow County (West), Oregon*

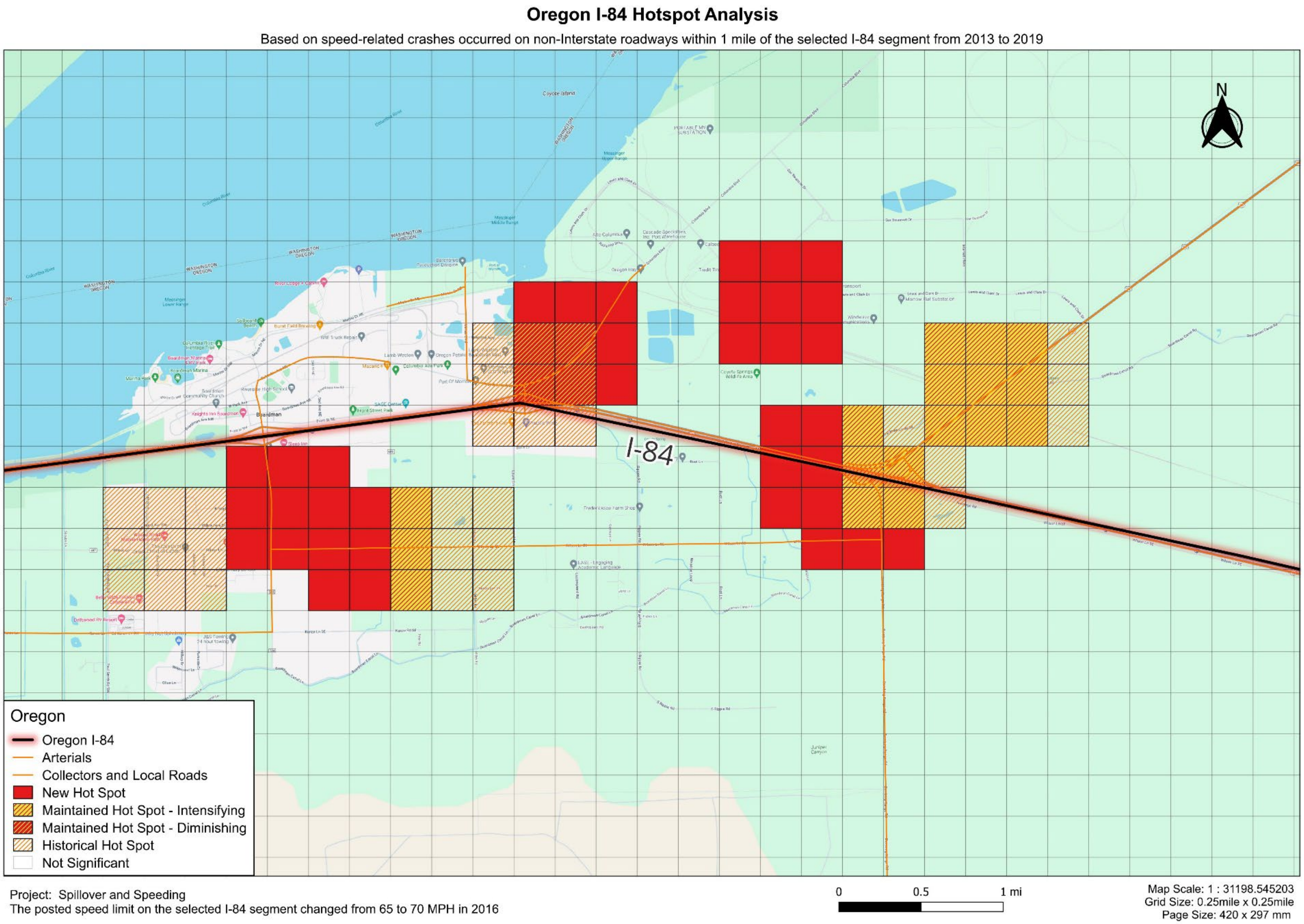


Figure 41. *Hotspots on Adjacent Roadways nearby I-84 in Morrow County (East) and Umatilla County (West), Oregon*

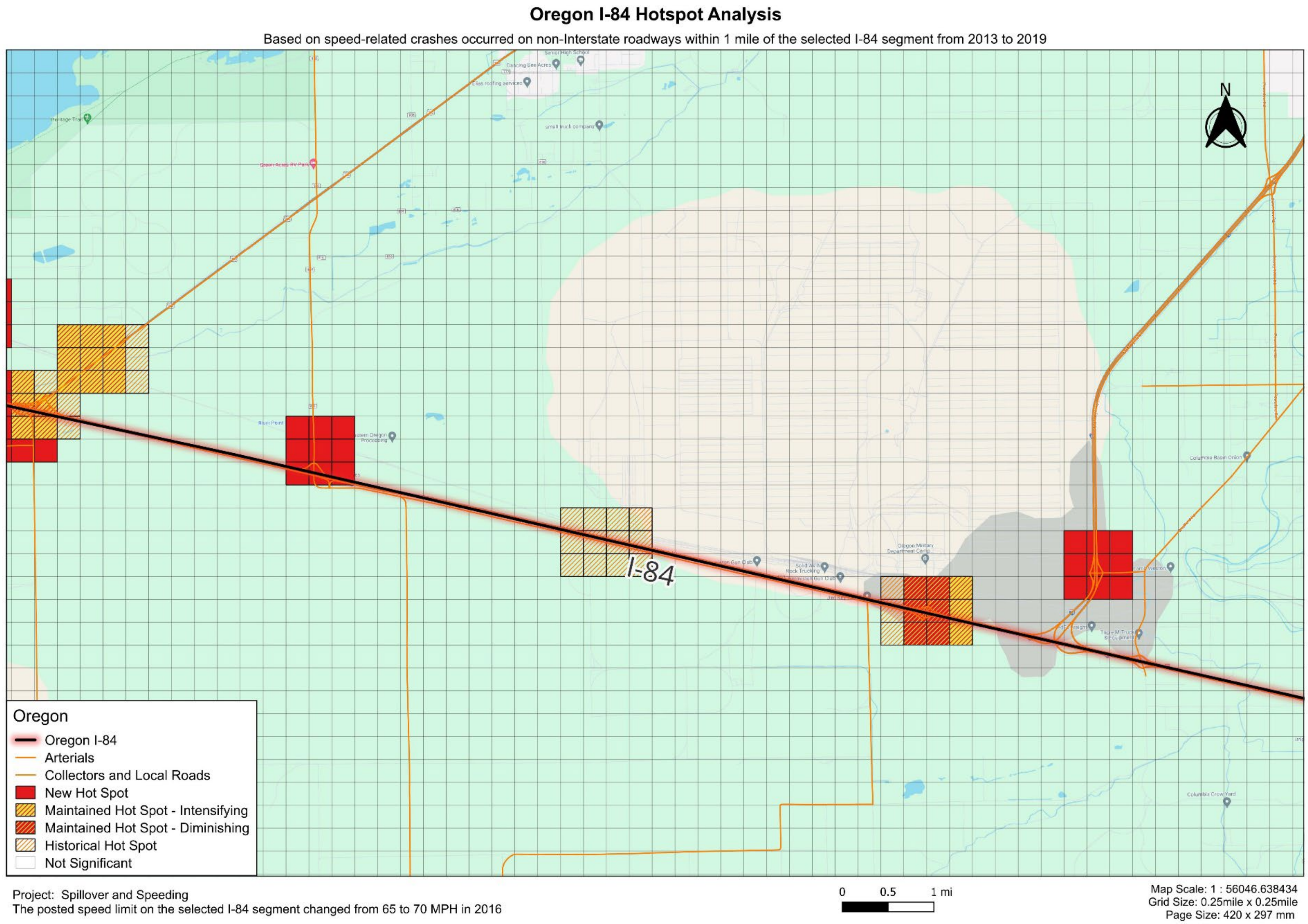


Figure 42. Hotspots on Adjacent Roadways nearby I-84 in Umatilla County (Central), Oregon

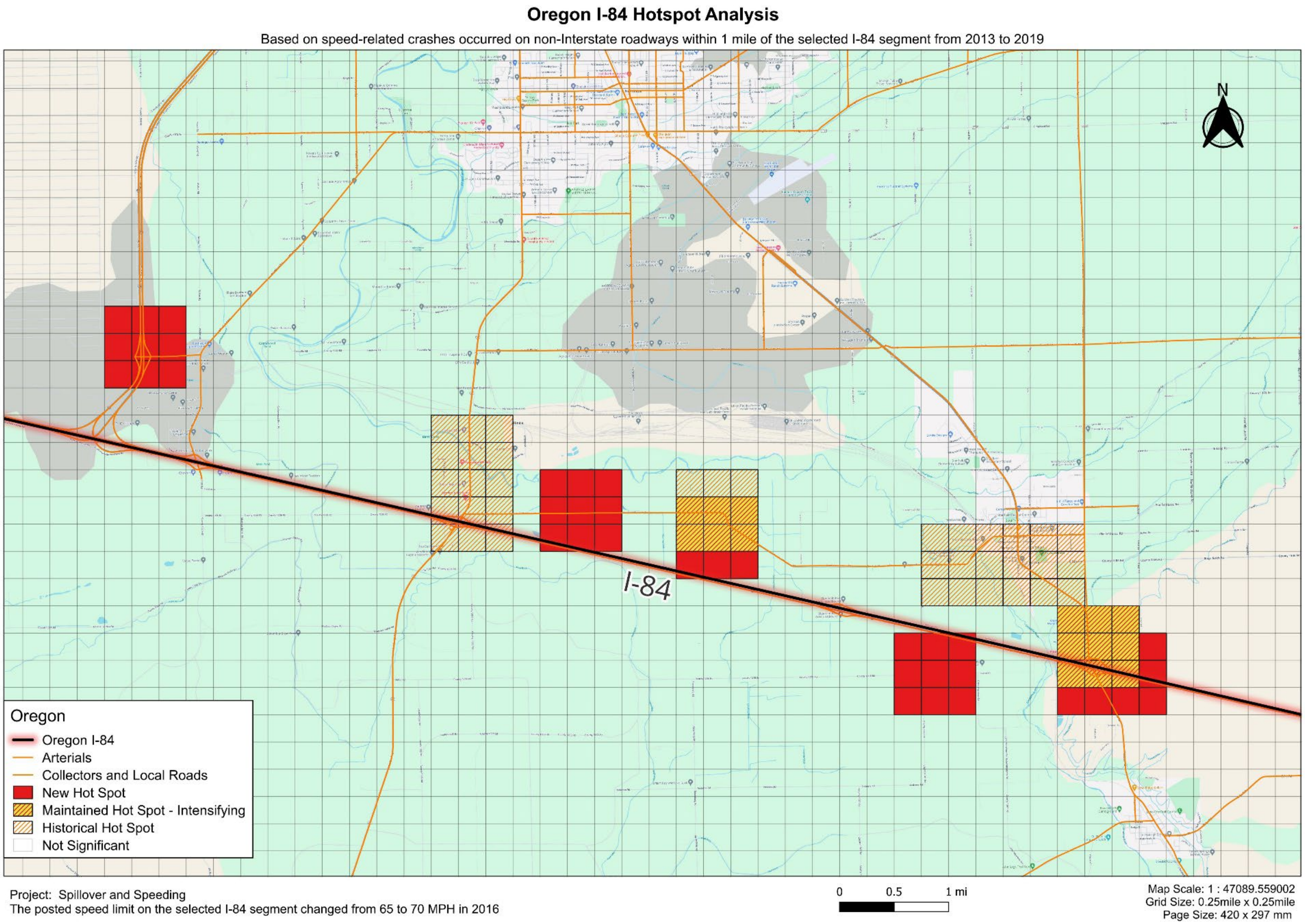


Figure 43. *Hotspots on Adjacent Roadways nearby I-84 in Umatilla County (East), Oregon*

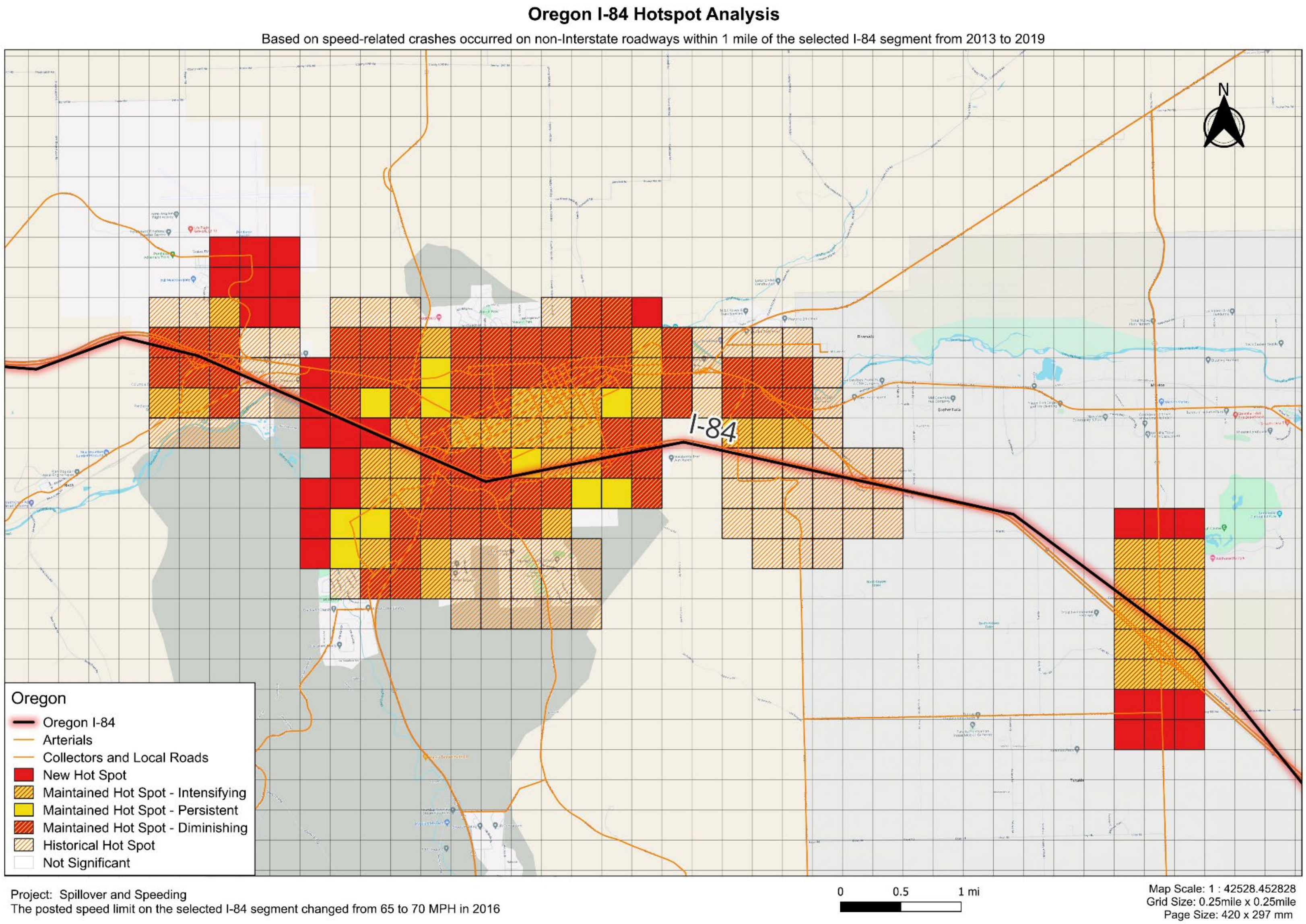


Figure 44. *Hotspots on Adjacent Roadways nearby I-84 in Union County (North), Oregon*

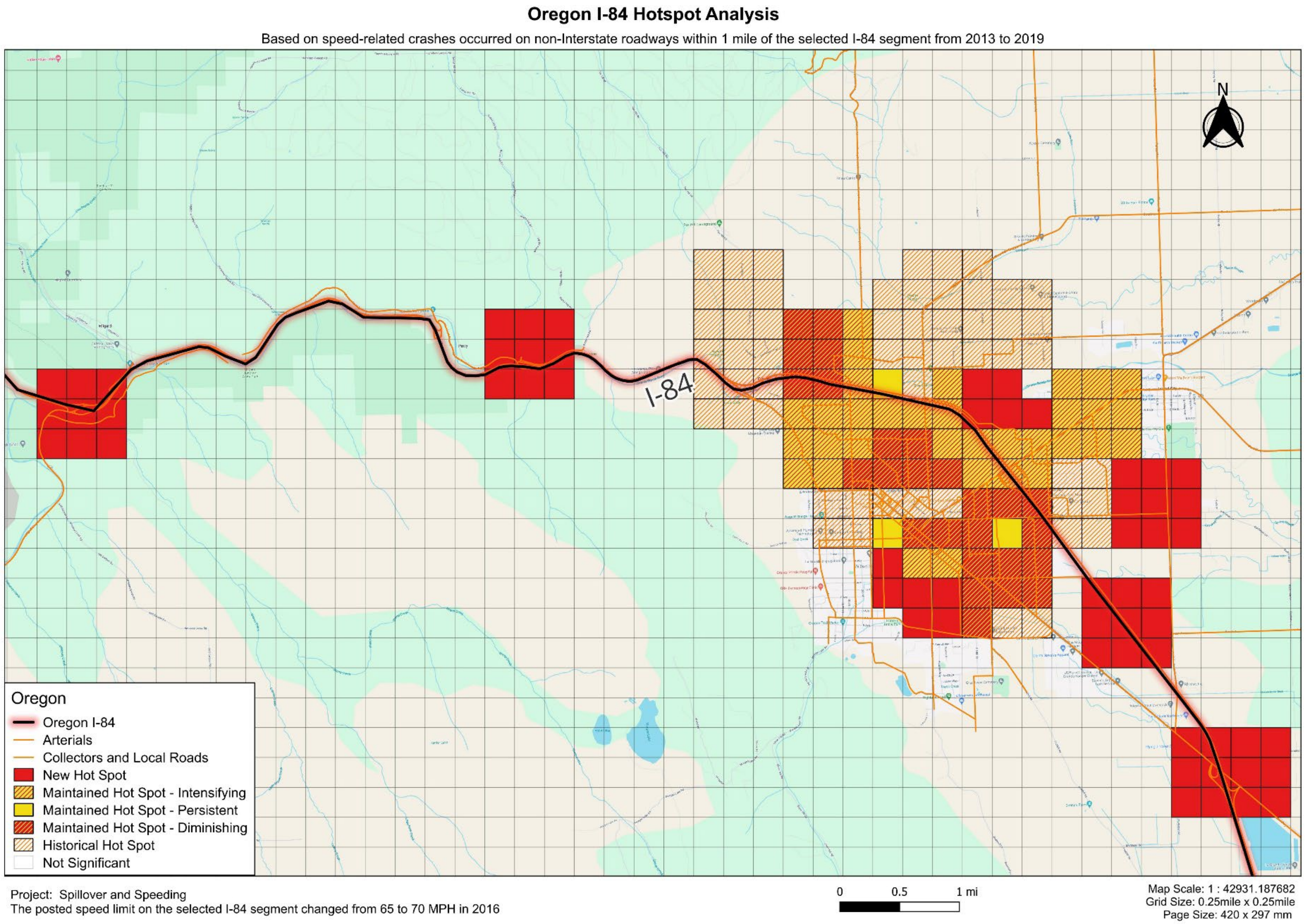


__Figure 45.__ Hotspots on Adjacent Roadways nearby I-84 in Union County (South), Oregon

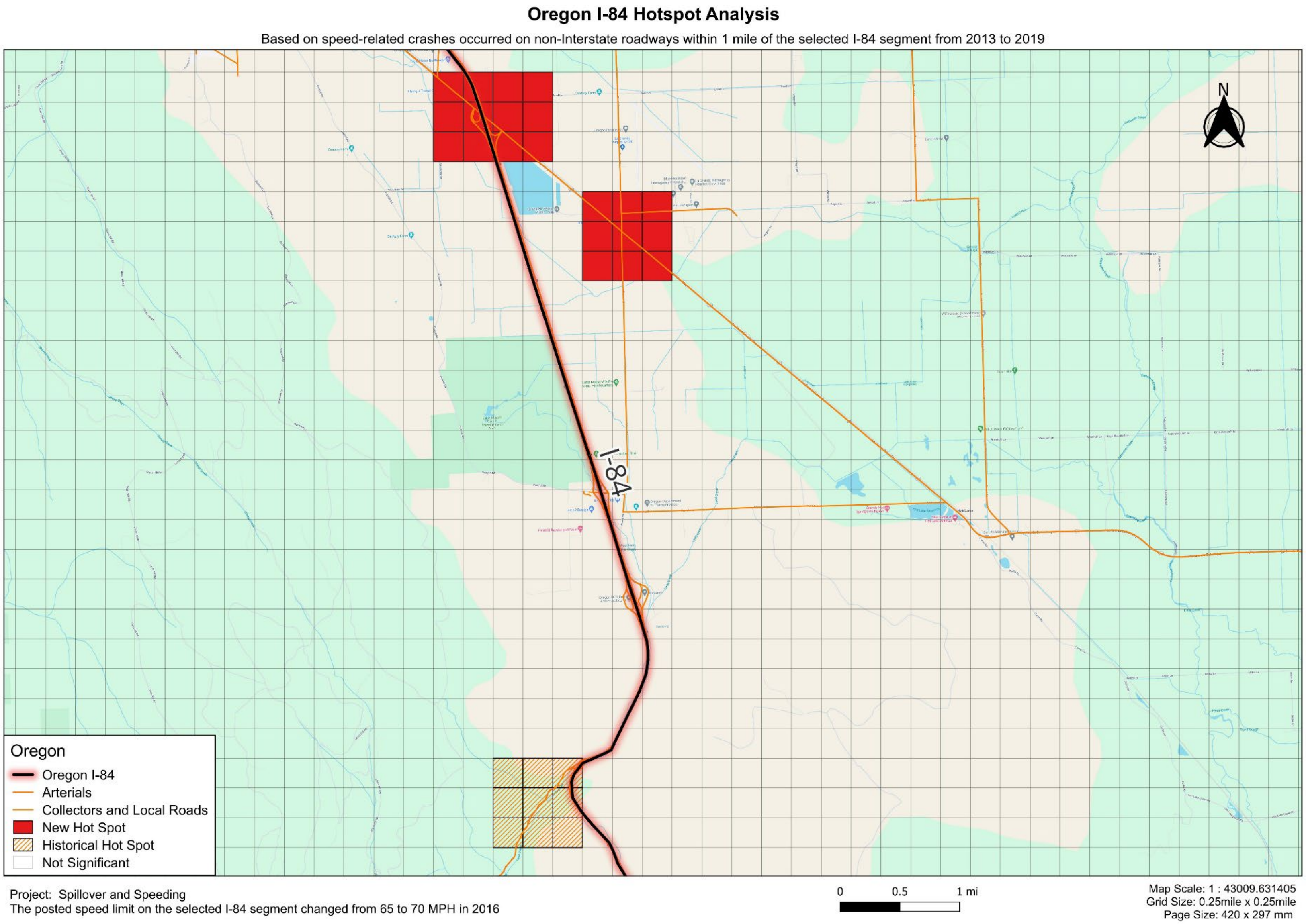


__Figure 46.__ Hotspots on Adjacent Roadways nearby I-84 in Union County (South) and Baker County (North), Oregon

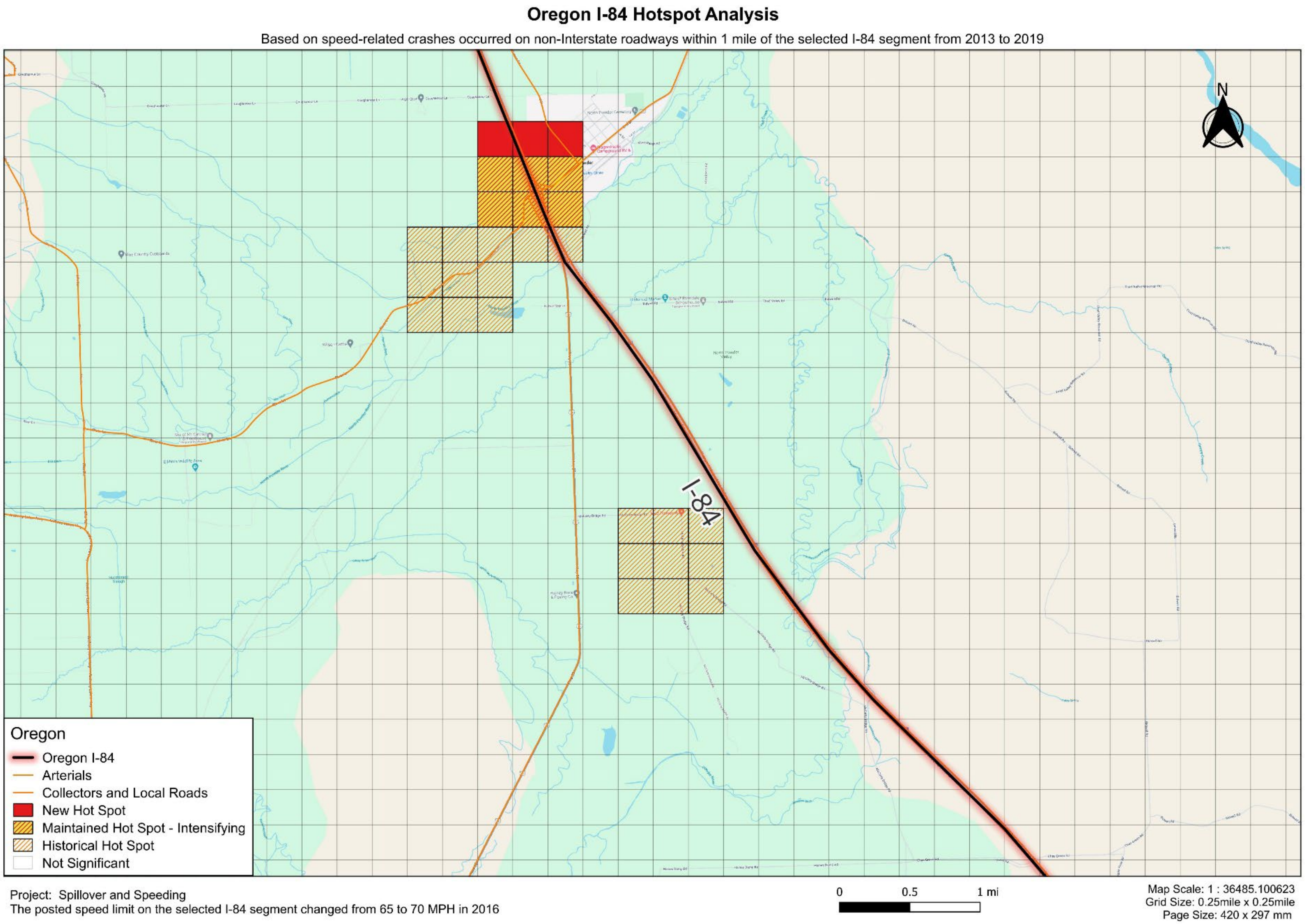


__Figure 47.__ Hotspots on Adjacent Roadways nearby I-84 in Baker County (North), Oregon

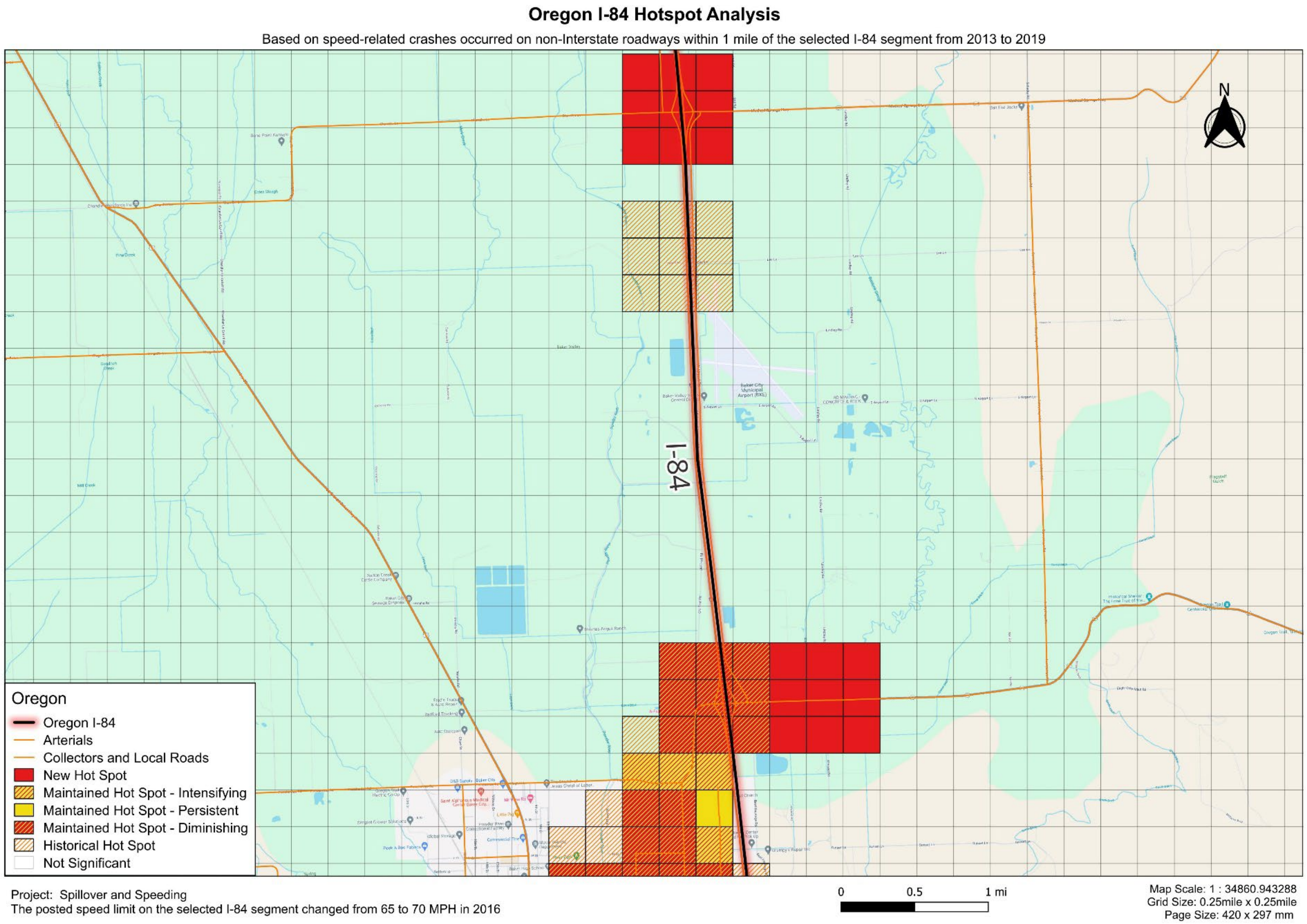


Figure 48. Hotspots on Adjacent Roadways nearby I-84 in Baker County (Central), Oregon

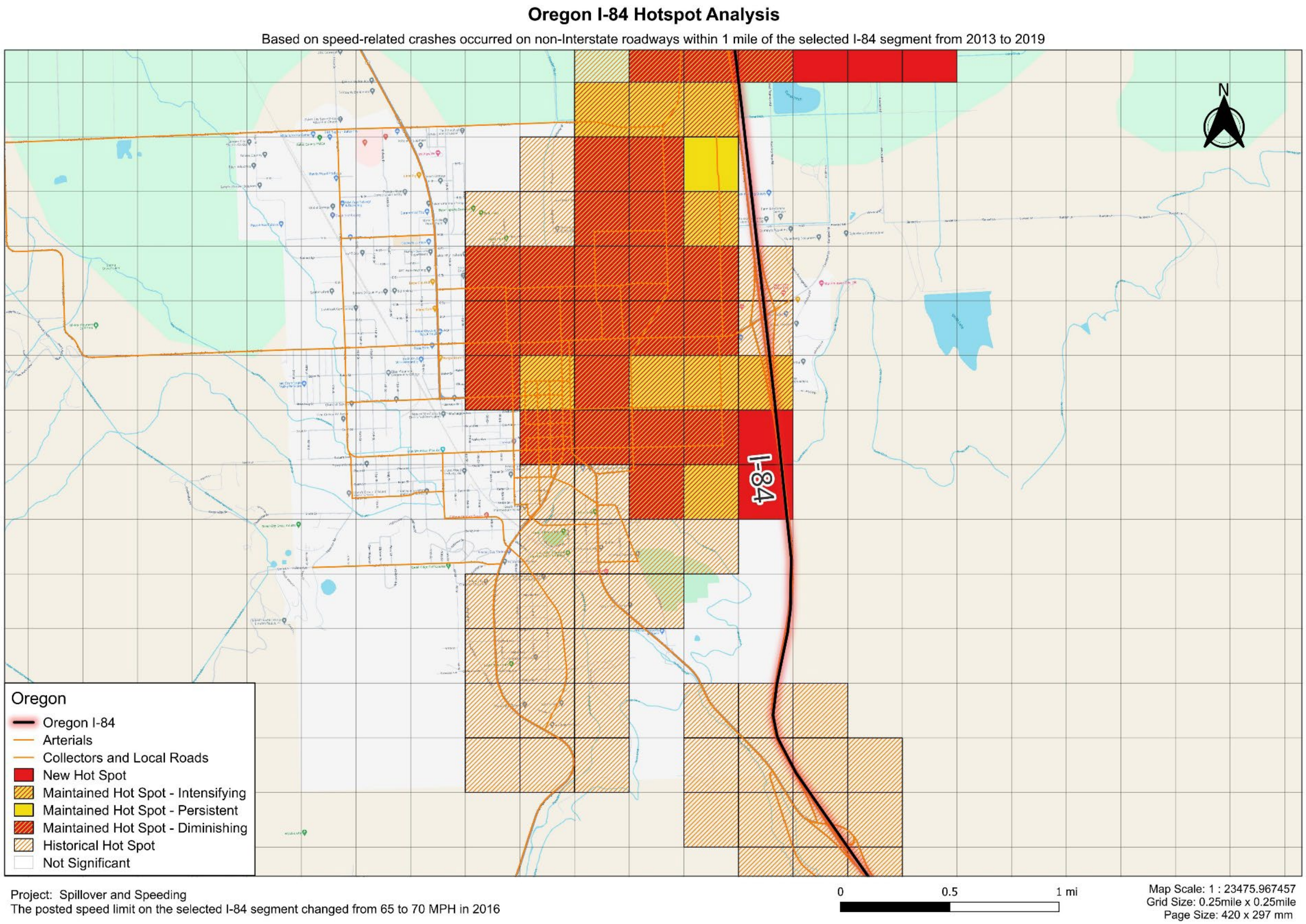


Figure 49. *Hotspots on Adjacent Roadways nearby I-84 in Baker County (South), Oregon*

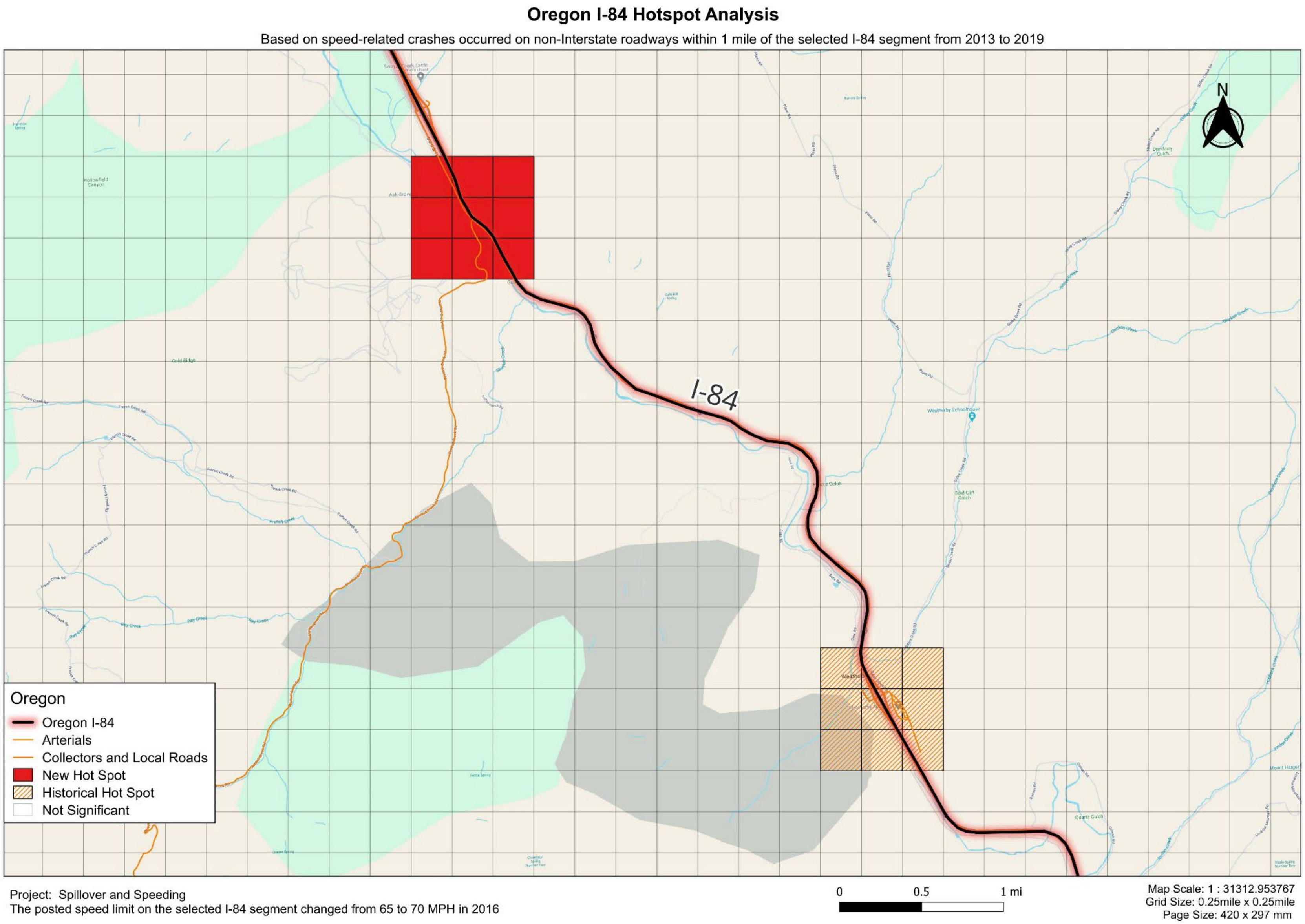


Figure 50. *Hotspots on Adjacent Roadways nearby I-84 in Baker County (South) and Malheur County (North), Oregon*

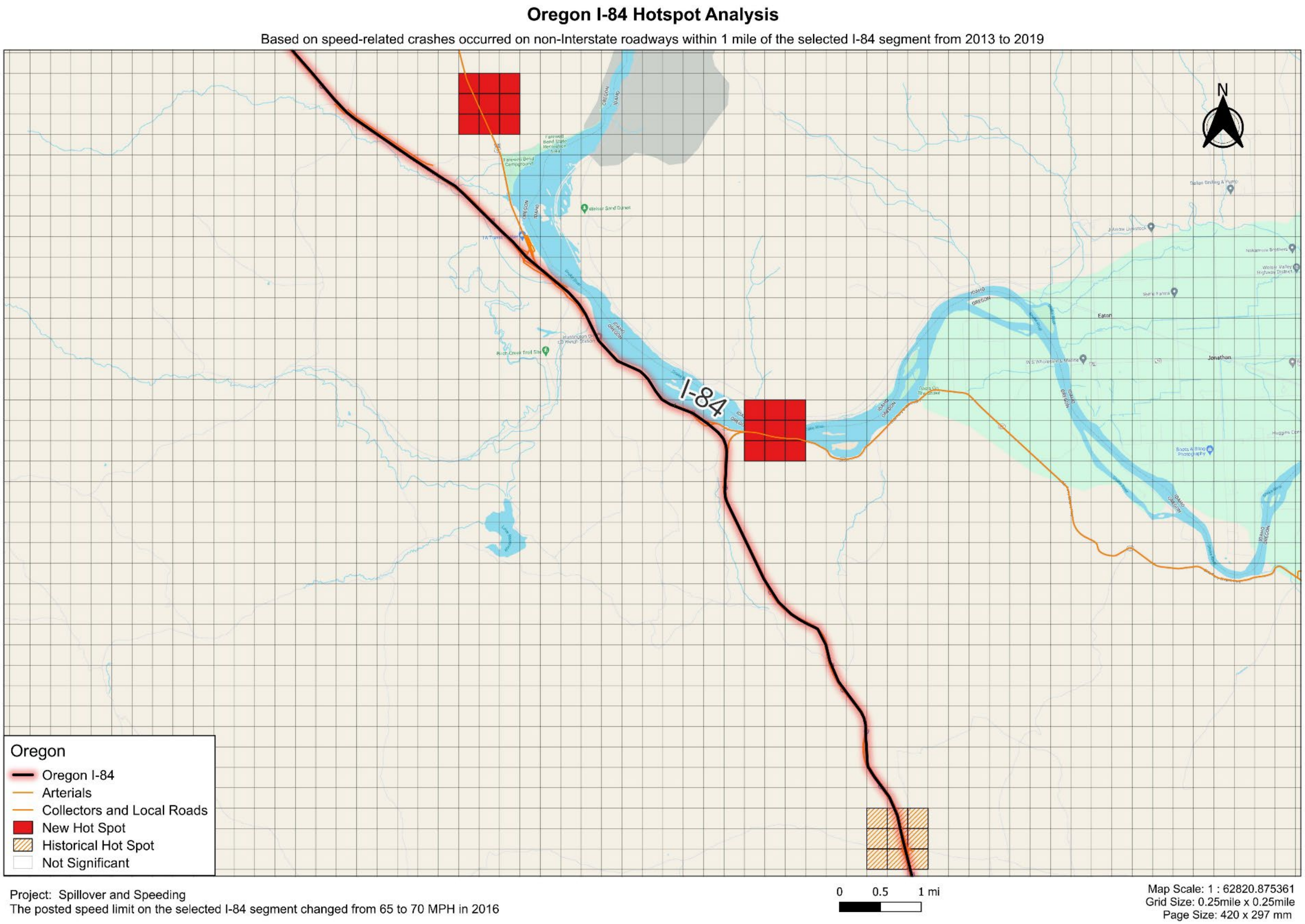
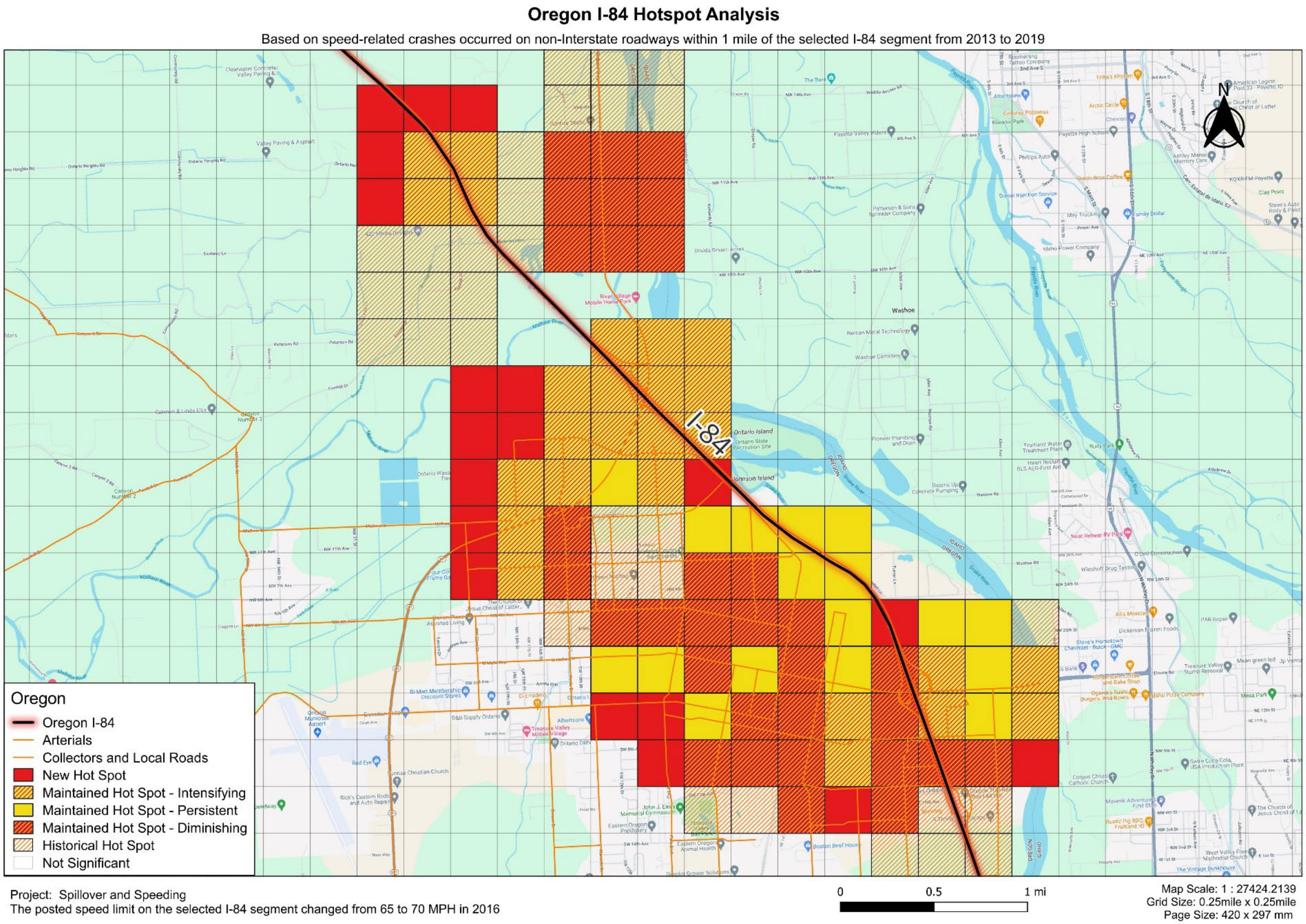


Figure 51. *Hotspots on Adjacent Roadways nearby I-84 in Malheur County (South), Oregon*



Discussion

The motivation of this work is to ensure roads and transportation networks in communities across the United States can be safer for their users by identifying potential safety risks due to spillover effects. When state-level transportation agencies raise the posted speed limits on Interstates, it is important to investigate whether there are any unintended safety impacts to roadways at adjacent local communities due to the propagation of high-speeds sustained by drivers exiting freeways. If any negative safety impacts exist, i.e., hot spots, they can clearly identify them so appropriate countermeasures can be implemented to eliminate them.

The literature review conducted as part of this work did not yield a conclusive answer regarding the presence and extent of spillover effects. Hence, a spatial analysis was carried out with the goal of offering additional insights regarding the spillover effect. This readily available method offers an effective way to visualize clusters of crashes or "hot spots" on local road networks caused by raising the posted speed limits on Interstates. This method provides a systemic and repeatable approach that is easy to use and replicate.

Using speed-related crash data publicly available from three states, the project team performed spatial analysis on adjacent roads of I-85 (Georgia), I-75 (Michigan), I-69 (Michigan), and I-84 (Oregon). New hot spots and maintained hot spots appeared at various locations in all case studies examined in this project. Several high-level takeaways and implications are presented below based on the spatial analysis results.

Takeaways and Implications from Case Studies

Comparing only 'before' and 'after' crash outcomes may underestimate the true safety impact across communities when raising the posted speed limit on Interstates. A preliminary analysis of aggregated crash counts alone did not indicate an increase in speed-related crashes in all locations examined in the study. Some arterials, collectors, and local streets within a 1-mile buffer from ramps of the three of the four Interstates examined in this project, i.e., I-85 (Georgia), I-75 (Michigan), and I-84 (Oregon), had lower speed-related crashes after the posted speed limits were raised. However, a spatial analysis uncovered hidden safety concerns (i.e., New Hot Spots and Maintained Hot Spots) on multiple adjacent roads along these three Interstates.

This project demonstrates how raising the posted speed limits on Interstates to accommodate higher operating speeds and increase traffic flow and throughput can inadvertently impact entities or networks of adjacent roads being operated and managed by county, city, and town transportation agencies. All case studies examined in this project showed the emergence of hot spots on roads adjacent to Interstates with new posted speed limits. To minimize unintended traffic safety consequences and better prepare local transportation departments, it is important for state-level departments to coordinate and work closely with other road agency partners when considering making posted speed limit adjustments on Interstates and state highways.

The spatial analysis approach employed in this project provides a visualization tool to measure the outcomes and identify at what level spillover effects can occur. The hotspot analysis performed in QGIS measures how speed-related crashes are correlated to each other in space across a study area. Figures from the spatial analysis presented in the 'Results' section not only identified hot spots, but also categorized them as New Hot Spot or Maintained Hot Spot (Intensifying, Persistent, or Diminishing). The categorization of hot spots can be helpful for public transportation agencies to prioritize funding and countermeasure implementation decisions.

When spillovers vary across locations, it is important for transportation departments to understand the diverse impact on different stakeholders and develop regional improvement plans and safety programs that target speeding concerns. As an example from Georgia's I-85 study area, most of the new hot spots (i.e., red color-coded areas shown in ***Figure 4***) concentrated on adjacent arterials near the beginning and end of that segment after the posted speed limit was raised from 55 mph to 65 mph. By visualizing these new hot spots, Georgia Department of Transportation can partner with local transportation agencies from surrounding counties and cities to perform an in-depth study and implement effective countermeasures to combat spillover effects, especially on underserved communities.

Michigan and Oregon locations examined in this study were mostly in rural settings and reducing traffic fatalities on these road environments can be challenging due to factors such as higher driving speeds, longer emergency response times, and inadequately maintained road infrastructure. Michigan and Oregon could use federal funding they receive from the High-Risk Rural Roads (HRRR) Program, along with spatial analysis results presented in this project, to prioritize roadway improvements at various rural communities. For example, the geospatial analysis performed was able to identify new hotspots after implementing the new posted speed limit in Michigan's I-75, in the counties of Chippewa (see ***Figure 7*** and ***Figure 8***) and Mackinac (see ***Figure 9*** and ***Figure 10***). In addition, new speeding concerns were identified for some neighboring communities along Michigan's I-69 after the posted speed limit was raised. Clinton County, as can be seen from ***Figure 28***, had several clusters of new speed-related crashes that were not a statistically significant problem previously.

Disaggregating the true safety impact for each community is the first step in realigning projects and programs affecting various local areas to commit to the prevention of fatalities and injuries on rural roads. For example, the study areas for Oregon covered eight counties, and after the posted speed limit was raised, clusters of new hot spots were prominent Wasco County (see ***Figure 37***) and Gilliam County (***Figure 39***), among others where speed-related crashes extended onto roads beyond the interchanges of I-84.

Transportation agencies from these two counties and their towns can utilize new traffic safety concerns identified from spatial analysis to work collaboratively with Oregon Department of Transportation and other state-level entities to attain funding and other resources so effective countermeasures can be applied to minimize the spillover effect caused by the posted speed limit change on I-84.

Through the results of the case studies presented in this project, it is clearly demonstrated that one change in the design and management of a road facility (i.e., raised the posted speed limit on the Interstate) resulted in adverse effects on other road facilities within a transportation network. To minimize unintended traffic safety consequences from posted speed limit changes on Interstates, transportation departments at the state level need to proactively work with agencies from counties, cities, and towns to discuss goals and plans, identify potential safety issues and mitigation strategies, and allocate resources to implement countermeasures. Adopting a Safe System approach is an example of how to proactively manage and operate a transportation network. Instead of focusing on adjusting posted speed limits based on operating speeds of vehicles or increase throughputs on a section of an Interstate, the state transportation department can work with other state and local partners to educate the public about the dangers of speeding, utilize technology to manage traffic flows and monitor dangerous driving behaviors, and modify roadway designs to promote safe driving behaviors and discourage activities such as speeding, red light running, and distracted driving. Together, policies, programs, and projects can make a positive impact and ensure communities are safe for all.

Limitations

The project team for this work made an earnest effort to examine whether changing to higher posted speed limits on Interstates can cause spillover effects, or a systemic propagation of unsafe behaviors that result in additional speed-related crashes on adjacent road facilities. A spatial analysis approach was used to identify locations of safety concerns (i.e., hot spots) in three case studies. Results presented in this report illustrate the importance of using a comprehensive framework to assess the traffic safety impact of posted speed limit changes. Due to several study limitations, these results should not be generalized to conclude that raising the posted speed limit on Interstates should never be considered because it will always lead to traffic safety issues on adjacent roadways.

Only three case studies were presented in this project because of data availability, one in urban setting (Georgia) and two in rural settings (Michigan and Oregon). Potential follow-on work would be to carry out additional spatial analysis with data from multiple locations and settings. Another limitation relates to assumptions and decisions made on the spatial analysis—hot spot results were presented in 0.25-by-0.25-mile grid layer imposed on a geographical area comprising roadways within 1-mile from Interstate ramps. Comparing results using different grid sizes and distances from the Interstate ramps could reveal additional insights. Although crashes from the year when the speed limit was raised were excluded from the analysis of this work to avoid introducing exogenous variables from travel patterns during an adoption period, spillover effects might manifest in diverse ways in the short term and the data used for this work may not reflect all manifestations.

Lastly, there could be other factors associated with these case studies that contributed to the emergence of hot spots unknown to the project team. For example, in 2017, a fire on Piedmont Road NE in Atlanta, Georgia, caused the collapse of a 92-foot bridge section of I-85. As a result, a 3-mile roadway segment along I-85 was closed to traffic for about one and a half months. This temporary closure occurred 2 miles west of the study area. It is not certain whether this road closure and traffic detours encouraged speeding behavior on nearby roadways and influenced the appearance of new hot spots to the west of the study area as shown in ***Figure 4***. Gathering additional details regarding external factors that could have contributed to traffic safety issues besides posted speed limit change can ensure an effective implementation of proper countermeasures.

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