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The effectiveness of low-cost traffic calming applications appropriate for main streets through rural communities

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The effectiveness of low-cost traffic calming applications appropriate for main streets through rural communities

by

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INTRODUCTION

Many rural communities have developed around highways or major county roads and as a result, the main street through small Iowa communities is often part of a high speed rural highway. Highways and county roads are characterized by high speeds outside the city limits and then transition into a reduced speed section through the rural community. Consequently, drivers passing through the community often enter at high speeds and then maintain those speeds throughout. Additionally, rural subdivisions build up along high speed roadways and encounter similar safety problems.

In 2004, there were 13,192 traffic fatalities (30% of all fatalities) in the United States which were a result of speed related crashes (1). The total number of crashes in rural areas is often lower than urban areas but is more likely to be severe due to higher vehicle speeds. Crashes in rural communities may be more likely to have a severe outcome since many small communities do not have emergency management services and consequently it takes longer for emergency personnel to reach crash victims. A Washington State study evaluated pedestrian/vehicle collisions over a three-year period and determined that the likelihood of a pedestrian dying in a rural collision was more than twice that for a pedestrian struck in an urban area (2). The study noted that the higher risk was most likely due to less rapidly available emergency services.

In addition to a higher accident potential and accident severity, high speeds may also have an effect on the quality of life for residents in a community. Some potential impacts of speeding may include:

- An increase in traffic noise and emissions
- Less bicycling, walking, and other forms of street life
- Less community interaction and involvement
- A higher crime rate
- Lower property values

When speeds in rural communities are problematic, traffic calming provides a potential solution. Small communities, however, often do not have the resources to conduct traffic studies to examine possible remedies. Although the Iowa Department of Transportation (DOT) has no jurisdiction unless a state highway is involved, they are often asked for guidance from residents and officials of small towns. Traffic calming has been used extensively in the United States in urban areas and a number of documents and studies are available that provide guidance on the use of different traffic calming devices on residential urban roadways. Most traffic calming techniques, however, have only been evaluated on low-speed roadways, generally local streets and collectors. The effectiveness of traffic calming along major routes that transition from high speed facilities to low speed facilities through rural communities is not well documented. Guidelines on the use of traffic calming devices that are appropriate are also not readily available. As a result, the community response to high speeds is frequently a request for traffic control, such as stop signs, even when not warranted. The Manual on Uniform Traffic Control Devices (MUTCD) specifically states that stop signs should not be used solely for speed control (3).

Traffic calming techniques can be used to achieve more than just speed reduction. They can also be used to control traffic volumes, improve transit access, and encourage bicycling and other forms of street life. However, the use of traffic calming is usually considered for local urban streets with traffic/pedestrian interaction, and a different approach is needed on higher speed roadways since their primary function is carrying traffic. Rural traffic calming attempts to balance personal safety and efficient mobility through the area while preserving the route's rural character.

Problem statement

There has been much research on the effectiveness of traffic calming in the United States and other countries around the world. The research has consistently pointed out that traffic calming measures can effectively reduce traffic speeds, volumes, or both. However, many of these studies have taken place in large urban communities such as Seattle, WA, Berkeley, CA, and West Palm Beach, FL. The traffic calming plans in these communities have been widespread and are too expensive for small communities to implement and maintain. Low-cost traffic calming solutions appropriate for small rural cities, such as those seen in Iowa, have not been evaluated. Also, strategies that are commonly used, such as speed enforcement, have not been analyzed to determine its impact on speeds.

Traffic patterns in small rural cities are also much different than large, densely populated cities. Traffic volumes are typically lower on main streets of rural communities, and the majority of the traffic is generally through traffic. There may also be a larger percentage of heavy trucks on rural roadways. The effectiveness of traffic calming in these areas has not been extensively analyzed.

Objectives

The purpose of this research was to evaluate and provide guidance on the use of different traffic calming techniques that can be used by both engineers and communities to select economically feasibly alternatives for conditions typical of Iowa's county roads and other major roads within small rural communities. To accomplish this, the following research objectives were identified:

1. Identify traffic calming strategies which are appropriate for major roadways in small Iowa communities (population less than 5,000) and conduct a literature review on the effectiveness and economic feasibility of these strategies.
2. Test and demonstrate several of the most promising technologies through pilot studies in several communities. Test existing traffic calming measures if a community already has measures in place.
3. Summarize the effectiveness of various applications in reducing speeds through these communities.

Background/literature review

Much research has been conducted on the effectiveness of traffic calming for urban areas, particularly on lower speed roadways, but there has not been as much research on traffic calming for rural communities that have developed around high-speed roadways in the

United States. Traffic calming in rural areas in the United Kingdom, as well as other areas in Europe, is more advanced than in the United States. The National Road Association and the Department of Transport (4) in the United Kingdom created a set of guidelines for using traffic calming techniques, particularly for major roads through villages. These techniques included cross-hatching, rumble strips, signing, landscaping, lane narrowing, and pavement markings. Although traffic calming in rural communities is widespread throughout Europe, the effectiveness of the different strategies in reducing speeds or accidents was not documented in any of the European literature that was reviewed. Furthermore, the economic feasibility of these techniques was not evaluated.

Definition of traffic calming

The Institute of Transportation Engineers developed a standard definition of traffic calming in 1997, which is as follows:

> *Traffic calming is the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users.* (5)

Traffic calming typically either focuses on reducing speeds or traffic volumes. On major rural routes, reducing speed is the primary goal since volume reduction is neither feasible nor desirable in most areas. Traffic calming essentially reduces vehicle speeds through the use of self-enforcing traffic engineering methods or road design. O'Connor (6) noted that a driver's perception of what is safe is related to road design which includes lane width, curvature, corner radii and available stopping sight distance. He added that posting of speed limits alone does not result in a significant reduction in speed since drivers typically drive at the speed they perceive as being safe. The Oregon DOT (7) agrees, stating that traffic calming slows traffic using either physical or psychological means. The physical constraints that are discussed, such as curb extensions, medians, chicanes, or on-street parking create friction and help hold down speeds. However, the Oregon DOT states that, in many instances, physically narrowing the roadway is not feasible or appropriate, such as along rural major through routes. They add that psychological measures, such as lane narrowing using pavement markings or landscaping, create the illusion of less space and convey the message to the driver that they are no longer on an open highway and need to reduce their speed.

History of traffic calming

Traffic calming began in the late 1960's as a response to cut-through traffic on local streets in the Dutch city of Delft. Residents of the city began using tables, benches, and parking bays to turn their streets into "woonerven," or "living yards" (8). The shared streets were thus turned into an obstacle course for vehicles to navigate (see Figure 1).

Figure 1: Early attempts of traffic calming in Delft, the Netherlands (9)

By the late 1970's, the idea of woonerven had spread into other European countries. Germany started using lane narrowings, textured surfaces, and roundabouts around 1977 (10). Similar traffic calming measures were also seen in Norway, England, Sweden, Switzerland, France, Austria, Israel, and Japan (11). The principles of traffic calming were eventually established in Australia, Canada, and the United States. Berkeley, California, is often credited with creating the first citywide traffic calming program in the United States in 1975 (11). Seattle, Washington, was also one of the first communities involved with neighborhood traffic calming. The city utilized diverters, street closures, and traffic circles to reduce cut-through traffic, speeds, and accidents. Seattle's early demonstration illustrated the wisdom of several practices:

- Testing complex area-wide treatments before implementing them permanently
- Assessing public support for the treatment
- Conducting before-and-after studies of traffic impacts
- Including traffic accidents among the impacts studied
- Working with emergency services to address their concerns
- Opting for the most conservative designs that will do the job (11)

Benefits of traffic calming

Lower speeds allow drivers to become more aware of their surroundings and allow for more reaction time. The Oregon DOT (7) illustrated what a driver is able to perceive as speeds increase from 15 to 40 mph. This is shown in Figure 2. As shown, a driver's area of focus is significantly increased at lower speeds.

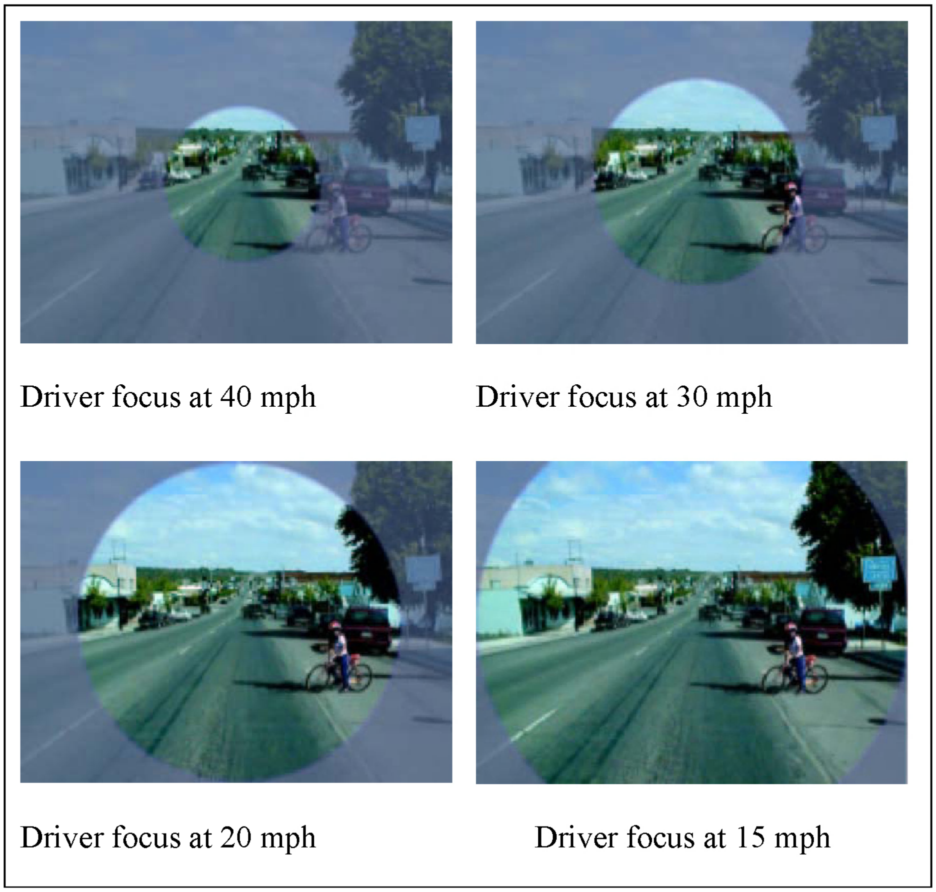

Figure 2: Driver focus at different speeds (7)

Lower speeds also reduce the likelihood and severity of vehicle crashes. The National Highway Traffic Safety Administration (NHTSA) estimates that the probability of death, disfigurement, or debilitating injury doubles for every 10 mph over 50 mph (12). Kloeden et al. (13) looked at the risk of crash involvement for sober drivers of cars in 60 km/h (37.3 mph) speed limit zones in Adelaide, Australia. The study included crashes where at least one person was transported from the crash in an ambulance. They found that 68% of vehicles involved in crashes were exceeding the speed limit. A total of 14% of drivers involved in casualty crashes were traveling faster than 80 km/h (49.7 mph). They also found that the risk of crash involvement approximately doubled for every 5 km/h (3.1 mph) increase above 50 km/h risk (31.1 mph). They indicated that the crash risk due to speeding is similar to the risk when driving with a blood alcohol concentration of 0.05 in urban areas.

The Federal Highway Administration (FHWA) estimates that each 1 mph reduction in speed may reduce injury crashes by 5 percent (14). In another source, FHWA (15) cites studies in Denmark and France for traffic calming on through roads in small towns and villages. In France, speed reductions between 7 to 13 mph have been observed while still preserving free-flowing traffic conditions. Along with reduced speeds, a 60% reduction in the average number of accidents was found in the 10 towns studied. The Denmark locations, in particular, reported a 5 to 6 mph reduction in speed and a reduction of 50% and 33% in total and injury accidents respectively in three towns.

Pedestrian safety is also improved at lower speeds. The Oregon DOT (7) reported speed statistics indicating that a pedestrian struck at 40 mph has an 85% chance of fatality. One struck at 30 mph has a 45% chance of being killed, and the risk drops to 15% if the pedestrian is struck at 20 mph.

Traffic calming also can help reduce traffic noise and emissions in a community. Pharoah et al. (16) reported that speed reductions from 50 kph (about 30 mph) to 30 kph (about 20 mph) typically reduce noise levels by 4-5 decibels or more in some circumstances. Traffic calming measures that reduce traffic speeds and smooth traffic flow may also reduce air pollution, while measures that increase stops may increase emissions. Actual impacts on noise and emissions vary depending on the measure used and conditions that may exist. For example, measures that cause more frequent acceleration can increase noise and air emissions. One study from the *Daily Express* (17) found that installing six speed humps on a previously 40 kph (about 25 mph) roadway increased NO_X emissions 10 times, CO emissions 3 times, and fuel consumption from 7.9 to 10 liters per 100 km. However, strategies that result in smooth traffic flow at moderate speeds provide the greatest benefits in noise and emission reduction. Replogle (18) reported on the emission impacts of a 50 kph (about 30 mph) to 30 kph (about 20 mph) speed reduction, based on driver type. Table 1 shows that this reduction in speed resulted in a reduction in emissions and fuel use, with the exception of fuel use for an “aggressive” driver.

Table 1: Effects of 50 kph (31 mph) to 30 kph (19 mph) speed reduction on emissions and fuel use (18)

	“Easy” Driver	“Aggressive” Driver
Carbon monoxide	-13%	-17%
VOCs	-22%	-10%
NOx	-48%	-32%
Fuel use	-7%	+7%

The City of San Jose, CA, implemented a neighborhood traffic calming plan in order to reduce through traffic, excessive speeding, noise, air emissions, and accidents, and provide a safer environment for pedestrians. The city’s objectives were attained; the number of collisions fell from 47 in the 9 months before the treatment to 27 in the 9 months after the treatment (19). Furthermore, neighborhood livability was enhanced, as seen in the resident survey in Table 2.

Table 2: Resident survey in San Jose, CA (19)

Problem Reported	% Residents Reporting Problem Before Traffic Calming	% Residents Reporting Problem After Traffic Calming
Air pollution from traffic	54	44
Noise from traffic	52	34
Safety of children	39	30
Pedestrian safety	43	28

Another benefit of traffic calming is that it may affect how residents of a community interact with one another. Slower traffic may encourage bicycling, walking, and other forms of street life. Appleyard (20) studied the effect of traffic calming on neighborhood interaction. He found that as the amount of traffic increased on a street, residents tended to have fewer friends and acquaintances among their neighbors, and the area they consider "home territory" declined. Burrington et al. (21) added that traffic calming may also discourage crime in a community. In a Dayton, OH, case study, Burrington studied the effects of reducing traffic volumes on neighborhood streets by utilizing traffic calming measures such as speed humps and street and alley closures. He found that traffic calming reduced violent crimes by 50%, non-violent crimes by 24%, and there was increased community involvement. In addition to reducing traffic volume, reducing speeds through a community can also help to reduce crime. Lockwood (22) studied the effects of reducing traffic and speed on an arterial in West Palm Beach, Florida. The case study found that when a community or urban neighborhood is no longer bisected by fast-moving traffic, people living along the arterial tend to use it more for pedestrian and cycling activity. Community interaction and crime prevention are often difficult to measure, but they are important secondary benefits that traffic calming may create.

The possible benefits of less noise and emissions, less crime, and more community interaction can also lead to higher property values. This can occur after a reduction in either traffic volume or speeds. Studies by Bagby and Hughes (23, 24) indicate that traffic calming which reduces traffic volumes on residential streets by several hundred vehicles per day increased house values by an average of 18%. Bagby (23) attempted to quantify this impact further, estimating that each reduction of 100 vehicles per day below 2,000 provides a 1% increase in adjacent residential property values. Other studies examined the effect that reducing traffic speed has on adjacent residential property values. Modra (25) reported that a 5-10 mph reduction in traffic speed can increase adjacent residential property values by about 2%. Lockwood (26) examined the effects of traffic calming in the Old Northwood neighborhood of West Palm Beach, Florida. The city used street closures, traffic circles, neckdowns, and speed humps in order to reduce speeds. A few years later, home sale prices had risen from an average of $65,000 to an average of $106,000. Other studies are not as conclusive. Other studies are not as conclusive. Edwards (27) paired neighborhoods in Gwinnett County, GA, that were treated with speed tables and similar neighborhoods that were untreated. The rate of price appreciation for home sales was then compared. For six neighborhood pairs, the neighborhoods that had speed tables showed more appreciation. For three pairs, there was less appreciation. For one pair, there was the same. Edwards noted that for most cases, the differences were only slight. Therefore, the researchers were "unable to demonstrate that installing humps will affect property values in any predictable way."

Liability of traffic calming

Studies indicate that traffic calming projects do not cause significant liability claims. In 1997, the Institute of Transportation Engineers (5) surveyed 68 agencies responsible for about 900 traffic calming projects. The survey found that only 6 lawsuits out of 1,500 filed against these agencies involved traffic calming, and only 2 of those lawsuits were successful. Litman (28) notes that the most common cause of claims were vehicle damage during construction and inadequately signed speed humps. He also noted that the monetary awards were relatively small. The Oregon DOT (7) pointed out ways that communities can minimize the number of lawsuits when implementing a traffic calming plan:

- Clear policy
- Good process that involves the public and documents the need
- Appropriate design based on established goals
- Consideration of users, especially the young, elderly, and disabled
- Clear and consistent signing and marking
- Proper maintenance

Review of rural traffic calming measures

There is much research on different traffic calming measures for urban settings, but little information is available about their effectiveness or appropriateness for rural communities. Considerations for implementation of traffic calming devices in rural communities versus urban areas include:

- **Design driver:** the typical user of roadway facilities is likely to be a rural resident who may be less likely to have encountered typical traffic calming devices than residents of urban communities. Furthermore, the typical user may be an older resident. Iowa ranks near the top in all older driver percentage groups – second only to Florida in drivers over age 85 (29).

- **Design vehicle:** heavy trucks frequently use rural arterials, and farm machinery is also prevalent on roadways around and through small communities. Therefore, devices need to be able to accommodate these vehicles.
- **Maintenance:** smaller communities and rural counties are less likely to have experience with maintaining traffic calming devices than larger urban areas. Additionally, they may have fewer resources to direct towards upkeep of the devices.
- **Roadway type:** most major roads through small communities are also major county roads. Devices which significantly alter the roadway may not be acceptable on high volume roadways with high speeds and large percentages of larger and heavier vehicles.

With these considerations, traffic calming measures were reviewed. The following is a review of existing information on various low-cost traffic calming measures that may be appropriate for some rural communities.

Transverse rumble strips

Rumble strips transmit sound and vibration to alert drivers to changing conditions. Rumble strips are often used on shoulders to reduce run-off-the-road crashes, and can be used on the mainline roadway to alert drivers of changing conditions, such as an upcoming town. In Iowa, transverse rumble strips are sometimes used on the approach to stop signs on rural roads. Typically three sets of rumble strips are used to alert motorists approaching stop signs.

Kamyab et al. (30) studied the use of rumble strips as a traffic calming measure in the City of Twin Lakes, Minnesota. They installed a set of nine grooved rumble strips placed perpendicular to the vehicle path to remind motorists of upcoming speed reduction zone. Rumble strips were used in speed transition zones where posted speeds change from 55 mph to 40 mph and then to 30 mph. The strips were placed on the highway before the 40 mph speed transition zone, as shown in Figure 3.

Figure 3: Transverse rumble strips (30)

Meyer (31) suggested that a series of rumble strips should be placed seven times the posted speed limit before the change the driver is being alerted to. In a series of rumble strips, each strip should be one foot for every 10 mph of the vehicle speed. So for example, on a roadway posted at 45 mph, each strip would be 4.5 feet apart.

Transverse rumble strips do not adversely affect emergency response times and do not interfere with vehicle operation. They are also relatively inexpensive, depending on whether the strips are portable or milled into the roadway. However, some disadvantages include noise, possible hazard for motorcyclists and bicyclists, high maintenance, and drainage (water or ice could pond in the strips). Vehicles may also try to swerve around rumble strips if they are not placed completely across the road.

Fontaine et al. (32) evaluated the use of portable rumble strips in work zones to reduce vehicle speeds. Rumble strips consisted of 12-foot long strips that were 4-inches wide and bright orange with adhesive backing. While they did not find a reduction in passenger vehicle speeds they did find a reduction in truck speeds of 3 to 5 mph.

Rumble strips are appropriate for the speed transition zone in a rural traffic calming area to alert drivers of an upcoming speed change. Use of rumble strips in a transition zone in a rural area is less likely to have an adverse noise impact since the transition area is likely to be located in a less populated area than for an urban area. Rumble strips are also appropriate for cross walks in high pedestrian areas. However, the Iowa DOT has indicated that they are not appropriate for use in Iowa except in advance of rural stop-controlled approaches. Therefore, the effectiveness of rumble strips was not tested in this study.

Chicanes

Chicanes (also called serpentines) are short, horizontal displacements in the roadway that create a curvilinear alignment which encourages slower speeds. An example of a chicane is shown in Figure 4. Ewing (11) stated that a similar effect can be achieved by alternating on-street parking from one side of the street to the other. This can be done by re-striping pavement markings for parking, or by constructing islands for parking bays. Other modifications of pavement markings can also help create a chicane.

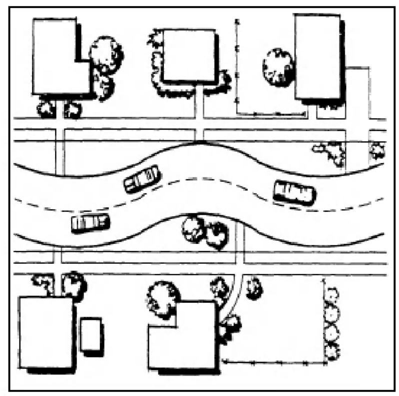

Figure 4: Chicane (11)

Chicanes, when properly designed, may be appropriate for rural main streets. Special considerations must be given to geometrics if there is a high percentage of truck traffic, because curb overtopping could be a problem if the lane shifts are too tight or closely spaced. The alignment must be carefully designed to be sure that heavy trucks and farm equipment are able to negotiate the curves. Chicanes should be placed 400 to 600 feet apart and normal turning radii for design vehicles should be accommodated. Kastenhofer (33) notes that key considerations are visibility and provision of advance warning signs. Alignment of the chicane should be shifted at least one lane-width and deflection angles should be at least 45 degrees. Center islands are also recommended, where appropriate, to prevent drivers from cutting across the center line.

Several studies have been completed on the use of chicanes as a traffic calming strategy. Macbeth (34) evaluated chicanes on an 8,000 vehicles-per-day arterial in Toronto. The roadway was 28 feet wide and chicanes were created using modular traffic calming islands, narrowing the roadway to 21 feet. He found that the 85th percentile speed was reduced from 50 km/h (31.1 mph) to 45 km/h (28.0 mph). Corkle et al. (35) summarized information from other studies and reported that chicanes may cause a 6% reduction in 85th percentile speeds.

Converging pavement markings

Converging pavement markings are usually converging transverse bars like those shown in Figure 5 or converging chevrons as seen in Figure 6. The markings should be spaced with decreasing spacing as a driver enters a transition zone. This gives drivers the perception that they are going too fast or speeding up and encourages them to reduce their speeds. They also alert drivers that they are entering a different area. They are low-cost solutions that do not affect vehicle operation or emergency response times. Some potential disadvantages include high maintenance and less effectiveness under winter conditions when markings may be less visible.

Figure 5: Transverse bars (36)

Corkle et al. (35) conducted a study in Minnesota using a converging chevron pattern in each travel lane as a traffic calming measure. The width of chevrons and spacing were decreased to give drivers the illusion that they were traveling faster than they actually were. They also placed 30 mph pavement markings and added high visibility wind spinners on speed limit signs. The roadway was a community collector street with an average daily traffic (ADT) of 4,000 vehicles per day. Data were collected before and one week after implementation. A reduction of 5 and 3 mph in mean speed (depending on the lane) were observed and a 7 and 5 mph reduction in 85^{th} percentile speed were found. Speeds were also

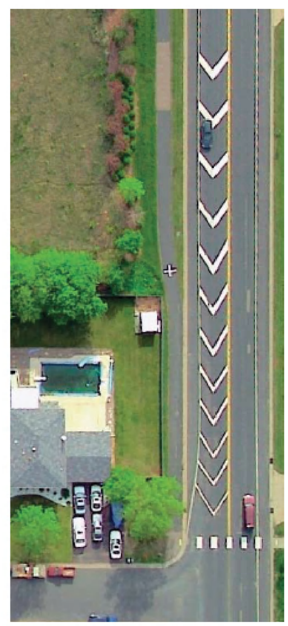

Figure 6: Aerial view of chevron lane markings in Eagan, MN (37)

collected 28 weeks after installation, and mean speed reductions were 4 and 2 mph (depending on the lane) and there was a 6 and 4 mph reduction in 85th percentile speed. Additionally, the highest speeds recorded were reduced from 58 to 44 mph and 53 to 45 mph one week after installation and 58 to 48 mph and 53 to 48 mph at 28 weeks after installation. The markings were repainted after four years since the investigators felt that the fading paint impacted the results. After repainting, they found similar speed reduction results as those conducted one week after initial installation.

<u>Surface treatments</u>

Colored or textured surfaces are common treatments in the United Kingdom and are often used in conjunction with gateways or other traffic calming measures to emphasize the presence of traffic calming features. Surface treatments, such as those seen in Figure 7, are usually used on the full width of the roadway and are typically in different colors or textures. They draw attention to the fact that something about the roadway is changing and provide visual clues to the driver that they have entered a different area. The treatments are also aesthetically pleasing, do not affect vehicle operation or emergency response times, and if surface coloring is used, there are no noise impacts.

Figure 7: Surface Treatment in Shropshire, UK (38)

Textured surfaces are typically placed in the transition zones before entering the town, and are often used in conjunction with other techniques, such as landscaping. Colored surface marking should be skid resistant and should be placed across both lanes so that drivers aren't tempted to change lanes to avoid the treatments.

Some disadvantages of surface coloring are high maintenance and less effectiveness in winter conditions. The surface coloring may also wear quickly during snow and ice removal. If textured surfaces are used, installation costs are higher and there may be an increase in noise. Some textured surfaces, such as bricks and cobblestones, can be difficult for bicyclists and pedestrians to negotiate. Like surface coloring, there may also be issues with snow and ice removal.

Studies often indicate an initial reduction in speed after installation. However, surface treatments are considered most effective in combination with other techniques. One study in Shropshire, UK, by the Department of the Environment, Transport, and the Regions (38) reported on the use of colored surface treatments in conjunction with speed limit signs. They used red patches 8 meters long across the full width of the roadway along with speed limit signs for each direction (as shown in Figure 7). This configuration was repeated at 10 locations throughout the city and was used along with other traffic calming measures. Reductions in both mean and 85th percentile speeds decreased although the study did not provide the exact reduction in speed.

Colored surface treatments are appropriate for traffic calming along major roadways in rural communities, especially in transition zones where the driver is being reminded of a change in roadway character. They are low-cost and do not present safety hazards associated with horizontal or vertical deflections. However, skid resistance must be considered; a large area of paint which fails to be skid resistant could become a significant safety hazard. Textured surfaces, such as cobblestones or other materials, may not be appropriate on major rural roads due to heavy loadings that may occur.

Dynamic speed displays and vehicle actuated signs

Dynamic speed signs and displays are usually radar activated signs that dynamically display approaching speeds for individual vehicles or display messages such as ‘SLOW DOWN’ or ‘REDUCE SPEED’ when a vehicle exceeds a certain speed. The devices such as those in Figures 8 and 9 can be portable or permanent. They alert drivers that they are speeding and create a sense of being monitored to the driver. They may also slow drivers who have radar detectors.

Figure 8: Vehicle actuated sign in Westminster, CO

Figure 9: Radar speed sign (39)

There are several studies that have shown that dynamic speed displays have a statistically significant effect in reducing mean speeds and percentage of drivers exceeding the posted speed limit. The Minnesota Department of Transportation (40) tested a radar-controlled speed display that constantly displayed the speeds of approaching traffic. The sign was tested in a work zone posted at 40 mph. Before the radar speed display was installed, the 85th percentile speed was 58 mph, and 14 percent of all traffic was exceeding 60 mph. After the speed sign was put in place, the 85th percentile speed was 53 mph, and only 1 percent of all traffic was exceeding 60 mph. The Department for Transport in the United Kingdom (4) found that the display trailers can reduce average speeds between 1 and 7 mph. They also suggest that they are more effective on a mobile basis since traffic may become immune when they are installed on a permanent basis.

Dynamic speed displays are appropriate for rural communities. They do not affect vehicle operation or emergency response times, and they can be implemented immediately and moved periodically to different locations. Installation costs can be higher than other strategies analyzed in this study, but the City of Winston-Salem (41) found that the displays are less expensive than enforcement in the long term. The speed displays do require regular maintenance and a power source, which might not be available for some locations. Motorists may become immune to the devices if there is no further perception of enforcement. Also, motorists may speed up to test the signs; this can be addressed by only reporting speeds to a certain threshold. Once the threshold is reached, a message such as 'SLOW DOWN' (seen in Figure 8) is displayed.

Enforcement

Enforcement is typically a police presence to monitor speeds and ticket violations. It is often used with other traffic calming devices to regulate behavior, but it may also be used by itself to reduce speeds. Photo-enforcement may be used as well.

Enforcement can be effective when used regularly. Police presence is helpful in getting the driver's attention and can be moved from location to location. The City of Winston-Salem (41) notes that enforcement also creates secondary benefits, such as reduced crime and increased sense of security. However, use of personnel for speed enforcement is typically not a high priority for police departments. Regular police presence, and the costs of manpower time and wages, can be very expensive even with the additional ticket revenue.

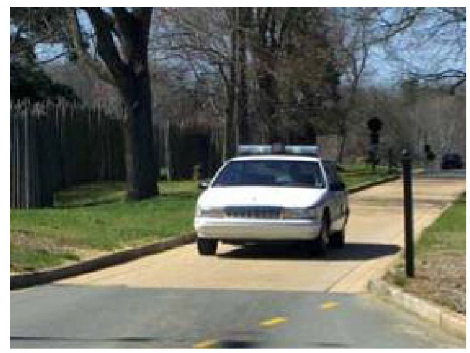

Figure 10: Enforcement (41)

Lane narrowing

Lane narrowing reduces the width of the travel portion of a lane. Narrowed lanes provide a feeling of constraint and cause drivers to reduce their speed. Caltrans (42) suggests using lane narrowing as a highway transition from rural to downtown and for main streets with an ADT less than 10,000. Reduction in level of service should also be considered when lane narrowing is used.

Lanes can either be physically narrowed or visually narrowed. Physical narrowing can be accomplished by use of center islands, curb build-outs, or chicanes but Sustrans (43) recommends that physical narrowing should be preceded by other traffic calming devices to prevent accidents.

Figure 11: Lane striping to narrow lanes (41)

Figure 12: Lane striping to narrow lanes (30)

Visually narrowing lanes is accomplished by re-painting shoulder markings (as seen in Figure 11) to widen the shoulder and decrease lane width. This can also provide space for bicyclists and pedestrians. However, if the shoulders are widened, there is less separation between on-coming vehicles. This may result in more head-on collisions. Another approach is to re-paint the median markings to widen the median and decrease lane width (as seen in Figure 12). This increases the separation between on-coming vehicles.

Another option to give the appearance of lane narrowing is to provide shoulder surfaces that are different than the roadway surface. Use of colored shoulders contrast the traveled way with the shoulders and can visually narrow the roadway, as shown in Figure 13. Colored shoulders typically last longer than markings on the roadway due to lower vehicle traffic. Another treatment is to actually construct travel lanes out of one material and the shoulders from another, such as concrete with asphalt, or using different roadway materials such as cobblestones or bricks. However, some materials such as cobblestones may present difficulties for pedestrians and bicyclists, particularly in wet conditions.

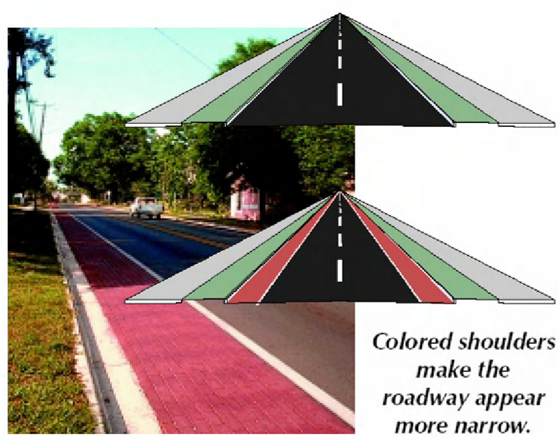

Figure 13: Colored shoulders to narrow lanes (7)

Lane narrowing does not affect vehicle operation or emergency response times. They can also be rapidly implemented and, since the markings are not in the traveled way, the markings will last longer.

Kamyab et al. (30) reported on the use of lane narrowing as a traffic calming measure in a 30 mph zone in Twin Lakes, Minnesota. He found a decrease in speeds of about 15 to 25 percent, but the speeds were still higher than the posted 30 mph speed limit by about 7 to 14 mph. Sustrans (43) analyzed lane narrowings in villages in the United Kingdom and found that the frequency and severity of injury accidents can be reduced between 25% and 50%.

Richards et al. (44) tested the impact of lane narrowing on speeds through a work zone. They used traffic cones to reduce lane widths to 12.5 ft. and then later reduced lane widths to 11.5 ft. When the lane width was reduced to 12.5 ft., there was an average speed reduction of 2.8 mph. Speeds dropped an average of 3.8 mph when the lane widths were reduced to 11.5 ft. The researchers determined that the difference in speed reduction between the 12.5 ft. lanes and the 11.5 ft. lanes was not statistically significant. They did note some problems with using lane width reduction. While the 11.5 ft. width lanes resulted in lower speeds than the 12.5 ft. width lanes, there was an increase in the standard deviation of the speeds. This may create more vehicle conflicts due to a higher variability in speeds. The researchers also added that trucks tended to cross over the lane line with the 11.5 ft. lanes when there were no vehicles beside them, creating a potential safety problem.

On-pavement speed signing

Figure 14: Speed limit pavement markings (41)

Speed limits can be painted on the roadway to remind drivers of the speed limit or to indicate a transition zone. The markings, such as those seen in Figure 14, should be placed at the same locations as speed limit signs. They are inexpensive to implement and do not affect vehicle operation or emergency response times. However, like the other on-pavement treatments, there will be high maintenance costs due to vehicles driving over the markings. No information on the effectiveness of on-pavement speed signing was found.

Speed tables

Speed tables are asphalt or rubber mounds that cover the full width of the roadway. Speed tables are essentially speed humps that have been modified with a flat top, thus reducing the disruption on vehicle operation. The flat top is typically long enough for the entire wheelbase of a passenger car to rest on top. The ramps of the speed table are also sloped more gently than speed humps. Therefore, design speeds for speed tables are higher than for speed humps. The most common type of speed table is the one designed by Seminole County, FL. The Seminole profile is 3 to 4 inches high and 14 to 22 feet long (11). An illustration of a typical speed table compared to a typical speed hump is shown in Figure 15.

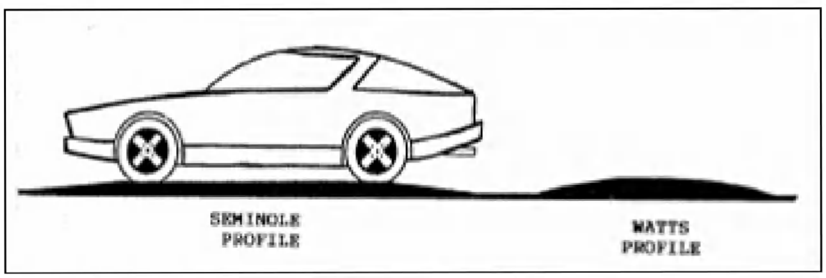

Figure 15: Seminole 22-foot speed table versus Watts 12-foot speed hump (45)

Speed tables are commonly being preferred over speed humps. This is in large part due to the delay of emergency service vehicles. Speed tables are less jarring and can allow larger emergency vehicles to cross with minimal disruption. Like speed humps, speed tables are designed according to the desired target speed. For instance, the speed table in Figure 16 is designed with a 30 mph design speed. The target speed can range up to 45 mph.

The Delaware Department of Transportation (46) established a set of guidelines describing when particular treatments should be installed. They do not recommend using speed tables for interstates or principle arterials. However, they do recommend using speed tables on minor arterials, collectors, and local roads where the daily volume is less than 10,000 vehicles per day and the posted speed limit is not greater than 35 mph.

Figure 16: 30 mph speed table

Ewing (11) reported the effects of speed tables at 58 locations and reported that 22 ft. speed tables can reduce the 85th percentile speeds about 18%. He also noted that longer tables are less effective at reducing speeds; for longer tables, the 85th percentile speeds can be reduced about 9%. Ewing also studied the number of collisions at eight locations before and after a speed table was introduced. He found that total collisions were reduced by 45%.

<u>Longitudinal channelizers</u>

Longitudinal channelizers are delineators that are commonly used to direct vehicles and prevent particular movements. Depending on where the channelizers are used, they may be between 18 and 36 inches tall, spaced about 32 inches apart, and may be yellow or orange in color. Figure 17 shows yellow channelizers being used to separate traffic movements.

Figure 17: Longitudinal channelizers (47)

The ability of longitudinal channelizers to reduce speed, however, is not well documented. The majority of research regarding the device pertains to their use at highway-railroad grade crossings. The North Carolina DOT, for instance, placed the delineators along the centerline of the roadway extending about 100 feet from the railroad gates in order to dissuade drivers from going around the gates (37). Afterward, they found that the delineators reduced violations by 77%. Channelizers have been used in work zones, high occupancy vehicle lanes, and ramp exits as well.

Longitudinal channelizers are also able to withstand an impact with a vehicle. Its flexible structure allows for them to quickly return to their initial position. Repeated impacts, however, may take its toll on the delineators, and they may eventually require some maintenance. One disadvantage of placing the delineators along the centerline is that wide trucks and farm machinery, which are common on rural Iowa roadways, may have difficulty maneuvering around them. Therefore, the channelizers should not be used on roadways with narrow lanes. The delineators also should not be placed so that they block driveways or cross-streets.

Summary of literature review

Since its application on European roadways in the mid-1900s, traffic calming has been influential in reducing the negative effects of motor vehicle use. Lower vehicle speeds can result in fewer and less severe crashes. It can also lead to less traffic noise and emissions, more community interaction, less crime, and higher property values.

Ten traffic calming measures that are applicable to rural roadways were reviewed. These measures were selected after giving consideration to the design driver, design vehicle, cost, and impact to the roadway. The design driver was assumed to be an older resident who has little experience with traffic calming devices. The measures had to accommodate large trucks and farm machinery, and they had to be inexpensive to install and maintain. Finally, the measure could not drastically alter the roadway due to the high volumes and high entering speeds that are present. The effectiveness of the ten measures was reviewed and is summarized in Table 3. The majority of the measures have little to no information on their effectiveness in rural communities.

Table 3: Review of effectiveness

Traffic calming measure	Effectiveness
Transverse rumble strips	● No reduction in passenger car speeds, but did reduce truck speeds by 3-5 mph (Fontaine, 2000)
Chicanes	● Reduced 85th percentile speed about 3 mph (Macbeth, 1998) ● Reduced 85th percentile speed by about 6% (Corkle,
Converging pavement markings	● Reduced average speeds 3-5 mph after 1 week and 2-4 mph after 1 month; reduced 85th percentile speeds 5-7 mph after 1 week and 4-6 mph after 1 month (Corkle, 2001)
Surface treatments	● Reductions in mean and 85th percentile speeds, no exact reduction reported (DETR, 2005)
Dynamic speed displays	● Reduction in 85th percentile speeds by 5 mph immediately after installation (Jackels, 1988)
Enforcement	● Previously not analyzed as a traffic calming measure
Lane narrowing	● Speed reduction of 15-20% (Kamyab, 2002) ● Reduction in mean speeds of 3-5 mph (Richards, 1985)
On-pavement speed signing	● Previously not analyzed as a traffic calming measure
Speed tables	● Reduction in 85th percentile speeds by about 18% (ITE, 1999)
Longitudinal channelizers	● Previously not analyzed as a traffic calming measure

PILOT STUDY LOCATIONS

The main research objective was to evaluate the use of different traffic calming treatments in rural Iowa communities. In order to solicit pilot study communities, the project was advertised in the Iowa League of Cities newsletter. The project scope was outlined in the newsletter, and rural Iowa communities that were interested in serving as a pilot study location were asked to contact the study team. In order for a community's main street to be selected for traffic calming, the community had to meet certain criteria. Some of the criteria included:

- Population must be 5,000 or less
- Traffic calming devices must not already be in place at any location along the roadway that will affect results (if traffic calming devices are already in place, the community may still be used to compare the town against a similar community without traffic calming)
- Locations cannot have experienced recent construction, reconstruction, or significant maintenance activities nor have construction or reconstruction scheduled
- Roadway must be a major through county or state route
- Roadway must be paved
- Roadway must continue through the community (roadway cannot terminate within or shortly beyond the community)
- Roadway must not be access controlled
- No adverse geometry is present, such as sharp horizontal curves or steep vertical curves at the entrances of the community
- Location in the state – communities furthest away were not considered if closer locations were available in order to facilitate data collection

A total of twenty-two communities responded to the newsletter and expressed their interest in the project. Of those, 20 were visited and 10 which appeared to be the most promising using the previous filtering criteria were ultimately selected. The ten towns were the City of Onawa, the City of Gilbert, the City of Roland, the City of McCallsburg, the City of Union, the City of Dexter, the City of West Branch, the City of Wapello, the City of Boyden, and the City of Aurelia.

There were also towns that were selected even though they did not respond to the initial newsletter. These towns were selected because they met the criteria and were nearby. Further analysis of these locations was conducted, analyzing geometry and determining if there was a traffic calming measure already in place. The analysis yielded eight more towns that could be used for the study. The eight towns were the City of Madrid, the City of Slater, the City of Woodward, the City of Minburn, the City of Stanhope, the City of Dallas Center, the City of Huxley, and the City of Albion.

Preliminary speed data collection

Occasionally, problems with speeding are "perceived" rather than actual – residents complain of speeding when in fact no evidence exists that a speeding problem is present. Therefore, the magnitude of each community's speeding problem, if one existed at all, needed to be determined. Identifying the scope of the traffic calming problem was used later on, as well, to answer the question as to where traffic calming should be implemented within the community.

Preliminary speeds were collected for the 10 communities that had volunteered and the 8 communities that were identified as potential locations by the study team. The data were collected using pneumatic road tubes spaced at 8 feet apart. The tubes were placed at a minimum of 3 locations per community. They were also placed at locations away from businesses or major driveways; this was done to cut down on the number of accelerating or decelerating vehicles that would affect the data. The presence of the tubes was assumed to have only a minor effect on driver behavior. Speeds were collected for at least 48 hours during the week, avoiding weekends. The method of determining whether a community had a speeding problem was based on the average speed, 85^{th} percentile speed, percent of vehicles traveling over the speed limit, percent of vehicles traveling 10 mph or more over the speed limit, etc. The data were used only to determine the magnitude of the speeding problem and for the selection of pilot study locations. Therefore, if a community was later selected, a more focused speed study would be conducted to be used as the "before" data.

Final site selection

The preliminary speeds that were collected were critical in determining the final pilot study locations. However, sensitive areas such as schools, parks, churches, swimming pools and other pedestrian generators near the roadway were also considered in the selection process. For instance, a community that had a speeding problem near a school would be viewed differently than a community that had a speeding problem at an undeveloped section of roadway.

The preliminary speed data indicated that 9 of the 18 communities had a speeding problem. A community was considered to have a speeding problem if the 85th percentile speeds were about 10 mph or more over the posted speed limit. Those communities were then narrowed to five after ranking them in terms of magnitude of the speeding problem and type of sensitive areas near the roadway. Transportation engineers at the Center for Transportation Research and Education determined potential treatments for each of the five communities. The treatments and locations were selected after considering where the speeding problem existed (downtown, in the transition zones of the town, or both). The potential treatments were then discussed with each community's city council to receive additional input or recommendations. The five communities, along with the selected treatments for each, are shown in Table 4. The exact locations of the treatments will be detailed in later sections.

Table 4: Pilot study locations

Community	Speeding problem?	Treatment(s)
Roland	Yes	Lane narrowing, converging chevrons, on-pavement speed signing
Union	Yes	Lane narrowing, converging bars
Gilbert	Yes	Speed table
Dexter	Yes	Surface treatments at entrances to community
Slater	Yes	Longitudinal channelizers, surface treatment

There were also communities which already had a traffic calming measure in place. They were selected as part of the study so that the effectiveness of the existing treatment could be analyzed. These communities are shown in Table 5.

Table 5: Pilot study locations with existing traffic calming measures

Community	Existing treatment
Huxley	Enforcement
Dexter	Enforcement
Albion	Speed display trailer

The City of Minburn was also selected for the study. The city did not have any traffic calming measures in place. However, traffic flow characteristics were similar in this community to the characteristics of Huxley and Dexter. Minburn was, therefore, selected to compare enforcement as a speed control measure.

A map illustrating the location of all of the pilot study locations is presented in Figure 18.

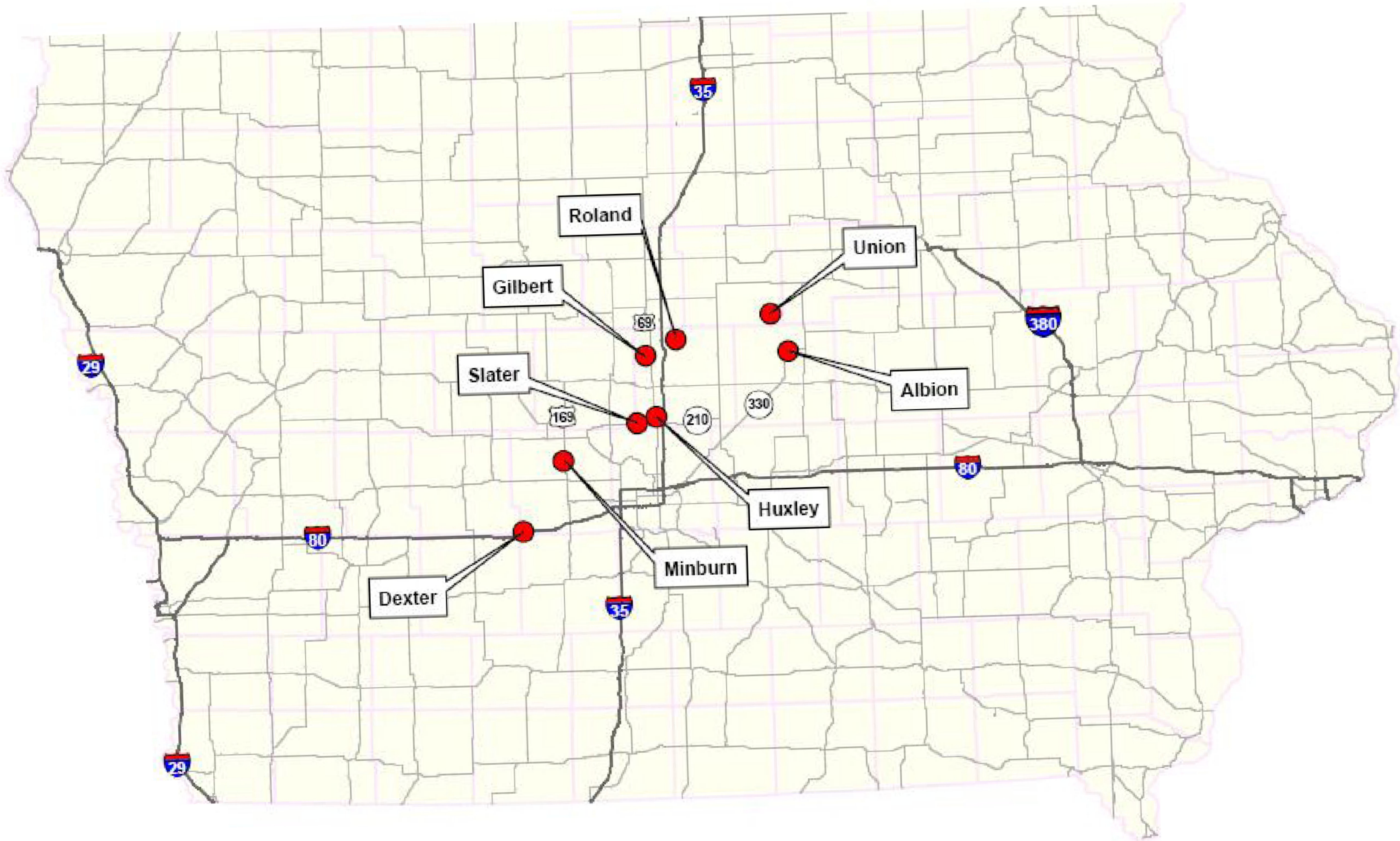

Figure 18: Map of pilot study locations

Collection of before and after data

Speed data were collected before and after implementing traffic calming in the pilot study communities. Pneumatic road tubes were used to collect individual vehicle speeds both upstream and downstream of where each traffic calming device was to be placed. Speeds were then analyzed about 1 month after the device was in place, at the same locations where the "before" data were gathered. Each site was analyzed for a period of three days (Tuesday, Wednesday, and Thursday). In order to evaluate normal traffic patterns, holidays and unusual events were avoided in the data collection. The effectiveness of each traffic calming strategy was measured by the following statistics:

- Changes in the mean and 85th percentile speeds

  These are standard measures that are typically used to compare speeds.

- Before and after standard deviations

  Standard deviation is a measure of variability of the data. For instance, a large standard deviation indicates that speeds are spread out from the mean speed. Conversely, a small standard deviation indicates that speeds are close to the mean speed. This is important because it provides a sense of how drivers react to the traffic calming device. If, for example, the standard deviation of speeds *decreases* after the treatment is installed, drivers are traveling closer to the mean speed. However, if the standard deviation *increases* after the treatment is installed, there is more variability in speeds after installation of the treatment.

- Excessive speeds

  Excessive speeding was defined as vehicles traveling at speeds greater than 10 mph over the posted speed limit. The percent of vehicles traveling over this threshold was determined for the before and after data. This is important since a reduction in excessive speeds, even if there is little change in the mean or 85^{th} percentile speed, can indicate success for a particular community.

To assess the impact of enforcement on speeds, speeds in three communities with similar traffic patterns but different levels of enforcement were compared. This is not a before and after analysis like what was used for the other communities. Therefore, other factors may exist between the communities and contribute to the differences in speeds.

Findings

The following describes each test site and the traffic calming treatment used, along with the before and after speed results.

Roland, IA – converging chevrons, lane narrowing, on-pavement speed signing

Roland, IA, is located about 45 miles north of Des Moines and has a population of 1,324. City officials responded to our initial newsletter, requesting to be a pilot study in the project. They noted that speeding was occurring on County Highway E18, their main route through town. Highway E18 is a 2-lane roadway that runs east/west through town and has an ADT of about 2,400. The posted speed limit is 55 mph outside of town and 25 mph at the center of town, with long transition zones on the west end of town and short transition zones on the east end of town. There is also a 4-way stop controlled intersection at the center of town. Some sensitive areas near the highway include a middle school, park, and swimming pool. Initial speed studies indicated speeding problems downtown and east of the 4-way stop. After reviewing the initial speed studies and consulting with city officials, a traffic calming plan was formed. The traffic calming plan is shown in Figure 19.

Converging chevron markings were selected to be used just west of downtown in order to slow down eastbound traffic before they reach the center of town. The same style of markings was also selected to be used on the east edge of town to slow down entering westbound traffic. Furthermore, lane narrowing was chosen due to the high speeds just east of the 4-way stop and also due to the varying lane widths through town. The original lane width was wider from the 4-way stop to the east edge of town (18 ft.) than at other locations along the highway (11 ft.). Shoulders were painted on the wider section of roadway, decreasing the traveled width from 18 ft. to 11 ft. On-pavement speed signing was also used at various locations as an added reminder to drivers. The traffic calming measures were selected after confirming that the measures did not violate guidelines set forth by the MUTCD. Figures 20-24 show the site before and after traffic calming was implemented.

The results of the speed analysis are presented in Tables 6-8. The converging chevrons caused only slight changes in speeds. At the west entrance of town, the converging chevrons had no effect on the average speed and increased the 85th percentile speed by 1 mph. There was also slightly more speed variability and a higher percentage of excessive speeds. At the east entrance of town, the chevrons caused reductions of 1 mph for both the average speed and 85th percentile speed. At this location, there was less speed variability and a lower percentage of excessive speeds.

Downtown, speeds were lower in one direction but higher in the other direction. The combination of lane narrowing and on-pavement speed signing for eastbound traffic caused an average speed reduction of 2 mph and an 85^{th} percentile speed reduction of 3 mph. Speed variability and excessive speeding were also reduced. For westbound traffic, the treatments were just downstream of the converging chevrons. However, the combination of converging chevrons, lane narrowing, and on-pavement speed signing actually caused an increase in both the average speed and 85^{th} percentile speed of 3 mph.

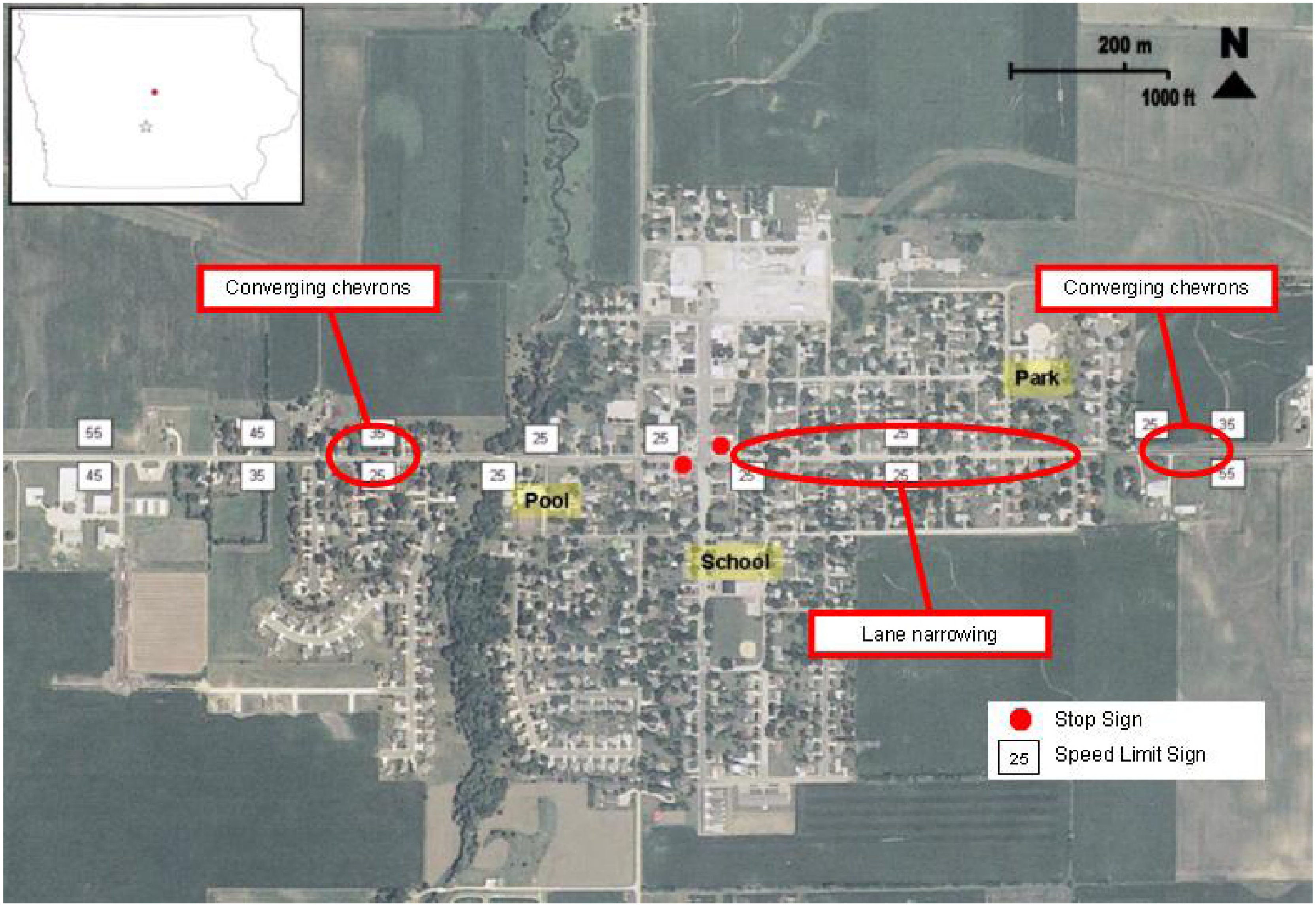

Figure 19: Roland, IA, traffic calming plan

Figure 20: Site before converging chevrons

Figure 21: Site after converging chevrons

Figure 22: Site before lane narrowing

Figure 23: Site after lane narrowing

Figure 24: On-pavement speed signing

Table 6: Analysis of converging chevrons in Roland, IA (west end, eastbound lane)

POSTED SPEED = 25 MPH	**Before**	**After**	**Change**	**% Change**
Average Speed	29	29	0	0.0%
85th Percentile Speed	34	35	1	2.9%
Standard Deviation	4.5	5.2	0.7	15.6%
% Vehicles Over Limit	85.9	85.6	-0.3	-0.3%
% Vehicles 5+ Over Limit	43.7	50.5	6.8	15.6%
% Vehicles 10+ Over Limit	9.1	14.0	4.9	53.8%
% Vehicles 15+ Over Limit	1.1	2.6	1.5	136.4%
Maximum Speed	48	56	8	16.7%
Count	4092	5167	1075	26.3%

Table 7: Analysis of converging chevrons in Roland, IA (east end, westbound lane)

POSTED SPEED = 25 MPH	**Before**	**After**	**Change**	**% Change**
Average Speed	30	29	-1	-3.3%
85th Percentile Speed	36	35	-1	-2.8%
Standard Deviation	6.4	6.0	-0.4	-6.3%
% Vehicles Over Limit	83.2	83.4	0.2	0.2%
% Vehicles 5+ Over Limit	51.4	47.8	-3.6	-7.0%
% Vehicles 10+ Over Limit	19.7	16.6	-3.1	-15.7%
% Vehicles 15+ Over Limit	5.4	4.0	-1.4	-25.9%
Maximum Speed	60	54	-6	-10.0%
Count	2397	2426	29	1.2%

Table 8: Analysis of lane narrowing with on-pavement speed signing in Roland, IA

POSTED SPEED = 25 MPH	Before	After	Change	% Change
Average Speed				
Eastbound	29	27	-2	-6.9%
Westbound	27	30	3	11.1%
85th Percentile Speed				
Eastbound	34	31	-3	-8.8%
Westbound	32	35	3	9.4%
Standard Deviation				
Eastbound	4.7	3.8	-0.90	-19.1%
Westbound	4.1	4.5	0.40	9.8%
% Vehicles Over Limit				
Eastbound	86.8	77	-9.8	-11.3%
Westbound	78.1	91	12.9	16.5%
% Vehicles 5+ Over Limit				
Eastbound	46.7	23.6	-23.1	-49.5%
Westbound	27.4	51.5	24.1	88.0%
% Vehicles 10+ Over Limit				
Eastbound	12.0	2.7	-9.3	-77.5%
Westbound	4.0	13.5	9.5	237.5%
% Vehicles 15+ Over Limit				
Eastbound	1.9	0.2	-1.7	-89.5%
Westbound	0.4	2.3	1.9	475.0%
Maximum Speed				
Eastbound	46	46	0	0.0%
Westbound	49	60	11	22.4%
Count				
Eastbound	2884	2681	-203	-7.0%
Westbound	2864	2708	-156	-5.4%

*Note: For westbound traffic, treatments were downstream of converging chevrons

Gilbert, IA –speed table

Gilbert, IA, is located about 40 miles north of Des Moines and has a population of 987. County Highway E23 is a two-lane roadway with an ADT of about 1,600 and runs east/west through the middle of the community. The posted speed limit is 55 mph outside of town and 25 mph at the center of town, with transition zones on each end of town. There is also a four-way stop controlled intersection at the center of town. The town has plans for a new middle school near Highway E23, and two other schools are already near the route. Furthermore, there are two parks nearby that generate additional pedestrian traffic.

Initial speed studies indicated speeding existed downtown and on the east end of town. Near the west edge of town, a rough set of railroad tracks that cross Highway E23 already help to slow drivers. Therefore, traffic calming was not considered in this area. Also, the city was considering installing a four-way stop controlled intersection on the east side of town and adjusting the speed zones east of town. As a result, this end of town was not considered for traffic calming. Instead traffic calming was focused downtown. After analyzing the initial speed studies and speaking with city officials, a traffic calming strategy was formed. Figure 25 shows the traffic calming plan. A speed table with a design speed of 30 mph was selected to be placed near the center of town. The Iowa DOT does not have formal guidelines for design of speed tables, so the Delaware DOT guidelines for speed tables were used with approval from the Iowa DOT. Speed table pavement markings approved by the MUTCD were used. Figures 26 and 27 show the site before and after traffic calming was implemented.

The speed analysis is presented in Table 9. The speed table reduced average speeds 3 mph and 4 mph for eastbound and westbound vehicles, respectively, at locations about a block away from the device. The 85th percentile speeds were also reduced for each direction by 4 mph. Furthermore, there was less speed variation and percentage of excessive speeds.

Speeds were also analyzed further downstream of the device to determine if speeds remained low through town. This location was in the 25 mph zone on the west side of the community. The average speed was reduced at this location from 33 mph to 30 mph, and the 85th percentile speed was reduced from 40 mph to 35 mph. Speed variation was reduced, and the percentage of vehicles traveling at excessive speeds was decreased from 41.5% to 16.2 %. Although there were considerable reductions in speeds downstream of the speed table, vehicles were still speeding at this location.

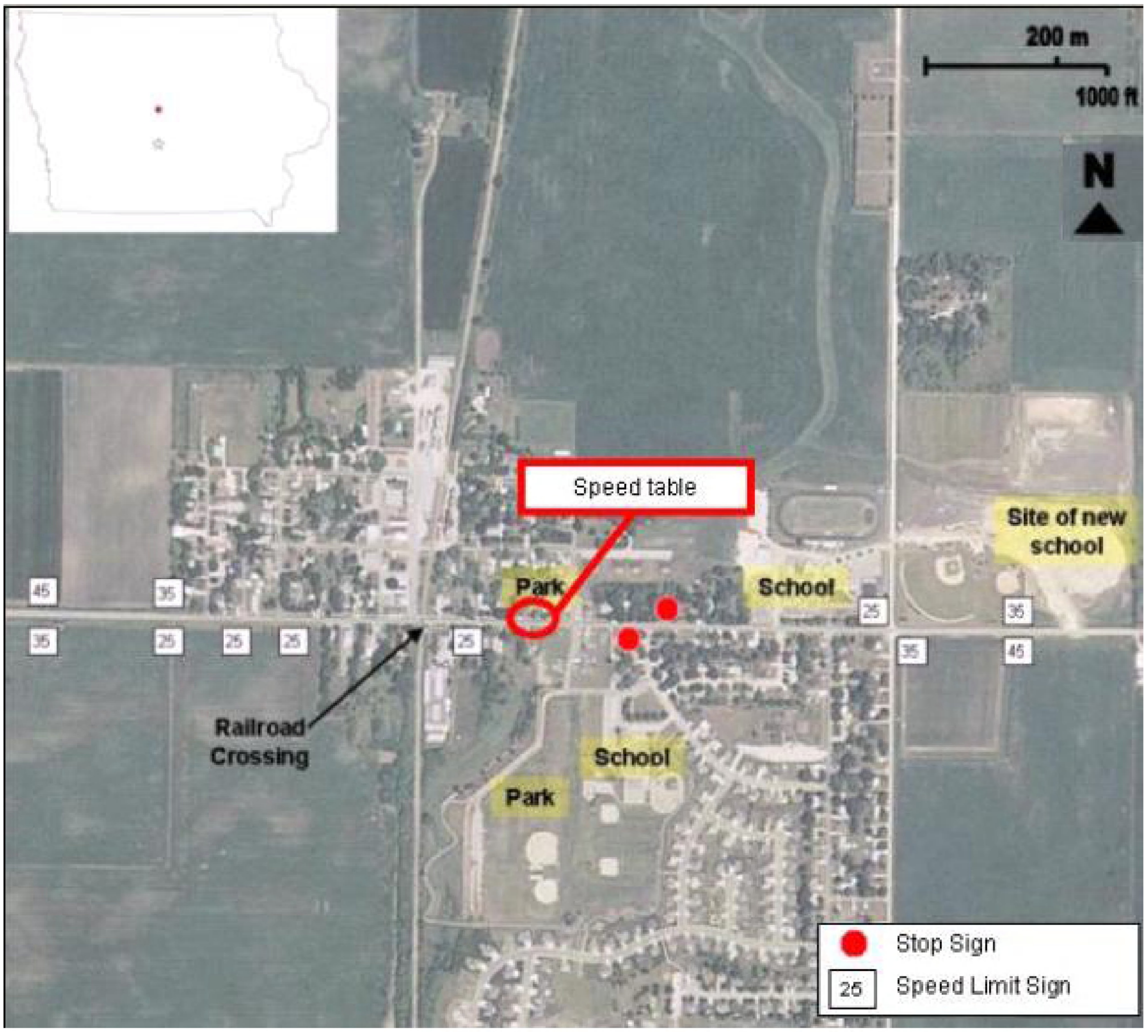

Figure 25: Gilbert, IA, traffic calming plan

Figure 26: Site before speed table

Figure 27: Site after speed table

Table 9: Analysis of speed table in Gilbert, IA

POSTED SPEED = 25 MPH	Before	After	Change	% Change
Average Speed				
Eastbound	26	23	-3	-11.5%
Westbound	30	26	-4	-13.3%
85th Percentile Speed				
Eastbound	32	28	-4	-12.5%
Westbound	34	30	-4	-11.8%
Standard Deviation				
Eastbound	6.0	4.5	-1.5	-25.0%
Westbound	4.4	4.1	-0.3	-6.8%
% Vehicles Over Limit				
Eastbound	64.2	31.9	-32.3	-50.3%
Westbound	89.6	63.6	-26	-29.0%
% Vehicles 5+ Over Limit				
Eastbound	28.2	6.0	-22.2	-78.7%
Westbound	51.3	16.9	-34.4	-67.1%
% Vehicles 10+ Over Limit				
Eastbound	6.3	0.7	-5.6	-88.9%
Westbound	12.2	2.0	-10.2	-83.6%
% Vehicles 15+ Over Limit				
Eastbound	0.8	0.1	-0.7	-87.5%
Westbound	1.2	0.1	-1.1	-91.7%
Maximum Speed				
Eastbound	45	46	1	2.2%
Westbound	48	43	-5	-10.4%
Count				
Eastbound	3859	3659	-200	-5.2%
Westbound	2467	2410	-57	-2.3%

Union, IA – converging bars, lane narrowing

Union, IA, is located about 60 miles northeast of Des Moines and has a population of 427. City officials responded to our initial newsletter, requesting to be a pilot study in the project. They noted that speeding was occurring on two main routes through town, County Highway D65 and County Highway S62/State Highway 215. Highway D65 is a 2-lane roadway that runs east/west through the middle of town and has an ADT of about 2,000. County Highway S62 (ADT~1,000) is a 2-lane roadway that runs from the center of town to the south, and State Highway 215 (ADT~1,600) runs from the center of town to the north. There is a two-way stop controlled intersection located where the two roadways meet, with Highway D65 having the right-of-way. Residents complained of high speeds on the north, south, and west edges of town. On the east edge of town, railroad tracks that cross Highway D65 help to significantly slow drivers that are entering town from the east. Therefore, this edge of town was not analyzed in the study. Some sensitive areas near the highways include a middle school, swimming pool, and golf course.

Initial speed studies indicated speeding problems on both State Highway 215 and County Highway S62, as well as on County Highway D65 on the west side of town. After examining the initial speed studies and speaking with city officials, the traffic calming plan seen in Figure 28 was produced. Converging transverse bars were selected to be used at the entrances to the town on the north, south, and west. Along State Highway 215, which originally had lane widths of 20 feet downtown, lanes were narrowed to about 11 feet. A left turn lane was also added for southbound traffic on Highway 215 as part of the lane narrowing. The traffic calming measures were submitted to the FHWA MUTCD committee and approval for experimental use was granted. Figures 29-32 show the site before and after traffic calming was installed.

The speed analysis is presented in Tables 10-13. The converging transverse bars had very little effect on reducing speeds. At the north end of town, the transverse bars resulted in an average speed increase of 1 mph and no change in the 85th percentile speed. The transverse bars at the west end caused no change in the average speed and a 1 mph increase in the 85th percentile speed. Finally, at the south end, the transverse bars caused reductions of both the average and 85th percentile speed of 1 mph. There was also very little change in speed variability and percentage of excessive speeds at all three locations.

Downtown, the lane narrowing also had little success, as speeds increased slightly. The average speed and 85th percentile speed for northbound vehicles were 2 mph higher. There was also more speed variability and excessive speeds in this direction. For southbound vehicles, the average speed increased 1 mph and the 85th percentile speed was unchanged. In this direction, there was little change in speed variability or excessive speeds.

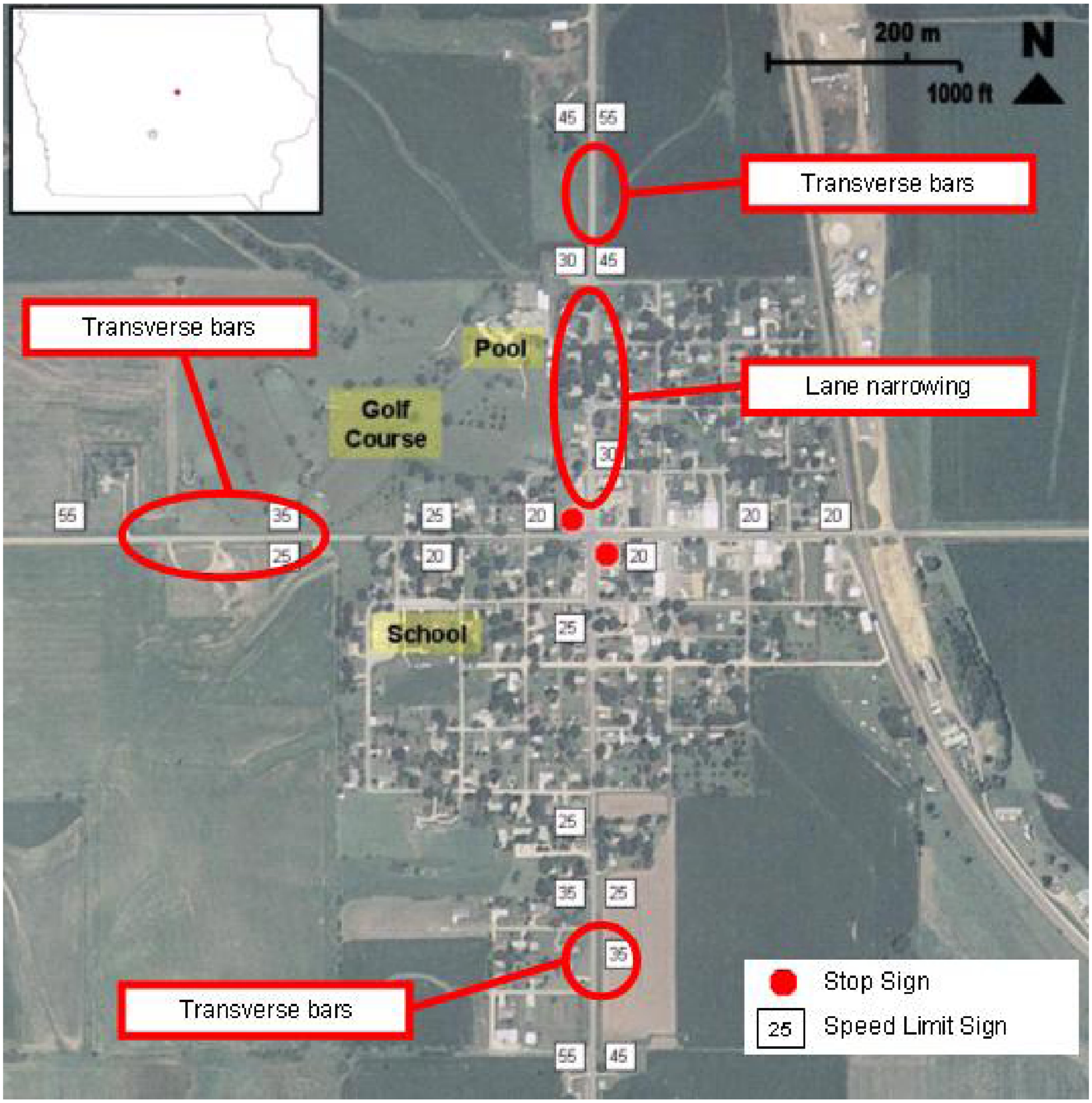

Figure 28: Union, IA, traffic calming plan

Figure 29: Site before lane narrowing

Figure 30: Site after lane narrowing

Figure 31: Site before transverse bars

Figure 32: Site after transverse bars

Table 10: Analysis of lane narrowing in Union, IA

POSTED SPEED = 30 MPH	**Before**	**After**	**Change**	**% Change**
Average Speed				
Northbound	28	30	2	7.1%
Southbound	28	28	0	0.0%
85th Percentile Speed				
Northbound	34	36	2	5.9%
Southbound	34	34	0	0.0%
Standard Deviation				
Northbound	5.7	6.0	0.3	5.3%
Southbound	5.4	5.4	0.0	0.0%
% Vehicles Over Limit				
Northbound	39.8	54.1	14.3	35.9%
Southbound	40.7	39.5	-1.2	-2.9%
% Vehicles 5+ Over Limit				
Northbound	10.3	21.0	10.7	103.9%
Southbound	11.9	10.7	-1.2	-10.1%
% Vehicles 10+ Over Limit				
Northbound	1.3	3.0	1.7	130.8%
Southbound	1.8	1.4	-0.4	-22.2%
% Vehicles 15+ Over Limit				
Northbound	0.2	0.3	0.1	50.0%
Southbound	0.2	0.2	0	0.0%
Maximum Speed				
Northbound	57	47	-10	-17.5%
Southbound	48	63	15	31.3%
Count				
Northbound	1963	1875	-88	-4.5%
Southbound	1697	2009	312	18.4%

Table 11: Analysis of transverse bars in Union, IA (north end, southbound lane)

POSTED SPEED = 30 MPH	Before	After	Change	% Change
Average Speed	33	34	1	3.0%
85th Percentile Speed	41	41	0	0.0%
Standard Deviation	7.1	6.8	-0.3	-4.2%
% Vehicles Over Limit	70.7	77.7	7	9.9%
% Vehicles 5+ Over Limit	41.1	48.5	7.4	18.0%
% Vehicles 10+ Over Limit	17.5	19.8	2.3	13.1%
% Vehicles 15+ Over Limit	4.3	5.2	0.9	20.9%
Maximum Speed	57	62	5	8.8%
Count	1887	1861	-26	-1.4%

Table 12: Analysis of transverse bars in Union, IA (west end, eastbound lane)

POSTED SPEED = 25 MPH	Before	After	Change	% Change
Average Speed	43	43	0	0.0%
85th Percentile Speed	51	52	1	2.0%
Standard Deviation	7.9	8.3	0.4	5.1%
% Vehicles Over Limit	98.1	97.4	-0.7	-0.7%
% Vehicles 5+ Over Limit	93.8	92.8	-1	-1.1%
% Vehicles 10+ Over Limit	86.8	85.0	-1.8	-2.1%
% Vehicles 15+ Over Limit	73.0	69.0	-4	-5.5%
Maximum Speed	69	65	-4	-5.8%
Count	671	674	3	0.4%

Table 13: Analysis of transverse bars in Union, IA (south end, northbound lane)

POSTED SPEED = 35 MPH	Before	After	Change	% Change
Average Speed	38	37	-1	-2.6%
85th Percentile Speed	47	46	-1	-2.1%
Standard Deviation	8.5	8.9	0.4	4.7%
% Vehicles Over Limit	69.3	66.1	-3.2	-4.6%
% Vehicles 5+ Over Limit	45.0	43.0	-2	-4.4%
% Vehicles 10+ Over Limit	20.9	19.9	-1	-4.8%
% Vehicles 15+ Over Limit	5.9	5.0	-0.9	-15.3%
Maximum Speed	96	63	-33	-34.4%
Count	920	816	-104	-11.3%

Slater, IA – longitudinal channelizers, surface treatment

Slater, IA, is located about 20 miles north of Des Moines and has a population of 1,306. City officials did not respond to our initial newsletter, but due to its close location and because it also met the criteria for the study, speeds in the town were analyzed to determine if a speeding problem existed. Two routes were examined – State Highway 210 and County Highway R38. Highway 210 is a 2-lane roadway that runs east/west through town and has an ADT of about 3,000. County Highway R38 is a 2-lane roadway that runs north/south through town and has an ADT of about 3,500 on the north side of town and about 2,500 on the south side town. There is a four-way stop controlled intersection located where the two roadways meet. Highway R38 also has a second four-way stop controlled intersection on the north side of town. Some sensitive areas near the highways include an elementary school near Highway R38 and a park near Highway 210.

Initial speed studies indicated a speeding problem on both routes. On the east end of town, there is a small transition zone, followed by a four-way stop. Therefore, traffic calming was not considered on this edge of town. After reviewing the initial speed studies and consulting with city officials, the traffic calming plan seen in Figure 33 was produced. Longitudinal channelizers were selected in order to slow down northbound traffic upon entering town from the south. This measure has not been previously analyzed as a traffic calming measure. For eastbound and westbound traffic on Highway 210, a surface treatment was preferred. The surface treatment was designed to be a painted “SLOW” message on the pavement. The traffic calming measures were selected after confirming that the measures did not violate guidelines set forth by the MUTCD. Figures 34-37 show the site before and after traffic calming was implemented.

The speed analysis is presented in Tables 14-15. The “SLOW” pavement marking on the west end of town had no effect on either the average speed or the 85th percentile speed for eastbound traffic. Speed variation and excessive speed percentage were slightly lower for this direction. For westbound vehicles, the average speed and the 85th percentile speed increased 1 mph. There was also a slight increase in speed variation and excessive speed percentage.

The longitudinal channelizers were much more effective in reducing speeds. The average speed was reduced 5 mph and the 85th percentile speed decreased 7 mph for both directions. Speed variation was also much lower, and excessive speeds were reduced between 50 and 75 percent.

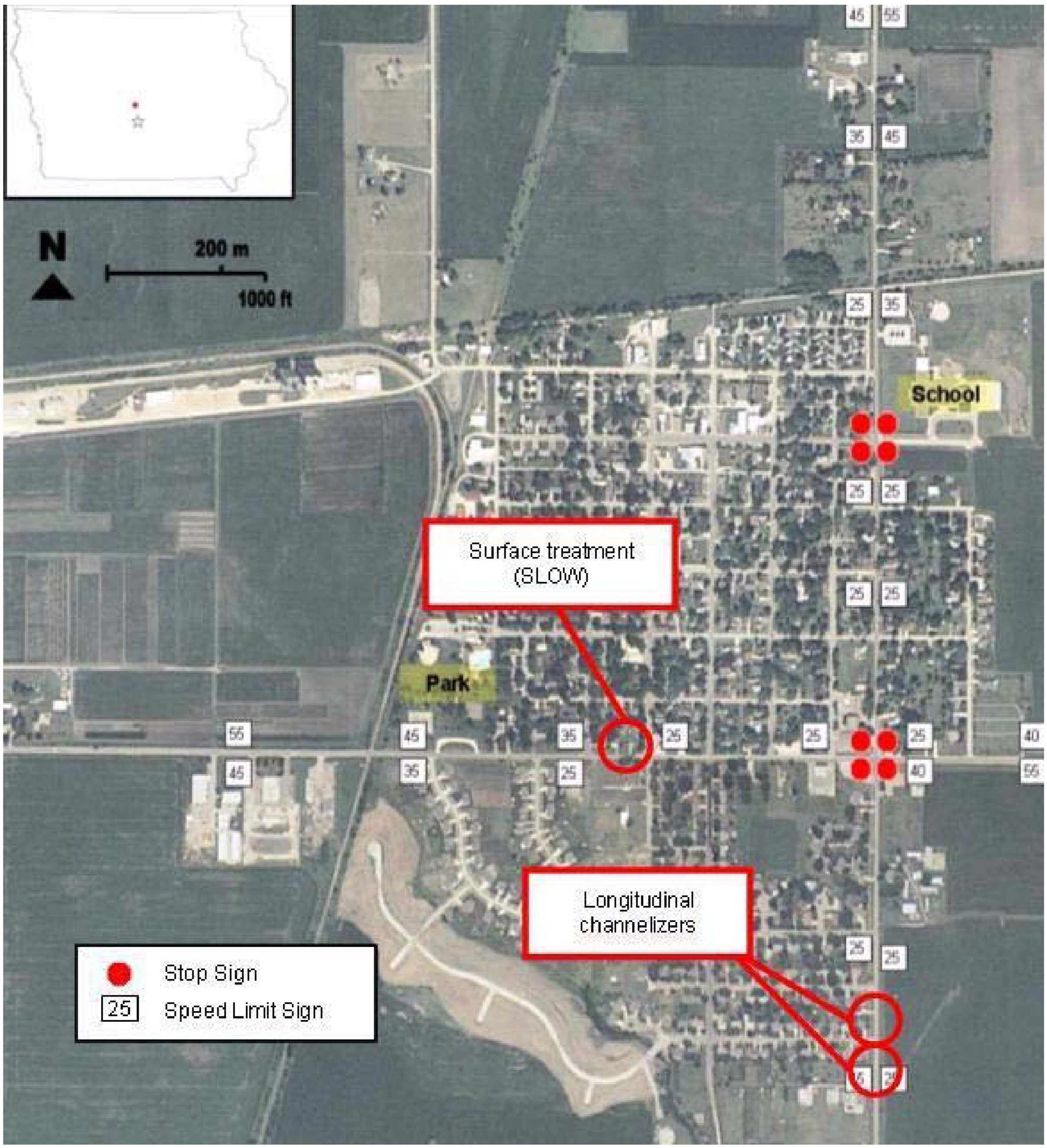

Figure 33: Slater, IA, traffic calming plan

Figure 34: Site before surface treatment

Figure 35: Site after surface treatment

Figure 36: Site before longitudinal channelizers

Figure 37: Site after longitudinal channelizers

Table 14: Analysis of surface treatment in Slater, IA

POSTED SPEED = 25 MPH	Before	After	Change	% Change
Average Speed				
Eastbound	29	29	0	0.0%
Westbound	30	31	1	3.3%
85th Percentile Speed				
Eastbound	35	35	0	0.0%
Westbound	36	37	1	2.8%
Standard Deviation				
Eastbound	5.1	4.8	-0.3	-5.9%
Westbound	5.4	5.3	-0.1	-1.9%
% Vehicles Over Limit				
Eastbound	83.6	83.6	0	0.0%
Westbound	86.1	88.4	2.3	2.7%
% Vehicles 5+ Over Limit				
Eastbound	48	46.7	-1.3	-2.7%
Westbound	53.3	59.3	6	11.3%
% Vehicles 10+ Over Limit				
Eastbound	14.7	12.9	-1.8	-12.2%
Westbound	20.6	23.4	2.8	13.6%
% Vehicles 15+ Over Limit				
Eastbound	2.6	1.9	-0.7	-26.9%
Westbound	4.8	4.9	0.1	2.1%
Maximum Speed				
Eastbound	51	50	-1	-2.0%
Westbound	56	60	4	7.1%
Count				
Eastbound	3615	3446	-169	-4.7%
Westbound	3444	3357	-87	-2.5%

Table 15: Analysis of longitudinal channelizers in Slater, IA

POSTED SPEED = 25 MPH	Before	After	Change	% Change
Average Speed				
Northbound	33	28	-5	-15.2%
Southbound	38	33	-5	-13.2%
85th Percentile Speed				
Northbound	41	34	-7	-17.1%
Southbound	46	39	-7	-15.2%
Standard Deviation				
Northbound	7.0	5.1	-1.9	-27.1%
Southbound	8.1	5.6	-2.5	-30.9%
% Vehicles Over Limit				
Northbound	89.9	78.4	-11.5	-12.8%
Southbound	91.5	95.3	3.8	4.2%
% Vehicles 5+ Over Limit				
Northbound	73.7	34.2	-39.5	-53.6%
Southbound	87.3	70.3	-17.0	-19.5%
% Vehicles 10+ Over Limit				
Northbound	43.4	10.9	-32.5	-74.9%
Southbound	71.8	33.8	-38.0	-52.9%
% Vehicles 15+ Over Limit				
Northbound	17.3	2.3	-15.0	-86.7%
Southbound	44.6	10.1	-34.5	-77.4%
Maximum Speed				
Northbound	64	64	0	0.0%
Southbound	66	73	7	10.6%
Count				
Northbound	2760	2645	-115	-4.2%
Southbound	2923	2839	-84	-2.9%

Dexter, IA – surface treatments

Dexter, IA, is located about 30 miles west of Des Moines and has a population of 689. City officials responded to our initial newsletter. They were concerned about speeding on their main route, County Highway F65. Residents complained of drivers entering town at high speeds. The posted speed limit is 55 mph outside of town and 35 mph at the center of town, with no transition zones on either end of town. There is also a '25 mph when flashing' zone near the center of town, which is in effect for about 45 minutes before and after school. Some sensitive areas near the highways include an elementary school, park, and metal fabrication plant. Trucks entering the fabrication plant, Ramark Industries, Inc., must back into the plant from the highway, a safety concern the city had expressed.

Initial speed studies indicated high vehicle speeds on the edges of town. Speeding was not nearly as severe downtown. After examining the initial speed studies and receiving input from city officials, a traffic calming plan was created. The plan is shown in Figure 38. A surface treatment at both ends of town was selected in order to slow down drivers as they entered the community. The surface treatment was a painted "35" on the roadway, followed by a painted "MPH" message. In addition to painting the treatments at both ends of town, city officials preferred to have a third location just west of the Ramark Industries, Inc., plant. This was done with the intention of slowing down eastbound traffic before they reached the plant. Therefore, a third location was tested for the eastbound lane only. The surface treatments were selected after confirming that the measures did not violate guidelines set forth by the MUTCD. Figures 39-42 show the site before and after traffic calming was implemented.

The speed analysis is presented in Tables 16-18. The surface treatments on the west end of town were effective in reducing speeds. At the curve treatment, the average speed and 85th percentile speed decreased 5 mph. Speed variation and excessive speed percentage were also reduced. The curve treatment combined with the treatment at the west city limit caused an eastbound average speed reduction of 2 mph and an 85th percentile reduction of 3 mph.

Westbound vehicle speeds were reduced at this location by 2 mph and 3 mph for average speed and 85th percentile speed, respectively.

The surface treatment at the east city limit was less effective, but the initial speeding problem was not quite as severe at this end of town. The treatment caused reductions of 1 mph for both the average speed and 85th percentile speed.

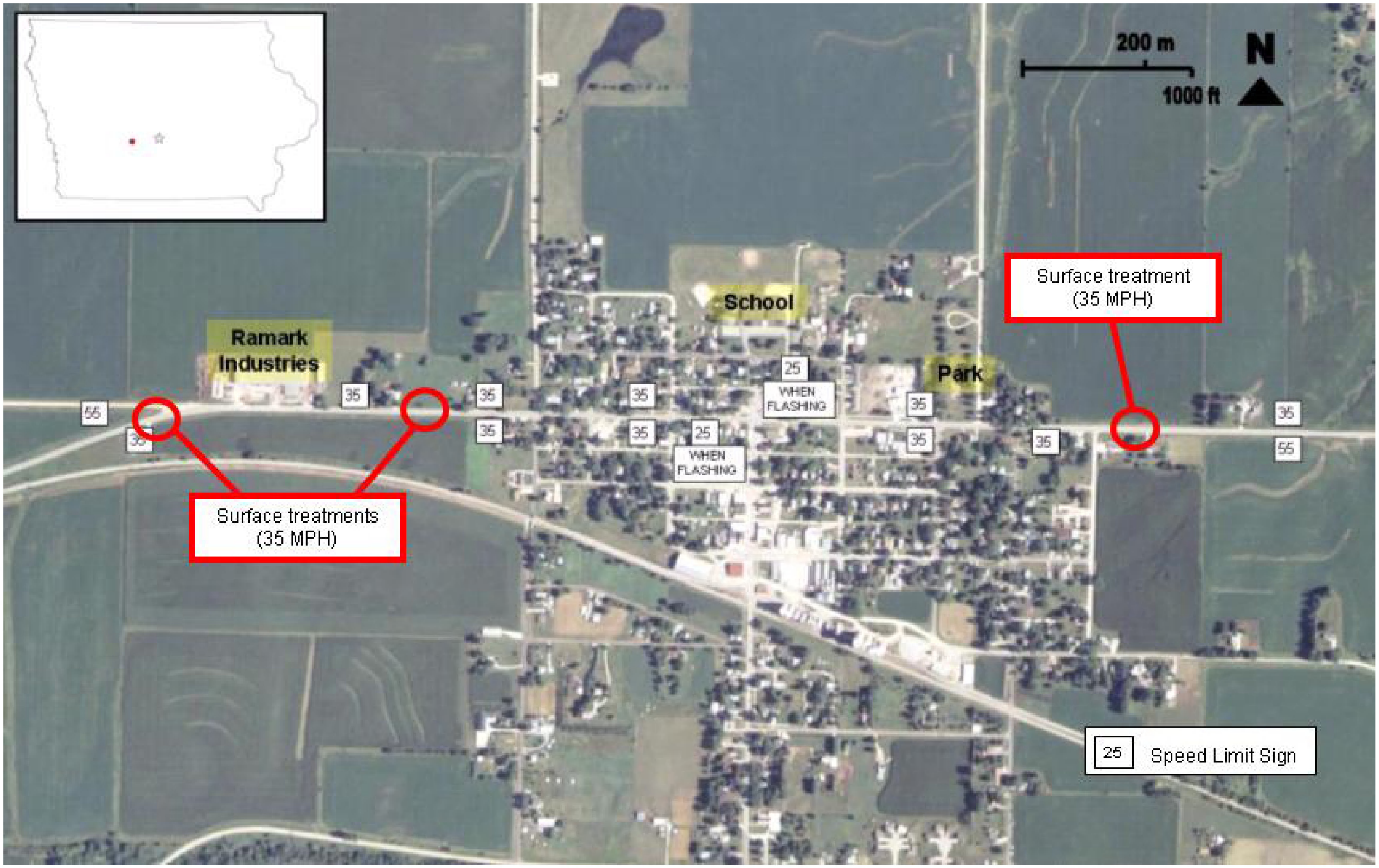

Figure 38: Dexter, IA, traffic calming plan

Figure 39: Site before surface treatment

Figure 41: Curve before surface treatment

Figure 40: Site after surface treatment

Figure 42: Curve after surface treatment

Table 16: Analysis of surface treatment in Dexter, IA (west curve, eastbound lane)

POSTED SPEED = 35 MPH	**Before**	**After**	**Change**	**% Change**
Average Speed	45	40	-5	-11.1%
85th Percentile Speed	52	47	-5	-9.6%
Standard Deviation	6.8	6.5	-0.3	-4.4%
% Vehicles Over Limit	96.5	81.6	-14.9	-15.4%
% Vehicles 5+ Over Limit	78.0	46.3	-31.7	-40.6%
% Vehicles 10+ Over Limit	53.4	23.0	-30.4	-56.9%
% Vehicles 15+ Over Limit	25.4	8.0	-17.4	-68.5%
Maximum Speed	76	67	-9	-11.8%
Count	2190	2150	-40	-1.8%

Table 17: Analysis of surface treatment in Dexter, IA (west city limit)

POSTED SPEED = 35 MPH	**Before**	**After**	**Change**	**% Change**
Average Speed				
Eastbound	37	35	-2	-5.4%
Westbound	39	37	-2	-5.1%
85th Percentile Speed				
Eastbound	43	40	-3	-7.0%
Westbound	45	42	-3	-6.7%
Standard Deviation				
Eastbound	5.3	4.8	-0.5	-9.4%
Westbound	5.3	4.8	-0.5	-9.4%
% Vehicles Over Limit				
Eastbound	70.0	56.6	-13.4	-19.1%
Westbound	82.0	70.4	-11.6	-14.1%
% Vehicles 5+ Over Limit				
Eastbound	30.2	15.1	-15.1	-50.0%
Westbound	43.0	26.2	-16.8	-39.1%
% Vehicles 10+ Over Limit				
Eastbound	9.2	3.9	-5.3	-57.6%
Westbound	13.9	6.1	-7.8	-56.1%
% Vehicles 15+ Over Limit				
Eastbound	2.1	0.8	-1.3	-61.9%
Westbound	3.5	0.8	-2.7	-77.1%
Maximum Speed				
Eastbound	57	61	4	7.0%
Westbound	65	65	0	0.0%
Count				
Eastbound	2323	2256	-67	-2.9%
Westbound	2391	2399	8	0.3%

*Note: This was the second treatment crossed by eastbound vehicles at this end of town

Table 18: Analysis of surface treatment in Dexter, IA (east end, westbound vehicles)

POSTED SPEED = 35 MPH	Before	After	Change	% Change
Average Speed	35	34	-1	-2.9%
85th Percentile Speed	40	39	-1	-2.5%
Standard Deviation	5.2	5.6	0.4	7.7%
% Vehicles Over Limit	49.0	45.5	-3.5	-7.1%
% Vehicles 5+ Over Limit	15.1	11.2	-3.9	-25.8%
% Vehicles 10+ Over Limit	3.5	2.2	-1.3	-37.1%
% Vehicles 15+ Over Limit	0.5	0.6	0.1	20.0%
Maximum Speed	56	87	31	55.4%
Count	4254	3849	-405	-9.5%

Albion, IA – dynamic speed display

Albion, IA, is located about 50 miles northeast of Des Moines and has a population of 592. One major road passes through the community, State Highway 330. Highway 330 is a two-lane roadway with an ADT of about 4,000. Much of the traffic is through traffic, as the roadway is often used by people traveling from Waterloo to Des Moines that wish to bypass the City of Marshalltown.

City officials did not respond to our original newsletter. However, since the town met the study criteria and owned a dynamic speed trailer, city officials agreed to be a part of the study. The dynamic speed trailer was occasionally being used before or after school at one of two locations along their main street. The north location, seen in Figure 43, is near the city's community center. When operating, the display faces to the north and displays the speed for southbound vehicles. City officials also occasionally place the display at the center of town. The downtown location, seen in Figure 43, is near the city's fire station. When operating, the display faces to the south and displays the speed for northbound vehicles. The city agreed to schedule when the display would be used to allow for data collection. After a period of not using the display, the "before" speed data were collected. Afterward, the display was used every day during school hours for one month. Speeds were collected at the same locations where the "before" speeds were collected after one month while the display was still in place.

The speed analysis is presented in Tables 19 and 20. The speed display caused only minor changes in speeds. At the north location, the average speed and 85^{th} percentile speed both increased 1 mph. At the downtown location, the average speed and 85^{th} percentile speed both decreased 1 mph. The small impact on speeds may be due to drivers being accustomed to seeing the speed display in use prior to the study.

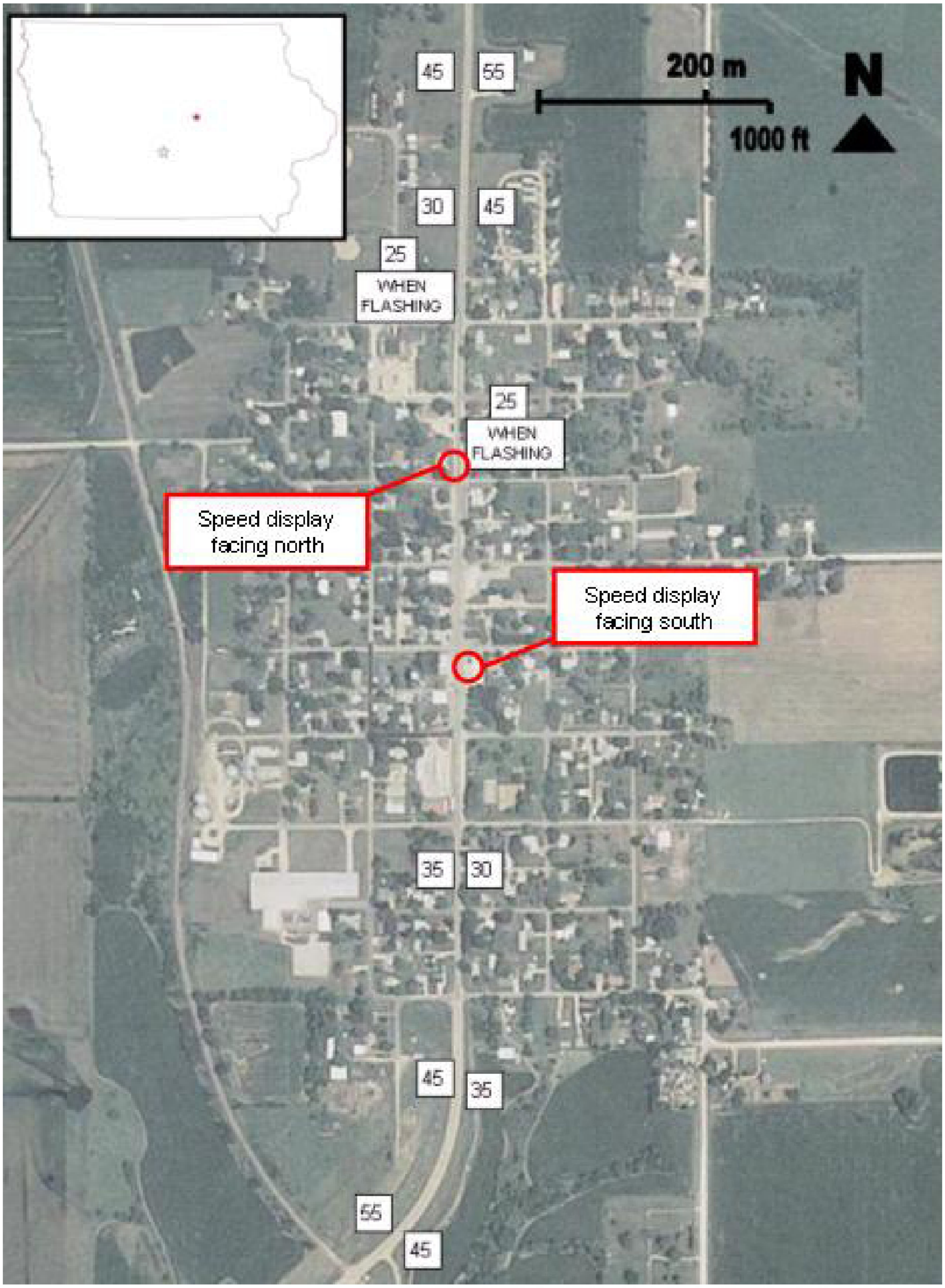

Figure 43: Albion, IA, existing traffic calming

Table 19: Analysis of speed display in Albion, IA (north location, southbound lane)

POSTED SPEED = 30 MPH	Before	After	Change	% Change
Average Speed	30	31	1	3.3%
85th Percentile Speed	35	36	1	2.9%
Standard Deviation	4.9	4.9	0	0.0%
% Vehicles Over Limit	57.9	68.6	10.7	18.5%
% Vehicles 5+ Over Limit	16.6	23.9	7.3	44.0%
% Vehicles 10+ Over Limit	2.9	3.9	1	34.5%
% Vehicles 15+ Over Limit	0.6	0.5	-0.1	-16.7%
Maximum Speed	50	47	-3	-6.0%
Count	2721	2796	75	2.8%

Table 20: Analysis of speed display in Albion, IA (downtown location, northbound lane)

POSTED SPEED = 30 MPH	Before	After	Change	% Change
Average Speed	30	29	-1	-3.3%
85th Percentile Speed	36	35	-1	-2.8%
Standard Deviation	5.6	5.8	0.2	3.6%
% Vehicles Over Limit	58.9	47.3	-11.6	-19.7%
% Vehicles 5+ Over Limit	20.2	13.0	-7.2	-35.6%
% Vehicles 10+ Over Limit	3.5	1.9	-1.6	-45.7%
% Vehicles 15+ Over Limit	0.3	0.0	-0.3	-100.0%
Maximum Speed	54	43	-11	-20.4%
Count	2785	2874	89	3.2%

Huxley, Dexter, and Minburn, IA – enforcement comparison

Many communities in Iowa use enforcement as a traffic calming strategy. Three communities with similar traffic patterns and characteristics, but different levels of enforcement, were analyzed to get a sense of how enforcement impacts speeds. These towns were not analyzed by a before and after speed analysis like the previous communities. Therefore, there may be other factors that account for the differences in speeds. The three communities were the City of Huxley, the City of Dexter, and the City of Minburn. The City of Huxley uses heavy enforcement, the City of Dexter (discussed previously) uses light enforcement, and the City of Minburn does not use any enforcement.

Huxley, IA, is located about 20 miles north of Des Moines and has a population of 2,316. One major road passes through the community, US Highway 69. The two-lane roadway has an ADT of about 5,500. The speed limit is 55 mph outside of town and 35 mph downtown, with 45 mph zones as transition zones. The layout of these zones is shown in Figure 44. Much of the traffic is through traffic largely due to Huxley's location between Des Moines and Ames, two much larger cities. The city uses heavy enforcement; the city police department typically patrols between 15 and 18 hours per day.

Minburn, IA, is located about 30 miles northwest of Des Moines and has a population of 391. US Highway 169 is the town's main route that passes north/south through the community. The route has an ADT of about 2,500. The speed limit is 55 mph outside of town and 35 mph downtown, with 45 mph transition zones at both ends of town. The layout of these zones is shown in Figure 45. Much of the traffic is through traffic largely due to Minburn's location between Adel, a much larger city, and US Highway 141, a major arterial. There is no enforcement currently used in Minburn other than occasional pass-through trips by state and county officers.

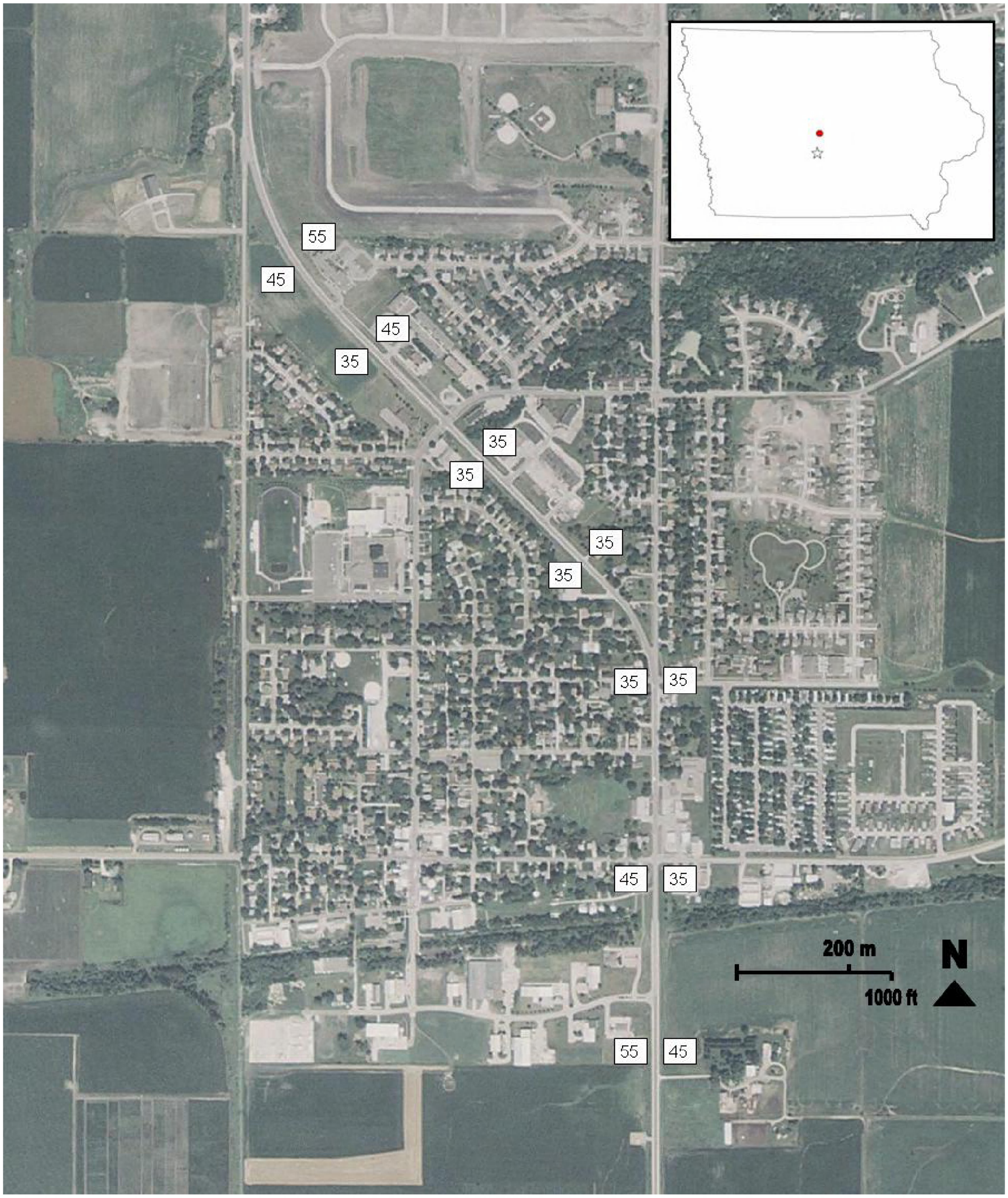

Figure 44: Map of Huxley, IA

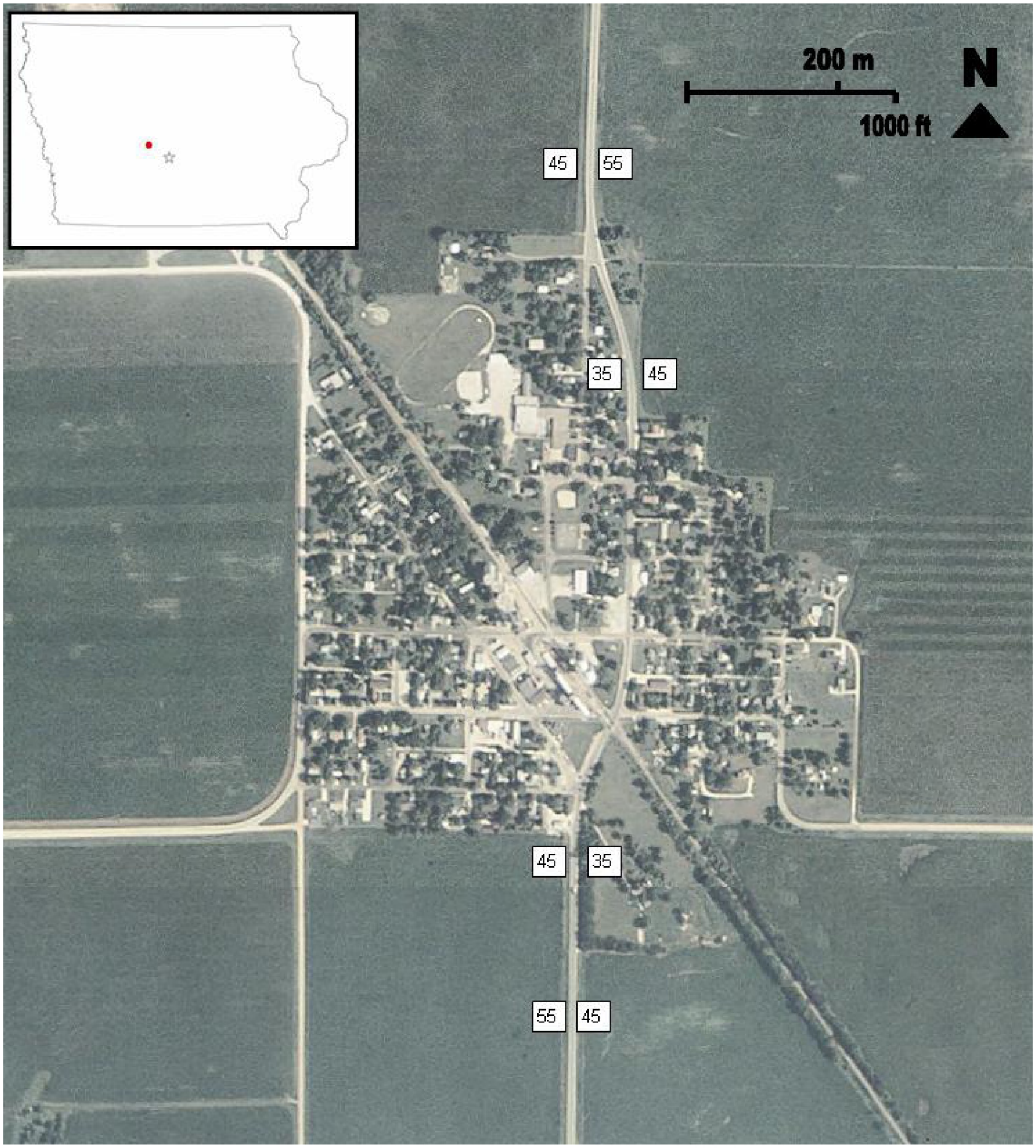

Figure 45: Map of Minburn, IA

Dexter, IA, was used as a pilot study location to test the effectiveness of surface treatments, which was discussed earlier. However, the city was previously analyzed to examine the effectiveness of enforcement. According to city officials, the City of Dexter uses enforcement approximately 4-5 hours per day. The city was used to compare their amount of enforcement with the amount of enforcement used in Huxley (15-18 hours/day) and Minburn (0 hours/day).

Three locations were analyzed in each of the three communities: the downtown 35 mph zone, and both transition zones. The resulting data are shown in Table 21. Since the speeds in the three towns are only compared, it is important to note that there may be other factors contributing to the differences in speeds. Therefore, the differences may not be entirely due to the level of enforcement.

The average speed for Huxley (the "heavy enforcement" community) and Minburn (the "no enforcement" community) were approximately the same for the downtown 35 mph zone. However, the speeds in the transition zones were 5 mph and 6 mph higher (about 14%) in the "no enforcement" community than in the "heavy enforcement" community. The 85th percentile speed in Huxley and Minburn were also similar in the downtown section, but the 85th percentile speeds were about 16% higher in the "no enforcement" community's transition zones. There was also more speed variation in the "no enforcement" community. The percentage of vehicles traveling within the pace speed range is higher for all zones in the "heavy enforcement" community than in the "no enforcement" community. Also, the percent of vehicles traveling 5, 10, and 15 mph over the speed limit was also much lower in all zones in the "heavy enforcement" community.

The downtown section of Dexter (the "light enforcement" community) was compared to the downtown section of Minburn (the "no enforcement" community). The posted speed limit was 35 mph in both sections. The average speed for the "light enforcement" community was 2 mph, or 6%, less than the average speed for the "no enforcement" community in this section. The 85th percentile speed was also 4 mph, or about 10%, less in the "light enforcement" town. In addition, the "light enforcement" town had a higher percentage of vehicles traveling within the pace speed range, and there was less speed variability. The transition zones were also analyzed in these communities, although the posted speed limit in Dexter (35 mph) was different than the speed limit in Minburn (45 mph). Overall, speeds exceeded the speed limit by about the same amount in the "light enforcement" transition zones than in the "no enforcement" transition zones. Average speeds for the "light enforcement" town were 1 and 3 mph over the speed limit, while average speeds for the "no enforcement" town were 0 and 1 mph over the speed limit. The 85th percentile speeds for the two towns were approximately the same. There was also more variability in speeds in the "no enforcement" transition zones.

The amount of enforcement was also studied for the two towns which use enforcement to control speeds. The downtown section of Huxley (the "heavy enforcement" community) was compared to the downtown section of Dexter (the "light enforcement" community). Overall, speeds were slightly higher in the "heavy enforcement" section. The average speed for the "heavy enforcement" community was 4 mph, or 11%, higher than for the "light enforcement" town. Also, the 85th percentile speed was 3 mph, or 8% higher in the "heavy enforcement" community. The maximum speed, pace speed range, and speed variability were all higher in the "heavy enforcement" community. However, there was more speeding in the transition zones of the "light enforcement" town than in the "heavy enforcement" town. These zones were analyzed despite having different speed limits. The average speeds for the "heavy enforcement" transition zones were both 5 mph under the posted speed limit, while the average speeds for the "light enforcement" transition zones were 1 and 3 mph over the speed limit. The 85th percentile speeds for the "heavy enforcement" transition zones were both 1 mph over the speed limit; the "light enforcement" transition zones were 7 and 8 mph over the speed limit. The percentage of vehicles traveling within the pace speed range was about the same for the transition zones of both communities. However, there was higher speed variability in the "light enforcement" transition zones.

Table 21: Comparison of speeds in 3 communities with varying levels of enforcement

*Note: Since this is only a comparison between communities and other factors may exist, the differences in speed may not be entirely due to level of enforcement.

	Huxley			Dexter			Minburn		
	North	Downtown	South	West	Downtown	East	North	Downtown	South
Speed Limit	45	35	45	35	35	35	45	35	45
Amount of Enforcement	HEAVY ENFORCEMENT 15-18 hours/day			LIGHT ENFORCEMENT 4-5 hours/day			NO ENFORCEMENT		
Avg. Speed	40 (-5)	36 (+1)	40 (-5)	38 (+3)	32 (-3)	36 (+1)	46 (+1)	34 (-1)	45 (+0)
85th %-ile Speed	46 (+1)	40 (+5)	46 (+1)	43 (+8)	37 (+2)	42 (+7)	53 (+8)	41 (+6)	54 (+9)
Maximum Speed	72 (+27)	68 (+33)	77 (+32)	65 (+30)	52 (+17)	62 (+27)	79 (+34)	65 (+30)	77 (+32)
Pace Speed	36-45	32-41	36-45	33-42	26-35	31-40	42-51	31-40	44-53
Percent in Pace	64.3	83.1	67.1	68.4	69.4	64.1	60.6	59.3	60.1
Percent Over Limit	18.4	57.5	15.4	66.9	18.1	51.8	54.8	44.0	66.1
Percent 5 Over Limit	3.6	11.4	2.3	29.4	3.1	20.1	28.8	15.1	35.1
Percent 10 Over Limit	0.4	1.5	0.2	8.3	0.6	4.9	10.2	3.2	8.9
Percent 15 Over Limit	0.1	0.3	0.1	2.1	0.4	0.9	2.4	0.7	1.4

(± x) : amount over/under speed limit

CONCLUSIONS

This project examined the effectiveness of eight traffic calming strategies that a small rural community can use to slow down traffic on their main street. Some of the measures were very successful, and some of the measures had almost no impact on speeds. Although these devices were evaluated in several rural communities, their effectiveness may differ depending on the community and if the measures are used in combination with other measures. Other factors, such as seasonal differences in speeds or other reasons that were not observed in the study, may have also contributed to the changes in speeds. Overall, the study produced the following results:

- The converging pavement markings had very little effect on speeds in Roland and Union (about 1 mph).
- The "35 MPH" surface treatments used in Dexter reduced speeds up to 5 mph, but the "SLOW" surface treatments used in Slater caused a slight increase in speeds (about 1 mph).
- The lane narrowing in Roland caused a 2 mph reduction for one direction of traffic, but a 3 mph increase in the other direction. In Union, the lane narrowing resulted in increases of 1-2 mph.
- The on-pavement speed signing was used in combination with other measures, but appeared to have very little impact on reducing speeds.
- The speed table in Gilbert resulted in a 2-4 mph reduction in average speeds. The 85th percentile speeds were reduced 3-5 mph.
- The longitudinal channelizers in Slater resulted in a 5 mph reduction in average speeds and a 7 mph reduction in 85th percentile speeds.
- The existing speed display trailer in Albion produced a 1 mph increase in speeds at one location and a 1 mph decrease in speeds at another location when it was in use. Since the speed display was an existing measure, drivers may have been acclimated to its presence.
- The impact of enforcement was analyzed by comparing three similar communities with different levels of enforcement. This form of analysis is different than the before and after analysis used for the other communities. Overall, both the "high

enforcement" community and the "low enforcement" community had lower speeds and less speed variation than the "no enforcement" community. The "high enforcement" town had higher speeds and more speed variation in the downtown section than the "low enforcement" town; however, the "low enforcement" town had higher speeds and more speed variation in the transition zones than the "high enforcement" town. Since this was only a comparison between three communities, the speed differences may not be entirely due to the level of enforcement.

The psychological traffic calming measures (converging markings and lane narrowing) had the least effectiveness, while the physical measures (speed table and longitudinal channelizers) had much more success in reducing speeds. This success was measured by the reduction in average and 85th percentile speed, as well as the reduction of speed variation and percentage of excessive speeds.

FUTURE STUDY

This study analyzed the effectiveness of traffic calming treatments after a period of one month. A future study may examine the effects of the installed traffic calming measures over a longer period of time. As drivers become accustomed to the devices, their behavior may change. Speed data may be collected after several months or after one year in order to analyze the change in behavior. Furthermore, a resident survey may be given in order to determine the perceived impact on speeds and the resident's preference of traffic calming measures.

Another future study may analyze the impacts of these rural traffic calming measures in other communities. The measures which had little effect on speeds in this study may have more success in different areas or in combination with different measures. Also, there may be other traffic calming measures that are appropriate for main streets of rural communities which were not analyzed in this study.

The spacing of traffic calming treatments in a community can also be a future study. If more than one traffic calming device is used in a community, which is commonly recommended, proper spacing should be used in order to maintain low speeds throughout the entire community.

This study did not analyze the effect of adjusting the existing speed zones or determine if the speed zones were appropriate. Inappropriate speed signing may occur in small communities due to the short length of roadway, sudden change in roadway environment, or lack of information regarding proper speed zone placement. A future study may analyze the impact of adjusting existing speed zones and/or removing inappropriate speed zones. One of the most common locations for inappropriate speed signing is in the transition areas. New businesses, schools, and subdivisions often build up in these areas and create a need for lower speed limits. This commonly results in transition zones that are either too long or too short. Furthermore, a future study may examine the impacts that a transition zone has on speeds in the downtown section of a community.

A future study may also attempt to perform a benefit/cost analysis of various traffic calming devices. Traffic calming often leads to many benefits besides lower speeds. These are often difficult to quantify. The installation and maintenance costs, along with the lost time associated with slower vehicle speeds, should be compared with these benefits in order to determine the benefit/cost ratio of each treatment.

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