JULY 2013

BEVERLY AND 2nd STREET INTERSECTION STUDY

DRAFT REPORT

CASPER AREA
METROPOLITAN PLANNING ORGANIZATION
Casper - Mills - Evansville - Bar Nunn - Natrona County

KLJ

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CHAPTER 1: EXECUTIVE SUMMARY

The intersection of Beverly Street with 2nd Street is the junction of two arterials that exchange high volumes of vehicular, pedestrian and bicycle traffic on a daily basis. Motorists and pedestrian conflicts have increased in recent years, marked by a pedestrian fatality in 2012. Reports indicate the crash occurred between an eastbound to northbound left-turning motorist during the permitted left-turn phase and a pedestrian crossing Beverly Street (similar conflict illustrated in Figure 1-1). Another pedestrian fatality occurred 11 days later, a quarter-mile to the east on 2nd Street at the intersection with Pennsylvania Avenue where no traffic control devices are present. The recent pedestrian crashes spurred the desire to further study safety at the intersection.

Figure 1-1 – Permitted Left-Turn Pedestrian Conflict

Crash analysis comparing this intersection to similar intersections throughout the metropolitan area indicates the location does not exhibit significant crash or injury/fatality tendencies. However, the results of a road safety audit completed at the intersection by a variety of local and outside experts indicated a wide array of potential safety concerns that may be remedied through a combination of engineering, education and enforcement improvements.

Safety is not the only transportation issue at the Beverly Street intersection with 2nd Street. The rising traffic volumes fueled in part by growth related to energy activity in the area has led to congestion. Carrying more than 40,000 vehicles each day, the intersection is one of the most active in the Casper metropolitan area. During the PM peak-hour, deficient traffic operations are experienced marked by substantial motorist delay where motorists often sit through several cycle lengths and long queue lengths that spill back across adjacent intersections and driveways (refer to Figure 1-2). Traffic operations continue to deteriorate as traffic volumes continue to grow.

Addressing the serious nature of pedestrian-vehicle crashes without unduly impacting traffic operations required a balance throughout the project. Currently, pedestrian and bicycle traffic only accounts for 0.03% of the total traffic at this intersection during the study periods. Additionally, the highest crash occurrences were rear-end crashes which are common at intersections experiencing high levels of congestion and stop-and-go traffic. In other words, impacting traffic operations may result in increased rear-end crashes.

Furthermore, the Beverly and 2nd Street intersection is fully built-out with businesses or residential homes on each intersection quadrant, leaving minimal available right-of-way for potential roadway expansion to address capacity or safety improvements. All improvements developed for the project balanced goals of preserving and enhancing scenic, aesthetic, historic, community and environmental resources while improving or maintaining safety, mobility and infrastructure conditions.

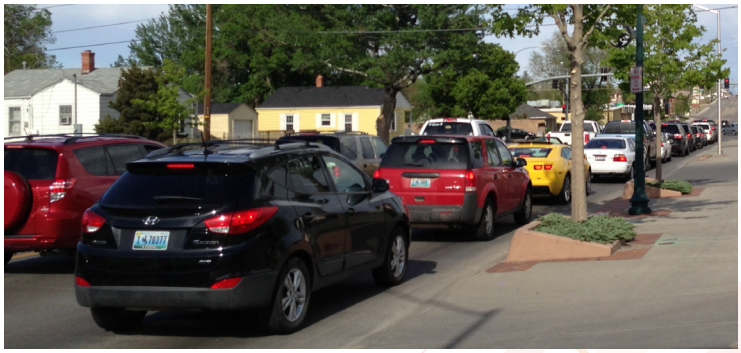


Figure 1-2 – Intersection Queue Lengths

In summary, the intersection of Beverly and 2nd Street is a complex mix of competing needs: multimodal safety, traffic operations and property functionality. To address existing safety concerns, a range of low-cost, short-term improvements were developed for immediate implementation. The improvements were void of property impacts to avoid controversy and ensure immediate implementation. The short-term improvements will, however, impact traffic operations, particularly as pedestrian, bicycle and vehicular volumes increase. To address future traffic operations deficiencies while limiting property impacts, long-term recommendations were also developed that were greater in scope and overall benefits. Refer to Figure 1-3 and Figure 1-4 for the short-term and long-term improvement recommendations.

Traditional improvement strategies (i.e. turn-lane, signal timing, etc.) are unable to meet level of service thresholds through the year 2035. These alternatives also typically impact buildings surrounding the intersection. As a result, a detailed analysis of alternative intersection design strategies were studied at this intersection. Corridor-wide improvement strategies were beyond the scope of this report but may be appropriate prior to implementation of long-term recommendations.

SHORT-TERM IMPROVEMENTS

Recommendation: Update the traffic signal controller to increase programming capabilities and program the controller to skip the permitted left-turn phase when a pedestrian call is placed. This will reduce pedestrian exposure when crossing the street. The traffic signal controller should be programmed to only receive pedestrian calls prior to the start of the permitted left-turn phase to prevent initiating and terminating the permitted phase within the green phase and affecting motorist expectance. Under this configuration, the controller should also have a recall on both 2nd Street and Beverly Street to prevent a scenario where the controller is resting in green with the permitted phase in operation and the pedestrian call is ignored.

Cost: $3,000

Recommendation: Replace the existing five-section protected/permitted left-turn heads with four-section protected/permitted flashing yellow arrow left-turn heads. Studies show that the flashing yellow arrow will decrease the potential for angled left-turn crashes at the intersection and provide corridor-wide signal timing benefits by allowing lagging protected left-turn phasing without the threat of a left-turn trap. It is important to note that the updated controlled identified in the previous recommendation is recommended to implement flashing yellow arrow operations.

Cost: $5,000

Recommendation: Update walk, pedestrian clearance, yellow and all-red times for the intersection to meet the Manual on Uniform Traffic Control Devices (MUTCD) standards and support and ensure pedestrians, bicyclists and motorists have enough time to safely traverse the intersection before conflicting with opposing traffic.

Cost: Incidental to signal improvements.

Recommendation: Implement LED no right turn blank out sign on each approach that can be activated during conflicting pedestrian walk phases. This improvement will minimize potential conflicts between pedestrians crossing the intersection and motorists focused on locating gaps in upstream traffic.

Cost: $12,000

Recommendation: Increase enforcement at the intersection to reduce likelihood of aggressive driving and traffic control noncompliance.

Cost: Dependent upon scope and magnitude of increased enforcement.

Recommendation: Develop a metropolitan-wide educational campaign to increase motorist awareness of pedestrians and vice versa. Efforts can range from brochures to presentations at local schools to television commercials.

Cost: Dependent upon scope and magnitude of educational campaign.

Recommendation: Restripe existing crosswalks, stripe stop bars and revise pedestrian signage where necessary to increase conspicuity of pedestrian crossing areas and stopping requirements and increase pedestrian awareness at the intersection.

Cost: $12,000

Recommendation: Reconstruct curb ramps to align with crosswalks and to include detectable warning panels for the visually impaired.

Cost: $19,000

Recommendation: Restrict parking within 30 feet of the intersection (applicable to the north and south approaches) to minimize conflicts between vehicles parked adjacent to the intersection and right-turning traffic at the intersection.

Cost: $100

Recommendation: Restrict parking in the Dragon Wall and Chopstix Asian Bistro parking stalls that requires motorists to back out into 2nd Street to exit, or block entrance onto the property as motorists back out of parking stall. This may require a completely revised parking layout to meet the City's parking standards.

Cost: Dependent upon scope of parking revisions.

Recommendation: Remove uncontrolled curb ramps within the functional area of the intersection to promote crossing at the controlled signalized crossings rather than uncontrolled locations that may interfere with motorist expectancy.

Cost: $3,500

Total Cost for Short-Term Improvements: $51,600 (does not include non-engineering improvements)

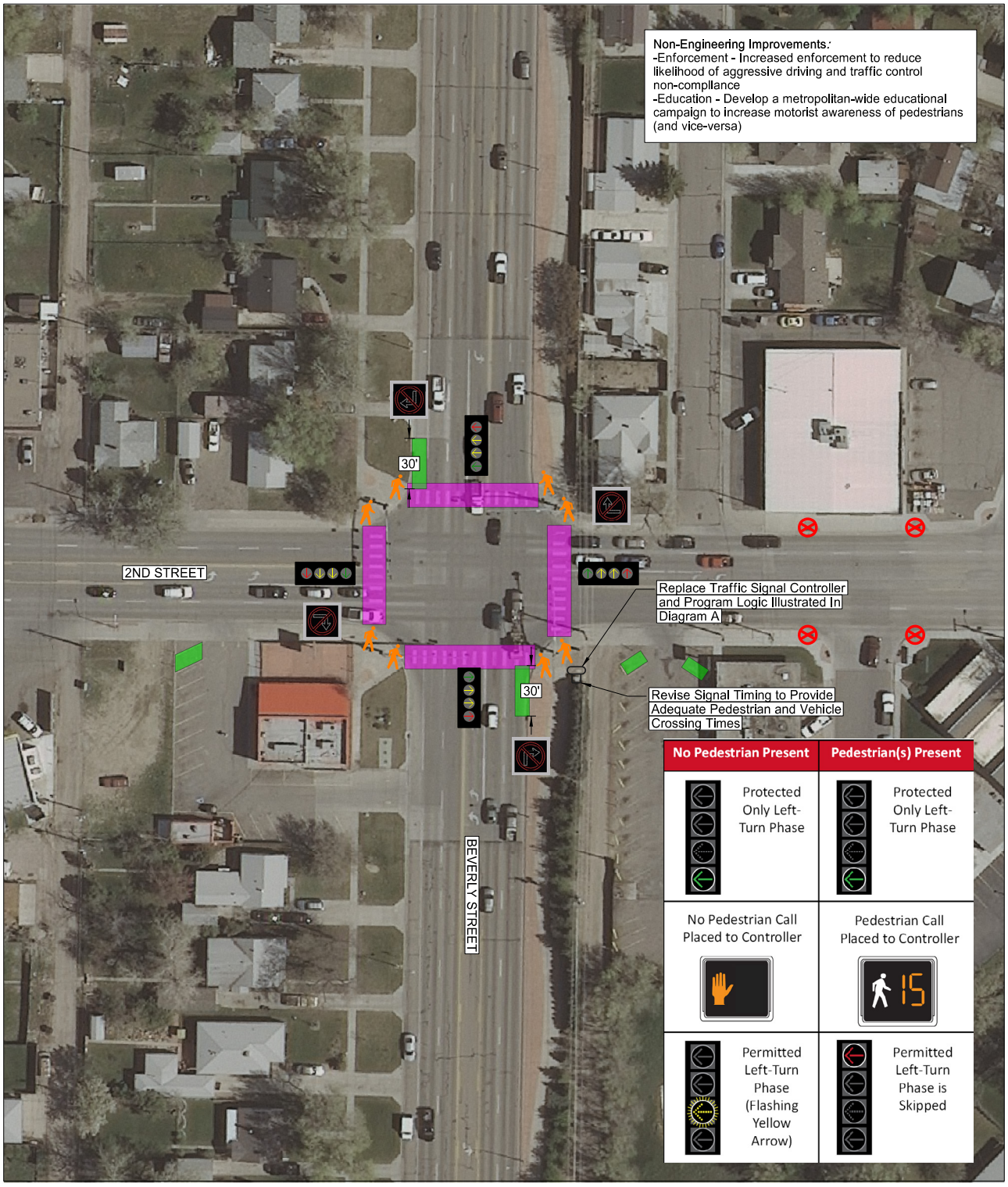


FIGURE 1-3
Short-Term
Improvement Plan

Figure 1-3 – Short-Term Improvement Plan

LONG-TERM IMPROVEMENTS

Recommendation: Revise the current configuration of the Beverly Street intersections of 1st, 2nd and 3rd Street to a bowtie intersection configuration (refer to Figure 1-4). This alternative provides the following benefits:

- Improved Intersection Operations: A 9% decrease in motorist delay at the intersection under forecasted 2035 traffic volumes (accounts for increased left-turn travel time). This increases to a 24% reduction in motorist delay under the highest 2035 growth scenario considered.
- Improved Corridor Progression: Removing the left-turn phasing from the central intersection reduces queue lengths by as much as 58%, alleviating many spillback conflicts across adjacent driveways and intersections.
- Reduced Angled Crash Potential: Eliminating the left-turn phase from the intersection improves pedestrian/bicycle safety and vehicular safety alike (crash types most susceptible to injuries and fatalities). In the past three years, this intersection experienced 9 angled vehicle crashes (3 of which resulted in injuries), 1 pedestrian fatality and 1 bicycle injury that would have been alleviated by removing the left-turn conflict from this intersection.
- Reduced Rear-End Crash Potential: Queue lengths will be substantially reduced, reducing likelihood for rear-end crashes. Nearly half of all crashes were rear-end crashes at this intersection (14 property damage-only crashes and 1 injury crash).
- Improved Safety at Upstream Intersections: Studies have found that total crashes, total injuries, total fatalities and vehicle-pedestrian crashes have been reduced by an average of 35%, 76%, 89% and 73% respectively when converting a traditional intersection to a roundabout. Specifically, 60% of the crashes at the upstream intersections of Beverly Street with 1st and 3rd Streets (5 crashes total) would have been alleviated if a roundabout were in place.
- Increased Pedestrian and Bicycle Convenience: The upstream roundabouts at the intersection of Beverly Street with 1st and 3rd Avenues offer additional safe and convenient crossing locations for pedestrians to traverse Beverly Street. Additionally, by removing existing left-turn lanes, medians can be implemented which offer refuge islands for pedestrians and bicyclists alike. Refuge islands not only allow pedestrians and bicycles to cross the intersection in stages, but studies have found that refuge islands increase motorist yielding percentages.
- Reduced Crash Potential Related to Upstream Access Points: By eliminating existing left-turn lanes, medians can be implemented at the intersection to serve as an outlet for access management. Using nationally recognized operations and safety factors, converting the 26 upstream full access points to right-in/right-out access points equates to an estimated 59% and 73% improvement to roadway progression and crash potential on the roadway links leading up to the study intersection. According to historic crash data, there were 2 property damage vehicle crashes and 1 bicycle injury crash that would have been alleviated if a median were present. One of the greatest benefits provided by the upstream roundabouts is that drivers forced to make right-in/right-out maneuvers at driveways can conveniently change directions via U-turn movements at the two proposed Beverly Street roundabouts.

Cost: $2,200,000 (2013 dollars) It is recommended this improvement only be considered during future planned roadway improvement projects. Thus, costs for the improvement can be consolidated with required roadway rehabilitation. According to the benefit-to-cost analysis conducted to compare the existing configuration with the bowtie configuration, the operational and safety benefits offered by the bowtie intersection equates to a cost saving of more than $15,000,000 for the public between 2013 and 2035.

Impacts: Although right-of-way is required to implement the proposed roundabouts and right-turn lanes, no buildings are directly impacted nor property functionality disturbed by the proposed improvement strategy.

Additional Considerations: Due to the potential for motorist confusion with this unique configuration, a combination of education, encouragement and enforcement may be necessary prior to implementation.

Optional Recommendation: Increase corner radii to better accommodate trucks at the central intersection. This will minimize potential for trucks off-tracking onto pedestrian areas and likelihood of trucks occupying multiple lanes when completing right-turn maneuvers.

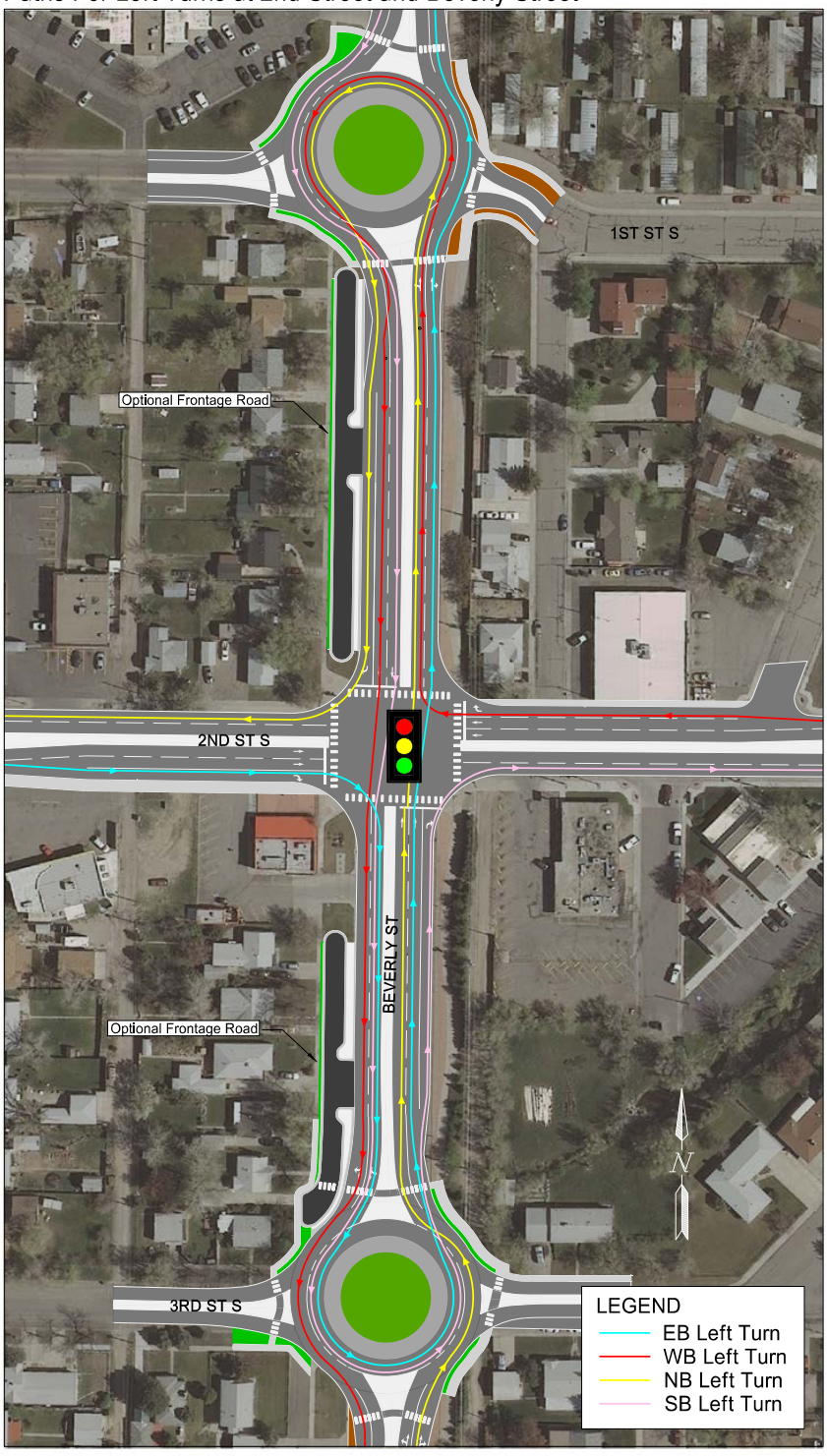
Cost: Incidental to cost of bowtie intersection

Optional Recommendation: Construct frontage roads on the west side of Beverly Street between 1st and 3rd Streets (refer to Figure 1-4). Frontage roads would be designed to be wide enough to provide parking and allow residents to efficiently back-out from their driveway. These frontage roads will provide the following benefits:

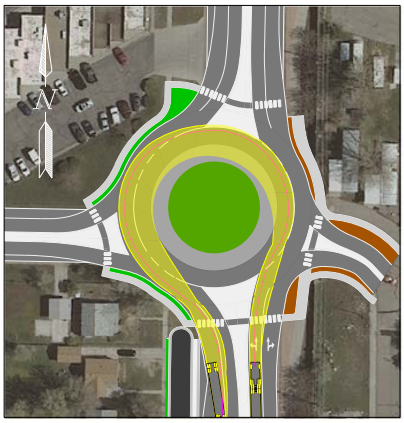
- Alleviate conflicts between motorists entering/exiting parking spots along Beverly Street
- Alleviate conflicts between residents backing-out their driveway and motorists on Beverly Street

Cost: $295,000 (2013 dollars)

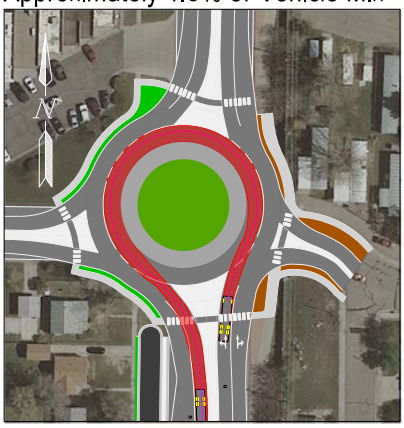
Paths For Left Turns at 2nd Street and Beverly Street



Swept Path of WB-67 Truck
Approximately 0.5% of Vehicle Mix



Swept Path of Single Unit Truck
Approximately 1.5% of Vehicle Mix



Swept Path of Passenger Car
Approximately 98% of Vehicle Mix

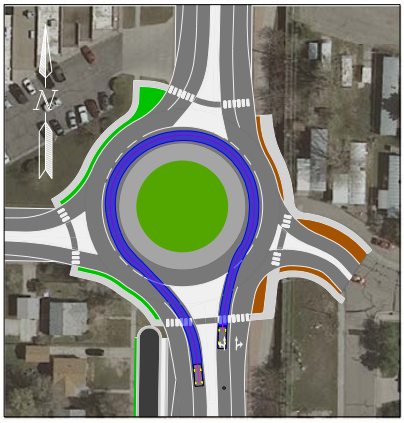


FIGURE 1-4
Long Term Improvement Plan

Figure 1-4 – Long-Term Improvement Plan (Bowtie Intersection Configuration)

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The intersection of Beverly Street and 2nd Street is the junction of two arterials that exchange high volumes of vehicular, pedestrian and bicycle traffic on a daily basis. Motorists and pedestrian conflicts have increased in recent years, marked by a pedestrian fatality in 2012. Reports indicate the crash occurred between an eastbound to northbound left-turning motorist during the permitted left-turn phase and a pedestrian crossing Beverly Street. Another pedestrian fatality occurred 11 days later, a quarter-mile to the east on 2nd Street at the intersection with Pennsylvania Avenue where no traffic control devices are present. The recent pedestrian crashes spurred the desire to further study safety at this intersection.

Pedestrian facilities must be designed to minimize pedestrian exposure and conflict points. According to national studies, pedestrians represent a disproportionate percentage of road-related fatalities, and thus, special focus should be given to addressing these safety concerns. Additionally, it is critical pedestrian facilities be designed safe, accessible and comfortable for people of all ability levels. Studies have found older age groups have a much greater possibility to be killed in a crash when compared to younger groups, which is important to note because the ages of the pedestrian fatalities in the past year on 2nd Street were 59 and 65.

Designing safe, accessible and comfortable walking and biking environments not only reduces vehicle-pedestrian crash potential but also provides the following benefits:

- **Health:** Multiple studies have found a direct correlation between availability of walking and biking facilities to obesity rates.
- **Reduced User Costs:** Sidewalks and multipurpose paths offer inexpensive transportation alternatives to roadway users. A recent study found most families spend far more on transportation than food.
- **Foster Strong Communities:** A recent study found that people who live in walkable communities are more likely to be socially engaged and trusting than residents living in less walkable communities.

Safety is not the only transportation issue at the Beverly Street and 2nd Street intersection. Rising traffic volumes fueled in part by the growth related to energy activity in the area has led to congestion. Carrying more than 40,000 vehicles each day, the intersection is one of the most active in the Casper metropolitan area. According to daily traffic counts collected by the Casper Metropolitan Planning Organization (MPO) in 2012, only five roadway approaches carry more traffic than the east approach of 2nd Street at Beverly Street (26,897 vehicles per day). During the PM peak-hour, deficient traffic operations are marked by substantial motorist delay where motorists often wait through several cycle lengths and long queue lengths that spillback across adjacent intersections and driveways.

Congestion is further exacerbated by the number of slow-moving vehicles entering the traffic stream from the 26 access points within one city block of the intersection. Refer to Figure 2-1 for an illustration of the current access density. The dense access spacing also contributes to safety concerns for pedestrians and bicycles crossing the driveways as well as for vehicles entering and exiting the access points. According to National Cooperative Highway Research Program (NCHRP) Report 420, Impact of Access Management Techniques, every unsignalized driveway increases the corridor crash rate by approximately 2%.

Figure 2-1 – Intersection Conflict Points

Safety and operational issues caused by dense access spacing potentially make an area less attractive to developers and the traveling public in general. This is in direct contrast to the preconceived notion of many who believe

access management, or access restrictions, will hurt land values and repel business. National studies have shown most people are comfortable with making a slightly longer trip, including U-turns, to access destination businesses if the ride is pleasant and congestion-free.

Although pass-by businesses (convenience stores, gas stations, fast food restaurants) may be impacted more by access management modifications than specialty services, studies have shown even pass-by businesses are not negatively impacted as long as reasonable access is provided. Finally, as traffic flow is made more efficient, the roadway can handle more traffic and congestion levels decrease, resulting in more motorists being exposed to area business.

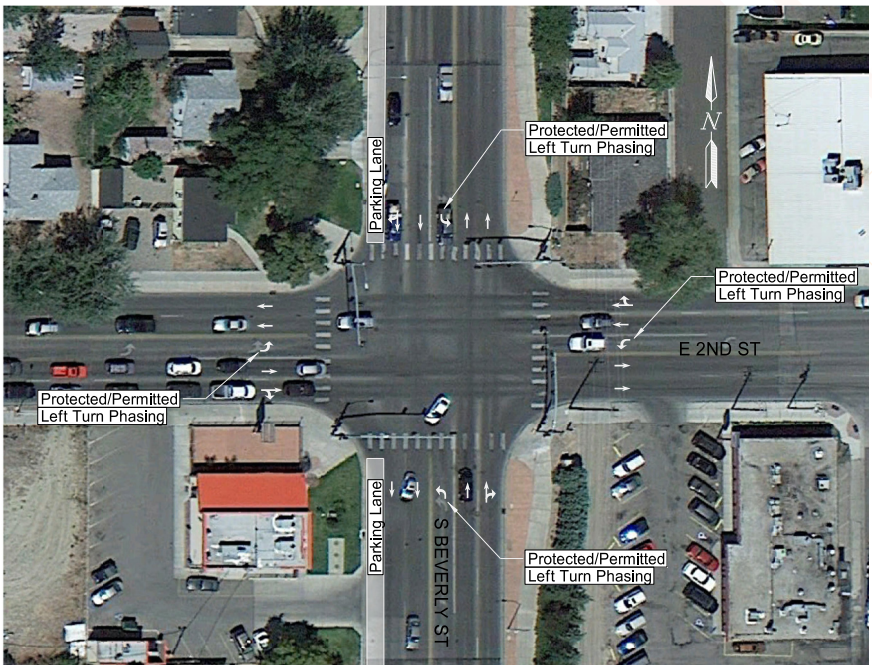

Figure 2-2 – Intersection Lane Configuration

The Beverly and 2nd Street intersection is fully built-out with businesses or residential homes on each intersection quadrant, leaving minimal available right-of-way for potential roadway expansion to address capacity or safety improvements. It is important to note however, there are parking lanes on the west side of Beverly Street that may be used for potential improvements. Refer to Figure 2-2 for an illustration of the current intersection lane configuration. Due to the limited amount of available right-of-way, the study team used a context-sensitive solution approach to ensure the corridor character is preserved when capacity and safety improvements are studied. This type of approach balances goals of preserving and enhancing scenic, aesthetic, historic, community and environmental resources, while improving or maintaining safety, mobility and infrastructure conditions

OVERALL APPROACH

To improve safety and operations of the Beverly and 2nd Street intersection under current and future traffic conditions, the following multi-faceted approach was developed (refer to Figure 3-1). The final intersection report will be developed based upon procedures and guidelines laid out by Federal Highway Administration (FHWA) Highway Safety Improvement Program (HSIP). HSIP provides funding to make critical safety improvements at high crash locations. With a focus on results, the program emphasizes a data-driven, strategic approach to improving highway safety through infrastructure-related improvements. This report was also developed based upon guidelines and requirements described in the Moving Ahead for Progress in the 21st Century Act (Map-21). MAP-21 creates a streamlined and performance-based surface transportation program and builds on many of the highway, transit, bike, and pedestrian programs and policies established in previous transportation bills.

Figure 3-1 – Study Approach

EVALUATION TOOLS

Road Safety Audit

Safety was first analyzed qualitatively through a Road Safety Audit (RSA). A RSA is a formal safety performance examination of an existing or future road or intersection by an independent audit team. The RSA team considers safety of all road users, qualitatively estimates and reports on road safety issues and opportunities for safety improvement. Qualitative safety evaluation is a proactive approach intended to resolve safety issues before they result in a serious crash. Experience with RSAs in the United States has proven to be substantially beneficial in reducing crash rates. For example, the New York Department of Transportation reported a 20% to 40% reduction in crashes at more than 300 high-crash locations once improvements developed during the RSA process were implemented.

As outlined in the FHWA Road Safety Audit Guidelines (FHWA-SA-06-06), the typical RSA procedure is illustrated in Figure 3-2. There are additional steps to be completed by the MPO after completion of the steps illustrated below such as preparing a formal response to the completed RSA and incorporating the findings into a project when appropriate. These steps are beyond the scope of this report.

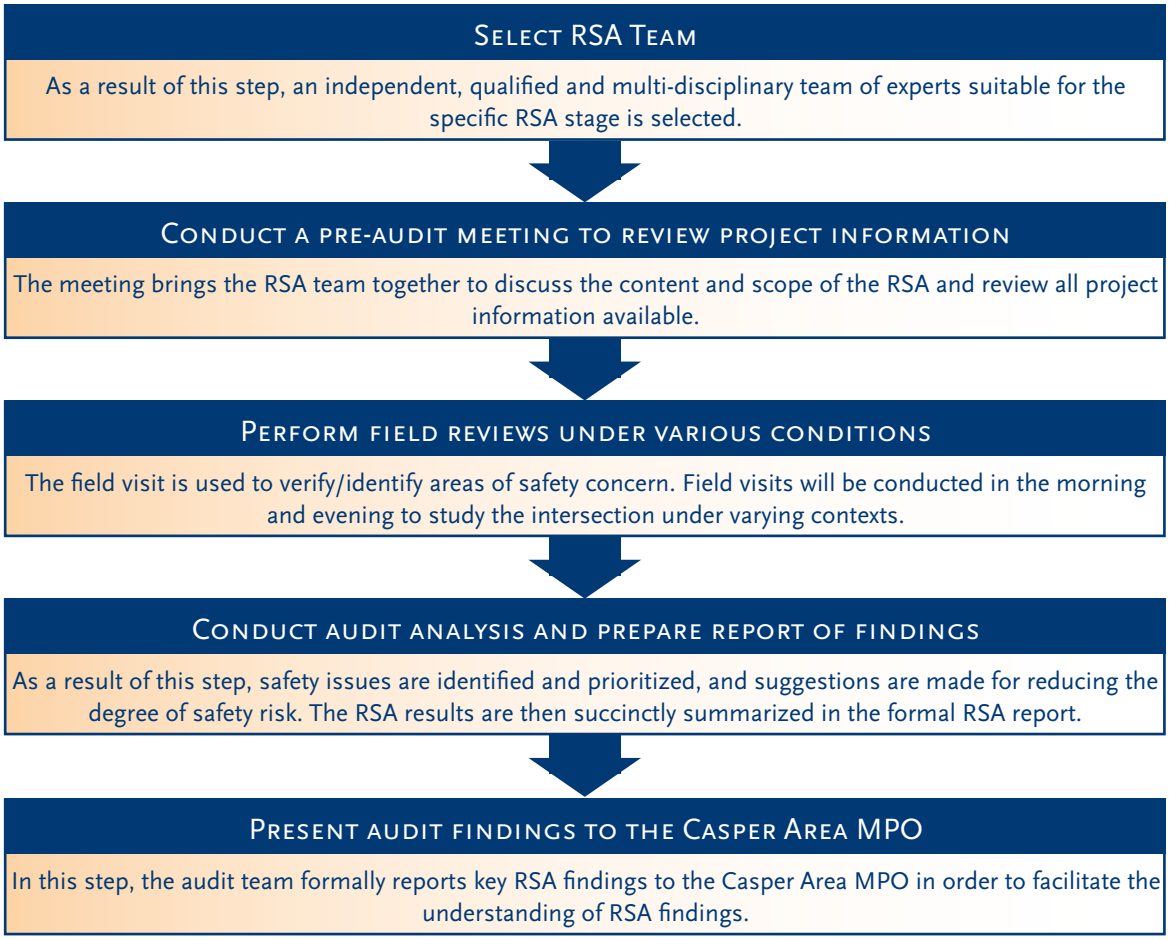

Figure 3-2 – Road Safety Audit Process

RSAs are performed by a team representing a variety of experience and expertise specifically tailored to the project. The audit team must not consist of any local representatives that have been involved in prior decisions at the intersection to ensure a fair and balanced review. The following people were included in the RSA process:

- Adrienne Hahn – KLJ
- Andrew Beamer – Casper City Engineer
- Bob Shannon – KLJ
- Dan Coryell – Acting Casper Streets Division Superintendent
- David Hough – Special Projects Coordinator
- Joy Clark – Casper MPO Staff
- Kevin Knopik – Casper Traffic Supervisor
- Rick Harrah – Public Services Director
- Sally Kerpchar – Casper MPO Planner
- Thomas McMurtry – KLJ

The RSA and associated meeting was held on May 9, 2013. During the pre-audit meeting, each auditor was instructed to document their independent observations regarding visibility, sight distance, signing and marking, traffic control and user perceptions for autos, trucks, bicycles, pedestrians and mobility impaired. Each auditor was provided with high-visibility safety vests, an aerial of the study intersection for note taking and traffic data information prior to the field review. Once the field review was completed, the audit team held a debriefing meeting to share their findings. Figure 3-3 is a picture from the RSA.

Figure 3-3 – Road Safety Audit Field Review

After the RSA team identified potential safety issues during the field review and ensuing meeting, each safety issue was evaluated. Specifically, the likely frequency and severity of crashes associated with each safety issue were qualitatively estimated, based on team members' experience and expectations. Expected crash frequency (Table 3-1) was qualitatively estimated on the basis of expected exposure (how many road users would likely be exposed to the identified safety issue) and probability (how likely was it that a collision would result from the identified issue). Expected crash severity (Table 3-2) was qualitatively estimated on the basis of factors such as anticipated speeds, expected collision types and the likelihood that vulnerable road users would be exposed. These two risk elements (frequency and severity) were then combined to obtain a qualitative risk assessment on the basis of the matrix shown in Table 3-3. Consequently, each safety issue was prioritized on the basis of a ranking between A (lowest risk and lowest priority) and F (highest risk and highest priority).

Table 3-1 – Frequency Rating

Estimated		Expected Crash Frequency (per RSA item)	Frequency Rating
Exposure	Probability		
High	High	10 or More Crashes Per Year	Frequent
Medium	High		
High	Medium	1 to 9 Crashes Per Year	Occasional
Medium	Medium		
Low	High		
High	Low	Less than 1 Crash Per Year, but More than 1 Crash Every Five Years	Infrequent
Low	Medium		
Medium	Low	Less than 1 Crash Every 5 Years	Rare
Low	Low		

Source: FHWA

Once each safety issue was identified and evaluated, improvement opportunities were developed. All safety issues, evaluation assessment ratings and improvement opportunities are summarized in this report. It is important to note that the purpose of this report is to assess the safety issues of this intersection in concert with all traffic operations issues and property impacts to find a balanced improvement approach. As such, rather than writing an independent RSA, the results were incorporated into this report.

Table 3-2 – Severity Rating

Typical Crashes Expected (per RSA item)	Expected Crash Severity	Severity Rating
Crashes involving high speeds or heavy vehicles, pedestrians or bicycles	Probable fatality or incapacitating injury	Extreme
Crashes involving medium to high speeds; head-on, crossing or off-road	Moderate to severe injury	High
Crashes involving medium to low speeds; left-turn and right-turn crashes	Minor to moderate injury	Moderate
Crashes involving low to medium speeds; rear-end or sideswipe crashes	Property damage only or minor injury	Low
Source: FHWA		

Table 3-3 – Crash Risk Assessment

Frequency Rating	Severity Rating			
	Low	Moderate	High	Extreme
Frequent	C	D	E	F
Occasional	B	C	D	E
Infrequent	A	B	C	D
Rare	A	A	B	C
A – Lowest Risk Level F – Highest Risk Level				
Source: FHWA				

Crash Analysis

Safety was also studied quantitatively by analyzing historic crash frequencies, patterns and severity for all roadway user types (vehicles, pedestrians and bicyclists). Evaluation of historic crash characteristics was completed to identify and quantify certain patterns correctable by geometric and traffic control improvements. Historic crash data was provided by the Wyoming Department of Transportation (WYDOT) for the period from January 1, 2010 to April 30, 2013.

Typically, intersections with a high number of crashes also carry high levels of traffic. Many times, a low volume location may have fewer overall crashes but on a per car basis have a much higher susceptibility to crashes. To evaluate whether the study intersection exhibited an overrepresented crash characteristics compared to similar intersections in the metropolitan area, the critical crash rate methodology was employed. This critical crash rate incorporates the number of crashes, design of the facility, type of intersection control, amount of exposure and the random nature of crashes to evaluate whether the intersection demonstrates statistically significant crash behavior.

Traffic Operations

Intersection and corridor capacity analysis was conducted to determine delay and level of service (LOS). LOS is a term used to describe operational performance of transportation infrastructure elements. Essentially, LOS is a grade value that corresponds to specific traffic characteristics within a given system. For example, at intersections, LOS is a function of average vehicle delay whereas LOS for an urban corridor is defined by the average travel speed. According to WYDOT standards, a LOS "A" or "B" is desirable with LOS "C" being the minimum acceptable threshold value, whereas LOS "D," "E" and "F" correspond to unacceptably deficient traffic conditions.

Initial intersection delay and LOS analysis was based upon Synchro model outputs. Synchro is a macroscopic traffic software program that applies the deterministic equations provided in the Highway Capacity Manual (HCM). Refer to Table 3-4 for an illustration of the signalized and unsignalized LOS ranges according to the Highway Capacity Manual.

Table 3-4 – Intersection Level of Service Thresholds

Control Delay (sec/veh)		Volume < Capacity	Volume > Capacity
Unsignalized	Signalized		
≤10	≤10	A	F
>10-15	>10-20	B	F
>15-25	>20-35	C	F
>25-35	>35-55	D	F
>35-50	>55-80	E	F
>50	>80	F	F
Source: Highway Capacity Manual			

The deterministic equations published in the HCM are not designed to evaluate oversaturated intersections (volume > capacity). If it is determined that during existing or future scenarios the intersection is anticipated to become oversaturated, a microscopic simulation model will be established to evaluated the intersection. Specifically, Vissim will be utilized in this study for any microscopic simulation analysis.

Microscopic models are based upon stochastic methodology. These models simulate and track vehicles within a network and record specific measures of effectiveness on an iterative basis. Simulation models will also be employed if alternative intersection configurations involve complex vehicle interactions that may not be fully felt using static equations.

Data Collection

To conduct capacity analysis, multiple layers of traffic data were collected at the study intersection. This included:

- Roadway geometrics
- AM and PM peak-hour turning movement counts including vehicle classifications, peak-hour factors and pedestrian and bicycle traffic volumes
- Queue length data to calibrate and validate the traffic models

Traffic Forecasting

Traffic operations analysis was conducted for existing and future 2035 conditions. Forecasted traffic volumes were developed using a blend of existing traffic characteristics, historic traffic growth rates, future land use and forecasted growth rates included in the most recent Long Range Transportation Plan (LRTP). The most recent LRTP was completed in 2007 and includes daily traffic volume forecasts to the year 2030. The LRTP cannot be used solely to forecast traffic because federal standards require a 20-year study horizon.

Due to intense traffic growth experienced in the Casper metro area, linear growth based upon historic volumes provides unrealistically high traffic forecasts. For example, using linear growth strategies results in forecasts greater than 40,000 vehicles per day on the east approach of 2nd Street. Not only is it unrealistic to maintain recent growth trends, the limited amount of capacity along this corridor limits the growth potential.

Although relatively outdated, the LRTP provides the most reliable source of traffic forecast data. As part of the LRTP, a travel demand model was developed based upon projected land use and growth patterns for the metropolitan area and calibrated to existing travel patterns. Developing a travel demand model is a massively detailed endeavor requiring multiple levels of analysis and review prior to adopting the forecasts.

Traffic Forecasts

Within the LRTP, traffic forecasts were developed for three growth scenarios: low (1.0% annual population growth), medium (1.25% annual population growth) and high (1.5% annual population growth). Growth rates were developed based upon 2000 Census Bureau data (the most recent data available at the time). Based upon an evaluation of metro-wide population growth from 2000 to 2010 (using Census Bureau data), a growth rate between the low and medium scenarios has been experienced in the Casper urbanized area and just slightly over the medium scenario for Natrona County in the past years.

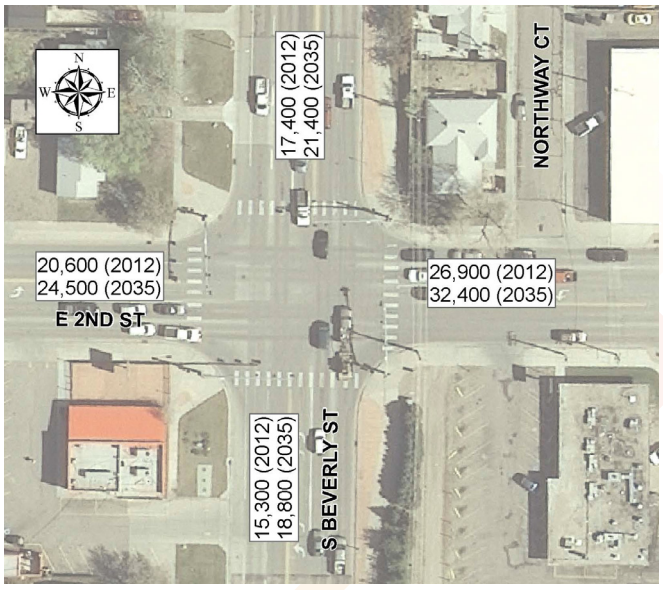

Figure 3-4 – Daily Traffic Forecasts

An evaluation of existing and forecasted traffic volumes indicates the volumes on Beverly Street have already eclipsed the forecasted daily traffic volumes for the low and medium growth scenarios. Contrarily, the high growth scenario was not eclipsed on any approach. As such, the high growth rates were used for analysis. Under the highest growth scenario, growth between 2005 (baseline year for the 2030 LRTP) and 2030 (forecasted year for the 2030 LRTP) resulted in a 0.95% annual traffic increase on Beverly Street and 0.85% annual traffic increase on 2nd Street. Applying these growth rates to the 2012 daily traffic values results in realistic future volumes greater than what is forecasted in the 2030 LRTP and lower than a linear growth pattern (refer to Figure 3-4). Once daily traffic volumes were developed, peak-hour turning movement counts were developed using a culmination of forecasted growth and existing distributions.

PUBLIC INVOLVEMENT

The project involved multiple layers of stakeholder and public involvement. In addition to the involvement required to complete the RSA, the following three separate presentations were given prior to adopting the final report:

- Present draft report to the public
- Present final report to MPO committees (combined meeting with MPO Policy Committee, Technical Committee and Citizens' Advisory Committee)
- Present final report to Casper City Council

CHAPTER 4: GOALS AND OBJECTIVES

Current federal legislation (MAP-21) places a greater emphasis on performance measures and monitoring. Based upon this emphasis, project goals and objectives were founded on the following SMART growth principles:

- Specific – Sufficient to guide approaches
- Measurable – Quantitative measurement
- Agreed – Consensus among partners
- Realistic – Can be accomplished
- Time-Bound – Identified time frame for accomplishment

Integration of the SMART guidelines within the Beverly Street and 2nd Street Intersection Study provides the following benefits:

- Helps inform and improve the decision making process
- Increased accountability for goals and objectives
- Complies with legislative mandates
- Improves internal organization and management
- Sets benchmarks for internal, local, national and peer urban area comparative evaluation

Goal 1: Perform qualitative and quantitative safety analyses to develop low-cost improvements that can be implemented immediately to reduce pedestrian and vehicular crash potential at the intersection.

Goal 2: Perform traffic operational analyses under existing and future traffic to determine future capacity and geometric needs and improvement triggers for the intersection that considers both safety needs and right-of-way impacts.

In addition to the goals tailored specifically to this study, MAP-21 also stipulates 7 national goals and performance targets. These goals are used to guide the planning process throughout this study. The 7 goals are described below.

- Safety – To achieve a significant reduction in traffic fatalities and serious injuries on all public roads
- Infrastructure Condition – To maintain the highway infrastructure asset system in a state of good repair
- Congestion Reduction – To achieve a significant reduction in congestion on the National Highway System
- System Reliability –To improve the efficiency of the surface transportation system
- Freight Movement and Economic Vitality – To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development.
- Environmental Sustainability – To enhance the performance of the transportation system while protecting and enhancing the natural environment
- Reduced Project Delivery Delays – To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices

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ROAD SAFETY AUDIT

Below is a summary of the safety issues identified by the RSA team during the field review. It is important to note that observations submitted by the RSA team not specifically dealing with safety are not included in this section of the report, but are incorporated in later relevant sections. Issues are ordered by crash risk assessment.

Permissive Intersection Movements

Observations: It was noted that motorists performing left-turn maneuvers focus on identifying gaps in opposing traffic but do not look for crossing pedestrians. Figure 5-1 illustrates this pedestrian-vehicle conflict point. This likely is due in part to the low frequency of pedestrian conflicts. However this scenario results in high-speed pedestrian-vehicle conflicts and a pedestrian fatality in 2012. This condition is further exacerbated when sun-glare is an issue during the morning and evening.

Frequency Rating: Occasional

Severity Rating: Extreme

Crash Risk Assessment: D

Potential Improvement Strategies: Eliminating permitted left-turn phases, implementing pedestrian exclusive phases and/or implementing pedestrian refuge islands.

Figure 5-1 – Permitted Left-Turn Pedestrian Conflict

Access Management

Observations: The RSA team noted that the driveways surrounding the intersection experience frequent conflicts due to close proximity to the intersection. Figure 5-2 illustrates a conflict between mainline traffic and vehicles exiting a driveway.

Frequency Rating: Occasional

Severity Rating: Moderate

Crash Risk Assessment: C

Potential Improvement Strategies: Access management strategies such as eliminating redundant access points, consolidating adjacent access points, relocating access points to lower volume street and implementing medians have been proven effective at reducing conflicts related to dense access spacing.

Figure 5-2 – Access Point Conflict

Signal Timing

Observations: According to the RSA team, the pedestrian walk and clearance intervals felt inadequate, particularly for slow or mobility impaired users. This is important to note as the pedestrian fatalities on 2nd Street in the past year were ages 59 and 65. Yellow and all-red clearance times also appeared abbreviated. An evaluation of existing walk, pedestrian clearance, yellow and all-red times indicated the timings did not meet the Manual on Uniform Traffic Control Devices standards and support.

Frequency Rating: Rare

Severity Rating: Extreme

Crash Risk Assessment: C

Potential Improvement Strategies: Update walk, pedestrian clearance, yellow and all-red times for the intersection to provide adequate and safe clearance time for pedestrians, bicycles and vehicles across the intersection.

Traffic Control Noncompliance

Observations: It was noted that aggressive drivers are not yielding to pedestrians and some are running red lights. It was also noted that some pedestrians begin crossing the street prior to the walk phase. These vehicular and pedestrian user behaviors in combination have the potential to result in a serious or potentially fatal conflict.

Frequency Rating: Rare

Severity Rating: Extreme

Crash Risk Assessment: C

Potential Improvement Strategies: User behavior typically cannot be adjusted via engineering methods. However, increased enforcement and education has proven to provide positive driver and pedestrian behavior benefits.

Uncontrolled Curb Ramps

Observations: There are four curb ramps leading pedestrian traffic across 2nd Street at uncontrolled locations less than 250 feet east of the central intersection. The ramps promote crossing at locations that will interfere with motorist expectancy and potentially increase crash potential.

Frequency Rating: Rare

Severity Rating: Extreme

Crash Risk Assessment: C

Potential Improvement Strategies: Remove curb ramps within the functional area of the intersection to funnel traffic to a controller location.

Pavement Markings and Signage

Observations: There are currently no stop-bar pavement markings to stop vehicles in advance of the crosswalk and it was not uncommon for motorists to stop in the crosswalk. The continental crosswalk thermoplastic pavement markings are worn out and missing at locations, particularly the northeast corner of the intersection. One pedestrian sign is mounted backwards above the pedestrian pushbutton. Finally, right-turn on red is permitted at the intersection and while yielding does not appear to be a concern between vehicles and pedestrians, right-turn vehicles primarily queue across the crosswalk to make this maneuver.

Frequency Rating: Rare

Severity Rating: Low

Crash Risk Assessment: A

Potential Improvement Strategies: Restripe existing crosswalks to increase conspicuity of pedestrian crossing locations, revise pedestrian signage where necessary to improve pedestrian awareness, stripe stop bars to promote stopping in advance of crosswalks and consider restricting right-turn on red to minimize queuing across crosswalks during right-turn movements.

Corner Radii

Observations: The northeast corner radii curb was broken, with evidence that large trucks had driven over the curb. The radii appeared adequate for passenger cars, with most tracking several feet from the curbs. Figure 5-3 illustrates the truck turning radii for a right-turning WB-67 (wheelbase of 67 feet in length) truck. WB-67 trucks are the largest truck anticipated at this intersection. It is important to note that trucks of this magnitude very infrequently use the study intersection, according to the data collected during the peak-hours. As illustrated in Figure 5-3, slight corner radii improvements may be made on the southwest and northwest corners to accommodate trucks whereas the northeast and southeast corners would require substantial corner radii improvements. This discrepancy is due to the presence of a parking lane that trucks can utilize when making turning maneuvers. However, this opportunity is void if the parking lane is occupied.

Slight increases to turning radii may be beneficial not only to improve truck operations but also to reduce the likelihood of truck trailer off-tracking onto curb ramps where pedestrians may be present. However, increasing the corner radii the extent necessary to avoid trucks from "jumping" the curb completely on the east corners would result is very large radii that may promote very fast turning speeds for passenger cars. Increased turning speeds increases the likelihood for injury or fatality if a vehicle-pedestrian crash were to occur during a right-turn movement. It is important to note that large trucks required to make sharp turning maneuvers will occupy both through lanes to avoid potentially impacting the traffic signal standard on the corner.

Frequency Rating: Rare

Severity Rating: Low

Crash Risk Assessment: A

Potential Improvement Strategies: Revise corner radii at the intersection to preserve the curbs on the corner and minimize conflicts between truck trailers off-tracking and pedestrians waiting at the intersection corner. Corner radii should not be substantially increased, however, to avoid promoting high-speed right-turning maneuvers by passenger vehicles. A multiple curb radii approach can be considered to balance truck requirements and passenger car speeds.

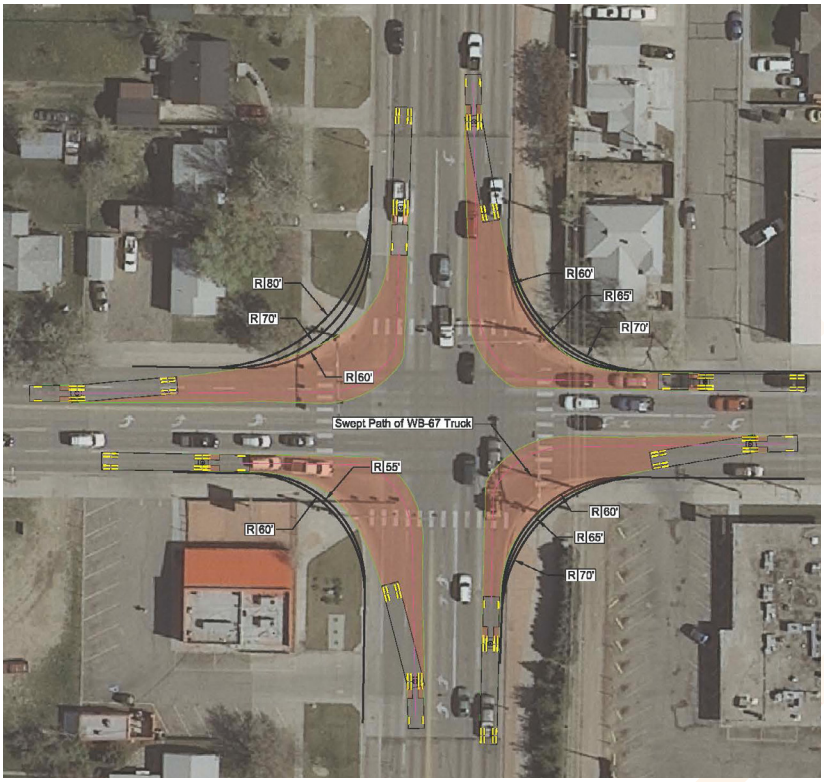


Figure 5-3 – Truck Turning Radii

Pedestrian Amenities

Observations: The following pedestrian amenity deficiencies were noted during the field review:

- Existing curb ramps were cracked/damaged, particularly on the southeast corner, potentially creating issues for individuals using wheelchairs.
- Ramps were not in line with the crosswalks, resulting in potential for pedestrians (particularly individuals with visual impairments) crossing outside of delineated crosswalks.
- Detectable warning panels are not present on curb ramps.
- Pushbutton placement did not meet ADA placement guidelines resulting in conflicting audible messages if both pushbuttons were activated on one corner.

Frequency Rating: Rare

Severity Rating: Low

Crash Risk Assessment: A

Potential Improvement Strategies: Revise curb ramps to align with crosswalks and include detectable warning panels at all ramps to improve crossing condition for pedestrians, particularly individuals with disabilities. Revise pushbutton locations to meet ADA guidelines.

Parking

Observations: The following parking deficiencies were noted during the field review:

- On-street parking was not restricted on the north or south approaches of the intersection. Vehicles parking directly adjacent to the intersection may create conflicts with mainline traffic when attempting to leave their parking space.
- The 11 residential driveways along Beverly Street require motorists to back out into traffic on a minor arterial. This results in crash conflicts and reduced capacity as slow moving vehicles enter the traffic stream and block multiple lanes of traffic.
- The parking lot layout at the Dragon Wall and Chopstix Asian Bistro restaurants on the southeast and southwest corners of the intersection included angled parking spots that require motorists to back out nearly onto 2nd Street when exiting the parking stall. This blocks access onto the site, potentially creating queues on 2nd Street that may interfere with motorist expectance.

Frequency Rating: Rare

Severity Rating: Low

Crash Risk Assessment: A

Potential Improvement Strategies:

- Restrict parking within 30 feet of the intersection to minimize potential for conflicts between vehicles exiting on-street parking stalls and motorists performing right-turns at the intersection.
- Revise parking layouts at the Dragon Wall and Chopstix Asian Bistro to minimize potential for blocked access points and queue lengths on 2nd Street as motorists attempt to access these sites.
- Revise driveway configurations along Beverly Street to minimize potential for conflicts and reduced capacity when motorists exit residential driveways.

HISTORIC CRASH ANALYSIS

Crash records were obtained from WYDOT. Three years and four months of crash records, from January 2010 through April 2013 indicated 31 crashes at the intersection of Beverly and 2nd Street. This includes 1 crash resulting in a fatality and 10 crashes resulting in an injury or possible injury.

The National Safety Council (NSC) estimates economic impact of crashes based on wage and productivity losses, medical expenses, administrative expenses, motor vehicle damage and employer costs due to injuries. Conservatively assuming that all "Possible Injuries" coded in the crash report inevitably resulted in an injury, the total costs associated with crashes at this intersection were approximately $716,700 per year.

As noted in the Study Approach chapter of the report, critical crash analysis was performed to evaluate whether the study intersection demonstrates statistically significant crash behavior. According to the Minnesota Department of Transportation (MnDOT), the agency that developed the critical crash rate approach; if an intersection has a crash rate above the critical crash rate, the intersection is considered "unsafe." For comparison, the critical crash rate analysis included intersections with the following characteristics:

- Controlled by traffic signal
- Four-legged intersection
- All approaches must be functionally classified as a collector or higher with a minimum of one approach classified as a principal arterial

Table 5-1 – Critical Crash Rates

Intersection		Total Crashes/ Year	Injury/ Fatality Crashes/ Year	Average Daily Traffic	Crash Rate/MEV	Total Critical Crash Rate	Injury/ Fatality Rate/MEV	Injury/ Fatality Critical Crash Rate
N/S Roadway	E/W Roadway							
Beverly Street	E Yellowstone Highway	7.2	1.2	22,712	0.87	1.06	0.14	0.38
Beverly Street	**2nd Street**	**9.3**	**3.3**	**36,707**	**0.69**	**1.01**	**0.25**	**0.35**
Center Street	1st Street	9.6	3.0	24,770	1.06	1.05	0.33	0.37
Curtis Street	E Yellowstone Highway	1.2	0.0	16,341	0.20	1.11	0.00	0.41
E Yellowstone Highway	1st Street	2.1	0.6	24,460	0.24	1.05	0.07	0.37
Poplar Street	Cy Avenue	14.7	3.3	32,308	1.25	1.02	0.28	0.36
Poplar Street	13th Street	7.5	3.0	19,736	1.04	1.08	0.42	0.39
Poplar Street	Collins Drive	6.9	2.1	30,814	0.61	1.03	0.19	0.36
Poplar Street	1st Street	12.6	3.3	33,843	1.02	1.02	0.27	0.35
Wolcott Street	1st Street	3.9	0.9	18,031	0.59	1.10	0.14	0.40
Wyoming Boulevard	Cy Avenue	20.1	6.6	36,260	1.52	1.01	0.50	0.35
Wyoming Boulevard	South Poplar Street	9.0	2.4	20,678	1.19	1.08	0.32	0.39
Wyoming Boulevard	Casper Mountain Road	3.9	1.8	21,230	0.50	1.07	0.23	0.39
Wyoming Boulevard	12th Street	7.2	2.7	28,023	0.70	1.04	0.26	0.36
Wyoming Boulevard	2nd Street	14.1	3.9	44,443	0.87	0.99	0.24	0.34

Crash data collection period from 1/1/2010 - 4/31/2013
Average daily traffic data from 2010 - 2012
MEV = Million Entering Vehicles
Cells with red shade highlight crash rates that exceed the critical crash rate
Critical crash rate was performed for a 90% confidence interval

According to the critical crash analysis, the intersection does not exhibit an overrepresented crash rate relative to similar intersections in the metropolitan area. In fact, 7 intersections with similar characteristics have higher total and injury/fatality crash rates than the study intersection.

Although the intersection does not exhibit statistically significant crash rates, there are still crash patterns at this intersection that would benefit from improvements. Further intersection analysis provided the following insight:

- Nearly 1/3 of all crashes at the intersection resulted in an injury (possible injury classification included) and 1 crash resulted in a fatality.
- In addition to the pedestrian fatality documented earlier in this report, a vehicle-bicycle crash occurred and resulted in an injury to the cyclist.
- After an analysis of crash types and time of occurrence there was no other evidence of glare causing crashes.
- 15% of crashes were angled crashes and nearly 80% of which were headed eastbound or westbound. Angled crashes are common with permitted left-turn phasing on high volume intersections.
- Nearly half of all crashes were rear-end crashes. Although rear-end crashes are prevalent at signalized intersections, it is important to note that 4/5 of these crashes were traveling eastbound and westbound which is disproportional to traffic volumes on these approaches. This potentially indicates stop and go traffic and need for improved corridor progression.

TRAFFIC OPERATIONS

Figure 5-4 illustrates the baseline evaluation of the intersection without any improvements. This includes both existing AM and PM peak-hour traffic operations and forecasted operations.

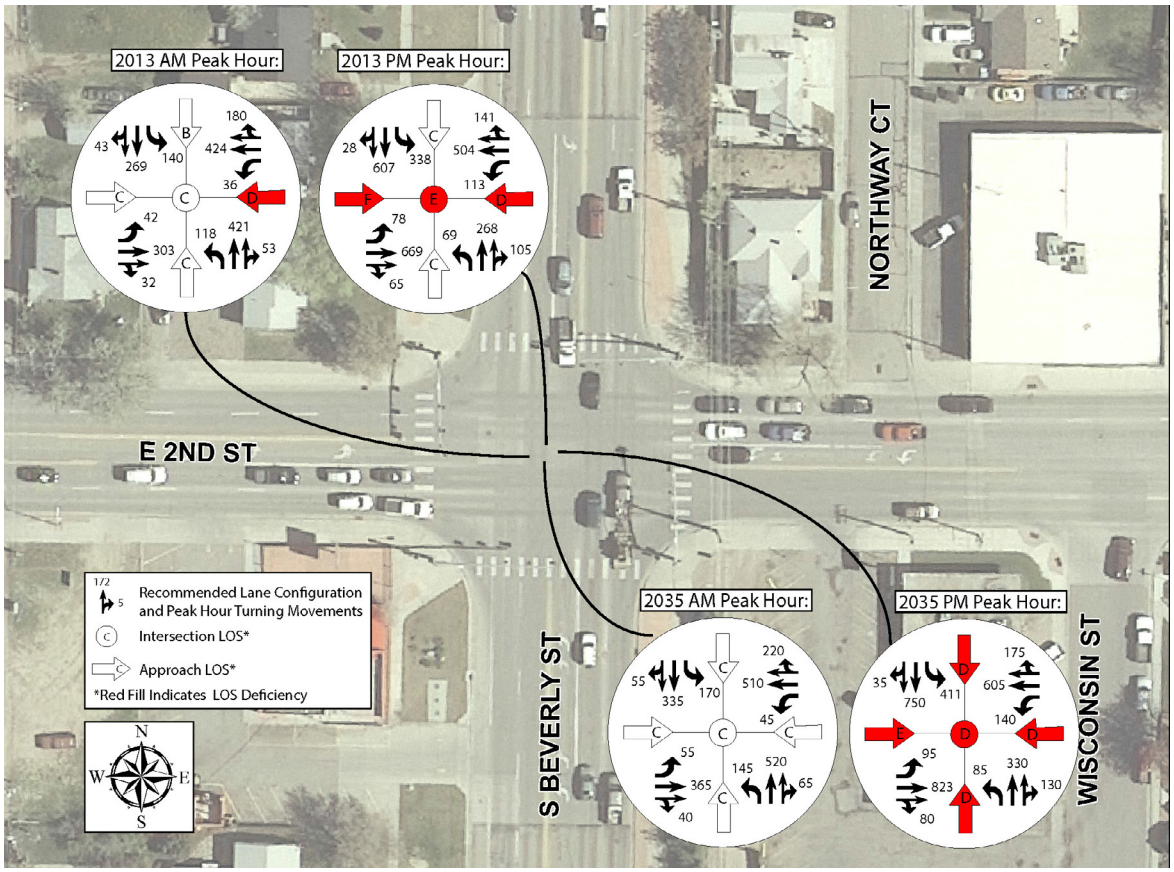


Figure 5-4 – No Build Traffic Operations

It is important to note the current timing pattern at the study intersection is designed with a cycle length that is not long enough to handle the pedestrian walk and clearance intervals and the yellow and all-red times. This does not mean the phases are skipped, but rather when a pedestrian phase is served, the cycle is broken. This eliminates any potential for coordination along Beverly or 2nd Street until the cycle length and intersection offset "catches up," which can be accomplished either via shortening or extending subsequent green phases. As part of this study, all future scenarios will be designed to handle the pedestrian phases at all times which will impact operations at the study intersection while allowing for future benefits in terms of corridor-wide coordination. This approach will also account for future increases in pedestrian and bicycle traffic through the intersection as the sidepath abutting Beverly Street is expanded. Refer to Appendix A – Study Assumptions for additional details regarding signal timing methodology.

Traditional Improvement Strategies

The project's challenge is balancing the serious nature of pedestrian-vehicle crashes without unduly impacting traffic operations. This is an important consideration as pedestrian and bicycle traffic currently only accounts for 0.03% of total traffic at this intersection during the study periods (Figure 5-5 illustrates the current intersection traffic demand). In addition, the highest crash occurrences were rear-end crashes which are common at intersections that experience high levels of congestion and stop and go traffic. In other words, impacting traffic operations may result in perpetuated or increased rear-end crashes.

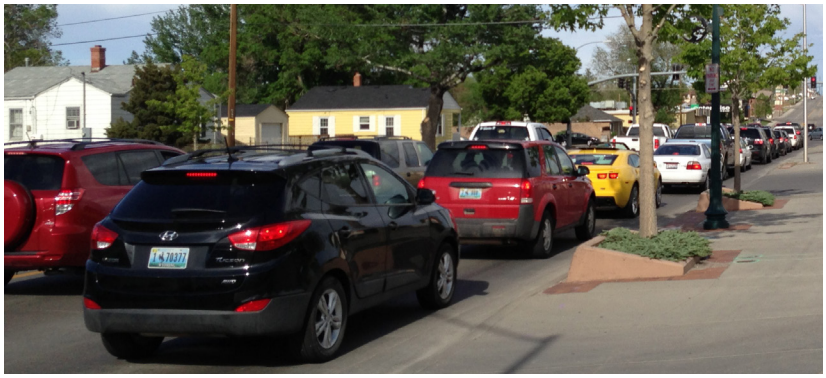


Figure 5-5 – Intersection Queue Lengths

It is likely that low pedestrian volumes are a major contributing factor to the vehicle-pedestrian crash issue at this intersection. Specifically, the pedestrian fatality occurred when a motorist was making a permitted left-turn maneuver. It is possible that the infrequent nature of pedestrian traffic at this intersection affected motorist expectancy. In other words, it is possible that drivers accustomed to a pedestrian-free environment do not scan for pedestrians prior to making a left-turn but rather only look for gaps in opposing vehicular traffic. Studies have found that as pedestrian and bicycle traffic volumes increase, the potential for crashes with these modes of travel decrease as motorists become more aware of their presence.

Based upon the results of the RSA and crash analysis, the following issues and traditional improvement strategies were developed that will have impacts on intersection operations. It is important to note that there are multiple improvement strategies that did not impact traffic operations and, as such, are not listed below.

- Convert protected/permitted left-turn phasing to protected only phasing to eliminate high-speed permissive conflicts between vehicles and pedestrians
- Update signal timing parameters:
  - Update pedestrian walk and clearance intervals to meet MUTCD standards and ensure ample crossing time for pedestrians across the intersection
  - Update yellow and all-red intervals to meet MUTCD standards to ensure safe clearance for motorists through the intersection when phases alternate
  - Update cycle length to allow for pedestrian walk and clearance intervals to be served without impacting corridor-wide progression
- Prohibit right-turn on red to limit potential for right-turning motorists to conflict with pedestrians
- Develop a pedestrian exclusive phase (also known as a pedestrian scramble) allowing pedestrian movements in every direction (including diagonally) during a period where all vehicular movements are prohibited (refer to Figure 5-6 for illustration of this type of improvement)

As illustrated in Figure 5-4, the bottleneck period is during the 2035 PM peak-hour. As such, this period was used as the control. If operations are acceptable under this traffic scenario, they will transitively be acceptable under all other study scenarios. As noted in the Study Approach chapter, the target LOS according to WYDOT is LOS "C." For each alternative listed above, signal optimization and turn lane improvements were considered. Table 5-2 illustrates the traffic operations analysis of each alternative.

As illustrated in Table 5-2, LOS "C" is unachievable with "traditional" improvement strategies such as signal timing or turn lane improvements. Additional through lanes were not considered as this type of improvement is not an intersection level solution but rather a corridor-wide improvement if effective lane utilization and full-scale benefits are to be achieved. Furthermore, 2nd Street carries nearly 50% more

Figure 5-6 – Example of Pedestrian Phase

Table 5-2 – Traditional Improvement Strategy Analysis

Improvement Strategy	Level of Service	Delay (sec/veh)	Optimal Lane Configuration [1]			
			Added Turn-Lanes [2]	Level of Service [3]	Delay (sec/veh)	Number of Impacted Buildings [4]
Updated Signal Timing Parameters	D	53.7	NBR, SBR, EBR, WBR	D	38.9	1
Protected-Only Left-Turn Phasing	F	74.1	NBL, SBL, EBL, WBL, NBR, SBR, EBR, WBR	D	41.9	5
Prohibited Right-Turn on Red	D	54.5	NBR, SBR, EBR, WBR	D	40.6	1
Exclusive Pedestrian Phase[5]	F	69.5	NBR, SBR, EBR, WBR	F	69.3	1

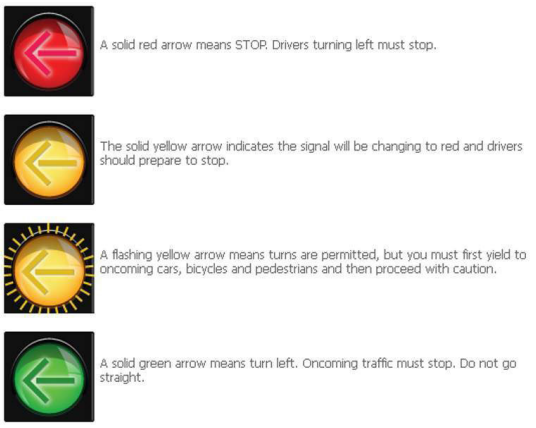
[1] Does not consider additional through lanes as this improvement is made on a corridor-wide basis.
[2] EB - Eastbound, WB - Westbound, NB - Northbound, SB - Southbound, L - Left, R - Right.
[3] Includes Signal Timing Optimization.
[4] Impacted Buildings include buildings directly impacted or properties where enough parking is removed that functionality is lost.
[5] Operations illustrated in table are during a pedestrian exclusive phase. The signal can be designed to skip this phase when a call is not present. However skipping this phase this will have impacts to overall corridor progression.

traffic than Beverly Street at this intersection and would benefit the most from additional through lanes. However, additional through lanes in each direction of 2nd Street results in countless building impacts. In summary, using traditional intersection improvement strategies either are incapable of meet LOS standards or result in substantial building impacts.

One option to balance pedestrian safety and traffic operational needs is to program the traffic signal controller to skip the permissive left-turn phase when a pedestrian call is present. In other words, the approach operates as protected-only left-turn phase when pedestrians are present and press the pushbuttons and protected/permitted when pedestrians are not present. Another option is to delay the start of the permitted phase. The traffic signal controller would be programmed to only receive pedestrian calls prior to the start of the permitted left-turn phase to prevent initiating and terminating the permitted phase within the green phase and affecting motorist expectance. If programmed in this fashion, it is recommended that the controller have a recall on both 2nd Street and Beverly Street to prevent the scenario where the controller is resting in green with the permitted phase in operation and the pedestrian call is ignored. The complexity of the programming is dependent upon the capabilities of the agency responsible for maintaining the intersection.

In terms of traffic operations, the intersection will operate at a LOS F (74.1 seconds/vehicle) if pedestrians are present on each approach and LOS D (53.7 seconds/vehicle) if no pedestrians are present during 2035 peak hour operations without any supplementary improvements. This is important to note because there are current plans to expand the pedestrian/bicycle sidepath that parallels Beverly Street. This will likely increase pedestrian and bicycle demand at the intersection, especially if safety is less of a concern at the location. In summary, under this programming as pedestrian/bicycle volumes increase the capacity of the intersection decreases.

If the intersection is converted from a traditional protected/permitted left-turn phase with permitted green ball to a flashing yellow arrow configuration, vehicular crash rates may be reduced according to findings from multiple studies. Furthermore, the flashing yellow arrow provides benefits in terms of arterial coordination as it alleviates the potential for the yellow-trap scenario and allows protected left-turn movements to be lagged.



Source: whatchsonomacounty.com

Figure 5-7 – Flashing Yellow Arrow Operation

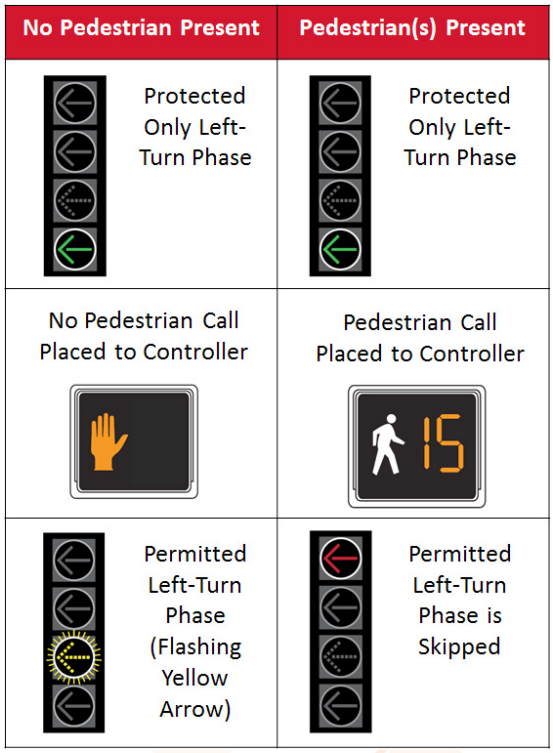


Figure 5-8 – Proposed Traffic Signal Controller Operations

It is important to note that the advanced controller logic required to implement the skipped permitted left-turn phase and flashing yellow arrow is not available in older controllers. Currently an Econolite controller is installed at the study intersection; however, the model of the controller was unknown at the time this report was prepared. To perform these functions it is required that an ASC3 controller (Econolite's latest model) be installed at the study intersection. Refer to Figure 5-8 for the proposed controller operation.

Similar to restricting permitted left-turning traffic when vehicles are present, LED no right-turn blank-out signs can be installed and activated during conflicting pedestrian walk phases. This type of conflict is most prevalent when motorists are scanning for gaps in upstream traffic to make a permitted right-turn on red to their left and pedestrians are crossing from their right. Figure 5-9 illustrates one potential LED blank-out sign that can be effectively employed.

Alternative Improvement Strategies

As illustrated in Table 5-2, all traditional improvement strategies result in one of the following scenarios:

- Reduced pedestrian/bicycle exposure but severely impacted traffic operations
- Reduced pedestrian/bicycle exposure and improved traffic operations but significant property impacts

As such, alternative improvement strategies were studied to determine applicability. Definitions, advantages, disadvantages and applications of each alternative category can be found in the Alternative Intersections/Interchanges: Informational Report (AIIR) produced by the Federal Highway Administration. Refer to Table 5-3 for an illustration of what alternative intersection designs were studied, which designs were discarded and why designs were discarded.

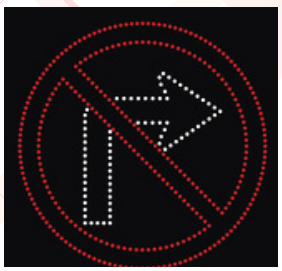


Figure 5-9 – LED Blank-Out Sign

The bowtie intersection configuration would eliminate direct left turns from the intersection. Drivers desiring to turn left from Beverly Street onto 2nd Street (yellow/purple routes on Figure 5-10) must first

travel through the main intersection, then execute a U-turn at the multilane roundabout downstream of the intersection. Drivers then turn right at 2nd Street. Drivers on 2nd Street desiring to turn left onto Beverly Street (magenta/red on Figure 5 10) must first turn right at the main intersection, execute a U-turn at the downstream multilane roundabout, and proceed back through the main intersection.

Intersection configurations requiring multiple vehicular decisions and unique travel patterns are more appropriately modeled using microscopic simulation models. However, prior to committing the great amount of effort required to develop a microscopic simulation model, HCM deterministic equations along with travel time estimates were used to estimate the impacts to traffic operations caused by this configuration.

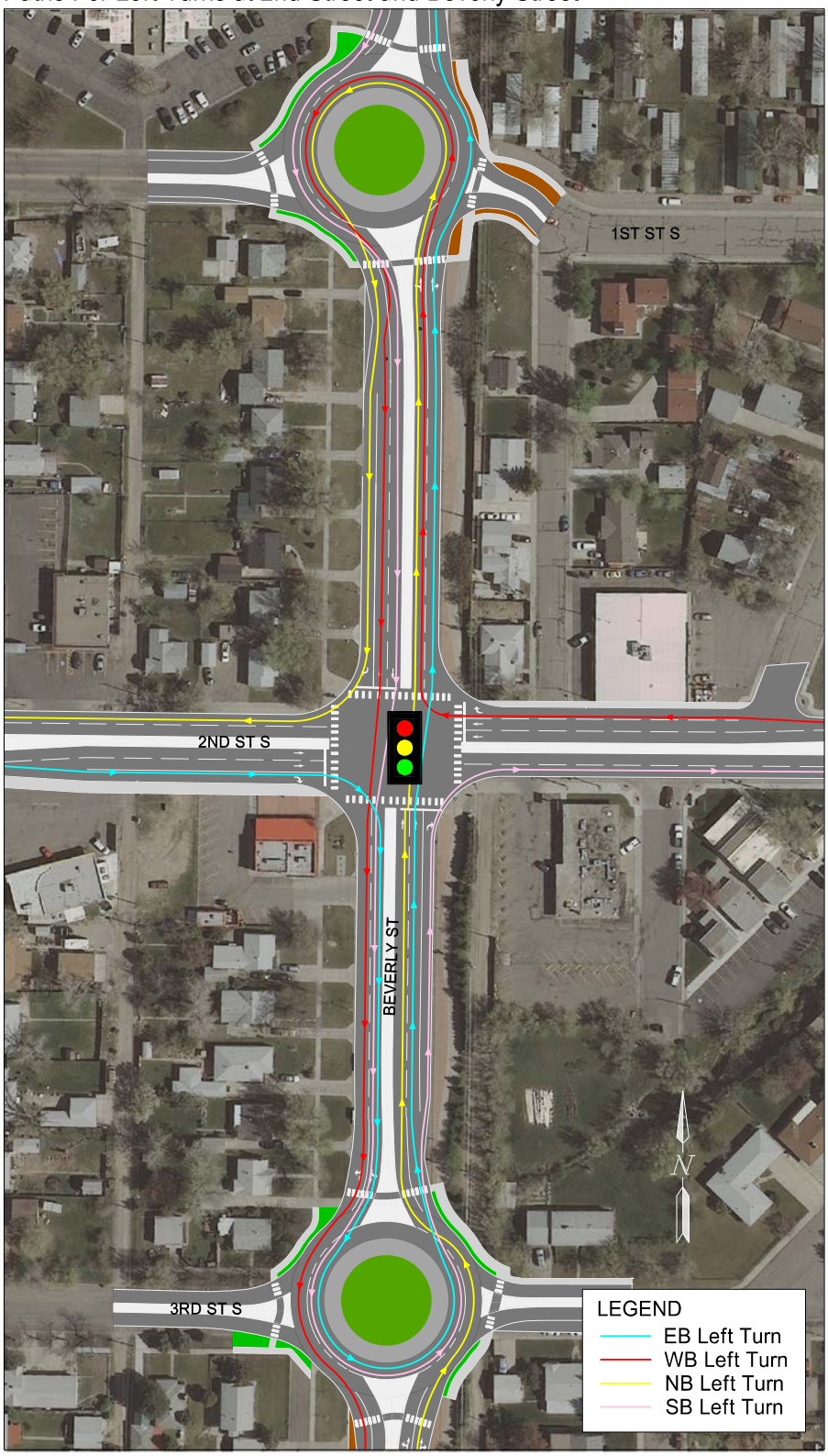
Table 5-3 – Alternative Intersection Design Evaluation

Intersection Configuration	Discarded/ Studied Further	Reason Discarded
All Interchange Configurations	Discarded	Significant building and adjacent property impacts
Roudabout	Discarded	Capacity and impacts to adjacent properties
Quadrant Intersection	Discarded	Increased volumes on adjacent local roads with dense access spacing
Displaced Left-Turn Intersection	Discarded	Building impacts and intersection spacing conflicts upstream of the study site
Reduced Crossing U-Turn Intersection	Discarded	Poor traffic Operations
Median U-Turn Intersections	Discarded	Property impacts at upstream intersections to adequately design for u-turn
Bowtie Intersection	Studied Further	_

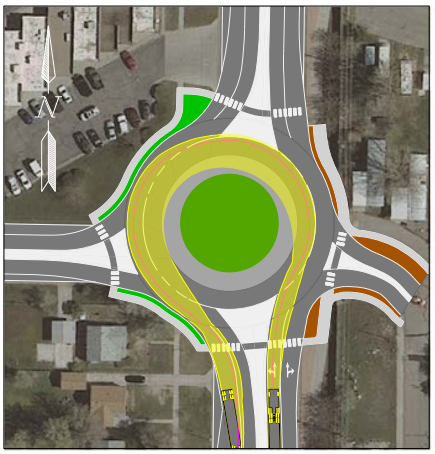
As illustrated in Figure 5-10, the adjacent multilane roundabouts used to facilitate the U-turn maneuvers are located at existing intersections of Beverly Street with 1st and 3rd Street. To fully evaluate the configuration, these upstream intersections need to be considered. Collecting data at adjacent intersections was beyond the scope of this report. For preliminary analysis, turning movement counts were estimated using average daily traffic counts, peak-hour distributions from the data collected at the Beverly and 2nd Street intersection and an estimation of daily traffic patterns based upon roadway use and regional traffic volumes. If the bowtie alternative is carried forward, it is recommended that turning movement counts be collected at these intersections and analyzed to validate assumptions.

Traffic forecasts at the intersections of Beverly Street with 1st and 3rd Street were developed using the same methodology as for the intersection of Beverly with 2nd Street. Based upon traffic forecasts at these intersections, it was estimated the intersection of Beverly and 1st Street would warrant a traffic control signal in the near future due to the limited number of gaps on Beverly Street and the number of conflicting motorists turning left onto the corridor. Details regarding this analysis are included in Appendix A – Study Assumptions.

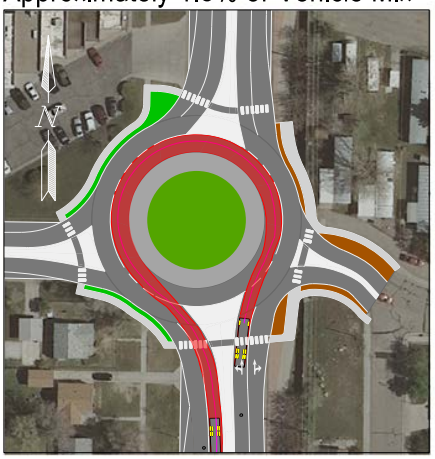
Paths For Left Turns at 2nd Street and Beverly Street



Swept Path of WB-67 Truck
Approximately 0.5% of Vehicle Mix



Swept Path of Single Unit Truck
Approximately 1.5% of Vehicle Mix



Swept Path of Passenger Car
Approximately 98% of Vehicle Mix

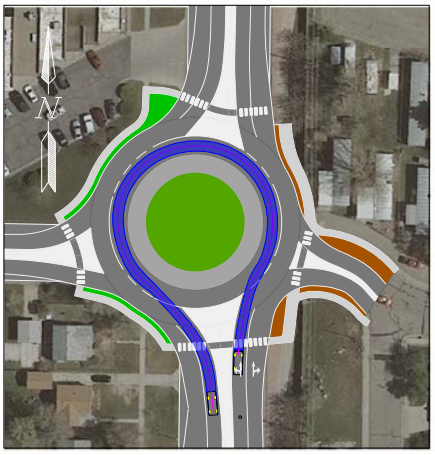


Figure 5-10 – Bowtie Intersection Configuration

After a preliminary analysis of the bowtie intersection, this configuration offers the following benefits when compared to current conditions:

Traffic Operations: The bowtie intersection involves complex vehicle interactions that may not be fully felt using static HCM equations. As a result, a Vissim microscopic simulation model was developed for this configuration and the existing configuration for comparative purposes. Analysis indicates a bowtie configuration will reduce motorist delays at the intersection of Beverly and 2nd Street by a modest 5% during existing peak-hour conditions and 9% during forecasted 2035 peak-hour operations, including the extra travel time required to make left-turn maneuvers at the intersection. It is important to note that left-turning traffic only accounts for 20% of the overall intersection traffic volume during the future peak-hour.

Potential for Future Growth: Due to the project magnitude required to implement a bowtie at the study site, a sensitivity analysis was conducted. The sensitivity analysis looks in the highest growth scenario possible for the intersection by 2035. This approach provides contingency planning for local agencies to prepare for "worst-case" scenarios while also highlighting potential triggers for when the particular project should be implemented. This is critical at the study intersection because recent traffic volume growth trends have been nearly 2% annually for the past 17 years, which is more than twice what is forecasted along these corridors through 2035. Using a 2% annual growth through 2035 illustrates how the current intersection becomes oversaturated while the bowtie configuration has excess capacity. Under this scenario the bowtie offers a 24% reduction of motorist travel time; this is significant because it is likely the bowtie will only be constructed at some point in the future. A 20-year study horizon from this future point will likely reflect the 2% sensitivity analysis growth.

Corridor Progression: By removing the four left-turn phases from the intersection and reallocating the saved green time to through movements, arterial progression and operations of Beverly Street and 2nd Street are improved, albeit at the expense of the left-turning movements at this intersection. Specifically, the bowtie configuration improves corridor progression substantially as indicated by 34%-48% reduction in queue lengths at this intersection during existing peak-hour operations, and as great as a 58% reduction in queue lengths during 2035 peak-hour operations. The improvement alleviates many spillback conflicts across adjacent driveways and intersections.

Overall Safety: Although no bowtie intersections are currently in practice, studies have found that implementation of a similar intersection configuration, the median U-turn intersection, has resulted in an overall reduction of rear-end, angle and sideswipe crashes by 17%, 96% and 61% respectively.

Angled Crashes: Eliminating the left-turn phase from the intersection improves pedestrian/bicycle safety and vehicular safety alike. Pedestrian/bicycle and angled left-turn crashes are the two crash types most susceptible to injuries and fatalities; according to the FHWA, angle and left-turn crashes account for 63% of fatal crashes at intersections. In the past three years, this intersection experienced 9 angled vehicle crashes (3 of which resulted in injuries), 1 pedestrian fatality and 1 bicycle injury would been alleviated by removing the left-turn conflict from this intersection.

Rear-End Crash Susceptibility: Nearly half of all crashes were rear-end crashes at this intersection (14 property damage-only crashes and 1 injury crash). Although rear-end crashes are prevalent at signalized intersections it is important to note that 4/5 of the crashes were traveling eastbound and westbound where queue lengths were observed as far as 600 feet from the intersection. This is important to note because motorist expectancy is commonly affected by long queue lengths unexpected by the driver, resulting in stop and go driving behavior and increased rear-end crash potential. As noted above, queue lengths will be substantially reduced with the bowtie configuration, reducing likelihood for rear-end crashes.

Safety at Upstream Intersection: Safety is improved at not only the central intersection but the upstream intersections of Beverly Street 1st and 3rd Streets as well. Roundabouts reduce the number of conflicts points where compared to traditional intersections. Specifically, studies have found that total crashes, injuries and fatalities have been reduced by an average of 35%, 76% and 89% respectively, although recent data suggests that an increase in property damage crashes, specifically sideswipe crashes are not

uncommon with multilane roundabouts. Additionally, studies have found that vehicle-pedestrian crashes are reduced by 73% on average when a traditional intersection is converted to a roundabout. The upstream Beverly Street intersections with 1st and 3rd Street have only experienced 3 and 2 crashes respectively during the past three years. However, 60% of these crashes would have been alleviated if a roundabout were in place.

Pedestrian and Bicycle Convenience: The upstream roundabouts at the intersection of Beverly Street with 1st and 3rd Streets offer additional safe and convenient crossing locations for pedestrians to traverse Beverly Street. Additionally, by removing existing left-turn lanes, medians can be implemented which offer refuge islands for pedestrians and bicyclists alike. Refuge islands not only allow pedestrians and bicycles to cross the intersection in stages, but studies have found that refuge islands increase motorist yielding percentages.

Access Management: By eliminating existing left-turn lanes, medians can be implemented at the intersection to serve as an outlet for access management. Access points introduce conflicts and friction into the traffic stream that lead to reduced corridor speeds and increased corridor crash potential. In fact, research included in the HCM found that roadway speeds were reduced an average of 2.5 miles per hour for every 10 access points per mile, up to a maximum of a 10 miles per hour reduction (at 40 access points per mile). Additionally, NCHRP Report 420 found that every unsignalized driveway increases the corridor crash rate by approximately 2%. Using this data, reconfiguring the 23 access points on Beverly and 2nd Street upstream of the study intersection from full access to right-in/right-out eliminates 73% of the conflict points while maintaining access to every property abutting the two corridors. Using the HCM and NCHRP operations and safety factors, this equates to a 59% and 73% improvement to roadway progression and crash potential on the roadway links leading up to the study intersection. According to historic crash data, two property damage vehicle crashes and one bicycle injury crash would have been alleviated if a median were present. One of the greatest benefits provided by the upstream roundabouts is that drivers forced to make right-in/right-out maneuvers at driveways can conveniently change directions via U-turn movements at the two proposed Beverly Street roundabouts.

Property Impacts: Although right-of-way is required to implement the proposed roundabouts and right-turn lanes, no buildings are directly impacted nor property functionality disturbed by the proposed improvement strategy. As previously noted, this contrasts the majority of traditional and alternative intersection designs studied for this location.

According to the FHWA publication Signalized Intersections: Informational Guide, disadvantages of the bowtie intersection relative to conventional intersection include the following aspects:

- Greater potential for driver confusion and driver disregard for the left-turn prohibition at the main intersection. However, increased signage and pavement markings in combination with an initial emphasis on enforcement have been proven to minimize this concern over the long-term.
- Increased distance and possibly delay for left-turning traffic
- Additional right-of-way needed for the roundabouts, and more circuitous arterial U-turns

Design of the multi-lane roundabouts requires semi tractor-trailers to encroach upon adjacent lanes when making a U-turn movement (required by motorists who formerly turned left at the central intersection). This will result in temporarily reduced roundabout capacity; specifically because a truck making a U-turn using the truck apron will occur at a very low speed. It is important to note, however, that during the study periods, no trucks of this magnitude were noted to make left-turn maneuvers (which will become U-turn maneuvers at the central intersection upon implementation of the bowtie).

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CHAPTER 6: FINAL IMPROVEMENT STRATEGY

The final improvement strategy incorporates both safety and traffic operations improvements. However, due to the immediate need for safety enhancements at the intersection, short-term and long-term recommendations are justified. Short-term improvements are specific to intersection safety and will be low-cost, high-benefit type improvements that can be implemented immediately. Long-term improvements will likely be capacity-based and include any improvement that cannot be easily funded in the near future.

Engineering improvement alternatives may range from geometric to signal timing revisions. However, it is important to note engineering improvements are only one aspect that must be considered when developing safety improvements, particularly for pedestrians. This study uses the 5 E's model when developing safety recommendations. The five E's are summarized below:

- Engineering – Creating operational and physical improvements to the infrastructure surrounding the intersection to reduce potential conflicts with motor vehicle traffic and establish safer and fully accessible crossings, walkways and bikeways.
- Education – Teaching pedestrian and bicyclists about the potential hazards present at the intersection, educating them on proposed improvements and launching driver safety campaigns.
- Enforcement – Partnering with local law enforcement to ensure traffic laws are obeyed (including enforcement of speeds, yielding to pedestrians in crossings and proper walking and cycling behaviors).
- Encouragement – Using events and activities to promote walking and bicycling.
- Evaluation – Monitoring and documenting outcomes and trends through data collection, including collection of data before and after the intervention(s).

LONG-TERM IMPROVEMENT PLAN

Benefit to Cost Analysis

The bowtie intersection configuration provides an improvement strategy that solves pedestrian, bicycle and vehicular safety issues while also improving overall traffic operations of the intersection. This improvement can also be implemented without any building impacts, unlike many other traditional improvement strategies. However, the bowtie does come with substantial roadway costs to implement the two multilane roundabouts upstream of the central intersection. It is estimated the proposed bowtie would cost approximately $2,200,000.

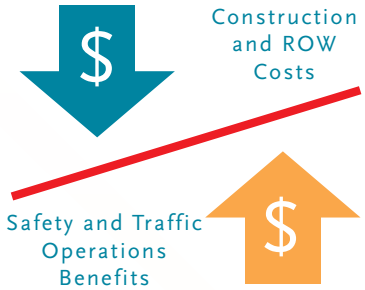

Figure 6-1 – Benefit vs. Cost Analysis

To evaluate whether the proposed bowtie is warranted, a benefit-to-cost (B/C) analysis was conducted at the intersection. The B/C was based upon a comparative analysis of the existing intersection configuration versus the bowtie configuration through the study horizon of 2035. Tangible benefits such as reductions in motorist delay and crashes were converted into quantifiable dollar amounts and compared against the capital costs of constructing the improvement, indirect costs such as right-of-way acquisition and recurring costs such as maintenance and operation (refer to Figure 6-1). Refer to Appendix A – Study Assumptions for details regarding how benefits were quantified into a dollar amount.

As illustrated in Table 6-1, the bowtie configuration has the potential to save the public more than $15,000,000 between 2013 and 2035 when crash, traffic operations and maintenance and operations benefits are quantified. This equates to an annual saving of more than $680,000. Due to the potential for motorist confusion with this unique configuration, a combination of education, encouragement and enforcement may be necessary prior to implementation.

It is important to note that long-term plans should also include more corridor-wide alternatives that were not considered as part of this study.

Table 6-1 – Bowtie Intersection Configuration vs. Existing Configuration with Signal Timing Improvements

Parameter	Costs and Benefits		
	2013	2035	Aggregated (2013-2035)
Construction	-$2,200,000	$0	-$2,200,000
Congestion	$204,100	$1,058,900	$13,892,500
Safety	$182,000	$160,600	$3,212,500
Maintenance and Operations	$4,200	$8,200	$135,600
Total	-$1,810,000	$1,227,700	$15,040,600

Optional Design Considerations

Corner Radii

As part of the bowtie design, corner radii at the Beverly and 2nd Street intersection is increased to 60 feet to improve truck turning operations and reduce likelihood for trucks off-tracking onto intersection corners and pedestrian curb ramps. This increase in radii will not completely alleviate the potential for trucks off-tracking over the intersection corners and onto pedestrian ramps. However, the increase in curb radii will not substantially increase passenger car turning speeds. An increase in turning speeds would result in an increase in serious crash potential between vehicles and pedestrians.

The bowtie intersection configuration requires right-turn lanes which will naturally affect the corner radii as well as new signal standards, corner radii adjustment would be incidental to the overall cost of the bowtie project. It is important to note that a multiple curb radii approach can be considered to balance truck requirements and passenger car speeds. However, this type of curve requires a more detailed review that should be considered during the design phase of the project.

Beverly Street Frontage Roads

Construct frontage roads on the west side of Beverly Street between 1st and 3rd Streets will provide the following benefits (refer to Figure 6-2):

- Alleviate conflicts between motorists entering/exiting parking spots along Beverly Street
- Alleviate conflicts between residents backing-out their driveway and motorists on Beverly Street

This not only benefits mainline traffic but makes accessing the residential properties safer and more efficient. This improvement will cost approximately $295,000 (2013 dollars).

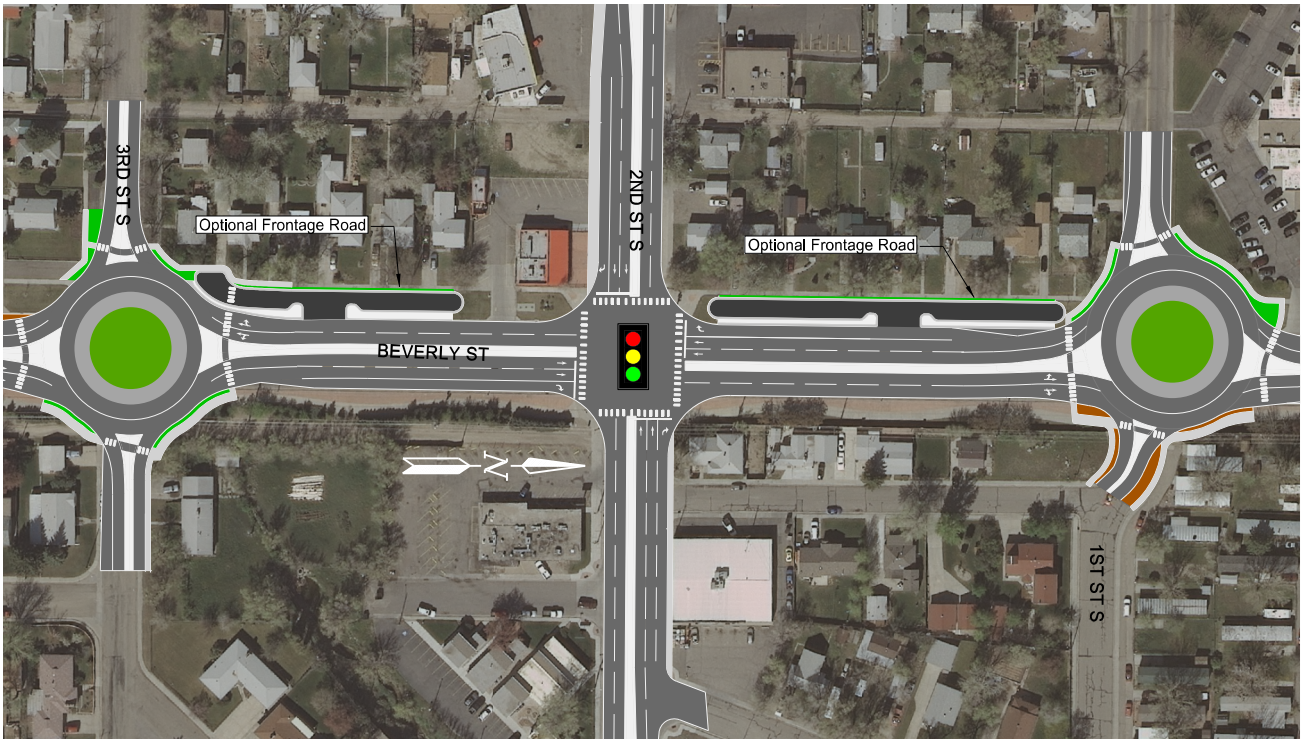

Figure 6-2 – Beverly Street Frontage Roads

SHORT-TERM IMPROVEMENT PLAN

Due to the cost associated with the bowtie intersection or other large-scale long-term improvements, it is unlikely the improvement will be built for several years. It is recommended the bowtie intersection only be considered during future planned roadway improvement projects so costs for the improvement can be consolidated with required roadway rehabilitation. As such, it is recommended the following high-impact low-cost improvements be considered for immediate implementation to improve pedestrian safety (refer to Figure 6-3 for illustration of the short-term improvement plan).

Recommendation: Update the traffic signal controller to increase programming capabilities and program the controller to skip the permitted left-turn phase when a pedestrian call is placed. This will reduce pedestrian exposure when crossing the street. The traffic signal controller should be programmed to only receive pedestrian calls prior to the start of the permitted left-turn phase to prevent initiating and terminating the permitted phase within the green phase and affecting motorist expectance. The controller shall also have a recall on both 2nd Street and Beverly Street to prevent a scenario where the controller is resting in green with the permitted phase in operation and the pedestrian call is ignored.

Cost: $3,000

Recommendation: Replace the existing five-section protected/permitted left-turn heads with four-section protected/permitted flashing yellow arrow left-turn heads. Studies show the flashing yellow arrow will decrease the potential for angled left-turn crashes at the intersection and provide corridor-wide signal timing benefits by allowing lagging protected left-turn phasing without the threat of a left-turn trap. It is important to note that the updated controlled identified in the previous recommendation is recommended to implement flashing yellow arrow operations.

Cost: $5,000

Recommendation: Update walk, pedestrian clearance, yellow and all-red times for the intersection to meet MUTCD standards and support, and ensure pedestrians, bicyclists and motorists have enough time to safely traverse the intersection before conflicting with opposing traffic.

Cost: Incidental to signal improvements

Recommendation: Implement LED no right turn blank out sign on each approach that can be activated during conflicting pedestrian walk phases. This improvement will minimize potential conflicts between pedestrians crossing the intersection and motorists focused on locating gaps in upstream traffic.

Cost: $12,000

Recommendation: Increase enforcement at the intersection to reduce likelihood of aggressive driving and traffic control noncompliance.

Cost: Dependent upon scope and magnitude of increased enforcement

Recommendation: Develop a metropolitan-wide educational campaign to increase motorist awareness of pedestrians and vice versa. Efforts can range from brochures to presentations at local schools to television commercials.

Cost: Dependent upon scope and magnitude of educational campaign

Recommendation: Restripe existing crosswalks, stripe stop bars and revise pedestrian signage where necessary to increase conspicuity of pedestrian crossing areas and stopping requirements and increase pedestrian awareness at the intersection.

Cost: $12,000

Recommendation: Reconstruct curb ramps to align with crosswalks and to include detectable warning panels for the persons with visual impairments.

Cost: $19,000

Recommendation: Restrict parking within 30 feet of the intersection (applicable to the north and south approaches) to minimize conflicts between vehicles parked adjacent to the intersection and right-turning traffic at the intersection.

Cost: $100

Recommendation: Restrict parking in the Dragon Wall and Chopstix Asian Bistro parking stalls that requires motorists to back out into 2nd Street to exit or block entrance onto the property as motorists back out of parking stall. This may require a completely revised parking layout to meet the City's parking standards.

Cost: Dependent upon scope of parking revisions.

Recommendation: Remove uncontrolled curb ramps within the functional area of the intersection to promote crossing at the controlled signalized crossings rather than uncontrolled locations that may interfere with motorist expectancy.

Cost: $3,500

Total Cost for Short-Term Improvements: $51,600 (does not include non-engineering improvements)

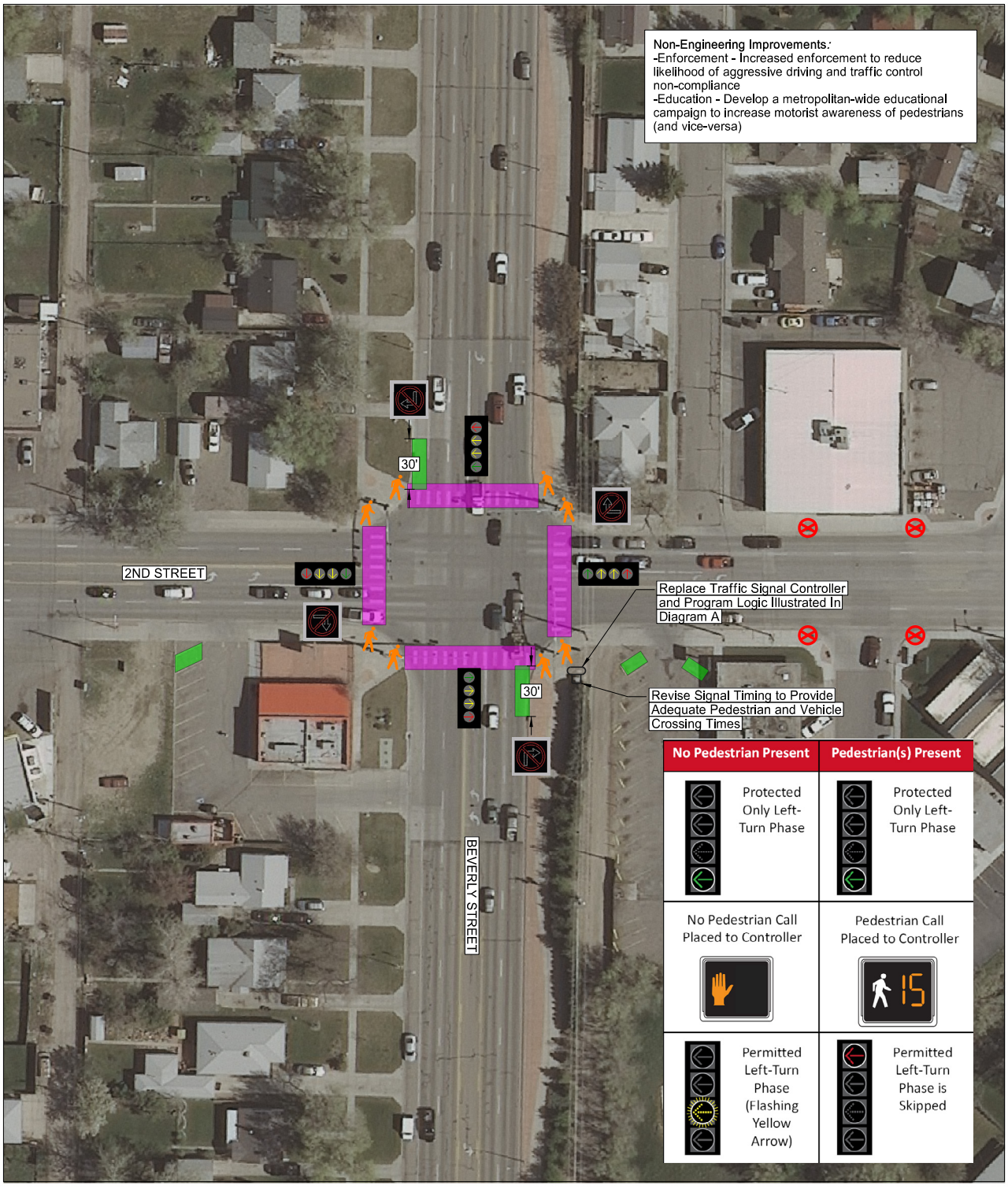

FIGURE 6-3
Short-Term Improvement Plan

Figure 6-3 – Short-Term Improvement Plan

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CHAPTER 7: CONCLUSIONS

The intersection of Beverly and 2nd Street is a complex mix of competing needs: multimodal safety, traffic operations, neighborhood cohesiveness and property functionality. To address safety concerns, a range of short-term improvements were developed for immediate implementation. To incorporate future traffic operations deficiencies while limiting property impacts, a full build-out to a bowtie intersection is a potential solution that is recommended to be studied further when funding becomes available and roadway rehabilitation is necessary.

ALIGNMENT WITH MAP-21 GOALS

This report was developed to meet the seven performance goals as outlined in MAP-21. Not only does this approach comply with legislative mandates, but it provides benchmarks for internal, local, national and peer urban area comparative analysis. Below is a summary of how each performance goal was accounted for during the planning process.

Safety: Recommendations were developed during the project to improve pedestrian, bicycle and vehicular safety at the study intersection based upon the results of a Road Safety Audit and historic crash analysis. Improvements ranged from short-term high-impact solutions intended to improve the highest risk safety issues and long-term solutions intended to alleviate all other remaining safety concerns.

Infrastructure Condition: Recommendations were developed to improve existing infrastructure including traffic signal control components, pavement markings, sidewalks and curb ramps. Additionally, the long-term improvement implementation strategy was developed to coordinate construction with future infrastructure rehabilitation projects to optimize infrastructure life cycles and minimize project costs and traffic impacts experienced during construction.

Congestion Reduction: Although the project's intent was to develop safety improvements for the study intersection, impacts to traffic operations were studied for each safety alternative and congestion reduction alternatives were also independently studied.

System Reliability/Freight Movement and Economic Vitality: Studies have found traffic incidents are responsible for as much as 25 percent of delays experienced on major arterials in the United States. By dually reducing crashes and improving overall intersection operations, system reliability, freight movement and economic vitality will all benefit. It is important to note neither 2nd Street nor Beverly Street are major freight corridors.

Environmental Sustainability: Although the natural environment is not a major project component, providing safety and operational improvements while preserving existing businesses and homes around the intersection were factored into all improvement decisions.

Reduced Project Delivery Delays: The report was developed based upon procedures and guidelines presented by the FHWA's HSIP in an effort to implement the project at an expedited pace. This approach is intended to reduce the time between planning and implementation. The HSIP program emphasizes a data-driven, strategic approach to improving highway safety through infrastructure-related improvements. To provide a data-driven approach, extreme detail was given to provide statistical evidence for each recommendation in this report, minimizing the need for additional analysis during the project development phase of future projects generated by this report.

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APPENDIX A: STUDY ASSUMPTIONS

Although this study relied on the best data available at the time of the report, planning 20+ years into the future relies on a myriad of variables and uncertainties. This appendix is intended to increase the transparency of the assumptions made during the study while separating these highly technical items from the body of the report to increase overall report readability. Below is a summary of the assumptions used during the study.

Model Calibration

Calibration is a critical aspect of developing a reliable model. For example, the FHWA found that calibration differences of 13 percent in the predicted speeds for existing conditions increased to differences of 69 percent in the forecasted speeds for future conditions. Traffic control signal operations were calibrated to queue length field data collected during the peak hours. Roundabout operations were calibrated to the roundabout capacity curves in the Highway Capacity Manual.

Signal Timing and Optimization

To provide signal coordination on 2nd Street it is necessary that each signal along the corridor have the same cycle lengths or a multiple of the cycle length (i.e. half cycle). Corridor cycle lengths are typically dictated by the intersection with the highest conflicting traffic volumes as this intersection requires the longest cycle length. Wyoming Boulevard is the only intersection along 2nd Street with higher traffic volumes than Beverly Street; however, Wyoming Boulevard is maintained and operated by WYDOT and is not planned for future coordination with 2nd Street. As such, the intersection of 2nd Street and Beverly Street will likely dictate the corridor cycle length through 2035. As such, no considerations of other intersections were given during signal timing development. Future consideration of other corridor-wide improvements may need to consider progression analysis with other traffic signals.

Cost Benefit Analysis Assumptions

The following assumptions were made to develop the cost benefit analysis documented in the *Final Improvement Strategy* chapter of the report:

- According to the National Safety Council, associated costs of a traffic fatality, nonfatal disabling injury and property damage crash were $1,420,000, $78,700 and $9,100 respectively.
- Rear-end crash reductions were directly associated with reduction to queue lengths.
- Future crash susceptibility was assumed to increase at the same rate as traffic volumes increased. This included injury/fatality crashes which, due to the small sample size, are much more prone to statistical regression. However, these types of crashes are extremely sensitive and were therefore handled conservatively.
- Inflation data from the past 25 years was used to project an inflation rate of 1.03% annually through 2035. This data is sourced to the Bureau of Labor Statistics.
- US Census Bureau median earning for workers data was used to estimate hourly wages for the purposes of lost time in productivity calculations. It was assumed the typical worker averaged 40-hour work weeks.
- Turning movement count and daily traffic data was used to correlate the peak-hour to the daily traffic volume. The WYDOT 2012 Automatic Traffic Recorder Report was then used to correlate the daily delay benefits to weekly, monthly and yearly benefits.
- Maintenance and operations benefits were based upon KLJ experience with a myriad of traffic signal systems.

Cost Estimates

Cost estimates were developed using the following information:

- Wyoming Department of Transportation average costs.
- Typical costs from historical KLJ project experience.
- Design assumptions provided by City of Casper Engineering staff.
- Right-of-Way costs from historical KLJ project experience from projects in the region and projects with similar characteristics and contexts.

Traffic Volumes at the Intersections of Beverly Street with 1st and 3rd Street

To fully evaluate this configuration, these upstream intersections need to be considered. Collecting data at adjacent intersections was beyond the scope of this report. For preliminary analysis, turning movement counts were estimated using average daily traffic counts, peak-hour distributions from the data collected at the Beverly and 2nd Street intersection and an estimation of daily traffic patterns based upon roadway use and regional traffic volumes. If this alternative is carried forward, it is recommended that turning movement counts be collected at these intersections to validate assumptions.

Traffic Forecasts at the Intersections of Beverly Street with 1st and 3rd Street

Traffic forecasts at the intersections of Beverly Street with 1st and 3rd Street were developed using the same methodology as for the intersection of Beverly with 2nd Street. The major difference being that the travel demand model only forecasts volumes on roadways functionally classified collector or greater. Thus, both approaches of 3rd Street and the east approach 1st Street with Beverly Street do not have forecasted traffic volumes. However, these roadways only carry local traffic and are fully built out. As such, zero growth is forecasted on these approaches. It is important to note that 3rd Street did not have daily traffic counts so estimates based upon a review of similar adjacent corridors were used.

Future Traffic Control at the Intersections of Beverly Street with 1st and 3rd Street

For a consistent comparison, the bowtie intersection must be compared against a no-build alternative that includes the upstream Beverly Street intersections with 1st and 3rd Streets. It is important to note that as traffic volumes increase along Beverly Street, the more likely the intersection of 1st Street (minor arterial) with Beverly Street (minor arterial) will warrant a traffic control signal.

The MUTCD includes nine warrants used to determine whether a traffic control signal is merited at a particular intersection. The warrants include standards for a number of unique scenarios; however, the only warrants applicable at this intersection were the Eight-Hour Vehicular Volume, Four-Hour Vehicular Volume and Pedestrian Volume warrants.

To estimate whether a traffic signal is warranted at this location, hourly traffic distribution data from local Automatic Traffic Counters (ATR) was analyzed to estimate eight hours of turning movement count data at the study intersections. Hourly distribution data is available at a limited number of locations throughout the state so the location with the most similar characteristics was utilized. This location was at Wyoming 255/Center Street at the railroad overpass because it is the only location within Natrona County with ATR data that is functionally classified as an urban minor arterial similar to both Beverly and 1st Street.

Typically, right-turning traffic is not included in warrant analysis. The rationale for this practice is these movements are usually made relatively easily, have minimal conflicts and therefore do not require a traffic signal to minimize delay or improve safety. Without the right-turns included in the analysis, the intersection of Beverly Street with 1st Street is not anticipated to meet traffic volume warrant thresholds until after the year 2030. Where substantial amounts of delay are experienced for right-turning traffic, many times 50% of the right-turning traffic is included in the analysis. If 50% of the estimated right-turning traffic is included in the analysis, then a traffic signal is warranted under existing conditions. For consistent comparative analysis between existing and future scenarios, it was assumed that a signal was installed at this upstream intersection during every baseline scenario.

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TRUSTED ADVISOR.

KLJ delivers quality and accuracy you expect from a trusted advisor and dedicated partner.

REGIONAL EXPERTISE.

KLJ is dedicated to improving the health, safety and welfare of our communities.

KLJ