August 2022

LOVELAND CITYWIDE

Roadway Safety Study

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INTRODUCTION

Roadway safety is a critical element to the mobility, security, livability, economics, and overall well-being in a community. The City of Loveland, Colorado endeavors to be a community where travel using any mode is safe and comfortable. Reducing the number and severity of crashes is a priority.

CITYWIDE SAFETY STUDY

In fall 2021, the City of Loveland's Traffic Operations Division began a Citywide Roadway Safety Study – a science based approach to roadway safety. The Study creates a proactive, holistic transportation safety framework and involves several components:

- A data-driven process to review, evaluate, and analyze roadway safety information,
- A public outreach process to gather roadway safety comments and concerns from community members,
- A roadmap of action items across multiple safety strategies to improve safety, and
- A process for ongoing and future safety reviews and evaluation.

The data review and public outreach processes have been previously completed and detailed in their own publications. This document serves as the 'roadmap' for continuous improvement related to safety. It includes the 'what' should be done, the 'where' the priorities lay, and the 'how' in terms of programs and partnerships. This document services as a comprehensive roadway safety action plan.

The effort ties into previously completed planning efforts / documents, including the transportation master plan called ***Connect Loveland***.

STAKEHOLDER COMMITTEE

The overall study was guided by a project management team, and stakeholder committee, whose members are shown in ***Table 1.***

The stakeholder committee was comprised of a broad range of professionals involved in transportation, with the goal of providing varying perspectives and experiences related to transportation. The Committee met three times, at the start of the project to develop the vision and goals for the project, in the middle of the project to review the data analysis and **Roadway Safety Summary**, and towards the end of the project to review the draft **Roadmap to Safety**.

Table 1. Citywide Safety Study Team

Project Management Team

Matt Ruder, Loveland Traffic (PM)
Nathan Beauheim, Loveland Traffic
Katie Guthrie, Trans Dev, Planning & Policy
Dave Klockeman, Transportation Engineering
Jodi Lessman, Loveland Public Works
Mike Halloran, Loveland Police Department

Stakeholder Committee Members

Bryan Harding, Loveland Parks and Rec
Marilyn Hilgenberg, Loveland Parks and Rec
Troy Bliss, Loveland Development Services
Jan Burreson, Loveland Police Department
Dustin Waldorf, Loveland Fire Rescue
Mike Larson, Thompson Valley EMS
Candice Folkers, City of Loveland Transit (COLT)
Bill Gleiforst, Larimer County Engineering
Matt Payne Thompson School District Transportation
Lesa Post, Thompson School Dist. Safety / Security
Katrina Kloberdanz, CDOT R4 Traffic
Rebecca Porter, CO Div Vocational Rehabilitation
Cate Townley, CDPHE

Consultant Team

Joe Olson, Next Phase Engineering
Martina Wilkinson, Next Phase Engineering
Alex Larson, Olsson
Jenna Friesen, Olsson
Taylor Plummer, Olsson

GOALS

The overall vision and goal of the project, as well as the sub goals, were developed by the Stakeholder Committee through a collaborative process and guides the entire project. See ***Table 2***.

Table 2. Project Vision and Goals

Project Vision:	**Loveland is a community where travel using any mode is safe and comfortable.**
Project Goal:	Reduce the number and severity of traffic crashes in Loveland.
Goal for Project Success:	Generate awareness around transportation safety and create an understanding that everyone plays a role in implementing realistic solutions for all modes of travel.
Goal for Education and Communication:	Develop an ongoing and engaging education campaign that is tailored to specific users with the message that everyone contributes to and benefits from a safe transportation system.
Goal for Emergency Response:	Safely reduce incident clearance time and delay to the public using technology, information sharing, and strong partnerships.
Goal for Enforcement:	Apply a data-driven approach and use tools to provide education and appropriate enforcement.
Goal for Engineering Infrastructure:	Use historical crash data to improve problematic locations and inform planning documents and engineering standards for the future.
Goal for Policies and Programs:	Systematically incorporate safety considerations into Loveland's standards, policies, and programs across all travel modes.

KEYS TO A SUCCESSFUL SAFETY PROGRAM

Roadway safety is complex, with a wide variety of elements that contribute to the number and severity of crashes. Likewise, the ability to positively impact safety is also multi-faceted. The overall keys to a successful safety program are detailed below, and many of these topics are discussed in subsequent sections of this report.

A ROBUST DATA FRAMEWORK

Complete, consistent, and current data is needed to make analysis as relevant as possible. This requires a strong partnership between City of Loveland Police Department and the Traffic Division. The deployment of the new DR3447 traffic crash form by the state of Colorado in the last year offers an opportunity for more detail, but also challenges in its complexity. More information on data-based action items is included later in the report.

GOOD RESOURCES, APPROPRIATELY APPLIED

There are numerous resources available that speak to roadway safety. It is important to utilize well-developed plans, peer reviewed research, and current best practices. An understanding of the strengths and weaknesses of each resource is key to applying the information appropriately.

For instance, the CDOT Strategic Safety plan is excellent for identifying overall strategies, initiatives, and targets, but is not detailed in terms of specific engineering or operational items for a local entity. The Federal Highway Administration (FHWA) Highway Safety Manual is most appropriate for the statistical methodology to evaluate locations. The Crash Modifications Clearinghouse is a helpful source for potential countermeasures, but generally does not provide context for a particular measure's crash reduction potential.

Appendix D includes a toolbox of countermeasures to be considered depending on the type of safety concern and includes both applicability and considerations for each countermeasure.

SYSTEMS-BASED APPROACH

Historically, roadway safety was often a reactive, spot review after a particular concerning event or pattern. It is now understood that there is more success when a proactive, comprehensive approach is used - one that is continuous and utilizes foundational elements of safety from a broad range of measures. Many resources (such as Federal Highway Administration's Local Road Safety Process, the Highway Safety Manual, and various Vision Zero Action Plans), recognize that a proactive systems-based program is best, generally reflected in the categories shown in ***Figure 1***.

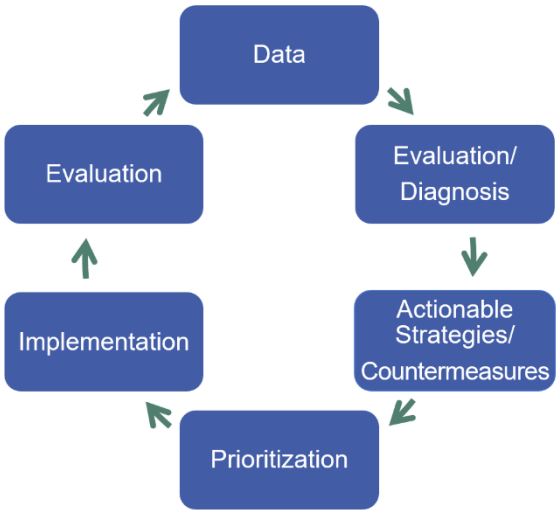


Figure 1. Systems-Based Elements

UTILIZING ALL THE "E"S

The transportation industry has used the "E"s of transportation safety for many years. The original "E"s included **engineering** (physical elements - transportation design, infrastructure and operations), **education** (information and programs to teach / inform the community), and **enforcement** (partnering with law enforcement to address traffic concerns and compliance) as the major components in impacting roadway safety. In recent years, additional "E"s have been added to reflect the complexity of safety and the importance of a continuous systems-based approach. **Encouragement** (using events and activities to promote safety among all modes), **evaluation** (planning, research and analysis), and **equity** (ensuring efforts benefit all demographic groups) are now also often utilized. All of them contribute to the overall safety of the system, and elements of all these "E"s are incorporated into this Roadmap to Safety.

COLLABORATION AND INCORPORATING VARYING INTERESTS

Roadway safety is impacted by everyone, from planners, to engineers, maintenance crews, law enforcement, and all road users. There are often various jurisdictions, and special interest groups such as school districts that also play a role in safety. Each group perceives safety through their own lens, yet they all share the common vision of fewer severe crashes.

The intentional partnerships among the groups is paramount, and many of the sections in this document detail the ongoing and continuous collaboration needed to support and improve roadway safety, including:

- The **Police Department** is responsible for the completion of the crash report. This has become computerized in recent years, and there was the recent implementation of a new statewide form. Police Department staff and Traffic Division staff are working together on how to transfer the data, maintain quality control, as well as understand completeness and consistency in how the form is filled out.
- **Other City Departments and / or Public Works Divisions** including planning, engineering, development review, parks, transit, maintenance, public information, and city leadership all have a role in supporting roadway safety.
- Other Jurisdictions such as the **Colorado Department of Transportation (CDOT) and Larimer County** have an opportunity to support safety through their own roadways, funding, standards, etc.
- **Thompson Valley School District** has over 14,000 students that travel to / from school each day. Their contribution to and consideration of traffic circulation patterns, including walking and bicycling routes is important.
- Emergency Services such as **Loveland Fire Rescue Authority and Thompson Valley Emergency Medical Services** play a critical role in responding to traffic crashes. Their skills, practices, and policies all influence minimizing impact of a crash.

The perspectives, input, and efforts from all these stakeholders are important elements to a systems-based program that improves safety.

DATA DRIVEN

The priorities and decisions made in connection with the Safety Study should focus on “Moving the Needle”, meaning to reduce the number and severity of crashes. The most successful programs use data to identify safety concerns and to measure the impact of countermeasures that are implemented.

Moving The Needle

UTILIZE FIELD-BASED ENGINEERING JUDGEMENT

The final key to a successful safety program is that effort must be more than a plan on paper – it must be actionable, realistic, and provide specific guidance for field implementation.

BUILDING ON CURRENT EFFORTS

It is important to note that there are many positive safety-based efforts already underway in the City of Loveland. A small sample of this includes:

- The support for roundabouts in the City, which are statistically safer than other forms of traffic control;
- The strong working partnership between the Police Department and the Traffic Division for the sharing and evaluation of data; and
- The efforts within the Traffic Division to address safety concerns. Examples include: work to eliminate negative offset left turn lanes, installing reflective backplates on signal heads, implementing flashing yellow arrows, adding leading pedestrian intervals, and adjusting striping and lane configurations.

These are just a few examples of many that illustrate that the commitment to roadway safety is not new in the City. Numerous efforts have been (and are currently) in process. The City’s interest in, and support for the Citywide Roadway Safety Project alone speaks to the priority placed on safety. This document re-iterates some of the good work already occurring and builds on those effort to further improve safety.

INFRASTRUCTURE

As noted earlier, one of the "E"s in transportation safety programs is engineering. This category represents the elements of transportation including design, infrastructure and operations. This section of the Roadmap lists infrastructure improvements at locations with identified traffic crash histories / patterns that can be addressed with physical changes – such as lane changes / additions, or how an intersection is operated. The Citywide Roadway Safety Study reviewed both intersections and corridors, with the outcomes detailed below.

INTERSECTIONS

The analysis of intersections began with the assignment of facility identification numbers for 596 intersections, so that crash reports at a specific intersection can be easily compiled regardless of whether there are small variations in how the location is referenced in the report. The locations were then reviewed, and those with multiple crashes were populated into an intersection screening spreadsheet. The spreadsheet uses a statistical approach that considers traffic volumes, intersection types and geometry to calculate 'expected crashes' and compares that to actual crashes to determine whether a location is experiencing more crashes than what would be expected. 162 intersections were evaluated and ranked based on a monetized metric called "Excess Crash Cost".

TOP 25 INTERSECTIONS

The intersection screening process resulted in a list of intersections ranked by those with the most excess crash cost – meaning locations that are experiencing significantly more crashes in number and / or severity than what would typically be expected given an intersection's volumes, geometrics, and control. The concept is that these locations are those which may have the most potential to reduce the number and severity of crashes. One focus area for this Roadmap to Safety is the list of the top 25 Intersections in Loveland. Each was reviewed, and the results represent the bulk of the infrastructure based recommendations for safety improvements.

Table 3 shows the top 25 intersections, how they were evaluated, and the outcomes based on that evaluation. Efforts included (with some intersections in multiple categories):

- Sixteen of the locations (generally the highest-ranking intersections) were evaluated through a comprehensive roadway safety audit.
- Three intersections had been recently improved (two with new control: 1 signal, 1 roundabout).
- Three intersections have capital projects in process whose designs will be reviewed through a safety lens.
- Seven intersections were selected for concept designs.
- The remaining five intersections (generally lower ranked locations) underwent a quick review to determine whether short term, low cost options were evident.

There were an additional four intersections that are shown at the bottom of ***Table 3*** that underwent either a concept design or safety audit. These intersections, while not in the top 25 in terms of excess crash costs, were selected based on a combination of public concern, crash trends, and / or staff knowledge of safety challenges that might be mitigated through review.

The outcomes columns in ***Table 3*** are the action items identified to support safety at these locations. They are divided into four categories:

- Design / Construction changes. These are larger scale construction based changes and may include major capital projects, reconstruction of channelized islands, signal construction etc. They typically will require a planning or design process, identified funding etc. The intersections for which concept designs were completed are listed in this category.
- Short Term, Low Cost Action. These are action items that can be addressed through shorter term, lower cost efforts, some of which might be able to be funded through ongoing operations, maintenance budgets. This

may include striping changes, signal head adjustments, etc. It also includes the efforts associated with reviewing capital project design plans.
- Operational Action. These are items that are specific to traffic signal timing and can be addressed by Traffic Division staff.
- Longer Term Items. This last column captures action items that are on longer lead times, depend on others (policy changes or development), awaiting maintenance schedules such as pavement overlays, or potential additional solutions to consider if the lower cost, shorter term action items do not result in meaningful reduction in crashes.

ADDITIONAL INTERSECTIONS

During the citywide safety summary analysis, there were several locations that did not rank in the top 25 intersections but were identified with a specific type of crash that warranted additional review. The locations were identified through both a pattern recognition process (which evaluates the percentage of a specific type of crash to determine whether it's more prevalent than expected), and through simple numbers of crashes. These intersections are listed in ***Table 4***. A review was completed at each location, looking at the crash patterns and details, geometry, volumes, etc. to determine whether there are specific countermeasures or recommendations at these locations that support greater safety.

Of the 26 additional locations, many do not indicate a specific crash pattern, and are recommended for continued monitoring. Four locations are identified for a comprehensive safety audit. These are locations with a complexity of crashes, where a thorough review is warranted. Finally, there are several locations where there are recommendations to consider refinement of left turn phasing.

GEOMETRIC CONCEPT DESIGNS

Specifics related to the ten geometric designs completed through the intersection reviews are included in ***Appendix A***. Each location is shown with relevant information / data, including a general layout and planning level cost estimates.

CORRIDOR REVIEWS

The final infrastructure related review was along ten corridors in the City. These segments of arterial roads were selected during the Roadway Safety Summary process, and represented locations where mid-block concerns were identified, or where there are a series of spot locations for review in proximity. The list of corridors, their start and end points, considerations, results of the review and specific next steps / recommendations are shown in ***Table 5***.

As discussed in the Safety Summary, 70% of crashes occur at intersections, and the corridor reviews reiterated that the locations of concern, and potential for safety based refinements are generally located at intersections.
- Three of the corridors included intersections where official safety audits were completed.
- One corridor has two intersections that are recommended for future safety audits.
- Three corridors in the downtown area are locations where the City has already recognized the need for studies.

Recommended action items for Infrastructure efforts:

1. Use Tables 3, 4, and 5 to guide action items at various locations.
2. Use the information in Appendix A for concept designs at 10 locations.

Table 3. Top Intersections – Safety Based Action Items

	Rank	Fac ID	Intersection: North-South Street	Intersection: East-West Street	Additional Review	Outcomes: Design/Construction	Outcomes: Short Term, Low Cost Action	Outcomes: Operational Action	Outcomes: Longer Term Items
Top 10 intersections	1	38	S Taft Ave	14th St SW	Safety Audit	Concept Design N/S double lefts, refine WB right			
	2	39	S Lincoln Ave US 287	14th St SE / SH 402	Safety Audit			Check clearance intervals Consider protected only lefts	Advocate for capital project-double lefts Advocate for red light cameras
	3	7	N Garfield Ave	E 29th St	Safety Audit		Trim trees for EB signal visibility		
	4	5	N Taft Ave	W 29th St	Safety Audit	Concept Design Use gore for WB double left	Restripe Eliminate N/S negative offset lefts	Consider protected only lefts	
	5	1	N Garfield Ave US 287	E 37th St	Safety Audit	Concept Design NB double lefts			
	6	15	N Taft Ave	W Eisenhower Blvd US 34	Safety Audit	CIP project design in process	Review CIP design for safety		
	7	13	N Wilson Ave	W Eisenhower Blvd US 34	Safety Audit		Reallocate road width (City effort underway)	SB right turn overlap Longer EB left turn phase	
	8	52	N Garfield Ave US 287	E 57th St	Safety Audit		Restripe Eliminate N/S negative offset lefts	Check vehicle extension, E/W detection Check splits/offset (use Max times) Consider protected only phasing if issue persists	
	9	84	N Garfield Ave US 287	W 65th St	Safety Audit			Lag the NB left turn	
	10	75	S Boise Ave	E 1st St	Safety Audit		Add 2nd overhead signal heads for E/W Add reflective backplates		
Next 15 intersections	11	57	N Garfield Ave US 287	W 45th St Knobcone Dr	Safety Audit	Concept Design Channelizing Island SE corne	Restripe Eliminate N/S negative offset lefts	Add E/W LPI Check offsets for arrivals at end of phase	
	12	353	S Taft Ave	10th St SW	Safety Audit	Concept Design Channelizing Island NW corn	Delineator glare screens for NB through traffic		Restrict NB left turns to simplify
	13	301	N Wilson Ave	W 57th St	Signal recently installed				
	14	14	N Van Buren Ave	E Eisenhower Blvd US 34	Safety Audit	CDOT reconstruct in 2024	Review CDOT design for safety		
	15	661	Washington Ave	E 1st St	Safety funding for signal	Concept Design E/W left turn lanes	Restripe to add E/W left turn lanes		
	16	55	N Wilson Ave	W 29th St	Safety Audit		Monitor SB approach turn crashes	Add E/W LPI Split adjustments, add time for EB/WB	
	17	34	N Taft Ave / S Taft	W 1st St	Safety Audit	Concept Design Channelizing islands all corners	Add advanced detection	Adjust progression speed	Advocate for red light cameras
	18	37	S Taft Ave	W Carlisle Dr	Safety Audit		Reflective backplates	Add E/W LPI Evaluate coordinated offset	
	19	22	N Taft Ave	W 8th St	Quick Review AT 7 INJ 7 Pattern: NB left turn AT crashes		Eliminate NB negative offset left	Consider protected only phasing if issue persists	
	20	215	Rocky Mountain A	Foxtrail Dr	Quick Review Sideswipes/RA crashes		Monitor- no current recommendations		Complete visibility and striping review if crashes persist
	21	224	N Monroe Ave	E 37th St	New Roundabout				
	22	774	CR 9E	14th St SE / SH 402	Quick Review SB left turns hitting WB Likely shadowing issue	Check for signal warrant			
	23	459	Madison Ave	E 7th St	Quick Review 6 crashes WB RA		Improve WB stop sign visibility Consider red curb/no parking along Madison		
	24	90	S Boise Ave	14th St SE / SH 402		CDOT reconstruct in 2024	Review CDOT design for safety		
	25	19	N Monroe Ave	E Eisenhower Blvd US 34	Quick Review WB RE crashes		Monitor - no current recommendations		
Other	29	773 775	CR 9 CR 7	14th St SE / SH 402	Quick Review	Concept Design WB left turn lanes			Advocate for improvements w/ developme Advocate for improvements w/ CDOT
	45	686	Eagle Dr	14th St SW	Safety Audit	Consider signalization			
	--	514	Boyd Lake Avenue	CR 20E	Quick Review	Concept Design SB, WB left turn lanes			
	--	537	Namaqua	W Eisenhower US 34	Quick Review	Concept Design Better turning radius, bike lanes			Concept ready for eventual overlay

Legend:

- 10 High priority locations for review
- Additional locations with potential for crash reduction
- Recently improved intersections
- Project in process
- Other Intersections selected due to public concern or staff knowledge

CR: County Road
SH: State Highway
CDOT: Colorado Dept of Transportation

NB: Northbound
SB: Southbound
EB: Eastbound
WB: Westbound

N/S: North and South
E/W: East and West
LPI: Leading Pedestrian Interval
CIP: Capital Improvement Program

AT: Approach Turn crash
RA: Right Angle Crash
RE: Rear End Crash
INJ: Injury Crash
RLR: Red Light Running

Table 4. Additional Intersections – Safety Based Action Items

Fac ID	Intersection		Crash Types (Number of crashes 2018-2020)						Considerations	Next Step	Specific Recommendation
	North-South Street	East-West Street	Approach Turn	Right Angle	Rear End	Injury Crashes	Bicycles	Ped-estrians			
91	Lincoln	SH 60	12			9			Overall rank #32 - 8 AT with 5 INJ for SB lefts, high speed		Coordinate w/ CDOT -protected only left turns
17	Cleveland	Eisenhower / US 34	9	10	21	8	1	1	Recently refined with striping	Recommend official safety audit	Consider lagging left for WB left
18	Lincoln	Eisenhower / US 34		5	21		2		Not as bad as Cleveland / US 34	Recommend official safety audit	
46	Redwood	Eisenhower / US 34	10		11	9			Overall rank #37. RLR, neg offset, long NB queues	Recommend official safety audit	
68	Garfield	71st	4			5			1 approach turn fatal w/ motorcycle		Consider protected only left turn phasing due to speeds
21	Boise	Eisenhower / US 34	16	10	31	9			Very busy, 16 RE crashes N/S, 16 RE crashes E/W	Recommend official safety audit	Consider left turn phasing review
76	Crossroads	Centerra/Fairgrounds	3		24				NB right turn a merge, not an accelerlation lane		Geometric review of NB right turn channelizing island
80	Centerra	Kendall Parkway	6		6	4			NB left turn visibility? Maybe SB RLR	Additional review recommended	Additional review recommended
58	Lincoln	29th			9			2	No pattern to ped crashes	Monitor	Check for N/S LPI
61	Wilson	43rd				5			Visibility of NW corner	No pattern, monitor	
63	Wilson	1st	5							No pattern, monitor	
347	Taft	10th		4					HSIP $ for SE corner - several crashes misplaced	No action recommended	
41	Garfield	Orchards	9	4	12				Overall rank #33, REs dispersed, busy	No pattern, monitor	
4	Buchanan	Garfield	4							No pattern, monitor	
8	Buchanan	29th	14	4	17	10			A lot of everything 9 N/S ATs	Monitor	
391	Cleveland	15th		12					Highest RA crash location in city - recently restriped	Monitor as it may have been addressed	
373	Lincoln	16th					2		Riding against traffic on sidewalk on east side	Monitor	
627	Washington	Eisenhower / US 34			6				Request to prohibit NB left turn	Monitor	
595	Silverleaf	29th		5					Large, unsignalized intersection - close privacy fences	Monitor	
651	Tyler	1st					2		No pattern to bike crashes	Monitor	
87	Madison	1st					1	1	EB bike/ped riding against traffic-conflicting w/ SB right turn	Monitor	
45	Madison	Silverleaf	3							Monitor	
453	Madison	16th		5					Variety of crashes - no distinct pattern	Monitor	
497	Denver	11th		4					All EB left turns conflicting w/ SB through (shadowing)	Monitor	
3	Duffield	37th	3			3			Request for E/W left turn lane	Monitor	Consideration for a road diet on 37th
569	Grant	37th		4		2			Very tight turn onto 37th. No pattern	Monitor	

Legend:

NB: Northbound
SB: Southbound
EB: Eastbound
WB: Westbound
N/S: North and South
E/W: East and West
LPI: Leading Pedestrian Interval
CDOT: Colorado Dept of Transportatio
AT: Approach Turn crash
RA: Right Angle Crash
RE: Rear End Crash
INJ: Injury Crash
RLR: Red Light Running

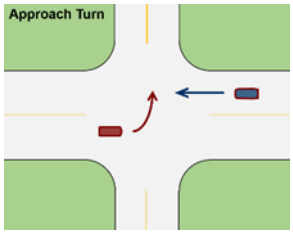
Table 5. Corridor Reviews – Safety Based Action Items

Corridor	Start Cross Street	End Cross Street	Considerations	Result	Specific Next Step / Recommendations
Wilson Ave	57th Street	Eisenhower	Arterial speeds, 3 ped fatalities Series of high ranking intersections	City is working on this corridor Recent Improvements: New signal at 57th, sidewalks Safety audits done at 2 locations, additional review at 43rd No additional recommendations at this time	
Taft Ave	Eisenhower / US 34	8th Street	Tight geometry , lack of turn lanes Lack of turn lanes	No crash pattern related to lack of turn lanes No recommendations at this time	
US 287	Orchards	29th Street	Very busy area / intersections Approach turn crashes	Trend indicates improving safety No recommendatinos at this time	
US 287 "Box Review"	15th to 13th	Garfield to Washington	Some recent refinements made SB Cleveland.	Major intersections (US 287 at SH 34) included in additional intersection reviews	Recommending official safety audit for 2 major Intersections. Note that audits should include approaches (+ about 1 block).
SB US 287 (Cleveland)	Eisenhower / US 34	7th Street	Review options for a road diet		City has a planning study planned to evaluate this option
SB US 287 (Cleveland)	7th Street	1st Street	Public comments, parking, visibility Pedestrian crossing locations		Study completed which recommended crosswalk at 3rd
NB US 287 (Lincoln)	1st Street	7th Street	Public comments, parking, visibility Pedestrian crossing locations		Study completed which recommended crosswalk at 3rd
Madison CFI	15th Street	Nickel	Highest public comment location in City. Complete overall review	No recommendations at this time	
Eisenhower / US 34	Denver Ave	Larimer Parkway	Review for RE crashes Merging / striping review		Recommend corridor review of outside lane striping related to merging areas
29th Street	Taft Ave	Garfield	7 bike crashes in corridor Focus on bike / ped connectivity Custer to Garfield - just 4 lanes, 6 T intersections	Safety audit completed at Taft and 29th Street	Recommend review for bicycle / pedestrian mobility improvements Future consideration could be review for road diet
29th Street	Garfield	Lincoln		Safety audit completed at Garfield and 29th Street Additional review completed at Lincoln and 29th Street Buchanan and 29th is impoving - monitor No additional recommendations at this time	

SPECIFIC CRASH TYPES

As detailed in the Roadway Safety Summary, there are several crash types that are over-represented in severe crashes with injuries. This section looks at two of the most notable crash types and offers specific next steps to positively impact safety.

APPROACH TURNS



In Loveland, approach turn crashes make up 9% of the total number of crashes in the City, but they account for nearly 20% of injury crashes. Because they often result in injuries, they are a high priority for reduction.

Approach turn crashes occur almost exclusively at intersections and predominantly at signalized intersections. Common contributing factors include:

- Miscalculation of the approach speed / distance of approaching traffic. This is often exacerbated by poor sight distance due to offset left turn lanes. See ***Figure 2*** for how opposing left turn lanes can 'shadow' visibility of through vehicles behind them.

- A high percentage of approach turn crashes at signalized intersections occur due to confusion during the phase change interval when left turns are occurring permissively (after yielding to oncoming traffic). Motorists waiting to turn left sometimes turn in front of oncoming traffic during the yellow (or red) interval assuming oncoming traffic can and will stop.

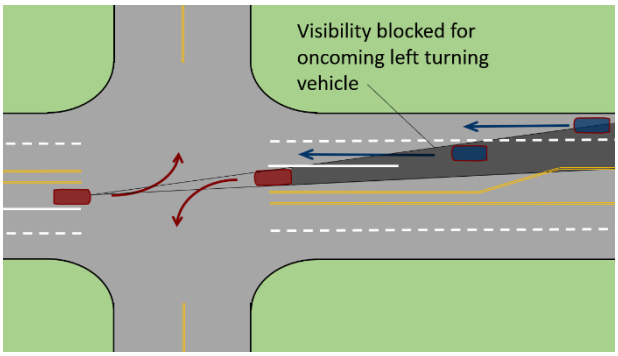


Figure 2. How Left Turn Offsets Can Impact Visibility

There are several countermeasures that can be considered to try to reduce approach turn crashes:

- Prohibit left turns.
- Improve visibility by reducing the negative offset between opposing left turn lanes.
- Install advanced detection to minimize conflicts during the phase change intervals.
- Adjust signal coordination (time relationships between signals) to minimize conflicts during the phase change intervals.
- Install left turn arrows, i.e., change permissive left turns to protected / permissive or protected only left turns.
- Change protected/permissive left turns to protected only left turns.
- Change leading left turn intervals to lagging left turn intervals – especially at T-intersections to minimize conflicts during the phase change intervals.
- Install red light enforcement cameras.

Protected only left turns are an effective countermeasure and may be relatively easy to implement. They are not without disadvantages. They usually increase delay, congestion, driver frustration and may increase other types of crashes – particularly rear end crashes. Analysis of operational impacts and crash tradeoffs need to be considered when determining the appropriate left turn phasing.

One alternative to reduce the negative impacts from protected left turn phasing is to utilize protected lefts by time of day only when they are most needed for crash reduction. This is most viable at intersections equipped with flashing

yellow arrows. Again, careful review of the conditions at an intersection, the crash history and consideration of the pros and cons is needed to make a final determination on the appropriate signal phasing.

Appendix B includes a standardized model left turn phasing evaluation process that can be utilized across the City. The approach is based on recent research and national best practices from the FHWA. It strives to balance the benefits of approach turn crash reduction with potential unintentional safety impacts, and operational considerations.

Note that city staff has long been completing left turn phasing evaluations on an as needed basis. The evaluation tool in ***Appendix B*** builds upon the work already done and enhances it by standardizing the approach and allowing evaluation to be documented and saved.

Recommended action items for Approach Turn crash reduction:

3. Implement the standardized left turn phasing evaluation process in spot locations (such as identified actions from safety audit results).
4. Over time complete a citywide left turn phasing review at all signalized intersections.
5. Continue to systematically reduce / remove negative offset left turn lanes.

VULNERABLE ROAD USERS

People using the transportation system as a person walking, on a bicycle, or on a motorcycle are involved in only 4% of all reported crashes, yet these road users are involved in 55% of all fatal crashes. This indicates that while crash numbers involving vulnerable road users are much lower than traditional vehicle crashes (averaging 18 pedestrian crashes, 21 bicycle crashes, and 36 motorcycle crashes per year), each crash is still impactful, and when they do occur, the crash result is often severe or even fatal, and therefore a high priority for safety considerations.

PEDESTRIAN SAFETY

As detailed in the **Roadway Safety Summary**, most crashes involving pedestrians occur at arterial intersections (more than 80%). The specific locations of the crashes are spread out throughout the City. All locations that experienced more than one pedestrian crash in the last three years (2018-2020) were evaluated for patterns, trends, and potential countermeasures. Those locations are shown in ***Table 6.***

Examples of countermeasures that can be considered for pedestrian safety include:

- Crosswalk evaluations for enhanced marking, signs, and control.
- Leading pedestrian intervals at signals to provide pedestrians a ‘head start’ before the adjacent green for vehicles.
- Protected pedestrian crossing time or change in left turn phasing for vehicles if conflicts exist with left turning vehicles.
- Construction of grade separated crossings (i.e., underpasses) of the busiest arterials.
- Sidewalk construction to eliminate sidewalk gaps.

As noted in the final column of ***Table 6,*** the results of the review of pedestrian crashes are included in other, overlapping efforts including the safety audits, corridor reviews, and additional intersection review. (Note that there is also a pedestrian related recommendation made as a part of the bicycle safety review along 29th street (see ***Table 8***).)

Table 6. Pedestrian Safety Location Review

Fac ID	Intersection		2018-2020 # Ped crashes	How Reviewed
	North-South Street	East-West Street		
	Wilson corridor - 57th to Eisenhower		3 Fatal	A part of corridor reviews
1	Garfield	37th	2	Safety audit completed
58	Lincoln	29th	2	Reviewed with additional intersections
15	Taft Ave	Eisenhower Blvd / US 34	2	Safety audit completed

One of the countermeasures noted above is providing protected pedestrian crossing time at a signalized intersection. This separates crossing pedestrians from opposing left turns in time and can be used on a cycle-by-cycle basis. Locations that may be well suited for this treatment include locations with significant pedestrian / bicycle crossing volumes, higher left turn volumes, and the presence of flashing yellow arrows. There are three locations in Loveland where this type of treatment may be appropriate, and they are listed in ***Table 7.*** None of the locations has a vulnerable road user crash pattern, but this treatment would serve as a pro-active measure to support safety. Note that the use of an audible signal with the pedestrian push button is recommended for these crossing to notify pedestrians with visual impairments when the crossing signal is on.

Table 7. Additional Pedestrian Improvements

Fac ID	North-South Street	East-West Street	Improvement
60	Wilson Ave	14th St SW	Protected only pedestrian crossing on east leg
65	Taft Ave	57th Street	Protected only pedestrian crossing on west and north leg
89	Denver Ave	1st Street	Protected only pedestrian crossing on north leg
	Trail crossing Boise Ave at the Loveland Canal Trail S of US 34		Center refuge median with center posted RRFB

There is an at-grade trail crossing of Boise Avenue south of Eisenhower at the Loveland Canal where there was substantial public concern about yielding behavior of motorists. There is an opportunity to add a center refuge island and post the lighted Rectangular Rapid Flashing Beacons (RRFBs) in the median, which should improve compliance. This improvement is also listed in Table 7.

For locations where a high use trail must cross a higher speed, higher volume arterial roadway, the use of a grade separated crossing such as an underpass may be most appropriate. These facilities support safety in that they completely separate the vulnerable road users from potential vehicular conflicts. The City's Transportation Master Plan Connect Loveland provides details on efforts surrounding grade separations.

Finally, education efforts for both pedestrians and motorists are an opportunity to reiterate legal and respectful behavior as various modes share the roadway space. Pedestrians ages 10-19 are overrepresented in pedestrian crashes, and they would be a good group to specifically target for education.

BICYCLE SAFETY

Bicycle crashes were also evaluated in the ***Roadway Safety Summary***. Like crashes involving pedestrians, the majority of bicycle crashes occur at arterial intersections. The locations of bicycle crashes are dispersed throughout the City.

All locations that experienced more than one bicycle crash in the last three years (2018-2020) were evaluated for patterns, trends, and potential countermeasures. Those locations are shown in ***Table 8*** together with how those locations were reviewed.

Table 8. Bicycle Safety Location Review

Fac ID	Intersection		2018-2020 # Bicycle crashes	How Reviewed
	North-South Street	East-West Street		
5	N Taft Ave	W 29th St	2	Safety audit completed
38	S Taft Ave	14th St SW	2	Safety audit completed
373	Lincoln	16th	2	A part of corridor reviews
18	Lincoln	Eisenhower / US 34	2	A part of corridor reviews
14	N Van Buren Ave	Eisenhower Blvd / US 34	2	Safety audit completed
	29th Street Corridor - Taft to Garfield		7	A part of corridor reviews, safety audit at Taft
651	Tyler	1st	2	Reviewed with additional intersections

For bicycle safety education, one target is to discourage the practice of bicyclists riding against traffic. Twenty five percent (25%) of all bike crashes involve a cyclist who was riding against traffic in the road (illegal) or on the sidewalk (technically legal). Motorists turning right off a side street look to their left for a gap in traffic, and often never see a bicyclist coming from the right.

MOTORCYCLE SAFETY

Motorcyclists use the same infrastructure as motor vehicles. Countermeasures to support motorcyclist safety include an education campaign to increase awareness of motorcyclists for motorists and encouraging helmet use. Enforcement efforts related to speeding may benefit motorcyclists as well.

Recommended action items to support safety for Vulnerable Road Users:

Pedestrians:

6. Continue constructing sidewalks in locations where there are gaps (see Policy discussion in the next section).
7. Consider pedestrian improvements listed in Table 7.
8. Continue pursuing construction of underpasses of the busiest roadways.
9. Support education campaigns targeted for pedestrians – especially youth pedestrians.

Bicyclists:

10. Continue constructing bicycle infrastructure through ‘complete streets’ approach (see Policy discussion in the next section).
11. Support education campaigns targeted for bicyclists – especially discouraging the practice of riding against traffic.

Motorcyclists:

12. Continue efforts for education and enforcement related to motorcycles.

POLICIES

The City of Loveland has several general practices it uses to approach the planning, implementation, operations, and management of its transportation system. These policies are not necessarily codified or adopted but represent stated objectives or approaches for internal use on how to proceed. Some can have an impact on creating a systemic safety culture and can set the guidance for reduction of crashes.

PEDESTRIAN AND BICYCLE INFRASTRUCTURE

As noted in the vulnerable road user crash discussion in the previous section, pedestrians and bicyclists are at increased risk for injury crashes. A 'complete streets' approach to transportation infrastructure ensures that roadways are constructed to support safety for all people including pedestrians, bicyclists, motorists and transit riders of all ages and abilities.

City of Loveland standards already require consideration of all road users in the design of roadways. A continued focus on how the transportation system works for multiple modes, and how to improve locations with deficiencies is important.

Specific items to support complete streets include:

- The Sidewalk Gap Program has been underway for several years. This includes gaps in infrastructure to access bus stops, as well as civic destinations across the community. This effort, managed by the Transportation Engineering Division has identified locations with missing sidewalks and is systematically making improvements. Staff working on the Sidewalk Gap Program should work with Traffic Division staff so that safety data can be used as one input into the prioritization process.
- More than 80% of bicycle and pedestrian crashes occur on the arterial system at intersections. A dedicated focus on improvements for arterial crossings is supportive of safety. This includes support for the construction of underpasses of the busiest roadways. A review of bicycle and pedestrian facilities should be included in every intersection project, but also consideration given for a citywide review of arterial crossings.

EMERGENCY RESPONSE

Emergency response is a reactive action. This makes improving safety of the transportation system through emergency response more difficult. However, there are a few items, including some that occur once a crash has been reported, that can contribute to the safety of people involved with the crash:

- Consider emergency vehicle access and ease of movement during project design.
- Prioritize safety of responding personnel and victims through equipment placement.
- Reduce incident clearance time to minimize secondary crashes in the backup or on alternate routes.
- Support and encourage the use of emerging technologies for information sharing regarding incidents.

TRAFFIC SIGNAL OPERATIONAL POLICY

Most roadway crashes in Loveland occur at signalized intersections. A traffic signal operational policy focused on safety is an important part of an overall traffic safety program. Consistent application of best practices and proven safety countermeasures can help users know what to expect, can help ensure proper operation and reliability, and can lead to a safer transportation system overall.

The City's Traffic Operations Division is already in the process of documenting operational policies. The audience for the document will be technical staff, primarily in the Traffic Division with the content providing guidance for application of consistent signal timing practices across the City. Elements to consider for inclusion in the policy are listed in ***Table 9***.

Table 9. Content List for Traffic Signal Operational Policy

Signal Installation policies	• When are signals installed?
Signal maintenance policies	• Preventative maintenance schedules • Malfunction notification processes • Response times to malfunctions • After-hours call out policies
Signal operational policies	• Yellow change interval • All-red clearance interval • Pedestrian clearance interval • Operation mode (free vs coordinated) • Left turn phasing type • Use of protected crosswalk signal phasing • Leading pedestrian intervals • Night-flash policy • Timing optimization strategies • Use of adaptive signal timing
Detector operational policies	• Type of detectors • Detector monitoring • Detector repair • Use of advanced detection

Recommended action items for Policies:

Pedestrian and Bicycle Infrastructure:

13. Continue to implement a 'complete streets' approach to transportation system project planning, design, construction, operations, and maintenance.
14. Continue the Sidewalk Gap Program, using safety data as one input to the prioritization process.
15. Focus on evaluation and improvement of arterial crossings for pedestrians and bicyclists.

Emergency Response:

16. Consider emergency vehicle access and ease of movement during project design.
17. Prioritize safety of responding personnel and victims through equipment placement.
18. Reduce incident clearance time to minimize secondary crashes in the backup or on alternate routes.
19. Support and encourage the use of emerging technologies for information sharing regarding incidents.

Traffic Signal Operational Policy:

20. Continue work on the update and details for the Traffic Signal Operational Policy.

PROGRAMS

Programmatic efforts include an outline of structured activities that support roadway safety. There are two main areas for programmatic actions to support roadway safety in the City of Loveland.

EDUCATION AND COMMUNICATION

Creating a 'culture of safety' in the City of Loveland requires participation and engagement from everyone in the community. Making a difference in how safety is perceived, prioritized, and acted upon is a shared responsibility. An ongoing broad-based education and communication campaign is essential to bringing the topic of roadway safety to the forefront and identify the ways that each community member can play a part in reducing the number and severity of crashes.

The purpose of an education campaign is to bring about positive behavior changes through education, increased awareness and encouragement. The messaging needs to be succinct (short and identifying a single 'nugget' of information) and relevant to the target audience. ***Table 10*** identifies some ideas for type of outreach, the target audience, and potential message for that audience. Resources for the messaging of the information can come from local data (i.e., the Roadway Safety Summary), or state and national resources. For instances, National Highway Traffic Safety Administration (NHTSA) offers materials for numerous traffic safety campaigns (See ***Figure 3.*** Visit trafficsafetymarketing.gov).

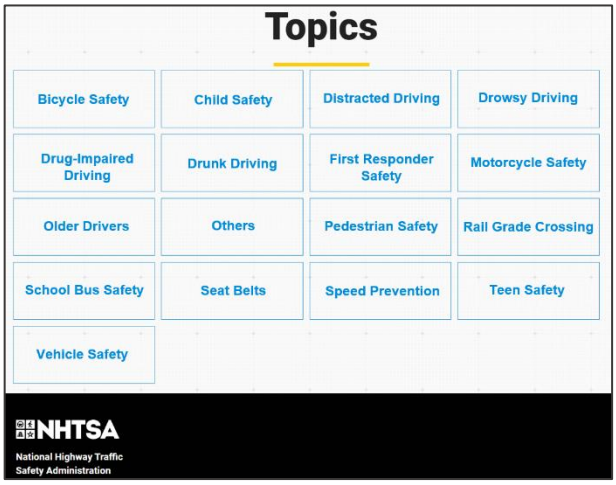


Figure 3. NHTSA Website of Countermeasures

Table 10. Education / Outreach Program Information Ideas

Type of Outreach
Facebook
Snapchat ad campaign
Utility bill insert (City Update)
Community newsletter
Thompson School District based programs (including Safe Routes to School)
Web-based dashboard to show how data informs strategies
Animated videos online / local channel
Programs / presentations to local groups

Sample Ideas for Messaging	
Target Audience	Message
Young drivers	DUI and distracted driving Watching for pedestrians, bicyclists Most frequent crash types
Older drivers	Challenges with left turns
Bicyclists	Don't ride against traffic
Pedestrians	Pressing the ped push button at signals Laws regarding crosswalks
Motorcyclists	Helmet usage
All	Roundabout education Seatbelt usage
Motorists	Look right before turning right (to watch for bicyclists and pedestrians traveling against traffic) Distracted driving Speeds Left turns

It is important to note that a robust education campaign requires substantial and continued time and effort. There should be sensitivity to the fact that no single city staff person or even department has the bandwidth to undertake an ongoing effort. There are two ways to potentially address the challenge of staffing an initiative:

- Create a core team of safety champions from multiple departments, disciplines etc. Participants could include city staff from planning, engineering, traffic and communications, community partners (school district, senior center etc.), appointees from advisory boards, law enforcement and more. The core team could meet regularly (perhaps every other month) and serve as liaisons to efforts in various departments.

- Hire a Roadway Safety Staff person. This would require a new position. Communities have created positions and hired staff to focus on safety, whether it's workplace safety, or roadway safety (such as CDOT). This person cannot be the only one undertaking safety initiatives, and a core team may still be needed, but they could provide the time and bandwidth to champion, coordinate, and manage efforts.

ENFORCEMENT

The Police Department is a key partner in the support for improving roadway safety. Their programmatic efforts related to both education and enforcement easily dovetail into efforts by the planning, engineering and traffic staff. The City of Loveland has a strong history of cooperation between the Police Department and the Traffic Division. This is most evident in the process to manage crash data, which is gathered by Police staff, and evaluated / analyzed by traffic staff. Action items listed in this section are largely support for the continuation of existing efforts.

Law enforcement has limited staffing, and less ability to respond to non-emergency issues than what community members sometimes would like. This highlights the need make the time / effort that law enforcement can spend on proactive roadway safety to be as strategic and targeted as possible. This includes the following:

- Because enforcement efforts are limited by available staff, it is most helpful to target those efforts in locations where crash data would indicate an issue that could be mitigated by enforcement. A consistent communication avenue between the Police Department and the Traffic Division can provide specific locations for a data-driven enforcement effort.

- Red light cameras can be controversial, with concern expressed by some that they may be placed for revenue generating efforts. Red light cameras are not currently used in Loveland. From a statistical safety perspective, red light cameras may tend to increase rear end crashes (often non-injury crashes) but tend to decrease red light running crashes (can be higher severity injury crashes). There is a mathematical safety evaluation that can be done to determine whether a location is a good candidate for a red light camera with results indicating if it's installation would improve safety. Red light cameras may also be helpful in locations where law enforcement does NOT have a safe location for staffed enforcement. If a location sees a lot of red light running, but there is not a safe location for staffed enforcement, then a red light camera may be beneficial. It is recommended that the City consider the use of red light cameras, but that they be placed only in locations where an evaluation would indicate that their presence would improve safety.

- A frequent complaint to city staff regards speeding vehicles. This is typical along straight stretches of arterial roadways, especially at the City fringes (such as north Wilson Avenue), but sometimes also includes neighborhood streets. A collaborative effort between the Police Department and the Traffic Division can help pinpoint locations where safe operating speeds may not be aligned with actual speeds, and especially locations where the speeding results in a crash pattern. A data driven approach to speed management can help strategically deploy limited law enforcement resources.

Recommended action items for Program elements:

Education and Communication:

21. Identify a core team of safety champions or hire a safety staff person.
22. Develop and implement a broad based, ongoing outreach and education campaign for roadway safety.

Enforcement:

23. Sharing crash data and analysis with the Police Department to identify priority areas for enforcement.
24. Support / encourage the use of red light cameras in locations where data analysis shows a likely safety benefit.
25. Collaborate between the Police Department and the Traffic Division on a data driven approach to speed management.

STANDARDS

The engineering design standards (typically the Larimer County Urban Area Street Standards or LCUASS and associated local Land Use Codes) were developed to provide uniformity, compatibility, and consistency in how roadways are designed in Loveland. The standards, which are a set of technical definitions and guidelines, are intended to provide a minimum set of performance and safety criteria.

Historically, standards have been quite good at addressing safety from a geometric and construction perspective – such as depth of asphalt, design of curves, drainage requirements etc. But they tend to provide a threshold for a 'nominal' standard (a minimum legally required), and do not address the potential for incremental improvement. In addition, over the course of many years of experience, it has become evident that some safety issues, especially operational items may have been inadvertently created due to the refinement of standards to support other interests. They are discussed below.

GENERAL STANDARDS

The largest area where operational safety concerns may arise is in the overlap of standards. For instance, the land use code may stipulate the number and spacing of required street trees to be planted between the sidewalk and roadway. However, when taken literally, this may result in street trees being planted directly in front of traffic control devices such as STOP signs (see ***Figure 4***).

Figure 4. Example: Street Trees Obscuring Stop Sign

The visibility of signs, the availability of required sight distance for entering and leaving roadways (often related to medians), and the interest in reducing negative offset left turn lanes may conflict with general standards, often related to landscaping. The City is aware of these potential conflicts and is working to address them including a recently added section in LCUASS to reduce negative offsets.

These types of items, when identified should be addressed through standards updates. Those staff overseeing standards changes should be fully informed and observant regarding how the standards may impact safety and make it a priority to address any overlapping issues.

SAFETY STANDARD

The LCUASS standards lists the term "safety" in several locations, with general guidance that safety is important. These statements, while beneficial are typically quite broad in nature and may or may not have the ability to require design refinement for safety purposes.

Projects understandably move through the design review process with an eye towards meeting engineering design requirements, Level of Service standards, construction timeframes, budget limitations etc. A helpful concept would be to strengthen the ability to review projects and make decisions based on roadway safety.

It is recommended that a team of staff be appointed to explore how a safety standard would be written and applied in Loveland. It may be beneficial to have the team be multi-jurisdictional to gather perspectives from other entities. The

effort could include a best practices review, and exploration of details that might go into a safety standard. There are some real challenges, and considerations and complexities to discuss including:

- How could Loveland require a 'safety review' for all projects, including capital projects, and development review projects?
- Who would do the review since development review teams and engineering teams would often not have the expertise to do the review?
- Could the standard be written much like a Level of Service review is done today? Could a Level of Service of Safety (like CDOT uses) standard be used?

Recommended action items for Standards:

26. Continue to identify, prioritize, and address standards that inadvertently create safety issues.
27. Identify a core team to explore the addition of a safety standard to the LCUASS.

PROCESSESS

The Safe System concept of roadway safety requires a holistic view of the road system and incorporates a proactive structure to continuously address safety. The system relies on a series of processes within each element. A few of the key processes are discussed below.

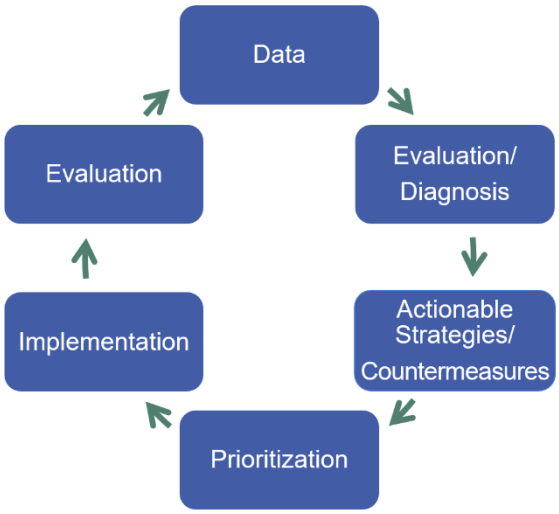


Figure 5. Systems-Based Elements

ANNUAL REVIEW OF CRASH DATA

The critical element of a data driven safety program is the quality of the data, and the process by which it is used. (The quality of the data is discussed in a subsequent section.)

The process for an annual review of the crash data was established through the ***Roadway Safety Summary*** completed in the fall of 2021. It involves utilizing the crash data obtained from the City of Loveland Police Department and evaluating it various ways. This includes a statistical review of intersection crash data using the methodology in the FHWA Highway Safety Manual to identify 'top' intersections for further safety reviews. It also involves completing a pattern recognition process, and then 'slicing and dicing' the data in more detailed ways to explore specific issues such as pedestrian crashes, etc.

Completing this process on an annual basis provides current information on the safety of the system and allows for a comparison from year to year to identify trends.

SAFETY AUDITS

The next step in the systems based approach is the evaluation and diagnosis effort. A Safety Audit process is recommended to be completed in locations that are identified for further review. The locations can be identified through the annual review of crash data (top intersections, or those trending with increasing crashes), through public comment, or as a standard practice for proposed capital projects. The safety audit process for the City of Loveland was developed following completion of the Roadway Safety Summary and is available for use.

The process involves establishment of an audit team, a data gathering element (land use, geometrics, volumes, operations, safety etc.), analysis, a field review, and identification of issues / concerns. It also includes a component where next steps for safety improvements are listed. These actionable strategies are based on known countermeasures to address the identified issue.

The form that guides the process is included in ***Appendix C***.

The countermeasure toolkit is included in ***Appendix D***. The toolkit is a compilation of typical items that can be used to counteract a particular type of crash pattern. The sources for the toolkit include the FHWA's Crash Modification Factors Clearinghouse, and the FHWA's list of proven safety countermeasures. The information in ***Appendix D*** also includes information on each countermeasure's applicability and considerations for their use.

ASSESSMENT AND EVALUATION

One element of projects that is often neglected is the after-action assessment and evaluation. Even with the best of intentions, once a project is complete, priorities and focus often shifts quickly to the next issue. To fully understand the impact of changes, a commitment to assessment and evaluation is important.

The process for this could be incorporated into the annual review of crash data. There can be a section in the report that lists the various projects completed, and the before / after data. This will help to identify those countermeasures that are effective.

INTEGRATING SAFETY INTO PROJECT DEVELOPMENT PROCESSES

The final process recommended is the formalization of integrating safety into the project development process. Certainly, many projects undertaken by the City of Loveland already involve safety elements. However, the degree to which safety is highlighted, reviewed, considered, and / or prioritized varies.

A typical project development process includes concept designs using technical engineering standards, a capacity analysis, and cost estimates, etc. Making the addition of a safety review and considerations for safety improvements a standard element of early concepts would further support safety in a systematic way. The creation of a 'safety standard' discussed in a prior section would help formalize the process.

The types of projects for which this could apply includes:

- **Capital Improvement Projects**. A requirement to complete a safety audit for each capital improvement project would serve as a starting point to ensure that safety is included in major city projects.
- **Maintenance and Overlay Projects**. The City already has a strong working relationship where overlay projects are reviewed by Traffic Division staff to see where low cost striping changes can benefit safety. This process should continue.
- **Developer Led Projects.** Development projects are closely tied to and almost exclusively reviewed against the LCUASS standards. A prior section discussed the potential benefit of developing a 'safety standard' that could provide the basis for requiring safety improvements as a development impact mitigation measure.
- **Jurisdictional Overlap**. There are often projects that occur on the fringes of the City where there may be multiple jurisdictions within the project impact area. Continuing coordination between the City and Larimer County is encouraged to explore ways of implementing safety improvements across jurisdictional boundaries.

Recommended action items for Processes:

28. Complete an annual review of crash data.
29. Utilize the newly developed safety audit process in locations of interest.
30. Commit to assessment and evaluation efforts after projects to determine effectiveness of countermeasures - can be a part of annual review.
31. Integrate safety considerations into the project development process for all types of projects.

FUNDING / BUDGETS

Funding is a challenge for every municipality. In the City of Loveland, there is no current, consistent, local funding stream for safety specific projects. The funding of safety projects is typically compiled from various sources including ongoing operational budgets (mostly the Traffic Division), and through the pursuit of state and federal grants.

STATE AND FEDERAL OPPORTUNITIES

The recently enacted federal Bipartisan Infrastructure Bill (BIL) established the new Safe Street and Roads for All (SS4A) program which funds initiatives to prevent roadway deaths and serious injuries. The grant opportunities connected with SS4A include the requirement to have a comprehensive safety plan and carry out projects and strategies identified in an Action Plan.

The City's efforts in the past year on the Citywide Roadway Safety Study has resulted in the ***Roadway Safety Summary***, and in this ***Roadmap To Safety***. These documents fit perfectly into meeting the requirements for safety funding. The identification of action items in this report, and the specific projects listed in ***Tables 3-5*** provide a basis to pursue funding opportunities.

Many state and federal funding opportunities require a percentage of 'local match funding'. Identifying a source for local match funds can be a challenge. Consideration could be given to set aside an ongoing fund specifically for local match dollars so that doesn't have to come from ongoing operations budgets.

LOCAL EFFORTS

There are several action items that can be considered at a local level to support funding for safety projects.

The Transportation Engineering Division oversees the Capital Improvement Plan (CIP) which outlines anticipated projects and how available funding will be allocated over the subsequent five years.

- **Incorporate safety reviews into CIP projects**. As noted in the Process Section, one recommendation is that safety considerations be consistently incorporated into CIP projects. This would allow for incremental safety improvements to be made within the existing list of projects.

- **Include dedicated safety projects in the CIP.** There is a review and prioritization process that occurs with updates to the CIP. The inclusion of safety projects on the list and allowing them to be reviewed and prioritized within the available CIP funding could result in additional safety projects being funded.

Finally, development as it occurs pays into a Capital Expansion Fee (CEF) fund to support regional transportation improvements not directly adjacent to / impacted by the development. A review of whether and how the fees could be used for safety projects in addition to capacity projects could be helpful.

Recommended action items for Funding / Budgets:

32. Continue to pursue state and federal funding for safety projects – especially funding available through the new federal infrastructure bill's Safe Streets For All (SS4A).
33. Consider a funding set aside to cover local match requirements for safety projects.
34. Ensure that safety considerations are incorporated into CIP projects.
35. Ensure that safety projects are listed, reviewed, prioritized as a part of the CIP.
36. Review the applicability of Capital Expansion Fees (CEFs) on safety projects.

IMPROVING THE DATA

The entire Roadway Safety Program and the starting point for its success is with the crash data. The more complete, accurate and consistent the data is, the more information it can provide on the causes, trends, and issues related to safety. The data is the basis for selecting locations for additional review, the data is an input to identifying issues, the data is used in prioritizing projects, and the data is important for the assessment and evaluation of completed efforts.

The City of Loveland's Police Department (whose officers fill in the crash forms) and the Traffic Division (where the data is sent to be analyzed) have worked very successfully together on the crash data. The processes for filling in the forms, and transferring the data works well.

Additional items to consider to further strengthen the quality of the data include:

- **Identifying the most important fields within DR3447**. The State of Colorado has recently implemented a new standardized traffic crash reporting form called the DR3447. It includes a much lengthier list of fields to be filled in, with some fields (and pages) that become active depending on the responses to early items in the form. The potential for additional details is helpful, but in some cases the length of the form becomes problematic for Police staff to fully fill out due to time constraints. A cooperative effort between Traffic and Police to identify the most important fields from an analysis perspective could provide opportunities to streamline input efforts if needed.

- **Consistent coding on crash form**. There are a number of ways that some parts of the form can be filled in. For instance, what type of crash is coded as an approach turn crash, or whether a crash is identified as intersection related or not can easily and understandably vary depending on the officer on scene. A concerted effort to provide training to develop an understanding of and consistency in how the critical fields are coded would increase the ability for the Traffic Division to analyze the data in greater detail.

- **Quality Control and Data Processing** Once the data has been transferred to the Traffic Division, it is processed into the Crash Magic system using a series of steps and calculated fields. Consideration should be given to adding a quality control step that involves a staff person reading the crash narrative and verifying / refining the data in the system. The staff person would need to be trained to provide a consistent approach, ensuring that facility IDs are added to the crash record, and crashes are geolocated to the correct location.

Recommended action items for Improving the Data:

37. Identify and share the most important fields within DR3447 to be completed.
38. Develop a consistent coding on the crash form for responding officers.
39. Add a quality control step during the data transfer and processing.

IMPLEMENTATION / ACTION PLAN

Action items that have been identified and detailed in all the previous sections are compiled and listed in ***Table 11***. In addition, a comment column with general prioritization has been added to help guide more pressing items. There are several items that are already ongoing or should be completed 'as needed' when applicable. There are some items identified as priorities or medium priorities or needing discussions with other departments.

There are two specific items to note:

- The infrastructure action items (#1 and #2) are actually numerous items from the relevant tables (3-5) and Appendix A. These lists of actions stand on their own and should be prioritized. Especially low cost and operational items should be addressed as soon as possible. The proposed geometric changes should be used to pursue grant funding especially through the new federal SS4A program.
- The items related to education are all combined and listed with the same comment: "Education campaign". City of Loveland staff should consider whether and how best to undertake such a campaign in terms of staffing and bandwidth.

Table 11. Summary of Action Items

Topic	#	Action Item Description	Comments
Infrastructure			
	1	Use Tables 3, 4, and 5 to guide action items at various locations	High Priority Items
	2	Use the information in Appendix A for concept designs at 10 locations	Priority for grants
Approach Turn Crashes			
	3	Implement the standardized left turn phasing evaluation process in spot locations (such as identified actions from safety audit results).	As needed
	4	Complete a citywide left turn phasing review at all signalized intersections.	Medium priority over time
	5	Continue to systematically reduce / remove negative offset left turn lanes.	Ongoing
Vulnerable Road Users			
	6	Pedestrians: Continue constructing sidewalks in locations where there are gaps.	Ongoing
	7	Pedestrians: Consider pedestrian improvements listed in Table 7.	High Priority item
	8	Pedestrians: Continue pursuing construction of underpasses of the busiest roadways	Ongoing
	9	Pedestrians: Support education campaigns targeted for pedestrians – especially youth pedestrians.	Education campaign
	10	Bicyclists: Continue constructing bicycle infrastructure through 'complete streets' approach.	Ongoing
	11	Bicyclists: Support education campaigns targeted for bicyclists – especially discouraging the practice of riding against traffic.	Education campaign
	12	Motorcyclists: Continue efforts for education and enforcement related to motorcycles.	Education campaign
Policies			
	13	Pedestrian and Bicycle Infrastructure: Continue to implement a 'complete streets' approach to transportation system project planning, design, construction, operations, and maintenance.	Ongoing
	14	Pedestrian and Bicycle Infrastructure: Continue the Sidewalk Gap Program, using safety data as one input to the prioritization process	Ongoing

	15	Pedestrian and Bicycle Infrastructure: Focus on evaluation and improvement of arterial crossings for pedestrians and bicyclists	Medium priority over time
	16	Emergency Response: Consider emergency vehicle access and ease of movement during project design.	Ongoing
	17	Emergency Response: Prioritize safety of responding personnel and victims through equipment placement.	Discuss with Emergency Response Staff
	18	Emergency Response: Reduce incident clearance time to minimize secondary crashes in the backup or on alternate routes.	Discuss with Emergency Response Staff
	19	Emergency Response: Support and encourage the use of emerging technologies for information sharing regarding incidents.	Discuss with Emergency Response Staff
	20	Traffic Signal Operational Policy: Continue work on the update and details for the Traffic Signal Operational Policy.	Ongoing
Programs			
	21	Education and Communication: Identify a core team of safety champions or hire a safety staff person.	Education campaign
	22	Education and Communication: Develop and implement a broad based, ongoing outreach and education campaign for roadway safety.	Education campaign
	23	Enforcement: Sharing crash data and analysis with the Police Department to identify priority areas for enforcement.	Discuss with Police Department Staff
	24	Enforcement: Support / encourage the use of red light cameras in locations where data analysis shows a likely safety benefit.	Discuss with Police Department Staff
	25	Enforcement: Collaborate between the Police Department and the Traffic Division on a data driven approach to speed management.	Discuss with Police Department Staff
Standards			
	26	Continue to identify, prioritize, and address standards that inadvertently create safety issues.	Ongoing
	27	Identify a core team to explore the addition of a safety standard to the LCUASS.	Priority
Processes			
	28	Complete an annual review of crash data.	Annual priority
	29	Utilize the newly developed safety audit process in locations of interest.	Ongoing
	30	Commit to assessment and evaluation efforts after projects to determine effectiveness of countermeasures - can be a part of annual review	As needed
	31	Integrate safety considerations into the project development process for all types of projects.	Priority
Funding / Budgets			
	32	Continue to pursue state and federal funding for safety projects – especially funding available through the new federal infrastructure bill's Safe Streets For All (SS4A).	Ongoing
	33	Consider a funding set aside to cover local match requirements for safety projects.	Discuss with Leadership
	34	Ensure that safety considerations are incorporated into CIP projects.	Priority - Discuss with Engineering
	35	Ensure that safety projects are listed, reviewed, prioritized as a part of the CIP	Priority - Discuss with Engineering
	36	Review the applicability of Capital Expansion Fees (CEFs) on safety projects.	
Improving the Data			
	37	Identify and share the most important fields within DR3447 to be completed.	Priority – work with Police Department
	38	Develop a consistent coding on the crash form for responding officers.	Priority – work with Police Department
	39	Add a quality control step during the data transfer and processing.	Priority

APPENDIX A

CONCEPTUAL INTERSECTION DESIGNS

- N Boyd Lake Avenue at CR 20E
- N Garfield Avenue at E 37th Street
- N Garfield Avenue at W 45th Street
- N Taft Avenue at W 1st Street
- N Taft Avenue at W 29th Street
- Namaqua Avenue at W Eisenhower Blvd
- S Taft Avenue at 10th Street SW
- S Taft Avenue at 14th Street SW
- Washington Avenue at E 1st Street
- SH 402 at CR 9 and at CR 7

BOYD LAKE AVE & CR 20E

Facility ID: 514

Issues:

- Rural level geometrics
- Long queues – especially WB
- SB bikes need to merge with SB through across RR
- Crash patterns: SB rear ends

Concept Design:

- Add auxiliary left turn lanes (SB and WB)
- Add pedestrian refuge in SE corner
- Utilize reversing curves for lane shift on east leg to reduce limits

Concept Cost:

- $706,000

Outcomes:

- SB and WB left turn lanes
- Limited improvement for trail users
- Operational impact: significant improvement
  - » pm: Overall 8.8 to 4
  - » pm: WB 39 to 16 sec

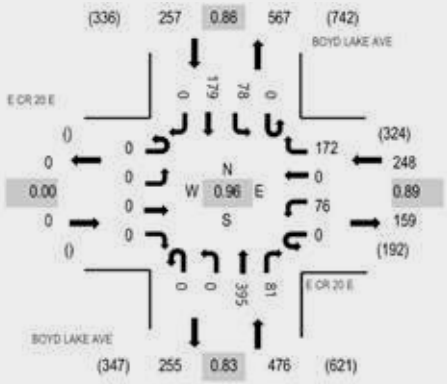
Considerations:

- Railroad impact
- Existing RRFB at south trail crossing
- Pedestrian and bicyclist flow and ADA accommodations

Posted/Design Speeds (mph):

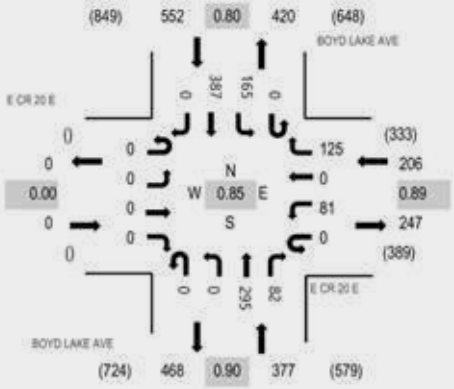
- NB: 40/45
- SB: 40/45
- EB: 45/50
- WB: 45/50

AM Turning Movement Counts



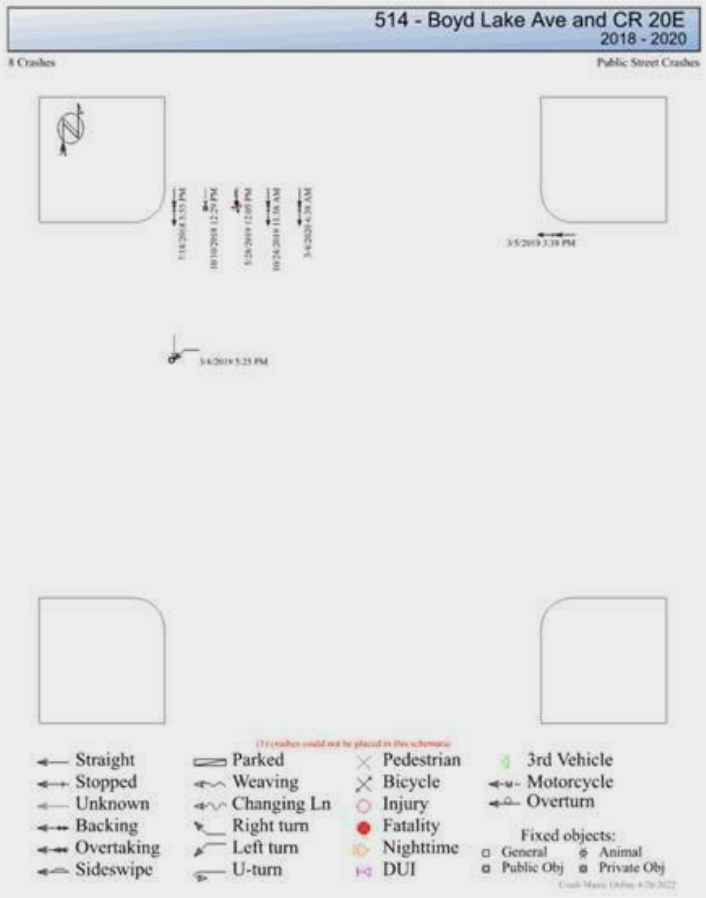
Note: Total study counts contained in parentheses.

PM Turning Movement Counts



Note: Total study counts contained in parentheses.

Crash Diagram – 2018-2020



Project Name: **Boyd Lake Ave & CR 20E**

Project Number: **021-03903**

Project Manager: **Jessica Burch**

Date: **8/8/2022**

	% Range	% Used	Cost	
Project Construction Items			$120,700.00	(A)
Contingencies	(15% - 30%) of (A)	30.0%	$36,300.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.0%	$0.00	(C)
Drainage/Water/Sewer	(3-10%) of (A+B) Default = 6%	10.0%	$15,700.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	5.0%	$8,700.00	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	25.0%	$45,400.00	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	10.0%	$22,700.00	(G)
Total of Construction Items	(A+B+C+D+E+F+G)		$249,500.00	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.0%	$5,000.00	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	15.0%	$37,425.00	(J)
Subtotal of Construction Cost	(H+I+J)		$291,925.00	(K)
Total Construction Engineering	24% of (K)	24.0%	$70,062.00	(L)
Total Preliminary Engineering	15% of (K)	15.0%	$43,788.75	(M)
Right of Way	Project Dependent		$300,000.00	(N)
Utilities	Project Dependent	N/A	$0.00	(O)
Estimated Total Project Cost			**$706,000.00**	(P)

Loveland Citywide Roadway Safety Study

Boyd Lake Ave & CR 20E
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

Boyd Lake Ave

CR 20E

6'

30'

12'

12'

12'

R 1039'
Reversing Curves
or consider
straight taper

355.1' Taper w/ Reversing Curves

Existing RRFB

Future Roundabout

Loveland Citywide Roadway Safety Study

Boyd Lake Ave & CR 20E - WB-67 LTs
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

N GARFIELD AVE & E 37TH ST

Facility ID: 1

Issues:

- Rank #5 in the city
- Crash patterns: NB approach turns, SB and EB rear end crashes, 2 ped crashes
- Crash history is prior to 37th St connection

Concept Design:

- Reallocate road width for NB double left turns, protected timing only
- Add positive offset for SB left turns, protected/permissive timing allowed
- Add NB right turn lane

Concept Cost:

- $203,000

Outcomes:

- NB double left, but lose the NB right turn lane
- Protected only left turns NB/SB
- WB-67 N/S left turns work concurrently
- Operational Impacts: minimal

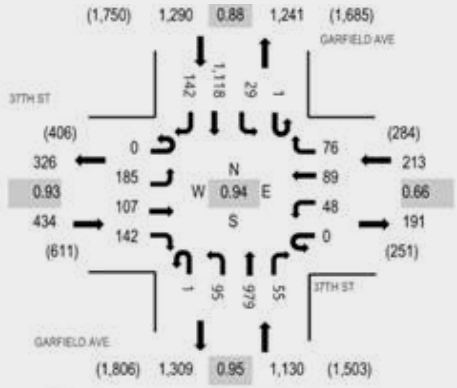
Considerations:

- Consider new transit center west of gas station on Grant when in design
- Review cross pan options – EB traffic slows for pans

Posted/Design Speeds (mph):

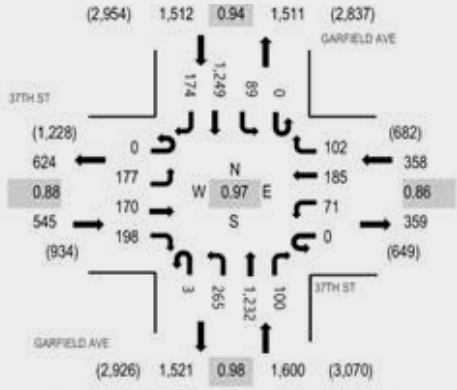
- NB: 50/55
- SB: 50/55
- EB: 35/40
- WB: 30/35

AM Turning Movement Counts



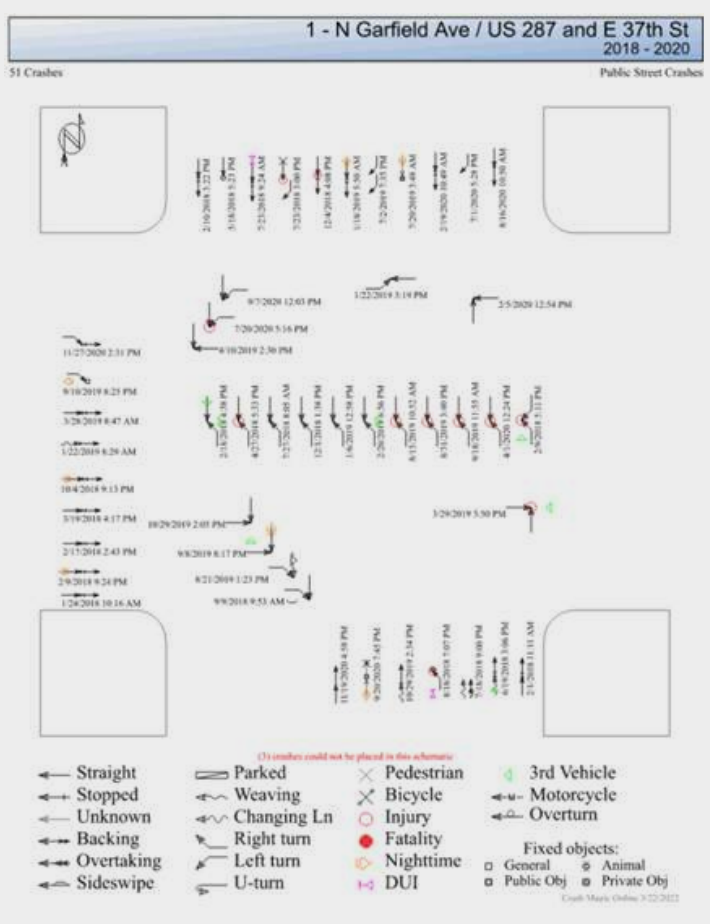
Note: Total study counts contained in parentheses.

PM Turning Movement Counts



Note: Total study counts contained in parentheses.

Crash Diagram – 2018-2020



Project Name: **N Garfield Ave & E 37th St**

Project Number: **021-03903**

Project Manager: **Jessica Burch**

Date: **8/8/2022**

	% Range	% Used	Cost	
Project Construction Items			$60,100.00	(A)
Contingencies	(15% - 30%) of (A)	30.0%	$18,100.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.0%	$0.00	(C)
Drainage/Water/Sewer	(3-10%) of (A+B) Default = 6%	10.0%	$7,900.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	5.0%	$4,400.00	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	25.0%	$22,700.00	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	10.0%	$11,400.00	(G)
Total of Construction Items	(A+B+C+D+E+F+G)		$124,600.00	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.0%	$2,500.00	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	15.0%	$18,690.00	(J)
Subtotal of Construction Cost	(H+I+J)		$145,790.00	(K)
Total Construction Engineering	24% of (K)	24.0%	$34,989.60	(L)
Total Preliminary Engineering	15% of (K)	15.0%	$21,868.50	(M)
Right of Way	Project Dependent	N/A	$0.00	(N)
Utilities	Project Dependent	N/A	$0.00	(O)
Estimated Total Project Cost			**$203,000.00**	(P)

Loveland Citywide Roadway Safety Study

N Garfield Ave & E 37th St
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

Loveland Citywide Roadway Safety Study

N Garfield Ave & E 37th St - Dual WB-67 LTs
Concept Design - Not For Construction

08-08-2022

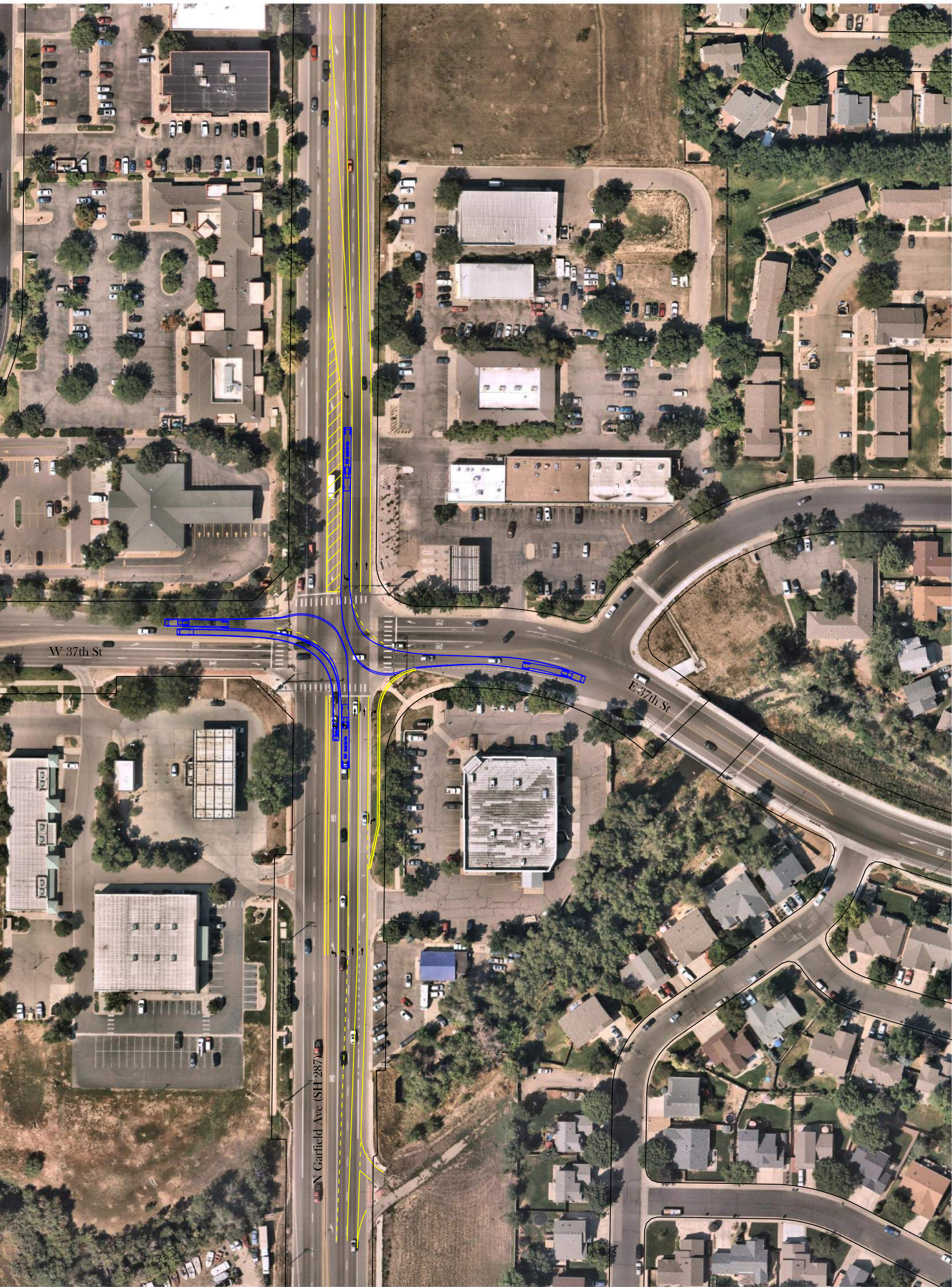
City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'



N GARFIELD AVE & W 45TH ST

Facility ID: 57

Issues:

- Long pedestrian crossing distances
- Crash patterns: limited patterns

Concept Design:

- Remove negative offset left turns by shifting NB lanes to the east
- Add NB right turn channelizing island

Concept Cost:

- $276,000

Outcomes:

- Shorten ped crossing distances
- Operational impact: minimal

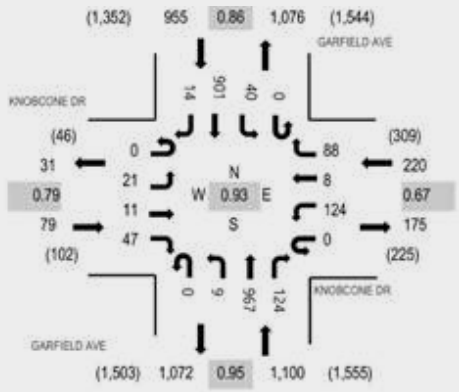
Considerations:

- Keep EB 45th right turn lane for commercial access east of intersection
- How drainage pan works with channelizing island in SE corner

Posted/Design Speeds (mph):

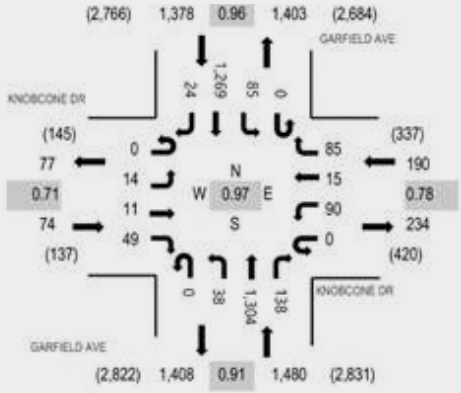
- NB: 50/55
- SB: 50/55
- EB: 35/35
- WB: 30/35

AM Turning Movement Counts



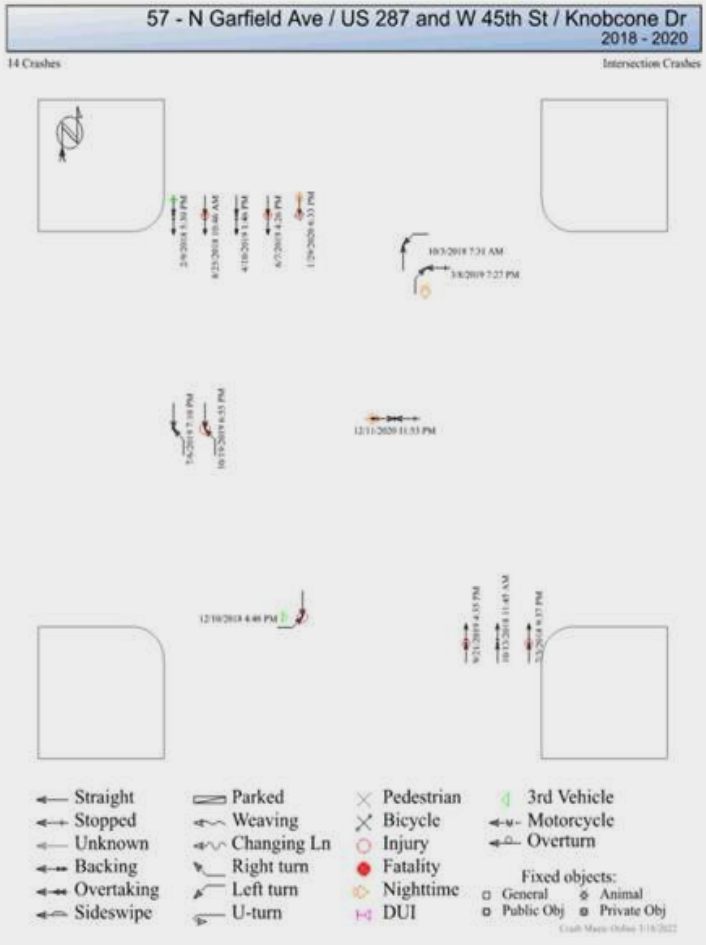
Note: Total study counts contained in parentheses.

PM Turning Movement Counts



Note: Total study counts contained in parentheses.

Crash Diagram – 2018-2020



Project Name: **N Garfield Ave & W 45th St (Knobcone)**

Project Number: **021-03903**

Project Manager: **Jessica Burch**

Date: **8/8/2022**

	% Range	% Used	Cost	
Project Construction Items			$81,800.00	(A)
Contingencies	(15% - 30%) of (A)	30.0%	$24,600.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.0%	$0.00	(C)
Drainage/Water/Sewer	(3-10%) of (A+B) Default = 6%	10.0%	$10,700.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	5.0%	$5,900.00	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	25.0%	$30,800.00	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	10.0%	$15,400.00	(G)
Total of Construction Items	(A+B+C+D+E+F+G)		$169,200.00	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.0%	$3,400.00	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	15.0%	$25,380.00	(J)
Subtotal of Construction Cost	(H+I+J)		$197,980.00	(K)
Total Construction Engineering	24% of (K)	24.0%	$47,515.20	(L)
Total Preliminary Engineering	15% of (K)	15.0%	$29,697.00	(M)
Right of Way	Project Dependent	N/A	$0.00	(N)
Utilities	Project Dependent	N/A	$0.00	(O)
Estimated Total Project Cost			**$276,000.00**	(P)

Loveland Citywide Roadway Safety Study

N Garfield Ave & W 45th St
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

Existing Bus Stop

385'

100'

11'

11'

12'

12'

14'

WB-67 Dual Left Turns can be run concurrently

W 45th St

Knobcone Dr

12'

10'

4'

12'

11'

11'

Existing Bus Stop

Existing Inlet to be Relocated

250'

N Garfield Ave (SH 287)

Loveland Citywide Roadway Safety Study

N Garfield Ave & W 45th St - Dual WB-67 LTs
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

W 45th St

Knobcone Dr

N Garfield Ave (SH 287)

N TAFT AVE & W 1ST ST

Facility ID: 34

Issues:

- Red light running and high speeds
- Long pedestrian crossings
- Crash patterns: approach turns, rear ends

Concept Design:

- Right turn channelizing islands and yield conditions for right turns, to reduce scope/size of intersection

Concept Cost:

- $3,528,000

Outcomes:

- Reduced ped crossing distances
- All new signal, and new cabinet location
- Operational impact: minimal
- Potential reduced speeds through intersection?

Considerations:

- Anticipated benefit / cost
- Right turn lane design

Posted/Design Speeds (mph):

- NB: 40/45
- SB: 40/45
- EB: 35/40
- WB: 35/40

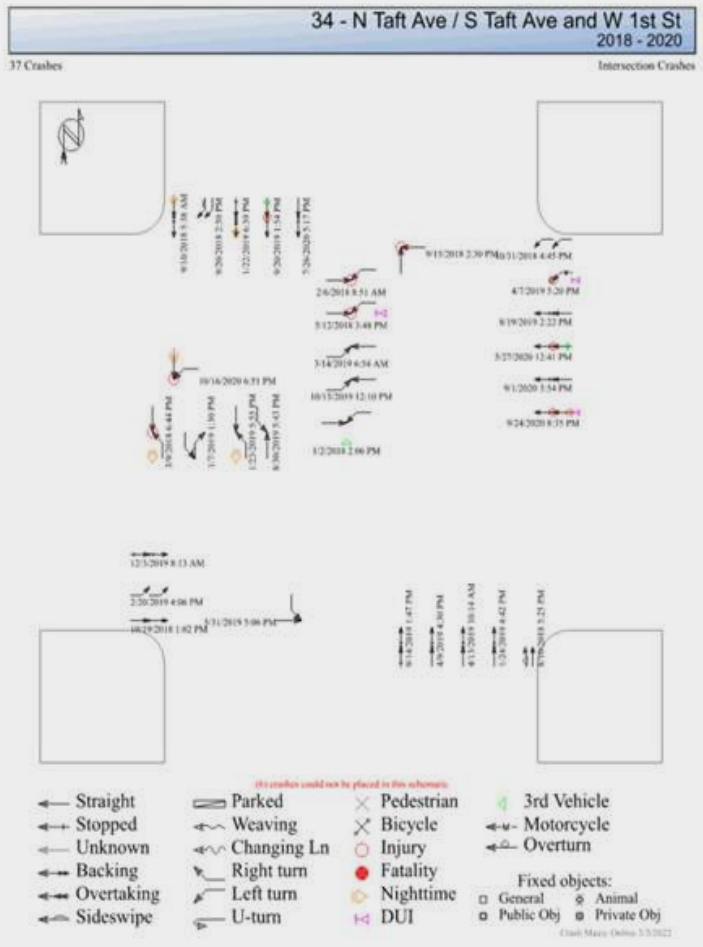
AM Turning Movement Counts

1st Street closed for construction…

PM Turning Movement Counts

1st Street closed for construction…

Crash Diagram – 2018-2020



Project Name: **N Taft Ave & W 1st St**

Project Number: **021-03903**

Project Manager: **Jessica Burch**

Date: **8/8/2022**

	% Range	% Used	Cost	
Project Construction Items			$574,000.00	(A)
Contingencies	(15% - 30%) of (A)	30.0%	$172,200.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.0%	$0.00	(C)
Drainage/Water/Sewer	(3-10%) of (A+B) Default = 6%	10.0%	$74,700.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	5.0%	$41,100.00	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	25.0%	$215,500.00	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	10.0%	$107,800.00	(G)
Total of Construction Items	(A+B+C+D+E+F+G)		$1,185,300.00	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.0%	$23,800.00	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	15.0%	$177,795.00	(J)
Subtotal of Construction Cost	(H+I+J)		$1,386,895.00	(K)
Total Construction Engineering	24% of (K)	24.0%	$332,854.80	(L)
Total Preliminary Engineering	15% of (K)	15.0%	$208,034.25	(M)
Right of Way	Project Dependent		$1,600,000.00	(N)
Utilities	Project Dependent	N/A	$0.00	(O)
Estimated Total Project Cost			**$3,528,000.00**	(P)

Loveland Citywide Roadway Safety Study

N Taft Ave & W 1st St
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

N Taft Ave

W 1st St

S Taft Ave

12'

Existing Inlet to be Relocated

45 LF Mast Arm

Look at adding accel lane too? Not sure this will slow down RT vehicles

5'

12'

11'

44892°

45 LF Mast Arm

Existing Signal System to be replaced

Existing Curve Thru Intersection to be evaluated during design

11'

12'

5'

45 LF Mast Arm

Shortens up all crossings

Existing Inlet to be Relocated

50 LF Mast Arm

Existing Inlet to be Relocated

12'

N TAFT AVE & W 29TH ST

Facility ID: 5

Issues:

- Rank #4 in the city
- WB congestion, negative offset turns
- Crash patterns: approach turns, rear end, and 2 bike crashes

Concept Design:

- Use gore area for WB double left turns
- Need new NW mast arm – 55-ft
- Move NB buffer between NB left turn and NB thru lanes to eliminate negative offset

Concept Cost:

- $276,000

Outcomes:

- Operational impact: pm: 19 to 21
- Potential additional green time for N/S could benefit approach turn crash numbers

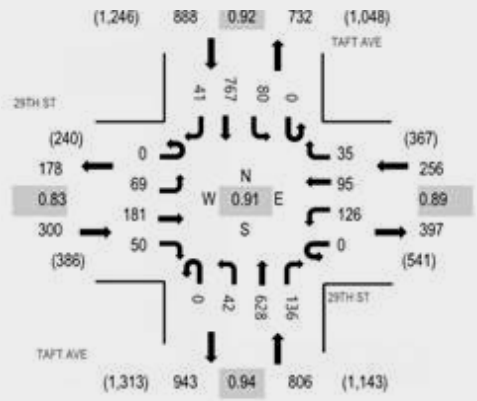
Considerations:

- Water Department has planned project here for 2023; consider combining any improvements into one mobilization

Posted/Design Speeds (mph):

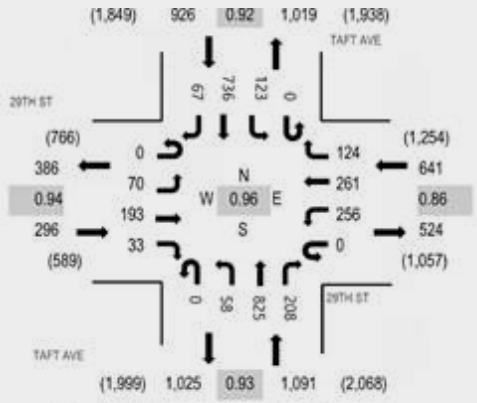
- NB: 35 /40
- SB: 35/40
- EB: 35/40
- WB: 35/40

AM Turning Movement Counts



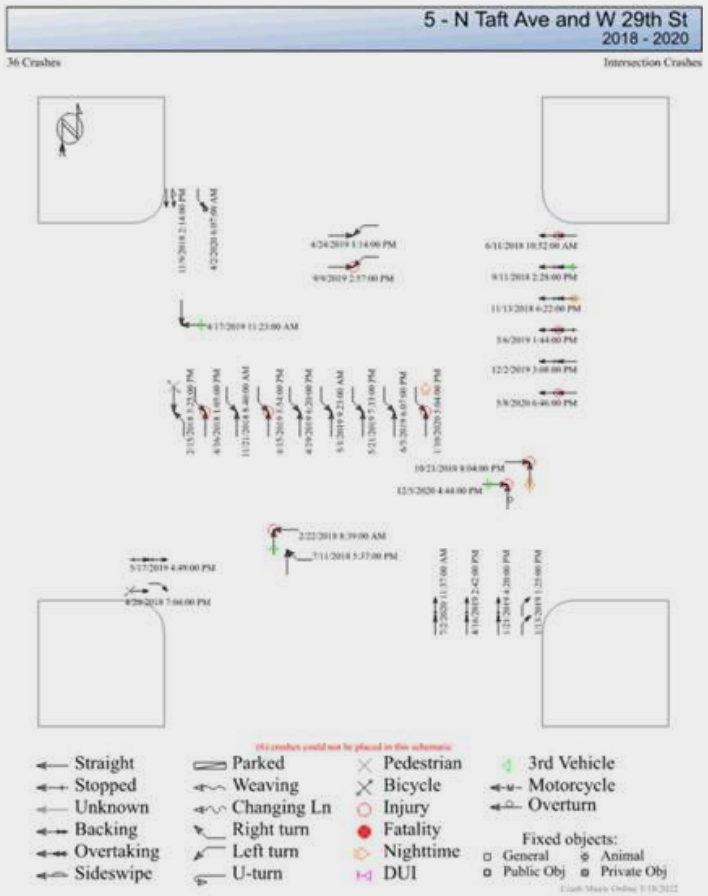
Note: Total study counts contained in parentheses.

PM Turning Movement Counts



Note: Total study counts contained in parentheses.

Crash Diagram – 2018-2020



Project Name: **N Taft Ave & W 29th St**

Project Number: **021-03903**

Project Manager: **Jessica Burch**

Date: **8/8/2022**

	% Range	% Used	Cost	
Project Construction Items			$81,700.00	(A)
Contingencies	(15% - 30%) of (A)	30.0%	$24,600.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.0%	$0.00	(C)
Drainage/Water/Sewer	(3-10%) of (A+B) Default = 6%	10.0%	$10,700.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	5.0%	$5,900.00	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	25.0%	$30,800.00	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	10.0%	$15,400.00	(G)
Total of Construction Items	(A+B+C+D+E+F+G)		$169,100.00	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.0%	$3,400.00	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	15.0%	$25,365.00	(J)
Subtotal of Construction Cost	(H+I+J)		$197,865.00	(K)
Total Construction Engineering	24% of (K)	24.0%	$47,487.60	(L)
Total Preliminary Engineering	15% of (K)	15.0%	$29,679.75	(M)
Right of Way	Project Dependent	N/A	$0.00	(N)
Utilities	Project Dependent	N/A	$0.00	(O)
Estimated Total Project Cost			**$276,000.00**	(P)

Loveland Citywide Roadway Safety Study

N Taft Ave & W 29th St
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

N Taft Ave

W 29th St

Replace WB Mast Arm with 55 LF Mast Arm

4' 12' 11' 10' 13' 4'

11'

11'

4' 12' 5' 12' 12' 12' 10' 12'

223'

131'

Loveland Citywide Roadway Safety Study

N Taft Ave & W 29th St - Dual WB-67 LTs
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

N Taft Ave

W 29th St

N Taft Ave

NAMAQUA AVE & US 34

Facility ID: 537

Issues:

- Acute angle and tight turning radius
- Significant public comments
- Bike issues – vehicle / bike conflicts
- Crash patterns: limited crash patterns

Concept Design:

- Reallocate roadway space to accommodate formal bike lanes, consistent lane widths and improve turning movements

Concept Cost:

- $1,772,000 overall
- $565,000 of overall is for mill/overlay

Outcomes:

- Re-stripe 1,400 feet of US 34
- Shift all lanes to north – improves all turning movements
- Creates bike lanes throughout
- Operational impact: minimal

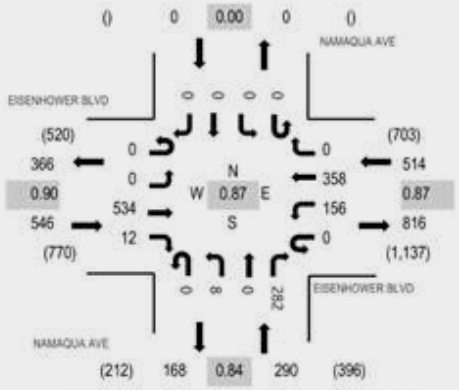
Considerations:

- Overlay required (for corridor)
- Numerous accesses along US 34
- Signal not warranted at this time

Posted/Design Speeds (mph):

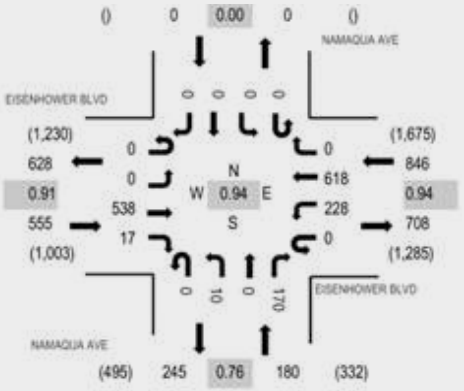
- NB: 35/40
- SB: 35/40
- EB: 45/50
- WB: 45/50

AM Turning Movement Counts



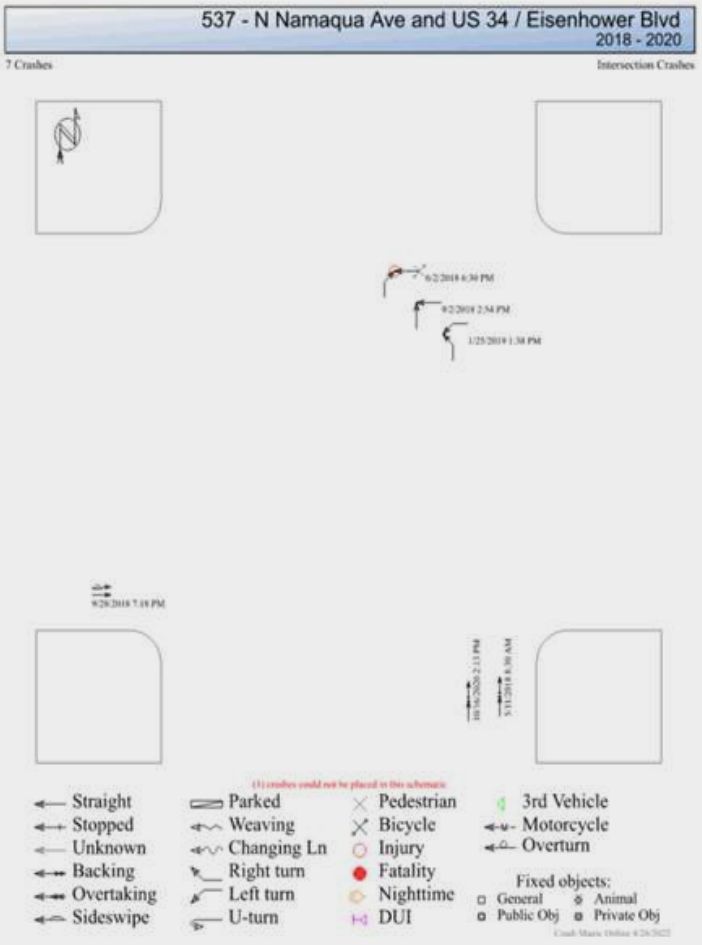
Note: Total study counts contained in parentheses.

PM Turning Movement Counts



Note: Total study counts contained in parentheses.

Crash Diagram – 2018-2020



Project Name: **Namaqua Ave & US 34**

Project Number: **021-03903**

Project Manager: **Jessica Burch**

Date: **8/8/2022**

	% Range	% Used	Cost	
Project Construction Items			$523,800.00	(A)
Contingencies	(15% - 30%) of (A)	30.0%	$157,200.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.0%	$0.00	(C)
Drainage/Water/Sewer	(3-10%) of (A+B) Default = 6%	10.0%	$68,100.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	5.0%	$37,500.00	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	25.0%	$196,700.00	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	10.0%	$98,400.00	(G)
Total of Construction Items	(A+B+C+D+E+F+G)		$1,081,700.00	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.0%	$21,700.00	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	15.0%	$162,255.00	(J)
Subtotal of Construction Cost	(H+I+J)		$1,265,655.00	(K)
Total Construction Engineering	24% of (K)	24.0%	$303,757.20	(L)
Total Preliminary Engineering	15% of (K)	15.0%	$189,848.25	(M)
Right of Way	Project Dependent		$12,500.00	(N)
Utilities	Project Dependent	N/A	$0.00	(O)
Estimated Total Project Cost			**$1,772,000.00**	(P)

Loveland Citywide Roadway Safety Study

Namaqua Ave & US 34
Concept Design - Not For Construction

08-08-2022

City of Loveland | Next Phase Engineering | olsson

N

0' 50' 100' 200'

Loveland Citywide Roadway Safety Study

Namaqua Ave & US 34 - WB-67 LTs
Concept Design - Not For Construction

08-08-2022

City of Loveland | Next Phase Engineering | olsson

N

0' 50' 100' 200'

Loveland Citywide Roadway Safety Study

Namaqua Ave & US 34 - WB-67 RTs
Concept Design - Not For Construction

08-08-2022

City of Loveland | Next Phase Engineering | olsson

N

0' 50' 100' 200'

S TAFT AVE & 10TH ST SW

Facility ID: 353

Issues:

- Crash patterns: right angle crashes – EB left turns with SB through (SB right turning vehicles shadow SB through vehicles)

Concept Design:

- SB right turn channelizing island so EB stop bar can be moved to the east
- Consider delineators in median for EB left traffic to differentiate between NB through vehicles and NB left turning vehicles
- Pull median nose to north to facilitate EB left turns
- Add mountable truck apron in the SW corner for traffic calming and provide space for updated curb ramp

Concept Cost:

- $527,000

Outcomes:

- Moves EB stop bar to east
- Operational impact: minimal

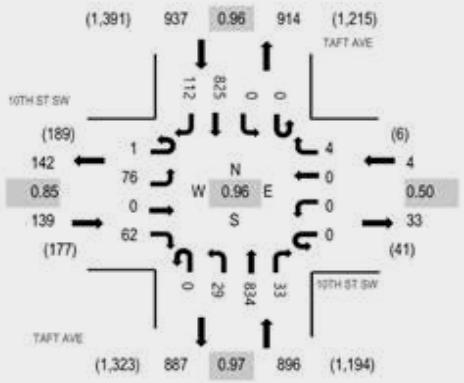
Considerations:

- N/A

Posted/Design Speeds (mph):

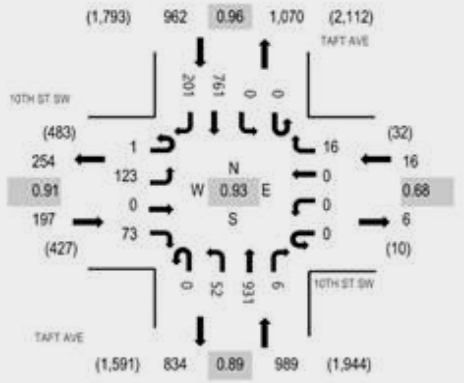
- NB: 40/45
- SB: 40/45
- EB: 30/35
- WB: 30/35

AM Turning Movement Counts



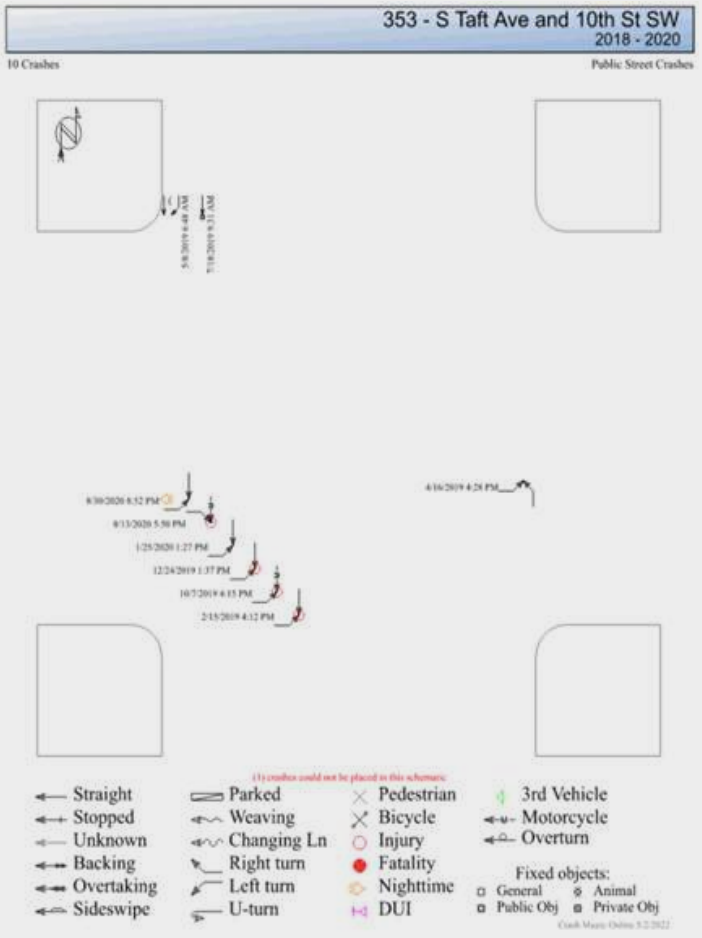
Note: Total study counts contained in parentheses.

PM Turning Movement Counts



Note: Total study counts contained in parentheses.

Crash Diagram – 2018-2020



Project Name: **S Taft Ave & 10th St SW**

Project Number: **021-03903**

Project Manager: **Jessica Burch**

Date: **8/8/2022**

	% Range	% Used	Cost	
Project Construction Items			$147,800.00	(A)
Contingencies	(15% - 30%) of (A)	30.0%	$44,400.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.0%	$0.00	(C)
Drainage/Water/Sewer	(3-10%) of (A+B) Default = 6%	10.0%	$19,300.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	5.0%	$10,600.00	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	25.0%	$55,600.00	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	10.0%	$27,800.00	(G)
Total of Construction Items	(A+B+C+D+E+F+G)		$305,500.00	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.0%	$6,200.00	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	15.0%	$45,825.00	(J)
Subtotal of Construction Cost	(H+I+J)		$357,525.00	(K)
Total Construction Engineering	24% of (K)	24.0%	$85,806.00	(L)
Total Preliminary Engineering	15% of (K)	15.0%	$53,628.75	(M)
Right of Way	Project Dependent		$30,000.00	(N)
Utilities	Project Dependent	N/A	$0.00	(O)
Estimated Total Project Cost			**$527,000.00**	(P)

Loveland Citywide Roadway Safety Study

S Taft Ave & 10th St SW
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

Loveland Citywide Roadway Safety Study

S Taft Ave & 10th St SW - WB-67 Turns
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

S TAFT AVE & 14TH ST SW

Facility ID: 38

Issues:

- Highest ranked intersection in Loveland for safety (and trending worse)
- Difficult sight lines due to curve of road, and vehicle speeds
- Crash patterns: approach turns, WB right turn rear ends

Concept Design:

- NB/SB double left turns
- Modify WB right turn to enforce yield condition

Concept Cost:

- $1,556,000

Outcomes:

- Concurrent left turns possible simultaneously
- Need new mast arm for NB approach – 60-ft
- Impacts to NE corner property
- Need median work, inlet relocation
- Operational impact: am: 20 to 25 pm: 25 to 30

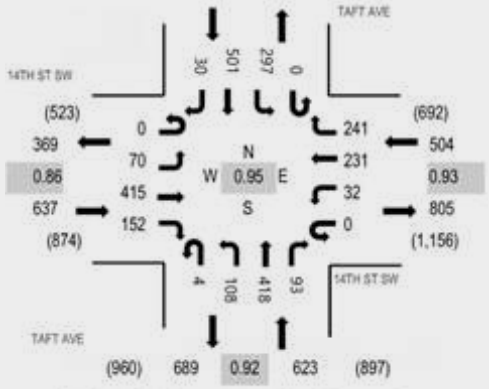
Considerations:

- No NB acceleration lane provided; to be consistent with Taft corridor

Posted/Design Speeds (mph):

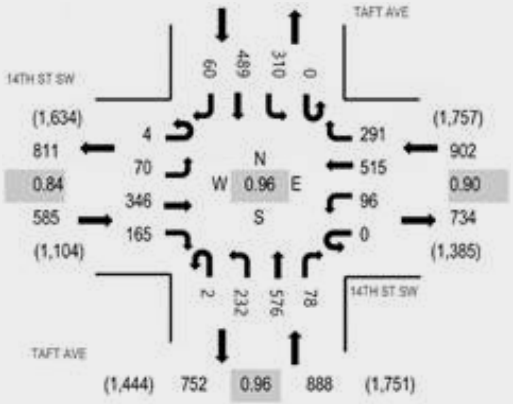
- NB: 40 /45
- SB: 40/45
- EB: 40/45
- WB: 40/45

AM Turning Movement Counts



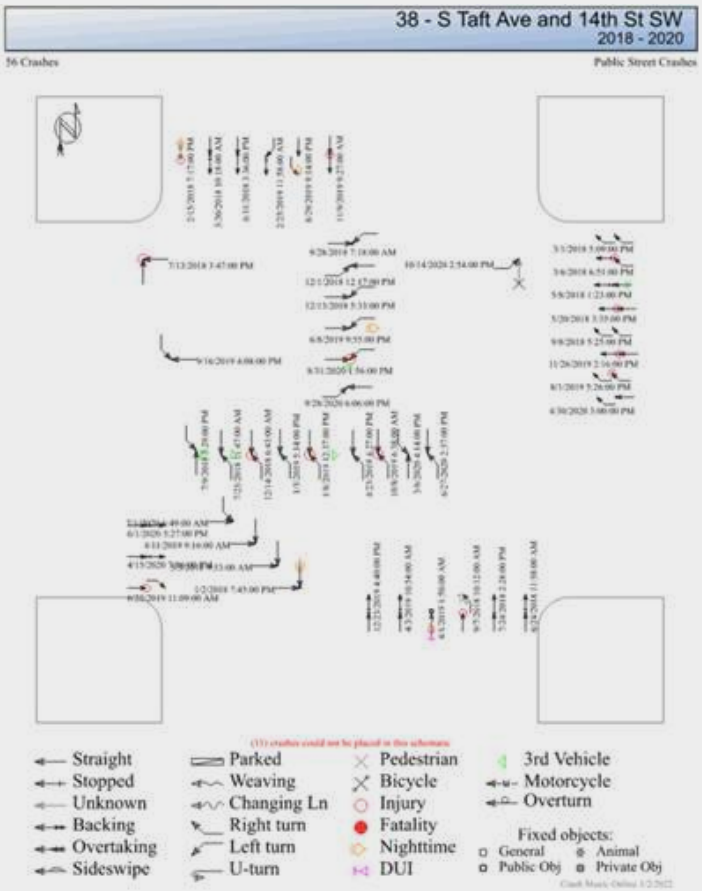
Note: Total study counts contained in parentheses.

PM Turning Movement Counts



Note: Total study counts contained in parentheses.

Crash Diagram – 2018-2020



Project Name: **S Taft Ave & 14th St SW**

Project Number: **021-03903**

Project Manager: **Jessica Burch**

Date: **8/8/2022**

	% Range	% Used	Cost	
Project Construction Items			$437,800.00	(A)
Contingencies	(15% - 30%) of (A)	30.0%	$131,400.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.0%	$0.00	(C)
Drainage/Water/Sewer	(3-10%) of (A+B) Default = 6%	10.0%	$57,000.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	5.0%	$31,400.00	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	25.0%	$164,400.00	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	10.0%	$82,200.00	(G)
Total of Construction Items	(A+B+C+D+E+F+G)		$904,200.00	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.0%	$18,100.00	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	15.0%	$135,630.00	(J)
Subtotal of Construction Cost	(H+I+J)		$1,057,930.00	(K)
Total Construction Engineering	24% of (K)	24.0%	$253,903.20	(L)
Total Preliminary Engineering	15% of (K)	15.0%	$158,689.50	(M)
Right of Way	Project Dependent		$85,000.00	(N)
Utilities	Project Dependent	N/A	$0.00	(O)
Estimated Total Project Cost			**$1,556,000.00**	(P)

Loveland Citywide Roadway Safety Study

S Taft Ave & 14th St SW
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

Existing Overhead Utility Pole

WB-67 Dual Left Turns can be run concurrently

Existing Inlet to be Relocated

Existing Fence to be Relocated

Existing Ramp to be Relocated

Change Mast Arm to 60 LF

14th St SW

Existing Inlet to be Relocated

11'
11'
6'
11'
11'
11'

S Taft Ave

Loveland Citywide Roadway Safety Study

S Taft Ave & 14th St SW
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

14th St SW

S Taft Ave

WASHINGTON AVE & E 1ST ST

Facility ID: 661

Issues:

- Future signal without dedicated E/W left turn lanes
- Long queues, lack of compliance with RRFB
- Crash patterns: right angle, 1 ped crash, 5 injury crashes
- Very limited right of way

Concept Design:

- E/W left turn lanes in preparation for signalization

Concept Cost:

- $29,000

Outcomes:

- Restriping only within existing curbs
- Mostly 11-ft lanes, but left turn lane is 10-ft
- 4-ft bike lanes on pavement
- No curb impacts

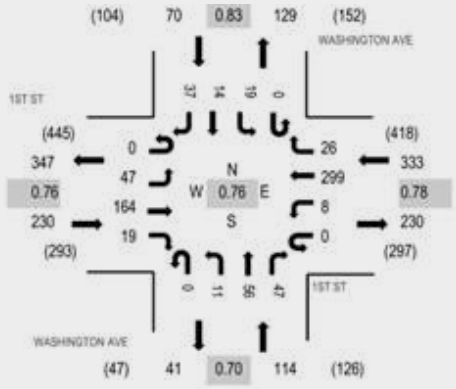
Considerations:

- Keep RRFB and add raised median on east side
- Consider bike lane connection to trail south at 4th St SE (include signing and striping updates with signal project)

Posted/Design Speeds (mph):

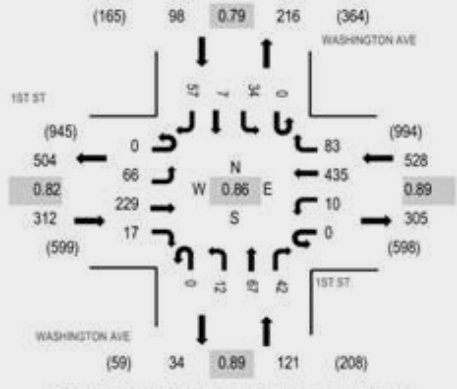
- NB: 30/35
- SB: 30/35
- EB: 30/35
- WB: 30/35

AM Turning Movement Counts



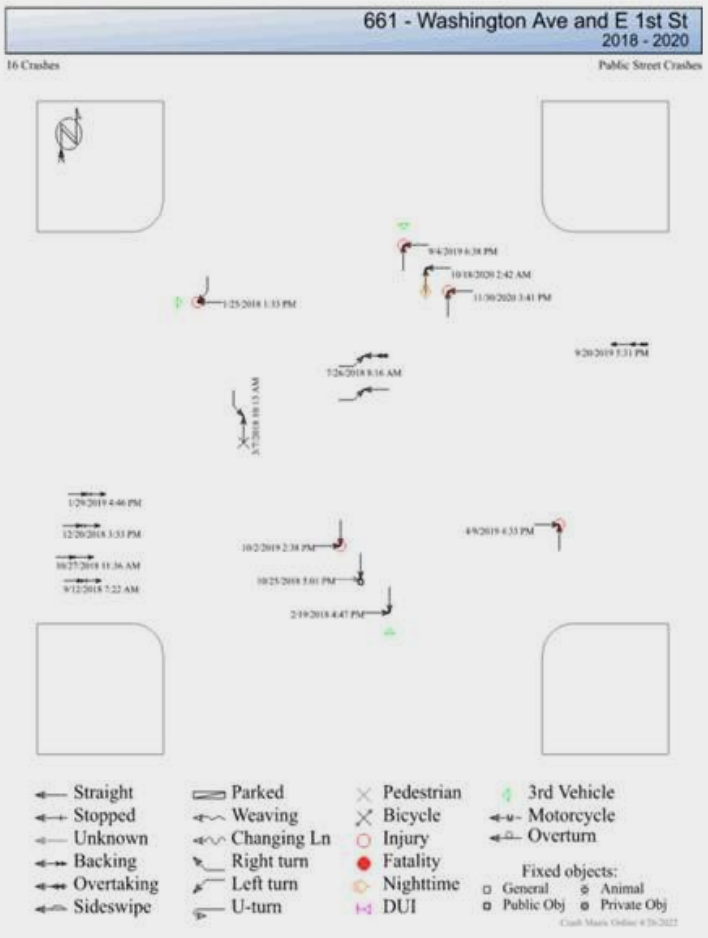
Note: Total study counts contained in parentheses.

PM Turning Movement Counts



Note: Total study counts contained in parentheses.

Crash Diagram – 2018-2020



Project Name: **Washington Ave & E 1st St**

Project Number: **021-03903**

Project Manager: **Jessica Burch**

Date: **8/8/2022**

	% Range	% Used	Cost	
Project Construction Items			$8,400.00	(A)
Contingencies	(15% - 30%) of (A)	30.0%	$2,600.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.0%	$0.00	(C)
Drainage/Water/Sewer	(3-10%) of (A+B) Default = 6%	10.0%	$1,100.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	5.0%	$700.00	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	25.0%	$3,200.00	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	10.0%	$1,600.00	(G)
Total of Construction Items	(A+B+C+D+E+F+G)		$17,600.00	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.0%	$400.00	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	15.0%	$2,640.00	(J)
Subtotal of Construction Cost	(H+I+J)		$20,640.00	(K)
Total Construction Engineering	24% of (K)	24.0%	$4,953.60	(L)
Total Preliminary Engineering	15% of (K)	15.0%	$3,096.00	(M)
Right of Way	Project Dependent	N/A	$0.00	(N)
Utilities	Project Dependent	N/A	$0.00	(O)
Estimated Total Project Cost			**$29,000.00**	(P)

Loveland Citywide Roadway Safety Study

Washington Ave & E 1st St
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

Washington Ave

E 1st St

Existing Fire Hydrant

Existing RRFB to be replaced by Proposed Signal

60'

105'

4'

10'

11'

11'

4'

SH 402 AT CR 9 AND CR 7

Facility ID: 773 & 775

Issues:

- High speed rural area without left turn lanes
- Crash patterns: rear end crashes on SH 402

Concept Design:

- SH 402 left turn lanes, including deceleration
- Approximately half-mile of roadway widening along SH 402 (per location)

Concept Cost:

- $4,063,000 (per location)

Outcomes:

- Long redirect tapers
- Operational impact: minimal

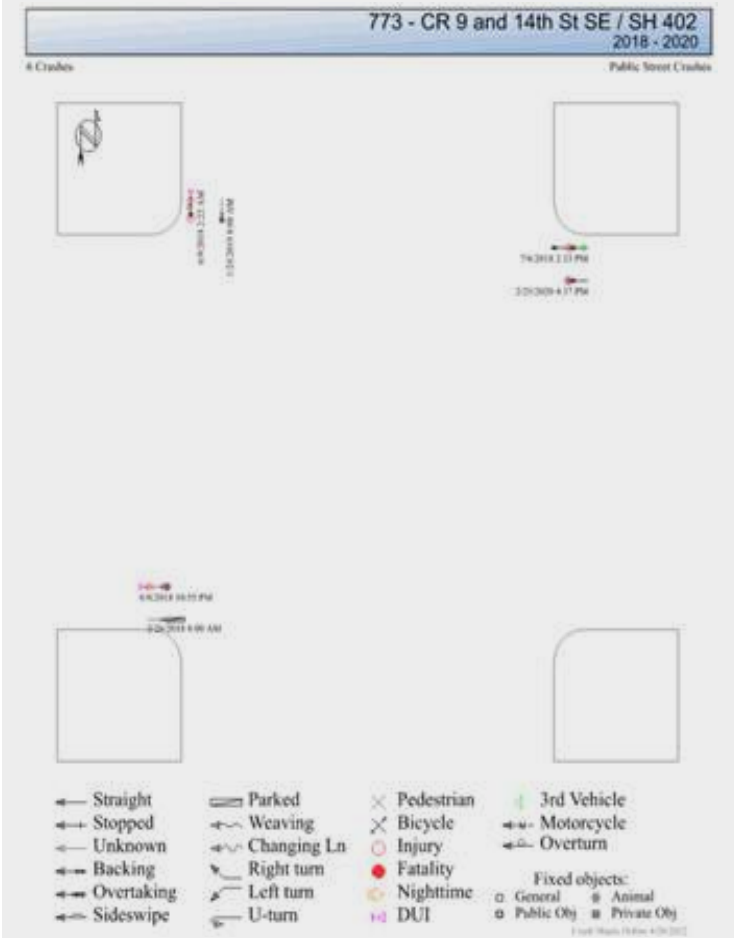
Considerations:

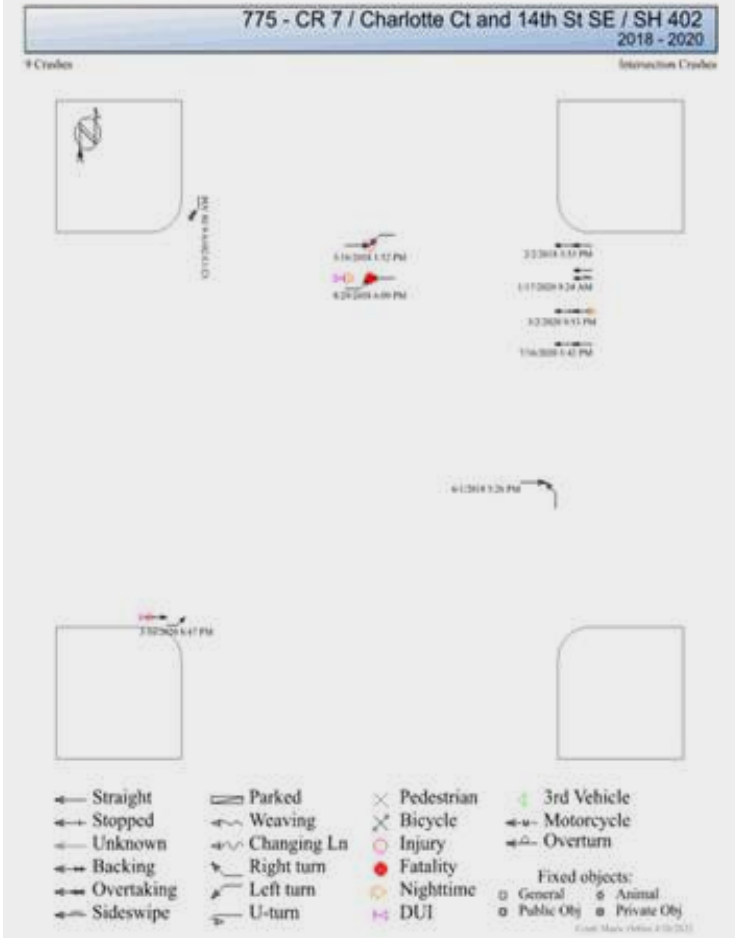
- Overhead utility impacts along corridor
- CR 7 not shown, similar layout requirements
- Potential interim solution until development builds ultimate SH 402 section

Posted/Design Speeds (mph):

- NB: 45/50
- SB: 45/50
- EB: 55/60
- WB: 55/60

Crash Diagram – 2018-2020





Project Name: **SH 402 at CR 9 and CR 7**

Project Number: **021-03903**

Project Manager: **Jessica Burch**

Date: **8/8/2022**

	% Range	% Used	Cost	
Project Construction Items			$614,100.00	(A)
Contingencies	(15% - 30%) of (A)	30.0%	$184,300.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.0%	$0.00	(C)
Drainage/Water/Sewer	(3-10%) of (A+B) Default = 6%	10.0%	$79,900.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	5.0%	$44,000.00	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	25.0%	$230,600.00	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	10.0%	$115,300.00	(G)
Total of Construction Items	(A+B+C+D+E+F+G)		$1,268,200.00	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.0%	$25,400.00	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	15.0%	$190,230.00	(J)
Subtotal of Construction Cost	(H+I+J)		$1,483,830.00	(K)
Total Construction Engineering	24% of (K)	24.0%	$356,119.20	(L)
Total Preliminary Engineering	15% of (K)	15.0%	$222,574.50	(M)
Right of Way	Project Dependent		$1,000,000.00	(N)
Utilities	Project Dependent		$1,000,000.00	(O)
Estimated Total Project Cost			**$4,063,000.00**	(P)

Loveland Citywide Roadway Safety Study

SH 402 at CR 9 and CR 7
Concept Design - Not For Construction

08-08-2022

City of Loveland

Next Phase Engineering

olsson

N

0' 50' 100' 200'

Existing Overhead Utility Pole

SH 402

CR 9

40'

100'

105'

12'

12'

12'

4'

4'

Existing Overhead Utility Pole

Existing Overhead Utility Pole

Existing Overhead Utility Pole

Existing Overhead Utility Pole

Existing Overhead Utility Pole

Existing Overhead Utility Pole

APPENDIX B

MODEL LEFT TURN PHASING APPROACH

APPROACH TO SELECTING LEFT TURN PHASING

Left turn phasing refers to how left turning vehicles are managed at signalized intersections. Three modes of operations for left turn phasing exist:

- Permitted left turns – Left turns may be made after yielding to oncoming traffic. Approaches with permitted only left turns may not have any designated left turn signal heads or may have a four-section head with flashing yellow arrows.
- Protected / permitted left turns – Left turns may be made with the right of way when a green arrow is displayed (protected) or after yielding to oncoming traffic when a green arrow is not displayed (permitted). Approaches with protected / permitted left turns may have older five-section 'doghouse' signal displays or a four-section head with a green arrow and a flashing yellow arrow. The protected phase may lead or lag the permitted phase.
- Protected left turns – Left turns may only be made when a green arrow is displayed. This type of approach utilizes a three-section signal head with green, yellow, and red arrows or a four-section head where the flashing yellow arrow is not utilized.

The selection of left turn phasing is important for traffic signal operations. The impact of the selection is complex, with safety, air pollution, congestion, and pedestrian delay all being affected. With the advent of the flashing yellow arrow signal display for permitted left turns, the option to vary the mode of operation by the time of day provides signal operators with the greatest flexibility to account for varying conditions throughout the day.

The least restrictive mode that provides for safe operation is generally the most desirable alternative. Adding additional phases (green arrows) at traffic signals tends to increase cycle lengths, overall delay, air pollution, and the risk of rear end and same direction sideswipe crashes. On the other hand, providing green arrows can reduce delay for left turning vehicles and reduce the risk of both left turn crashes that tend to be more severe than rear end/sideswipe collisions, and pedestrian crashes in adjacent crosswalks. Therefore, operational choices must be made considering site specific conditions and the advantages and disadvantages of each alternative.

The flow chart on the following page provides general guidance in selecting the most appropriate left turn phasing mode given a variety of conditions. Safety should be the primary consideration. Yet each location is different and has factors beyond left turn phasing that affect safety. Consideration should also be given to incremental changes and continued monitoring that is reflective of the concept that the least restrictive mode that provides for safe operation is the most desirable. There are four main considerations when evaluating left turn phasing:

SIGHT DISTANCE

The sight distance criterion is based on whether turning vehicles can adequately see oncoming traffic to make a timely, informed, and safe decision. The threshold of 5.5 seconds of travel time is based on guidance in the AASHTO Policy on Geometric Design. The sight distance can be impacted by opposing left turning vehicles (creating 'shadowing' of adjacent through vehicles), landscaping, or geometrics of the road (such as horizontal or vertical curves). The threshold implicitly incorporates speed in the equation, as higher speed roadways will require greater sight distance.

If sight distance obstructions can be removed, then monitoring of the intersection may be appropriate to determine whether improved sight distance adequately supports safety. Engineering judgment should be used when evaluating sight distance as other factors such as the number of opposing through and left turn lanes, may affect the complexity of left turns and impact the required sight distance.

CRASH HISTORY

Locations with a history of left turning crashes should be reviewed for more restrictive left turn phasing. To help determine the appropriate number of left turn crashes used as the threshold for consideration of left turn arrows, an evaluation of the tradeoffs between left turn crash risk and rear end crash risk was undertaken. The resource used was the Federal Highway Administration's Crash Modification Factors Clearinghouse. Under most circumstances, it was found that three (3) left turn crashes / year on an approach was an appropriate number to warrant consideration of left turn phasing that offsets the increased rear end / sideswipe crash risk.

ADJACENT BICYCLISTS / PEDESTRIANS

Locations where the left turning vehicles conflict with an adjacent multi-use trail or crosswalk with pedestrian safety concerns should be considered for the application of a cycle-by-cycle protected pedestrian phase. This requires a four-section signal head whereby when the pedestrian push button is activated, the left turn phase is protected only (red arrow) while the pedestrians and bicyclists cross the roadway. The cycle-by-cycle programming allows the intersection to function with a more permissive left turn phasing when pedestrians are not present.

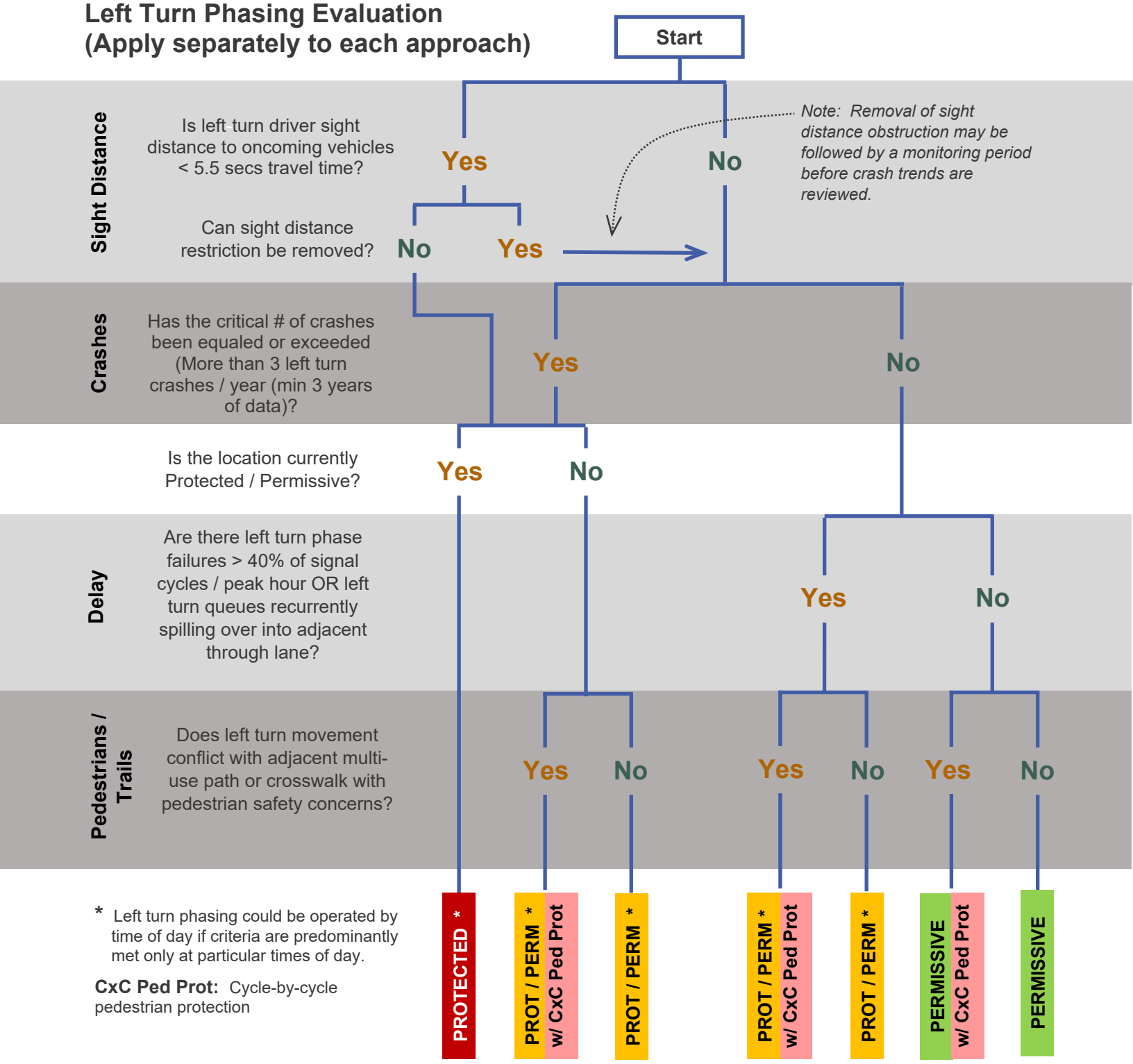
DELAY

Volume, congestion, and delay criteria have historically been determined through the cross product of left turning volumes multiplied by opposing through volumes. This is an easy calculation but does not necessarily reflect the underlying issues for why left turn phasing should be considered. The flowchart on the next page indicates that the delay review should identify whether there are consistent left turn phase failures (which result in excessive delay and the potential for significant end-of-phase turns that can result in approach turn crashes) or left turning queues that consistently impact through traffic.

THE USE OF ENGINEERING JUDGMENT

The four areas of review discussed above and the flowchart on the next page provide general guidance for a consistent review across the City for left turn phasing. As noted earlier, each location is different, and a nuanced review using engineering judgment should be completed to determine whether more restrictive or more permissive phasing is appropriate, or whether incremental changes (such as permissive to protected/permissive before implementing protected only phasing) are reasonable. Additional considerations may include the overall scale of the intersection and complexity in making turns, as well as whether opposing traffic arrives in distinct platoons.

Left Turn Phasing Evaluation (Apply separately to each approach)



* Left turn phasing could be operated by time of day if criteria are predominantly met only at particular times of day.

CxC Ped Prot: Cycle-by-cycle pedestrian protection

Source: Adapted and modified from FHWA NCHRP Report 812 for City of Loveland specific conditions.

These guidelines should be utilized in concert with engineering judgment and field-based conditions including:

- Scale of the intersection and complexity of making a turn, and
- Platooning of approaching vehicles.

APPENDIX C

SAFETY AUDIT FORM

ROADWAY SAFETY AUDIT FORM

Location: _____ **Facility ID:** _____

Reason for the Audit: _____

Audit Team: Lead: _____ **Date:** _____

Additional Members: _____

A Roadway Safety Audit is a formal safety performance examination of a transportation facility that quantitively and qualitatively reviews safety performance, identifies, and analyzes concerns and offers opportunities for improvement in safety for all road users.

The City of Loveland's audit process focuses on how the location under review can be improved from a holistic 'safe systems' perspective. The analysis considers all road users and involves a review of the available data and analysis, physical elements, operational and maintenance element, the people element (such as behavior), and considers countermeasures in all strategic categories (see Loveland's toolbox of countermeasures). It's a performance driven process that can be used to identify quick fixes, low-cost improvements, or projects that can be prioritized among others based on the greatest potential to reduce number and severity of crashes.

Step Number Information and Data Needs, and Topics	What to Do	Notes	"So What" Areas of concern Early ideas for corrective measures
Step 1. Location Overview			
☐ Aerial map ☐ Functional classification ☐ Land use and zoning ☐ Right of Way mapping ☐ Design plans (if available)	Identify project limits Gather and review mapping and other area information to become holistically familiar with the area. Consider logical origins / destinations, nearby generators (parks, schools, commercial area) and associated travel routes		

Items to Consider		Notes	Areas of Concern
Step 2. Crash Data			
☐ 3-5 years of crash data ☐ Intersection screening ☐ Pattern recognition ☐ Crash diagram	Review overall data, intersection screening and pattern recognition Number and types of crashes Vulnerable Road Users		
Step 3. Operational Review			
☐ Turning movement counts ☐ Daily volumes – current and historic ☐ Control / signal timing information ☐ Speed Limits ☐ Speed data (if available)	Complete Intersection Operational Analysis Look for congestion, queues, how volumes have changed over time (growing area?) or new patterns Consider how operational review dovetails with crash data		
Step 4. Public Perception / Input Review			
☐ Resident input	Review number, types and patterns of complaints		

Step 5. Field Review (add additional sheets if needed)

- *Wear proper safety equipment (safety vests)*
- *For each category consider all road users, all directions of travel: entering, exiting, turning, etc.*
- *Be open minded and curious. Make notes. Take photos. Consider info / takeaways from Steps 1-4.*
- *Review may need to be done during different times of day (i.e., nighttime, off-peak).*

Note day / time / weather of review

Day:

Time:

Weather:

Items to Consider		Notes	Areas of Concern
Geometric Review	Note lanes, widths, tapers, etc. Look for skid marks, scuff marks, curb damage, vehicle tracking paths		
Signs, and Markings	Note anomalies, missing devices, or signs in poor condition		
Visibility	Signal heads, signs, sight distance		
Area Access Points	Identify driveways, intersections etc.		
Pedestrian and Bicycle Facilities	Look for facility continuity, crossing options, potential conflicts points with vehicles		
Transit Facilities	Bus stops and associated facilities (including sidewalks on approach)		
Truck Activity	# and type of trucks, truck movements		
Maintenance	Pavement, curbs, sidewalks, plowing etc.		
Human Factors (Behaviors, Education / Enforcement Needs, and Positive Guidance)	Watch behaviors – consider user capabilities / limitations. Think about the location from a user's perspective		
Potential Perceived Safety Concerns	Level of comfort, walkability		
Type of Road Users	Multi modal activity		

Step 6. Summary Information and Proposed Countermeasures (add additional sheets if needed)

- *Provide bulleted summary of identified areas of concern from steps 1-5.*
- *Identify level of risk for each concern.*
- *Restrict comments to those that have bearing on safety.*
- *Use specific and descriptive language. Avoid broad statements such as 'unsafe' or 'deficient'.*
- *Should not focus on standards compliance unless non-compliance is a relevant safety issue*
- *Identify proposed countermeasures and needed follow up actions.*
- *Countermeasures should be constructive and realistic.*
- *Consider all strategies in toolbox.*

Risk levels:

1. Standards compliance or perceived safety
2. Potential to impact crashes
3. Documented crash history
4. Urgent matter for prompt action or high priority

Issue (with Description)	Risk Level	Countermeasure	Specific Actions / Next Steps

Step 7. Decision and Documentation

Decision: Explain whether the reason for the audit has been addressed or determined that no action is appropriate or justified at this time.

- ☐ Completed form
- ☐ Additional data / materials (including crash information, analysis sheets, photos, etc.) from steps 1-5 as attachments
- ☐ Detailed notations on Specific Actions / Next Steps (highlighted yellow)

APPENDIX D

TOOLKIT OF COUNTERMEASURES

Toolbox of Safety Countermeasures

11-Aug-22

Location / Type of Crash	Countermeasure	Signing and Striping	Operations / Traffic Control	Low Cost Infrastructure	Infrastructure - Capital	Maintenance	Enforcement	Education	Proram	Standards / Policies	Applicability	Considerations / Cautions
Speed												
	Additional speed limit signs	X										Negligible impact
	Road diet / narrowing of lanes	X		X							Lower volume roads (<15,000 VPD)	Maybe able to add other features such as bike lanes, center turn lane. Be careful about impact at intersections where auxiliary lanes are needed.
	Progression with slower speed		X								Corridor with consistent, coordinated signals	May impact timing of cross corridors
	Add side friction - channelizing islands/bumpouts			X	X						Channelizing islands requires right turn lane.	shorten ped distances. May require relocating signal poles.
	Add parking	X		X							Can be easy if road is wide - striping only	Watch for visibility at intersections, door zone
	Narrower roads				X					X	Could be a standards based approach	11 ft mimimum of pavement (not including pan). Could be done with striping (wider bike lanes).
	Speed Cameras						X				Needs to be allowed by Loveland	Need realistic speed limits and data driven
	Neighborhood mitigation - feedback signs, humps			X					X		Neighborhood, local and collector streets.	Best if done as a consistent program with evaluation.
	Neighborhood outreach							X			Best if done within a holistic education campaign.	Requires considerable staff time.
	Review Speed limit		X							X	Where prevailing speeds differ from the posted speed.	Changing speed limit found to have limited impact on travel speeds.
	Targeted enforcement						X				Where speeding concerns exist.	Can provide data-driven locations to Police. Limited staff availability.
Intersections												
Approach Turn												
	Eliminate offset left turns	X								X	In urban areas where head on crashes not	
	Limit / eliminate allowed turns		X									Can be political, watch for traffic detours to other
	Platoon creation		X								Corridor with signals.	May be done with coordinated signal timing.
	Protected only left turn phasing		X								Use Left Turn Phasing flowchart	May cause increased delay.
	Lagging left turn phasing		X								Works well at T intersections	Watch for yellow trap at 4 legged intersections.
	FYA - protected only by time of day		X								If crashes are prominent at specfic times of day (congestion based).	Need four section head
	See also Red Light Running											
Right Angle												
Unsignalized Intersections	Stop Ahead Signs	X									Stop sign running crash pattern	
	Stop Ahead Pavement Markings	X									Stop sign running crash pattern	Best to use durable markings for less maintenance
	Oversized STOP sign	X									Stop sign running crash pattern	May require a double post

Location / Type of Crash	Countermeasure	Signing and Striping	Operations / Traffic Control	Low Cost Infrastructure	Infrastructure - Capital	Maintenance	Enforcement	Education	Proram	Standards / Policies	Applicability	Considerations / Cautions
	Stop line	X									Stop sign running crash pattern	Best to use durable markings for less maintenance
	Gate post stop signs (median)	X									Stop sign running crash pattern and if there's a	
	Improve STOP sign retroreflectivity	X									Stop sign running crash pattern	
	Improve sight distance					X					Failure to Yield after stop crash pattern	
	Remove adjacent on street parking		X								Failure to Yield after stop crash pattern	Can be political. Typically, at least two spaces need to be removed from the through street on each side of the stopped approach(es).
	Implement RI/RO or 3/4 movement		X		X						Failure to Yield after stop crash pattern	Can be politically difficult. Signage only not effective - requires raised channelization
	Install All-Way STOP	X	X								Unsignalized intersection	Consider MUTCD all-way STOP guidelines
	Install traffic signal		X		X						Warrant study needed	Consider MUTCD signal warrants
Signalized Intersections	Prohibit Right Turn on Red	X									Failure to Yield after stop crash pattern.	Requires enforcement. Increases number of right turns on green.
	Eliminate night flash		X									Best at intersections equipped to operate fully-
	See also Red Light Running											
Other	Install Roundabout				X					X	Unsignalized or signalized intersection	May require additional ROW.
Rear End												
	Addition of right, left turn auxiliary lanes				X						Unsignalized or signalized intersection	If bike lane exists, move it to left of a right turn lane.
	Free right turn lane				X						Unsignalized or signalized intersection	May require channelizing island.
	Road Diet	X		X							Unsignalized or signalized intersection - in locations where there are no auxiliary left turn lanes and diet creates space for one	
Signalized Intersections	Offset changes - fewer arrivals at change of phase		X								In coordinated corridor	
	Dilemma zone detection		X								Higher speed intersection approaches	Requires actuated coordination when signals coordinated
	Adaptive signal control		X								Areas with varying side street volumes.	Increased requirements for detection.
	Remove unwarranted signal		X									Consider MUTCD signal warrants
	Convert protected lefts to protected/permitted		X								In congested locations	To increase capacity, but may increase left turn crashes
	Provide more green time to affected approaches		X									Consider operational impacts to other movements
	Remove red light camera						X				If red light camera is present	Do evaluation for appropriateness
Red Light Running	Signal Ahead signs	X									For locations with limited visibility of signal	Be cautious about sign clutter
	Offset changes - fewer arrivals at change of phase		X								Coordinated corridor	
	Dilemma zone detection		X								Higher speed intersection approaches	Requires actuated coordination when signals coordinated

Location / Type of Crash	Countermeasure	Signing and Striping	Operations / Traffic Control	Low Cost Infrastructure	Infrastructure - Capital	Maintenance	Enforcement	Education	Proram	Standards / Policies	Applicability	Considerations / Cautions
	Add another signal head		X								Where visibility is a concern.	
	Yellow change intervals		X									Consider ITE recommendations
	All red clearance interval		X									Consider ITE recommendations
	Flashing beacon advance warning of signal		X									Could be prepare to stop when flashing - synchronized with signal
	Backplates w/ reflective borders			X								Low cost
	Visibility of signal heads					X					For locations with limited visibility of signal	
	Red light cameras						X				Needs to be allowed by Loveland. Do evaluation for appropriateness - does it increse safety?	May increase rear end crashes
Run off Road - T Intersection												
	Double arrow	X										
	End of road 9-balls	X										
	T intersection advance warning sign	X									Especially applicable if visibility of intersection is limited.	
	Add centerline, STOP AHEAD markings, STOP bar	X									Especially applicable if visibility of intersection is limited.	
	Oversize stop signs	X										
	Flashing lights on stop signs	X										Requires ongoing maintenance. Not recommended due to consistency issues and standard of care concerns.
	Rumble strips on approach			X							Best in non-residential areas	Can be noisy. Do not place rumbles in bike lane
	Retroreflectivity of STOP signs					X					If signs are faded	
Other												
	Add signal		X									Consider MUTCD signal warrants
	Remove signal		X									Consider MUTCD signal warrants
	ALL WAY STOP		X									Consider MUTCD all-way STOP guidelines
	Add median islands/strip curbing			X								Can help delineate opposing lanes
	Remove / limit nearby driveways			X								Requires outreach and alternative options
	Street lighting					X					If crashes are nightime related	
	Improve geometry - align lanes, reduce angles				X							May require substantial effort - capital project
Roadway Segments												
Roadway Departure	Enhanced delineation for horizontal curves	X										Could be signing or striping (arrows, chevrons etc.). Ensure edge striping is in good condition
	Wider edge lines	X										

Location / Type of Crash	Countermeasure	Signing and Striping	Operations / Traffic Control	Low Cost Infrastructure	Infrastructure - Capital	Maintenance	Enforcement	Education	Proram	Standards / Policies	Applicability	Considerations / Cautions
	Safety Edge			X							For locations w/o curbing	Allows vehicles to correct back onto road. Best if done during maintenance activities
	Adding curb			X								Consider drainge impacts
	Rumble strips			X								Can be noisy - Use caution in residential areas. Do not put rumbles in bike lane.
	Geometric design improvements				X						For example sharp horizontal curves.	
	Widen shoulders				X						In locations with narrow roadways	Also supports bicycle mobility
Head On	Centerline stripe	X									If no striping exists	
	Medians			X								
	Median barriers			X								
	Centerline rumbles			X								
	Add TWLTL				X						Could be done thorugh a road diet	Consider volumes
	Replace TWLTL with raised median				X						If unregulated turns are contributing to crashes	Consider turning movements and driveway accesses. May require outreach.
Accesses / Driveways	Limit turns from driveways - especially lefts		X									Likely requires physical modifications - signage not enough. Requires outreach
	Medians			X	X							Requires outreach.
	Add TWLTL				X						Could be done thorugh a road diet	Consider volumes
	Improve visibility of driveway					X					If visibility is limited	Could be done through landscape trimming
	Corridor access management									X	Longer commercial corridor	Planning / outreach study may be needed
	Change driveway density									X		Longer term land use approach
Pedestrian Crashes												
Intersections	Crosswalk markings	X									Where warranted.	Avoid overuse.
	Leading pedestrian intervals		X								Signalized intersection	Caution if left turn phasing is present
	Relocate ped push button		X								Signalized intersection where signal pole shadows waiting ped	
	Prohibit right turns on red		X								Could be done on a cycle by cycle basis	Requires enforcement. Increases right turns on green.
	Protected ped time for crossing (red arrow)		X									Ped actuated cycle by cycle
	Pedestrian countdown timer		X									Now required by MUTCD.
	Street lighting			X							If crashes are nighttime related	
	Add channelizing islands at right turn lanes				X						Can shorten pedestrian crossing distances	
	Training people to push the button							X				Best if part of an education campaign

Location / Type of Crash	Countermeasure	Signing and Striping	Operations / Traffic Control	Low Cost Infrastructure	Infrastructure - Capital	Maintenance	Enforcement	Education	Proram	Standards / Policies	Applicability	Considerations / Cautions
Uncontrolled Crossings												
	Review for crosswalk markings	X										Consider City's crossing guidelines.
	Review for visibility of peds (curves/ vegetation)					X					If visibility is a concern	
	Crosswalk signage (state law in pavement, advance etc)	X									Visibility enhancements	
	RRFB / PHB / Ped signal		X									Consider City's crossing guidelines.
	Road diet to eliminate multiple threat			X							Lower volume roads (<15,000 VPD)	Consider vehicle volumes
	Median refuge for 2-stage crossing			X								
	Grade separation - underpass				X						For high use trails under higher speed, higher volume arterials	Consider City's crossing guidelines.
	Street lighting			X							If crashes are nighttime related	
	Education campaign							X				
Road Segments												
	Adding sidewalk				X						Where sidewalks are missing.	
	Widen sidewalk				X						Where sidewalks are substandard, or used more like multi-use path.	
	Add separation - detached sidewalk				X							Requires wider ROW.
	Add curbing between travel lanes / walk			X								Impacts plowing / maintenance.
	Wayfinding to better routes	X						X				If encouraging people to use low stress routes, then arterial crossings become more important.
	Street lighting			X							If crashes are nighttime related	
Bicycle Crashes												
Intersections												
	Bring bike lanes to intersection	X										Needs context sensitive design using standards and guildelines .
	Bike lanes to left of right turn lanes	X										Required by MUTCD
	Green paint?	X									Recommended in high conflict areas and where bikes have the right of way.	Caution for overuse. Consider maintenance requirements.
	Bike signal		X								Where bikes are on a separate facility.	Follow MUTCD requirements.
	Education - for both bicyclists/motorists							X			To reduce riding against traffic, and to get motorists to look right before turning right.	
Uncontrolled Crossings												
	Two-way path signage	X										
	Vehicle crossing signs on bike paths	X										

Location / Type of Crash	Countermeasure	Signing and Striping	Operations / Traffic Control	Low Cost Infrastructure	Infrastructure - Capital	Maintenance	Enforcement	Education	Proram	Standards / Policies	Applicability	Considerations / Cautions
	Review for enhanced treatment		X									Consider City's crossing guidelines.
	RRFB, PHB, bike signal		X									Consider City's crossing guidelines.
	Grade separation - underpass				X						For high use trails under higher speed, higher volume arterials	Consider City's crossing guidelines.
	Wayfinding	X						X				If encouraging people to use low stress routes, then arterial crossings become more important.
	Education							X			To reduce riding against traffic, and to get motorists to look right before turning right.	
Road Segments												
	Bike lane striping	X										
	Wider bike lane striping (6")	X										
	Buffer striping	X										
	Protected bike lanes			X								Consider maintenance requirements. Can impact driveways. Need to carefully consider how to manage bike lane at intersections (right hooks
	Parking buffer	X									If bike crashes are door zone crashes	
	Reverse angle parking	X									If bike crashes are due to backing vehicles	Check if allowed, needs education, wider parking slots
Snow and Ice Crashes												
	Pavement friction management			X								Need to work with Streets Department
	Coordination with sanding / plowing					X						Need to work with Streets Department

SOURCES

FHWA *Crash Modification Factors Clearinghouse*
FHWA *Proven Safety Countermeasures*
FHWA *Highway Safety Manual*