C I T Y O F B O U L D E R
TRANSPORTATION ADVISORY BOARD
AGENDA ITEM

MEETING DATE: June 8, 2015

AGENDA TITLE: Public hearing and consideration on a recommendation to City Council regarding Living Lab Phase II "rightsizing" transportation pilot projects, as part of the implementation of the Transportation Master Plan.

PRESENTER/S:
Michael Gardner-Sweeney, Acting Director of Public Works for Transportation
Kathleen Bracke, GO Boulder Manager
Dave (DK) Kemp, Senior Transportation Planner
Marni Ratzel, Senior Transportation Planner
Bill Cowern, Transportation Operations Engineer
Shannon Young, Transportation Engineer

EXECUTIVE SUMMARY:

This memo shares the draft memorandum for the June 16, 2015 City Council agenda item regarding a motion to approve the Complete Streets Living Lab Phase II "rightsizing" transportation pilot projects, as part of the implementation of the Transportation Master Plan. The Living Lab Phase II candidate corridors under consideration for rightsizing include segments of Iris Avenue, Folsom Street, 55th Street, and 63rd Street.

STAFF RECOMMENDATION

The staff recommendation is to install Complete Streets Living Lab pilot projects to test rightsizing design treatments for 12 to 18 months on each of the four candidate corridors. The combination of an in-depth technical analysis and the community input process has guided the staff recommendation to install the rightsizing projects in Summer 2015. If approved by City Council, staff will utilize technical analysis as well as walk/bike audits, social media, and public meetings to gather community input and evaluate the new street configurations for 12 to 18 months following the project installation.

TAB ACTION

Staff requests TAB consideration of a recommendation to City Council regarding the installation of Living Lab Phase II pilot projects, as part of the implementation of the Transportation Master Plan.

NEXT STEPS:

On Tuesday, June 16, 2015, the City Council will take action and consider a motion, based on the staff and TAB recommendations, to approve the Complete Streets Living Lab Phase II pilot projects on the following arterial roadways: Iris Avenue (Broadway to Folsom Street); Folsom Street (Valmont Road to Colorado Avenue); 55th Street (Pearl Parkway to Arapahoe Avenue); and 63rd Street (Lookout Road to Gunbarrel Avenue/Nautilus Drive). See **Attachment F** of the attached memo for details.

Agenda packets for Council Meetings are posted by 3:30 p.m. on the Friday prior to each council meeting. Materials may be viewed at:
https://bouldercolorado.gov/city-council/city-council-meetings

ATTACHMENT: Draft of June 16, 2015 City Council Memo

CITY OF BOULDER
CITY COUNCIL AGENDA ITEM

MEETING DATE: June 16, 2015

AGENDA TITLE: Consider motion to approve Living Lab Phase II "rightsizing" transportation pilot projects, as part of the implementation of the Transportation Master Plan.

PRESENTER/S: Jane S. Brautigam, City Manager
Maureen Rait, Executive Director of Public Works
Michael Gardner-Sweeney, Acting Director of Public Works for Transportation
Kathleen Bracke, GO Boulder Manager
Dave (DK) Kemp, Senior Transportation Planner
Marni Ratzel, Senior Transportation Planner
Bill Cowern, Transportation Operations Engineer
Shannon Young, Transportation Engineer

EXECUTIVE SUMMARY

An action item of the Transportation Master Plan (TMP) implementation plan is to install "Complete Street" projects through the Living Lab program. Introduced during the TMP update process, the Living Lab approach installs pilot projects to test new roadway designs, allow experimentation and gather community feedback on the user experience.

The concept of street rightsizing involves the reallocation or repurposing of existing street space to safely and comfortably accommodate people walking, bicycling, and driving while reducing motor vehicle speeds, as well as the frequency and severity of motor vehicle collisions. The pilot project evaluation is envisioned as a before/after analysis of technical data, user experience and observational surveys, which will inform the development of a network of low-stress bicycle routes, enhance transit access, and create a more pedestrian-friendly community.

The Living Lab Phase II candidate corridors under consideration for rightsizing include segments of Iris Avenue, Folsom Street, 55th Street, and 63rd Street. A map of the candidate corridors is provided in **Attachment A**. Rightsizing the candidate corridors is

operationally feasible, and staff has created design options to strike a balance among all travel options.

Based upon the guidance from City Council provided during the Feb. 24, 2015 study session discussion, the Transportation Division developed an enhanced and focused public process to gather community input on the Living Lab Phase II design options.

The combination of an in-depth technical analysis and the community input process has guided the staff recommendation to install the rightsizing projects in July and August 2015. For the 12 to 18 months following the project installation, staff will utilize walk/bike audits, social media, and public meetings to gather community input and evaluate the new street configurations.

Staff will periodically brief the Transportation Advisory Board (TAB) and City Council with updates and will request input during the pilot project evaluation phase. Following the evaluation period, staff will return to the TAB and City Council to report on the successes and challenges associated with the rightsizing pilot projects.

STAFF RECOMMENDATION

Suggested Motion Language:
Staff requests council consideration of this matter and action in the form of the following motion:

Motion to approve Complete Streets Living Lab pilot projects to test rightsizing design treatments for 12 to 18 months, as recommended by staff in **Attachment F,** on the following arterial roadways: Iris Avenue (Broadway to Folsom Street); Folsom Street (Valmont Road to Colorado Avenue); 55th Street (Pearl Parkway to Arapahoe Avenue); and 63rd Street (Lookout Road to Gunbarrel Avenue/Nautilus Drive).

COMMUNITY SUSTAINABILITY ASSESSMENTS AND IMPACTS

Economic: The Living Lab pilot projects are a cost-efficient strategy to test transportation designs and roadway treatments to evaluate safety, increase comfort and decrease collisions on city streets.

Environmental: The Living Lab pilot projects are intended to help achieve the city's TMP objectives of reducing single-occupancy vehicle (SOV) travel, managing traffic congestion, and reducing air pollution emissions, including greenhouse gases (GHGs). Biking and walking are zero-emission transportation options that reduce GHG pollution, and transit and transportation demand management (TDM) programs are key to reducing the number of trips made by SOVs.

Social: The Living Lab pilot projects will further the city's social sustainability goals by increasing transportation mobility, access and safety for all members of the community,

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including expanding transportation choices for those with low income, older adults and children.

OTHER IMPACTS

- **Fiscal:** The Phase II Living Lab program is supported by existing funding in the city's 2015 budget. The estimated installation cost for completing all four corridors is approximately $300,000. There will also be additional maintenance costs associated with keeping pavement markings and protected bike lane elements in place throughout the experiment.
- **Staff time:** Staff resources for this project are included in the 2015 budget.

BOARD FEEDBACK:

Transportation Advisory Board (TAB)

The TAB has been involved with the community engagement for the Living Lab, providing input on the scope and schedule of the process. Below are links to the TAB meeting packets, along with the final TAB minutes for each meeting.

- Sept. 8, 2014 – Staff briefing and TAB input regarding the Bicycle Living Lab evaluation update and next steps. View the TAB minutes from Sept. 8.
- Feb. 9, 2015 – Staff briefing and TAB input regarding the six-month TMP implementation check-in with City Council. View the TAB minutes from Feb. 9.
- April 13, 2015 – Staff briefing and TAB input regarding the Complete Streets Phase II Living Laboratory program and TAB minutes of April 13, 2015.
- May 11, 2015 – Staff briefing and TAB input regarding the Complete Streets Phase II Living Laboratory program and TAB minutes of May 11, 2015.

On June 8, 2015, the Transportation Advisory Board (TAB) held a public hearing to consider a recommendation to City Council. The motion was to:

- _____

The draft minutes from the June 8, 2015 TAB meeting are available at [link].

PUBLIC OUTREACH AND FEEDBACK:

Based upon the guidance from City Council provided during the Feb. 24, 2015 study session discussion, the Transportation Division developed an enhanced and focused public process to gather community input on the Living Lab Phase II design options. Throughout May and early June, a series of stakeholder meetings and pop-up events were conducted to share information and request public comments on the rightsizing design options under consideration. The Transportation Advisory Board (TAB) hosted an open house on May 20 and has been engaged in the development of the corridor projects since the inception of the Living Lab Phase II program.

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A calendar with details about all of the public forums is included in **Attachment B**. More than 150 community members directly participated in the May 20 open house and pop-up event engagement opportunities, with others using social media and email to provide input on the proposed design options. Individual comments received prior to distribution of this memo are available on the project web page and key themes are summarized later in this section of the memo.

Community engagement has included an extensive social media presence, including a Living Lab introduction video that was shared on Twitter, Facebook and Inspire Boulder. The video has been played more than 380 times since its release on Saturday May 16, 2015. Additionally, several community partners have supported and promoted the community engagement events via their social media outlets.

The www.BoulderLivingLab.net Web page provides project information and an online comment form. Stakeholders interested in receiving emails with periodic updates may sign up for the Boulder Living Lab email newsletter, which will be used to distribute one or two messages a month regarding the Living Lab program, including upcoming engagement opportunities, throughout the duration of the rightsizing pilot projects.

These Web-based tools have enhanced the city's ability to reach new and diverse populations when combined with traditional approaches of print media, open houses and board meetings.

In addition to the aforementioned outreach methods, the project team also presented and received input on design options from the University of Colorado's Pedestrian Safety Committee, Growing Up Boulder, and Better Boulder organizations. To address specific concerns from residents adjacent to the proposed project areas, homeowners' association meetings were also held with the Heritage Meadows and Melody Catalpa neighborhoods. Letters from community organizations received prior to the distribution of this memo are included in **Attachment C**.

While a variety of comments were received, most were supportive of the pilot projects and testing rightsizing design treatments. Common themes of public input are summarized below.

Considerations on the rightsizing approach

- Striking a balance among travel modes is important along these corridors.
- Design aesthetics are important, even for temporary installations, as design often influences perceptions and behaviors.
- Winter maintenance is a concern.
- The efficiency of motor vehicle traffic flow and congestion along the candidate corridors is a concern, especially in the event of emergency response situations.

Support for testing rightsizing treatments

- Improves safety of bicyclists and pedestrians crossing these arterial roadways.
- Encourages people to make active trips by walking and bicycling.

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- More buffer is better – it creates a safe separated environment for non-motorized modes within the street.
- Increases walking and biking comfort.
- Improves and provides more north-south bicycling route options.
- Slows motor vehicle speeds.

Concerns for testing rightsizing treatments
- Increases cyclist and bus interactions.
- Delays of vehicles turning left onto Iris Avenue from streets without traffic signals.
- Delays along 55th Street due to the train crossing, tractor trailer trucks and buses.
- Increased traffic along 63rd Street due to the residential and commercial developments recently completed and underway.

Ongoing community engagement during pilot projects
If council approves installation of the pilot projects, staff proposes an active, ongoing community engagement process throughout the duration to seek feedback from the public about their experiences using the new street configurations. This community feedback will be used along with the before/after technical analysis to determine future phases and locations for the Living Lab program.

BACKGROUND
Boulder is committed to providing the best infrastructure for the community to walk, bike, bus, or drive safely and efficiently. Boulder is not alone in this goal, as the U.S. Department of Transportation's Secretary Foxx recently challenged mayors and local elected officials to take significant action to improve safety for bicyclists and pedestrians of all ages and abilities during the next year.

The vision of the city's Transportation Master Plan (TMP) is to create and maintain a safe and efficient transportation system that meets the sustainability goals of the community to accommodate increased trips by providing travel choices and reducing the share of single-occupant vehicle (SOV) trips. The TMP objectives include safety improvements for people using all transportation options while working "Toward Vision Zero" for fatal and serious injury crashes. The 2014 TMP enhanced objectives include reducing SOV travel to 20 percent of all trips for residents and to 60 percent of work trips for non-residents, as well as reducing vehicle miles traveled for both residents and non-resident employees. In addition, the 2014 TMP increases the city's previous goals for walking, biking, and transit mode share. Currently, Boulder residents ride the bus at twice the national average, walk three times as much, and bicycle at 21 times the national average. The 2014 TMP sets ambitious, yet realistic, goals of 30 percent bike, 25 percent walk, and 10 percent transit mode share for all trips taken within the city.

To accomplish these goals, the TMP's Complete Streets focus area strives to accommodate people walking, biking, riding buses, and driving as city transportation facilities are planned, designed, constructed, and maintained. This approach develops the balanced and complete multimodal transportation system needed to enhance safety and

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increase access while shifting trips away from single-occupant vehicles. An emphasis is to increase walk and bike trips made by women, older adults and families.

Complete Streets Living Lab Program
The Complete Streets Living Lab pilot projects program, which began as part of the 2014 TMP update, is intended to enhance the existing transportation system for cyclists of all ages and riding abilities. The Living Lab program is being deployed in phases of pilot projects, with qualitative and quantitative analysis, including extensive community feedback, to evaluate the potential for long-term application in Boulder. The Living Lab program builds on prior city experience with "rightsizing" streets such as north Broadway, west Table Mesa Drive, and Baseline Road, as well as from similar work being done in peer cities and national/international examples.

The first phase of Living Lab projects is providing a forum for testing new, innovative facilities and contemporary treatments to improve Boulder's existing bicycle infrastructure. Phase I projects have been opportunistic and primarily bicycle-related, with a focused public engagement process prior to installations and a robust evaluation process after installation, including community feedback, technical evaluation, and field "before and after" behavior observations. Phase I experiences have informed Phase II.

Phase II – Complete Streets Corridors
From a complete streets perspective, corridor enhancements include repurposing street space to better serve all travel options. Responding to input from the community, boards, and City Council during the 2014 TMP update, staff has developed a set of candidate 2015 Phase II Living Lab projects. Potential Phase II projects include a "rightsizing" approach along four candidate corridors, including Iris Avenue, Folsom Street, 55th Street and 63rd Street. These projects are primarily comprised of signing, striping, and markings, and do not include major capital improvements. These projects are temporary in nature, which makes them relatively simple to modify or remove. The impetus of these pilot projects is to collect empirical data to understand and gauge the effectiveness of innovative street designs that increase comfort and safety for people using all modes of transportation along each of the proposed corridors.

Staff anticipates the overall safety of the candidate corridors will be improved by providing center turn lanes where they do not exist today, reducing the number of lanes that pedestrians and vehicles need to cross from side streets, reducing motor vehicle speeds and increasing the visibility of vulnerable users traveling along the corridors. Other benefits of rightsizing include improved safety and comfort for bicyclists by widening and buffering the bike lanes from vehicle travel lanes, fewer vehicle travel lanes for pedestrians to cross, and improved access to transit.

Roadway rightsizing is a practice of revisiting a street design and repurposing vehicle lanes to enhance how the street works for pedestrians, cyclists, and transit users (within the context of adjacent land uses) while maintaining appropriate functionality for motor vehicle trips. Rightsizing projects have been implemented across the United States, with significant benefits for all users. Peer cities that have enhanced bike and walk travel

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options through rightsizing include Portland, OR; Seattle, WA; Charlotte and Raleigh, NC; Tampa, FL; New York, NY; and Washington, D.C.

While the rightsizing term is new to our community, the concept is not. The city has repurposed vehicle lanes to enhance bicycle facilities along Baseline Road from Mohawk to 30th Street and from 28th to 30th Street; Table Mesa Drive from Broadway to Lehigh Street; 13th Street from Canyon Boulevard to Spruce Streets; Broadway north of Norwood Avenue; and, more recently, Broadway between Linden and Norwood avenues. The pilot project evaluation will inform the development of a network of low-stress bicycle routes, enhance transit access, and create a more pedestrian-friendly community.

ANALYSIS

The Transportation Division has conducted an extensive analysis of the four proposed corridors and has developed multimodal evaluation criteria that have been previously vetted through the TAB and City Council.

The analysis has yielded the development of conceptual design options based upon the TMP goals of enhancing the bicycling, walking, and transit experience, improving safety, and managing potential trade-offs such as vehicle travel time delays. The multimodal technical analysis, including results of a dynamic system analysis using VISSIM modeling of the four proposed corridors, is provided in **Attachment D**.

Research from peer cities shows that rightsizing projects have resulted in decreased crashes and vehicle speeds while increasing bicycle trips. According to the American Association of State Highway and Transportation Officials (ASSHTO) Highway Safety Manual, an estimated 29 percent reduction in vehicle collisions occurs following the installation of rightsizing treatments.

Locally, staff compiled a collision history detailing the quantity and types of collisions along each of the four proposed corridors. Staff anticipates that the rightsizing treatments will reduce a portion of these collisions. A summary can be found in **Attachment E.**

Highlights of Multimodal Analysis

The results of the technical analysis have provided a basis for understanding the operational and safety benefits and challenges associated with rightsizing the four candidate corridors. From an operational perspective, rightsizing each of the candidate corridors is feasible, provides multimodal benefits, and supports the goals of the TMP. At the intersections of Iris Avenue at Broadway and of Folsom Street at Arapahoe Avenue, the analysis indicates that rightsizing would significantly increase vehicle travel time by creating a compounding queue effect. To address these operational challenges, staff prepared multiple design options for community consideration.

Design Options

Rightsizing four-lane arterials can be generally accomplished using two different lane configurations: four-to-two lane conversion or four-to-three lane conversion. The technical analysis revealed several operational challenges associated with the four-to-two lane

conversion, including vehicle left-turn difficulties and the potential for increased rear-end collisions. Therefore, staff proceeded with design options based upon the four-to-three lane conversion, which allows for the installation of a continuous vehicle left-turn lane while maintaining a buffer between the vehicle lane and the bicycle lane. When comparing the two lane configurations side by side, the addition of the continuous left-turn lane allows vehicles to transition from the through lane into to the left-turn lane, thereby maintaining corridor throughput for motor vehicles.

Physical Separation Types for Bike Lane Facilities
A buffered bike lane is a facility that creates space between the vehicle travel lane and the bike lane. The buffer is typically demarcated with striping. A protected bike lane, or "cycle track" is similar to a buffered bike lane, but is equipped with a method of physical separation. Several options exist to physically separate bike lanes from vehicle travel lanes. Staff recommends utilizing temporary vertical elements (flexible delineators) to provide physical separation during the experimentation phase of the rightsizing projects. If any of the projects are deemed unsuccessful; this temporary protection will be less costly to remove. Opportunities to improve the aesthetic appeal of the protective barriers can be evaluated following the conclusion of the experiment.

Project Corridors

Folsom Street *(Valmont Road to Arapahoe Avenue) – Existing conditions: Four/five-lane arterial roadway with substandard bike lanes in each direction.*

The goals of rightsizing can be accomplished successfully along the majority of the corridor. The operational challenges associated with Folsom Street are in the section between Pearl Street and Arapahoe Avenue, with the greatest challenge at the Arapahoe Avenue intersection. Currently, dual southbound left-turn lanes at this intersection accommodate the bulk of the turning movements during the evening peak time, as traffic is generally moving from a northwest to southeast direction. Rightsizing the intersection of Arapahoe Avenue (Option 1) involves the removal of one of the southbound left turn lanes, which would create significant travel time delays for motor vehicle drivers, but would create a seamless, enhanced travel lane for bicyclists.

Option 2 would be to extend the rightsizing treatment to Canyon Boulevard, leaving the existing four-lane segment of road between Canyon Boulevard and Arapahoe Avenue to better accommodate motor vehicle traffic. Additional modifications can be made to improve the comfort and safety of bicyclists along this segment of the road while improving the overall performance of the corridor, as compared to Option 1.

Option 3 would provide the least amount of travel time delay for motor vehicles and would address operational challenges between Canyon Boulevard and Pearl Street, but would have an impact on the bicycle facility by lengthening the gap between the proposed protected bike lanes at South Street and the buffered bike lanes south of Arapahoe Avenue.

The following table describes the design options and associated considerations.

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Option	Consideration

Folsom 1
Valmont Road to Arapahoe Avenue – Includes removal of one of the dual southbound left-turn lanes.
	• Provides a protected bikeway along the entire length of the corridor in both directions.
	• Increases delay and travel time of southbound traffic between Canyon Boulevard and Arapahoe Avenue. The traffic queues would extend along a large portion of corridor.
	• More than doubles average southbound motor vehicle travel time in the evening peak time.
	  o Existing travel time: 3 minutes 12 seconds
	  o Option #1 forecasted travel time: 6 minutes 35 seconds (105% increase from existing travel time).
	• Has the greatest potential for traffic diversion and corresponding impact on adjacent transportation facilities.

Folsom 2
Valmont Road to Canyon Boulevard – Maintains dual southbound left-turn lanes at Arapahoe Avenue
	• Maintains the vehicular capacity of southbound Arapahoe Avenue for high-volume, southbound left-turn movements.
	• Reduces southbound queues from impacting the entire corridor, when compared to Option 1.
	• Mitigates potential increase in motor vehicle travel time in the PM peak period:
	  o Existing travel time: 3 minutes 12 seconds.
	  o Option #2 forecasted travel time: 4 minutes 30 seconds (41% percent increase from existing travel time).
	• Provides a southbound bike box at Arapahoe Avenue.
	• Has less potential for traffic diversion and corresponding impact on adjacent transportation facilities than Option 1.

Folsom 3 Valmont Road to South Street - Maintains dual southbound left-turn lanes at Arapahoe Avenue	Same as Option 2, except: • Improves vehicular operations at Arapahoe Avenue and Canyon Boulevard intersections. • Results in less motor vehicle travel time when compared to other two options. • Truncates the protected bike lanes to South Street widening gap of enhanced bicycle facility. • Introduces a lane reduction with a merge for northbound vehicles. • Has the least potential for traffic diversion and corresponding impact on adjacent transportation facilities.

Based on the technical analysis, staff recommends Option 2, which would install protected bike lanes along Folsom Street from Valmont Road to Canyon Boulevard. To increase bicyclists' comfort and safety in the non-rightsized segment between Canyon Boulevard and Arapahoe Avenue, a one-foot buffer stripe would be installed between the bike and travel lanes. Staff would also install and experiment with a bike box facility on Folsom Street at Arapahoe Avenue to improve visibility and queuing space for bicyclists

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at this intersection. The recommendation would include installation of buffered bike lanes south of Arapahoe Avenue along Folsom Street to connect to Colorado Avenue and the University of Colorado Boulder. The estimated installation cost of Option 2 is $140,000.

Iris Avenue *(Broadway to Folsom Street) – Existing conditions: Four-lane arterial roadway with substandard bike lanes in each direction.*

The goals of rightsizing can be accomplished successfully along the majority of the corridor. The operational challenge for rightsizing the full extent of Iris Avenue exists at the Broadway intersection during the evening peak time. Currently, dual westbound left-turn lanes on Iris Avenue accommodate the bulk of vehicle turning movements at the intersection. Removing one of the left-turn lanes (Option 2) at this location in order to rightsize the intersection would create significant travel delays and corresponding vehicle queuing along westbound Iris Avenue, with vehicles estimated to back up as far as 19th Street during the weekday evening peak time between 3 and 7 p.m. However; rightsizing the intersection of Iris Avenue and Broadway would also create a seamless, enhanced bike lane within the roadway.

Option 1 would maintain the dual left-turn lanes on Iris Avenue at Broadway to accommodate the bulk of left-turning motor vehicles. A traditional non-buffered bike lane would extend from the end point of the rightsize treatment to the intersection. Staff also proposes to construct an extension of the multi-use path along the north side of Iris Avenue to connect 16th Street to Broadway and better accommodate bicyclists.

Currently, the volumes of traffic along Iris Avenue make it difficult to turn left from side streets during certain times of the day. Some community members have expressed concern that repurposing a lane in each direction will exacerbate this condition. To address this concern, staff is conducting additional study to measure before and after conditions. Staff anticipates that conditions will generally improve following the rightsizing installation, since left-turn vehicles will cross one lane of traffic instead of the current two lanes. Vehicles may also enter into the continuous left-turn lane from side streets to transition safely into the through lane. Additionally, left-turning vehicles from Iris Avenue onto side streets such as 16th and 22nd streets may transition from the through lane into the continuous left-turn lane. Staff also anticipates that this design feature may also mitigate the potential for rear-end collisions.

The following table describes the design options and associated considerations.

Option	Consideration
Iris 1 Maintain two westbound left-turn lanes at intersection of Iris Avenue and Broadway	• Maintains vehicular capacity at Broadway for high-volume left turns and mitigates most of the potential travel time increase. • Slightly increases WB motor vehicle travel time in the PM peak period: o Existing travel time: 2 minutes 54 seconds.

	o Option #1 forecasted travel time: 3 minutes 6 seconds (7% increase in travel time from existing travel time). • Has the least potential for diversion of traffic and corresponding impacts to adjacent roadways.
Iris 2 Remove one westbound left-turn lane at Broadway	• Provides a protected bikeway along the entire length of the corridor in both directions. • Allows a double-buffered westbound bikeway at Broadway. • Increases westbound traffic delays and queues at Broadway. The queue blocks vehicles from reaching appropriate turn lanes and resulting compounding queues were modeled to extend east to 19th Street. • Increases average WB travel time significantly (double) in the PM peak period: o Existing travel time: 2 minutes 54seconds o Option 2 forecasted travel time: 4 minutes 50 seconds (98% increase from existing travel time). • Has the greatest potential for diversion of traffic and corresponding impact to adjacent roadways.

Staff recommends Option 1. Maintain the dual westbound left-turn lanes at Iris Avenue at Broadway. Construct an extension of the multi-use path on the north side of Iris to connect Broadway to 16th Street that would better accommodate less confident or non-seasoned bicyclists. Right-size Iris Avenue from Folsom Avenue to roughly 300' east of Broadway and install protected bike lanes. The estimated installation cost of Option 1 is $89,000.

63rd Street *(Lookout Road to Gunbarrel Avenue/Nautilus Drive) – Existing conditions: Five-lane arterial roadway with no bike lanes.*

Staff recommends rightsizing the full extent of the proposed project along 63rd Street from Lookout Road to Gunbarrel Avenue/Nautilus Drive. 63rd Street presents no significant operational challenges to achieve the goals of rightsizing. The vehicle lanes can be reduced to one through lane in each direction without any significant travel delays, while also accommodating buffered bike lanes in both directions. The corridor is currently operating at high level of service for motor vehicles. Staff's analysis indicates that the rightsized corridor will continue to function with limited travel delays, even with the anticipated level of development in Gunbarrel. The estimated installation cost is $46,000.

55th Street *(Pearl Parkway to Arapahoe Road) – Existing conditions: Five-lane arterial roadway with standard bike lanes in each direction.*

Staff recommends rightsizing the full extent of the proposed project along 55th Street from Pearl Parkway to Arapahoe Avenue. 55th Street presents no significant operational

challenges to achieve the goals of rightsizing. The vehicle lanes can be reduced to one through lane in each direction without any significant travel delays, while also accommodating buffered bike lanes in both directions. The only operational caveat to 55th Street concerns the Burlington Northern Sante Fe (BNSF) railroad crossing. Currently, irregular and infrequent trains crossing 55th Street can sometimes cause traffic congestion. The rightsizing may exacerbate this traffic congestion in some instances when the train passes through 55th Street. The estimated installation cost is $54,000.

Staff Recommendation Summary

The staff-recommended conceptual designs are provided in **Attachment F** and details of the corridor plans, design options, renderings, and open house materials can be viewed on www.BoulderLivingLab.net.

Living Lab Phase II Evaluation Criteria
Rightsizing pilot projects installed as part of the Living Lab are anticipated to continue for 12 to 18 months. Performance monitoring will include several qualitative and quantitative measurements. A matrix of quantitative and qualitative transportation data collection and evaluation measures for each corridor is provided in **Attachment G.** Staff collected "before" data in April and May 2015. Post-installation data collection will continue throughout the duration of the pilot projects.

Following the installation of the pilot projects, community feedback will be gathered through social media and direct contact with city staff through traditional correspondence and walk/bike audits.

A Low-stress Bicycling Network Connectivity analysis underway citywide will provide an understanding of the functionality of the existing bike network and quantify the value of the rightsizing pilot projects. High-stress streets are measured as those with high speed limits, limited or nonexistent bike lanes and signage, and large distances to cross at intersections. A before/after level analysis of the Living Lab pilot projects is planned to determine whether these treatments reduce stress levels for bicyclists. The low-stress network analysis also will help guide prioritization of potential transportation improvement projects that would create a connected low-stress bicycle network. Additionally, the results of rightsizing pilot projects will inform the development of bikeway design installation guidelines and refine multimodal access policy, as identified in the update of the 2014 Transportation Master Plan.

NEXT STEPS
If the proposed Living Lab pilot projects are approved by City Council, staff will proceed with the installations on Folsom Street and Iris Avenue in July, and on 63rd and 55th streets in August. The city will coordinate the installations with existing special events and back to school travel needs in order to mitigate any potential conflicts. The pilot program will include ongoing community outreach on the experiments, along with ongoing evaluation to encourage public participation and input throughout the 12- to 18-

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month project duration. Corridors will be evaluated at the end of the experiment to determine if corridor improvements remain, are modified or removed.

Please visit www.BoulderLivingLab.net for more information.

ATTACHMENTS:

- Attachment A: Map of Living Lab Phase II candidate corridors
- Attachment B: Spring 2015 engagement opportunities calendar
- Attachment C: Letters from community organizations
- Attachment D: Multimodal technical analysis memo
- Attachment E: Safety Analysis for Phase II Living Laboratory Projects
- Attachment F: Proposed corridor design options
- Attachment G: Project evaluation criteria

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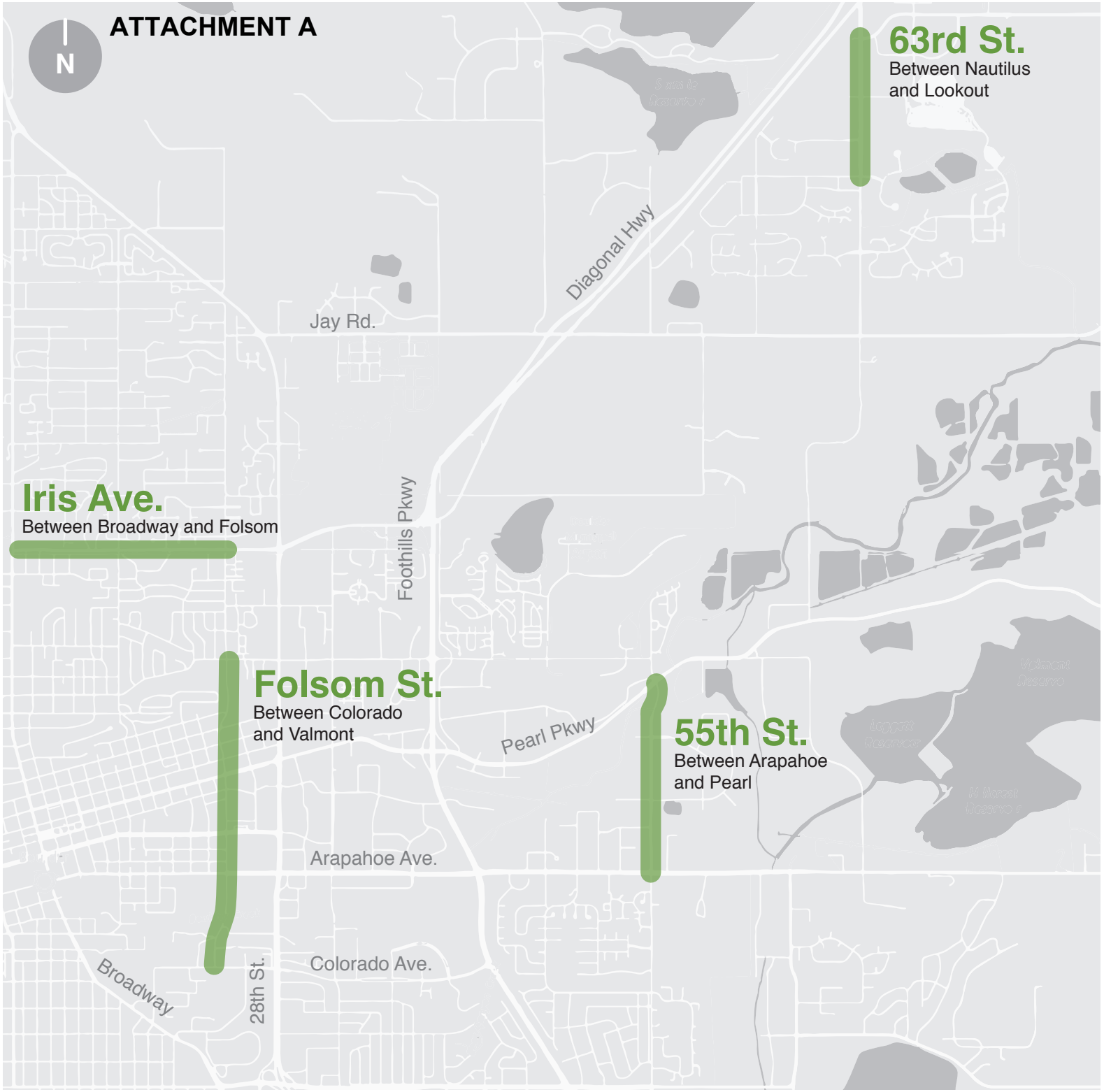
ATTACHMENT A



LIVING LAB

Rightsizing Candidate Corridors Map

For more information visit:
BoulderLivingLab.net

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ATTACHMENT B

Spring 2015 Engagement Calendar

Monday	Tuesday	Wednesday	Thursday
4	5	6	7
East Stakeholder Meeting 4 to 6 p.m. Valmont Presbyterian Church	**Pop Up Events** Iris Foothill Elementary 7:45-8:15am **City Council Meeting** 6 pm	**West Stakeholder Meeting** 4 to 6 p.m. Unity Spiritual Center of Boulder	**Walk/Bike Audit** Iris + Folsom 4 to 6 p.m. **Pop Up Events** McGuckins 11:00am-2:00pm
11	12	13	14
TAB Meeting 6 p.m.	**Pop Up Events 55th** Upslope 4 - 6 p.m.	**Presentation to Better Boulder**	
18	19	20	21
Pop Up Events 63rd Street Avery Tap Room		**Living Lab Open House** 4 to 6 p.m. BMOCA	**Walk/Bike Audit** 55th 4 to 6 p.m.
25	26	27	28
Memorial Day			**Presentation to Boulder Chamber**
1	2	3	4
Walk/Bike Audit 63rd 4 to 6 p.m.	**Neighborhood Meetings** Iris Avenue		
8	9	10	11
TAB Meeting Council Chambers 6 p.m.			
15	16	17	18
	Council Meeting Council Chambers 6 p.m.		

May 18, 2015

Better Boulder supports the proposed "rightsizing" pilot projects on Iris, Folson, 55th and 63rd street. We believe that these projects can make our roads safer, create a more pleasant environment for people walking and cycling, and thus give more people real choices in how they travel. A sustainable future for Boulder requires a city that is designed for people, not just for cars.

Many other communities have taken 4 lane arterials and retrofitted them into complete streets, and have found that there are multiple benefits. Studies have shown that at the type of traffic volumes found on these streets, road diets don't increase congestion, and that neighboring businesses see no negative impacts. According to the US Department of Transportation, studies show that road diets reduce traffic crashes by an average of 29 percent.

At the same time, we believe that the city should be very thoughtful about how these projects are implemented. It is important that these be successful, and receive wide community support. We are encouraged by the detailed corridor analysis that the city has performed, which shows that over the vast majority of these corridors rightsizing can be done with little increased vehicle delay. The studies identify two problematic sections – Iris from Broadway to 15th and the section of Folsom from South Street to Arapahoe. We would recommend a careful approach that avoids additional vehicle congestion in these locations in order to maximize the likelihood that the pilot project will be well-received by residents who use all transportation modes.

We also support the pilot approach, allowing modifications to improve performance as we learn how these work in practice on these particular corridors. However, the appearance matters – it is important that these by beautiful, not just functional, so we would encourage, for example, the use of planters rather than plastic bollards.

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ATTACHMENT C

FOX TUTTLE HERNANDEZ
TRANSPORTATION GROUP

MEMORANDUM

To: David Kemp, City of Boulder

From: Bill Fox, PE
Steve Tuttle, PE, PTOE

Date: April 29, 2015

Project: Living Lab "Rightsizing" Corridor Evaluations

Subject: Technical Summary

As part of the ongoing Living Lab project, the Fox Tuttle Hernandez Transportation Group has been working with City of Boulder staff to evaluate potential changes to several roadway corridors to better optimize effective use of existing roadway widths for all modes of travel. These "rightsizing" evaluations have included several stages of evaluation and preliminary concept design to identify impacts and trade-offs between current and proposed operating conditions. The purpose of this memorandum is to summarize these efforts.

Candidate corridors being considered for the rightsizing pilot project design treatments include:

- Iris Avenue from Broadway to Folsom Street
- Folsom Street from Arapahoe Avenue to Valmont Road
- 55th Street from Arapahoe Avenue to Pearl Parkway
- 63rd Street from Lookout Road to Gunbarrel Avenue

All of these roadways, except 63rd Street, currently have on-street bicycle lanes with two through lanes in each direction and with varying left-turn lane accommodations. An initial assessment of

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daily traffic volumes by City Staff along these corridors suggests there is the potential for repurposing an existing through lane in each direction to enhance multi-modal travel. The more detailed assessments that have been performed by Fox Tuttle Hernandez are described in the following text.

Preliminary Level of Service Screening

Fox Tuttle Hernandez performed a comparison of vehicle Level of Service (LOS) modeling at signalized intersections using Synchro software between the existing and future roadway design. The existing laneage on each corridor was compared to the possible repurpose of one through lane per direction to provide an improved bicycle facility. This analysis was summarized in detail in a memo to staff dated December 31, 2014. The results of this LOS screening showed that the majority of the corridor intersections could operate with repurposed vehicular lanes without significant impacts to overall intersection or individual approach movement LOS. The screening also identified key intersections and traffic movements along the Iris Avenue, Folsom Street, and 55th Street corridors where removal of existing vehicular lanes would result in poor LOS (typically LOS E or F), particularly in the PM peak hours due to heavy traffic volumes. These key locations include:

Level of Service: *To measure and describe the operational status of an intersections a grading system referred to as "Level of Service" (LOS) is used that is defined by the Highway Capacity Manual. LOS characterizes the operation conditions of traffic flow, ranging from LOS A (very good, free flow) to LOS F (congested and sometimes oversaturated). These grades represent the perspective of drivers and are an indication of the comfort and convenience associated with traveling through the intersections. The intersection LOS is represented as a delay in seconds per vehicle for the intersection as a whole and for each turning movement.*

- Iris Avenue – Westbound Approach at Broadway (existing dual-left turn lane)
- Folsom Street – Southbound Approach at Arapahoe Avenue (existing dual-left turn lane)
- Folsom Street – Northbound and Southbound Approach at Canyon Boulevard
- Folsom Street – Northbound Approach at Pearl Street
- 55th Street – Southbound Approach at Arapahoe Avenue (existing dual-left turn lanes)

The capacity analysis of 63rd Street focused on the signalized intersections at Lookout Road and at Spine Road. The LOS results indicated that the rightsizing of 63rd Street will not impact the overall LOS of either intersection. Lookout Road will have LOS C overall in both scenarios and Spine Road will have LOS B overall in both scenarios. The movement LOS will remain the same as existing even

with the repurposing of one travel lane and there would be relatively low impacts to the vehicular operations along the corridor. Due to the acceptable LOS results with one travel lane repurposed on 63rd Street, it was determined that further evaluation in VISSIM was unnecessary.

Deciding to Rightsize between 4 to 3 Lanes OR 4 to 2 Lanes

Currently, Iris Avenue and the northern segment of Folsom Street have 4 travel lanes with no center turn lane between the larger signalized intersections. In these sections there is the potential to rightsize to either 2 or 3 lanes, where the 3 lane segments would maintain a two way center turn lane in the middle of the roadway. Maintaining a center turn lane allows left turning motorists to move out of the through lane when slowing and potentially waiting to turn left at a driveway or unsignalized intersection. Eliminating the center turn lane allows for wider buffers, but also results in the potential for an increase in traffic accidents, particularly rear-end collisions.

Based on a review of existing traffic counts and information in the National Cooperative Highway Research Program's (NCHRP) Report 279, *Intersection Channelization Design Guide* (see Appendix for reference materials), and the Federal Highway Administration's (FHWA) *Road Diet Informational Guide*, it is recommended to eliminate the rightsize opton from 4 to 2 lanes. The minor street volumes compared to the main street volumes indicated that Iris Avenue and Folsom Street (north section) needed to provide a center turn lane to reduce the potential congestion and conflict with left-turning vehicles. All of these areas still allowed for a significant buffer between the through lane and the bike lane in each direction.

The corridors of 55th Street and 63rd Street were not considered for a 4 to 2 lane conversion because there are physical medians and prohibit restriping to a 4 to 2 lane conversion. The medians provide left-turn lanes where necessary and divide the roadway along the entire length of the study areas. It is proposed that these corridors rightsize from a 4 to 3 lane roadway, with the center lane maintaining the existing median.

Travel Time and VISSIM Modeling

While the LOS analysis using Synchro modeling provided a high-level, macroscopic view of projected intersection delays, VISSIM software modeling was then used to provide a microscopic simulation of traffic flow for both vehicles and bicycles along the Iris Avenue, Folsom Street, and 55th Street corridors. VISSIM modeling provides a three dimensional depiction of the corridor and models all vehicles and traffic controls. The model can be viewed to observe traffic queues and vehicular interactions, while also providing quantitative results such as corridor and segment travel times. While individual intersection LOS results provided by the Synchro model are a

common metric used by transportation engineers, travel times are more easily understood by a greater audience and also tell more about potential impacts on a corridor-length basis.

The VISSIM models for Iris Avenue, Folsom Street, and 55th Street were created for existing AM and PM peak hour conditions, with existing laneage, vehicular volumes, bicycle volumes, pedestrian crossing volumes, existing signals and signal timing. To validate the accuracy of the VISSIM model and determine if any calibration was needed, the VISSIM travel time results were compared to travel time data collected in the field for these corridors.

Existing travel time was collected manually for Iris Avenue, Folsom Street, and 55th Street. On the week of November 18, travel time runs were completed for each corridor during the AM and PM peak hours. The data collection plan and methodology is consistent with the *Travel Time Data Collection Handbook (FHWA, March 1998)*.

Six travel time runs for each direction were performed for each corridor. The start and end times, control point times, and stopped times were recorded during each run. The start location was the upstream intersection from the beginning of first intersection of the rightsize corridor. The signalized intersections were identified as the control points where the time was taken when the stop bar was crossed. The amount of delay was recorded when the vehicle slowed or stopped (less than 5 mph). The end of the travel time was the downstream intersection from the last intersection of the study corridor. All of the recorded times provided the total trip time, running time, stopped time, travel speed, and running speed per travel time run and as an average per peak hour. The data is provided in the Appendix.

The field-collected travel time results were then compared to the VISSIM results for the existing AM and PM peak hour conditions. The results are summarized on charts depicting the elapsed travel time from the start of the study corridor (crossing the near-side stop bar), through to the end of the study corridor for each direction of travel (passing the near-side stop bar of the final intersection). Note that this differs slightly from the "raw" travel time data, which also included the time on the approach to the first intersection in the total travel time. These charts are provided in the Appendix. The charts illustrate that the VISSIM travel time results are very similar to existing field conditions for all scenarios, indicating that the VISSIM model was well calibrated and will provide a useful tool in predicting the effects of corridor rightsizing.

The existing-condition VISSIM models were then modified for several laneage scenarios, with the variations related to addressing the "key" locations noted on page 2 of this report. The travel time charts for each scenario evaluated, which compare each laneage scenario with the "existing"

VISSIM (calibrated) travel time, are provided in the Appendix. The travel time charts are summarized by direction of travel and time period, and include the following information:

- Existing travel time
- Modified laneage travel time. Note that for any corridor, "VISSIM-01" on the travel time chart refers to a repurposed lane in each direction and with reduction of a dual left-turn to a single-left turn for the following approaches (Iris Avenue westbound at Broadway, Folsom Avenue southbound at Arapahoe Avenue, and 55th Street southbound at Arapahoe). "VISSIM-02" refers to a scenario with a repurposed through lane in each direction but maintaining the dual left-turn lanes noted above.
- The "high" travel time for the worst 10-min period of the scenario which had the highest increase in travel time; this was used to evaluate potential variation between the average and worst travel times throughout the hour, particularly where the VISSIM model showed compounding queues and delay extending significant lengths of the corridors, which would continue to build throughout much of the peak hour.
- For the peak hours and directions determined to be most critical (highest potential increases in travel times), there are also charts that show the existing and modified travel times for the "shoulder" peak periods from 3pm-5pm and 6pm-8pm, for some context to what impacts there may be to travel times outside of the peak hour. The volumes used for these "shoulder" peak hours were based on City of Boulder hourly count data at nearby count stations.

The results are summarized and discussed, as follows, with travel time charts provided in the Appendix:

<u>Iris Avenue:</u>

Existing Conditions:

- In the AM peak hour, the VISSIM existing eastbound and westbound travel times averaged 2:33 and 2:42, respectively. In the PM peak hour, the existing eastbound and westbound travel times averaged 2:26 and 2:54, respectively.

Rightsizing Options:

1. Repurpose one through lane in each direction but with maintaining the westbound dual left-turn lanes at Broadway, average travel times increased as follows:
    - AM eastbound: from 2:33 to 2:38
    - AM westbound: from 2:42 to 2:58
    - PM eastbound: from 2:26 to 2:39
    - PM westbound: from 2:54 to 3:06
2. Repurpose one through lane in each direction and repurpose one of the westbound left-turn lanes at Broadway to widen the existing bicycle lanes, average travel times increased as follows:
    - AM eastbound: from 2:33 to 2:41
    - AM westbound: from 2:42 to 3:12, with majority of this added delay on the Broadway approach
    - PM eastbound: from 2:26 to 2:39
    - PM westbound: from 2:54 to 4:50, with majority of this added delay on the Broadway approach and queues spilling back from Broadway through 16th Street
    - Further analysis of the PM westbound data showed that during the worst 10-min period, travel times could be as high as 6.5 minutes with this lane configuration

<u>Folsom Street:</u>

Existing Conditions:

- In the AM peak hour, the VISSIM existing northbound and southbound travel times averaged 2:25 and 2:56, respectively. In the PM peak hour, the existing northbound and southbound travel times averaged 3:31 and 3:12, respectively.

Rightsizing Options:

1. Repurpose one through lane in each direction and maintain the southbound dual left-turn lanes at Arapahoe Avenue, average travel times increased as follows:
    - AM northbound: from 2:25 to 2:45
    - AM southbound: from 2:56 to 3:01
    - PM northbound: from 3:31 to 4:47, with majority of this added delay on the Folsom approach to Pearl Street; further analysis indicated travel times as high as 6:00 during the worst 10-min period.
    - PM southbound: from 3:12 to 4:30, with majority of this added delay on the approach to Canyon Boulevard.
2. Repurpose one through lane in each direction and repurpose one of the southbound left-turn lanes at Arapahoe Avenue to widen the existing bicycle lanes, average travel times increased as follows:
    - AM northbound: from 2:25 to 2:45
    - AM southbound: from 2:56 to 3:02
    - PM northbound: from 3:31 to 4:48, with majority of this added delay on the Folsom approach to Pearl Street; further analysis indicated travel times as high as 6:00 during the worst 10-min period.
    - PM southbound: from 3:12 to 6:35, with majority of this added delay on the approaches to Arapahoe and Canyon; further analysis indicated travel times as high as 8.5 min during the worst 10-min period, with queues extending north of Pine towards Valmont

<u>55th Street:</u>

Existing Conditions:

- In the AM peak hour, the VISSIM existing northbound and southbound travel times averaged 2:15 and 2:10, respectively. In the PM peak hour, the existing northbound and southbound travel times averaged 2:49 and 2:16, respectively.

Rightsizing Options:

1. Repurpose one through lane in each direction, a single northbound left turn lane at Pearl Parkway, a single westbound left-turn lane on Pearl Parkway to southbound 55th Street, and maintain the southbound dual left-turn lanes at Arapahoe Avenue, average travel times increased as follows:
    - AM northbound: from 2:15 to 2:30
    - AM southbound: from 2:10 to 2:17
    - PM northbound: no increase (this is due to improved operation of the northbound left-turn at Pearl Parkway operating as a protected-permissive single left-turn lane vs. the existing dual protected-only operation, offsetting any delay created by the repurposed through lane along the corridor)
    - PM southbound: from 2:16 to 2:26
2. Repurpose one through lane in each direction and reduce to one southbound left turn lane at Arapahoe Avenue:
    - AM northbound: from 2:15 to 2:30
    - AM southbound: from 2:10 to 2:26
    - PM northbound: no increase (this is due to improved operation of the northbound left-turn at Pearl Parkway operating as a protected-permissive single left-turn lane vs. the existing dual protected-only operation, offsetting any delay created by the repurposed through lane along the corridor)
    - PM southbound: from 2:16 to 5:35, with delays and queues initially building up from Arapahoe but then extending the length of the corridor through each signal; further analysis indicated travel times as high as 10.5 min during the worst 10-min period.

- VISSIM modeling of the existing at-grade railroad crossing between Western Avenue and Central Avenue showed that northbound traffic queues during the AM peak hour (the heaviest northbound traffic period) could extend south to Arapahoe Avenue if the train

event lasted 6 minutes. With the repurposed scenario, the queue would back to Arapahoe Avenue with a 3 minute train event.

The following table summarizes the travel time for each roadway and scenario as described above:

Direction	Peak Hour	Existing	Alternative 1 Rightsize and maintain dual lefts at key Intersection	Alternative 2 Rightsize and reduce to single left at key Intersection
Iris Avenue				
Eastbound	AM	2:33	2:38 (+0:05)	2:41 (+0:08)
	PM	2:26	2:39 (+0:13)	2:39 (+0:13)
Westbound	AM	2:42	2:58 (+0:16)	3:12 (+0:30)
	PM	2:54	3:06 (+0:12)	4:50 (+1:56)
Folsom Street				
Northbound	AM	2:25	2:45 (+0:20)	2:45 (+0:20)
	PM	3:31	4:47 (+1:16)	4:48 (+1:17)
Southbound	AM	2:56	3:01 (+0:05)	3:02 (+0:06)
	PM	3:12	4:30 (+1:18)	6:35 (+3:23)
55th Street				
Northbound	AM	2:15	2:30 (+0:15)	2:30 (+0:15)
	PM	2:49	2:49 (no change)	2:49 (no change)
Southbound	AM	2:10	2:17 (+0:07)	2:26 (+0:16)
	PM	2:16	2:26 (+0:10)	5:35 (+3:19)

The results of the VISSIM modeling for the Iris Avenue, Folsom Avenue, and 55th Street corridors largely confirmed the LOS analysis and that 1) most of the corridor lengths could function with repurposed through lanes and 2) the key approaches and movements noted above could experience long vehicular delays and corresponding increases in corridor travel time if the laneage were reduced on these approaches. The VISSIM modeling and travel time estimates also illustrated the compounding nature of decreased capacity for heavy movements, where traffic queues could quickly extend for several intersections upstream from a bottleneck. The resulting effect on travel times due to multi-block queues spilling back from these heavy movements would be expected to result in some diversion onto other roadways.

Multimodal Enhancements

It should be noted that the decrease in roadway capacity and increase in travel time is a negative impact on vehicles traveling along the corridors, however, the bicyclists and pedestrians are expected to have an increased level of service, safety, and comfort.

Bicyclist experience will improve and they will benefit from:

- Wider bike lanes for comfort and to safely pass other bicyclists
- Buffer from vehicular traffic
- Protection from vehicular traffic encroaching on bike lane (where flexible delineators are provided)
- Slower automobile traffic due to narrower travel lanes
- Enhanced right-turn treatments at high volume intersections
- Increased driver awareness of the bike facility

Pedestrian experience will also improve and they will benefit from:

- Shorter crossing distances since the buffer can be used as a refuge
- Buffer from vehicular traffic that will minimize the "splash zone" and encourage use of the entire sidewalk width
- Slower automobile traffic due to narrower travel lanes creating a better walking environment

With any rightsizing project there are trade-offs between modes of travel and the goal is to balance the available space and level of service for all users.

Design Considerations

On Iris Avenue and Folsom Street the dual left-turns noted previously are locations where maintaining both left-turn lanes would preclude significant improvement to the existing on-street bicycle lanes. The buffered bikeway would have to end prior to the distance required to accommodate the dual left-turn lanes. The LOS analysis indicated the need to maintain the dual left-turn lanes. Further evaluation with VISSIM determined there will be significant queues, blocked turn lanes, and excessive delay if the rightsizing project changed the dual left-turns to a single left-turn (refer to the Travel Time and VISSIM section for more detail).

On 55th Street at Arapahoe Avenue, the roadway width is able to accommodate the buffered bike lanes in both directions while maintaining the dual left-turn lanes. The through lane alignment

across Arapahoe Avenue in both directions was slightly altered to provide the dual lefts and the buffered bikeway.

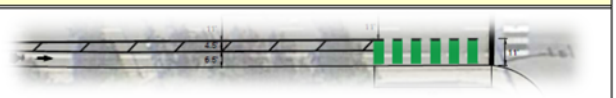
The repurposing of an existing through lane in each direction facilitates the addition of buffered bike lanes. Each corridor varies in width, number of accesses, type of center median, number of bus stops, and travel mode composition, which greatly informed the design of each rightsize corridor. The following design elements are being proposed on each of the studied corridors to fit within the existing roadway width:

Corridor		Bike Lane	Buffer	Travel Lane	Center Lane / Median	Flexible Delineators
Iris Avenue		6.5'	3'	11'	10.5'	Yes
Folsom Street						
North of Spruce St		7'	3.5'	10'	10.5'	Yes
South of Spruce St		7'	6' – 7.5'	10' – 11'	15' – 16'	Yes
55th Street		7'	10'	11'	2' – 14'	No
63rd Street		7'	6'	12'	14'	No

Note: Some variations in the widths occur at signalized intersections to accommodate turn lanes and right-turn treatments.

It should be noted that it is proposed to install a 10-foot multi-use path on the north side of Iris Avenue between Broadway and 16th Street to alleviate some of the conflict for westbound turning bicyclists and vehicles.

As part of this Living Lab project, three design options were created for right-turn treatments at the signalized intersections. These were developed based on information in the NCHRP Intersection Channelization Design Guide, from the National Association of City Transportation Official's (NACTO) Bikeway Design Guide design guidelines and right-turning volume. It is anticipated that the evaluation process will study the compliance and safety of each treatment for further use. The following table lists and illustrates the three right-turn treatments used throughout the four rightsizing corridors.

Right-Turn Treatment	Right-Turning Volume (vph)	Illustration
Skip with Green Dash	1-75	
Mixing Zone	76-125	
Buffered Transition	126+	

On April 7, 2015 staff from the City and Fox Tuttle Hernandez presented the conceptual design on Folsom Street to NACTO in a webinar that was broadcast nationally for a design critique. The purpose of the critique was to gather feedback on additional design options for the corridor and learn from the critics past experiences on similar projects. The project team has received the comments and suggestions which will be discussed further in a future meeting.

Additional designs were created to address the operational challenges as listed previously. The VISSIM analysis indicated that the rightsizing the entire length of the corridor and removing the existing dual left-turn lanes on some of the study corridors has significant impacts to the vehicular capacity and travel time. Therefore, alternative designs were created for Iris Avenue and Folsom Street. The following table lists some considerations with each scenario:

Alternative		Considerations
Iris Avenue		
1	Maintain dual WB dual lefts at Broadway	• Maintains vehicular capacity at Broadway for high-volume left-turn and mitigates most the potential corridor travel time increase with rightsizing • Significantly reduces potential WB queues when compared to full rightsize option. • Shortens the length of the potential EB buffered bikeway to 13th Street. • Narrows travel lanes in both directions for length of left-turn lane/taper
2	Full rightsize and reduce to single WB left at Broadway	• Provides buffered bikeway the entire length of the corridor in both directions. • Allows double buffered bikeway at Broadway WB. • Increases delay and queue of WB traffic at Broadway. The queue blocks vehicles from reaching appropriate turn lane and resulting compounding queues were modeled to extend east to 19th Street • Increases average WB travel time significantly (nearly double) in the PM peak hour.

Alternative	Considerations
Folsom Street	
1 Rightsize between Valmont Rd and Canyon Blvd and maintains dual left at Arapahoe Ave	• Maintains vehicular capacity SB at Arapahoe for high-volume left-turn • Reduces SB queues from impacting entire corridor when compared to full rightsize option. • Mitigates potential increases of the VISSIM-modeled average travel time to less than 78 seconds in each direction and during both peak hours. • Moves the beginning of the NB buffered bikeway to Canyon Blvd. • Ends the SB buffered bikeway at Canyon Blvd. • Provides a SB bike box at Arapahoe Ave. • Provides wider bike lane between Canyon Blvd and Arapahoe Ave.
2 Full rightsize and reduce to single SB left at Arapahoe Ave	• Provides buffered bikeway the entire length of the corridor in both directions. • Increases delay and queue of SB traffic between Canyon Blvd and Arapahoe Ave. The queues extents a large portion of corridor. • Increases average SB travel time significantly (nearly double) in the PM peak hour. • Increases NB travel time by one minute 17 seconds in the PM peak hour.
3 Rightsize between Valmont Rd and South St and maintains dual left at Arapahoe Ave	• Improves vehicular operations at Arapahoe Ave and Canyon Blvd. • Reduces SB queues from impacting entire corridor when compared to full rightsize option. • Results in less travel time increase compared to other alternatives. • Moves the beginning of the NB buffered bikeway to South St. • Ends the SB buffered bikeway at South St. • Provides a SB bike box at Arapahoe Ave. • Provides wider bike lane between Canyon Blvd and Arapahoe Ave. • Introduces a lane reduction with merge for NB vehicles.

As a part of this project, there is potential for the Folsom Street corridor to extend south of Arapahoe Avenue to Colorado Avenue. A conceptual design has been drafted and is currently under review. Further evaluation is needed along this portion of Folsom Street to determine the impacts to the existing intersections, left-turn lanes, and bicycle safety up/down the hill.

/BF/SGT

Appendix:

NCHRP Report 279, *Intersection Channelization Design Guide*
Field Travel Time Data
Travel Time Charts – Iris Avenue
Travel Time Charts – Folsom Street
Travel Time Charts – 55th Street

Appendix:

NCHRP Report 279, Intersection Channelization Design Guide

Field Travel Time Data

Travel Time Charts – Iris Avenue

Travel Time Charts – Folsom Street

Travel Time Charts – 55th Street

ATTACHMENT D

NCHRP Report 279, Intersection Channelization Design Guide

ATTACHMENT D

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM REPORT 279

INTERSECTION CHANNELIZATION DESIGN GUIDE

TIMOTHY R. NEUMAN
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Evanston, Illinois

RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS IN COOPERATION WITH THE FEDERAL HIGHWAY ADMINISTRATION

AREAS OF INTEREST:

FACILITIES DESIGN
OPERATIONS AND TRAFFIC CONTROL
(HIGHWAY TRANSPORTATION)

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C.

NOVEMBER 1985

ATTACHMENT D

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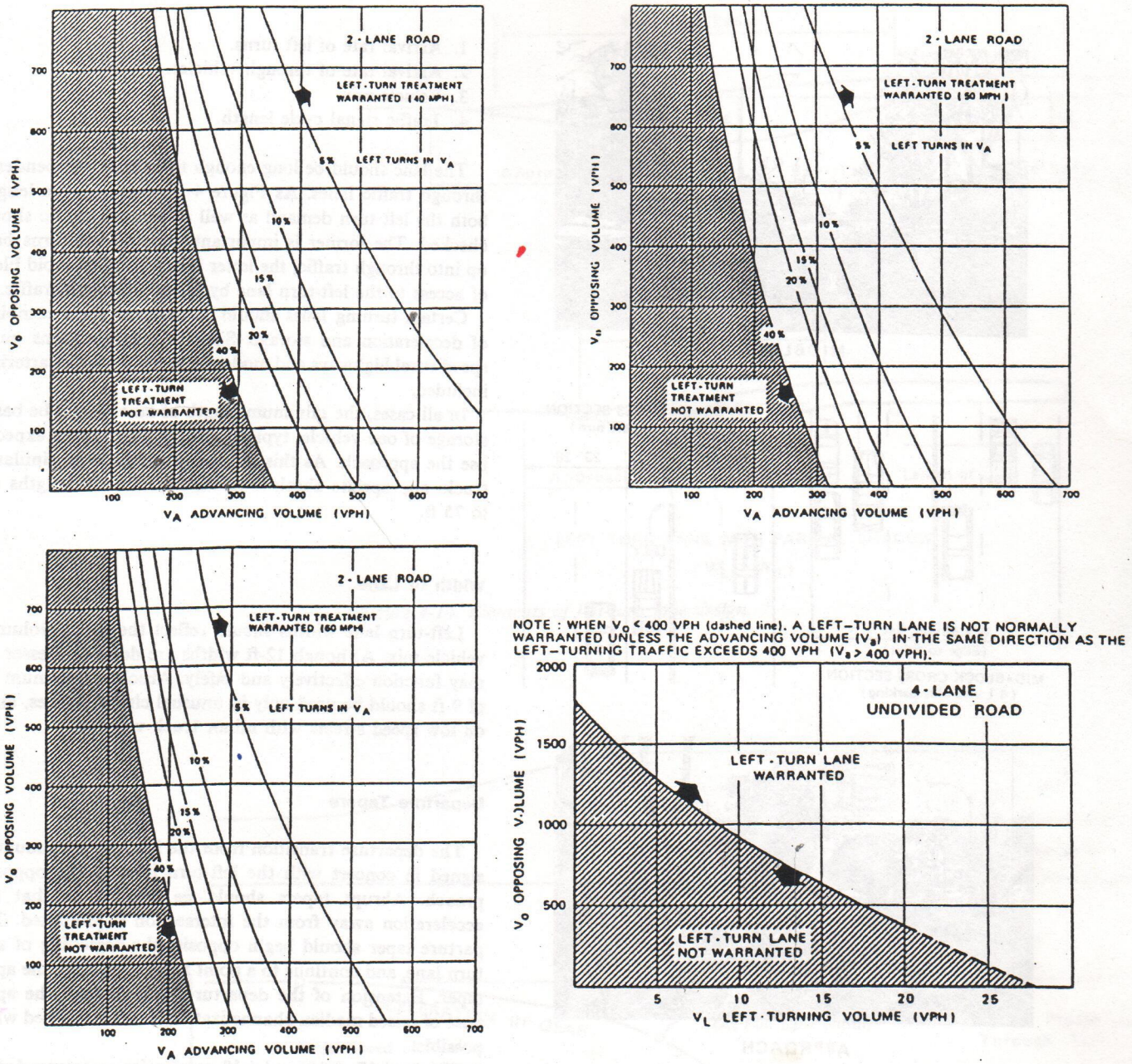


Figure 4-12. Volume warrants for left-turn lanes at unsignalized intersections. (Source: Ref. 4-7)

a partially shadowed left-turn lane, as illustrated in Figure 4-14. With partially shadowed left-turn lanes, the offset created by the approach taper does not entirely protect or "shadow" the turn lane.

Length of Lane

The left-turn lane length is among the most important design element of left-turn lanes. Its design is directly tied to the particular function of the lane, which is based on prevailing speeds, traffic volumes, and traffic control. The design basis for length can be deceleration, storage, or a combination of both.

Left-turn lanes on high-speed highways should be designed to accommodate vehicle deceleration and braking. The channelization principle of removing slow or decelerating vehicles from through traffic applies at such locations. Figure 4-15 illustrates the functional basis for design of deceleration-based left-turn lanes according to AASHTO. The assumed "reasonable" driver behavior includes deceleration in gear for 3 sec., followed by comfortable braking completely within the turning lane. Where constraints exist and speeds are moderate, an al-

$L_d/_b$ -- Length of Taper and Lane For Deceleration and Braking

Functional Basis: To provide sufficient length for a vehicle to decelerate and brake entirely outside the through traffic lanes

Desirable Design: Deceleration in gear for 3 seconds (occurs over bay taper) followed by comfortable braking to a stopped position

Design Values For $L_d/_b$

S--Speed (mph)	Length (ft) Total	Lane	Bay Taper
30	235	90	(145)
40	315	125	(190)
50	435	195	(240)
60	530	240	(290)

Minimum Design: Braking begins at 2/3 full lane width, with minimum 50-foot storage. For low speeds only, the following values apply:

Design Values For $L_d/_b$

S--Speed (mph)	Length (ft) Total	Lane	Bay Taper
30	230	50	(180)
35	250	70	(180)
40	280	100	(180)
45	320	140	(180)

Figure 4-18. Guidelines for design lengths of left-turn lanes.

L_s -- Length of Lane For Storage (Full Width Lane)

Functional Basis: To provide sufficient length for a reasonable number of vehicles to queue within the lane without affecting other lanes

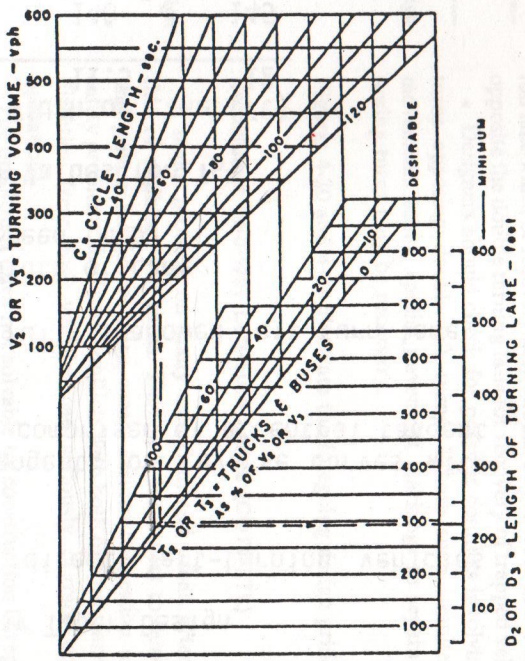
Desirable Design: Based on twice the mean arrival rate (per cycle for signals, per 2-minute period for stop control) during the peak hour of traffic

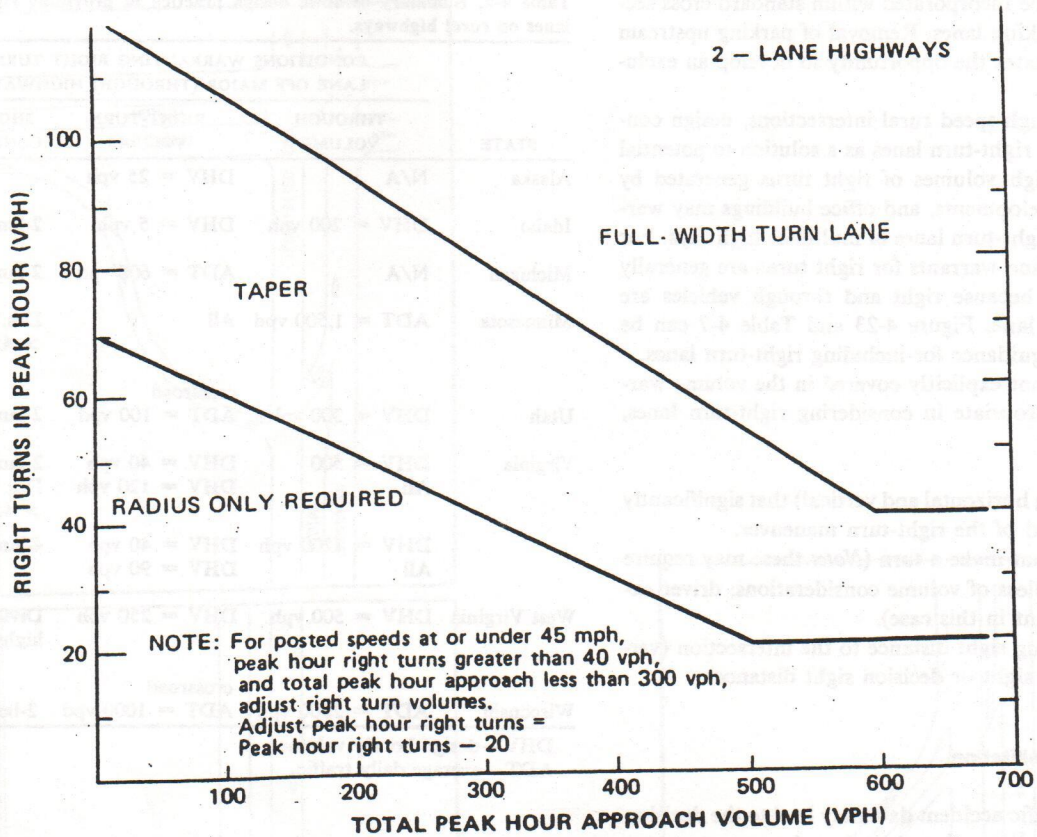
Minimum Design: Based on mean arrival rate, with minimum storage for one vehicle

L_s for Stop Control

DHV (vph)	L_s (ft)
≤60	50-75
61-120	100
121-180	150
>180	200 or more

L_s for Traffic Signal Control





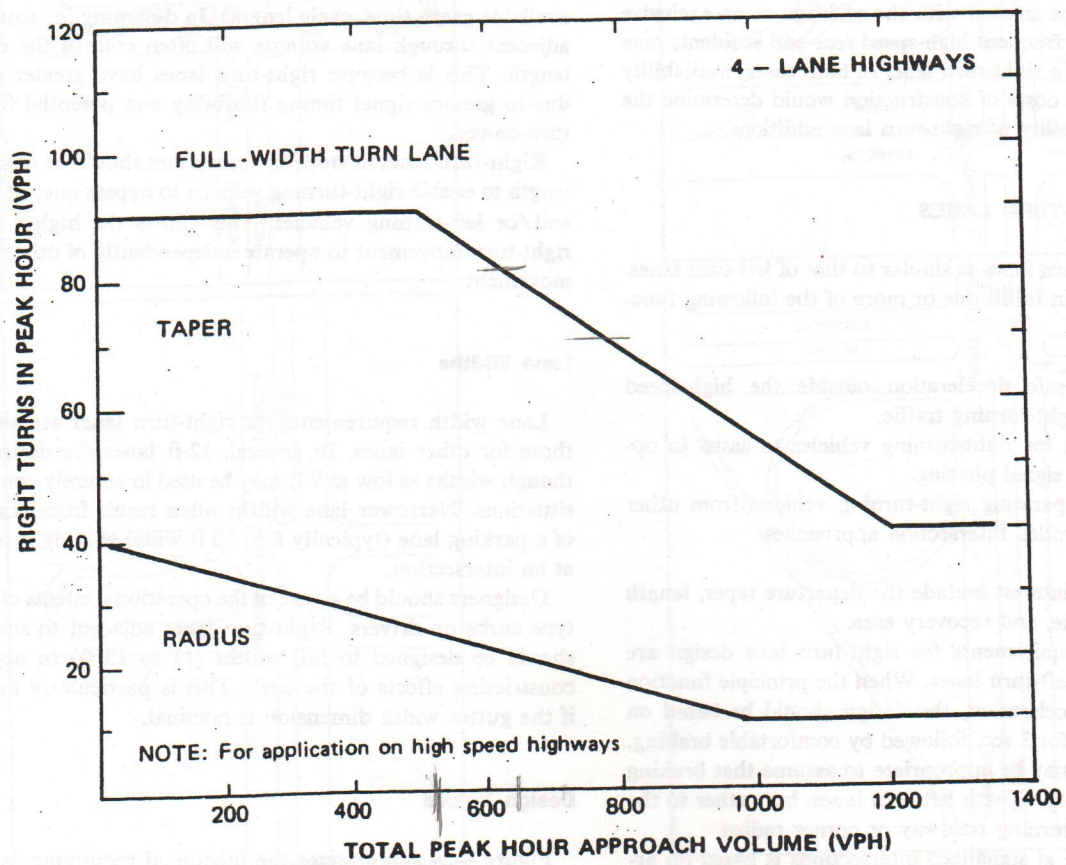


Figure 4-23. Traffic volume guidelines for design of right-turn lanes. (Source: Ref. *4-11*)

$L_d/_b$ -- Length of Taper and Lane For Deceleration and Braking

Functional Basis: To provide sufficient length for a vehicle to decelerate and brake entirely outside the through traffic lanes.

Desirable Design: Deceleration in gear for 3 seconds (occurs over bay taper) followed by comfortable braking to a stopped position or to the design speed of the corner radius.

Design Values For $L_d/_b$

For Design Speed of Corner Radius (mph)

Highway Design speed, V (mph)	Stop Condition*	15	20	25	30
30	235	185	160	140	-
40	315	295	265	235	185
50	435	405	385	355	315
60	530	500	490	460	430
65	570	540	530	490	480
70	615	590	570	550	510

*Appropriate for right turn lanes on approaches to stop signs and traffic signals.

L_s -- Length of Lane For Storage (Full Width Lane)

Functional Basis: To provide sufficient length for a reasonable number of vehicles to queue within the lane without affecting other lanes.

Desirable Design: Based on twice the mean arrival rate (per cycle for signals, per 2-minute period for stop control) during the peak hour of traffic.

Minimum Design: Based on mean arrival rate, with minimum storage for one vehicle.

L_s for Stop Control

DHV (vph)	L_s (ft)
≤60	50-75
61-120	100
121-180	150
>180	200 or more

L_s for Traffic Signal Control

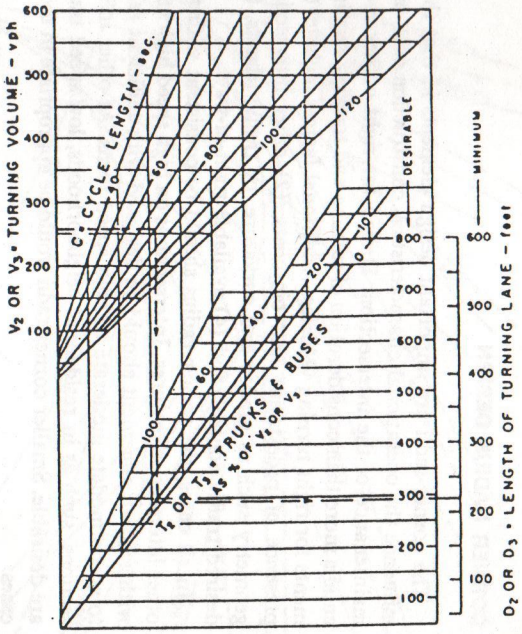


Figure 4-24. Guidelines for design lengths of right-turn lanes.

Field Travel Time Data

ATTACHMENT D

Iris Avenue
Travel Time Data
AM Peak 7:30 AM
Date: 11/18/2014
Weather:

From: Retail Access w/o 28th Ave
To: Hawthorne Ave (Westbound)
Juniper Ave (Eastbound)

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Broadway	16th St	19th St	22nd St	Folsom St	Location	Time	Cause	Notes							
East	1	0:15	1:21	1:47	2:10	2:35	Broadway	0:36	Signal		1.24	2:58	2:22	0:36	25	31	
	2	0:26	0:57	1:38	2:07	2:45	Broadway Folsom St	0:18 0:09	Signal Signal		1.24	3:09	2:42	0:27	24	28	Posted speed limit is 35 mph. The school zone near 22nd is 20 mph. Occurred during morning travel time.
	3	0:36	1:09	1:34	2:02	2:35	Broadway	0:26	Signal		1.24	2:58	2:32	0:26	25	29	School zone flashing.
	4	0:54	1:28	2:37	3:10	3:48	Broadway 19th St	0:41 0:35	Signal Signal	Arrived on FYA, did not get a gap.	1.24	4:12	2:56	1:16	18	25	School zone flashing.
	5	0:45	1:15	1:57	2:32	3:01	Broadway 19th St	0:30 0:08	Signal Signal		1.24	3:26	2:48	0:38	22	27	
	6	0:38	1:08	2:15	2:39	3:29	Broadway 19th St Folsom St	0:26 0:36 0:11	Signal Signal Signal		1.24	3:56	2:43	1:13	19	27	
	Average	***0:35***	***1:13***	***1:58***	***2:26***	***3:02***					***Average***	***3:26***	***2:40***	***0:46***	***22***	***28***	

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Folsom St	22nd St	19th St	16th St	Broadway	Location	Time	Cause	Notes							
West	1	0:36	1:11	1:38	2:08	2:44	Folsom St Broadway	0:09 0:31	Signal Signal		1.28	3:37	2:57	0:40	21	26	
	2	0:25	1:01	1:30	1:57	3:15	Broadway	0:46	Signal		1.28	3:35	2:49	0:46	21	27	The WB left at Folsom St had a queue of 14 vehicles that blocked through lane.
	3	0:21	0:59	2:23	2:56	3:50	19th St Broadway Hawthorne	0:42 0:16 0:06	Signal Signal Bus stop	Arrived at stop bar at 1:40.	1.28	4:28	3:24	1:04	17	23	School zone flashing.
	4	0:26	0:57	1:21	1:49	2:56	Broadway	0:25	Signal		1.28	3:13	2:48	0:25	24	27	The WB left at Folsom St had a queue blocking through lane. School zone on Iris off, but is flashing on Broadway.
	5	0:24	0:52	1:37	2:09	2:39	19th St	0:10	Signal		1.28	2:56	2:46	0:10	26	28	
	6	0:42	1:12	1:49	2:17	3:32	Folsom St 19th St Broadway	0:15 0:06 0:45	Signal Signal Signal	 Arrived at stop bar at 2:50.	1.28	3:48	2:42	1:06	20	28	
	Average	***0:29***	***1:02***	***1:43***	***2:12***	***3:09***					***Average***	***3:36***	***2:54***	***0:41***	***22***	***27***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

ATTACHMENT D

Iris Avenue
Travel Time Data
PM Peak 4:30 PM
Date: 11/18/2014
Weather:

From: Retail Access w/o 28th Ave
To: Hawthorne Ave (Westbound)
Juniper Ave (Eastbound)

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Broadway	16th St	19th St	22nd St	Folsom St	Location	Time	Cause	Notes							
East	1	0:30	1:04	1:34	1:58	2:27	Broadway	0:18	Signal	Arrived at stop bar at 0:13.	1.24	2:55	2:37	0:18	26	28	
	2	0:43	1:14	2:15	2:41	3:26	Broadway 19th St Folsom St	0:32 0:30 0:10	Signal Signal Signal	Arrived on FYA, did not get a gap.	1.24	3:55	2:43	1:12	19	27	
	3	0:43	1:13	1:38	1:59	2:28	Broadway 28th St	0:28 0:45	Signal Signal	Arrived on FYA, did not get a gap. Queue from 28th extended to Iris Ct Walk (1000 ft)	1.24	3:45	2:32	1:13	20	29	
	4	1:51	2:23	2:47	3:09	3:34	Broadway	1:43	Signal	Arrived on green, did not make it through green or FYA. Queue extended past Juniper Ave.	1.24	3:57	2:14	1:43	19	33	
	5	1:12	1:44	2:40	3:05	3:45	Broadway 19th St Folsom St	0:54 0:20 0:05	Signal Signal Signal		1.24	4:12	2:53	1:19	18	26	
	6	1:40	2:10	2:35	2:55	3:22	Broadway	1:28	Signal	Arrived on yellow arrow.	1.24	3:45	2:17	1:28	20	33	
	Average	***1:06***	***1:38***	***2:14***	***2:37***	***3:10***					***Average***	***3:44***	***2:32***	***1:12***	***20***	***29***	

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Folsom St	22nd St	19th St	16th St	Broadway	Location	Time	Cause	Notes							
West	1	0:30	1:05	1:39	2:13	2:43	Folsom St 19th St	0:01 0:03	Signal Signal		1.28	3:02	2:58	0:04	25	26	
	2	0:47	1:27	1:55	2:27	4:14	Folsom St 19th St Broadway	0:18 0:03 1:12	Signal Signal Signal	Arrived at stop bar at 0:34.	1.28	4:32	2:59	1:33	17	26	EB at Folsom queued 8+ vehicles in both lanes.
	3	0:25	0:55	1:17	1:45	2:50	Broadway	0:32	Signal		1.28	3:07	2:35	0:32	25	30	
	4	1:07	1:41	2:08	2:39	3:57	Folsom St Broadway	0:31 0:41	Signal Signal		1.28	4:13	3:01	1:12	18	25	
	5	0:38	1:11	1:44	2:13	4:01	Folsom St 19th St Broadway	0:09 0:03 1:04	Signal Signal Signal		1.28	4:17	3:01	1:16	18	25	
	6	1:06	1:57	2:24	2:53	4:10	Folsom St 22nd St Broadway	0:38 0:11 0:46	Signal Ped Signal Signal		1.28	4:27	2:52	1:35	17	27	
	Average	***0:45***	***1:22***	***1:51***	***2:21***	***3:39***					***Average***	***3:56***	***2:54***	***1:02***	***20***	***27***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

ATTACHMENT D

Folsom Street From: Harvest Manor Apartment Access To: Fremont Street

Travel Time Data

AM Peak 7:30 AM
Date: 11/19/2014
Weather: 37 degrees, partly cloudy

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Arapahoe Ave	Canyon Blvd	Pearl St	Pine St	Valmont Rd/ Edgewood Dr	Location	Time	Cause	Notes							
North	1	0:18	0:42	1:28	1:49	2:42	Pearl St Mapleton Ave	0:08 0:03	Signal Left-Turn		1.28	3:02	2:51	0:11	25	27	
	2	0:42	1:07	1:54	2:14	2:57	Arapahoe Ave Pearl St	0:21 0:12	Signal Signal		1.28	3:14	2:41	0:33	24	29	
	3	1:00	1:29	2:12	2:42	3:28	Arapahoe Ave Pearl St Spruce St	0:40 0:05 0:05	Signal Signal Ped Signal		1.28	3:49	2:59	0:50	20	26	There is a high volume of bicyclists on Folsom.
	4	0:17	0:38	1:21	1:44	2:27	Walnut St	0:07	Ped Signal		1.28	2:46	2:39	0:07	28	29	
	5	0:36	1:04	1:52	2:15	2:56	Arapahoe Ave Pearl St	0:13 0:10	Signal Signal		1.28	3:14	2:51	0:23	24	27	
	6	1:36	2:01	2:49	3:09	4:00	Arapahoe Ave Pearl St Valmont Rd	1:15 0:10 0:02	Signal Signal Signal		1.28	4:22	3:07	1:15	18	25	
	7	0:14	0:34	1:16	1:34	2:23	Pearl St	0:03	Signal		1.28	2:42	2:39	0:03	28	29	
	Average	***0:40***	***1:05***	***1:50***	***2:12***	***2:59***					***Average***	***17:20***	***11:19***	***0:28***	***24***	***27***	

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Valmont Rd/ Edgewood Dr	Pine St	Pearl St	Canyon Blvd	Arapahoe Ave	Location	Time	Cause	Notes							
South	1	0:14	1:01	1:20	2:00	3:19	Canyon Blvd Arapahoe Ave	0:03 0:44	Signal Signal		1.28	3:41	2:54	0:47	21	26	Posted Speed Limit 30 mph
	2	0:16	1:08	1:28	1:59	3:20	Pine St Arapahoe Ave	0:03 0:55	Right-turn RT & Signal	RT vehicle was waiting for crossing bike. RT vehicle was waiting for crossing peds.	1.28	3:04	2:06	0:58	25	37	
	3	0:36	1:27	1:47	2:24	3:29	Valmont Rd Arapahoe Ave	0:19 0:46	Signal Signal		1.28	4:02	2:57	1:05	19	26	
	4	1:15	2:05	2:24	3:03	4:21	Valmont Rd Arapahoe Ave	0:53 0:50	Signal Signal		1.28	4:42	2:59	1:43	16	26	
	5	0:14	0:57	1:15	1:46	2:37	Arapahoe Ave	0:21	Signal		1.28	2:58	2:37	0:21	26	29	
	6	0:16	0:59	1:18	1:51	2:54	Arapahoe Ave	0:24	Signal		1.28	3:12	2:48	0:24	24	27	
	7	0:17	1:02	1:25	3:15	4:35	Canyon Blvd Canyon Blvd Arapahoe Ave	0:12 1:05 0:49	Right-turn Signal Signal		1.28	4:56	4:44	0:12	16	16	
	Average	***0:26***	***1:14***	***1:33***	***2:19***	***3:30***					***Average***	***3:47***	***3:00***	***0:47***	***21***	***27***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

ATTACHMENT D

Folsom Street From: Harvest Manor Apartment Access To: Fremont Street

Travel Time Data

PM Peak 4:30 PM
Date: 11/19/2014
Weather: 37 degrees, Clear Skies

Direction	Trip No.	Time at Control Points: Arapahoe Ave	Canyon Blvd	Pearl St	Pine St	Valmont Rd/ Edgewood Dr	Stops: Location	Time	Cause	Notes	Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
North	1	0:19	1:04	1:55	2:17	3:05	Goss St	0:12	Ped Signal		1.28	3:30	3:05	0:25	22	25	
							Pearl St	0:13	Signal								
	2	0:43	1:11	2:14	2:34	3:35	Arapahoe Ave	0:18	Signal		1.28	4:03	3:19	0:44	19	23	
							Pearl St	0:19	Signal								
							Valmont Rd	0:07	Signal								
	3	0:37	2:22	3:51	4:12	5:29	Arapahoe Ave	0:14	Signal		1.28	6:02	3:32	2:30	13	22	
							Goss St	0:09	Ped Signal								
							Canyon Blvd	1:04	Signal								
							Pearl St	0:47	Signal								
							Access across from Mobile Home Access	0:16	Left-Turn								
	4	0:15	2:01	3:25	3:49	4:41	Goss St	0:21	Ped Signal		1.28	5:10	3:22	1:48	15	23	
							Canyon Blvd	0:47	Signal								
							Pearl St	0:40	Signal								
	5	0:30	0:55	2:09	2:44	3:43	Arapahoe Ave	0:04	Signal		1.28	4:18	3:27	0:51	18	22	
							Pearl St	0:33	Signal								
							Spruce St	0:04	Ped Signal								
							Valmont Rd	0:10	Signal	Arrived on green but at back of queue.							
	6	1:36	2:02	3:17	3:44	4:40	Arapahoe Ave	1:16	Signal		1.28	5:03	3:47	1:16	15	20	
							Pearl St	0:35	Signal								
	Average	***0:40***	***1:35***	***2:48***	***3:13***	***4:12***					***Average***	***4:41***	***3:25***	***1:15***	***17***	***23***	

Direction	Trip No.	Time at Control Points: Valmont Rd/ Edgewood Dr	Pine St	Pearl St	Canyon Blvd	Arapahoe Ave	Stops: Location	Time	Cause	Notes	Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
South	1	0:40	1:31	1:51	2:24	2:53	Valmont Rd	0:16	Signal		1.28	3:20	3:04	0:16	23	25	
	2	0:24	1:13	1:32	2:22	4:08	Canyon Blvd	0:13	Signal	Queue extended 8 vehicles.	1.28	4:27	2:58	1:29	17	26	
							Arapahoe Ave	0:05	Signal	Arrived at the back of queue. Did not make it through green.							
							Arapahoe Ave	1:11	Signal								
	3	0:19	1:07	1:28	3:22	3:57	Walnut St	0:05	Ped Signal		1.28	4:18	3:11	1:07	18	24	
							Canyon Blvd	1:02	Signal								
	4	0:19	1:06	2:26	3:22	3:58	Pearl St	0:54	Signal		1.28	4:20	3:16	1:04	18	24	
							Canyon Blvd	0:10	Signal								
	5	0:37	1:29	1:48	3:39	4:15	Valmont Rd	0:16	Signal		1.28	4:38	3:09	1:29	17	24	
							Canyon Blvd	1:13	Signal								
	6	0:19	1:08	1:45	2:16	3:28	Pearl St	0:43	Signal		1.28	3:47	3:02	0:45	20	25	
							Canyon Blvd	0:02	Right-Turn								
	Average	***0:26***	***1:15***	***1:48***	***2:54***	***3:46***					***Average***	***4:08***	***3:06***	***1:01***	***19***	***25***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

ATTACHMENT D

55th Street From: Lodge Ln (south) To: Valmont Rd corner (USPS)

Travel Time Data

AM Peak 7:30 AM
Date: 11/20/2014
Weather: 28 degrees, Clear skies

Direction	Trip No.	Time at Control Points				Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Arapahoe Ave	Central Ave	Flatirons Pkwy	Pearl St/ Valmont Rd	Location	Time	Cause	Notes							
North	1	1:44	2:23	2:49	3:24	Arapahoe Ave Pearl St	1:05 0:05	Signal Signal		1.27	3:42	2:32	1:10	21	30	
	2	1:42	2:20	2:47	3:33	Arapahoe Ave Pearl St	1:10 0:14	Signal Signal		1.27	3:51	2:27	1:24	20	31	Posted speed between Pearl St and Flatirons is 35 mph. Majority of 55th St is 40 mph.
	3	0:42	1:24	1:50	3:10	Arapahoe Ave Pearl St	0:05 0:51	Signal Signal		1.27	3:29	2:33	0:56	22	30	
	4	0:26	0:59	1:24	2:54	Pearl St	0:58	Signal		1.27	3:10	2:12	0:58	24	35	Buses stop at the railroad tracks for a few seconds before crossing.
	5	0:50	1:40	2:40	3:29	Arapahoe Ave Flatirons Pkwy Pearl St	0:20 0:25 0:13	Signal Signal Signal		1.27	3:44	2:46	0:58	20	28	
	6	1:38	2:56	3:26	3:51	Arapahoe Ave Central Pkey	1:09 0:32	Signal Signal	Arrived at stop bar at 0:29. Arrived at stop bar at 2:28.	1.27	4:05	2:24	1:41	19	32	
	Average	***1:10***	***1:57***	***2:29***	***3:23***					***Average***	***3:40***	***2:29***	***1:11***	***21***	***31***	

Direction	Trip No.	Time at Control Points				Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Pearl St/ Valmont Rd	Flatirons Pkwy	Central Ave	Arapahoe Ave	Location	Time	Cause	Notes							
South	1	0:13	0:41	1:08	2:30	Arapahoe Ave	0:44	Signal		1.27	3:06	2:22	0:44	25	32	
	2	0:16	0:44	1:13	2:30	Arapahoe Ave	0:31	Signal		1.27	3:10	2:39	0:31	24	29	Vehicles slow over railroad tracks.
	3	1:13	1:40	2:07	2:45	Pearl St	0:56	Signal		1.27	3:17	2:21	0:56	23	32	
	4	0:26	1:00	1:22	2:08	Pearl St Arapahoe Ave	0:07 0:03	Signal Signal	Queue extended 10 vehicles.	1.27	2:41	2:31	0:10	28	30	
	5	1:07	1:37	2:04	3:09	Pearl St Pearl St Arapahoe Ave	0:07 0:43 0:08	RT & Signal Signal Signal	 Queue extended 12 vehicles.	1.27	3:41	2:43	0:58	21	28	
	6	0:26	1:25	1:50	2:30	Pearl St Arapahoe Ave	0:09 0:25	Signal Signal	 Arrived at stop bar at 2:13.	1.27	3:02	2:28	0:34	25	31	SB Pearl St queued about 200 feet. SB left-turn at Flatirons Pkwy queued into through lane.
	Average	***0:36***	***1:11***	***1:37***	***2:35***					***Average***	***3:09***	***2:30***	***0:38***	***24***	***30***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

ATTACHMENT D

55th Street From: Lodge Ln (south) To: Valmont Rd corner (USPS)

Travel Time Data

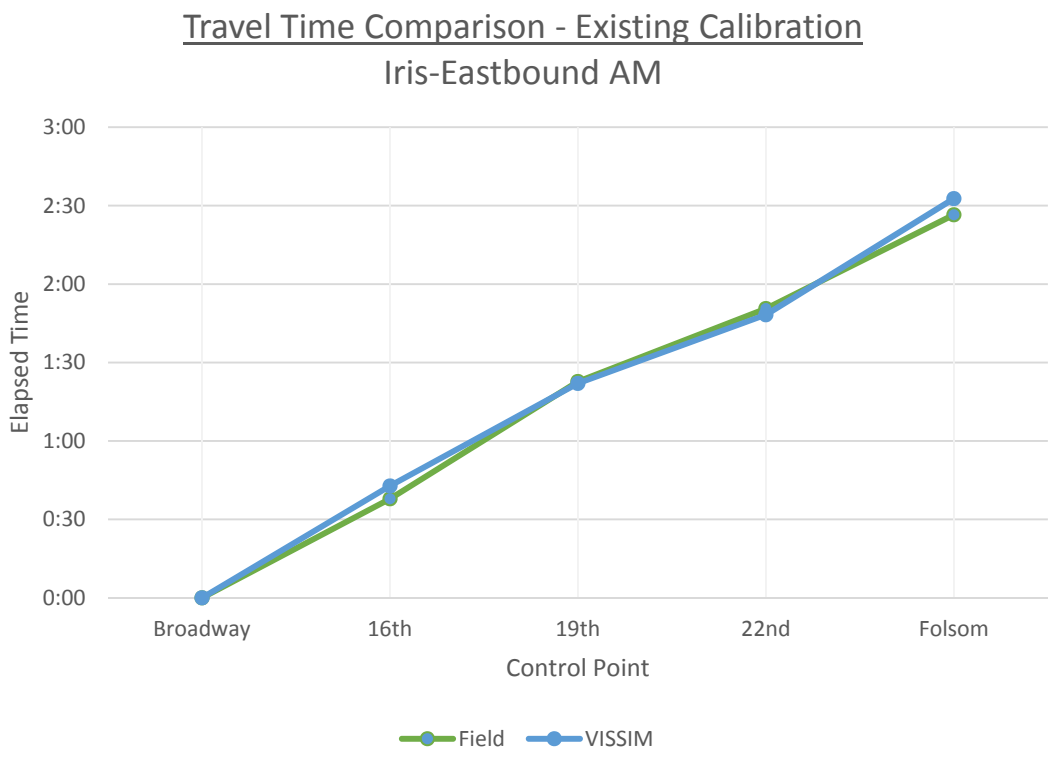
PM Peak 4:30 PM
Date: 11/20/2014
Weather: 45 degrees, Cloudy

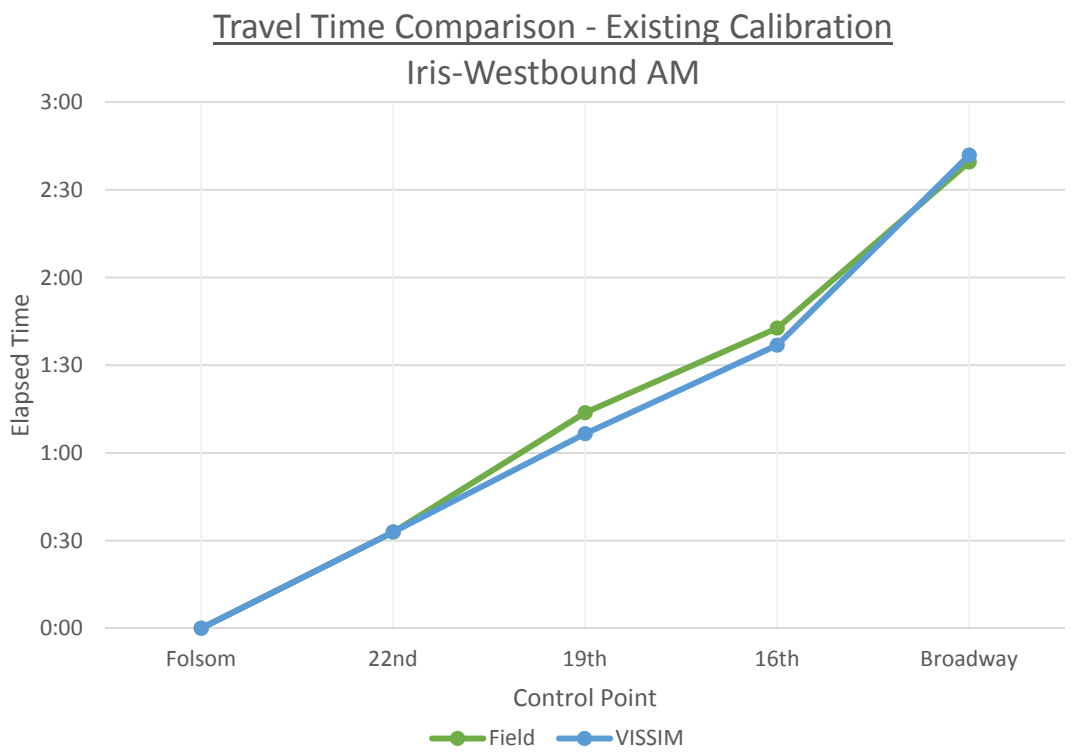
Direction	Trip No.	Time at Control Points				Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Arapahoe Ave	Central Ave	Flatirons Pkwy	Pearl St/ Valmont Rd	Location	Time	Cause	Notes							
North	1	0:34	1:11	1:43	2:57	Pearl St	0:39	Signal		1.27	3:14	2:35	0:39	24	29	The north/southbound left phases at Pearl are Protected.
	2	1:50	2:36	3:35	4:41	Arapahoe Ave Flatiron Pkwy Pearl St	1:17 0:25 0:30	Signal Signal Signal	Arrived at stop bar at 0:34. Arrived at stop bar at 3:10.	1.27	4:58	2:46	2:12	15	28	The north/southbound left phases at Arapahoe are Permitted. Slow for people crossing the railroad.
	3	0:25	1:28	2:03	3:47	Central Ave Pearl St Pearl St	0:19 0:04 0:53	Signal Signal Signal	Arrived at the back of queue (15 vehicles). Did not make it through green. Arrived at stop bar at 2:52.	1.27	4:09	2:53	1:16	18	26	
	4	0:28	2:08	2:41	4:40	Railroad Crossing Central Ave Pearl St Pearl St	0:38 0:10 0:27 0:49	Train Signal Signal Signal	As gates raised, it was slow to get to speed and through next intersection. Queue extended 18 vehicles in right lane. Majority of vehicles turning right	1.27	5:03	2:59	2:04	15	26	
	5	1:42	2:20	2:48	4:13	Arapahoe Ave Pearl St	1:05 0:43	Signal Signal		1.27	4:30	2:42	1:48	17	28	At Arapahoe: all left phases are permitted except the WBL, which is protected. The northbound right-turning vehicles create delay for the through vehicles and the queue can extend to the bridge.
	6	1:47	2:30	3:01	3:37	Arapahoe Ave	1:18	Signal	Arrived at stop bar at 0:28.	1.27	3:52	2:34	1:18	20	30	
	Average	***1:07***	***2:02***	***2:38***	***3:59***					***Average***	***4:17***	***2:44***	***1:32***	***18***	***28***	

Direction	Trip No.	Time at Control Points				Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Pearl St/ Valmont Rd	Flatirons Pkwy	Central Ave	Arapahoe Ave	Location	Time	Cause	Notes							
South	1	0:14	0:45	1:13	2:26	Railroad Crossing Pearl St	0:09 0:12	Bus stopped Signal	 Queue extended 200 ft	1.27	3:03	2:42	0:21	25	28	
	2	0:14	0:44	1:15	2:05	Arapahoe Ave	0:09	Signal	Arrived at back of queue when green started.	1.27	2:39	2:30	0:09	29	30	
	3	0:30	1:09	1:38	2:46	Pearl St Flatiron Pkwy Arapahoe Ave	0:09 0:02 0:17	Signal Signal Signal	Queue extended 10 vehicles. Queue extended 8 vehicles.	1.27	3:23	2:55	0:28	23	26	
	4	1:05	1:39	2:11	3:41	Pearl St Arapahoe Ave	0:45 0:39	Signal Signal	 Queue extended 500 ft.	1.27	4:28	3:04	1:24	17	25	
	5	1:06	1:40	2:11	3:32	Pearl St Railroad Crossing Arapahoe Ave Access s/o Arapahoe (gas station)	0:47 0:03 0:23 0:02	Signal Bus stop Signal Left-turn		1.27	4:16	3:01	1:15	18	25	
	6	0:13	0:41	1:08	3:01	Arapahoe Ave	1:15	Signal	Arrived at stop bar at 1:46.	1.27	3:34	2:19	1:15	21	33	
	Average	***0:33***	***1:06***	***1:36***	***2:55***					***Average***	***3:33***	***2:45***	***0:48***	***22***	***28***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

Travel Time Charts – Iris Avenue


Travel Time Comparison - Existing Calibration
Iris-Eastbound AM
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Broadway
16th
19th
22nd
Folsom
Control Point
Field
VISSIM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Iris-Westbound AM
3:00
2:30
2:00
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0:00
Elapsed Time
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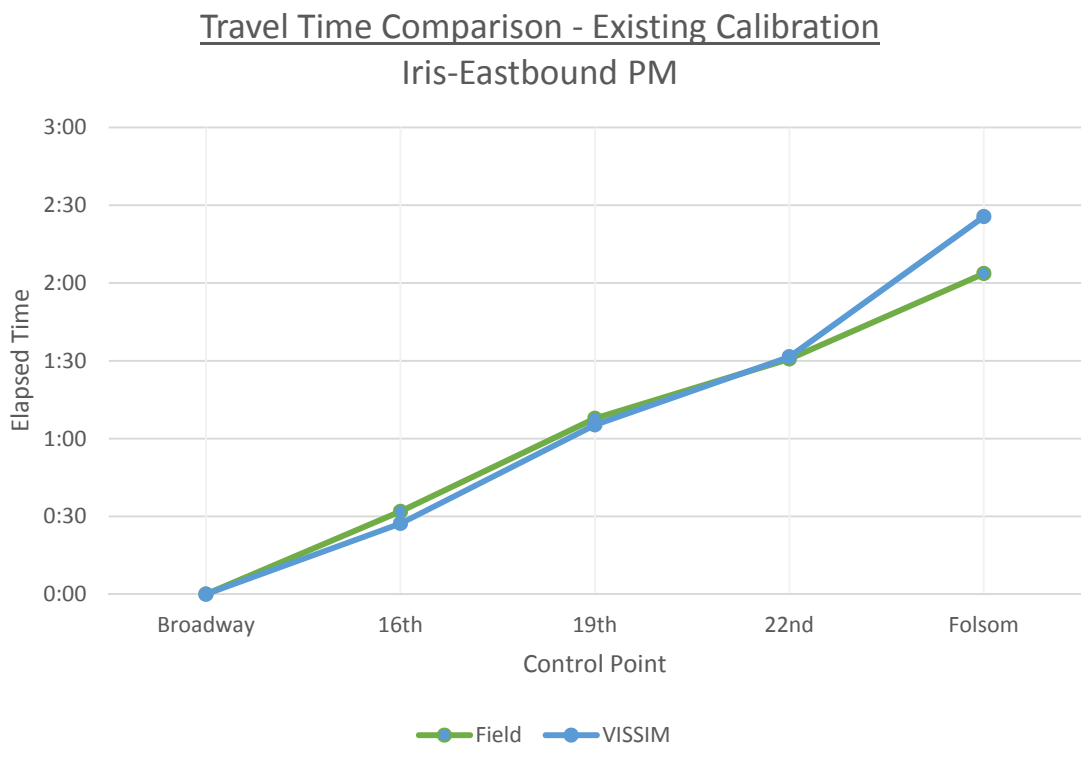
16th
Broadway
Control Point
Field
VISSIM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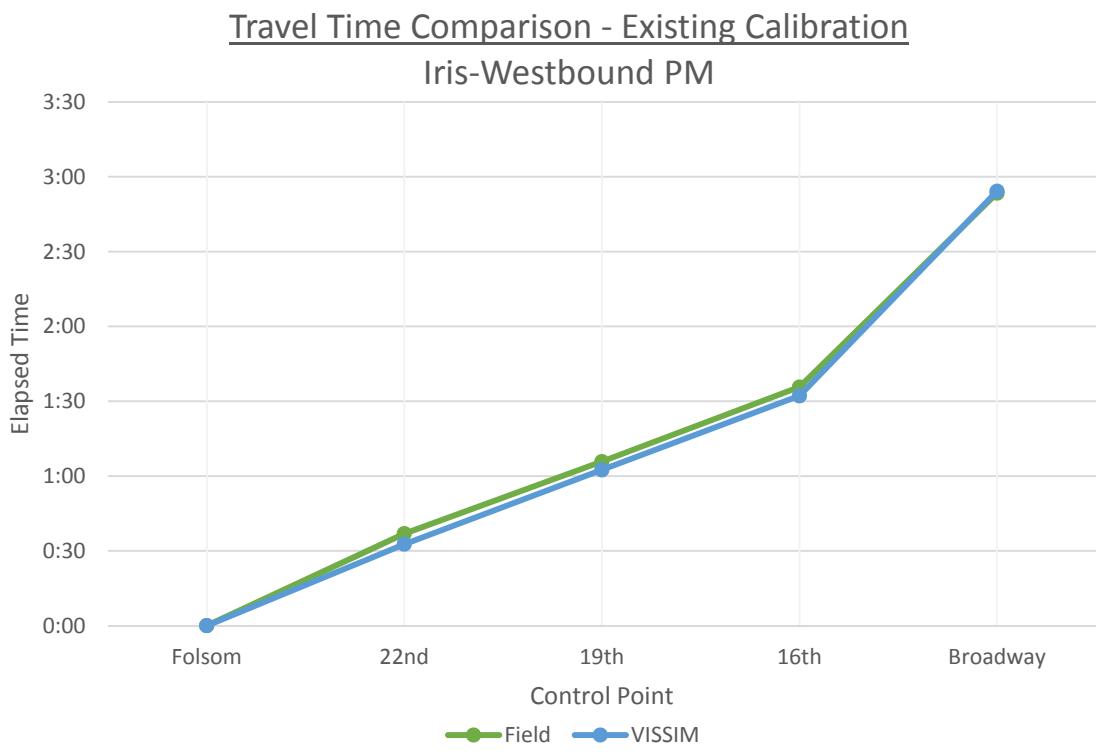
Iris-Eastbound PM
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Broadway
16th
19th
22nd
Folsom
Control Point
Field
VISSIM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Iris-Westbound PM
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3:00
2:30
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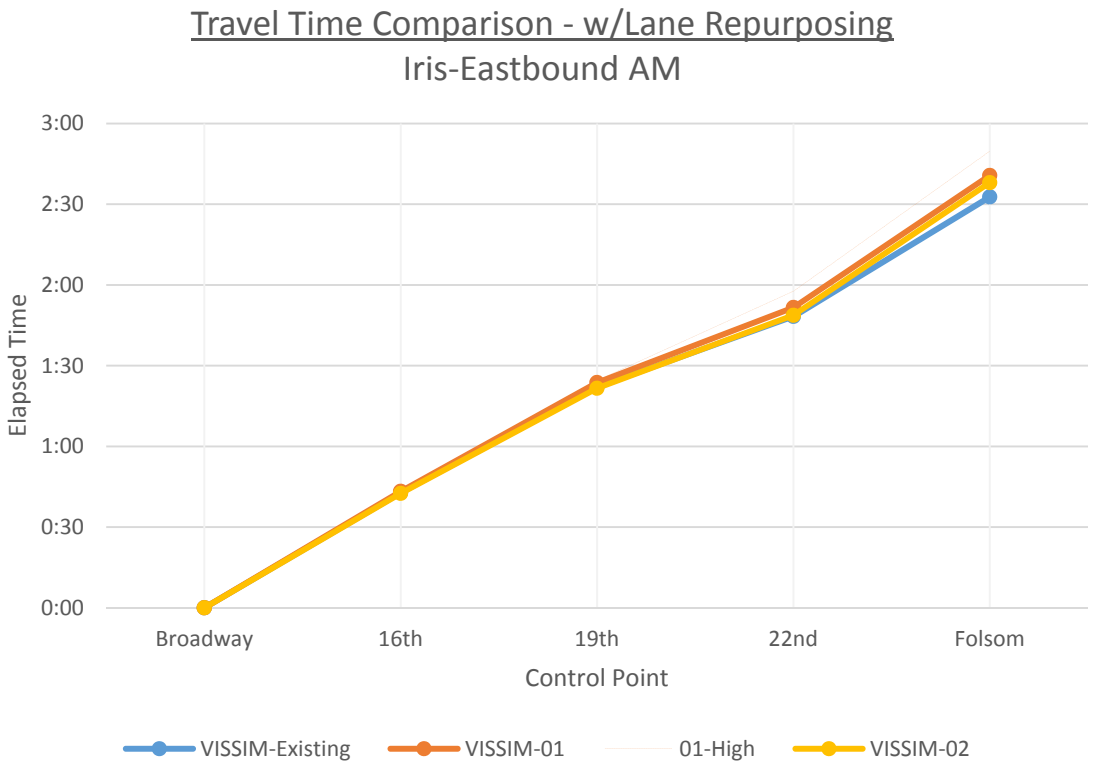
16th
Broadway
Control Point
Field
VISSIM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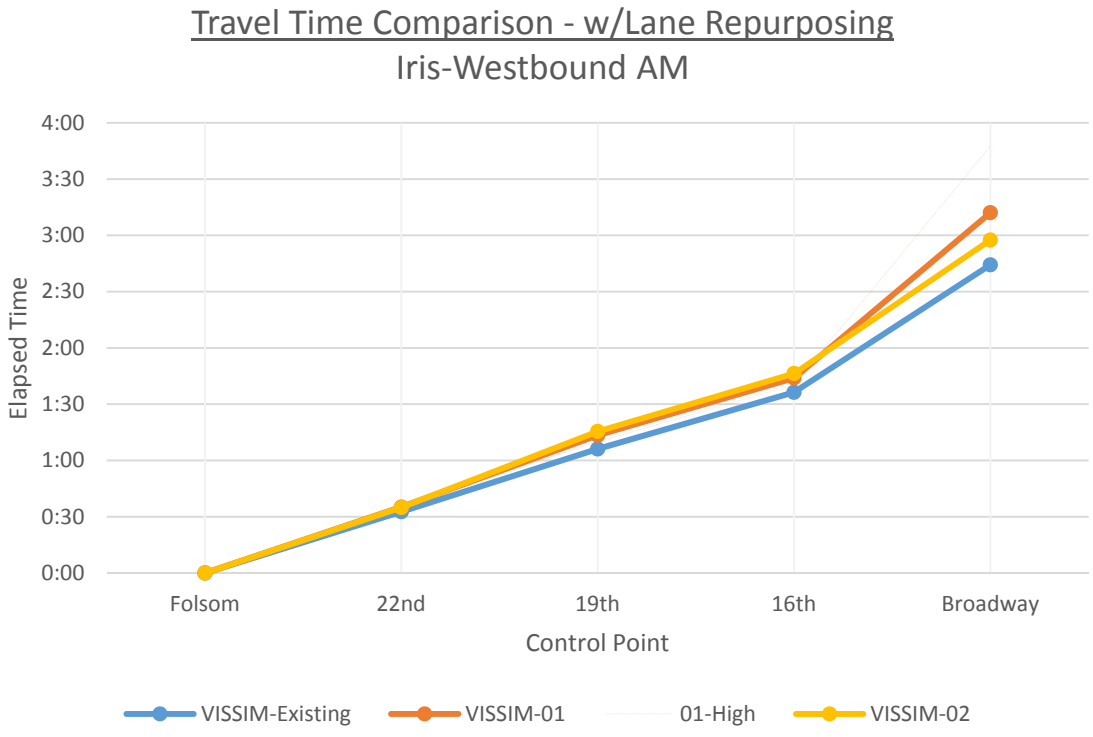
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Broadway
16th
19th
22nd
Folsom
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02


Travel Time Comparison - w/Lane Repurposing
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3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Folsom
22nd
19th
16th
Broadway
Control Point
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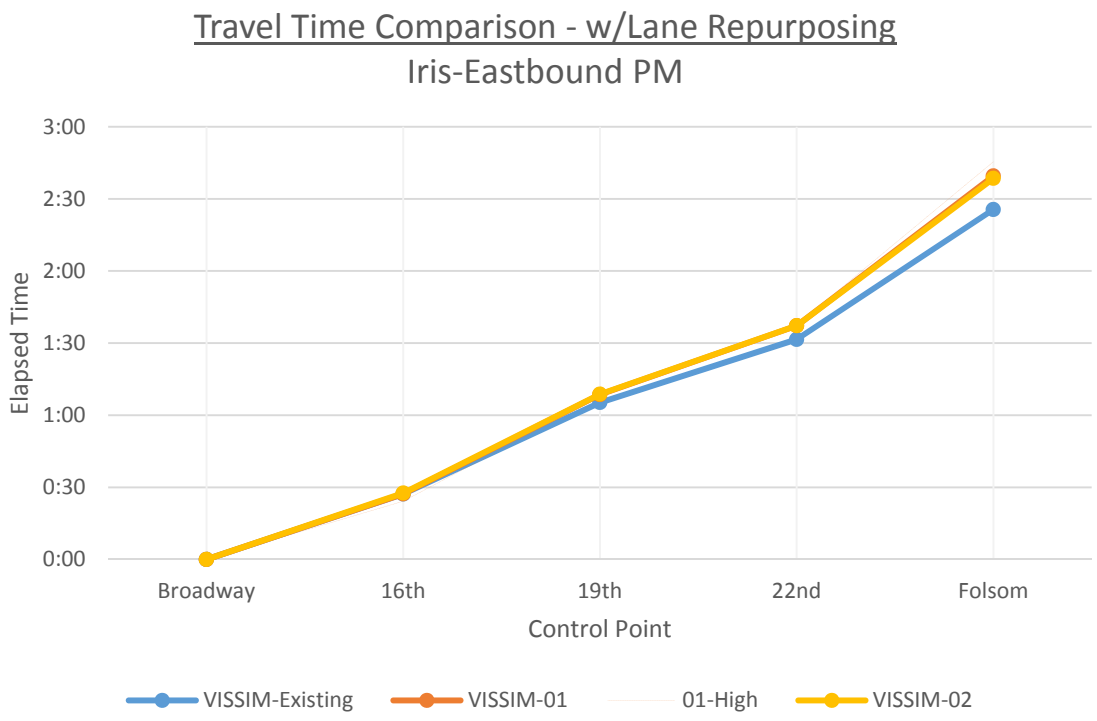
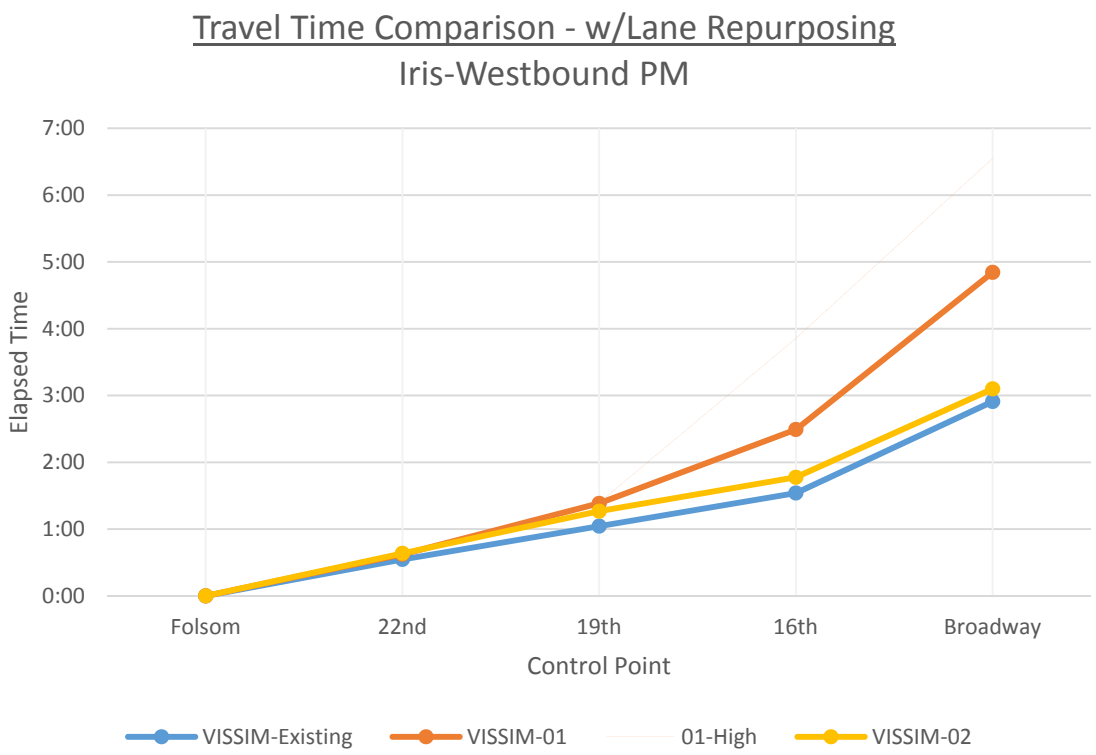
VISSIM-01
01-High
VISSIM-02


Travel Time Comparison - w/Lane Repurposing
Iris-Eastbound PM
Elapsed Time
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Broadway
16th
19th
22nd
Folsom
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02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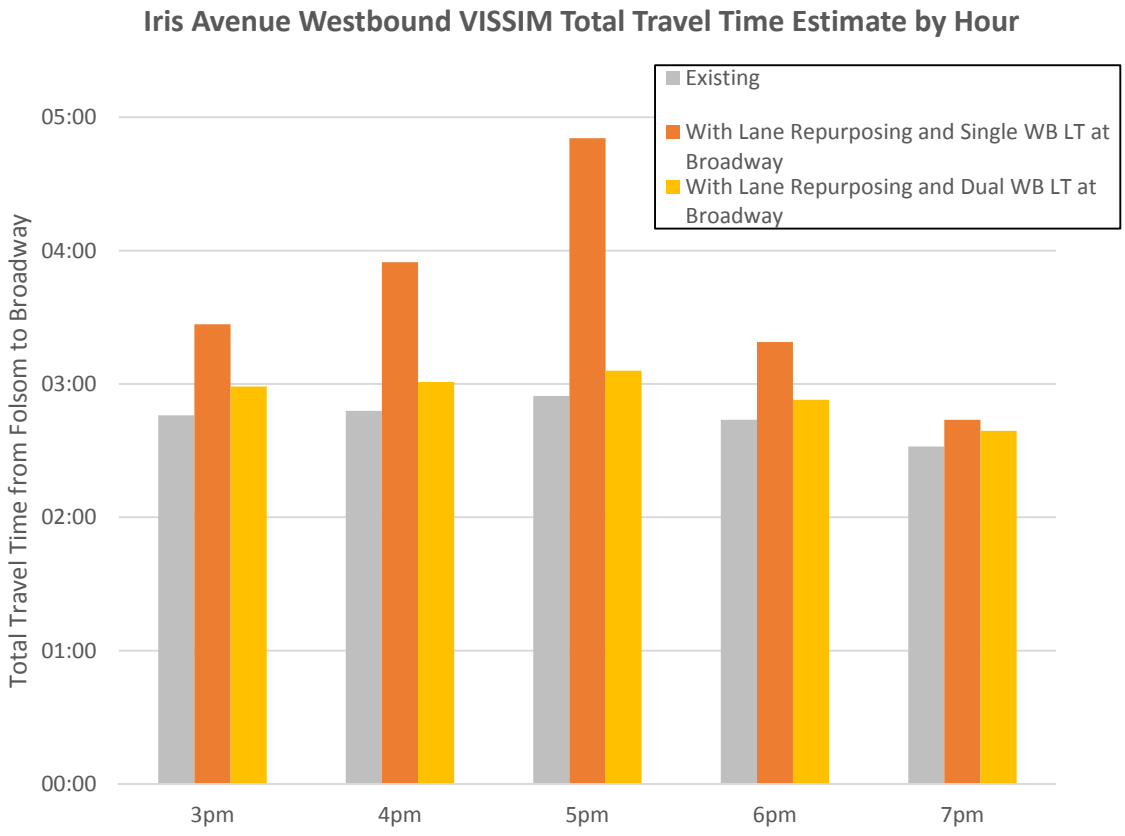
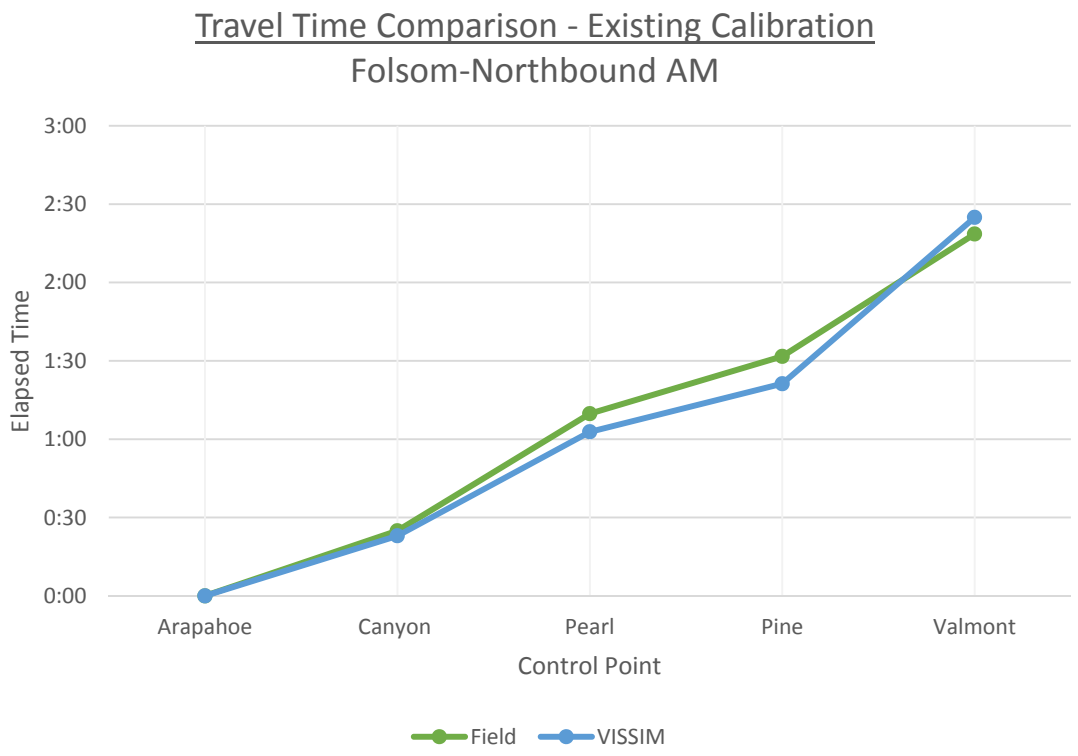
5:00
4:00
3:00
2:00
1:00
0:00
Folsom
22nd
19th
16th
Broadway
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02

ATTACHMENT D



Travel Time Charts – Folsom Street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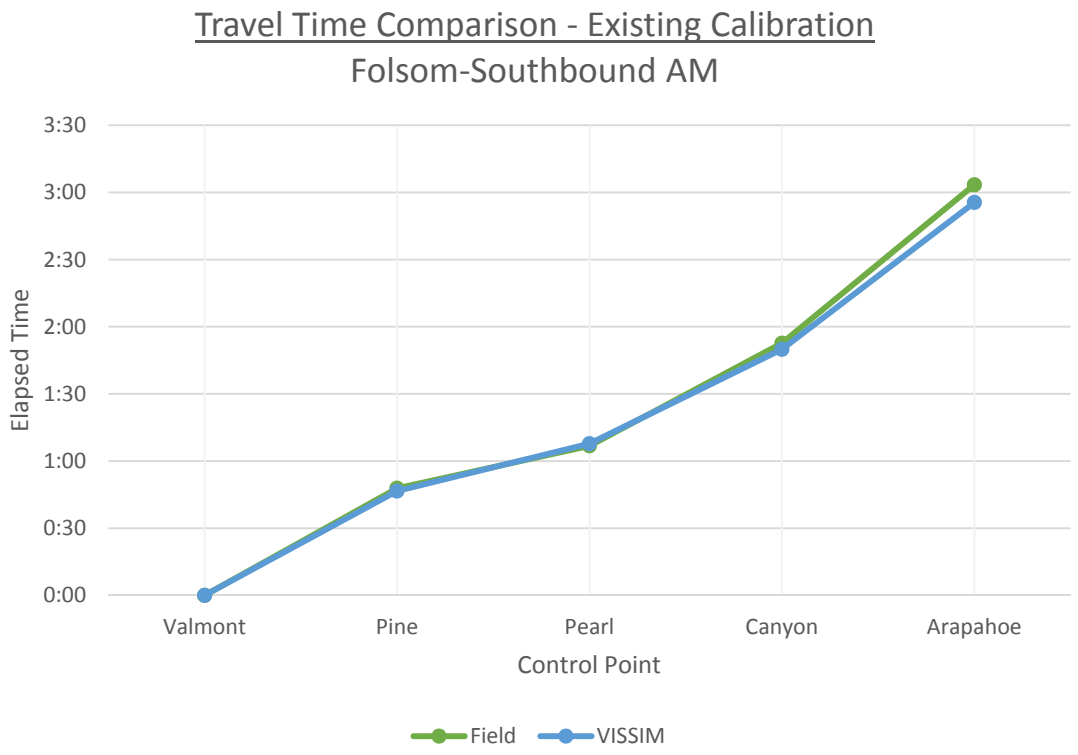
Folsom-Northbound AM
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Arapahoe
Canyon
Pearl
Pine
Valmont
Control Point
Field
VISSIM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Folsom-Southbound AM
3:30
3:00
2:30
2:00
1:30
1:00
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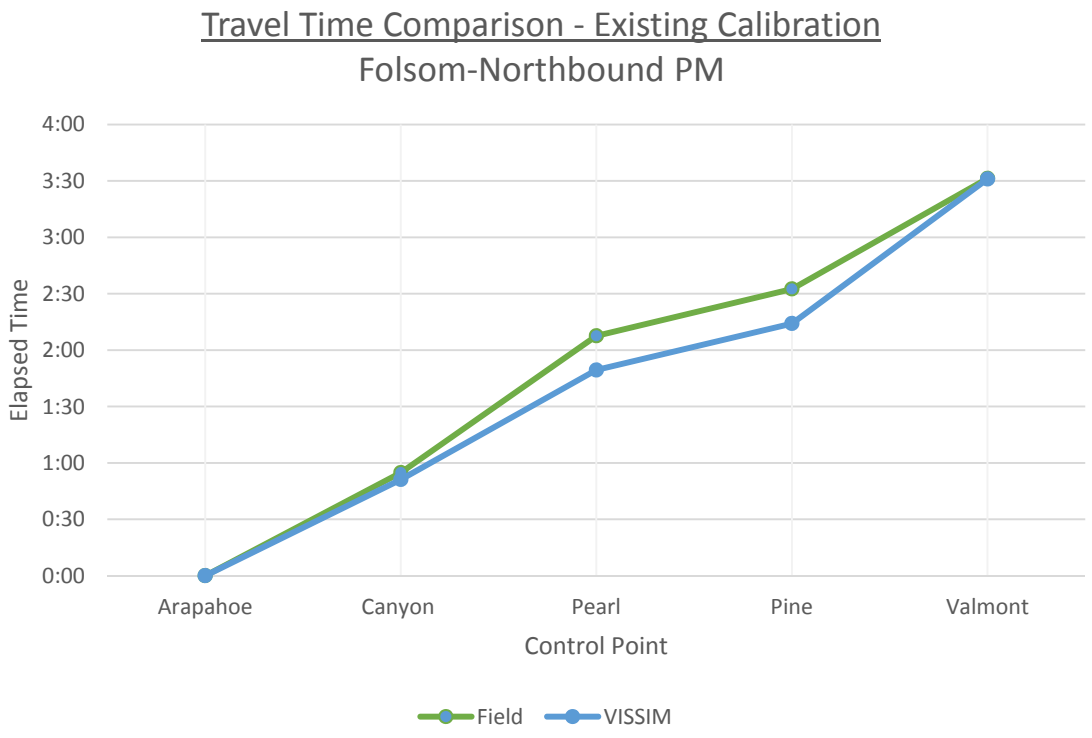
0:00
Elapsed Time
Valmont
Pine
Pearl
Canyon
Arapahoe
Control Point
Field
VISSIM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Folsom-Northbound PM
Elapsed Time
4:00
3:30
3:00
2:30
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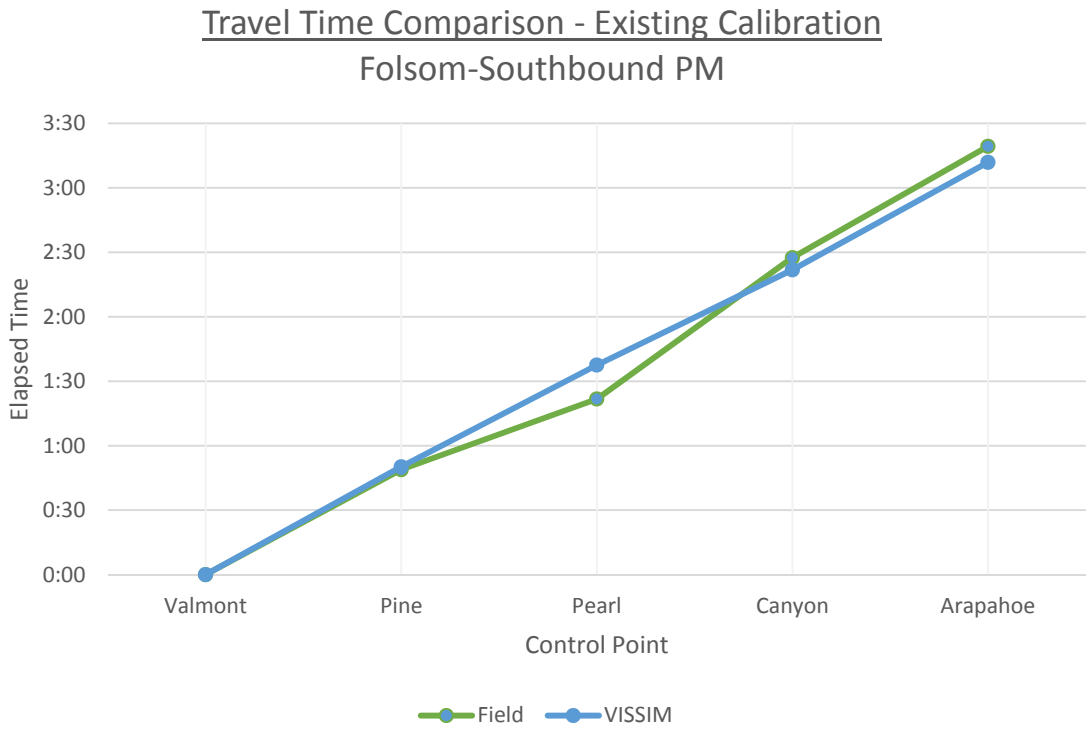
Arapahoe
Canyon
Pearl
Pine
Valmont
Control Point
Field
VISSIM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Folsom-Southbound PM
Elapsed Time
3:30
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2:30
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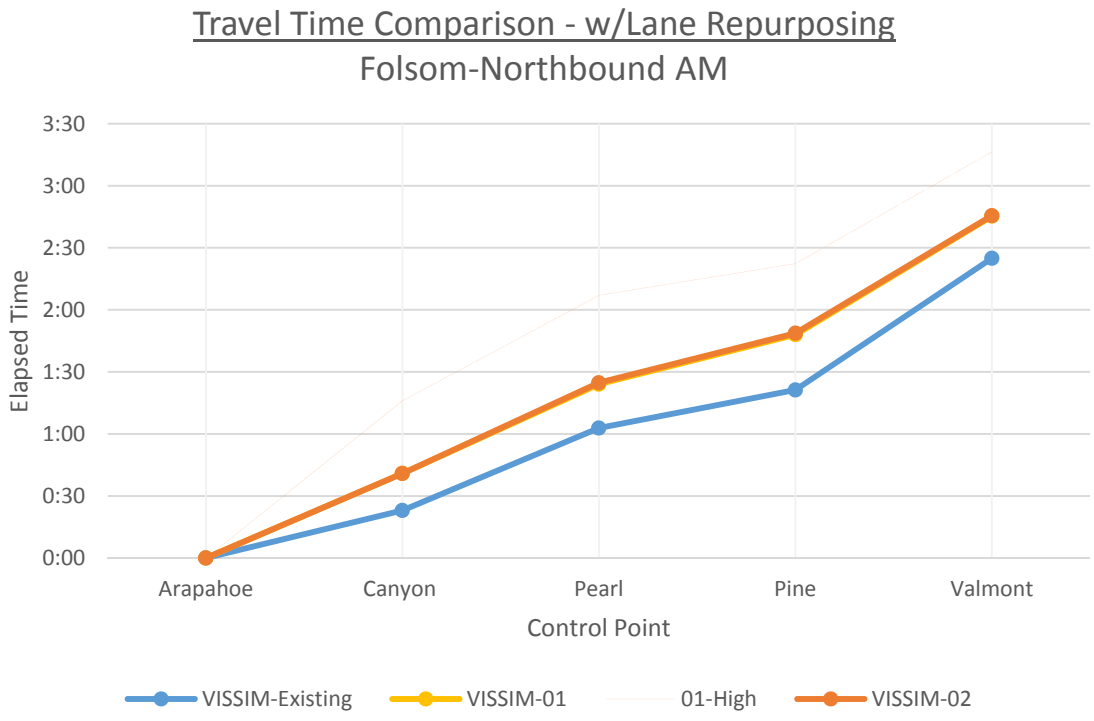
Valmont
Pine
Pearl
Canyon
Arapahoe
Control Point
Field
VISSIM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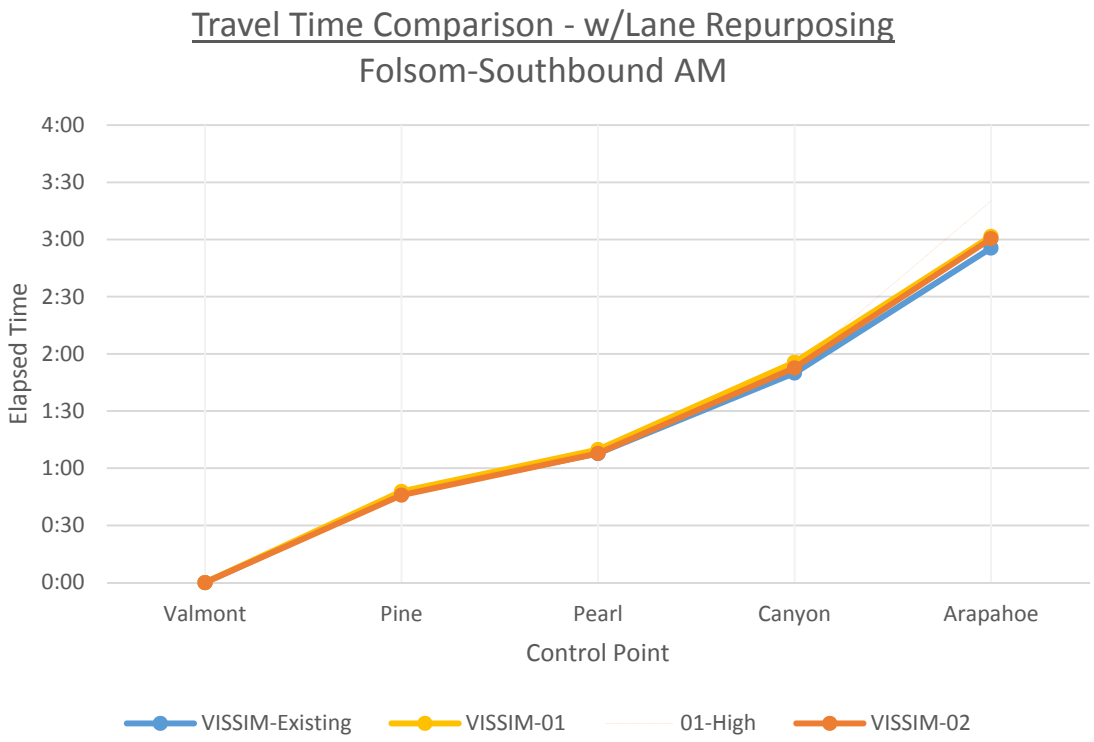
Folsom-Northbound AM
Elapsed Time
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Arapahoe
Canyon
Pearl
Pine
Valmont
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02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Folsom-Southbound AM
Elapsed Time
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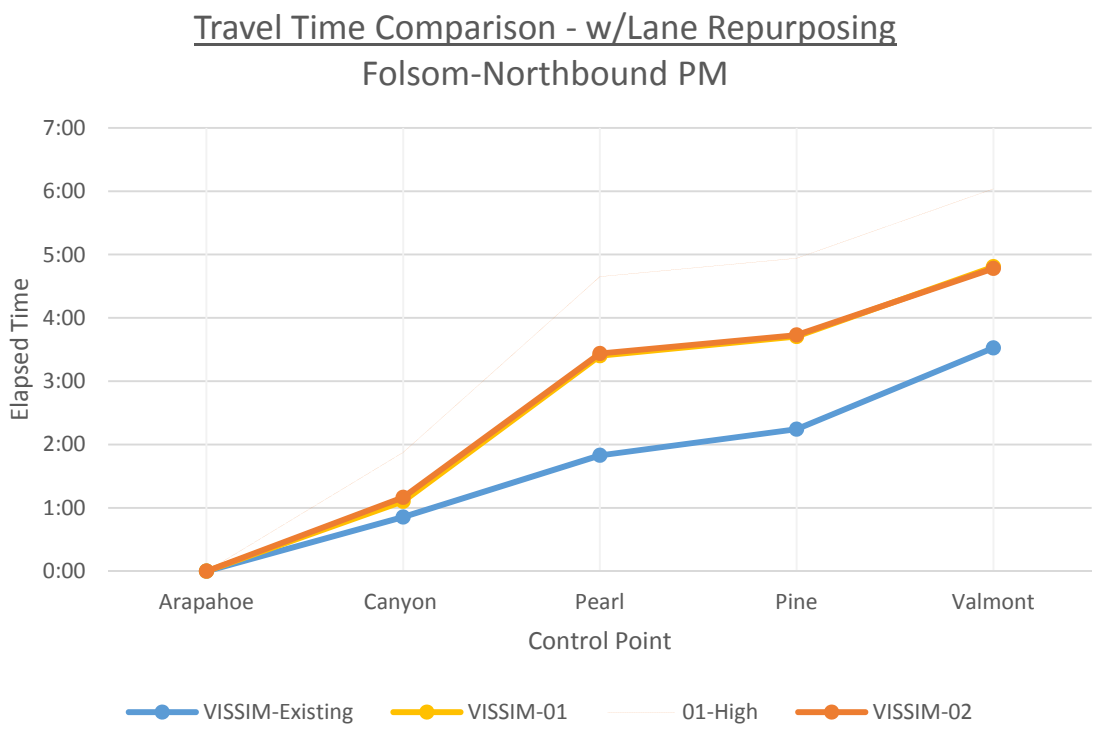
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Valmont
Pine
Pearl
Canyon
Arapahoe
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02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Folsom-Northbound PM
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4:00
3:00
2:00
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Arapahoe
Canyon
Pearl
Pine
Valmont
Control Point
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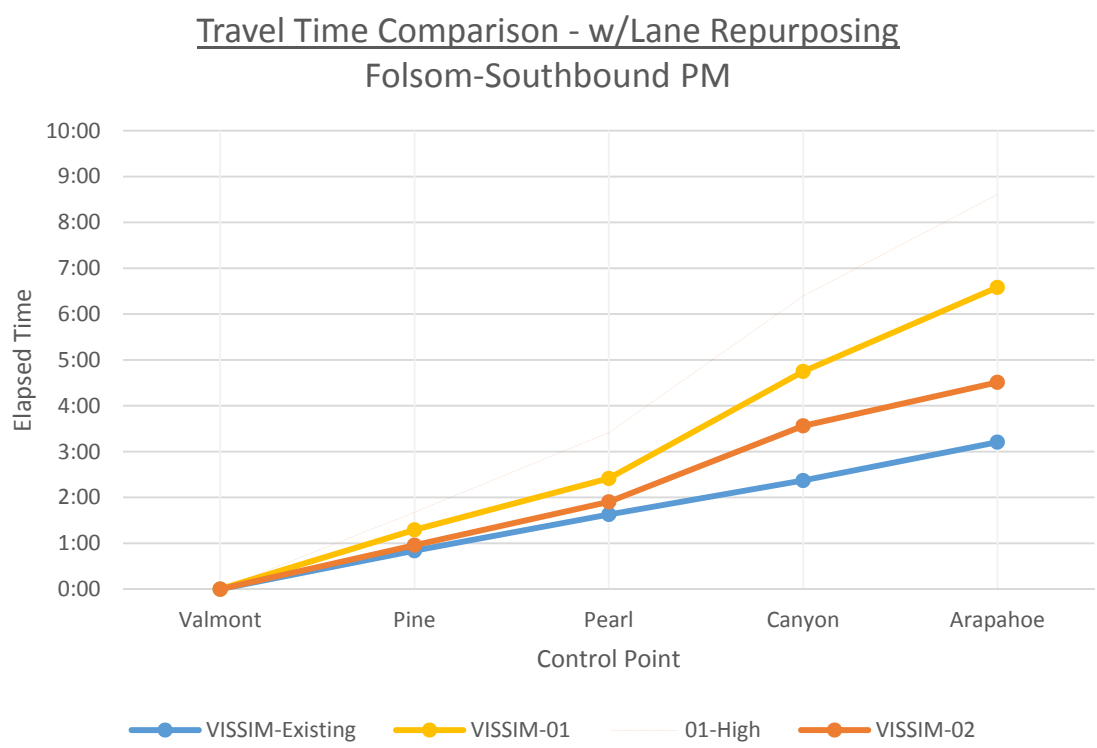
VISSIM-01
01-High
VISSIM-02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Folsom-Southbound PM
Elapsed Time
10:00
9:00
8:00
7:00
6:00
5:00
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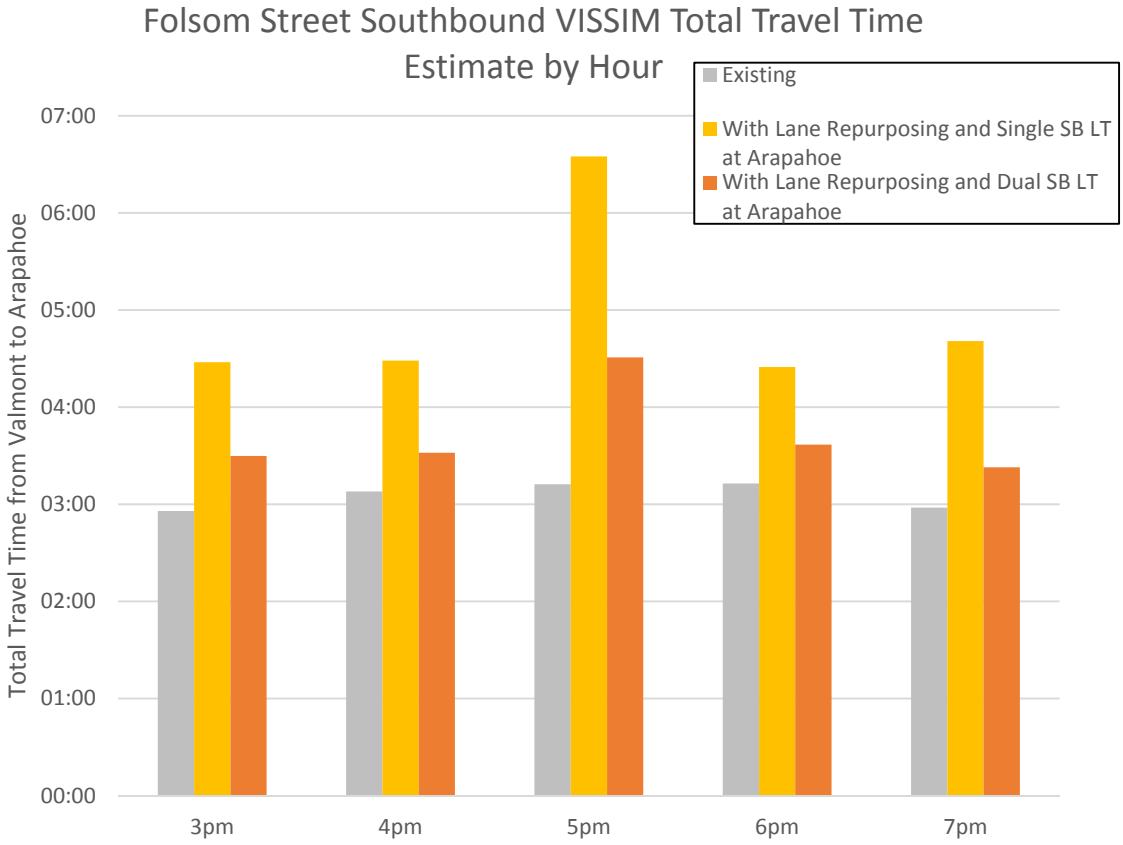
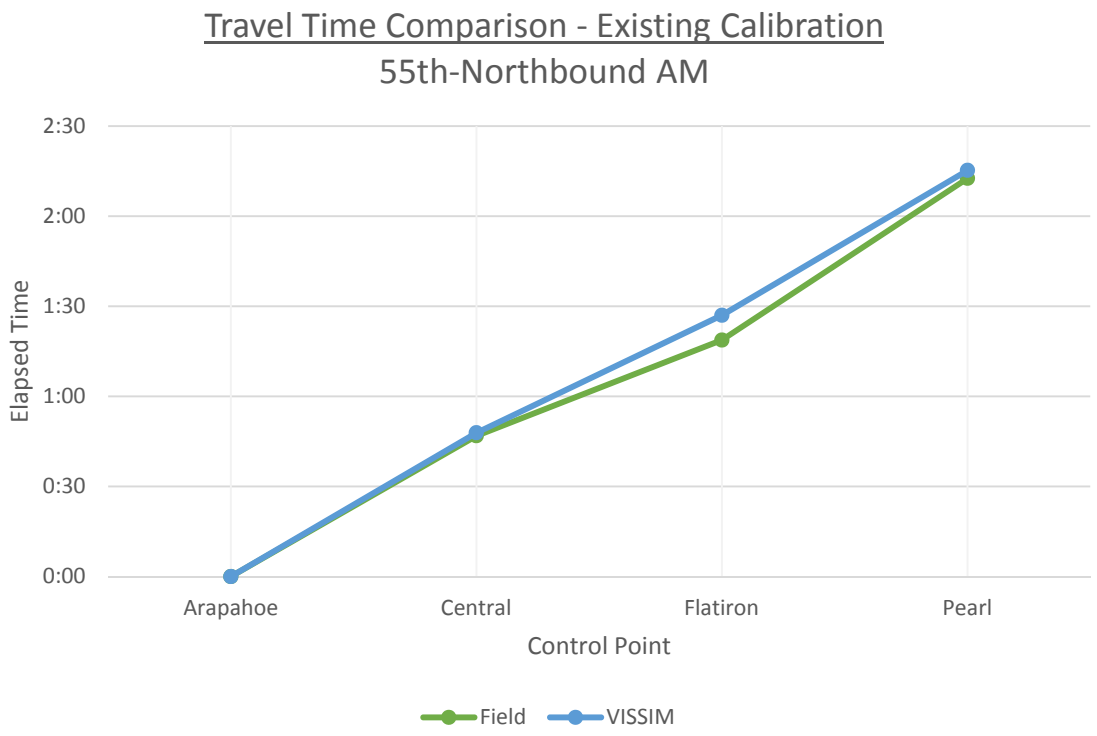
2:00
1:00
0:00
Valmont
Pine
Pearl
Canyon
Arapahoe
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02

ATTACHMENT D



Travel Time Charts – 55th Street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0:00
Elapsed Time
Arapahoe
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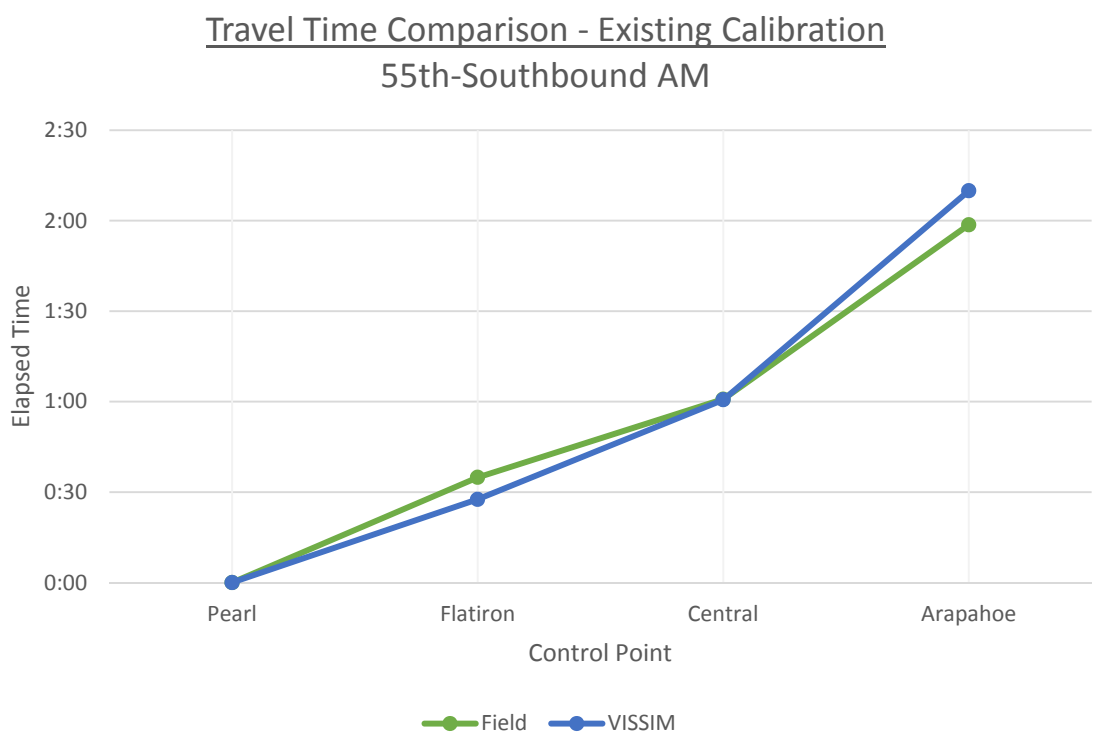
Pearl
Control Point
Field
VISSIM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2:30
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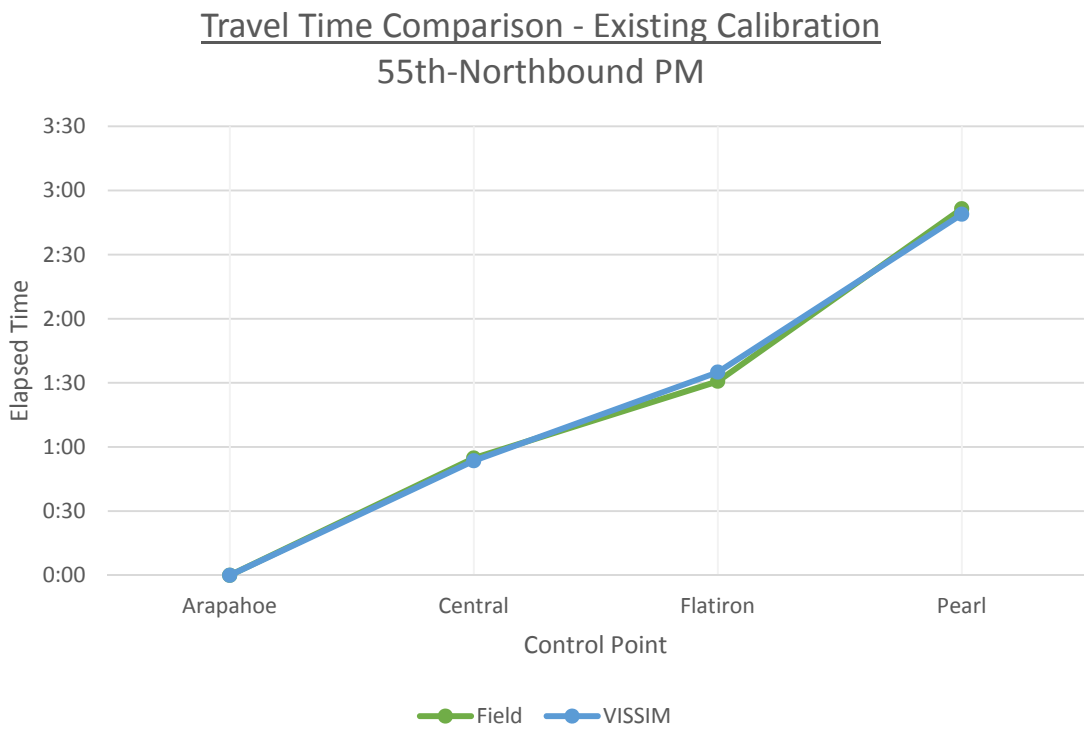
Elapsed Time
Pearl
Flatiron
Central
Arapahoe
Control Point
Field
VISSIM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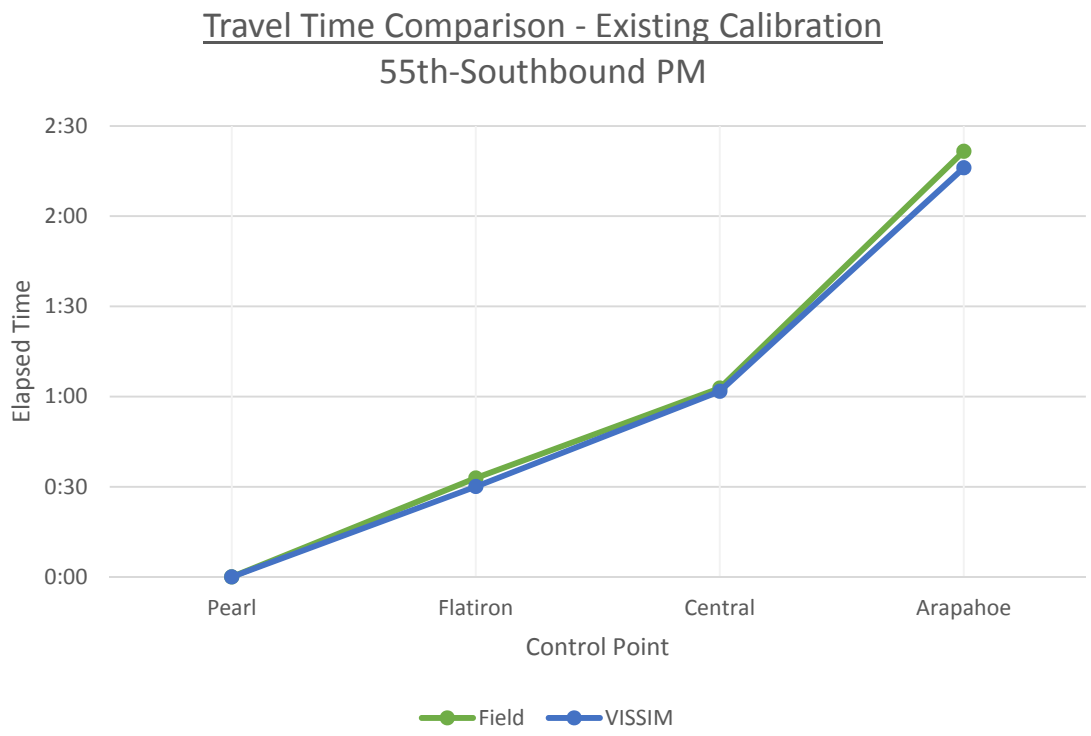
Pearl
Control Point
Field
VISSIM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Elapsed Time
Pearl
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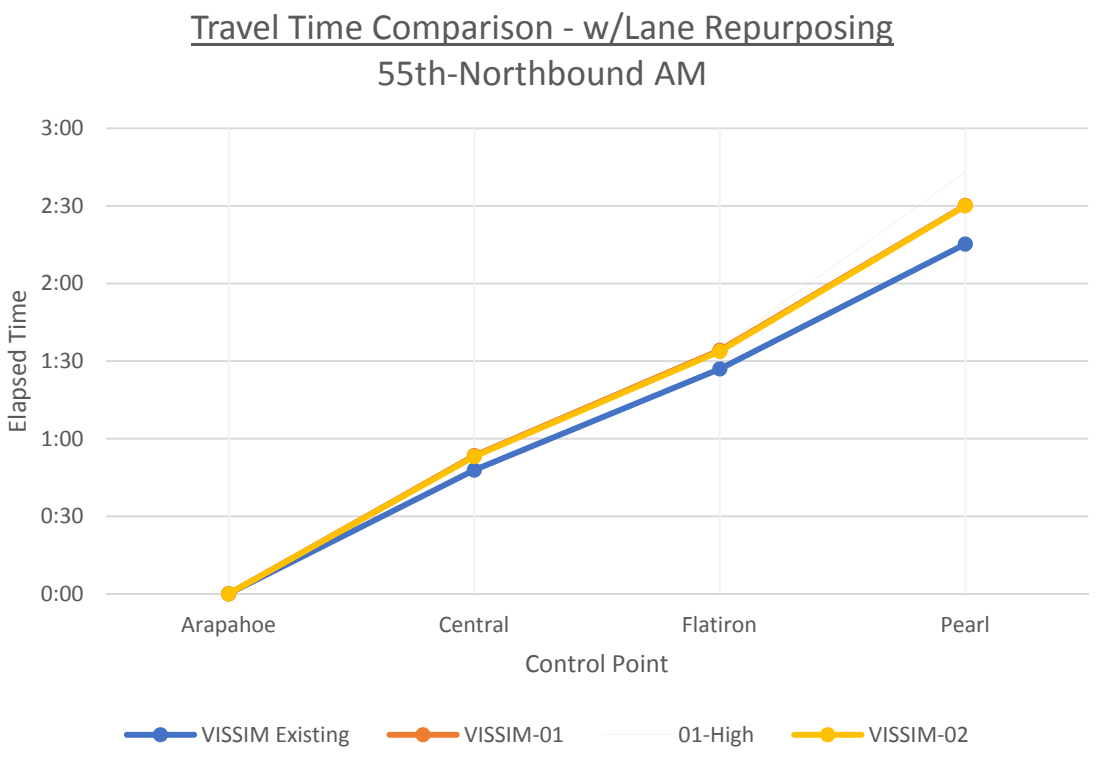
Arapahoe
Control Point
Field
VISSIM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3:00
2:30
2:00
1:30
1:00
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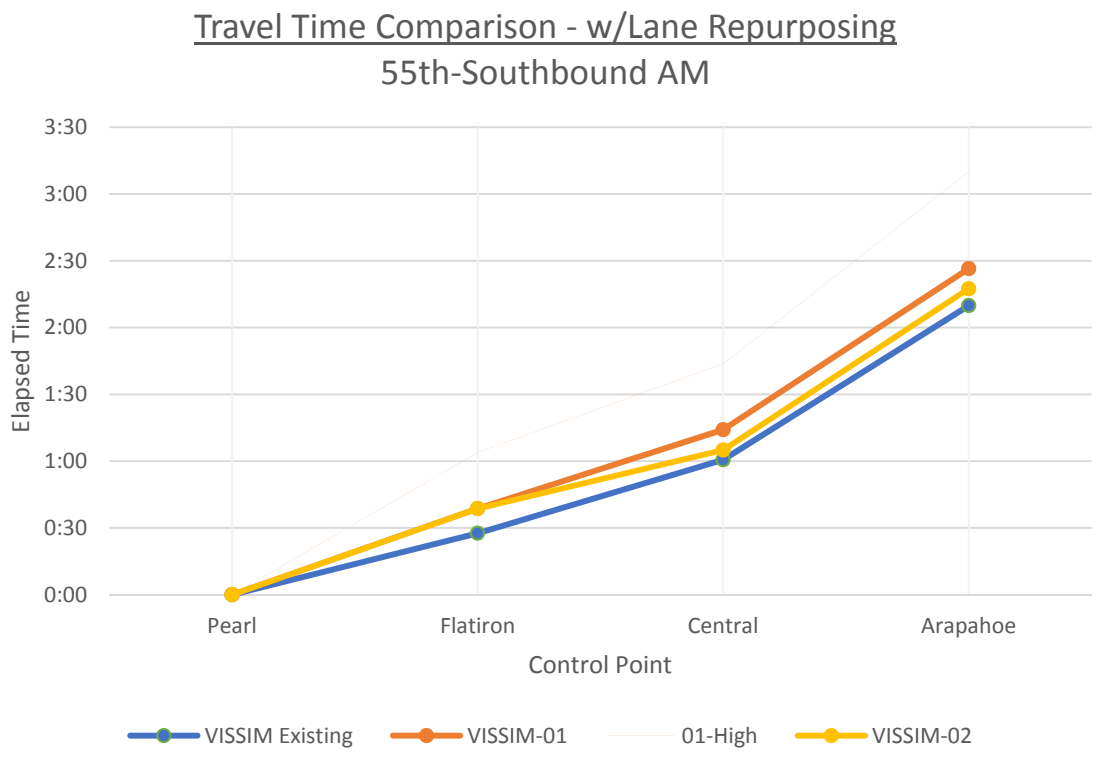
0:00
Elapsed Time
Arapahoe
Central
Flatiron
Pearl
Control Point
VISSIM Existing
VISSIM-01
01-High
VISSIM-02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2:00
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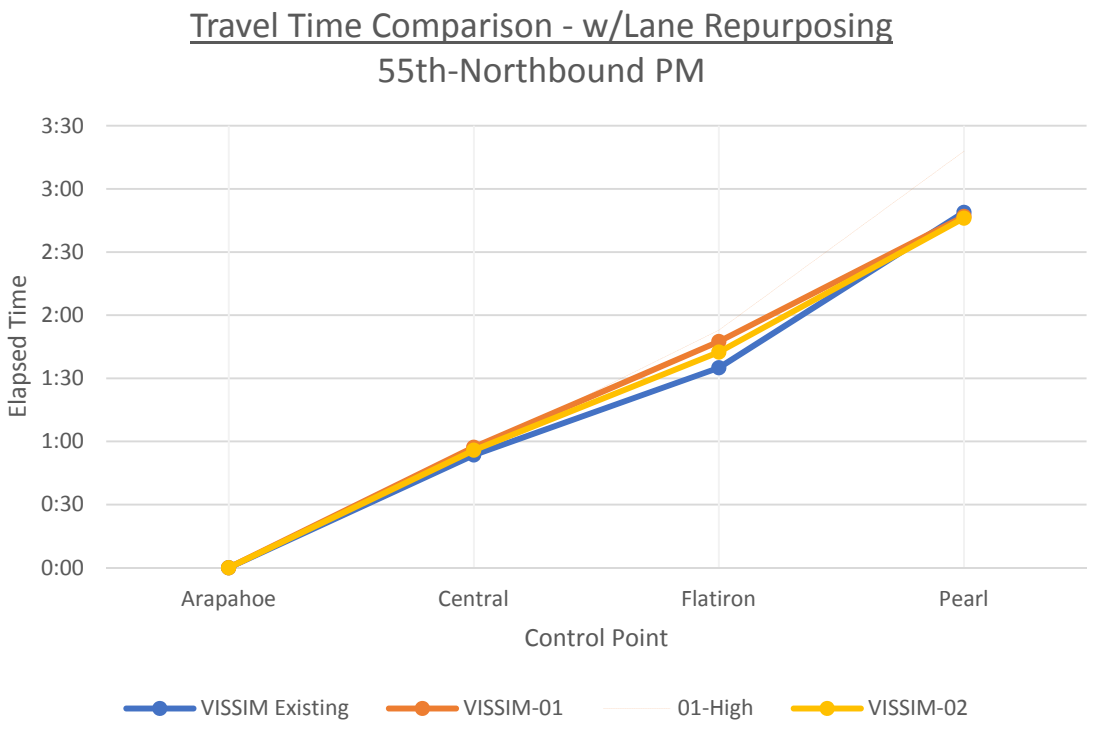
VISSIM-01
01-High
VISSIM-02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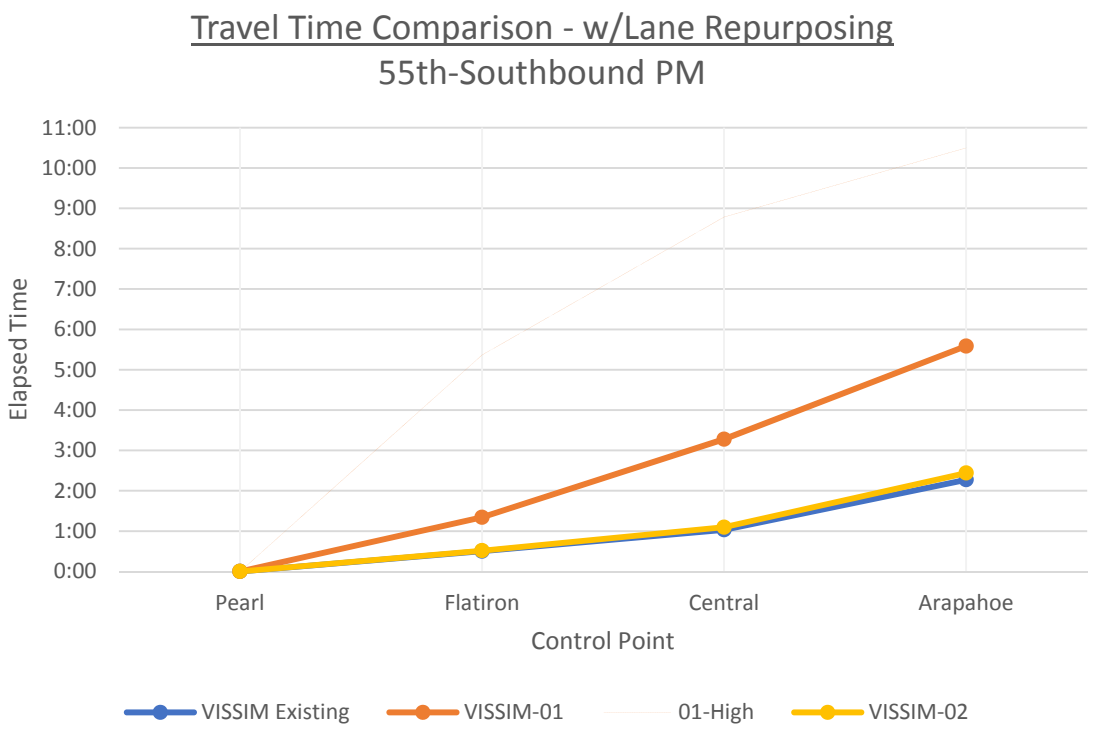
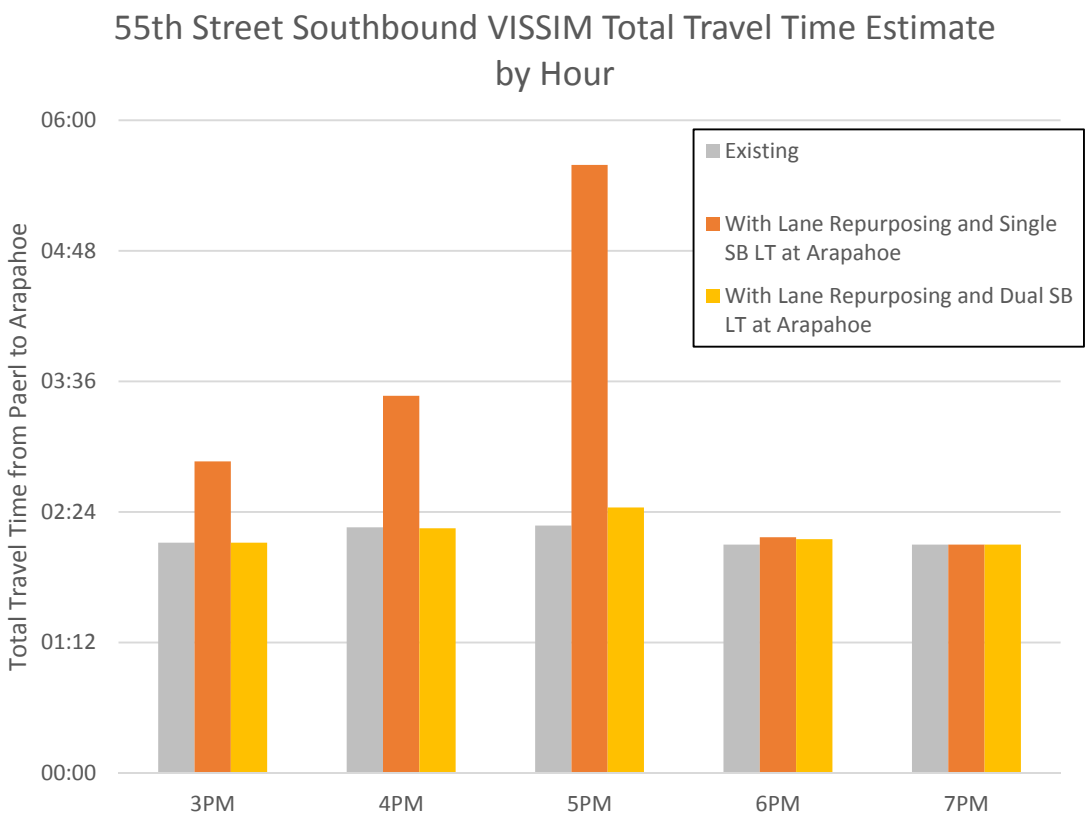
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Arapahoe
Central
Flatiron
Pearl
Control Point
VISSIM Existing
VISSIM-01
01-High
VISSIM-02


Travel Time Comparison - w/Lane Repurposing
55th-Southbound PM
11:00
10:00
9:00
8:00
7:00
6:00
5:00
4:00
3:00
2:00
1:00
0:00
Elapsed Time
Pearl
Flatiron
Central
Arapahoe
Control Point
VISSIM Existing
VISSIM-01
01-High
VISSIM-02

ATTACHMENT D



ATTACHMENT E

CITY OF BOULDER

Department of Public Works Transportation Division
P.O. Box 791
1739 Broadway
Boulder, Colorado 80306
(303) 441-3266

Inter-Office Memorandum

TO: **Bill Cowern, Transportation Operations Engineer**

FROM: **Shannon Young, Transportation Engineer**

DATE: **May 19, 2015**

SUBJECT: **Safety Analysis for Phase II Living Laboratory Projects**

As part of the evaluation process of the complete streets Phase II Living Laboratory, the potential safety benefits of rightsizing projects were considered. Crash data from each proposed corridor was compiled and reviewed to determine existing crash trends which may be mitigated by the implementation of the proposed projects. The purpose of this memo is to summarize the findings of this evaluation.

Expected Crash Reduction
The Highway Safety Manual (HSM) provides information about the effects on crash frequency of various safety treatments, geometric design characteristics, and operational characteristics. The effects are quantified in the form of crash modification factors (CMF) which are based on published transportation safety research. CMFs can be applied to historic crash data in order to estimate the expected crash frequency after a treatment is installed.

The HSM presents a CMF for removing through lanes or "road diets" which is applicable to the Living Laboratory Phase II rightsizing projects. Based on the CMF, the potential crash effect of a four to three lane conversions on an urban arterial is a 29% reduction in crashes for all crash types and all severities.

Crash Types Susceptible to Mitigation
While an overall decrease in the frequency of crashes is expected, the implementation of a rightsizing project has the potential to decrease the frequency of certain crash types and increase others. The inclusion of various right-turn treatments in the Living Labs projects could provide additional benefits to bicycle-related crash frequency. The following crash types could be mitigated by the implementation of the rightsizing projects.

> Left-Turn Rear End: The addition of a two-way left-turn lane or left-turn lanes at intersections would provide space for vehicles waiting to turn left onto a side street and reduce the chances of being rear-ended.

Sideswipe-Same Direction: By repurposing a lane in each direction, there would only be one through lane in each direction and vehicles would no longer be switching lanes or traveling side-by-side.

Sideswipe-Opposite Direction: A two-way left-turn lane would provide additional space between opposing lanes of traffic, reducing the chances of a sideswipe between vehicles traveling in opposite directions.

Left-Turns from Side Streets: At unsignalized intersections, the two-way left-turn lane would provide space for vehicles to make a two-stage left-turn, and thus, they would only need to cross one lane of traffic at a time.

Pedestrian Crossing: The reduced crossing distance and reduced number of vehicle lanes results in safer crossing opportunities for pedestrians at unsignalized locations.

Right Hook: The installation of specialized right-turn treatments at signalized intersections should reduce collisions between bicyclists and right-turning vehicles.

Conversely, the potential increased congestion associated with the installation of a rightsizing project could result in an increase in rear-end collisions. However, a decrease in speeds along the corridors due to rightsizing may result in additional safety benefits and decreased crash frequency of other crash types.

Crashes by Corridor

In order to better understand the potential safety benefits of the proposed rightsizing projects, historic crash data from each candidate corridor was reviewed to determine how many crashes susceptible to mitigation have been occurring. Crash data from the past three years (2012-2014) at intersections and on segments along the corridors was used for the analysis. The crash types considered susceptible to correction vary from corridor to corridor, as the proposed facilities are different depending on the corridor and segment.

Iris Avenue

Along Iris Avenue, west of Broadway to Folsom Street, 59 crashes have occurred during the last three years. Existing crash trends which may be lessened by a four to three lane conversion include rear ends due to vehicles waiting to turn left at 16th Street and 17th Street, right angle crashes from vehicles turning left from side streets along the corridor, and right hook crashes at Folsom Street. Of the 59 crashes along the corridor, about 12 (20%) of them could be considered potentially correctable by a rightsizing project.

Folsom Street

A total of 242 crashes occurred at the intersections and on segments along Folsom Street between and including Valmont Road and Arapahoe Avenue. Potentially mitigatable crashes along Folsom Street include left-turn rear ends at Pine Street and South Street, right hook crashes at Valmont Road, Pearl Street, and Arapahoe Avenue, and sideswipes due to lane changes along the corridor. Depending on the limits chosen for the rightsizing project, the number of

potentially correctable crashes ranges from 7 to 9 and 7% to 10% of total crashes.

55th Street

From Pearl Parkway/Valmont Road to north of Arapahoe Avenue, 55th Street experienced 71 crashes within the past three years. Of the 71 total crashes, 11 (15%) were considered correctable. Most of the crashes which could be mitigated by a rightsizing project on 55th Street were right angle crashes involving eastbound vehicles turning left from Western Avenue or the driveway access north of Arapahoe Avenue. A four to three lane conversion on 55th Street would reduce the number lanes to navigate across at each location and would provide a two-way left-turn lane at the driveway access north of Arapahoe Avenue.

63rd Street

A total of 47 crashes were reported at the intersections on 63rd Street from Lookout Road to Gunbarrel Avenue/Nautilus Drive during the past three years. Twenty-three of these crashes occurred at Lookout Road and are not likely to be mitigated by the proposed rightsizing project. Since 63rd Street has a raised median and limited intersections, the potential reduction in crash frequency is lower than the other corridors. The only existing crash trend which may be corrected is right angle crashes at Longbow Drive involving eastbound left-turns. These crashes represent 6% of the total crashes on the corridor.

Conclusion

Some of the existing crash trends on Iris Avenue, Folsom Street, 55th Street, and 63rd Street could be mitigated by the implementation of the Phase II Living Laboratory rightsizing projects. Since the historic crashes and proposed facilities are different on each corridor, the potential safety benefits also vary. The frequency of crash types considered correctable by the proposed projects ranges from 6% to 20% on the candidate corridors. Actual crash reductions may be higher or lower than these projections as a result of increased congestion, decreased speeds, or changes in traffic volumes.

Appendix:
Crash Summaries by Corridor

Appendix

Crash Summaries by Corridor

Iris Avenue

Intersection/Segment	Total Crashes				Correctable Crashes	
	2012	2013	2014	Total		
Iris Ave and 13th St	3	0	1	4	2	50%
Iris Ave and 14th St	1	1	0	2	0	0%
Iris Ave and 15th St	1	1	1	3	1	33%
Iris Ave and 16th St	2	5	4	11	4	36%
Iris Ave and Iris Ct	0	1	1	2	0	0%
Iris Ave and 17th St	1	0	0	1	1	100%
Iris Ave and 19th St	4	2	1	7	0	0%
Iris Ave and 22nd St	1	0	0	1	0	0%
Iris Ave and Hermosa Dr	0	0	2	2	1	50%
Iris Ave and 25th St	1	0	1	2	0	0%
Iris Ave and Folsom St	4	12	8	24	3	13%
Total	**18**	**22**	**19**	**59**	**12**	**20%**

Folsom Street

Intersection/Segment	Total Crashes				Correctable Crashes	
	2012	2013	2014	Total		
Folsom St and Valmont Rd	6	5	6	17	2	12%
Folsom St and Bluff St	1	0	3	4	0	0%
Folsom St and Mapleton Ave	0	0	1	1	0	0%
Folsom St and Pine St	9	8	4	21	2	10%
Folsom St and Spruce St	5	5	0	10	0	0%
Folsom St and Pearl St	11	7	8	26	3	12%
Folsom St and Walnut St	1	3	1	5	0	0%
Subtotal	**33**	**28**	**23**	**84**	**7**	**8%**
Folsom St and South St	1	2	0	3	1	33%
Folsom St from South St to Canyon Blvd	3	1	0	4	1	25%
Subtotal	**37**	**31**	**23**	**91**	**9**	**10%**
Folsom St and Canyon Blvd	16	28	25	69	0	0%
Folsom St from Canyon Blvd to Goss St	1	2	0	3	1	33%
Folsom St and Goss St	5	0	0	5	1	20%
Folsom St and Grove St	2	2	2	6	0	0%
Folsom St and Arapahoe Ave	24	21	23	68	5	7%
Total	**85**	**84**	**73**	**242**	**16**	**7%**

55th Street

Intersection/Segment	Total Crashes				Correctable Crashes	
	2012	2013	2014	Total		
55th St and Pearl Pkwy/Valmont Rd	20	13	9	42	0	0%
55th St and Flatirion Ln	1	2	1	4	1	25%
55th St and Mine Way	0	1	0	1	1	100%
55th St and Central Ave	4	4	0	8	0	0%
55th St and Western Ave	4	3	1	8	5	63%
55th St from Western to Arapahoe	2	5	1	8	4	50%
Total	31	28	12	71	11	15%

63rd Street

Intersection/Segment	Total Crashes				Correctable Crashes	
	2012	2013	2014	Total		
63rd St and Lookout Rd	11	4	8	23	0	0%
63rd St and Spine Rd	6	7	5	18	0	0%
63rd St and Longbow Dr	2	0	1	3	0	0%
63rd St and Gunbarrel Ave/Nautilus Dr	2	0	1	3	3	100%
Total	**21**	**11**	**15**	**47**	**3**	**6%**

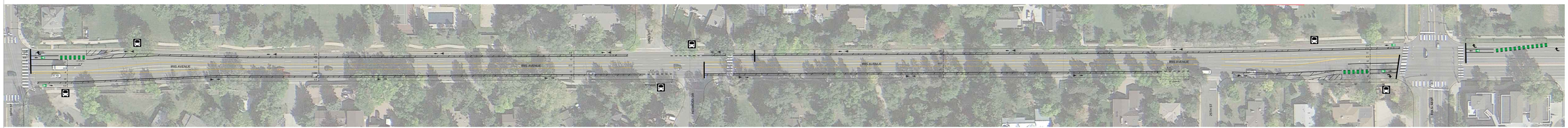
BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -
IRIS AVENUE

N

4/29/2015

REDUCE TO ONE WESTBOUND LEFT AT BROADWAY



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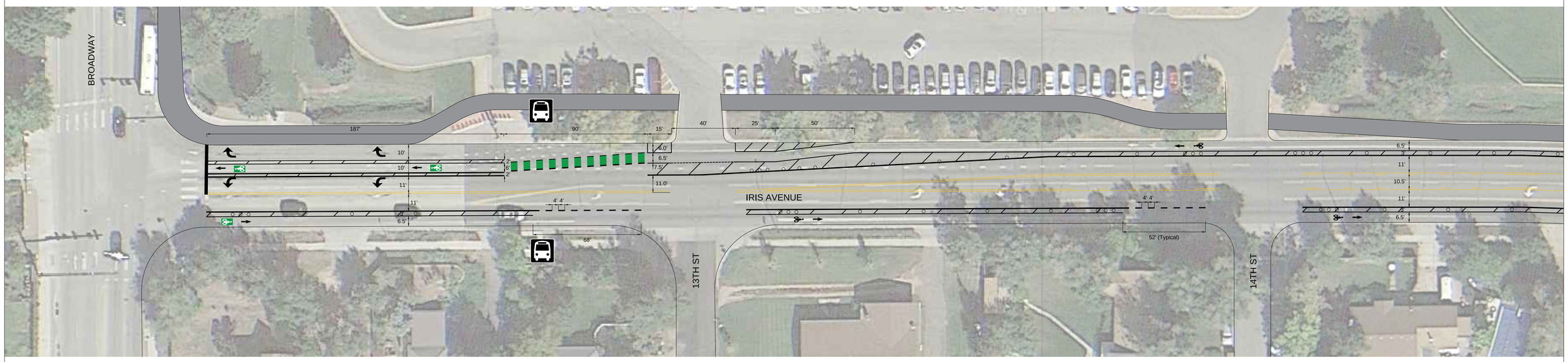
N

4/25/2015

BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -

IRIS AVENUE



REDUCE TO ONE WESTBOUND LEFT AT BROADWAY

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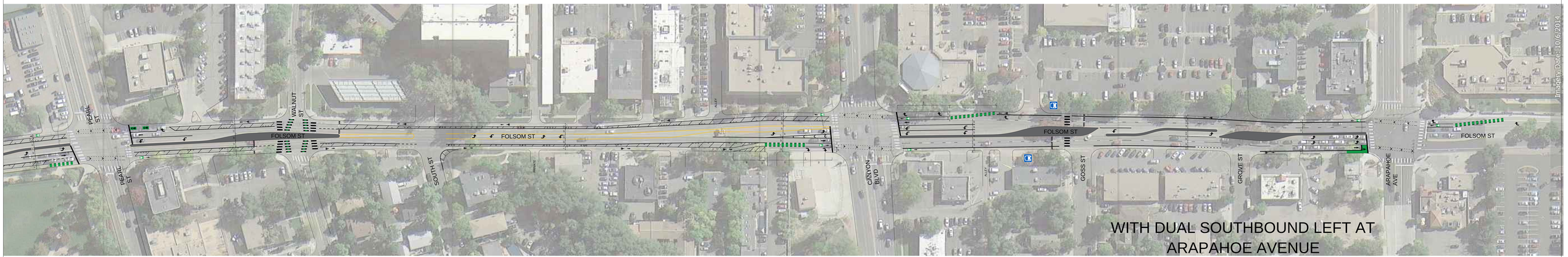
LIVING LABS RIGHT-SIZING -
FOLSOM STREET

4/25/2015



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LIVING LABS RIGHT-SIZING -
FOLSOM STREET

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WITH SINGLE SOUTHBOUND LEFT AT
ARAPAHOE AVENUE

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LIVING LABS RIGHT-SIZING -
FOLSOM STREET

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RIGHTSIZING BETWEEN VALMONT ROAD AND SOUTH STREET

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LIVING LABS RIGHT-SIZING -
FOLSOM STREET

4/25/2015

WITH DUAL SOUTHBOUND LEFT AT
CANYON BOULEVARD

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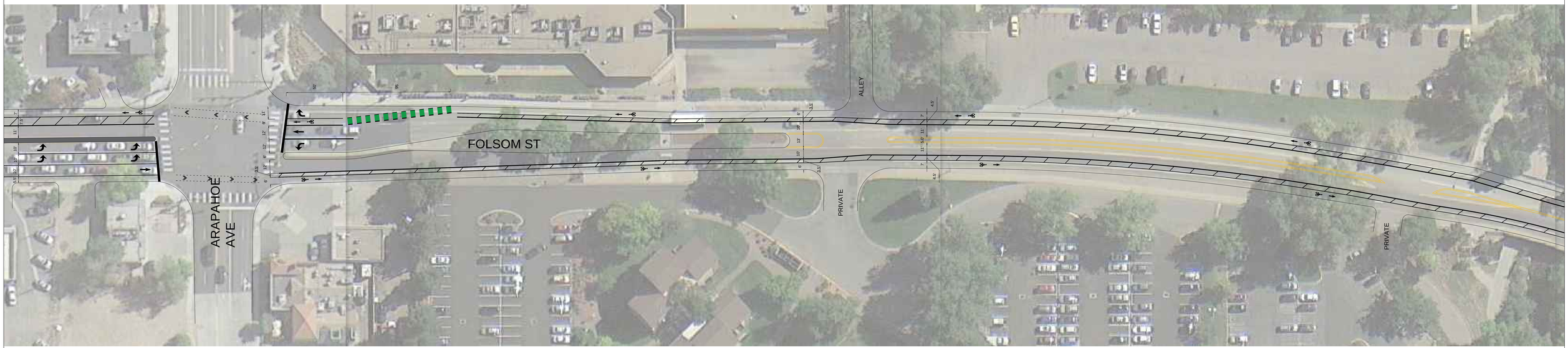
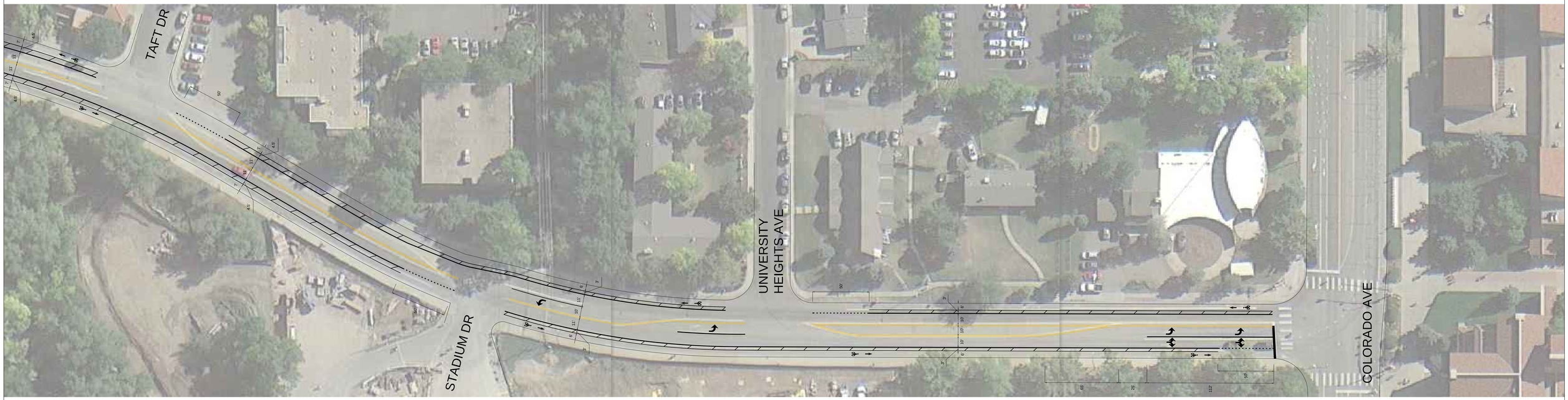
LIVING LABS RIGHT-SIZING -

FOLSOM STREET (SOUTH)

4/23/2015





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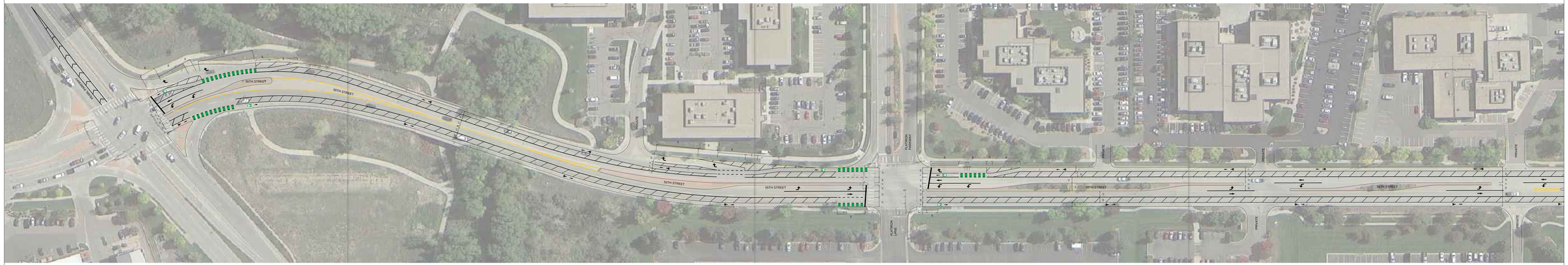
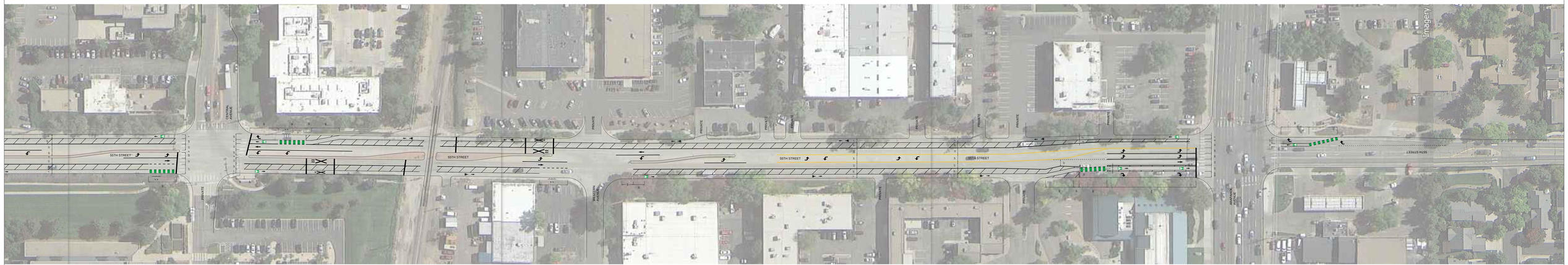
LIVING LABS RIGHT-SIZING -
55TH STREET

4/25/2015





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BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -
63RD STREET

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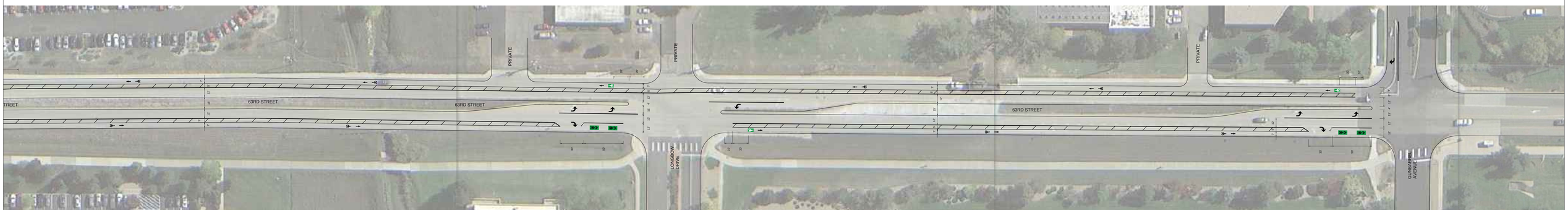
4/25/2015



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Living Lab – Phase II Rightsizing Evaluation Criteria

Evaluation Criteria	Data Collection	Data Collection Method	Data Analyzed	Data Collection Time Frame	Collection & Analysis
SAFETY					
Crash History	All corridors	Review City of Boulder Crash Reports	• Fatal & serious injury crashes • Crashes involving bicyclist or pedestrian • Crash type trends (rear end, approach turn, right angle, etc.)	Before: • 5 years (2010-15) After: • 9 months • 1 year	City Staff
Right Turn Treatments & Turning Movement Conflicts	Folsom & Canyon Folsom & Pearl Iris & Broadway Iris & 19th 55th & Arapahoe 63rd & Spine (additional TBD)	Video Observation (AM & PM peak)	• Bicycle, pedestrian, and vehicle interactions in right turn treatments • Right or left turning motorist failure to yield to pedestrian or bicycle • Number of evasive actions taken by individual (cyclist, pedestrian, or motorist) • Compliance of users with signage and striping treatment	Before: • Summer 2015 After: • 3 months • 6 months • 9 months	FTH
MOTOR VEHICLES					
Volume	All corridors (locations listed below)	Jamar, Miovision, Wavetronix	• 24 hour counts of vehicles	Before: • Summer 2015 After: • 3 months • 6 months • 9 months	City Staff
Speed	All corridors (locations listed below)	Jamar, Miovision, Wavetronix	• Average daily speed of vehicles	Before: • Summer 2015 After: • 3 months • 6 months • 9 months	City Staff

Travel Time By Segment	Iris Folsom 55th 63rd	Field data collection	• Average driving time by segment for each corridor, both directions	Before: • Fall 2014 After: • 9 months	FTH
Intersection LOS / Capacity Analysis	All corridors	Turning Count Movement Data (AM & PM peak)	• Synchro capacity analysis for each intersection turning movement using data collected during City turning movement counts	Before: • Fall 2014 After: • 9 months	FTH
Left Turn Queue Length	Folsom & Canyon Folsom & Pearl Iris & Broadway	Video Observation (AM & PM peak)	• Average & maximum queue • Number of times left-turn queue blocks through lane	Before: • Summer 2015 After: • 3 months • 9 months	FTH
BICYCLES					
Volume	Folsom & Canyon Folsom & Pearl Iris & Broadway Iris & 19th 55th & Arapahoe 63rd & Spine	Before: Video Observation (AM & PM peak) After: 24 Hour Counters Video Observation (AM & PM peak)	• Bicycle volume by direction, time of day, and location within right of way	Before: • Summer 2015 After: • 3 months • 6 months • 9 months	FTH / City Staff
Demographics	Folsom & Canyon Folsom & Pearl Iris & Broadway Iris & 19th 55th & Arapahoe 63rd & Spine	Video Observation (AM & PM peak)	• Number of male, female, and children cyclists • Number of "commuters" (backpacks or bags on bike) • Number of cyclists wearing "lycra kits"	Before: • Summer 2015 After: • 3 months • 6 months • 9 months	FTH
Bicycle "Level of Service"	All Corridors	Facility design	• Measures to be determined	Before: • Spring 2015 After: • Spring 2016	City Staff / FTH TBD
PEDESTRIANS					
Crossing Volume	Folsom & Canyon	Video Observation	• Number of crossing pedestrians by	Before:	FTH

	Folsom & Pearl Iris & Broadway Iris & 19th 55th & Arapahoe 63rd & Spine	(AM & PM peak)	direction and time of day	• Summer 2015 After: • 3 months • 6 months • 9 months	
Non-auto Transportation to BVSD School	Iris	BVSD, Landon Hilliard	• Number of students accessing Foothills Elementary school along Iris by non-auto mode	Before: • Fall 2014 & Spring 2015 After: • Fall 2015 & Spring 2016	City Staff
Pedestrian "Level of Service"	All Corridors	Facility design	• Measures to be determined	Before: • Spring 2015 After: • Spring 2016	City Staff / FTH TBD
TRANSIT					
Ridership	Stops on All Corridors	RTD data	• Number of passengers boarding and alighting at stops along rightsized corridors	Before: • Fall 2014 & Spring 2015 After: • Fall 2015 & Spring 2016	FTH
Bus On-Time Performance	Stops on All Corridors	RTD data	• Percent of buses with on-time arrival at stops along rightsized corridors	Before: • Fall 2014 & Spring 2015 After: • Fall 2015 & Spring 2016	FTH
Bus Transition From Buffer to Travel Lane	RTD Stops: Folsom & Goss Iris & 22nd/Hermosa	Observation (AM & PM peak)	• Maximum and average length of time buses wait to merge	After: • Fall 2015 & Spring 2016	FTH
Transit and Bicycle Interactions	RTD Stops: Folsom & Goss Iris & 22nd/Hermosa	Observation (AM & PM Peak)	• Interactions and yielding behaviors of cyclists, transit vehicles in buffer, and motorists in travel lane	After: • Fall 2015 & Spring 2016	FTH
ECONOMIC					
Sales Tax	All Corridors Citywide	City of Boulder Finance Department	• Change in sales tax revenues of businesses along corridor in	Before: • Spring 2015	City Staff

			relation to change in sales tax revenues Citywide	After: • Spring 2016	
Property Values	All Corridors Citywide	Boulder County Assessor's Office	• Change in property values along corridor in relation to change in property values Citywide	Before: • Spring 2015 After: • Spring 2016	City Staff
PUBLIC FEEDBACK					
Public Feedback	All Corridors	Open Houses, Online Feedback, Popup Demontrations	• Online and community feedback	Before: • Ongoing After: • Ongoing	City Staff