Memorandum:
Bend Central District MMA

To:	Wendy Robinson, City of Bend
From:	Chris Maciejewski, P.E., PTOE, Ray Delahanty, AICP, and Ben Fuller, EIT – DKS Associates
Copy:	Devin Hearing, Rod Cathcart, Oregon Department of Transportation (ODOT)
Date:	May 7, 2014
Re:	**Tech Memo #9 MMA Boundary Map and Proposed Transportation Network**

Overview

This memorandum presents an evaluation of the preferred transportation network for the Bend Central District under forecast 2030 conditions. Topics covered as part of the evaluation include the following:

- Forecasting approach for 2030 traffic volumes
- Multimodal Level of Service (MMLOS) results
- Intersection operations and queuing analysis results
- Sensitivity analyses for minor modifications to the preferred network

The Preferred Transportation Network and MMA Boundary

Through previous project work, the City, ODOT staff, and the consulting team developed new land use assumptions and a Multimodal Mixed Use Area (MMA) boundary for the district. The land use assumptions were carried into the traffic forecasting work, which is detailed in a later section of this memorandum.

The project team developed evaluation criteria and analyzed four network options that had been laid out in the earlier Bend Central Area Plan (2007). Based on this evaluation, the group's recommendation was for a hybrid option incorporating desired elements from the different network options. This hybrid option, which is evaluated in detail in this memorandum, assumes the following key features:

- North of Greenwood Avenue, 3rd Street will continue to include five lanes (two travel lanes in each direction and a center turn lane, possibly with a median in some locations). It will also include bicycle lanes, which will require restriping and/or possible modest right-of-way acquisition.
- South of Franklin Avenue, 3rd Street will continue to include three lanes (one travel lane in each direction and a center turn lane, possibly with a median in some locations). It also will include bicycle lanes, improved pedestrian facilities and possibly on-street parking in some locations. While 3rd Street will likely transition from five lanes to three lanes somewhere between Greenwood Avenue and Franklin Avenue, this analysis assumes that the five-lane section continues all the way to Franklin Avenue.

- Long-term improvements to 2nd and 4th Streets will include bike lanes and on-street parking, plus a twelve-foot pedestrian zone (sidewalk/planted buffer), incorporating a five-foot easement on each side of the street. In the shorter term, interim improvements that can be accommodated within the existing roadway may be phased in and may not include all of these elements.
- On-street parking would not have to be contiguous on both sides of the street on 2nd and 4th Streets but could be interrupted by planting areas or other features in some locations where wider sidewalks or planting areas are desirable and appropriate and/or where less right-of-way is available. The analysis in this memorandum assumes that on-street parking is provided consistently along both streets.
- Intersections throughout the study area and particularly at crossings of major north/south and east/west streets will be improved to better facilitate bicycle and pedestrian movements and crossings. However, these intersection treatments are not incorporated into this memorandums' MMLOS link-level analysis.
- 2nd Street will continue directly north to Revere in the existing right-of-way but is not assumed to continue north from there.
- Traffic movement between 3rd Street and 2nd and 4th Streets occurs via basic street grid connections throughout the study area.
- It is assumed that opportunities to travel between 3rd and 4th Streets north of Revere (e.g., at Underwood) exist, but large connections similar to those envisioned in the Expanded Grid network alternative are not assumed.
- Assumed travel speeds on 2nd and 4th are 25 mph; travel speeds on 3rd Street are assumed to be 35 mph. An additional sensitivity analysis evaluates how lower speeds on 2nd and 4th Streets might affect MMLOS results.
- A Hawthorne Avenue connection to downtown will accommodate bikes, pedestrians and transit. Cars are also assumed to be accommodated in this analysis, but would likely be discouraged to some degree via roadway design and lower travel speeds. Hawthorne Avenue is assumed to operate at a 25 mph speed in this analysis.
- This analysis assumes that traffic controls at major intersections are generally signals due to proximity to the existing signals along the highway corridor. However, the City may prefer roundabouts at certain locations.
- A roundabout on 3rd Street/Burnside Avenue, where the 2nd Street and 4th Street corridors connect into 3rd Street, is assumed.

The MMA boundary and key characteristics of the preferred transportation network are shown in Figure 1.

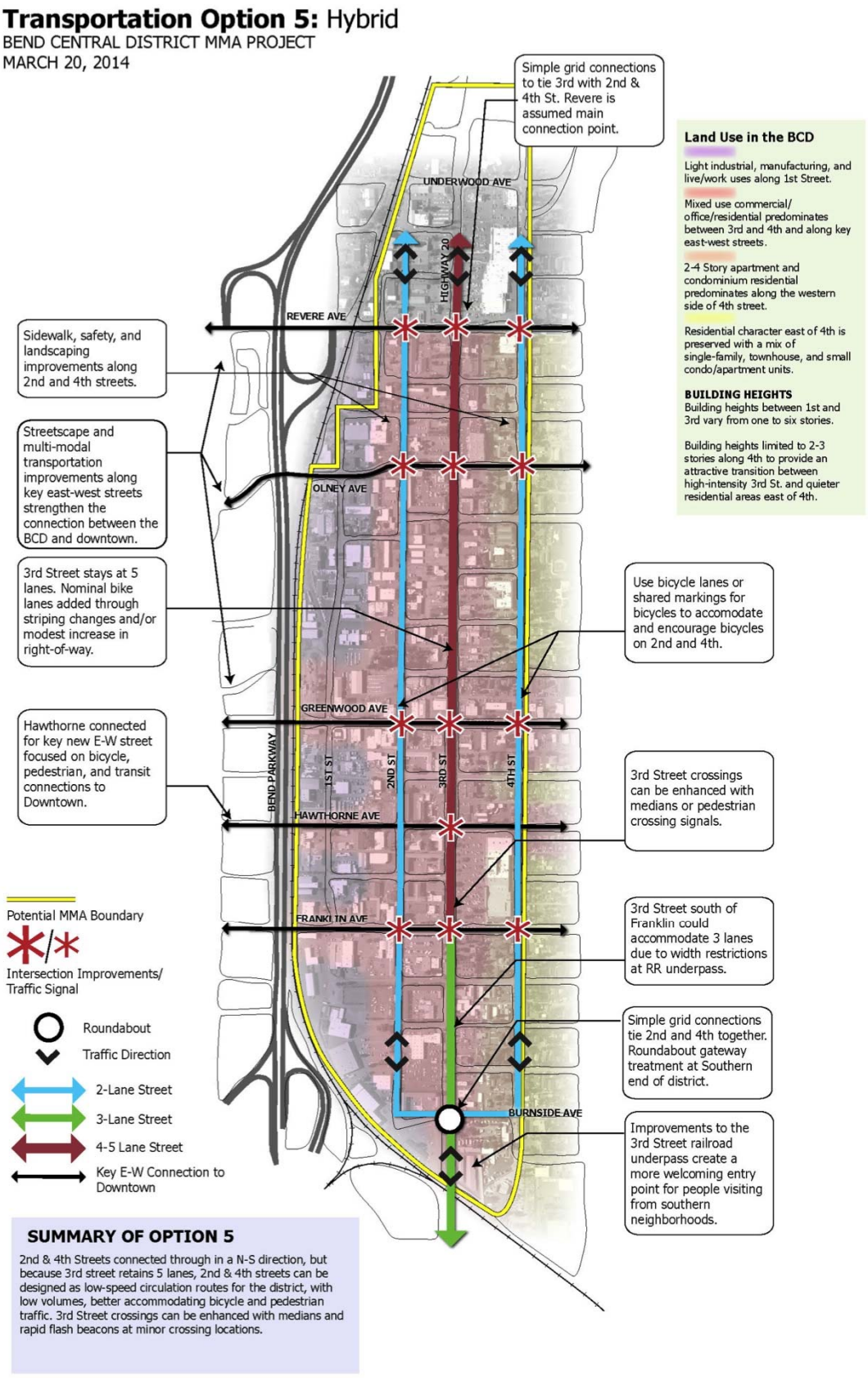

FIGURE 1: PREFERRED TRANSPORTATION NETWORK AND MMA BOUNDARY

Methodology

To perform Multimodal Level of Service (MMLOS) analysis and traffic forecasting, a mesoscopic model was developed. The mesoscopic model is a windowed subarea of the Bend Metropolitan Planning Organization (BMPO) travel demand model that incorporates attributes used to calculate node delay, based on Highway Capacity Manual (HCM) analysis, to further refine trip assignment.

The mesoscopic model was calibrated by comparing the base year 2003 model assignment to traffic counts collected at 23 study intersections in and around the study area.[1] After calibrating the base year model, ODOT's Transportation Planning Analysis Unit (TPAU) performed a 2030 BMPO model run, which accounts for proposed transportation improvements and future land use assumptions for the Bend Central District, including the Hawthorne Avenue undercrossing of the Bend Parkway and a narrower 3rd Street cross-section south of Franklin Avenue.[2] A future year mesoscopic model was then developed by coding proposed transportation improvements and by assigning the windowed 2030 trip table (generated from the 2030 BMPO model run) to the network.

The 2030 mesoscopic model volumes were post-processed using seasonally-factored 2013 traffic counts as a base and applying an increment from the growth between the 2003 mesoscopic model volumes and the 2030 mesoscopic model volumes. The final 2030 motor vehicle volumes were used for intersection operation and queuing analysis.

Pedestrian and bicycle level of service analysis was incorporated into the mesoscopic model as well. The methodology used in this analysis did not included the full set of MMLOS variables, but has been modified to include those that can be analyzed within the model environment, such as cross-section elements, traffic volumes, and traffic speeds. [3]

[1] See Technical Memorandum 5 for detail on model calibration.
[2] See Technical Memorandum 4 for detail on future Bend Central District land use assumptions.
[3] See Appendix for details regarding how the Highway Capacity Manual MMLOS calculations were modified.

MMLOS Results

This section summarizes the performance of the preferred network for people walking and biking in the Central District under 2030 PM Peak conditions. MMLOS analysis is sensitive to a variety of variables including traffic volumes, traffic speeds, and street cross-section elements. As noted previously, north of Franklin Street, 3rd Street is generally assumed to be configured as it is today, but with slightly narrower travel lanes or a modest increase in right-of-way in order to accommodate a four-foot bike lane in each direction. South of Franklin Street, 3rd Street would be narrowed to three travel lanes. Both 2nd and 4th Streets would be reconfigured to incorporate enhanced bicycle and pedestrian facilities. Figure 2 shows the cross-section assumed for 2ndand 4th Streets.

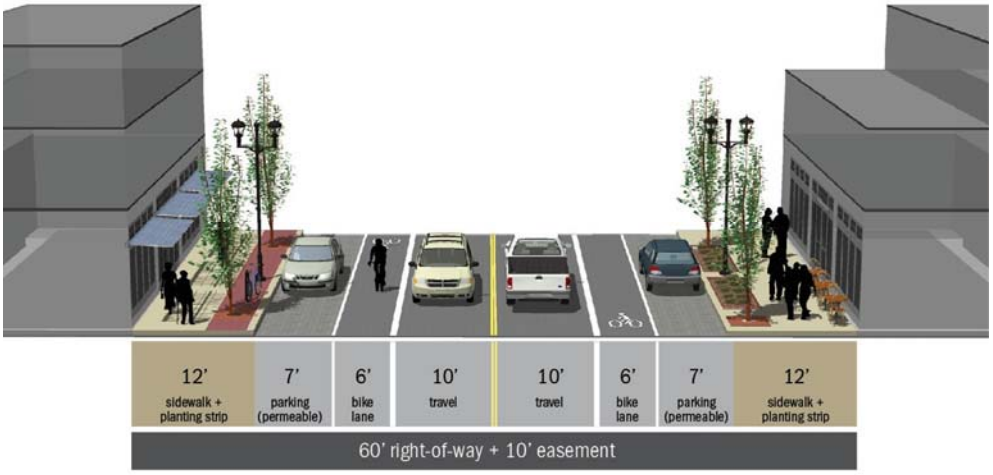

FIGURE 2: ASSUMED CROSS-SECTION FOR 2ND AND 4TH STREETS

Pedestrian Results

Results of the pedestrian MMLOS analysis are shown in Figure 3. 2nd and 4th Streets perform well for pedestrians, providing LOS A on nearly all of each street between Revere Avenue and Burnside Avenue. This is generally due to the wide pedestrian zone in the assumed cross-section and relatively low motor vehicle volumes. 3rd Street performs at LOS C for the five-lane section north of Greenwood Avenue, where traffic volumes and right-of-way demands are the highest. Pedestrian LOS is better south of Greenwood Avenue.

Bicycle Results

Bicycle performance, shown in Figure 4, varies along 2nd and 4th Street, but is mostly LOS C. Traffic volumes and speeds adjacent to the bike lane, as well as the proximity of on-street parking (creating risk of "dooring"), contribute to a bicycling environment with moderate stress levels. 3rd Street, with its narrow bike lanes and higher traffic volumes and speeds, performs poorly, generally between D and F.

West of the MMA area, the new Hawthorne Avenue undercrossing provides a low-stress connection for people riding bikes between Downtown Bend and the Central District. The Hawthorne connection operates at LOS A for pedestrians and cyclists, while other connections range from LOS B to E for cyclists.

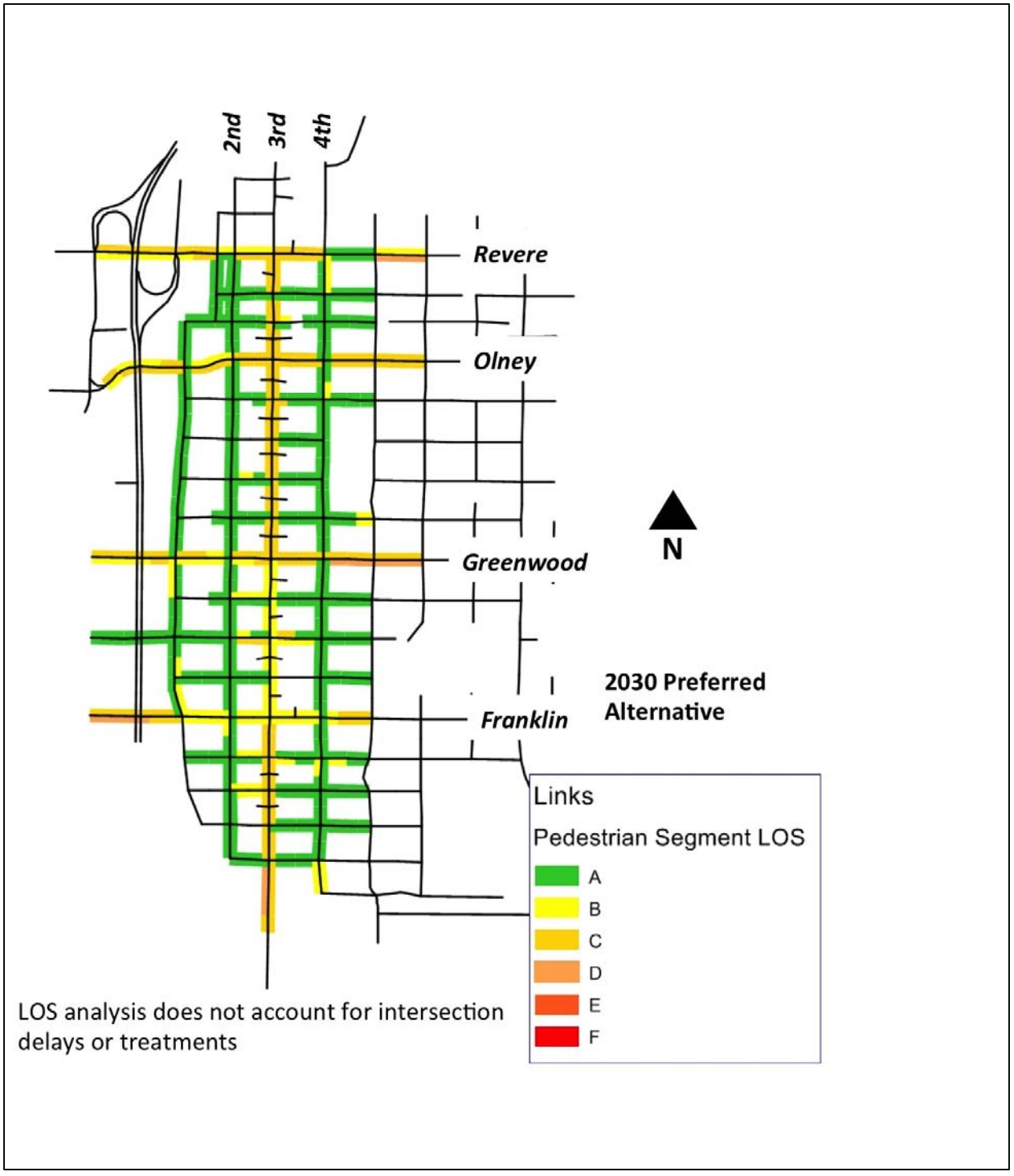

FIGURE 3: PEDESTRIAN MMLOS RESULTS, PREFERRED NETWORK (2030 PM)

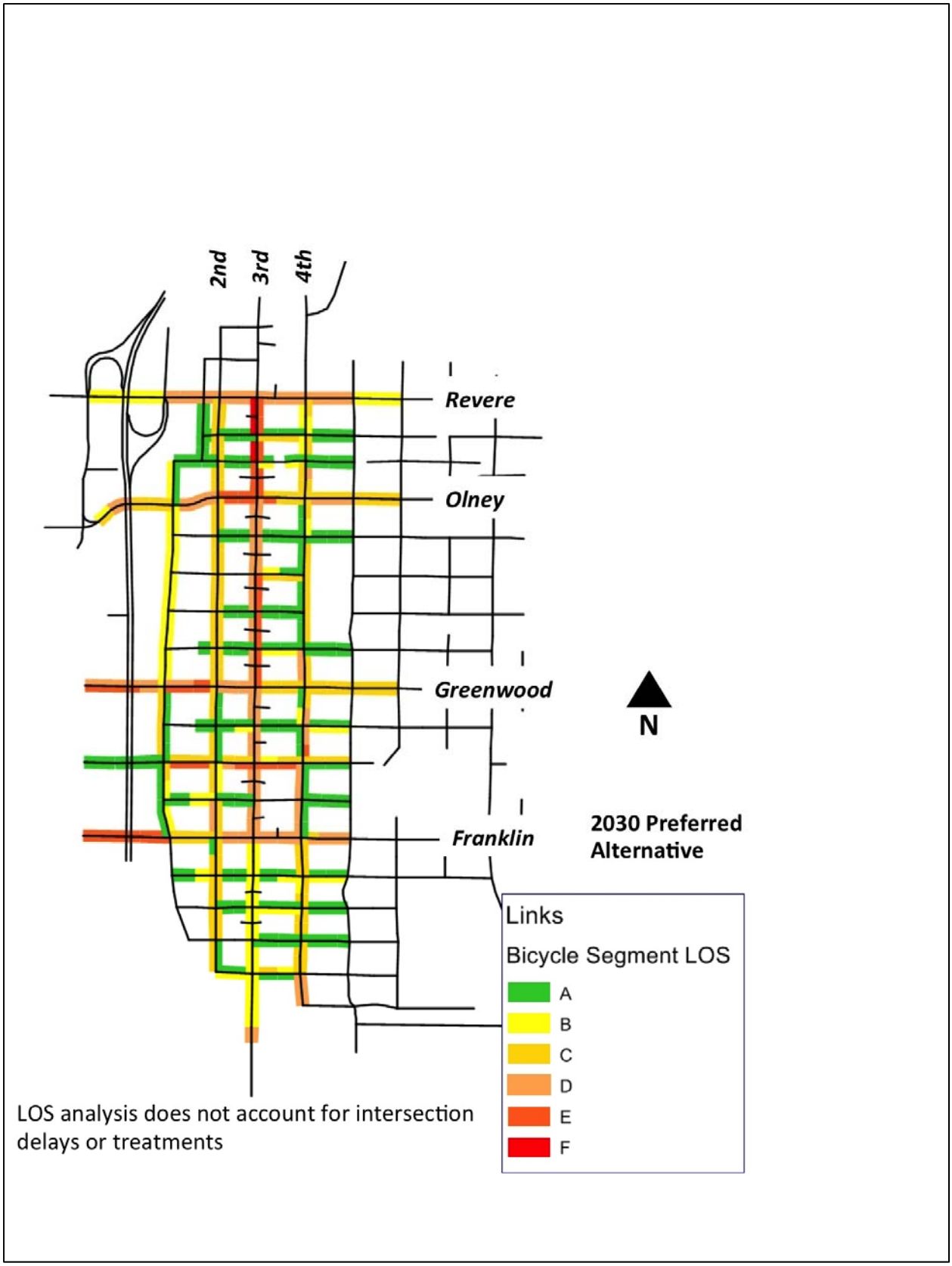

FIGURE 4: BICYCLE MMLOS RESULTS, PREFERRED NETWORK (2030 PM)

Intersection Operations

Intersection operational analysis was performed for the study intersections utilizing Synchro with the post-processed turn volumes. The results, displayed in Table 1, show higher levels of congestion than the model plots shown in prior alternatives screening, including at the US 97 ramp terminals. This is because prior analysis used raw model volumes while the analysis presented here uses seasonally factored, post-processed forecast volumes.

Operations for intersections under baseline Metropolitan Transportation Plan (MTP) conditions are shown for comparison. The MTP results assume the currently adopted future land use with no network improvements in the Central District. The results are taken from the Bend Central Area Plan, and did not utilize a windowed subarea mesoscopic model.

TABLE 1: 2030 P.M. PEAK HOUR INTERSECTION OPERATIONS

Intersection	*Mobility Target*	*V/C Ratio*	*Delay*	*LOS*	*V/C Ratio*	*Delay*
		Preferred MMA Network			**Baseline**	
US 97 Southbound/Revere Avenue	0.85*	0.74	13.4	B	0.83	20.6
US 97 Northbound/Revere Avenue	0.85*	0.74	20.7	C	0.92	27.8
US 97 Southbound/Colorado Avenue	0.85*	0.64	9.0	A	0.74	26.0
US 97 Northbound/Colorado Avenue	0.85*	**1.13**	58.6	F	> 1.0	> 80.0
3rd Street/Revere Avenue	0.90	0.85	42.2	D	1.22	> 80.0
3rd Street/Olney Avenue	0.90	0.80	39.5	D	1.15	> 80.0
3rd Street/Greenwood Avenue	0.90	**1.05**	108.0	F	1.42	> 80.0
3rd Street/Franklin Avenue	1.00	0.92	52.9	D	1.11	81.1
8th Street/Greenwood Avenue	0.85	**1.05**	87.5	F	-	-

Bold and Red indicates intersection does not meet its mobility target
V/C ratio: volume-to-capacity ratio; LOS = level of service; delay measured in seconds per vehicle
*Mobility target may be increased to 0.90 if it is determined that ramp queuing will not extend into the deceleration area

As shown in Table 1**,** intersections in general perform better under the preferred network than under baseline conditions, which assume slightly less intense land use in the Central District, but do not have the enhancements of this project's preferred network. The difference is particularly significant along 3rd Street, where all study intersections failed to meet targets under the baseline, but only one (3rd Street/Greenwood Avenue) fails to meet targets under the preferred network and land use. This improvement in operations demonstrates the traffic benefits o f the network enhancements, particularly on the parallel streets of 2nd and 4th Streets**.** Based on the analysis results, it appears that an alternate mobility target (e.g., utilizing average weekday instead of 30th-highest hour conditions) may be appropriate to evaluate for implementation through a larger-scale transportation evaluation, such as the Bend MPO Metropolitan Transportation Plan update.

Three of the nine study intersections analyzed in Synchro are expected to operate worse than mobility targets in the p.m. peak hour in 2030. The US 97 Northbound/Colorado Avenue Intersection is an unsignalized intersection that is expected to experience high levels of delay for the stop-controlled left-turn movement. The 3rd Street and 8th Street signalized intersections along Greenwood currently do not meet mobility targets, and will continue to not meet mobility targets with growing demand through 2030 if no other changes are made to the transportation network.

Vehicle Queuing

This section evaluates vehicle queuing at Bend Parkway ramp terminals, which are under Oregon Department of Transportation (ODOT) jurisdiction, to determine if there is potential for queuing to extend onto US 97. **Note that a comparison of regional model runs with and without the modified Central District land use shows that the new land use results in slightly less volume at the ramp terminal intersections.** Therefore, while queuing analysis was not performed for the baseline future scenario, it is expected the conditions described below are slightly better than what would be expected under an analysis using baseline (adopted Metropolitan Transportation Plan) forecasts. In other words, queuing issues are primarily the result of overall regional traffic growth, rather than impacts from future land use within the MMA study area or implementation of related transportation improvements there.

TABLE 2: 2030 P.M. PEAK HOUR US 97 RAMP QUEUING

Intersection	*Ramp Length (ft)*	*Queuing (ft)*	
		Average	*95th Percentile*
US 97 Southbound/Revere Avenue	1030	450	**1,050**
US 97 Northbound/Revere Avenue	850	775	**1,350**
US 97 Southbound/Colorado Avenue	800	225	425
US 97 Northbound/Colorado Avenue	845	675	**1,350**

Bold and Red indicates 95th percentile queuing exceeds ramp length

As shown in Table 2, 95th percentile queues for three of the four ramps are expected to exceed available storage on the ramps in the p.m. peak hour by 2030, resulting in queue spillback onto the highway. While the US 97 Southbound ramp queuing at Revere Avenue exceeds the ramp storage by a slight margin, major queuing issues exist for the US 97 Northbound ramps at Revere Avenue and Colorado Avenue.

Queuing issues are projected at the US 97 Northbound/Revere Avenue ramp due to limited storage for the northbound right movement (which is often blocked by the northbound left/through movement), and due to the need for significant green time for the approaches on Revere Avenue (in order to serve the conflicting unprotected eastbound left and westbound through movements). A potential solution could be a road diet on Revere Avenue, changing the cross section to one through lane in each direction and center turn lane. This would allow for protected left turn phasing at the ramp terminal signals. This concept would need to be studied in more detail by the City and ODOT.

Queuing issues exist at the US 97 Northbound/Colorado Avenue ramp because the southbound left vehicles cannot find gaps in traffic at this unsignalized intersection. Options here include enhanced intersection control such as a roundabout or a signal, either of which could better accommodate southbound left turning movements. A new control for this intersection would need to be studied in more detail by the City and ODOT.

To the extent that implementation of the MMA Plan is projected to have any future significant safety or mobility impacts on the state highway system, the City and ODOT will monitor those potential impacts and agree on strategies to address them. The City and ODOT would also be expected to monitor potential impacts associated with regional traffic growth which would occur regardless of what happens within the MMA. Strategies for monitoring and addressing impacts could include the following, among others:

- Establish and implement a schedule for conducting traffic counts on facilities that are projected to exceed capacity during the planning horizon; if counts exceed a certain threshold, identify a process for mitigating impacts on mobility or safety.
- Identify a process for addressing safety issues as evidenced by accident rates that exceed local or state thresholds.
- Address any needed facility mitigation or improvement solutions in the next update of the City of Bend's Transportation System Plan (TSP).

Sensitivity Analyses

Analysis of the preferred network relied on specific assumptions about elements such as street cross-sections, intersection configurations, and signed speed limits. City staff also expressed interest in an assessment of how certain changes to these assumptions might affect MMLOS, traffic operations, and/or traffic patterns. This section presents analysis for two scenarios:

- **Reduced speeds on 2nd and 4th Streets.** Understanding that reduced motor vehicle speeds could improve bicycle LOS on these two streets, the network was analyzed with speed on these streets reduced from 25 mph to 20 mph.
- **Franklin Avenue Road Diet.** Franklin Avenue currently features a five-lane cross-section that starts at 1st Street and ends between 4th and 5th Streets, narrowing to a two-lane cross-section on either end. The City requested an assessment of the impact of reducing Franklin to a three-lane cross-section through this area.

Reduced speeds on 2nd and 4th Streets

The City could potentially use traffic calming strategies to reduce speeds on 2nd and 4th Streets, which could positively impact bicycle LOS, and potentially pedestrian LOS, in two ways:

- All other things being equal, reduced vehicle speeds on 2nd and 4th would directly lead to a more favorable bicycle LOS calculation
- Reduced vehicle speeds may also divert some traffic away from 2nd and 4th Streets, with the reduced motor vehicle volumes improving the bicycle LOS calculation

Pedestrian and bicycle LOS results for this traffic calming option are shown in Figure 5 and Figure 6. Pedestrian performance is similar to that of the preferred network. Bicycle performance is significantly

better on 2nd and 4th Streets than under the preferred network, improving to LOS B with some segments of LOS A. 3rd Street performs poorly for people biking, similar to the preferred network.

The motor vehicle speed changes on 2nd and 4th Streets alter traffic patterns on the network. The largest impacts are at the southern end of the study area, between Franklin Avenue and Burnside Avenue, where a significant amount of traffic that was using 2nd Street under the preferred network shifts over to 3rd Street. Through the middle of the study area, around 100 vehicles during the peak hour would likely shift from 2nd and 4th Streets northbound to 3rd Street northbound, while the southbound shifts are much smaller.

These traffic volume shifts would likely have an impact on intersection operations, particularly at 3rd Street/Greenwood Avenue. More detailed analysis, similar to what has been performed for the preferred network, would be needed to better assess the impacts.

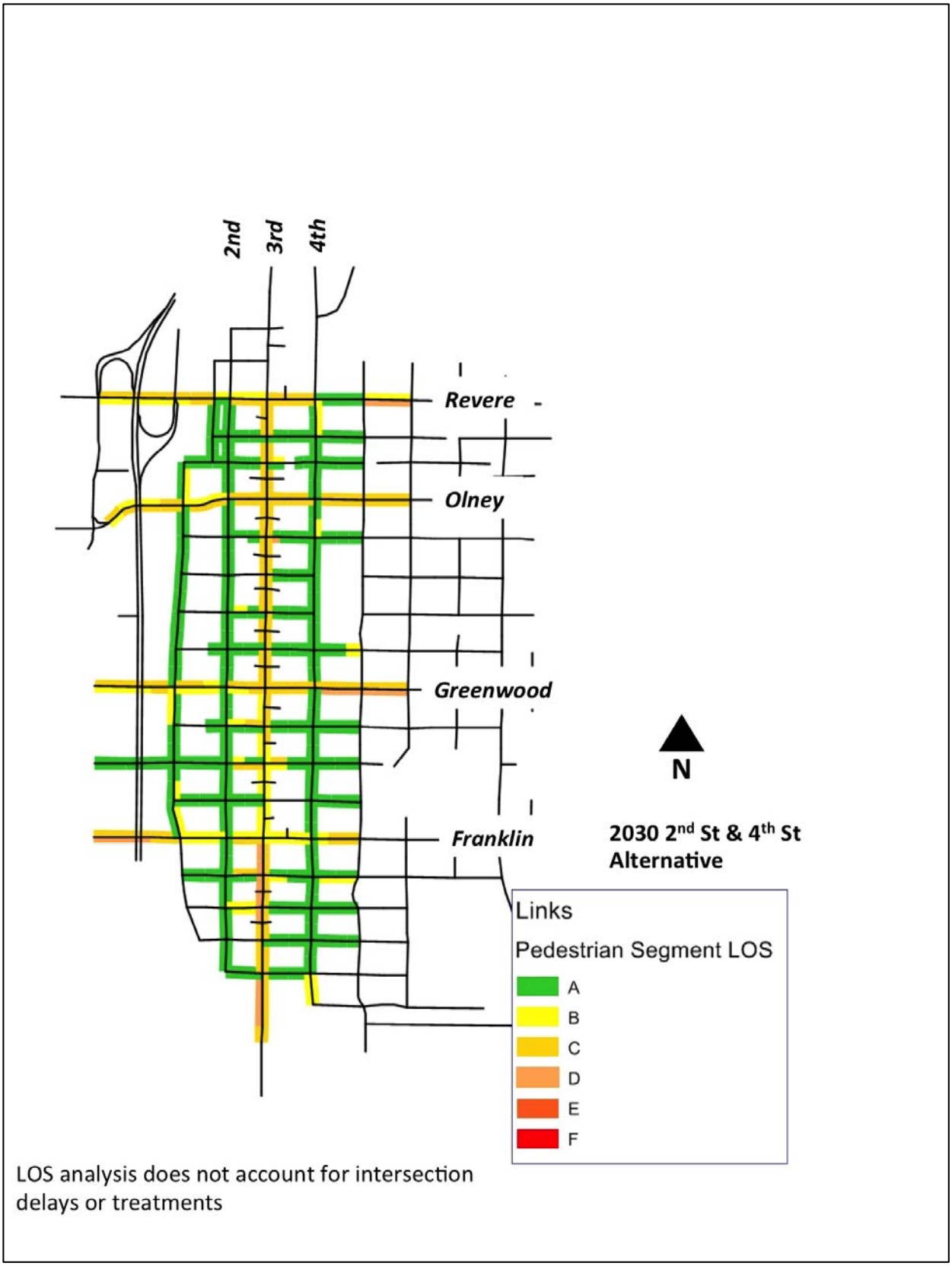

FIGURE 5: PEDESTRIAN MMLOS RESULTS, 2ND STREET/4TH STREET TRAFFIC CALMING OPTION (2030 PM)

FIGURE 6: BICYCLE MMLOS RESULTS, 2ND STREET/4TH STREET TRAFFIC CALMING OPTION (2030 PM)

Franklin Avenue Road Diet

The City has expressed an interest in understanding the potential changes to traffic operations if the cross-section of Franklin Avenue between 1st Street and 5th Street were narrowed to three lanes (one though lane in each direction with a center turn lane). Figure 7 and Figure 8 show how the intersection operations, as evaluated within the focus area model, compare between the Franklin road diet option and the preferred network, respectively. Note that this analysis assumes that 3rd Street has a five lane cross-section at the north leg of the 3rd Street/Franklin Avenue intersection. Traffic operations may be degraded if 3rd Street is narrowed north of Franklin. Operational analysis shown in these figures is based on raw volumes in the 2030 focus area model, and differs from the analysis based on post-processed volumes shown in Table 1.

Among the intersections assumed to be signalized, only 2nd Street/Franklin Avenue and 3rd Street Franklin Avenue appear to perform significantly worse under the road diet option, operating at LOS D rather than LOS C. Signalized intersections on Greenwood Avenue and other larger facilities are not significantly affected.

An analysis of traffic pattern changes between the road diet option and the preferred network shows minimal traffic diversion. Significant changes in vehicle routing are localized to Franklin Avenue itself and parallel streets 1-2 blocks in each direction. Impacts to other arterial corridors, such as Greenwood Avenue, are limited to around 20-30 vehicles in each direction in the PM peak hour, and do not appear to significantly affect intersection operations.

Note that full post-processing and operational analysis would be needed to confirm these impacts.

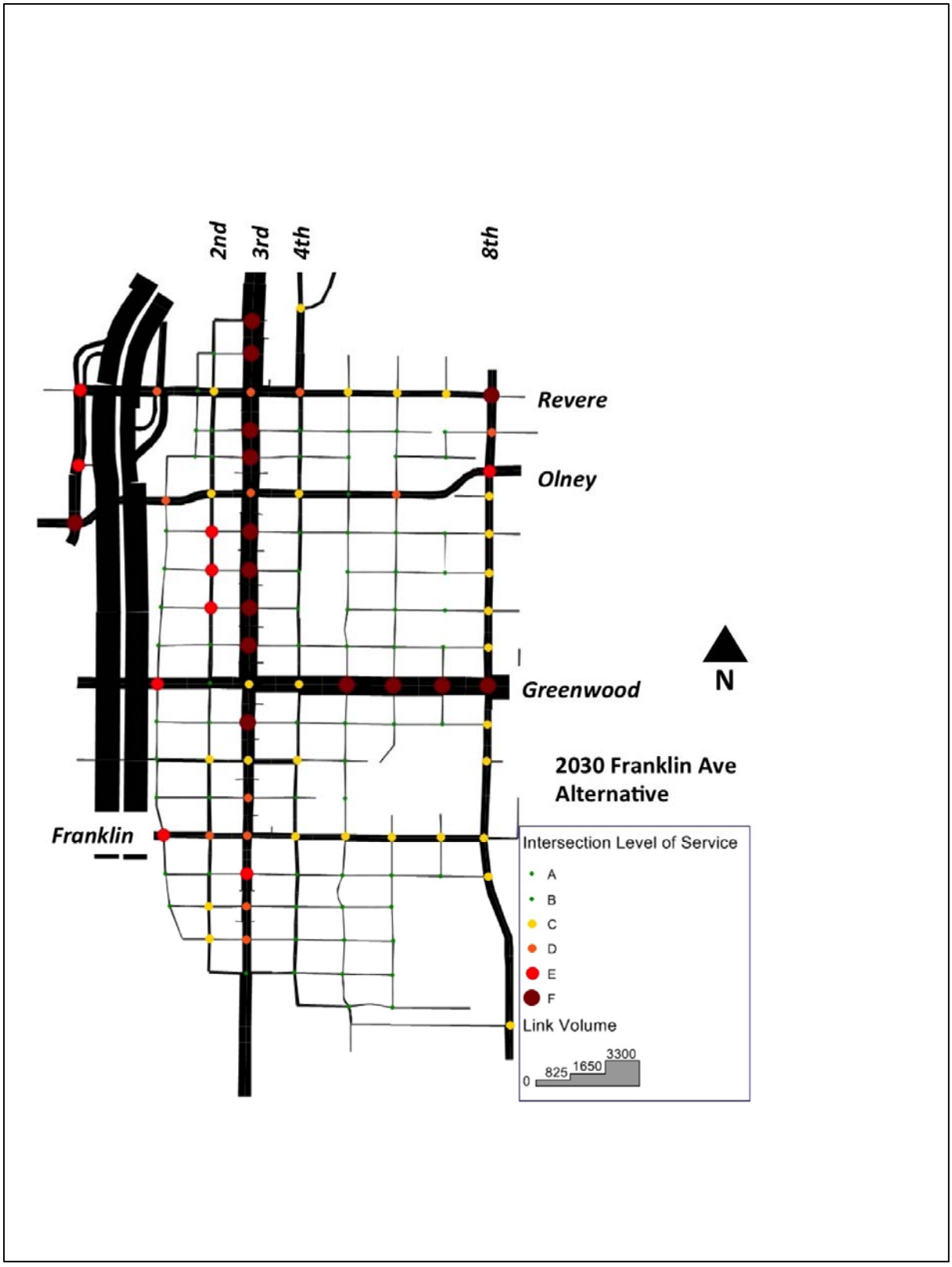

FIGURE 7: MOTOR VEHICLE LOS RESULTS, FRANKLIN AVENUE ROAD DIET (2030 PM MODEL VOLUMES)

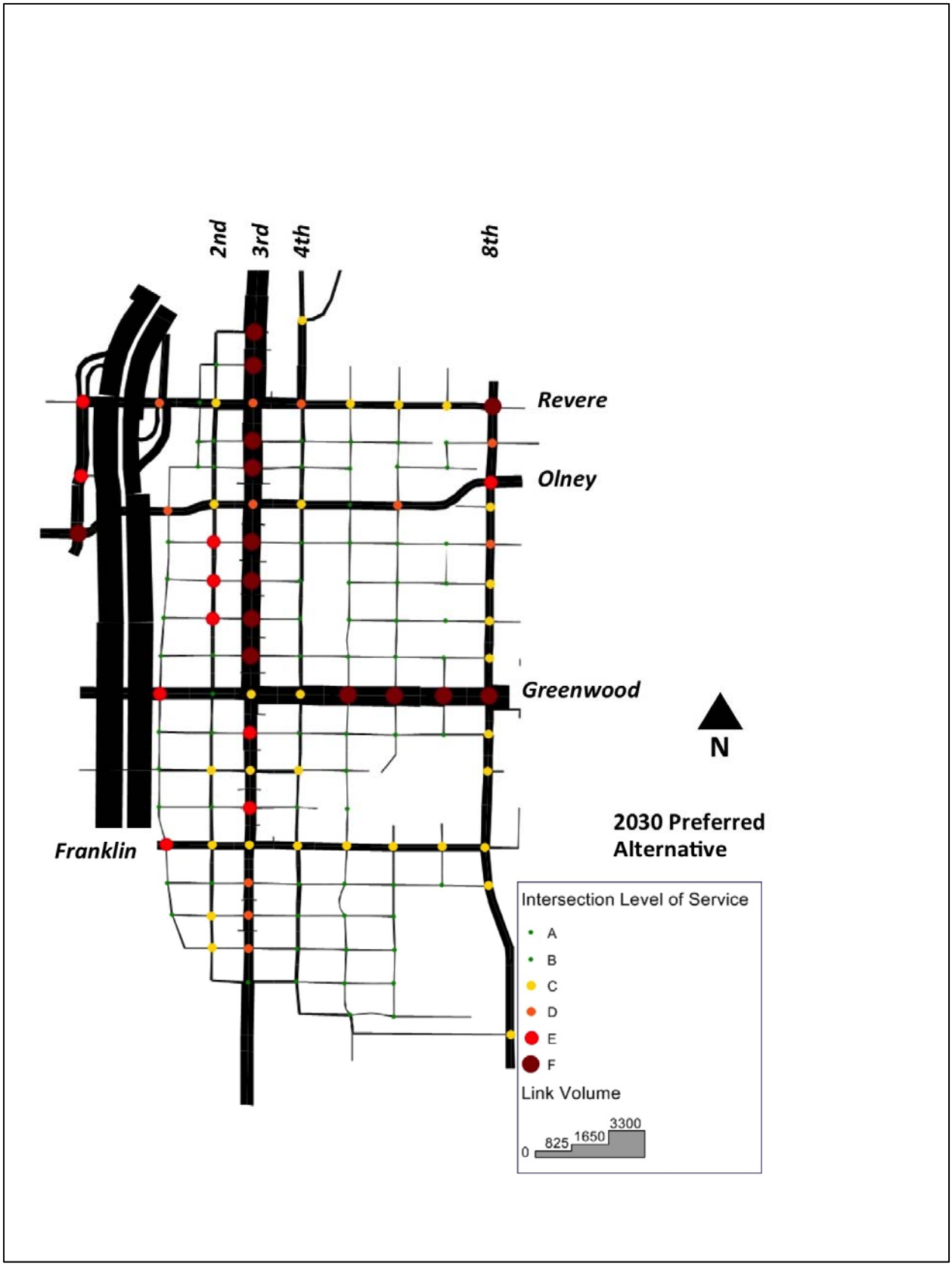

FIGURE 8: PREFERRED NETWORK, MOTOR VEHICLE LOS RESULTS (2030 PM MODEL VOLUMES – NOT POST-PROCESSED)