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MEMORANDUM

January 5, 2021

To: Eric B. Eby, P.E., Parking and Transportation Engineer
Organization: Department of Public Works, City of Portsmouth
From: Jeremy Chrzan, P.E., PTOE, LEED AP, Multimodal Design Practice Lead

Re: Middle Street Bike Lane Peer Review

Toole Design has completed a review of the Middle Street Bike Lane design plans and implementation to assess concerns of safety and compliance with applicable design guidelines and best practices. The review included a review of the construction plans, as well as an on-site assessment to observe street operations and measure intersection sight distances and the constructed lane widths. Toole Design also reviewed the requested modifications from City Council, to place the on-street parking against the curb and locate the bike lane between the travel lane and parking lane. This memorandum summarizes our review of the existing design and implementation, the City Council requested modifications, and our suggested revisions for the Middle Street corridor.

Middle Street Bike Lane Review

Existing Conditions Review

Toole Design visited the project corridor (Middle Street from Cabot Street to Lincoln Avenue) on Monday, November 10, 2020 beginning around 7:20 AM. General observations were made, the installed pavement markings and signs were compared against the proposed plans, and sight distances were measured at each intersection.

General Observations

The review team was on-site for several hours and made observations that helped to inform our review and recommendations.

- As the site assessment was conducted in the Fall, leaves often covered at least 1’ to 3’ of the right side of the bike lanes, making the bike lanes appear narrower. People biking were often observed riding closer to the left side of the bike lanes where leaves occupied the right side; however, even in areas without leaves people biking tended to stay closer to the left edge of the bike lanes.
- A lack of vertical elements (flexible delineator, curb, etc.) in painted buffers means that parked vehicles can physically encroach into the buffer between the on-street parking and bike lane; however, when motorists parked within the designated parking spaces, the opened vehicle doors were not observed protruding into the bike lanes. See Figure 1.
- The crown of the roadway follows the baseline of the design plans and therefore deviates from the current painted center line in some portions of the roadway. This is particularly noticeable through the curve

between Aldrich Rd and Park St/Cass St. In this section, vehicles often drove on/over the NB bike lane buffer or the double yellow centerline travelling southbound.

- Although the pavement was often in reasonable condition, it exhibited some cracking, a variety of areas of disturbance from utility patches/installations, and an exposed pavement seam between Union Street and Cabot Street within the bike lane. See Figure 1.
- In addition to the above noted pavement seam within the bike lane between Cabot Street and Union Street, a catch basin also exists in this vicinity with some crumbling pavement surrounding it and a noticeable drop in elevation from the pavement surface to the catch basin grate. See Figure 1.

Figure 1: Photo of pavement seam and catch basin at start of southbound bike lane, and parked car with open door visible

- The pavement marking lane lines appeared to be traffic paint rather than thermoplastic pavement markings. The existing markings were faded throughout the corridor.
- Flexible delineators were installed in some locations but were inconsistent and did not match the design plans.
- Some southbound bicyclists were observed traveling in the travel lane and waiting to enter the bike lane until Union Street.
- Bicyclists who entered at the bike lane taper south of Cabot Street often slowed down if they saw that a person was active at the on-street parking spaces. Additionally, the bicyclists would often not directly follow the painted taper but would instead ride over the painted buffer nearest the curb to move further away from the parked vehicles.

Sight Distance Measurements

Two different sight distances were measured for each intersection within the project corridor. These intersection sight distances were checked in conformance with the AASHTO “A Policy on Geometric Designs of Streets and Highways” and the Portsmouth Department of Public Works “Driveway Rules and Procedures.” Stopping sight distances (SSD) on Middle Street were measured to confirm if a motorist could see and stop if a person or vehicle was about to enter the intersection. Intersection sight distances (ISD) were measured from the point of view of a motorist on a side street looking left and right along Middle Street to see if a vehicle is approaching. These measured sight distances, and the Minimum SSD and Desirable ISD based on the 30mph posted and observed speeds, are summarized in Table 1. The Minimum SSD and Desirable ISD values may be reduced when the posted speed limit is reduced to 25mph, as approved by the City, and if observed speeds are reduced.

The measurements for ISD were taken from the stop bar and 15’ back from the edge of the curbline where necessary. Although this is standard practice for measuring sight distances, in practice drivers do not assess sight distances from a single location but instead they pull up to the stop bar, assess if pedestrians are present, then advance forward to check for the presence of bicycle traffic, and then advance forward to check for approaching motorist traffic. This method allows a motorist to position themselves in the locations where they can best see approaching street users. This is particularly important for locations where on-street parking may be present so that a driver can identify the location where they can best see approaching traffic based on the specific vehicles that may or may not be parked in the on-street parking spaces, and their ability to see through a parked vehicle’s window, across their hood, or between gaps in the vehicles. Where the ISD is less than desirable, these locations

were often limited by roadway geometry, adjacent vegetation, adjacent buildings, or on-street parking. Although the provision of ISD is desirable at intersections to allow a motorist exiting the side streets to do so without Middle Street traffic slowing, the minimum requirement for any intersection is to at least provide the minimum SSD.

The measurements for SSD were taken from the face of curb at the side streets to the center of the travel lane on Middle Street. All intersections met the minimum SSD. Pedestrians were observed using the painted buffer between the bike lane and traffic lane as a de facto pedestrian refuge. This allows a pedestrian to position themselves to be more visible to an approaching motorist and effectively increases the available sight distance. Similarly, the available sight distance is improved when drivers advance forward to stop at the edge of the travel lane instead of at the curbline as discussed in the ISD summary.

Based on measured distances and observations about how the intersections operate, it appears that sight distances are generally good, but some locations would benefit from trimming adjacent roadside vegetation and some minor adjustments to on-street parking would be desirable to increase intersection visibility. These recommendations are outlined at the end of this memorandum.

Table 1: Stopping and Intersection Sight Distances

Location/Sight Distance	Minimum SSD	Measured SSD	Desirable ISD	Measured ISD
Middle Street at Lincoln Avenue:				
From the North	200’	305’	335’	182’ **
From the South	200’	500’+	290’	500’+
Middle Street at Aldrich Road*:				
From the North	200’	500’+	290’	500’+
From the South	200’	500’+	335’	133’ / 112’ **
Middle Street at Park Street*:				
From the North	200’	500’+	335’	500’+
From the South	200’	254’	290’	188’ / 143’ **
Middle Street at Cass Street:				
From the North	200’	207’	290’	187’ **
From the South	200’	380’	335’	390’
Middle Street at Wilbird Street:				
From the North	200’	500’+	335’	198’ **
From the South	200’	500’+	290’	480’
Middle Street at Madison Street:				
From the North	200’	451’	290’	131’ **
From the South	200’	215’	335’	68’ **
Middle Street at Union Street Eastbound:				
From the North	200’	495’	290’	95’ **
From the South	200’	500’+	335’	97’ **
Middle Street at Union Street Westbound:				
From the North	200’	500’+	335’	170’ **
From the South	200’	500’+	290’	128’ **
Middle Street at Highland Street:				
From the North	200’	500’+	335’	500’+
From the South	200’	500’+	290’	500’+
Middle Street at Cabot Street:				
From the North	200’	307’	290’	125’ **
From the South	200’	250’	335’	97’ **

* Due to the setback of the minor street STOP bar, two ISD measurements were collected; one from 15’ from the major street edge of roadway and one from the location of the STOP bar.

** Although Measured ISD is less than Desirable, in all cases the Minimum SSD is provided at each intersection. Additionally, the available ISD is significantly higher than indicated as drivers advance forward from the curbline into the bike lane to check for on-coming motorist traffic.

In addition to reviewing intersection and stopping sight distances, the team reviewed the sight distance conditions at the start of the southbound bike lane from the perspective of a person exiting an on-street parking space. This location was reviewed because it was the location of the only bicycle crash on the corridor. In this location, bicyclists are transitioning from a shared lane to a separated bike lane immediately behind the parked cars, so this could complicate a passenger's ability to see an approaching bicyclist. Our team's review found that when a passenger leans forward, they can better see the entirety of the bike lane and portions of the adjacent travel lane; however, additional recommendations to increase the sightlines at this location are included at the end of this memorandum.

Figure 2: Passenger's view from on-street parking if leaning forward in seat, with the approaching travel lane and entirety of bike lane visible

Lane Width Measurements

The lane widths proposed on the plans do not always match those installed in the field. Some select locations have motorist travel lane widths less than 10 ft wide; 9 ft 7 in. was the narrowest lane we measured. Although this is not a concern on straight segments of roadway, narrower lanes through curved sections of roadway can be somewhat more difficult for a motorist to navigate and may be the reason why some motorists were observed encroaching over the double yellow line or into the painted buffer along the bike lane.

Safety Data Review

Crash Data

Toole Design reviewed the crash data provided by the City. Based on the three years of data available, it appears that 26 crashes occurred the year prior to the implementation of the bike lane, 26 crashes occurred the first year that the bike lane was installed, and 12 crashes occurred the second year after the bike lane was installed. As such, there has been an overall decrease in crashes since the bike lanes were installed. A review of the crashes themselves showed that motorists struck parked vehicles 5 times in the first year of the bike lane installation and only 1 time in the second year. This reduction in number of overall crashes and reduction in drivers crashing into parked vehicles may imply a growing familiarity with the current conditions. A crash between a bicyclist and a passenger opening their door occurred in the second year of installation and is the only reported bicyclist crash in the two years since installation. Suggestions to address this crash type are included at the end of this memorandum. Other than the crashes with parked vehicles and the bicyclist-dooring incident, it appears that all other crashes were related to driver error and not directly attributable to the presence of the bike lane, on-street parking, available sight distances, etc.

Speed Data

Speed studies were provided by the City from 2014 through 2020. Although there were only a few locations where speed data was taken consistently from the same location, it appears that motorist travel speeds have not changed since the bike lane was installed with 50th, 85th, and 95th percentile speeds typically changing no more than +/- 1mph from year to year. The 95th percentile speeds (i.e. the fastest drivers) varied from 31 to 36mph and the average speeds varied from 26 to 31mph.

Review of City Council Request

Toole Design was asked to review the request from City Council to modify the bike lanes by reconfiguring the roadway to place the on-street parking against the curb and the bike lanes between the curbside parking and the vehicular travel lanes.

As stated on the City's Planning Department website, the goal of this project was "to make travel along a critical section of Route 1 safer and more appealing for pedestrians and bicyclists of all ages." This provision to accommodate people of all ages and abilities is a recognition that many people are interested in bicycling for transportation, but that most people are not comfortable bicycling with motor vehicles.

In 2019, the Federal Highway Administration (FHWA) released the Bikeway Selection Guide discussing this issue of accommodating people of all ages and abilities. Using a methodology that considers a person's level of comfort when bicycling on streets, they developed the bikeway selection table shown in Figure 3.

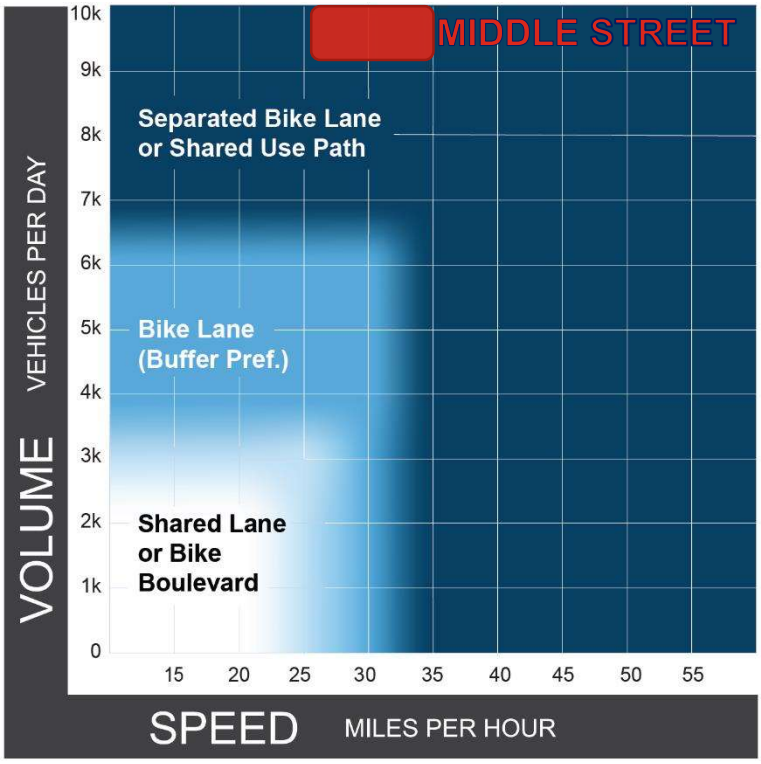

Figure 3: FHWA Preferred Bikeway Type - Middle Street identified

Figure 3 illustrates that as motor vehicle speeds and volumes increase, the need for additional separation from motorists similarly increases.

In reviewing the conditions of Middle Street through the project area, the traffic volumes are around 10,000 vehicles per day pointing to a need for separation between bicyclists and motorists to accommodate people of all ages and abilities. Similarly, with motorist speeds of the fastest drivers exceeding 30mph the provision of increased separation between people driving and biking is desirable.

In addition to the desire to make the street safer for people walking and biking, the crash data implies that at least in the most recent year for which crash data was available the current configuration has also increased motorist safety.

Finally, the location of the bike lane between the curbline and on-street parking generally results in better sight lines for drivers exiting driveways and side streets to see people bicycling first before advancing forward to look for motorists. If the bike lane were moved to the other side of on-street parking, it would effectively reduce the ISD because drivers exiting driveway and side streets would need to be able to view a bicyclist traveling adjacent to the on-street parking instead of only the motorist in the center of their lane like they do today. If the Council-requested conventional bike lane were implemented, we would recommend reducing the number of on-street parking spaces compared to the current conditions, and removal of the parking entirely in some areas, to provide adequate intersection and driveway sight distances to the bike lane.

Recommendations for Middle Street

After review of the site conditions, provided engineering plans, and available data, Toole Design recommends that the current separated bike lane configuration should generally remain, but that some modifications be implemented to improve the safety and comfort for all street users.

1. **Roadway resurfacing and restriping:** The pavement condition exhibits areas of cracking, unevenness, pavement scarring from utility work, lane striping, and crack sealing, as well as catch basin grates at different elevations from the surrounding pavement. Resurfacing the roadway will provide a smooth and stable surface allowing bicyclists to use the entirety of the provided bike lane and provide clarity of the lanes for motorists. When resurfacing the roadway, the roadway crown should align with the striped roadway centerline and the catch basin grates adjusted to match the pavement surface. It is recommended that all pavement markings should be retroreflective thermoplastic to guide motorists through the street alignment. Where horizontal curves exist, consider the use of reflective raised pavement markings to better guide motorists through the street alignment.
2. **Lane width considerations:** When restriping the roadway, ensure that all 10-foot wide lanes are installed to meet this minimum width. However, where horizontal curves exist along the corridor, consider balancing the lane widths to provide equal lane widths in each direction, i.e. 10.5’ wide for both lanes instead of 11’ in one direction and 10’ in the other direction. This may help to address the over-tracking seen in the field where motorists traversed over the bike lane buffer.
3. **Bike lane alteration near Cabot Street:** The transition for a southbound bicyclist from the shared lane to the separated bike lane near Cabot Street should be adjusted to avoid the transition occurring immediately behind the on-street parking. As depicted in Figure 4, the preferred option would be to remove the on-street parking space immediately south of Cabot Street and begin the bike lane at Cabot Street. Removal of this parking space would maximize the amount of time that a bicyclist is visible to people entering/exiting the on-street parking further to the south. This parking removal would also increase the ISD and SSD at this intersection and help to make pedestrians more visible at the crosswalk. Alternatively, the taper could occur immediately south of this on-street parking space (approximately

Station 49+50), but this would not increase any intersection sight distances at Cabot Street. Although the shared lane markings could be removed from southbound Middle Street in this section, we recommend retaining these markings so that bicyclists already traveling southbound who wish to turn left on Highland Street can more easily make this connection. Bicyclists connecting from Cabot Street to Highland Street

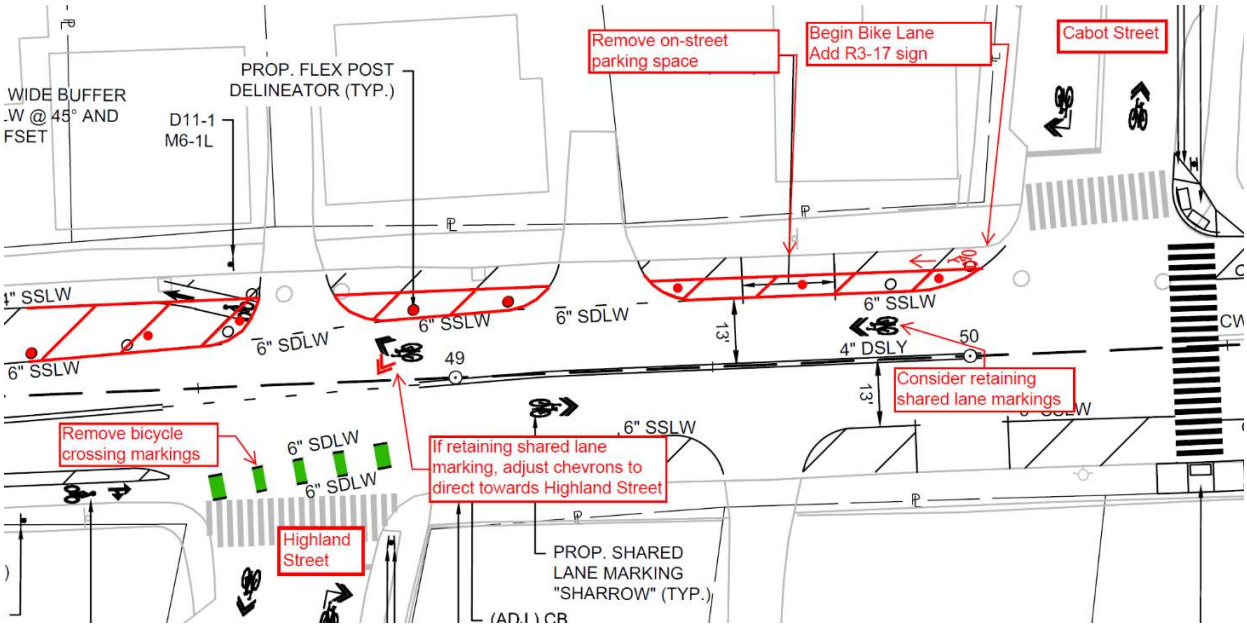

Figure 4: Preferred bike lane alteration near Cabot Street

can use the shared lane; however, it is more likely that bicyclists will use the separated bike lane and then use the driveway across from Highland Street to make this connection.

4. **Increase sight distances:** In addition to trimming vegetation at intersections, it is recommended that one (1) on-street parking space be removed south of Cabot and south of Madison Street. At both locations the parking limits sight distances for motorists and can also block sightlines between motorists and crossing pedestrians. Given that the parking space near Madison Street is also designated as a handicapped space, it is recommended that this sign be relocated to the first space on Madison Street. The removal of this parking space will also allow for an adjustment to the horizontal roadway alignment, as depicted in Figure 5, to replace the existing reverse curve with a single horizontal curve, essentially straightening the street for drivers.

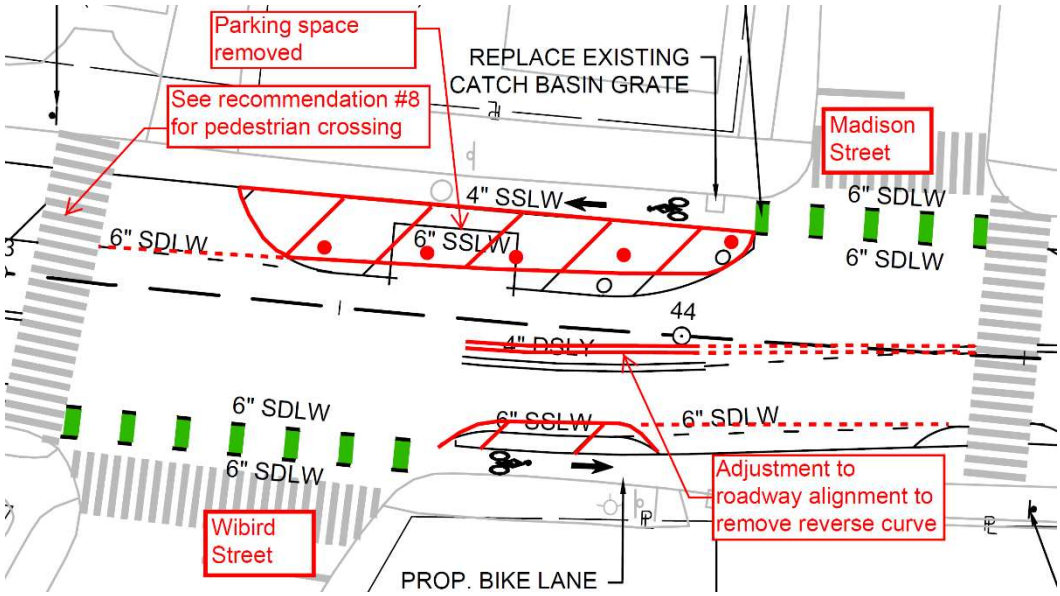

Figure 5: Parking space removal near Madison Street and Middle Street realignment

5. **Delineators to address on-street parking:** The crash data indicates that drivers had struck parked vehicles, particularly at locations where parking is located along the outside of a curve, such as the parking across from Lincoln Ave. Where these conditions exist, consider adding delineators preceding the on-street parking. Although the delineators could be installed along the edge line parallel to the roadway, it may be beneficial to install delineators along a taper (see Figure 6) so that they are more visible to drivers and can guide towards the travel lane. Delineator posts may also be considered within the buffer between the bike lane and on-street parking to help motorists to avoid parking in the buffer. If provided, these delineators should be located near the front wheel of the vehicle to avoid conflicts with opening doors and to maintain access aisles in front of and behind each vehicle.

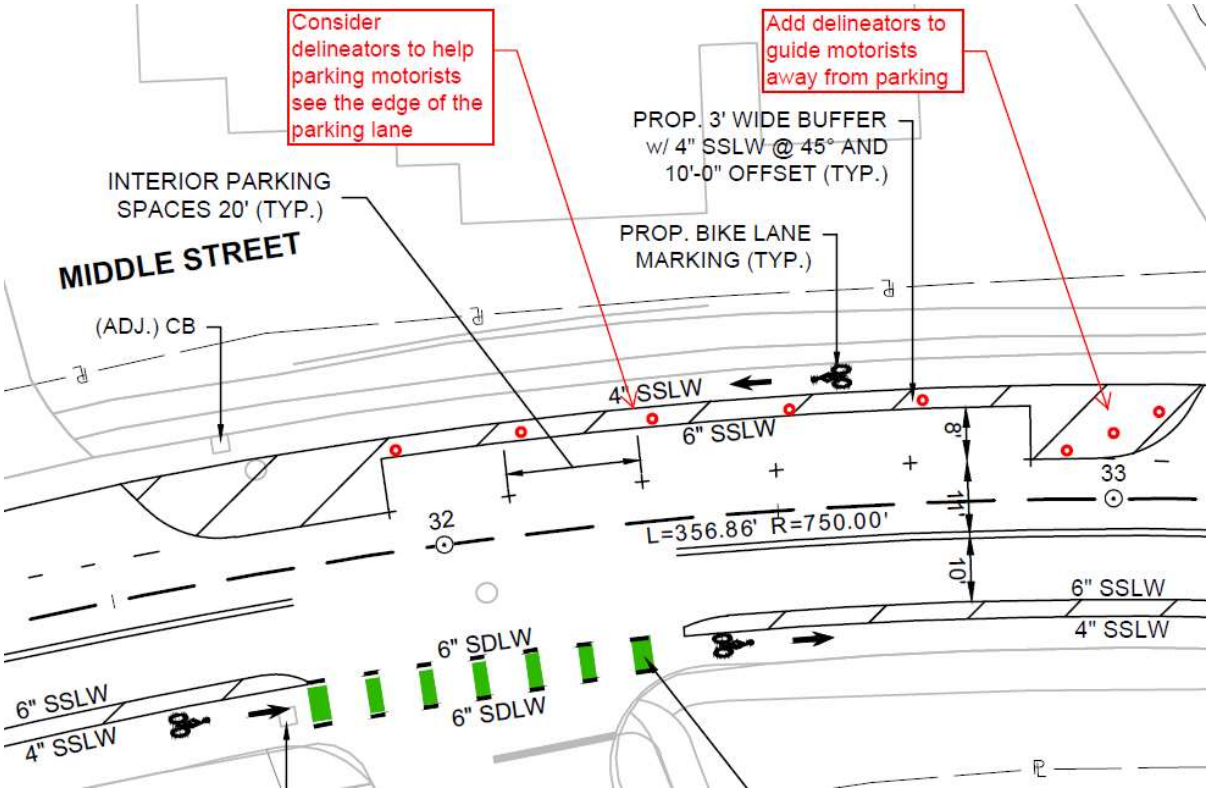

Figure 6: Delineator post recommendations approaching and along on-street parking

6. **Delineators:** The flexible delineator posts observed in the field did not match the locations shown on the original project plans nor the redlined plans dated March 2019. We recognize that the City's goal is to balance the safety goals of the project, the overall corridor aesthetics, and the number of posts installed in the field (which must then be maintained and are ultimately removed each winter). As noted in Figure 3, the entirety of this corridor would benefit from separated bike lanes, but if that is not possible we recommend prioritizing the locations of delineators at intersections to control the speeds of turning vehicles, at areas of parking as noted above, and along selections of buffered bike lane where the curvature of the roadway may cause motorists to encroach into the bike lane buffer. For aesthetics, other vertical elements could be considered to replace some of the traditional flexible delineators. The K71, or the more decorative K72, flexible delineators shown in Figure 7 could be considered. They are physically wider than traditional flexible delineators, which increases their visibility, but perform similarly if struck by a vehicle. Alternatively, decorative planters could be installed in the buffer and where space permits moved to the edge of sidewalk (top of curb) during the winter months.

Figure 7: K71 flexible delineators (left) and K72 flexible delineator (right)

7. **Green conflict markings:** The use of green pavement markings within intersections are intended to be used as a supplement to bicycle lane extension lines. The northbound bike lane ends at Highland Street and does not extend through this intersection; as such, the green conflict markings should not be provided across this intersection. The design may be revised to dash the bicycle lane buffer immediately south of Highland Street to signify to bicyclists that they may begin to merge into the shared lane.
8. **Pedestrian crossing improvement:** The original construction plans identified a Rectangular Rapid Flashing Beacon (RRFB) to be installed for the pedestrian crossing of Middle Street south of Wibird Street. This RRFB was not present at the time of our site visit and should be provided in accordance with the approved plans. However, the on-street parking south of the pedestrian crossing blocks a northbound motorist's view of the pedestrians until they are at the edge of the travel lane, and similarly blocks a pedestrian's view of approaching motorists until they've reached the edge of the travel lane. A pedestrian crossing refuge median should be considered to allow a pedestrian to get closer to the edge of the travel lane to be visible to approaching motorists. If this median is installed, the RRFB sign assembly should be installed on the median as depicted in Figure 8.

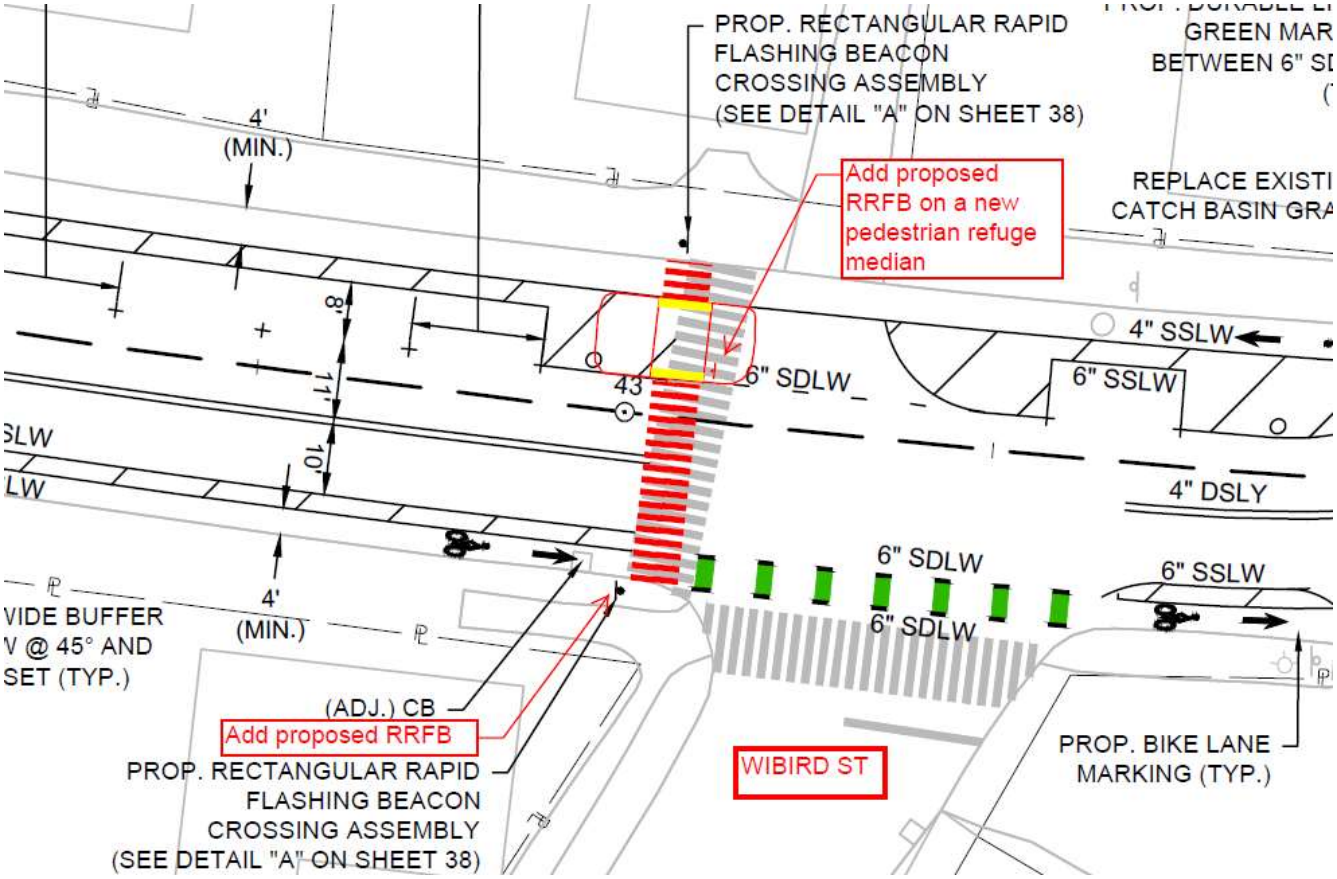

Figure 8: Pedestrian crossing recommendation for Middle Street at Wibird Street