



## FINAL MEMORANDUM

**TO:** Jamie Parks  
Section Leader, Livable Streets

**THROUGH:** Matt Lasky  
Innovation and Policy Team Leader, Livable Streets

**FROM:** Ellen Robinson  
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**DATE:** August 22, 2016

**SUBJECT:** Fell and Oak Streets Panhandle-Adjacent Bikeway Feasibility Analysis

A preliminary study was performed of the feasibility and potential cost of implementing curbside protected bike lanes within the right-of-way of Fell Street and Oak Street adjacent to the Panhandle of Golden Gate Park. This memorandum summarizes possible design options, constraints, and estimated costs of this project at a preliminary planning level. Protected bicycle facilities parallel to the Panhandle have potential to provide additional capacity for travel by bicycle between San Francisco's eastern and western neighborhoods, but would come with trade-offs in terms of on-street parking supply and/or vehicle travel delay on Oak Street. The analysis was completed to address multiple requests from members of the public that the SFMTA add protected bike lanes to both Fell Street and Oak Street.

The memorandum does not make a recommendation as to whether the SFMTA should pursue protected bike lanes on Fell Street and Oak Street, which must be balanced against other citywide priorities and include community input. This cost and feasibility analysis included here will inform future SFMTA project prioritizations for updates to the 5-year Capital Improvement Program.

### SUMMARY

Fell and Oak streets can accommodate protected bikeways. The bullets below summarize the memo, including aspects related to designs, costs and tradeoffs.

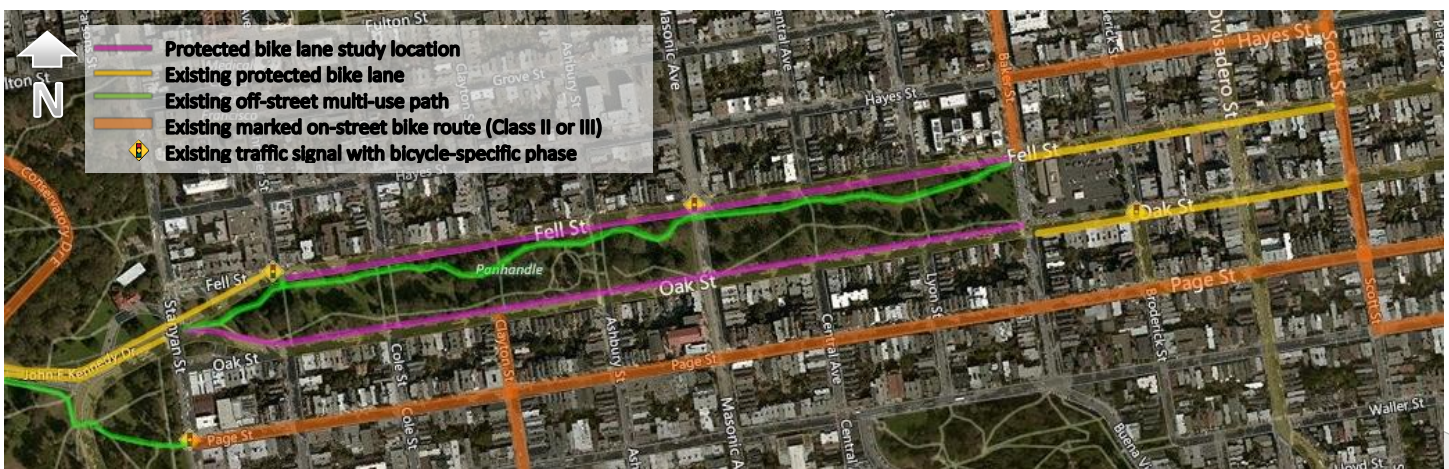
- One-way, parking-protected bike lanes could be accommodated on Oak Street and/or Fell Street
- Protected bike lanes meeting NACTO design standards, could be accommodated by removing one of the four travel lanes on both Oak Street and Fell Street
- With the addition of protected bike lanes, remaining travel lanes on both streets would generally maintain 9'-6" to 10' widths similar to existing conditions
- Construction cost would range between \$1.6 and \$3.9 million. The majority of the cost is for intersection treatments (i.e., signal modifications, pedestrian refuge islands and striping within intersections)

- For the protected bike lanes to be an attractive alternative to the multi-use path, they should be excluded from signal control at the three-legged intersections along the park. This treatment alone would require relocating signal poles at up to 11 intersections and accounts for between \$0.9 and \$1.5 million of the estimated project cost.
- Connections to existing bikeways on Fell Street would be relatively simple; connections along Oak Street present more challenges.
- Several locations will require significant trade-offs between the level of comfort for the bicycle facility, delay to bicyclists, drivers and Muni, and construction cost. These locations include Oak Street between Stanyan and Shrader streets, the Oak Street/Masonic Street intersection, and the Oak Street/Baker Street intersection.

## EXISTING CONDITIONS

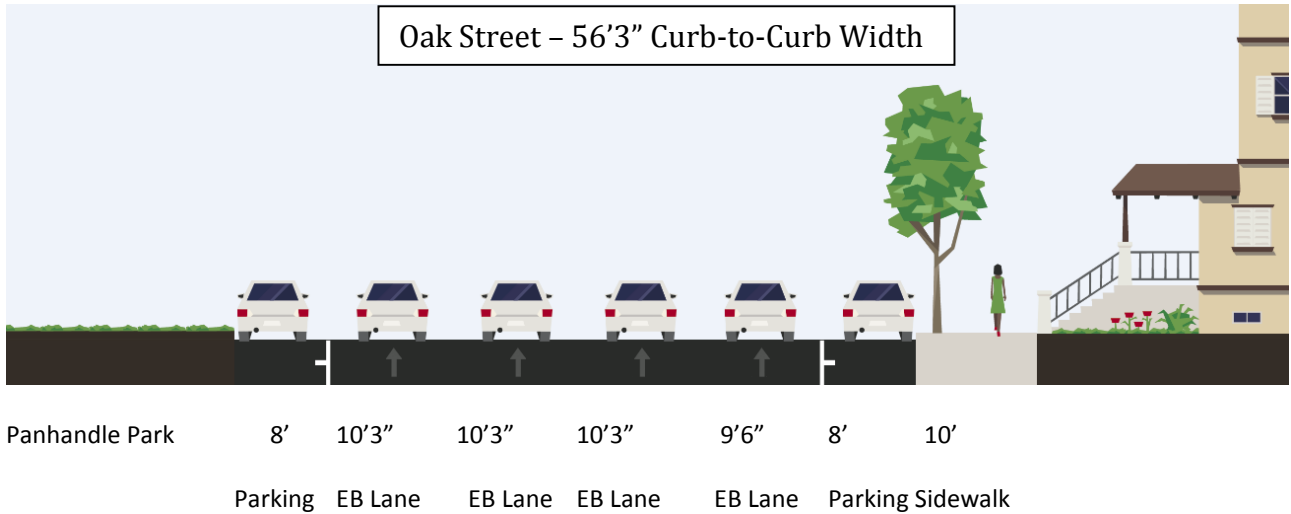
Fell Street and Oak Street operate as a one-way couplet. Oak Street is one-way eastbound and Fell Street is one-way westbound, both with four traffic lanes and curbside parallel parking on both sides within the project area. **Figure 1** shows a map of the project corridor. East of the project area, Fell Street and Oak Street each have three travel lanes. Curbside bikeways were installed on Fell and Oak streets between Baker Street and Scott Street in 2012, providing a more comfortable and convenient bicycling connection between the Panhandle bike path and the “Wiggle” bicycle route.

The Panhandle multi-use path is 12 feet wide with a marked centerline. The path is a high demand recreational and utilitarian transportation facility: peak pedestrian and bicycle volumes are both approximately 500 users per hour during weekday mornings and afternoons. There is community interest in studying on-street bicycle facilities adjacent to the Panhandle with the goals of providing more bicycle capacity along the corridor, making the multi-use path more comfortable for a variety of users, and reducing motor vehicle speeds along Fell Street and Oak Street. Ideally, on-street bikeways would attract faster, travel-time sensitive bicyclists away from the multi-use path.

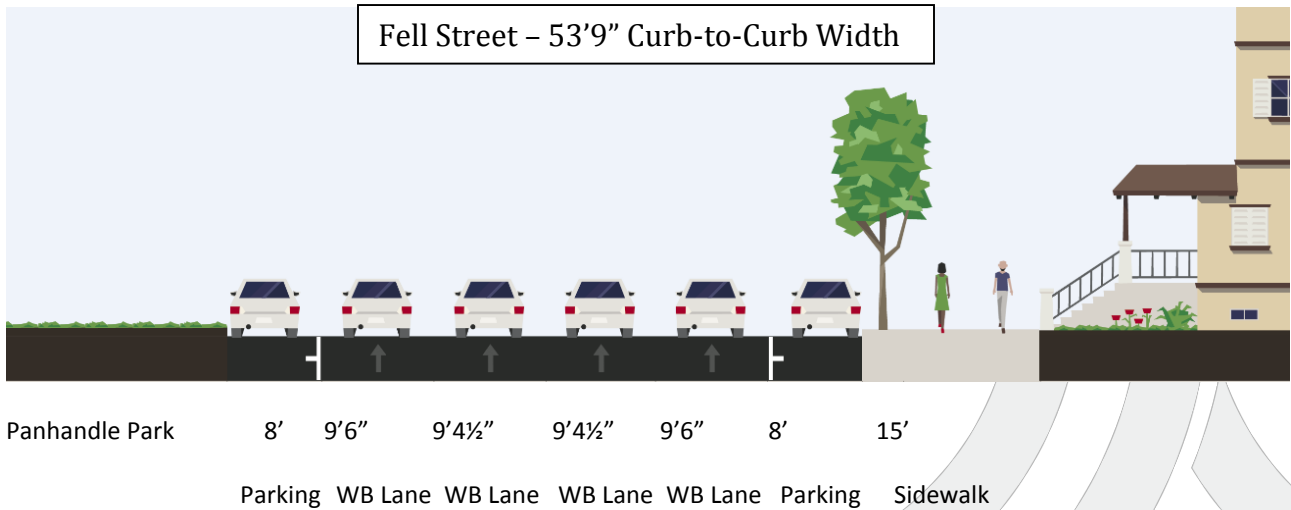


**Figure 1 Map of Project Area with bicycle facilities highlighted**

Both Oak Street and Fell Street have a right-of-way width of 68'-9" where they border the park but the sidewalks differ in width (15' on the north side of Fell Street, 10' on the south side of Oak Street), leaving different curb-to-curb widths on the otherwise generally symmetrical streets. The sidewalks bordering the park have been officially abolished<sup>1</sup>, with the north and south park paths serving as replacements. The result is that Fell Street is 53'-9" curb-to-curb, while Oak Street varies in curb-to-curb with between 56'-3" and 56'-9"<sup>2</sup>. **Figures 2 and 3** show typical midblock cross-sections of Oak Street and Fell Street, respectively. The project area has a slight grade in the east to west direction. Fell Street ranges from 0.7 to 2.1 percent uphill, and Oak Street from 0.7 to 1.7 percent downhill.



**Figure 2 Existing configuration of Oak Street between Shrader and Ashbury streets, looking east**



**Figure 3 Existing configuration of Fell Street looking west**

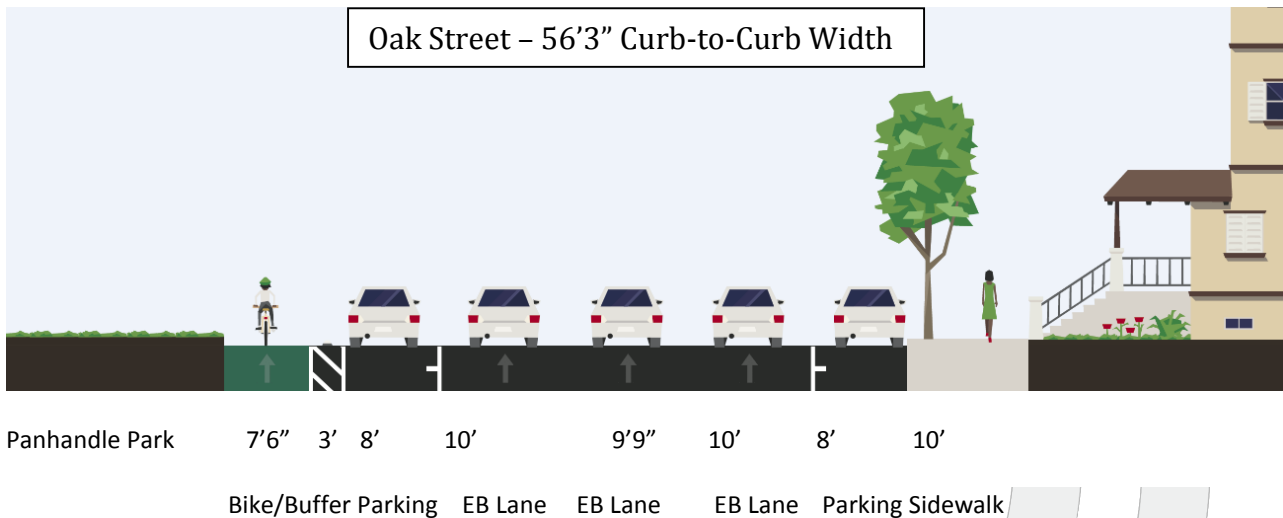
<sup>1</sup> San Francisco Public Works Grade Map, Key Map numbers 38, 40 and 51; retrieved May 31, 2016.

<sup>2</sup> The official width of Oak Street is a consistent 56'-9" from Shrader Street to Baker Street. However, SFMTA official striping drawings show Oak Street as 56'-3" wide from Shrader Street to Masonic Avenue, and 56'-9" wide from Masonic Avenue to Baker Street. For the purposes of this analysis the more conservative 56'-3" is assumed.

OPPORTUNITIES AND CONSTRAINTS

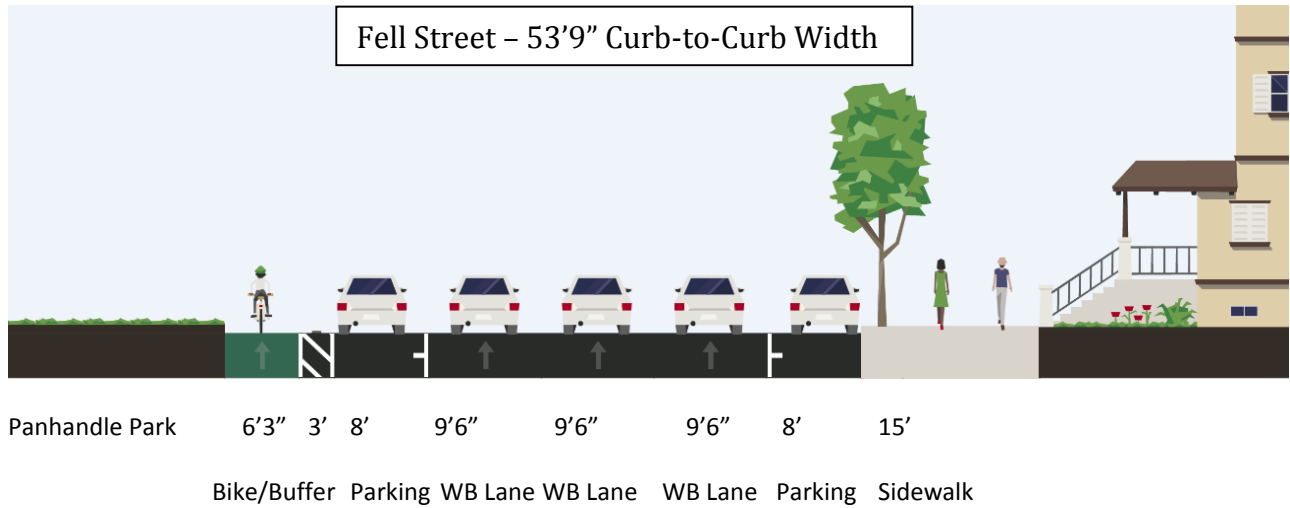
Given the existing cross-sections of Oak Street and Fell Street, each street could accommodate a one-way, parking-protected bike lane adjacent to the Panhandle by removing one of the four travel lanes between Baker Street and Shrader Street and moving the park-side parking lane so that it “floats” outside of the bikeway. The travel lane reduction would have relatively minor consequences in terms of travel delay and traffic operations as these four-lane segments feed to/from three-lane segments west of Stanyan Street and east of Baker Street.

The NACTO recommended width for protected bike lanes with high bicycle volumes and a two-foot wide gutter (as is generally present on Oak Street and Fell Street) is 7'-6" to allow for passing.<sup>3</sup> Eight-foot wide parking lanes with three-foot wide buffers are also recommended to match the NACTO-specified minimum total parking-protection width of 11 feet. The cross-sections shown in **Figures 4 and 5** aim to meet these recommended dimensions while maintaining a minimum general travel lane width of 9'-6". Though 9'-6" is narrow end for San Francisco lane width standards, it is wider than the existing middle lanes on Fell Street that are currently only 9'-4½". On Oak Street, the bikeway could be at least 7'-6" wide, and the outside travel lane could be 10 feet wide to help drivers feel more comfortable parking without encroaching into the buffer space. On Fell Street, the bikeway could be only 6'-3" wide, not meeting the recommended 7'-6", but exceeding the NACTO-recommended minimum protected bike lane width of 5'-6" for single-file bicycle travel.



**Figure 4 Possible configuration of Oak Street with bikeway looking east**

<sup>3</sup> Source: NACTO Urban Bikeway Design Guide cycle track design guidance, available at <http://nacto.org/publication/urban-bikeway-design-guide/cycle-tracks/one-way-protected-cycle-tracks/>. Formula is 7 feet (the recommended width for one-way, high-volume cycle tracks), plus the width of the gutter in excess of 18 inches.



**Figure 5 Possible configuration of Fell Street with bikeway looking west**

Intersections along Fell Street can be retrofitted to include a south side protected bike lane relatively easily because bike signals are already in place for the nearby multi-use path. The design of Oak Street should generally mirror the Fell Street design, but presents greater challenges due to higher traffic volumes and challenging connections to the existing bikeways on JFK Drive and on Oak Street east of Baker Street. A key issue that requires further technical study to determine the potential project's practicality: whether a bikeway can safely be added to the narrower section of Oak Street between Stanyan Street and Shrader Street, through a combination of lane-narrowing or roadway widening into the park. If this proves inadvisable, bicyclists would need to be allowed on the southern park path on this block to enter the new protected bike lane at Shrader Street. Design challenges arise at two other locations on Oak Street. The first is management of the high-volume left-turn from Oak Street onto Masonic Street that would cross the new bikeway. The second is the transition south to meet the existing protected bike lane at Baker Street.

Around 75 of the approximately 280 unmarked parking spaces along the north and south edges of the Panhandle would need to be repurposed to accommodate turn lanes and provide daylighting at intersections. The location where the most spaces would be removed is on Oak Street approaching Masonic Avenue.

### **Potential for a Two-Way Bicycle Facility**

Alternatively, a two-way protected bike lane would fit within the curb-to-curb width of either street by removing the parking lane adjacent to the park in addition to one of the four travel lanes. This would shift all of the traffic operation and parking trade-offs of a pair of one-way protected bike lanes onto one street with more intense levels, leaving the other street generally unaffected. Fell Street would be the logical choice for such a facility as it carries lower peak traffic volume than Oak Street and already has the necessary separated bicycle phasing at the intersections with Masonic Street and Shrader Street. A two-way facility may require the bikeway to be controlled by traffic signals to facilitate pedestrian crossing of the protected bike lane at the six minor street "T" intersections along the panhandle and may reduce the cost of the project (depending on whether bike-specific signals are used) but would increase delay for cyclists and detract from the utility of the protected bike lanes for commuter and recreational bicyclists. Additionally, a two-way bike facility would have a greater effect on traffic

operations along Fell Street than a one-way bike facility, as there would be insufficient right-of-way for a dedicated turn lane approaching Masonic Street. A two-way facility would also require removing all of the approximately 140 unmarked parking spaces along the Panhandle Park side of the street, nearly double the amount that would be removed with a pair of one-way protected bike lanes. The cost for this type of facility would likely be approximately one-half to two-thirds of the cost of the two one-way protected bike lanes option. Despite the potential capital cost savings, due to the limitations at minor street intersections and expected level of parking loss, a two-way protected bike facility is not recommended.

## COST ESTIMATE

The cost of installing one-way protected bike lanes on the blocks between Baker Street and Shrader Street, *exclusive of intersection treatments*, would range from approximately \$150,000 to \$680,000 depending on whether they are painted green and if wheel stops or other raised features are installed in the parking buffer. The majority of costs for implementation would be from intersection treatments required for safe operations. Table 1 summarizes the complexity and design treatment options for the project area intersections and associated cost range; further detail is in the attachment. *The total construction cost for the project would be between \$1.6 million and \$3.9 million (\$1.2 million to \$3.0 million per mile of new protected bike lane).* The exact cost depends heavily on design choices for the bikeway and intersection treatments, as well as the level of utility and curb ramp modifications required.



**Table 1: Key Design Issues and Potential Costs**

		Estimated Cost Range	
Design Component	Issues	Low	High
<b>Connections to Existing Bikeways</b>		<b>\$110,000</b>	<b>\$720,000</b>
Oak St. between Stanyan St. and Shrader St.	Narrow curb-to-curb width and high traffic volume, may require roadway widening to accommodate bikeway	\$40,000	\$500,000
Fell St./Shrader St.	Southside-to-northside bikeway transition manageable with additions to existing bike signal, possible pedestrian refuge island and signal pole relocation	\$30,000	\$150,000
Oak St./Baker St.	Northside-to-southside bikeway transition requires new bike signal and signal phase changes; potential delays for eastbound bicyclists and Baker St. traffic	\$30,000	\$60,000
Fell St./Baker St.	Minor striping changes only	\$10,000	\$10,000
<b>Intermediate Intersections</b>		<b>\$970,000</b>	<b>\$1,620,000</b>
Fell St./Masonic Ave.	Relatively simple signal modification for lane realignment	\$30,000	\$30,000
Oak St./Masonic Ave.	High-volume left turn movement will require trade-off between bikeway separation and traffic delay	\$0	\$60,000
Minor Street "T" intersections (11 intersections)	Install ped refuge islands and relocate traffic signals from park to islands to exclude cyclists from signal control	\$940,000	\$1,530,000
<b>Base Protected bike lane, Shrader to Baker exclusive of intersections</b>		<b>\$150,000</b>	<b>\$680,000</b>
<b>Construction Subtotal</b>		<b>\$1,230,000</b>	<b>\$3,020,000</b>
Traffic Control (5%); Mobilization (5%); Construction Support (10%)		\$250,000	\$600,000
Construction Contingency (10%)		\$120,000	\$300,000
<b>Construction Total</b>		<b>\$1,600,000</b>	<b>\$3,920,000</b>

## PRELIMINARY ANALYSIS OF KEY DESIGN ISSUES

The following describes potential design treatments at key locations for a pair of one-way eastbound and westbound protected bike lanes adjacent to the panhandle of Golden Gate Park on Oak and Fell Streets. These locations occur where the new bikeways would connect to the existing bikeways on Oak and Fell streets and JFK Drive, as well as at intersections along Oak and Fell streets within the project corridor.

### CONNECTIONS TO EXISTING PROTECTED BIKE LANES

The street cross-sections discussed above are typical for Oak and Fell streets between Baker and Shrader streets. This section describes how connections could be provided between the new protected bike lanes and the existing bikeways to the east and west.

#### Oak Street between Stanyan and Shrader streets

The most logical connection between the existing bikeway on JFK Drive/Kezar Drive and a new facility on Oak Street would be on the north side of Oak Street across Stanyan Street from the existing median bike lane on Kezar Drive. At its narrowest point, as shown in **Figure 6**, this section of Oak Street is 36 feet wide. A six-foot curbside bike lane could be added within the existing curb lines by narrowing the general travel lanes to 10 feet, but such lane narrowing may not be advisable due to the curvature of the road on this section. Preliminary analysis shows that removing one of the three general travel lanes on this section of Oak Street would result in lengthy queues on Kezar Drive spilling back to Lincoln Way for several hours a day and diversion of several hundred vehicles to alternative east-west routes or to local side streets during the weekday morning peak period. Alternative solutions would be to: (1) widen this section of Oak Street by up to six feet into the park, or (2) allow eastbound bicycle use on the southern Panhandle path between Stanyan Street and Shrader Street, and begin the protected bike lane on Oak Street east of Shrader Street. The construction cost for this segment would range from \$40,000 to \$500,000 depending on the alignment.



**Figure 6** Aerial photo of Oak Street between Stanyan (left) and Shrader (right) streets, curb-to-curb width labeled



### **Fell Street at Shrader Street**

An existing bicycle signal at the intersection of Fell and Shrader streets allows westbound bicyclists to leave the multi-use path in the park, crossing Fell Street diagonally to enter a curbside, buffered bike lane on the north side of Fell Street that continues to the JFK bikeway. With additional bicycle signal heads, bicyclists coming from the new protected bike lane could use the protected portion of the bicycle phase to make a similar movement. To manage potential conflicts between pedestrians crossing Fell Street and bicyclists travelling westbound, either the signal phasing could be changed to separate the bicycle and pedestrian movements, increasing delay for Fell Street drivers along Fell Street, or the pedestrian signals could be moved to a new pedestrian refuge island. Construction of the signal modifications and would cost approximately \$30,000 to \$150,000 depending on the final design.

### **Oak Street at Baker Street**

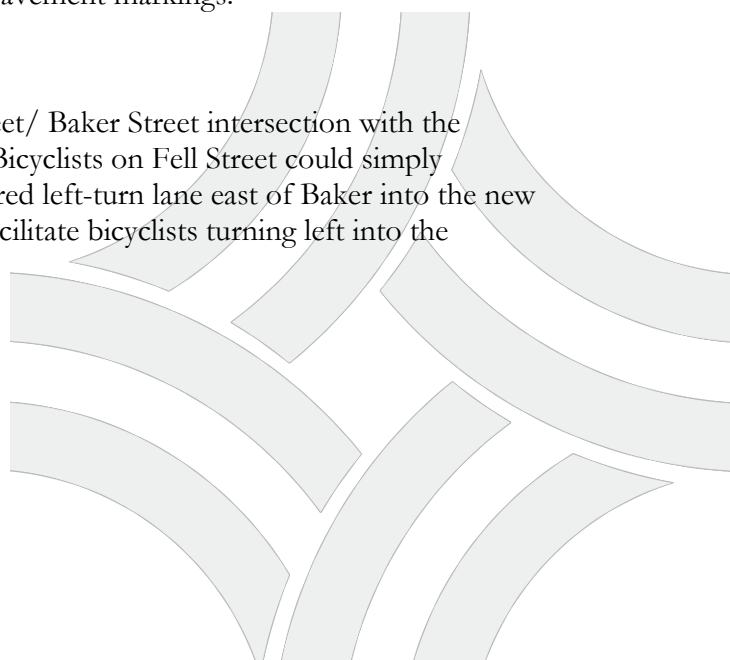
Eastbound cyclists using the new north-side protected bike lane along Oak Street would need to transition to the existing south-side, median-protected bikeway east of Baker Street. A similar signalization to the diagonal bicycle phase described above at the Fell Street/Shrader Street intersection could be used at this location. The existing southbound Baker Street split phase could be converted to a southbound protected-left only phase, disallowing southbound through-traffic and pedestrians using the western crosswalk during that time. The new diagonal bicycle phase could then be permitted simultaneously with the protected southbound left, with a path marked in the intersection to keep westbound bicyclists away from left-turning vehicles. Bicyclists coming from southbound Baker Street and eastbound Oak Street would need to merge to enter the south-side bikeway on Oak Street, which may be challenging. This would provide a single-stage crossing for bicyclists, but for only a short portion of the 90-second signal cycle.

A combination of bicycle signals and bike boxes could be used instead to facilitate a two-stage movement for eastbound through-bicyclists. This would increase their travel time, but would also eliminate the need for them to merge with bicyclists coming from southbound Baker Street before entering the median-separated protected bike lane. Excessive delay may result in some cyclists continuing east on Oak Street in the northernmost general travel lane, rather than waiting to transition over to the south-side bikeway.

Both of the above signal control schemes at the Baker Street/Oak Street intersection would cost approximately \$30,000 for signal modifications, signs and pavement markings.

### **Fell Street at Baker Street**

No major design changes would be required at the Fell Street/ Baker Street intersection with the addition of the new protected bike lane north of the park. Bicyclists on Fell Street could simply continue straight from the existing protected bike lane/shared left-turn lane east of Baker into the new facility. One parking space would need to be removed to facilitate bicyclists turning left into the protected bike lane from southbound Baker Street.



## INTERIOR INTERSECTION TREATMENTS

Conditions at several locations along the corridor warrant special attention even at a highly conceptual design level. The potential issues raised by heavy traffic volumes, space constraints and/or potential user conflicts at these locations are discussed in this section, along with possible design solutions and associated costs.

### Masonic Avenue Intersections

Masonic Avenue is the only street that continues through the Panhandle, and design of protected bike lanes would need to manage the left-turns from Oak Street and Fell Street to Masonic Avenue that would cross the new bikeways here. Left-turn lanes could be provided at the approach of each street to Masonic Avenue in the shadow of the floating parking lane. Morning peak left-turn volumes of over 800 vehicles per hour (vph) from Oak Street onto Masonic Avenue suggest the need for a block-long turn lane, which would replace approximately 19 parking spaces on the north side of Oak Street.

Westbound left-turns off of Fell Street onto Masonic Avenue are much lower at approximately 200 vph, so a pocket similar in length to the existing 150-foot turn pocket at this location would likely be sufficient<sup>4</sup>.

On the Fell Street approach to Masonic Avenue, the protected bike lane could be continued to the intersection and the existing signal phasing, which was designed to separate left-turning traffic from pedestrians and bicyclists crossing from the multi-use path, could be maintained. The mast arm facing Fell Street on the south side would probably need to be replaced with a longer one with two mast-arm mounted signal heads, which would cost approximately \$30,000.

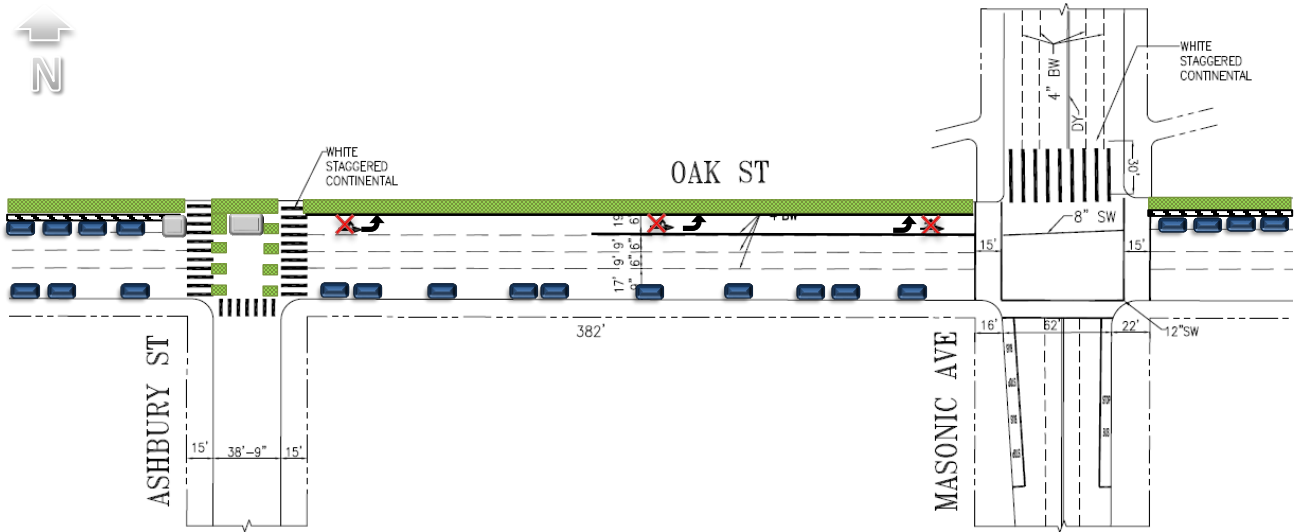
A mirror of the configuration and signal phasing at the Fell Street/Masonic Street intersection would be desirable to fully protect the new Oak Street protected bike lane. This would mean installing new bicycle signal heads to allow bicyclists and pedestrians to cross Masonic Avenue on the north side of Oak Street during the same phase. The permitted-protected eastbound left-turn phase would then be converted to a lagging protected-only phase after the bicycle and pedestrian phase ends. Here, the high existing volumes of left-turning traffic from Oak Street onto Masonic present perhaps the greatest challenge to the one-way protected bike lane concept: preliminary traffic analysis predicts that disallowing left-turns from Oak Street during the north-side pedestrian (and new bicycle) phase would result in left-turn queues spilling back multiple blocks for at least an hour during the weekday morning peak period. Combined with the reduction in through-lanes upstream from four to three, such queueing would disrupt the traffic progression along the corridor, thereby considerably reducing Oak Street's vehicle capacity and result in additional congestion. This intersection design is illustrated in **Figure 7** and would cost approximately \$60,000 to install.

To avoid a major increase in travel time along the corridor, the bikeway would need to be shifted away from the curb, providing a weave section for left-turning drivers to merge into the left-turn pocket to the left of the bikeway well ahead of the intersection as shown in **Figure 8**. This is a common SFMTA treatment for bikeways at high-volume vehicle turn locations, and has been implemented elsewhere on

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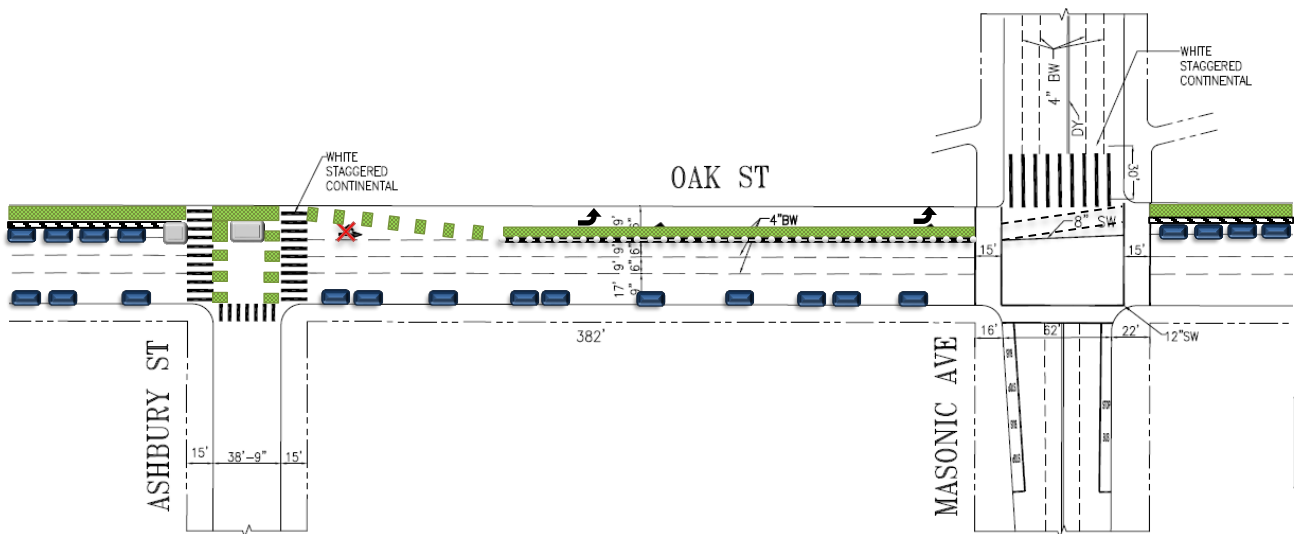
<sup>4</sup> Turning volumes from two-hour AM and PM peak-period counts conducted Tuesday, April 12<sup>th</sup>, 2016. Required turn lane storage lengths are estimated from preliminary traffic analysis by SFMTA staff.

the corridor, including on the Fell Street and Oak Street approaches to Divisadero Street. This design would introduce a link in the protected bike lane with less separation from vehicle traffic than the rest of the project area



**Figure 7 Sketch of Oak Street at Masonic Avenue with curbside bikeway and (protected) left-turn lane**

. Conflicts between bicycle riders and drivers could be minimized in this design in two ways: by providing a narrow buffer with delineator posts outside of the bikeway where it is between the left-turn and through-lanes, and potentially using signal timing to reduce cyclists and the platoon of traffic on Oak Street arriving at the weave point at the same time. This configuration would need to be analyzed to ensure that large vehicles could make the eastbound left-turn from a curbside left-turn lane. The cost of this treatment would be minimal.



**Figure 8 Sketch of Oak Street at Masonic Avenue with curbside left-turn lane and delineator-buffered bike lane**

Other design treatments that the SFMTA has used to manage vehicle turns across curbside bikeways are not recommended at this location. The “mixing zone” treatment that the SFMTA installed at other locations on Oak Street and Fell Street (see Oak Street at Broderick Street) is contraindicated by high vehicle turning volumes. Permitting turns across the curbside bikeway during the pedestrian and bicycle crossing phase, installing “crossbike” markings and signs directing turning drivers to yield to bicycles and pedestrians, similar to the treatment on westbound Market Street at Buchanan Street, is similarly inadvisable. The collision history at this location indicates that driver yielding behavior for this movement is not consistent<sup>5</sup>, and there is little reason to expect them to do a better job of seeing and yielding to faster-moving bicyclists coming up on their left.

### Minor Street Intersections

The minor cross-streets in the project area from east to west are Lyon Street, Central Avenue, Ashbury Street, Clayton Street, Cole Street, and Shrader Street. Each is a consistent width of 38'-9" curb-to-curb with 15-foot wide sidewalks. All of these streets are discontinued at the park, each forming a pair of “T” intersections at Oak and Fell streets. The preferred control for the protected bike lane at these “T” intersections is to exclude it from the traffic signal, allowing bicyclists to proceed through the intersection without stopping unless a pedestrian is crossing the bikeway. Due to the relatively low pedestrian volumes at these intersections, it is expected that people using the protected bike lane would routinely violate the signal if required to stop during every pedestrian phase, creating unpredictability and likely conflict between users on foot and on bicycles. This treatment also recognizes that in order to attract many bicycle commuters, the new protected bike lanes would need to be time-competitive with the existing multi-use path that has the advantage of a single traffic control signal for the length of the Panhandle.

Excluding the protected bike lane from the traffic signal requires installing new pedestrian refuge islands in the shadow of the parking strip. The existing vehicle and pedestrian signal heads currently located within the park would also need to be relocated to new poles on the pedestrian refuge islands. Implementing these changes would cost between \$70,000 and \$150,000 per intersection, and require the removal of approximately four parking spaces per intersection. Over the eleven minor-street “T” intersections along the Panhandle (excluding Fell Street/Shrader Street which has been discussed separately), the total cost would be between \$0.9 and \$1.5 million dollars and approximately 48 parking spaces would be removed.

This design introduces a variety of benefits and compromises for pedestrians crossing to and from the park at the minor intersections:

- Pedestrians would be required to wait for gaps in bicycle traffic to cross the protected bike lane (which may present new challenges to people with low or no vision). Design treatments for the protected bike lanes (e.g., stencil messages, rumble strips, signs) should also be considered to clearly indicate the necessity of yielding to pedestrians to people on bicycles.
- The signalized portion of the crossing would decrease in distance by approximately 15 feet

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<sup>5</sup> Per SFPD/SFMTA records, there have been four reported incidents in the past five years of pedestrians in this crosswalk being struck and injured by drivers turning left off of Oak Street failing to yield.

- The signal upgrades would create an opportunity to open some or all of crosswalks which are currently de facto closed (unmarked and blocked by parked cars) at the intersections of Clayton, Central and Lyon streets at Oak and Fell streets (six crosswalks total). This would require an additional investment in street lighting and curb ramps.

Figure 9 below shows an example image adjacent to Prospect Park in Brooklyn, NY where signal equipment was relocated to a new median island adjacent to a protected bike path. As described above, similar modifications would be required at 11 intersections along Fell Street and Oak Street in order to allow safe and efficient operation of the protected bike lanes.



**Figure 9 Example image of minor street T intersection adjacent to Prospect Park in Brooklyn, NY**