



MEMORANDUM

Date: December 1, 2020

To: Pete Vollmann, City of Oakland
Nicole Ferrara, City of Oakland

From: Rob Rees and Lee Reis, Fehr & Peers

Subject: Howard Terminal – Collision History Analysis

OK16-0125.06

The Oakland A's are proposing a ballpark and non-ballpark development at Howard Terminal in Oakland, California. The City of Oakland Transportation Impact Review Guidelines (TIRG) approved April 14, 2017 requires an evaluation of the most recent five years of vehicle, pedestrian, and bicycle collision data for all study intersections plus roadway segments in proximity to the project. Fehr & Peers identified 76 study intersections based on the TIRG criteria and communications with the City of Oakland. This analysis also considers 52 study segments.

1. Safety Analysis

A five-year history (January 1, 2012 to December 31, 2016) of collision data in the study area was obtained from the Statewide Integrated Traffic Records System (SWITRS) and evaluated for this collision analysis. The 76 study intersections are shown in **Figure 1**, and the 52 study segments are shown in **Figure 2**. Collision data from the Federal Railroad Administration was also reviewed for the railroad crossings along Embarcadero West, but no collisions were reported in the analysis timeframe.¹ **Table 1A** summarizes the collision data by type and location for intersections, and **Table 1B** summarizes the same information for segments. **Table 2A** summarizes the collision data by severity and location for intersections, and **Table 2B** summarizes the same information for segments.

¹ There was one railroad collision in 2017 at the Washington Street crossing that caused two injuries and no fatalities, one collision in 2019 at the Market Street crossing that caused no injuries, and one collision at the Broadway crossing that caused no injuries. This memorandum considers 2012-2016 because SWITRS data for 2017 and later was considered provisional at the time of the Notice of Preparation (NOP).



Table 1A: Summary of Collisions by Type – Intersection Collisions

ID #	Intersection	Head-on	Side-swipe	Rear End	Broad-side	Hit Object	Over-turned	Not Stated / Other	Pedestrian-Involved	Bicycle-Involved	Total
1	Union at 5th	0	2	0	1	0	1	1	0	0	5
2	Union at 7th	2	3	4	6	0	0	0	0	1	16
3	Adeline at 3rd	1	5	1	0	0	0	0	0	0	7
4	Adeline at 5th	0	2	2	5	1	3	0	0	1	14
5	Adeline at 7th	1	1	1	8	1	0	0	0	1	13
6	Market at Embarcadero	0	0	0	0	0	0	0	0	0	0
7	Market at 3rd	0	0	1	12	0	1	0	0	0	14
8	Market at 5th	1	4	3	20	0	0	0	1	2	31
9	Market at 6th	0	1	0	2	0	0	0	0	1	4
10	Market at 7th	2	2	5	8	0	0	1	0	1	19
11	Market at 8th	0	1	1	3	2	0	0	1	1	9
12	Market at 10th	0	1	1	4	0	0	0	1	1	8
13	Market at 12th	0	0	0	5	0	0	0	0	1	6
14	Market at 14th	1	0	0	4	2	0	0	2	2	11
15	Market at 18th	1	3	0	5	1	0	0	2	1	13
16	Market at 24th	0	0	3	0	0	0	0	1	0	4
17	Market at 26th	0	2	0	4	1	0	0	0	0	7
18	Market at West Grand	4	2	5	3	3	0	0	1	0	18
19	Market at San Pablo	1	0	0	0	0	0	0	0	2	3
20	Brush at 3rd	2	2	1	5	0	0	1	0	0	11
21	Brush at 5th	0	0	1	11	0	1	0	0	0	13
22	Brush at 6th	0	1	0	2	0	0	0	0	0	3



Table 1A: Summary of Collisions by Type – Intersection Collisions

ID #	Intersection	Head-on	Side-swipe	Rear End	Broad-side	Hit Object	Over-turned	Not Stated / Other	Pedestrian-Involved	Bicycle-Involved	Total
23	Brush at 7th	0	7	2	7	0	0	0	0	0	16
24	Brush at 11th	0	4	1	6	0	0	0	1	0	12
25	Brush at 12th	1	4	2	7	1	0	0	7	1	23
26	Brush at 14th	0	5	1	7	1	0	0	0	0	14
27	Brush at 17th	2	6	3	13	2	0	0	0	2	28
28	Brush at 18th	0	3	2	18	1	0	1	1	0	26
29	Castro at 3rd	0	0	0	0	0	0	0	0	0	0
30	Castro at 5th	0	3	1	6	0	0	0	0	1	11
31	Castro at 6th	0	0	1	2	0	0	0	0	0	3
32	Castro at 7th	0	3	1	0	1	0	0	0	0	5
33	Castro at 11th	1	2	5	9	0	0	0	0	1	18
34	Castro at 12th	0	5	1	13	1	0	0	0	0	20
35	Castro at 14th	1	4	1	8	0	0	1	1	3	19
36	Castro at 17th	0	3	7	8	0	0	0	1	0	19
37	Castro at 18th	0	0	1	5	0	0	0	1	0	7
38	Martin Luther King Jr. Way at Embarcadero West	0	0	0	0	0	0	0	0	0	0
39	Martin Luther King Jr. Way at 2nd	0	0	0	0	0	0	0	0	1	1
40	Martin Luther King Jr. Way at 3rd	0	1	0	2	0	0	0	0	1	4
41	Martin Luther King Jr. Way at 4th	0	1	0	1	0	0	0	0	0	2
42	Martin Luther King Jr. Way at 5th	0	1	1	15	2	0	0	0	0	19
43	Martin Luther King Jr. Way at 6th	0	0	0	2	0	0	0	0	0	2



Table 1A: Summary of Collisions by Type – Intersection Collisions

ID #	Intersection	Head-on	Side-swipe	Rear End	Broad-side	Hit Object	Over-turned	Not Stated / Other	Pedestrian-Involved	Bicycle-Involved	Total
44	Martin Luther King Jr. Way at 7th	1	3	0	19	0	0	0	1	1	25
45	Martin Luther King Jr. Way at 8th	0	3	0	9	0	1	0	0	0	13
46	Martin Luther King Jr. Way at 10th	0	1	0	5	0	0	0	0	0	6
47	Martin Luther King Jr. Way at 11th	1	0	0	25	0	0	0	1	0	27
48	Martin Luther King Jr. Way at 12th	0	0	1	8	0	0	0	0	0	9
49	Martin Luther King Jr. Way at 14th	2	7	0	12	0	0	0	0	1	22
50	Martin Luther King Jr. Way at 16 th	0	0	2	1	0	0	0	0	0	3
51	Martin Luther King Jr. Way at 17th	2	3	1	9	1	0	0	0	0	16
52	Martin Luther King Jr. Way at 18th	0	1	0	2	1	0	1	1	0	6
53	Jefferson at 3rd	0	0	0	1	0	0	0	0	1	2
54	Jefferson at 5th	0	2	1	2	0	0	1	0	0	6
55	Jefferson at 7th	0	2	2	9	0	0	0	0	0	13
56	Jefferson at 8th	0	1	1	3	0	0	0	0	0	5
57	Clay at Embarcadero West	0	0	0	0	2	0	0	0	0	2
58	Clay at 3rd	0	0	1	2	0	0	0	0	0	3
59	Washington at Embarcadero West	1	0	0	0	0	0	0	1	1	3
60	Washington at 3rd	0	0	0	0	0	0	0	0	0	0
61	Washington at 5th	1	3	0	10	0	0	0	1	0	15
62	Washington at 6th	0	0	2	0	0	0	2	0	3	7
63	Washington at 7th	1	1	2	1	0	0	0	0	0	5
64	Washington at 8th	0	3	2	1	0	0	0	2	0	8
65	Broadway at Embarcadero West	0	1	1	0	2	0	1	0	0	5



Table 1A: Summary of Collisions by Type – Intersection Collisions

ID #	Intersection	Head-on	Side-swipe	Rear End	Broad-side	Hit Object	Over-turned	Not Stated / Other	Pedestrian-Involved	Bicycle-Involved	Total
66	Broadway at 3rd	0	2	3	1	0	0	1	3	2	12
67	Broadway at 5th	4	13	9	7	0	0	1	3	0	37
68	Broadway at 6th	1	4	8	3	1	0	0	1	2	20
69	Broadway at 7th	0	8	7	8	2	0	0	1	0	26
70	Broadway at 8th	1	3	3	4	0	0	0	0	2	13
71	Franklin at 7th	0	1	2	0	0	0	0	2	1	6
72	Franklin at 8th	0	4	4	2	1	0	1	1	0	13
73	Webster at 7th	0	6	3	8	0	0	1	6	1	25
74	Webster at 8th	0	19	4	4	0	0	1	1	0	29
75	Harrison at 7th	0	10	16	1	5	0	0	3	0	35
76	Harrison at 8th	0	1	4	7	0	0	2	1	2	17
Total		36	186	138	401	35	7	17	50	42	912

Source: SWITRS, 2012-2016; Fehr & Peers, 2020.



Table 1B: Summary of Collisions by Type - Segment Collisions

ID #	Segment	Head-on	Side-swipe	Rear End	Broad-side	Hit Object	Over-turned	Not Stated / Other	Pedestrian-Involved	Bicycle-Involved	Total
1	3rd: Union to Magnolia	0	0	0	0	0	0	0	0	1	1
2	3rd: Magnolia to Adeline	0	0	0	0	0	0	0	0	0	0
3	3rd: Adeline to Chestnut	0	0	0	0	0	0	0	0	0	0
4	3rd: Chestnut to Linden	0	0	0	0	0	0	0	0	0	0
5	3rd: Linden to Filbert	0	0	0	0	0	0	0	0	0	0
6	3rd: Filbert to Myrtle	0	0	0	0	0	0	0	0	0	0
7	3rd: Myrtle to Market	0	0	0	0	0	0	0	0	0	0
8	3rd: Market to Brush	0	0	0	0	0	0	0	0	0	0
9	3rd: Brush to Castro	0	0	0	0	0	0	0	0	0	0
10	3rd: Castro to Martin Luther King Jr. Way	0	0	0	0	0	0	0	0	0	0
11	3rd: Martin Luther King Jr. Way to Jefferson	0	2	0	0	0	0	0	0	0	2
12	3rd: Jefferson to Clay	0	0	0	0	0	0	0	0	0	0
13	3rd: Clay to Washington	0	0	0	0	0	0	0	0	0	0
14	3rd: Washington to Broadway	0	0	0	0	0	0	0	0	0	0
15	Embarcadero West: Market to Martin Luther King Jr. Way	0	0	0	0	0	0	0	0	0	0
16	Embarcadero West: Martin Luther King Jr. Way to Jefferson	0	0	0	0	1	0	1	0	0	2
17	Embarcadero West: Jefferson to Clay	0	0	0	0	0	0	1	0	0	1
18	Embarcadero West: Clay to Washington	0	0	0	0	0	0	0	0	0	0
19	Embarcadero West: Washington to Broadway	0	0	0	0	1	1	0	0	0	2



Table 1B: Summary of Collisions by Type - Segment Collisions

ID #	Segment	Head-on	Side-swipe	Rear End	Broad-side	Hit Object	Over-turned	Not Stated / Other	Pedestrian-Involved	Bicycle-Involved	Total
41	Washington: 6th to 7th	0	0	0	0	0	0	0	0	0	0
42	Washington: 7th to 8th	0	0	0	0	0	0	0	0	0	0
43	Washington: 8th to 9th	0	0	0	0	0	0	0	0	0	0
44	Washington: 9th to 10th	0	0	0	0	0	0	0	0	0	0
45	Broadway: Embarcadero West to 2nd	0	0	0	0	1	0	0	0	0	1
46	Broadway: 2nd to 3rd	0	0	0	0	0	0	0	1	0	1
47	Broadway: 3rd to 4th	0	1	0	0	0	0	0	0	0	1
48	Broadway: 4th to 5th	0	0	0	0	0	0	0	0	0	0
49	Broadway: 5th to 6th	0	0	0	0	0	0	0	0	0	0
50	Broadway: 6th to 7th	0	0	0	0	0	0	0	0	0	0
51	Broadway: 7th to 8th	0	0	0	0	0	0	0	1	0	1
52	Broadway: 8th to 9th	0	0	0	0	0	0	0	0	0	0
Total		0	4	0	0	4	1	3	2	1	15

Source: SWITRS, 2012-2016; Fehr & Peers, 2020.



Table 2A: Summary of Collision Severity - Intersection Collisions

ID#	Intersection	Property Damage Only Collisions	Injury Collisions	Fatality Collisions	Total	Person-Injuries			
						Bike	Pedestrian	Driver/ Passenger	Total
1	Union at 5th	3	1	1	5	0	0	2	2
2	Union at 7th	9	7	0	16	1	0	7	8
3	Adeline at 3rd	7	0	0	7	0	0	0	0
4	Adeline at 5th	5	9	0	14	1	0	15	16
5	Adeline at 7th	7	6	0	13	0	0	9	9
6	Market at Embarcadero	0	0	0	0	0	0	0	0
7	Market at 3 rd	10	4	0	14	0	0	6	6
8	Market at 5th	18	12	1	31	1	1	16	18
9	Market at 6th	3	1	0	4	0	0	1	1
10	Market at 7th	12	7	0	19	1	0	13	14
11	Market at 8th	6	3	0	9	1	1	3	5
12	Market at 10th	5	3	0	8	1	1	1	3
13	Market at 12th	3	3	0	6	1	0	2	3
14	Market at 14th	4	7	0	11	1	2	7	10
15	Market at 18th	8	5	0	13	1	1	5	7
16	Market at 24th	3	1	0	4	0	1	0	1
17	Market at 26th	2	5	0	7	0	0	9	9
18	Market at West Grand	13	5	0	18	0	1	6	7
19	Market at San Pablo	0	3	0	3	2	1	0	3
20	Brush at 3rd	8	3	0	11	0	0	3	3



Table 2A: Summary of Collision Severity - Intersection Collisions

ID#	Intersection	Property Damage Only Collisions	Injury Collisions	Fatality Collisions	Total	Person-Injuries			
						Bike	Pedestrian	Driver/ Passenger	Total
21	Brush at 5th	9	4	0	13	0	0	9	9
22	Brush at 6th	2	1	0	3	0	0	1	1
23	Brush at 7th	8	8	0	16	0	0	11	11
24	Brush at 11th	9	3	0	12	0	1	7	8
25	Brush at 12th	9	14	0	23	1	8	7	16
26	Brush at 14th	6	8	0	14	0	0	11	11
27	Brush at 17th	21	7	0	28	2	0	9	11
28	Brush at 18th	14	12	0	26	0	2	17	19
29	Castro at 3rd	0	0	0	0	0	0	0	0
30	Castro at 5th	5	6	0	11	1	0	9	10
31	Castro at 6th	1	2	0	3	0	0	6	6
32	Castro at 7th	5	0	0	5	0	0	0	0
33	Castro at 11th	13	5	0	18	1	0	4	5
34	Castro at 12th	14	6	0	20	0	1	8	9
35	Castro at 14th	11	8	0	19	2	1	8	11
36	Castro at 17th	10	9	0	19	0	1	8	9
37	Castro at 18th	4	3	0	7	0	1	4	5
38	Martin Luther King Jr. Way at Embarcadero	0	0	0	0	0	0	0	0
39	Martin Luther King Jr. Way at 2nd	0	1	0	1	1	0	0	1
40	Martin Luther King Jr. Way at 3rd	3	1	0	4	1	0	0	1



Table 2A: Summary of Collision Severity - Intersection Collisions

ID#	Intersection	Property Damage Only Collisions	Injury Collisions	Fatality Collisions	Total	Person-Injuries			
						Bike	Pedestrian	Driver/ Passenger	Total
61	Washington at 5th	8	7	0	15	0	1	7	8
62	Washington at 6th	4	3	0	7	2	0	4	6
63	Washington at 7th	5	0	0	5	0	0	0	0
64	Washington at 8th	3	5	0	8	0	2	4	6
65	Broadway at Embarcadero West	5	0	0	5	0	0	0	0
66	Broadway at 3rd	4	8	0	12	1	3	5	9
67	Broadway at 5th	28	8	1	37	0	2	10	12
68	Broadway at 6th	13	7	0	20	2	1	5	8
69	Broadway at 7th	16	10	0	26	0	1	11	12
70	Broadway at 8th	9	4	0	13	1	1	2	4
71	Franklin at 7th	3	2	1	6	1	1	0	2
72	Franklin at 8th	10	3	0	13	0	1	2	3
73	Webster at 7th	12	13	0	25	1	6	8	15
74	Webster at 8th	27	2	0	29	0	1	1	2
75	Harrison at 7th	26	9	0	35	0	3	10	13
76	Harrison at 8th	7	10	0	17	1	1	9	11
Total		552	356	4	912	32	54	413	499

Source: SWITRS, 2012-2016; Fehr & Peers, 2020.



Table 2B: Summary of Collision Severity - Segment Collisions

ID #	Segment	Property Damage Only Collisions	Injury Collisions	Fatality Collisions	Total	Person-Injuries			
						Bike	Ped	Driver/ Passenger	Total
38	Washington: 3rd to 4th	0	0	0	0	0	0	0	0
39	Washington: 4th to 5th	0	0	0	0	0	0	0	0
40	Washington: 5th to 6th	0	0	0	0	0	0	0	0
41	Washington: 6th to 7th	0	0	0	0	0	0	0	0
42	Washington: 7th to 8th	0	0	0	0	0	0	0	0
43	Washington: 8th to 9th	0	0	0	0	0	0	0	0
44	Washington: 9th to 10th	0	0	0	0	0	0	0	0
45	Broadway: Embarcadero West to 2nd	1	0	0	1	0	0	0	0
46	Broadway: 2nd to 3rd	0	1	0	1	0	1	0	1
47	Broadway: 3rd to 4th	1	0	0	1	0	0	0	0
48	Broadway: 4th to 5th	0	0	0	0	0	0	0	0
49	Broadway: 5th to 6th	0	0	0	0	0	0	0	0
50	Broadway: 6th to 7th	0	0	0	0	0	0	0	0
51	Broadway: 7th to 8th	0	1	0	1	0	1	0	1
52	Broadway: 8th to 9th	0	0	0	0	0	0	0	0
Total		11	4	0	15	1	2	1	4

Source: SWITRS, 2012-2016; Fehr & Peers, 2020.



As shown in **Table 1A**, 912 collisions were reported during this five-year timeframe at the study intersections. The top three collision types were broadside (44 percent), sideswipe (20 percent), and rear-end (15 percent) collisions and most collisions were due to failure to follow traffic signals and signs (37 percent) and improper turning (18 percent). Pedestrians were involved in five percent of the reported collisions, and bicyclists were involved in seven percent. Thirty-nine percent of the reported collisions resulted in injuries and four resulted in a fatality, as shown in **Table 2A**.

As shown in **Table 1B**, 15 collisions were reported during this five-year timeframe at the study segments. The top two collision types were sideswipe (27 percent) and hit object (27 percent). Most collisions were due to unsafe starting and backing (20 percent), improper turning (20 percent), and driving or bicycling under the influence of alcohol and drugs (20 percent). Pedestrians were involved in 13 percent of the reported collisions, and bicyclists were involved in 7 percent. Twenty-seven percent of the reported collisions resulted in injuries, as shown in **Table 2B**.

The following describes the four fatal collisions:

- A fatal single-party collision occurred at the 5th Street/Union Street intersection on April 21, 2014 in the early morning as the motorist turned westbound at the signalized intersection onto the I-880 ramp. The data does not identify any other information about this collision.
- A fatal collision occurred at the Market Street/5th Street intersection on December 17, 2013, as a northbound bicyclist was stopped at the signalized intersection and hit by a truck. The collision occurred at night. There are streetlights present on the north leg and the east leg but are absent at the south leg and west leg of the intersection.
- A fatal collision occurred in the early morning hours at the intersection of Broadway/5th Street intersection on May 19, 2015. A motorist was hit broadside by a truck violating the traffic signal and travelling at an unsafe speed in the southbound direction. The southbound intersection approach is under the I-880 freeway and is illuminated with minimal lighting. The collision involved alcohol. This intersection is currently under design review as part of the larger Oakland Alameda Access and Circulation Project.
- A fatal collision occurred at the intersection of Franklin Street/7th Street intersection on December 18, 2015 involving a pedestrian crossing southbound on the crosswalk violating a walk sign at a signalized intersection.



A Critical Crash Rate analysis² was conducted to determine which study intersections and segments experienced high crash rates (number of crashes per million entering vehicles per year) when compared to similar intersection and segment types within the analysis population. Intersections or segments with crash rates greater than the critical rate are identified as intersections or segments to be evaluated for collision trends. Appendix A, **Table A-1** and **Table A-2**, present predicted and actual collision frequencies for the 76 study intersections and the 52 study segments, respectively. See Appendix B for the methodology used to identify the critical crash rate for each study intersection and study segment.

According to the TIRG, intersections or roadway segments with collision frequency greater than the predicted frequency should have their collision trends and potential roadway or intersection modifications evaluated in greater detail to determine if the project could influence the frequency. If the project does contribute to an existing problem, improvements are recommended to alleviate the potential effects of the project. The project is assumed to contribute to an existing problem if it adds 100 or more vehicles in the AM or PM peak periods to an intersection or segment that is identified through the Critical Crash Rate analysis. This analysis only considers vehicle volumes in the AM and PM peak periods from non-ballpark development since that would be the daily conditions, rather than including special event volumes.

The next section describes the recommendations for the eleven study intersections with collision frequency greater than the predicted frequency where the project is assumed to contribute to an existing problem. As detailed in the section, two study intersections and two study segments have a collision frequency greater than the predicted frequency, but the project is not assumed to contribute to an existing problem.

² Highway Safety Manual (Part B, Chapter 4, Section 4.4.2.5)



2. Recommended Improvements

Recommended improvements have been developed referencing the Federal Highway Administration’s Crash Modification Factor (CMF) Clearinghouse. Safety treatments from the CMF Clearinghouse recommended at study locations that have a higher reported collision frequency than predicted by HSM are described in **Table 3**.

Table 3: CMF Clearinghouse Recommendations 4- and 5-Star Ratings

#	CMF Recommendation Measure	CMF ID	CMF	CMF Standard Error	CRF ¹	CRF Standard Error	FHWA Rating
1	Convert minor-road stop control to all-way stop control	310	0.25	0.03	75	3	5-star
2	Install a traffic signal	320	0.33	0.24	67	24	4-star
3	Illumination	578	0.69	0.07	32	7	4-star
4	Road diet from 4- to 3- lanes	5554	0.81	.005	19	54	4-star
5	Add 3-inch yellow reflective sheeting to signal backplates	1410	0.85	0.005	15	0.5	4-star
6	Replace 8-inch red signal heads with 12-inch ²	2333	0.58	0.07	42	7	4-star

Notes:

1. CRF = Crash Reduction Factor
2. The stated CRF applies to angle crash types only.

Source: CMF Clearinghouse, 2019; Fehr & Peers, 2019.

As shown in **Table A-1**, thirteen study intersections have a higher reported collision frequency than predicted by the HSM, as discussed below.

- **Market Street & 3rd Street (#7):** This two-way stop-controlled intersection experienced 14 collisions over the course of the five-year period. Broadside collisions were the primary collisions at this intersection (86%); 83% of the collisions involved motorists travelling in the southbound direction and 57% of the collisions involved vehicle right-of-way violations.

Recommendation:

- Install a traffic signal: Signalize the intersection with permitted east/west phasing, a protected southbound left-turn phase, and left-turn prohibition for northbound



left-turns. (CMF #2). Add 3-inch yellow reflective sheeting to signal backplates. (CMF #5)

- Market Street & 5th Street (#8): This signalized intersection experienced 31 collisions over the five-year period. Collisions that occurred were primarily broadside (65%) of which 80% included traffic signals and signs violation as the primary collision factor and 75% included motorists travelling in the northbound or southbound direction. There was one collision involving a pedestrian and 2 collisions involving a bicyclist of which one was fatality. Two of the three bicycle and pedestrian collisions involved a northbound motorist.

Recommendations:

- Evaluate luminance using lighting criteria published by Illuminating Engineering Society (IES). Or, the City may use its own lighting design criteria. (CMF #3)
- Add 3-inch yellow reflective sheeting to signal backplates. (CMF #5)
- Replace 8-inch red signal heads with 12-inch signal heads. (CMF #6)

Other measures to consider include improving signal visibility, upgrading traffic signals, adding overhead signal heads, and installing high visibility crosswalks and bicycle lane markings through the intersection. These considerations do not have 4- and 5-Star ratings and so there is less confidence in the results of the studies that produced their CMF.

- Brush Street & 3rd Street (#20): This two-way stop-controlled intersection experienced 11 collisions over the course of the five-year period. The collisions that occurred at this intersection were primarily broadside (45%) and primarily involved trucks. 80% of the broadside collisions involved a motorist travelling in the southbound direction. Other types of collisions which occurred at this intersection are head-on and side-swipe collisions.

Recommendations:

- Convert minor-road stop control to all-way stop control: Install stop signs at all intersection approaches. (CMF #1)
- Brush Street & 17th Street (#27): This signalized intersection experienced 28 collisions over the course of the five-year period. The collisions that occurred at this intersection were primarily broadside (54%) of which 80% of the collisions involved a violation of traffic signals and signs as the primary collision factor and 87% involved motorists travelling in the southbound direction. Two of the broadside collisions caused by motorists involved bicyclists resulting in complaints of pain.



Recommendations:

- Add 3-inch yellow reflective sheeting to signal backplates at the Brush Street southbound approach. (CMF #5)
- Replace 8-inch red signal heads with 12-inch signal heads at the Brush Street southbound approach. (CMF #6)

Other measures to consider include improving signal visibility, evaluating red clearance intervals, and installing an additional signal head(s). These considerations do not have 4- and 5-Star ratings and so there is less confidence in the results of the studies that produced their CMF.

- Brush Street & 18th Street (#28): This signalized intersection experienced 26 collisions over the course of the five-year period of which one collision involved a pedestrian. The collisions that occurred at this intersection were primarily broadside (69%). 88% of the broadside collisions involved a motorist travelling the southbound direction and 78% of the collisions involved a traffic signal or signs violation.

Recommendations:

- Add 3-inch yellow reflective sheeting to signal backplates at the Brush Street southbound approach. (CMF #5)
- Replace 8-inch red signal heads with 12-inch signal heads at the Brush Street southbound approach. (CMF #6)

Other measures to consider include improving signal visibility, evaluating red clearance intervals, installing an additional signal head(s), and installing high visibility crosswalks. These considerations do not have 4- and 5-Star ratings and so there is less confidence in the results of the studies that produced their CMF.

- Martin Luther King Jr. Way & 7th Street (#44): This signalized intersection experienced 25 collisions over the five-year period of which one collision involved a pedestrian and another involved a bicyclist. The collisions that occurred at this intersection were primarily broadside (76%). 53% of the broadside collisions occurred by motorists travelling in the northbound direction and 89% of the collisions involved a traffic signal or signs violation.

Recommendations:

- Road diet from 4- to 3-lanes: Evaluate Martin Luther King Jr. Way for a 4- to 3-lane road diet (CMF #4)



- Add 3-inch yellow reflective sheeting to signal backplates. (CMF #5)
- Replace 8-inch red signal heads with 12-inch signal heads. (CMF #6)

Other measures to consider include improving lighting and signal visibility, adding overhead signal heads, evaluating red clearance intervals, providing left-turn lanes, and installing high visibility crosswalks and bicycle lane markings through the intersection. These non-CEQA considerations do not have 4- and 5-Star ratings and so there is less confidence in the results of the studies that produced their CMF.

- Martin Luther King Jr. Way & 8th Street (#45): This signalized intersection experienced 13 collisions over the five-year period. Collisions that occurred were primarily broadside (69%). 66% of the broadside collisions occurred by motorists travelling in the westbound direction and 89% of the collisions involved a traffic signal or signs violation.

Recommendations:

- Road diet from 4- to 3-lanes: Evaluate Martin Luther King Jr. Way for a 4- to 3-lane road diet (CMF #4)
- Add 3-inch yellow reflective sheeting to signal backplates. (CMF #5)
- Replace 8-inch red signal heads with 12-inch signal heads. (CMF #6)

Other measures to consider include improving lighting and signal visibility, adding overhead signal heads, evaluating red clearance intervals, providing left-turn lanes, and installing high visibility crosswalks and bike lane markings through the intersection. These non-CEQA considerations do not have 4- and 5-Star ratings so there is less confidence in results of studies that produced their CMF.

- Martin Luther King Jr. Way & 11th Street (#47): This signalized intersection experienced 27 collisions over the course of the five-year period of which one collision involved a pedestrian. The collisions that occurred at this intersection were primarily broadside (93%) of which 92% involved a traffic signal or signs violation. 48% of the broadside collisions occurred by motorists travelling in the northbound direction and 40% of the broadside collisions occurred by motorists travelling in the southbound direction.

Recommendations:

- Road diet from 4- to 3-lanes: Evaluate Martin Luther King Jr. Way for a 4- to 3-lane road diet (CMF #4)
- Add 3-inch yellow reflective sheeting to signal backplates. (CMF #5)



- Replace 8-inch red signal heads with 12-inch signal heads. (CMF #6)

Other measures to consider include improving lighting and signal visibility, adding overhead signal heads, evaluating red clearance intervals, providing left-turn lanes, and installing high visibility crosswalks and bicycle lane markings through the intersection if bike lanes are provided with the road diet. These non-CEQA considerations do not have 4- and 5-Star ratings and so there is less confidence in the results of the studies that produced their CMF.

- Martin Luther King Jr. Way & 14th Street (#49): This signalized intersection experienced 26 collisions over the course of the five-year period of which one collision involved a pedestrian and another which involved a bicyclist. The collisions that occurred at this intersection were primarily broadside (55%) and sideswipe (32%). 62% of the broadside collisions occurred by motorists travelling in the northbound direction, 46% involved a traffic signals or signs violation, and 23% involved automobile right of way violations.

Recommendations:

- Road diet from 4- to 3-lanes: Evaluate Martin Luther King Jr. Way for a 4- to 3-lane road diet (CMF #4)
- Add 3-inch yellow reflective sheeting to signal backplates at the 14th Street northbound approach. (CMF #5)
- Replace 8-inch red signal heads with 12-inch signal heads at the 14th Street northbound approach. (CMF #6)

Other measures to consider include improving lighting and signal visibility, adding overhead signal heads, evaluating red clearance intervals, installing high visibility crosswalks and bicycle lane markings through the intersection if bike lanes are provided with the road diet. These considerations do not have 4- and 5-Star ratings and so there is less confidence in the results of the studies that produced their CMF.

- Martin Luther King Jr. Way & 17th Street (#51): This signalized intersection experienced 16 collisions over the course of the five-year period. The collisions that occurred at this intersection were primarily broadside (56%). 44% of the broadside collisions occurred by motorists travelling in the eastbound direction and 78% of the collisions involved traffic signals and signs violation.

Recommendations:

- Road diet from 4- to 3-lanes: Evaluate Martin Luther King Jr. Way for a 4- to 3-lane road diet (CMF #4)



- Add 3-inch yellow reflective sheeting to signal backplates at the Martin Luther King Jr. Way eastbound approach. (CMF #5)
- Replace 8-inch red signal heads with 12-inch signal heads at the Martin Luther King Jr. Way eastbound approach. (CMF #6)

Other measures to consider include improving lighting and signal visibility, upgrading signal timing, adding overhead signal heads, evaluating red clearance intervals, installing an additional signal head(s), and installing high visibility crosswalks. These considerations do not have 4- and 5-Star ratings and so there is less confidence in the results of the studies that produced their CMF.

- Broadway & 5th Street (#67): This signalized intersection experienced 37 collisions over the course of the five-year period. The collisions that occurred at this intersection were primarily sideswipe (35%) and rear-end (24%). Primary collision factors involved in these collisions were improper turning (32%), traffic signals and signs violation (24%) and unsafe speeds (14%). Broadway through 5th Street has a combination of shared lanes and lane offsets that contribute to collisions. There were three collisions involving a pedestrian and one collision involving a fatality as described in the section above. All three pedestrians were travelling in the crosswalk during the time of the collision with two pedestrians travelling in the northbound direction and one travelling in the southbound direction. Additionally, two of the three pedestrian collisions involved a motorist travelling in the eastbound direction. This intersection is currently under design review as part of the larger Oakland Alameda Access and Circulation Project.

Recommendations:

- Evaluate luminance using the lighting design criteria published by the Illuminating Engineering Society (IES). Alternatively, the City may use its own lighting design requirements. (CMF #3)
- Add 3-inch yellow reflective sheeting to signal backplates at approaches. (CMF #5)
- Replace 8-inch red signal heads with 12-inch heads at all approaches. (CMF #6)

Other measures to consider include removing one motor vehicle lane in either direction to provide bus-only lanes, removing the eastbound right-turn lane, improving signal visibility, upgrading traffic signals, evaluating red clearance intervals, and installing high visibility crosswalks and pedestrian curb extensions. These considerations do not have 4- and 5-Star ratings and so there is less confidence in the results of the studies that produced their CMF.



- Franklin Street & 8th Street (#72): This signalized intersection experienced 13 collisions over the course of the five-year period of which one collision involved a pedestrian. The collisions that occurred at this intersection were primarily sideswipe (31%) and rear-end (31%). 54% of the collisions occurred by motorists travelling in the westbound direction of which 71% involved an improper turning violation. Other primary collision factors at this intersection include unsafe speed, and unsafe backing of vehicle. The project contributes a low number of trips to the intersection. Based on TIRG guidelines, the intersection does not qualify for improvement recommendations as part of the project development.
- Webster Street & 8th Street (#74): This signalized intersection experienced 29 collisions over the course of the five-year period of which one collision involved a pedestrian. The collisions were primarily sideswipe (66%). 74% of the sideswipe collisions occurred by motorists travelling in the southbound direction and 79% of the collisions involved an improper turning violation. These crashes are consistent with drivers making lane changes to get in the correct lane for the Webster Tube. The project contributes a low number of trips to the intersection. Based on TIRG guidelines, the intersection does not qualify for improvement recommendations as part of the project development.

As shown in **Table A-2**, two study segments have a higher reported collision frequency than predicted by the HSM, as discussed below.

- Embarcadero West: Martin Luther King Junior Way to Jefferson Street (#16): This segment experienced two collisions over the course of the five-year period. One collision involved a hit object and the reason for the other collision was not stated in the data. Both collisions resulted in property damage. The Project would change this segment of Embarcadero West to a bike and pedestrian corridor.
- Embarcadero West: Washington Street to Broadway (#19): This segment experienced two collisions over the course of the five-year period. One collision involved a hit object and the second involved an overturn which resulted in an injury. The project contributes a low number of trips to the segment. Railroad improvements proposed with the Project would change this segment of Embarcadero West to a bike and pedestrian corridor.

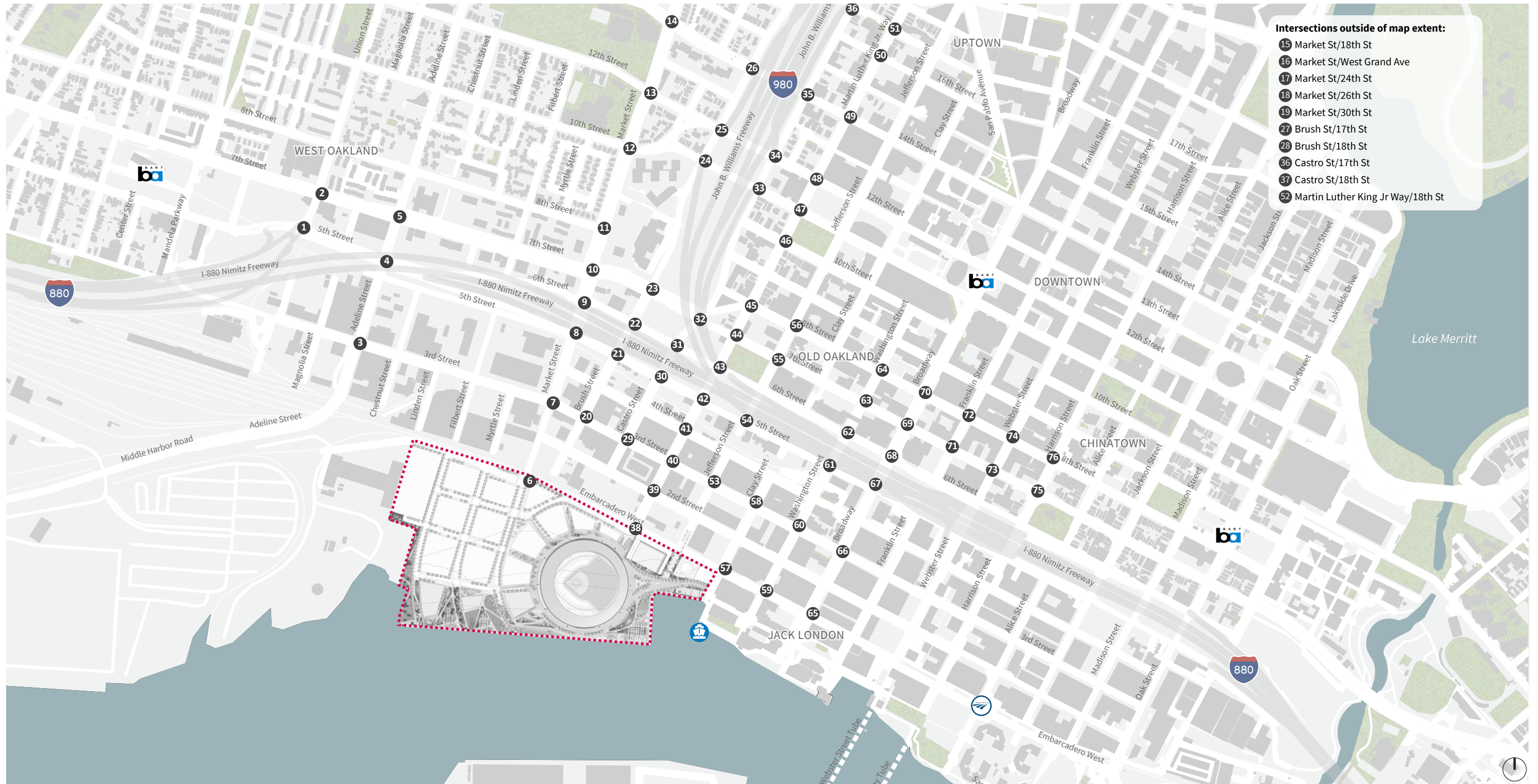
Attachments:

Figure 1 – Study Intersections

Figure 2 – Study Segments

Appendix A – HSM Critical Rate Analysis Worksheets

Appendix B – Critical Crash Rate Methodology



- Intersections outside of map extent:**
- 15 Market St/18th St
 - 16 Market St/West Grand Ave
 - 17 Market St/24th St
 - 18 Market St/26th St
 - 19 Market St/30th St
 - 27 Brush St/17th St
 - 28 Brush St/18th St
 - 36 Castro St/17th St
 - 37 Castro St/18th St
 - 52 Martin Luther King Jr Way/18th St

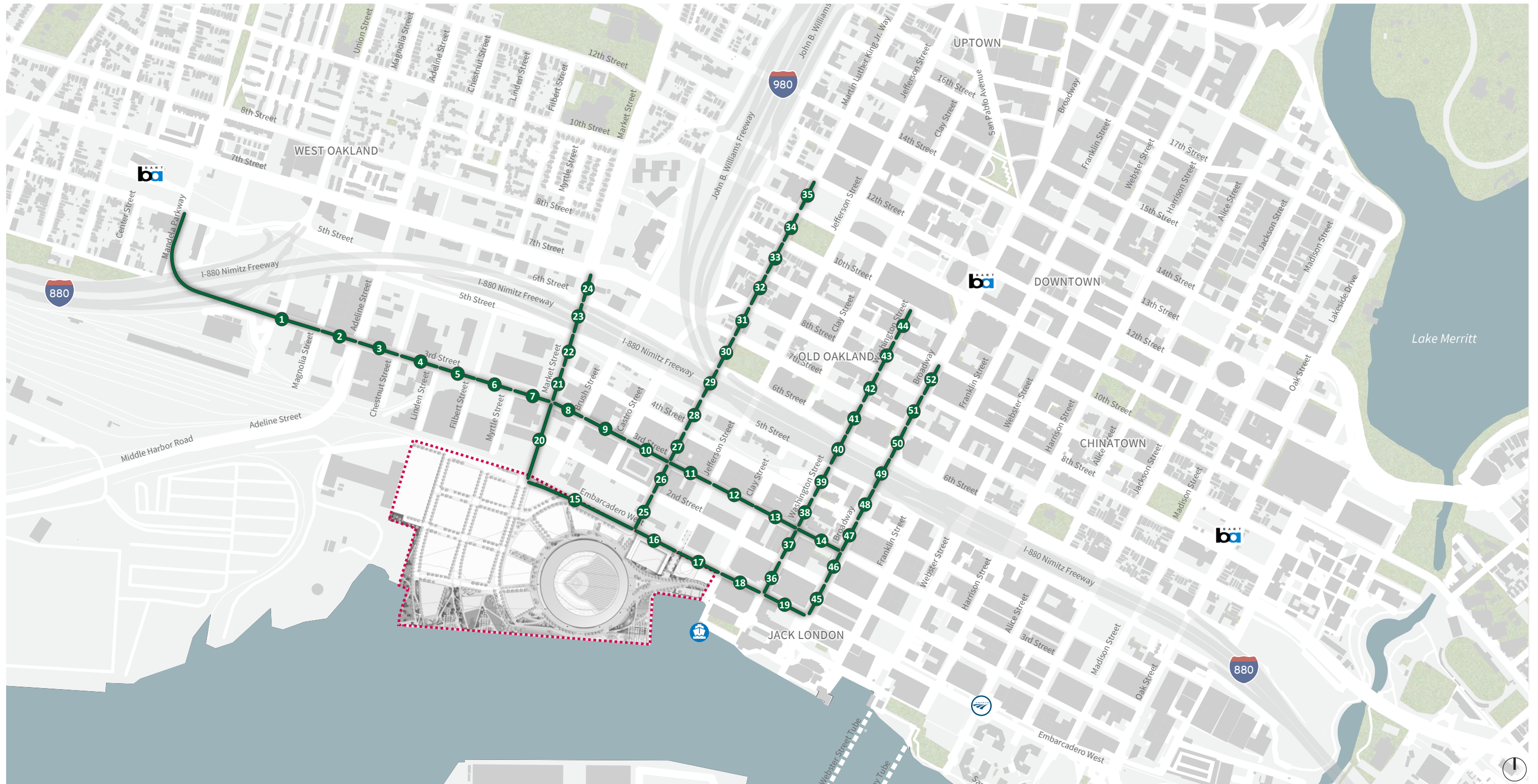
- LEGEND**
- Project Boundary
 - Study Intersection



- BART Station
- Amtrak
- Ferry



Figure 1

Study Intersection Locations



- LEGEND**
-  Project Boundary
 -  Study Segment




-  BART Station
-  Amtrak
-  Ferry



Figure 2

Study Segment Locations



APPENDIX A – HSM Critical Rate Analysis Worksheets

**TABLE A-1
CRITICAL RATE ANALYSIS - INTERSECTION COLLISIONS**

Int ID	Intersection	AADT Entering Intersection [a]	5 Year MEV [b]	5 Year Crash Total	Int Type [c]	Crash Rate [d]	Ref Crash Rate [e]	Critical Rate [f]	Over Critical [g]
1	Union St/5th St	19,420	35	5	Urban 4SG	0.14	0.53	0.75	Under
2	Union St/7th St	18,190	33	16	Urban 4SG	0.48	0.53	0.76	Under
3	Adeline St/3rd St	11,460	21	7	Urban 5+SG	0.33	0.49	0.77	Under
4	Adeline St/5th St	15,750	29	14	Urban 4SG	0.49	0.53	0.77	Under
5	Adeline St/7th St	21,570	39	13	Urban 4SG	0.33	0.53	0.74	Under
6	Market St/Embarcadero	1,500	3	0	Urban 4ST	0.00	0.33	1.08	Under
7	Market St/3rd	9,910	18	14	Urban 4ST	0.77	0.33	0.58	Over
8	Market St/5th St	10,640	19	31	Urban 4SG	1.60	0.53	0.83	Over
9	Market St/6th St	7,400	14	4	Urban 5+SG	0.30	0.49	0.84	Under
10	Market St/7th St	23,790	43	19	Urban 4SG	0.44	0.53	0.73	Under
11	Market St/8th St	9,510	17	9	Urban 4SG	0.52	0.53	0.85	Under
12	Market St/10th St	9,160	17	8	Urban 4SG	0.48	0.53	0.86	Under
13	Market St/12th St	7,600	14	6	Urban 4SG	0.43	0.53	0.89	Under
14	Market St/14th St	18,470	34	11	Urban 4SG	0.33	0.53	0.75	Under
15	Market St/18th St	11,300	21	13	Urban 4SG	0.63	0.53	0.82	Under
16	Market St/24th St	6,060	11	4	Urban 4ST	0.36	0.33	0.66	Under
17	Market St/26th St	5,940	11	7	Urban 4SG	0.65	0.53	0.94	Under
18	Market St/West Grand	22,150	40	18	Urban 4SG	0.45	0.53	0.73	Under
19	Market St/San Pablo Av	17,620	32	3	Urban 5+SG	0.09	0.49	0.71	Under
20	Brush St/3rd St	8,610	16	11	Urban 4ST	0.70	0.33	0.60	Over
21	Brush St/5th St	13,950	25	13	Urban 4SG	0.51	0.53	0.79	Under
22	Brush St/6th St	6,050	11	3	Urban 4SG	0.27	0.53	0.94	Under
23	Brush St/7th St	27,120	49	16	Urban 4SG	0.32	0.53	0.71	Under
24	Brush St/11th St	20,420	37	12	Urban 5+SG	0.32	0.49	0.69	Under
25	Brush St/12th St	19,420	35	23	Urban 5+SG	0.65	0.49	0.70	Under
26	Brush St/14th St	18,310	33	14	Urban 4SG	0.42	0.53	0.76	Under
27	Brush St/17th St	9,960	18	28	Urban 5+SG	1.54	0.49	0.79	Over
28	Brush St/18th St	18,800	34	26	Urban 5+SG	0.76	0.49	0.70	Over
29	Castro St/3rd St	7,630	14	0	Urban 4ST	0.00	0.33	0.62	Under
30	Castro St/5th St	14,620	27	11	Urban 4ST	0.41	0.33	0.53	Under
31	Castro St/6th St	4,960	9	3	Urban 4SG	0.33	0.53	0.99	Under
32	Castro St/7th St	23,530	43	5	Urban 5+SG	0.12	0.49	0.68	Under
33	Castro St/11th St	21,400	39	18	Urban 5+SG	0.46	0.49	0.69	Under
34	Castro St/12th St	22,810	42	20	Urban 5+SG	0.48	0.49	0.68	Under
35	Castro St/14th St	17,840	33	19	Urban 4SG	0.58	0.53	0.76	Under
36	Castro St/17th St	20,080	37	19	Urban 5+SG	0.52	0.49	0.70	Under
37	Castro St/18th St	20,160	37	7	Urban 5+SG	0.19	0.49	0.70	Under
38	Martin Luther King Jr Way/Embarcadero	2,620	5	0	Urban 4ST	0.00	0.33	0.87	Under
39	Martin Luther King Jr Way/2nd St	3,870	7	1	Urban 4ST	0.14	0.33	0.76	Under
40	Martin Luther King Jr Way/3rd St	8,960	16	4	Urban 4ST	0.24	0.33	0.59	Under
41	Martin Luther King Jr Way/4th St	6,490	12	2	Urban 4ST	0.17	0.33	0.65	Under
42	Martin Luther King Jr Way/5th St	14,780	27	19	Urban 4SG	0.70	0.53	0.78	Under

**TABLE A-1
CRITICAL RATE ANALYSIS - INTERSECTION COLLISIONS**

Int ID	Intersection	AADT Entering Intersection [a]	5 Year MEV [b]	5 Year Crash Total	Int Type [c]	Crash Rate [d]	Ref Crash Rate [e]	Critical Rate [f]	Over Critical [g]
43	Martin Luther King Jr Way/6th St	4,320	8	2	Urban 4SG	0.25	0.53	1.02	Under
44	Martin Luther King Jr Way/7th St	16,330	30	25	Urban 4SG	0.84	0.53	0.77	Over
45	Martin Luther King Jr Way/8th St	7,120	13	13	Urban 5+SG	1.00	0.49	0.85	Over
46	Martin Luther King Jr Way/10th St	4,270	8	6	Urban 4SG	0.77	0.53	1.03	Under
47	Martin Luther King Jr Way/11th St	9,570	17	27	Urban 4SG	1.55	0.53	0.85	Over
48	Martin Luther King Jr Way/12th St	11,040	20	9	Urban 4SG	0.45	0.53	0.83	Under
49	Martin Luther King Jr Way/14th St	15,350	28	22	Urban 4SG	0.79	0.53	0.78	Over
50	Martin Luther King Jr Way/16th St	5,660	10	3	Urban 4SG	0.29	0.53	0.96	Under
51	Martin Luther King Jr Way/17th St	7,760	14	16	Urban 4SG	1.13	0.53	0.89	Over
52	Martin Luther King Jr Way/18th St	7,900	14	6	Urban 4SG	0.42	0.53	0.88	Under
53	Jefferson St/3rd St	6,030	11	2	Urban 4ST	0.18	0.33	0.66	Under
54	Jefferson St/5th St	11,630	21	6	Urban 4SG	0.28	0.53	0.82	Under
55	Jefferson St/7th St	16,880	31	13	Urban 4SG	0.42	0.53	0.77	Under
56	Jefferson St/8th St	6,080	11	5	Urban 4SG	0.45	0.53	0.94	Under
57	Clay St/Embarcadero West	3,350	6	2	Urban 4ST	0.33	0.33	0.79	Under
58	Clay St/3rd St	6,940	13	3	Urban 4ST	0.24	0.33	0.63	Under
59	Washington St/Embarcadero West	3,500	6	3	Urban 4ST	0.47	0.33	0.78	Under
60	Washington St/3rd St	7,900	14	0	Urban 4ST	0.00	0.33	0.61	Under
61	Washington St/5th St	14,810	27	15	Urban 4SG	0.55	0.53	0.78	Under
62	Washington St/6th St	4,100	7	7	Urban 4SG	0.94	0.53	1.04	Under
63	Washington St/7th St	18,480	34	5	Urban 4SG	0.15	0.53	0.75	Under
64	Washington St/8th St	5,840	11	8	Urban 4SG	0.75	0.53	0.95	Under
65	Broadway/Embarcadero West	5,140	9	5	Urban 4ST	0.53	0.33	0.69	Under
66	Broadway/3rd St	10,030	18	12	Urban 4SG	0.66	0.53	0.84	Under
67	Broadway/5th St	25,670	47	37	Urban 5+SG	0.79	0.49	0.67	Over
68	Broadway/6th St	15,990	29	20	Urban 4SG	0.69	0.53	0.77	Under
69	Broadway/7th St	29,200	53	26	Urban 4SG	0.49	0.53	0.71	Under
70	Broadway/8th St	15,250	28	13	Urban 4SG	0.47	0.53	0.78	Under
71	Franklin St/7th St	20,110	37	6	Urban 4SG	0.16	0.53	0.75	Under
72	Franklin St/8th St	7,940	14	13	Urban 4SG	0.90	0.53	0.88	Over
73	Webster St/7th St	29,060	53	25	Urban 5+SG	0.47	0.49	0.66	Under
74	Webster St/8th St	16,680	30	29	Urban 4SG	0.95	0.53	0.77	Over
75	Harrison St/7th St	31,360	57	35	Urban 4SG	0.61	0.53	0.70	Under
76	Harrison St/8th St	16,670	30	17	Urban 4SG	0.56	0.53	0.77	Under

Notes:

Based on 2010 Highway Safety Manual Critical Rate Methodology

[a] AADT = (PM peak hour intersection volume)*k-factor

[b] 5-year MEV = (AADT)*5*365/1,000,000

[c] 3ST = 3 legged stop-controlled intersections

4ST = 4 legged stop-controlled intersections

3SG = 3 legged signalized intersection

4SG = 4 legged signalized intersection

**TABLE A-1
CRITICAL RATE ANALYSIS - INTERSECTION COLLISIONS**

Int ID	Intersection	AADT Entering Intersection [a]	5 Year MEV [b]	5 Year Crash Total	Int Type [c]	Crash Rate [d]	Ref Crash Rate [e]	Critical Rate [f]	Over Critical [g]
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5+ SG = 5 or more legged signalized intersection

[d] Crash rate = (5-Year Crash Total)/(5-Year MEV)

[e] Ref. Crash Rate = weighted average crash rate based on local data by intersection type

[f] Critical Rate is based on 95% confidence interval

[g] Intersections with a crash rate greater than Critical Rate are flagged for further review, these locations are shown in bold

**TABLE A-2
CRITICAL RATE ANALYSIS - SEGMENT COLLISIONS**

Seg ID	Segment	AADT Entering Intersection [a]	Segment Length	5 Year MVMT [b]	5 Year Crash Total	Segment Type [c]	Crash Rate [d]	Ref Crash Rate [e]	Critical Rate [f]	Over Critical [g]
1	3rd Street: Union Street to Magnolia Street	3,630	0	0	1	Urban 2U	2.42	0.63	3.86	Under
2	3rd Street: Magnolia Street to Adeline Street	3,630	0	0	0	Urban 2U	0.00	0.63	4.08	Under
3	3rd Street: Adeline Street to Chestnut Street	4,100	0	0	0	Urban 2U	0.00	0.63	3.58	Under
4	3rd Street: Chestnut Street to Linden Street	4,100	0	0	0	Urban 2U	0.00	0.63	3.67	Under
5	3rd Street: Linden Street to Filbert Street	4,100	0	0	0	Urban 2U	0.00	0.63	3.70	Under
6	3rd Street: Filbert Street to Myrtle Street	8,200	0	1	0	Urban 2U	0.00	0.63	2.59	Under
7	3rd Street: Myrtle Street to Market Street	8,270	0	1	0	Urban 2U	0.00	0.63	2.50	Under
8	3rd Street: Market Street to Brush Street	8,010	0	1	0	Urban 2U	0.00	0.63	2.83	Under
9	3rd Street: Brush Street to Castro Street	6,860	0	1	0	Urban 2U	0.00	0.63	2.56	Under
10	3rd Street: Castro Street to Martin Luther King Jr Way	6,450	0	1	0	Urban 2U	0.00	0.63	2.64	Under
11	3rd Street: Martin Luther King Jr Way to Jefferson Street	5,730	0	1	2	Urban 2U	2.66	0.63	2.80	Under
12	3rd Street: Jefferson Street to Clay Street	5,560	0	1	0	Urban 2U	0.00	0.63	2.86	Under
13	3rd Street: Clay Street to Washington Street	5,460	0	1	0	Urban 2U	0.00	0.63	2.87	Under
14	3rd Street: Washington Street to Broadway	5,160	0	1	0	Urban 2U	0.00	0.63	2.91	Under
15	Embarcadero West: Market Street to Martin Luther King Jr Way	610	0	0	0	Urban 2U	0.00	0.63	6.19	Under
16	Embarcadero West: Martin Luther King Jr Way to Jefferson Street	1,470	0	0	2	Urban 2U	10.09	0.63	6.08	Over
17	Embarcadero West: Jefferson Street to Clay Street	1,470	0	0	1	Urban 2U	5.25	0.63	6.24	Under
18	Embarcadero West: Clay Street to Washington Street	2,540	0	0	0	Urban 2U	0.00	0.63	4.42	Under
19	Embarcadero West: Washington Street to Broadway	2,880	0	0	2	Urban 2U	5.02	0.63	3.95	Over
20	Market Street: Embarcadero West to 3rd Street	1,140	0	0	1	Urban 4U	3.85	0.89	5.86	Under
21	Market Street: 3rd Street to 4th Street	2,500	0	0	0	Urban 4D	0.00	0.53	4.97	Under
22	Market Street: 4th Street to 5th Street	2,750	0	0	0	Urban 4D	0.00	0.53	4.62	Under
23	Market Street: 5th Street to 6th Street	2,940	0	0	0	Urban 4D	0.00	0.53	4.81	Under
24	Market Street: 6th Street to 7th Street	4,610	0	0	0	Urban 4D	0.00	0.53	3.59	Under
25	Martin Luther King Jr Way: Embarcadero West to 2nd Street	1,990	0	0	1	Urban 4U	4.41	0.89	6.36	Under
26	Martin Luther King Jr Way: 2nd Street to 3rd Street	2,950	0	0	0	Urban 4U	0.00	0.89	5.61	Under
27	Martin Luther King Jr Way: 3rd Street to 4th Street	2,870	0	0	0	Urban 4U	0.00	0.89	5.64	Under
28	Martin Luther King Jr Way: 4th Street to 5th Street	4,240	0	0	0	Urban 4U	0.00	0.89	4.54	Under
29	Martin Luther King Jr Way: 5th Street to 6th Street	3,160	0	0	0	Urban 4U	0.00	0.89	5.39	Under
30	Martin Luther King Jr Way: 6th Street to 7th Street	2,230	0	0	0	Urban 4U	0.00	0.89	6.56	Under
31	Martin Luther King Jr Way: 7th Street to 8th Street	2,590	0	0	0	Urban 4U	0.00	0.89	6.06	Under
32	Martin Luther King Jr Way: 8th Street to 9th Street	2,520	0	0	0	Urban 4U	0.00	0.89	6.03	Under
33	Martin Luther King Jr Way: 9th Street to 10th Street	3,130	0	0	1	Urban 4U	3.36	0.89	5.42	Under
34	Martin Luther King Jr Way: 10th Street to 11th Street	3,190	0	0	0	Urban 4U	0.00	0.89	5.31	Under
35	Martin Luther King Jr Way: 11th Street to 12th Street	2,960	0	0	0	Urban 4U	0.00	0.89	5.54	Under
36	Washington Street: Embarcadero West to 2nd Street	1,020	0	0	0	Urban 2U	0.00	0.63	9.60	Under
37	Washington Street: 2nd Street to 3rd Street	2,030	0	0	0	Urban 2U	0.00	0.63	6.12	Under
38	Washington Street: 3rd Street to 4th Street	3,010	0	0	0	Urban 2U	0.00	0.63	4.81	Under
39	Washington Street: 4th Street to 5th Street	4,200	0	0	0	Urban 2U	0.00	0.63	3.90	Under
40	Washington Street: 5th Street to 6th Street	2,830	0	0	0	Urban 2U	0.00	0.63	4.95	Under
41	Washington Street: 6th Street to 7th Street	2,680	0	0	0	Urban 2U	0.00	0.63	5.18	Under
42	Washington Street: 7th Street to 8th Street	2,090	0	0	0	Urban 2U	0.00	0.63	6.00	Under
43	Washington Street: 8th Street to 9th Street	1,760	0	0	0	Urban 2U	0.00	0.63	6.81	Under
44	Washington Street: 9th Street to 10th Street	1,760	0	0	0	Urban 2U	0.00	0.63	6.72	Under
45	Broadway: Embarcadero West to 2nd Street	2,730	0	0	1	Urban 4D	3.78	0.53	4.75	Under

TABLE A-2 CRITICAL RATE ANALYSIS - SEGMENT COLLISIONS										
Seg ID	Segment	AADT Entering Intersection [a]	Segment Length	5 Year MVMT [b]	5 Year Crash Total	Segment Type [c]	Crash Rate [d]	Ref Crash Rate [e]	Critical Rate [f]	Over Critical [g]
46	Broadway: 2nd Street to 3rd Street	3,970	0	0	1	Urban 4D	2.56	0.53	3.72	Under
47	Broadway: 3rd Street to 4th Street	6,360	0	1	1	Urban 4D	1.65	0.53	2.89	Under
48	Broadway: 4th Street to 5th Street	8,800	0	1	0	Urban 4D	0.00	0.53	2.41	Under
49	Broadway: 5th Street to 6th Street	9,870	0	1	0	Urban 4D	0.00	0.53	2.30	Under
50	Broadway: 6th Street to 7th Street	12,260	0	1	0	Urban 4D	0.00	0.53	2.01	Under
51	Broadway: 7th Street to 8th Street	10,650	0	1	1	Urban 4D	0.99	0.53	2.21	Under
52	Broadway: 8th Street to 9th Street	11,130	0	1	0	Urban 4D	0.00	0.53	2.15	Under

Notes:

Based on 2010 Highway Safety Manual Critical Rate methodology

[a] AADT = (PM peak hour intersection volume)*k-factor

[b] 5-year MVMT = (AADT)*5*365/1,000,000

[c] Urban 2U = Urban 2-lane undivided roadway

Urban 3T = Urban 3-lane roadway with a two-way left-turn lane

Urban 4U = Urban 4-lane undivided roadway

Urban 4D = Urban 4-lane divided roadway

Urban 5T = Urban 5-lane roadway with a two-way left-turn lane

[d] Crash rate = (5-Year Crash Total)/(5-Year MEV)

[e] Ref. Crash Rate = weighted average crash rate based on local data by intersection type

[f] Critical Rate is based on 95% confidence interval

[g] Intersections with a crash rate greater than Critical Rate are flagged for further review, these locations are shown in bold



APPENDIX B – Critical Crash Rate Methodology

This methodology is presented in the Highway Safety Manual, Part B, Chapter 4, Section 4.4.2.5.

Step 1: At each intersection, calculate the volume on a Million Entering Vehicle (MEV) basis

$$MEV = \frac{AADT \times 365 \times n}{1,000,000}$$

MEV = Million Entering Years

n = Number of Years

Step 2: Calculate the crash rate at each intersection

$$R = \frac{\text{Crash Total}}{MEV_n}$$

R = Observed Crash Rate

Step 3: Calculate the average crash per population

Divide the intersections into varying populations (groups) based on operational (e.g., signalized, stop-controlled, roundabout) and/or geometric (e.g., three-leg, four-leg) differences.

$$R_a = \frac{\sum_{i=1} (N_{obs,i})}{\sum_{i=1} (MEV_i)}$$

R_a = Average crash rate for reference population a

Step 4: Calculate a critical crash rate for each intersection

$$R_c = R_a + \text{Confidence Level} \times \sqrt{\frac{R_a}{MEV_n} + \frac{1}{2 \times MEV_n}}$$

R_c = Critical Crash Rate

Table 4-9 in the Highway Safety Manual gives P-levels to correspond to differing confidence levels. Typical use would be 95% confidence (P=1.645).

Step 5: Compare observed crash rate with critical crash rate

Compare the critical crash rate with the crash rate for each intersection. Any intersection with a crash rate that exceeds its critical rate should be flagged for further review.