



8950 Cal Center Dr Suite 340
Sacramento, CA 9826-3225
916.368-2000
www.dksassociates.com

MEMORANDUM

DATE: February 22, 2019

TO: Ryan Kohagura, Cynthia Smith, Kin Yeung, and Jasdeep Randhawa - Caltrans

FROM: John Long and John Gibb - DKS Associates

SUBJECT: SR 51 Travel Demand Model Validation

Caltrans has contracted with DKS Associates to evaluate a range of alternative improvements on State Route 51 (SR 51) between the post miles 1.0 and 4.4 in Sacramento County. The latest available version of SACOG's regional activity-based travel demand model (SACSIM) will be utilized to develop project forecasts. The memorandum describes the validation of a "focused" version of SACOG's SACSIM model to 2017 Base Year conditions based on detailed traffic count data collected on and near SR 51.

VALIDATION CRITERIA

The performance of the base year model for the 4-hour AM and PM peak periods has been evaluated using both static and dynamic validation tests. The static evaluation uses the following validation criteria outlined in Task Order 3 (03A2782):

- At least 75 % of the roadway links with traffic counts should be within the Caltrans deviation threshold, which differs based on magnitude of the count.
- Estimate of correlation between the model estimates and observed counts should be at least 0.88
- Percent root mean square error (RMSE) for the roadway links with counts in the project study area should not exceed 40%.

The Task Order also calls for three dynamic tests: add lanes to a link, add a link and subtract a link.

REVIEW OF TRAFFIC COUNT DATA

Traffic counts were obtained from the detailed data collected by Caltrans under Task Order 16 (03A2393) in September 2017. As part of that Task Order, Wood Rodgers "balanced" the mainline volumes by starting with SR 51 mainline counts near the American River (with some

volume adjustments) and then used count data for on-ramps and off-ramps to calculate mainline counts both upstream and downstream from the starting point. This balancing calculation was conducted separately for northbound and southbound flows along SR 51.

DKS identified an error in “balanced” mainline volume calculations. Wood Rodgers had subtracted the ramp volume # 66 from the northbound SR 51 mainline volume. That ramp, however, splits off from a freeway collector - not the mainline. This error affected all of the northbound mainline volumes downstream from the Arden Way off ramp. The correction adds 2,516 vehicles to the northbound 4-hour AM and 5,230 to the northbound 4-hour PM “balanced” flows.

Table 1 summarizes the “raw” and “balanced” volume data with the correction applied by DKS to the “balanced” peak hour and 4-hour flows. **Figure 1** shows existing travel lanes along SR 51 and the locations of the mainline count and “balanced” volume data

A review of the data in **Table 1** confirms that SR 51 is very congested throughout the peak periods, as indicated by the following:

- The volume during the highest hour within the four-hour AM peak period is 27 percent for the total AM four-hour traffic volume. The volume during the highest hour within the four-hour PM peak period is 25 percent of the total PM four-hour traffic volume. This demonstrates that volumes along SR 51 are extremely “flat” through a full four hour period.
- The peak hour volume per travel lane in portions of the SR 51 corridor, where substantial queueing is usually observed, is well below the typical capacity of the freeway lane - especially northbound SR 51 between US 50 and E Street during the PM peak hour.

Under these extreme levels of traffic congestion, not all travel demand is “served” along SR 51 in any hour during peak periods and it can be expected that the travel demand model will predict volumes that exceed peak hour “flows” (observed volumes). In such case, the impediments will be documented and the deviation between modeled and observed counts will be considered when developing future traffic forecasts and inputs for the operational analysis.

INITIAL BASE YEAR MODEL REVIEW AND REFINEMENT

The following steps were taken to prepare an “initial” base year model:

- DKS started with the latest version of SACOG’s SACSIM model and used available data to prepare land use inputs for a 2017 Base Year.
- DKS reviewed and updated SACOG’s networks to ensure recent transportation improvements are included in 2017 Base Year transportation networks

Table 1
Summary of SR 51 Counts and Balanced Volumes

Direction	Post mile	Segment			AM						PM						Lanes				Volume per Lane (w/o aux lane)		Pk Hr vol/ 4 Hr Vol		
		Vol #	Bal #	Location	Peak Hour			4 Hour Peak Period			Peak Hour			4 Hour Peak Period			HOV	Mixed	Aux	Total	AM	PM	AM	PM	
					Vol	Bal	Diff	Vol	Bal	Diff	Vol	Bal	Diff	Vol	Bal	Diff									
Northbound			503	Over US 50		4,293			16,784			3,087			13,166		1	3		4	1,073	772	0.256	0.234	
	0.10	98		at T St	3,990			14,299			2,940			11,781			1	3		4	998	735	0.279	0.250	
			504	between US 50 and N St		6,151			24,466			4,344			19,474		1	3	1	5	1,538	1,086	0.251	0.223	
	0.68	99	505	at P St	4,212	4,976	764	15,254	20,059	4,805	2,857	3,658	801	12,420	16,600	4,180		4		4	1,053	915	0.276	0.230	
			506	between P and H St		5,575			21,615			4,218			18,666			4	1	5	1,394	1,055	0.258	0.226	
	1.16	100	507	at J St	4,773	4,669	-104	17,785	18,413	628	3,438	4,218	780	15,068	18,666	3,598		4		4	1,193	860	0.268	0.228	
	1.50	101	508	at E St	5,126	5,121	-5	19,206	19,882	676	3,730	4,228	498	16,551	18,648	2,097		3		3	1,709	1,243	0.267	0.225	
	2.00	102	509	at North of A St	5,575	5,653	78	20,604	21,404	800	4,696	5,010	314	19,804	21,276	1,472		3		3	1,858	1,565	0.271	0.237	
	2.40	103		at Elvas UP	5,819	5,653	-166	22,966	21,404	-1,562	4,895	5,010	115	20,383	21,276	893		3		3	1,940	1,632	0.253	0.240	
	3.00	104		at Tribute Rd	6,053	5,653	-400	22,404	21,404	-1,000	5,010	5,010	0	21,276	21,276	0		3	1	4	2,018	1,670	0.270	0.235	
	3.48	105	510	EB Exposition Blvd	4,072	4,658	586	14,665	17,752	3,087	3,545	4,341	796	14,861	18,404	3,543		3	1	4	1,357	1,182	0.278	0.239	
	3.82	106		SR 160 IC	3,956			14,818			5,364			21,740				2		2	1,978	2,682	0.267	0.247	
			511	between Arden and El Camino		5,072			18,584			6,492			24,829			3	1	4	1,691	2,164	0.273	0.261	
	5.10	107	512	at Glenrose Ave	4,626	4,986	360	16,570	17,906	1,336	5,364	5,895	531	21,740	22,829	1,089		3	1	4	1,542	1,788	0.279	0.247	
			513	between Marconi and Howe		4,353			15,576			4,987			19,117			3		3	1,451	1,662	0.279	0.261	
	5.90	108		at Howe Ave	3,934			14,121			4,292			17,657				3		3	1,311	1,431	0.279	0.243	
			514	between Howe and Bell		4,540			16,155			5,164			19,738			3		3	1,513	1,721	0.281	0.262	
			515	between Bell and Fulton		4,474			15,858			5,008			19,198			3		3	1,491	1,669	0.282	0.261	
	6.87	109		at NB Fulton Ave	3,996			14,043			4,261			17,748				3		3	1,332	1,420	0.285	0.240	
			516	between Fulton and Auburn		4,996			17,359			5,775			21,978			3	1	4	1,665	1,925	0.288	0.263	
			517	between Auburn and Watt		4,767			16,565			5,413			20,756			3		3	1,589	1,804	0.288	0.261	
	7.85	110		at SB Watt Ave	4,320			15,115			4,717			19,676				3		3	1,440	1,572	0.286	0.240	
	8.05	111		at NB Watt Ave	3,876			13,580			4,423			18,287				3		3	1,292	1,474	0.285	0.242	
	8.27	112	518	at North of Watt Ave	4,589	4,994	405	16,028	17,324	1,296	5,141	5,852	711	21,235	22,222	987		3	1	4	1,530	1,714	0.286	0.242	
Southbound	8.25	121	523	at North of Watt Ave	4,529	4,794	265	18,136	19,595	1,459	4,178	4,637	459	16,156	17,994	1,838		3		3	1,510	1,393	0.250	0.259	
	7.55	120	524	at Auburn Blvd	4,995	5,337	342	20,244	21,540	1,296	4,794	5,171	377	18,318	19,913	1,595		3		3	1,665	1,598	0.247	0.262	
			525	b/w Auburn and Fulton		5,812			22,910			5,387			20,720			3		3	1,937	1,796	0.254	0.260	
	6.85	119		at NB Fulton Ave	4,955			19,052			4,082			15,892				3		3	1,652	1,361	0.247	0.257	
	6.68	118		at SB Fulton Ave	5,008			19,349			4,135			16,195				3		3	1,669	1,378	0.247	0.255	
	6.18	117	526	at Bell St	5,840	5,651	-189	22,078	21,616	-462	4,643	4,773	130	18,112	18,825	713		3		3	1,947	1,548	0.265	0.256	
			527	at Marconi		5,569			21,248			4,617			18,195			3		3	1,856	1,539	0.262	0.254	
			528	between Marconi and El Camino		7,182			26,081			5,368			21,129			3	1	4	2,394	1,789	0.275	0.254	
			529	between El Camino and Arden		7,535			27,637			5,665			22,257			3	1	4	2,512	1,888	0.273	0.255	
			530	between Arden and Exposition		5,575			20,626			4,672			18,209			3			1,858	1,557	0.270	0.257	
	3.41	116		at WB Exposition Blvd	5,439			19,896			4,367			17,161				3	1	4	1,813	1,456	0.265	0.254	
	3.32	115		at EB Exposition Blvd	5,996			20,686			5,376			21,430				3	1	4	1,999	1,792	0.265	0.251	
	2.00	114	531	at North of A St	5,978	6,075	97	22,374	22,104	-270	5,227	5,696	469	21,090	21,804	714		3		3	1,993	1,742	0.267	0.248	
			532	between E St and J St		5,699			20,680			5,300			20,413				3		3	1,900	1,767	0.276	0.260
	1.19	113	533	at J St	4,709	4,883	174	17,193	17,571	378	4,545	4,812	267	17,659	18,546	887	1	3		4	1,177	1,136	0.274	0.257	
			534	between H St and P St		5,941			20,609			5,797			21,950		1	3	1	5	1,485	1,449	0.288	0.264	
			535	between P St and N St		4,998			17,791			5,312			19,997		1	3		4	1,250	1,328	0.281	0.266	
			536	between N St and US 50 Connectors		5,903			20,708			6,800			25,406		1	3	1	5	1,476	1,700	0.285	0.268	
			537	over Us 50		3,001			10,351			4,671			16,362		1	3		4	750	1,168	0.290	0.285	
Segments substantially constrained by upstream queuing =																Average				1,600	1,515	0.27	0.25		

Figure 1 - Lane Configuration Diagram for SR 51

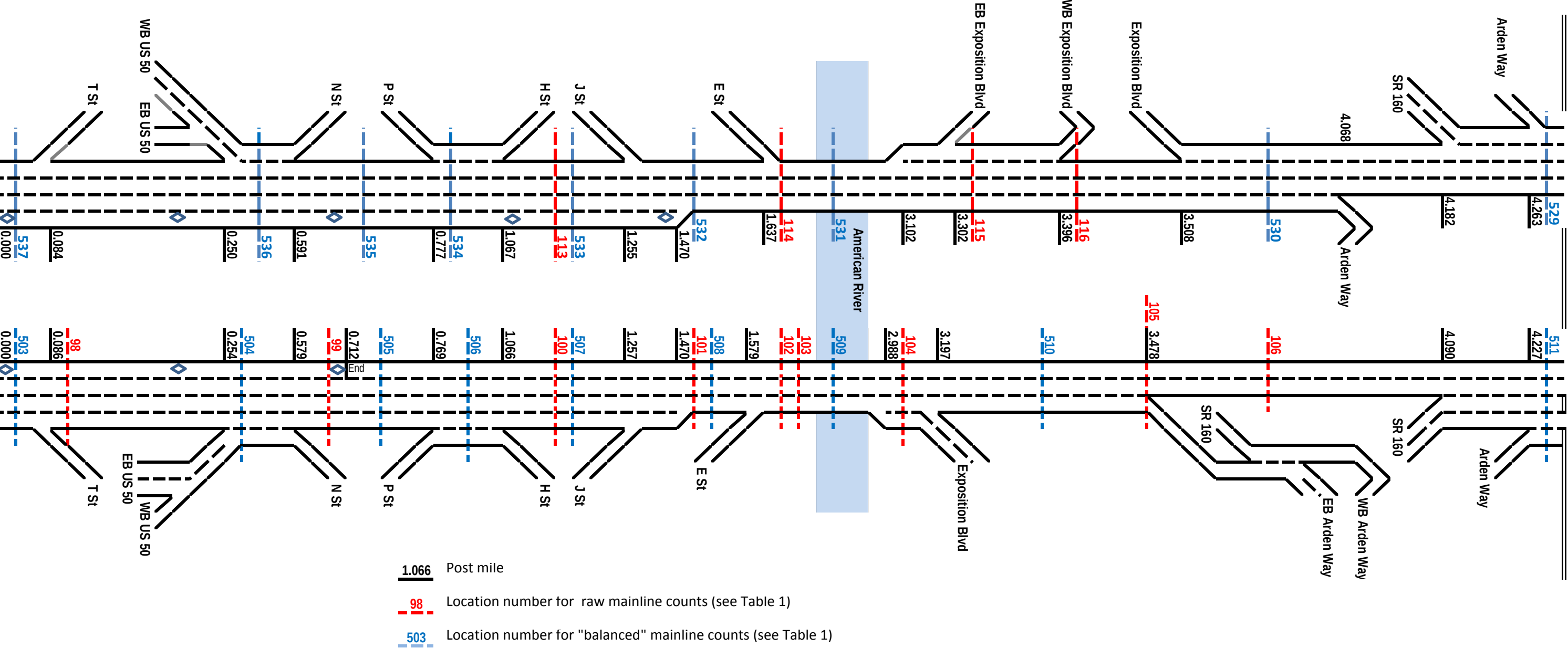
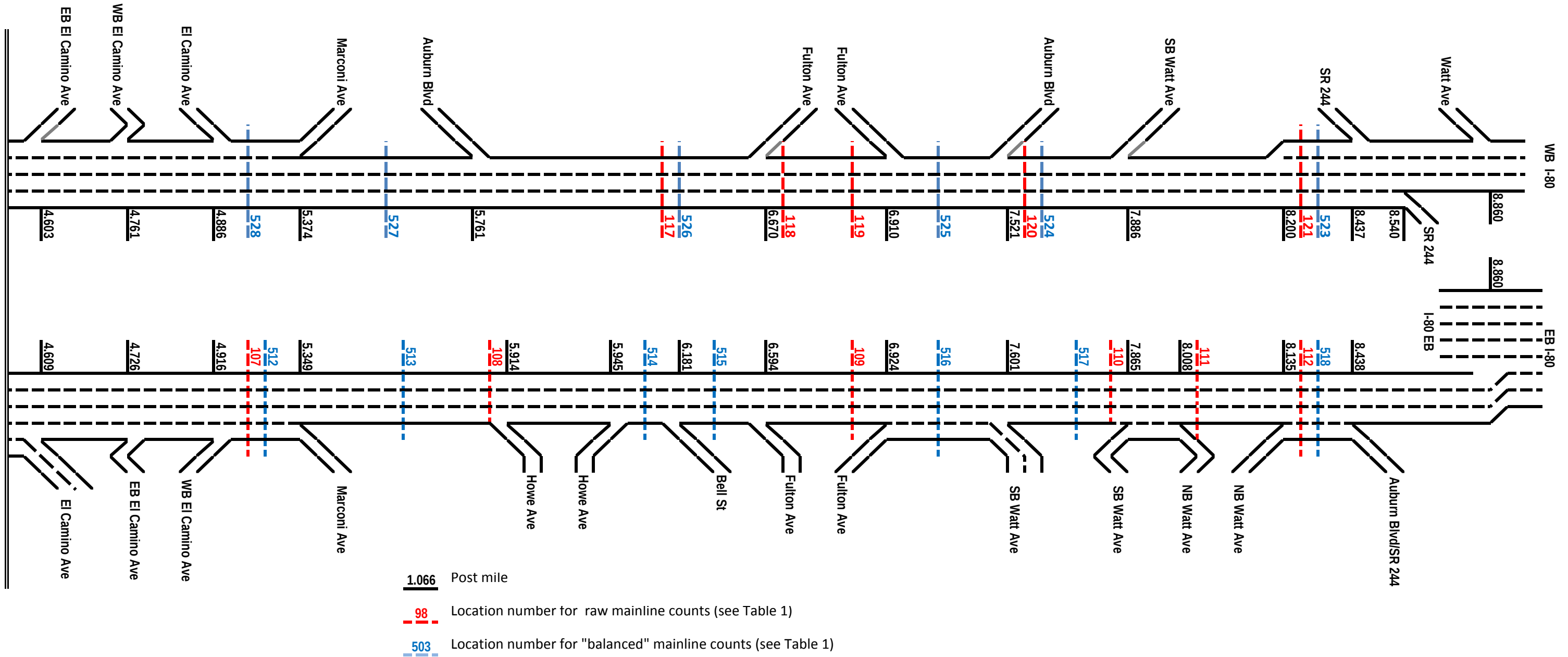


Figure 1 - Lane Configuration Diagram for SR 51



- DKS carefully reviewed SACOG’s network near SR 51 and made adjustments to number of lanes and free-flow speeds to reflect existing conditions. This review included the SR 51 mainline (HOV, mixed flow and auxiliary lanes) and ramps along SR 51, as well as on connecting roadways and key parallel roadways.

VALIDATION RUNS AND MODEL REFINEMENTS

The model validation involved iterative runs of the 2017 Base Year model with refinements during each iteration to bring predicted volumes closer to “balanced” volume data. Due to the “flat” nature of volumes throughout the peak periods, the validation focused on the 4-hour AM and PM peak periods.

During initial runs, the biggest differences between the model volumes and counts appear to occur during PM peak period in the northbound direction north of the American River. However, the error in “balanced” flow calculations (described above) was discovered. The model mainline volumes were close to the corrected mainline balanced flows.

The model refinements involved the following:

- Refinements to the model network detail in the complex ramp system at the Arden Way/SR160/SR 51 interchange
- Splitting a number of TAZs in several areas north of the American River – along with some added local roadways - to improve traffic assignments on ramps along SR 51.
- Further adjustments to model speeds and capacities on connecting roadways as well as on key parallel roadways.

STATIC VALIDATION RESULTS

Table 2 compares model volume for mainline segments of SR 51 to 4-hour “balanced” count data. **Tables 3 and 4** compare model volumes to counts on individual ramps along northbound and southbound SR 51, respectively - with separate comparisons for on-ramps and off ramps.

Caltrans guidelines for model validation utilize FHWA’s “desirable deviation” curve to define thresholds for the model volume deviation from traffic counts. The larger the actual traffic volume, the lower the desirable deviation. The FHWA curve was designed to evaluate daily volumes. The focus of the validation for SR 51, however, is the peak periods. DKS used an accepted method to scale the FHWA daily volume curve to a 4-hour volume curve using a ratio of 4-hour to daily volumes.

Figures 2 and 3 show the deviation of model volumes to counts were compared to the “desirable deviation” curve. Separate symbols are used to show the deviation of mainline volumes versus ramp volumes.

Table 5 shows the key measures for evaluating the model validation.

Table 2
Comparison - SR 51 Balanced Counts to Model Volumes

Dir	Segment		AM 4 Hour			PM 4 Hour			
	No	Location	Count	Model	M/C	Count	Model	M/C	
NB	503	Over US 50	16,784	21,260	1.27	13,166	16,677	1.27	
	504	between US 50 and N St	24,466	26,526	1.08	19,474	23,255	1.19	
	505	at P St	20,059	20,799	1.04	16,600	19,078	1.15	
	506	between P St and H St	21,615	22,786	1.05	18,666	21,929	1.17	
	507	at J St	18,413	18,077	0.98	18,666	18,596	1.00	
	508	at E St	19,882	20,628	1.04	18,648	21,444	1.15	
	509	at American River	21,404	21,662	1.01	21,276	24,293	1.14	
	510	EB Exposition Blvd	17,752	15,019	0.85	18,404	17,711	0.96	
	511	between Arden Way and El Camino Ave	18,584	17,331	0.93	24,829	26,370	1.06	
	512	at Glenrose Ave	17,906	15,999	0.89	22,829	24,998	1.10	
	513	between Marconi Ave and Howe Ave	15,576	13,529	0.87	19,117	20,085	1.05	
	514	between Howe Ave and Bell St	16,155	15,167	0.94	19,738	21,945	1.11	
	515	between Bell St and Fulton Ave	15,858	14,864	0.94	19,189	21,510	1.12	
	516	between Fulton Ave and Auburn Blvd	17,359	16,918	0.97	21,978	24,195	1.10	
	517	between Auburn Blvd and Watt Ave	16,565	14,881	0.90	20,756	22,189	1.07	
	518	North of Watt Ave	17,324	15,450	0.89	22,222	23,498	1.06	
	SB	523	North of Watt Ave	19,595	18,475	0.94	17,994	14,717	0.82
		524	at Auburn Blvd	21,540	20,782	0.96	19,913	17,406	0.87
525		between Auburn and Fulton	22,910	22,714	0.99	20,720	18,946	0.91	
526		at Bell St	21,616	18,925	0.88	18,825	15,829	0.84	
527		at Marconi	21,248	18,566	0.87	18,195	15,208	0.84	
528		between Marconi and El Camino	26,081	22,494	0.86	21,129	17,625	0.83	
529		between El Camino and Arden	27,637	25,450	0.92	22,257	20,896	0.94	
530		between Arden and Exposition	20,626	19,611	0.95	18,209	17,629	0.97	
531		at North of A St	22,104	23,952	1.08	21,804	24,028	1.10	
532		between E and J	20,680	21,237	1.03	20,413	22,218	1.09	
533		at J St	17,571	16,730	0.95	18,546	19,503	1.05	
534		between H and P	20,609	19,340	0.94	21,950	24,908	1.13	
535		between P and N	17,791	15,627	0.88	19,997	22,720	1.14	
536		between N and US 50 Connectors	20,708	18,677	0.90	25,406	28,520	1.12	
537		over US 50	10,351	13,436	1.30	16,362	22,442	1.37	
Total			606,769	586,912	0.97	617,278	650,368	1.05	
M/C < 0.85						M/C > 1.15			

Table 3
Model Volume to Count Comparison - SR 51 Northbound Mainline

No	Ramp	On-Ramps						Off Ramps					
		AM 4 Hour			PM 4 Hour			AM 4 Hour			PM 4 Hour		
		Count	Model	M/C	Count	Model	M/C	Count	Model	M/C	Count	Model	M/C
2009	T St Off							1,933	2,239	1.16	836	878	1.05
44	WB US 50 On	3,022	1,997	0.66	2,926	2,992	1.02						
46	EB US 50 On	6,593	5,509	0.84	4,218	4,464	1.06						
2011	N St Off							4,407	5,727	1.30	2,874	4,178	1.45
1013	P St On	1,556	1,987	1.28	2,066	2,850	1.38						
2015	H St Off							3,202	4,708	1.47	2,491	3,333	1.34
1017	J St On	1,469	2,550	1.74	2,473	2,847	1.15						
1019	E St On	1,522	1,033	0.68	2,628	2,849	1.08						
60	EB Exposition Blvd Off							3,652	6,641	1.82	2,872	6,583	2.29
63	Arden Way Off							2,546	2,255	0.89	2,819	1,876	0.67
52	NB SR 160 On	2,381	3,636	1.53	7,998	8,016	1.00						
65	EB Arden Way On	997	930	0.93	1,246	2,521	2.02						
2025	El Camino Ave Off							1,918	2,339	1.22	3,466	3,080	0.89
70	EB El Camino Ave On	492	705	1.43	607	710	1.17						
69	WB El Camino Ave On	748	301	0.40	859	997	1.16						
2027	Marconi Ave Off							2,330	2,470	1.06	3,712	4,913	1.32
2030	Howe Ave Off							102	0	0.00	364	316	0.87
1030	Howe Ave On	681	1,638	2.41	985	2,175	2.21						
2032	Bell St Off							297	303	1.02	549	434	0.79
2033	Fulton Ave Off							377	564	1.50	428	220	0.51
1034	Fulton Ave On	1,878	1,946	1.04	3,217	2,118	0.66						
2036	Auburn Blvd Off							794	2,035	2.56	1,222	2,006	1.64
76	SB Watt Ave On	164	65	0.40	306	189	0.62						
77	NB Watt Ave Off							1,570	1,665	1.06	1,450	1,565	1.08
78	NB Watt Ave On	2,165	2,168	1.00	2,610	2,685	1.03						
79	SR 244 Off							1,364	2,352	1.72	1,415	2,938	2.08
	Total	23,668	24,465	1.03	32,139	35,413	1.10	24,492	33,298	1.36	24,498	32,320	1.32
M/C < 0.7											M/C > 1.3		

Table 4
Model Volume to Count Comparison - SR 51 Southbound Mainline

No	Ramp	On-Ramps						Off Ramps					
		AM 4 Hour			PM 4 Hour			AM 4 Hour			PM 4 Hour		
		Count	Model	M/C	Count	Model	M/C	Count	Model	M/C	Count	Model	M/C
133	Watt Ave Off							2,065	965	0.47	2,262	1,982	0.88
83	SR 244 On	1,530	2,076	1.36	1,378	1,873	1.36						
81	SR 244 Off							746	391	0.52	1,175	203	0.17
75	SB Watt Ave On	1,945	2,307	1.19	1,919	2,688	1.40						
74	Auburn Blvd On	1,370	1,931	1.41	807	1,539	1.91						
2035	Fulton Ave Off							2,125	4,702	2.21	2,801	4,179	1.49
1035	Fulton Ave On	831	914	1.10	906	1,061	1.17						
2031	Auburn Blvd Off							368	359	0.98	630	621	0.99
73	Marconi Ave On	4,833	3,928	0.81	2,934	2,417	0.82						
2026	El Camino Ave Off							977	677	0.69	1,638	935	0.57
71	WB El Camino Ave On	1,024	2,541	2.48	1,543	3,250	2.11						
72	EB El Camino Ave On	1,509	1,092	0.72	1,223	956	0.78						
2024	Arden Way Off							2,188	1,372	0.63	2,283	1,020	0.45
53	SB SR 160 Off							6,689	5,368	0.80	4,733	3,853	0.81
68	WB Arden Way On	1,866	903	0.48	2,968	1,606	0.54						
2022	Exposition Blvd Off							1,156	933	0.81	803	421	0.52
61	WB Exposition Blvd On	1,594	3,094	1.94	2,526	4,111	1.63						
62	EB Exposition Blvd On	1,040	2,178	2.09	1,872	2,708	1.45						
2020	E St Off							1,424	2,714	1.91	1,391	1,809	1.30
2018	J St Off							3,109	4,506	1.45	1,867	2,713	1.45
1016	H St On	3,038	2,609	0.86	3,404	5,404	1.59						
2014	P St Off							2,818	3,712	1.32	1,953	2,188	1.12
1012	N St On	2,917	3,052	1.05	5,409	5,800	1.07						
50	WB US 50 Off							5,176	5,721	1.11	5,436	7,824	1.44
51	EB US 50 Off							5,733	2,262	0.39	5,025	2,407	0.48
1010	T St On	552	479	0.87	1,417	1,746	1.23						
		24,049	27,104	1.13	28,306	35,159	1.24	34,574	33,682	0.97	31,997	30,155	0.94
M/C < 0.7											M/C > 1.3		

Figure 2: AM 4-hour Model Volume Deviation from Desirable Thresholds

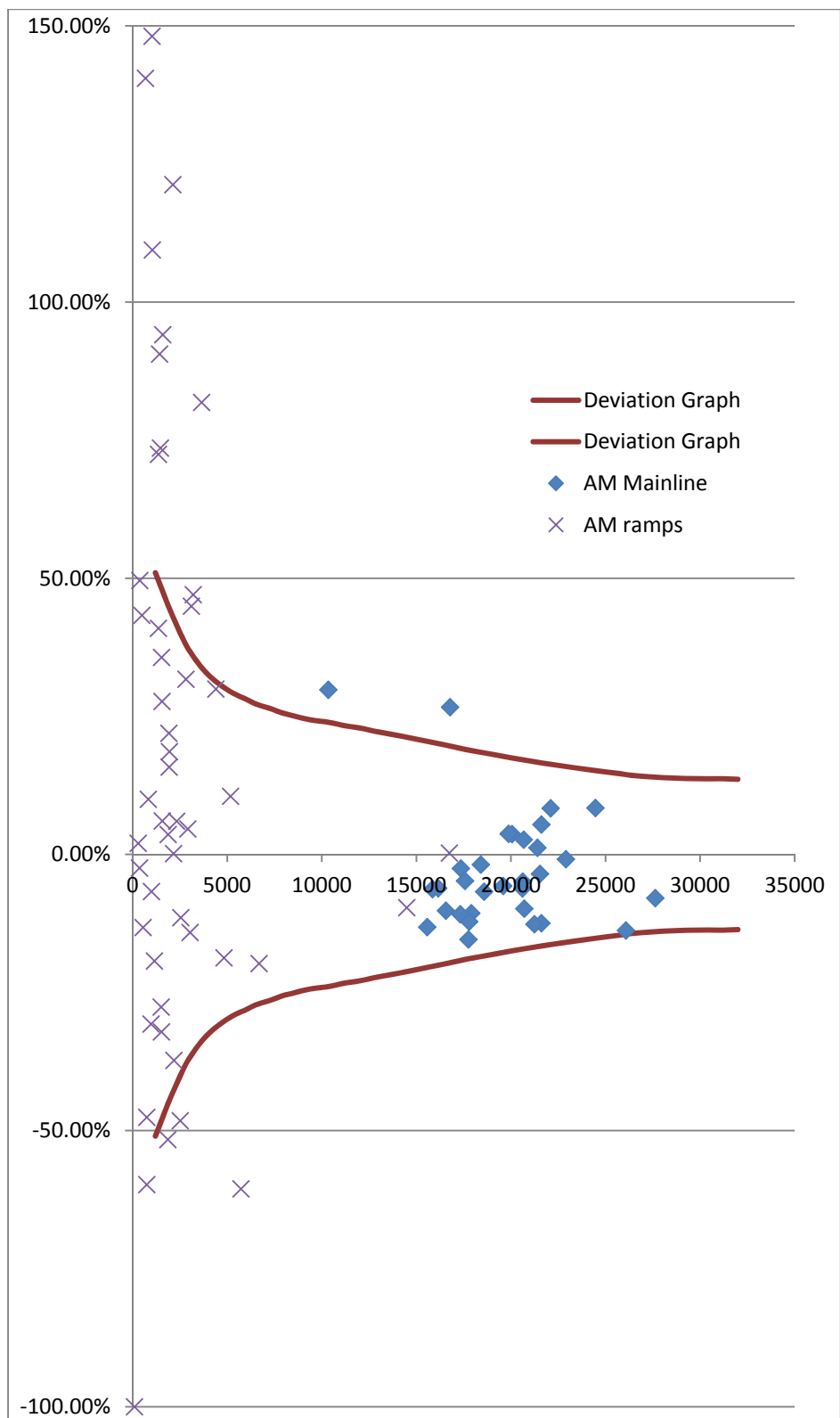


Figure 3: PM 4-hour Model Volume Deviation from Desirable Thresholds

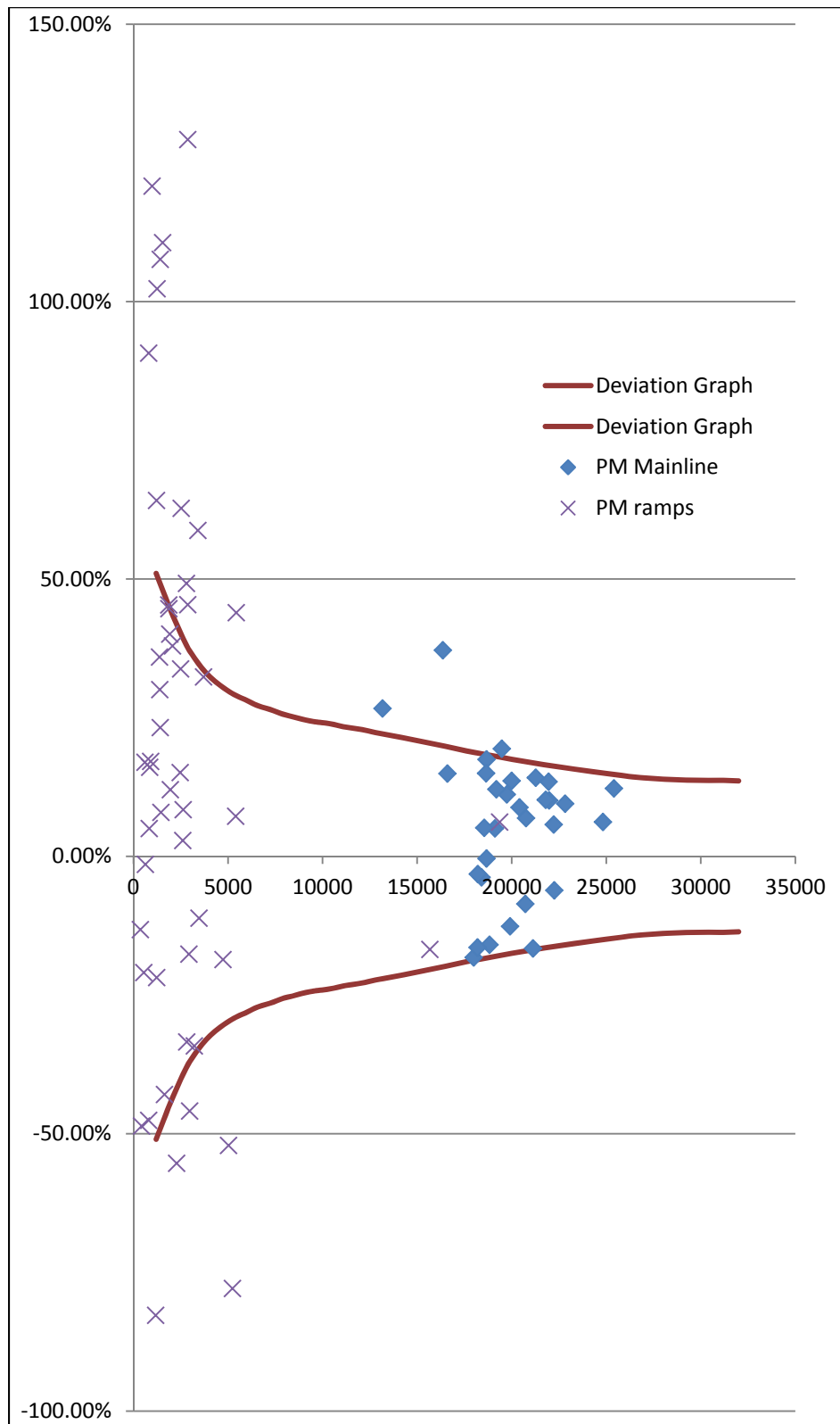


Table 5 Key Validation Measures			
Measures	AM 4 Hr	PM 4 Hr	Target
SR 51 Mainline			
Segments within Desirable Deviation	29	27	
Segments outside Desirable Deviation	2	4	
Total Segments	31	31	
Percent within	94%	87%	>75%
Correlation	0.86	0.70	>0.88
RMSE	10%	13%	<40%
Average Model/Count	0.97	1.05	
SR 51 Ramps			
Segments within Desirable Deviation	36	33	
Segments outside Desirable Deviation	15	18	
Total Segments	51	51	
Percent within	71%	65%	>75%
Correlation	0.94	0.93	>0.88
RMSE	43%	47%	<40%
Average Model/Count	1.09	1.08	

The conclusions that can be drawn from the results of the static validation tests are:

- For mainline SR 51, nearly all segments are within the desirable deviation and the percent root mean square error is acceptable. The correlation between the model estimates and observed counts is somewhat low but it is impacted by the high levels of traffic congestion and constrained flow, especially during the PM peak period. As discussed above, not all travel demand is “served” along SR 51 in any hour during peak periods and it can be expected that the travel demand model will predict volumes that exceed observed peak hour “flows”.
- The percent of ramps along SR 51 that are within the desirable deviation and the percent root mean square error are close to the target validation thresholds. The volume on many of the SR 51 ramps is low. Over 40% of the ramps have 4-hour peak period volumes less than 1,500 vehicles, which would have a desirable deviation greater than 50%. If these low volume roadways were excluded from the statistics in Table 5, the root mean square error is acceptable.

Best practice is to use the model to forecast the change in traffic volumes rather than using the forecast volume directly from the model. To account for model error, future year forecasts will be developed using the “delta method” which accounts for error between base year model estimates and observed counts.



DYNAMIC VALIDATION TEST AND RESULTS

The Task Order calls for three dynamic tests: add lanes to a link, add a link and subtract a link, which are discussed below:

Add Lanes to a link

This test involved add a transition lane to NB SR 51 between the lane drop south of E St on ramp (MP 1.47) to the beginning of existing aux lane south of Exposition Blvd off ramp (MP 2.988). Figures 4 and 5 are “delta plots” which show the change in 4-hour AM and 4-hour PM volumes on the roadway network, respectively.

The transition lane was added to a critical bottleneck on SR 51 and thus it should be expected to add a significant amount of traffic to northbound SR 51 and cause reduction on alternative routes over a wide area. Figures 4 and 5 show that the model performs as expected.

Add a link

This test involved adding the proposed American River crossing at Truxel Rd. Figures 6 and 7 are “delta plots” which show the change in 4-hour AM and 4-hour PM volumes on the roadway network, respectively.

Given the limited number and capacity of river crossings, it expected that this new link would both reduce traffic on other crossings and, due to re-distribution of trips, cause more total traffic to cross the American River. Figures 6 and 7 show that the model performs as expected.

Subtract a link

This test involved subtracting the Arden Way on- ramp to southbound 51 (existing left side mainline entrance) Figures 8 and 9 are “delta plots” which show the change in 4-hour AM and 4-hour PM volumes on the roadway network, respectively.

The on-ramp serves both eastbound and westbound Arden Way. Other ramps on the west side of SR 51 provide access to SR 160 but not to southbound SR 51. Thus it expected that removing this ramp would cause traffic to shift to the nearest ramp – the westbound Exposition Way to southbound Exposition Way on-ramp. Figures 8 and 9 show that the model performs as expected.

Figure 4
AM 4 Hr Volume Change
Add lanes to a link

red increase
green decrease

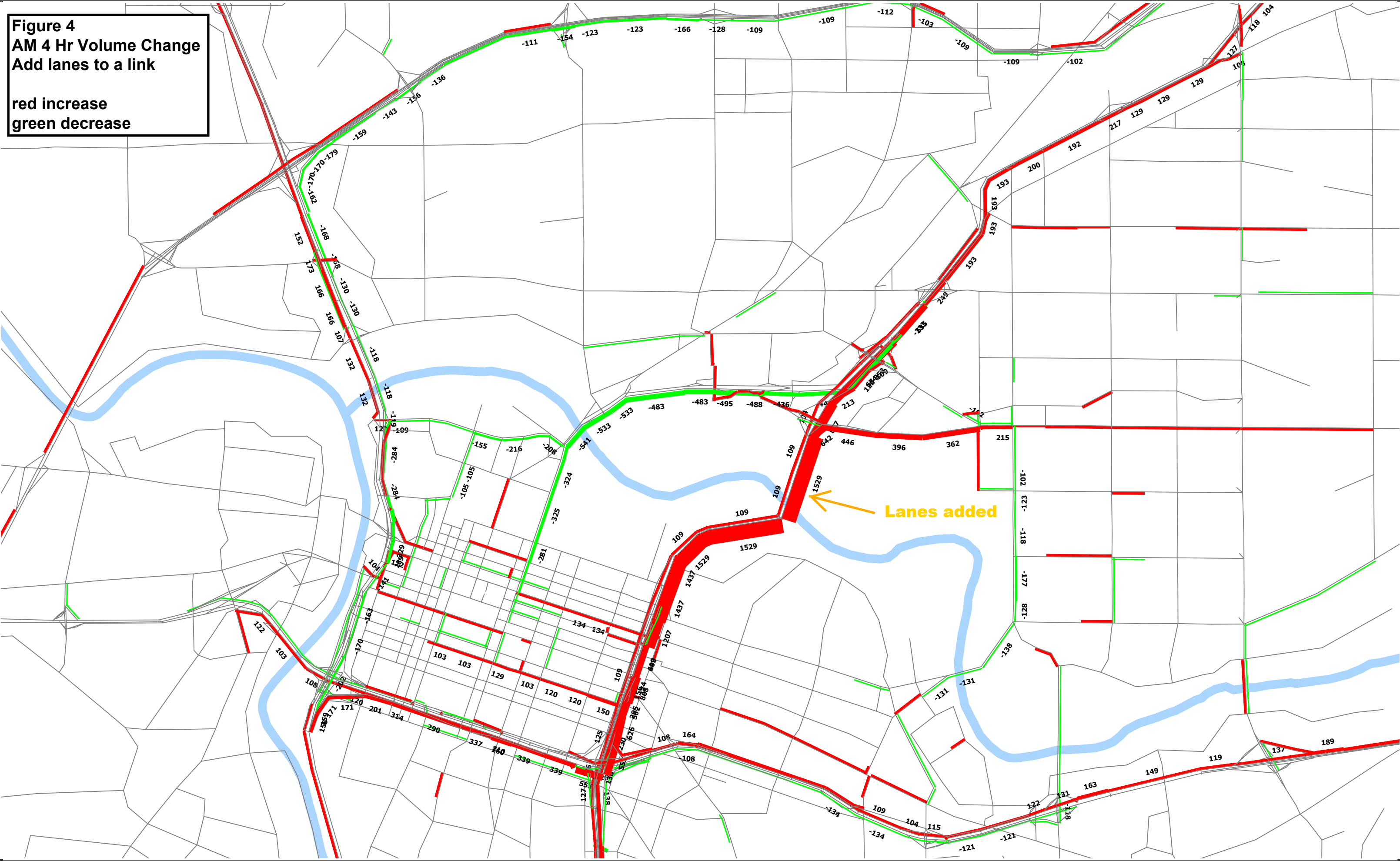


Figure 5
PM 4 Hr Volume Change
Add lanes to a link

red increase
green decrease

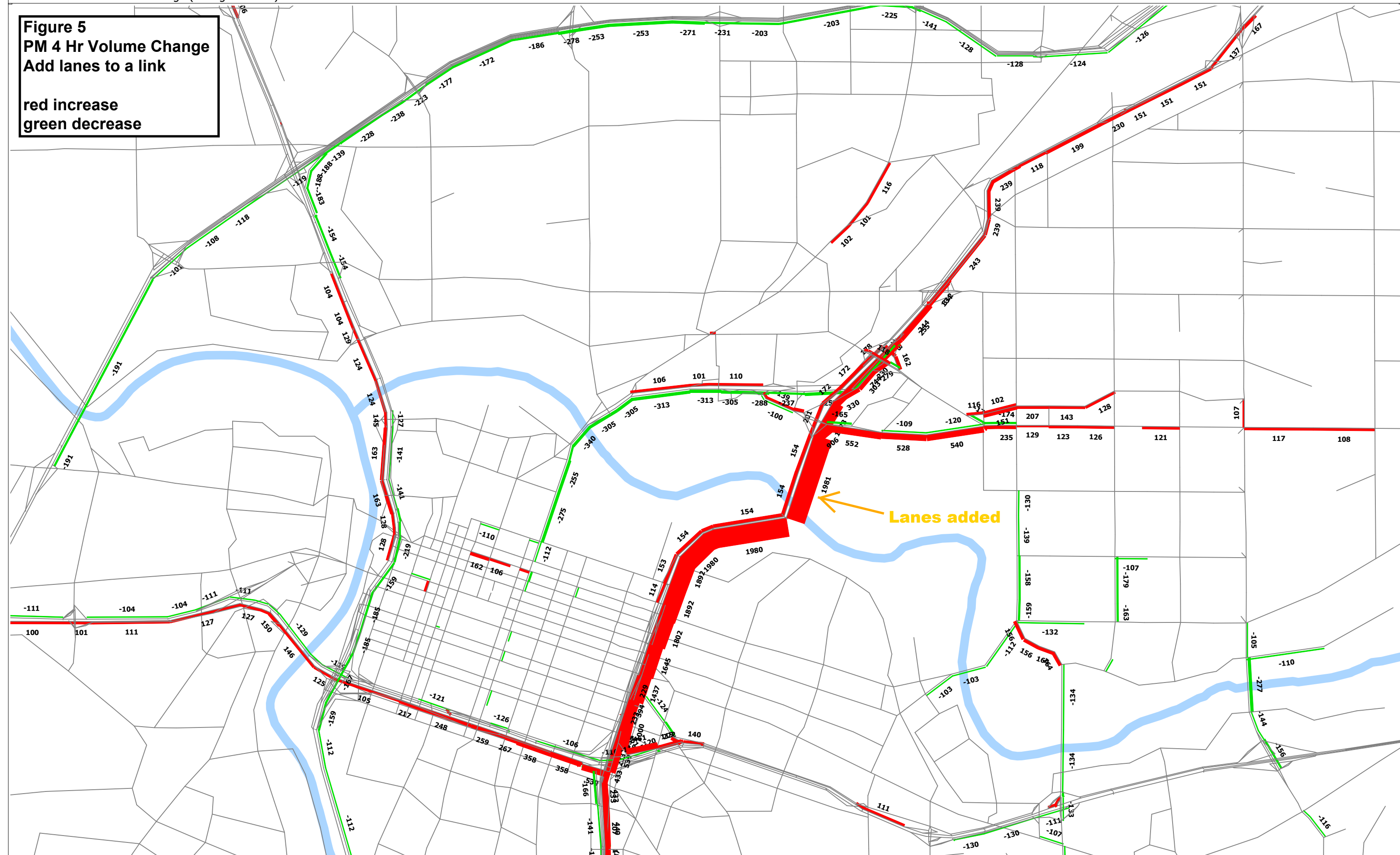


Figure 6
AM 4 Hr Volume Change
Add link

red increase
green decrease

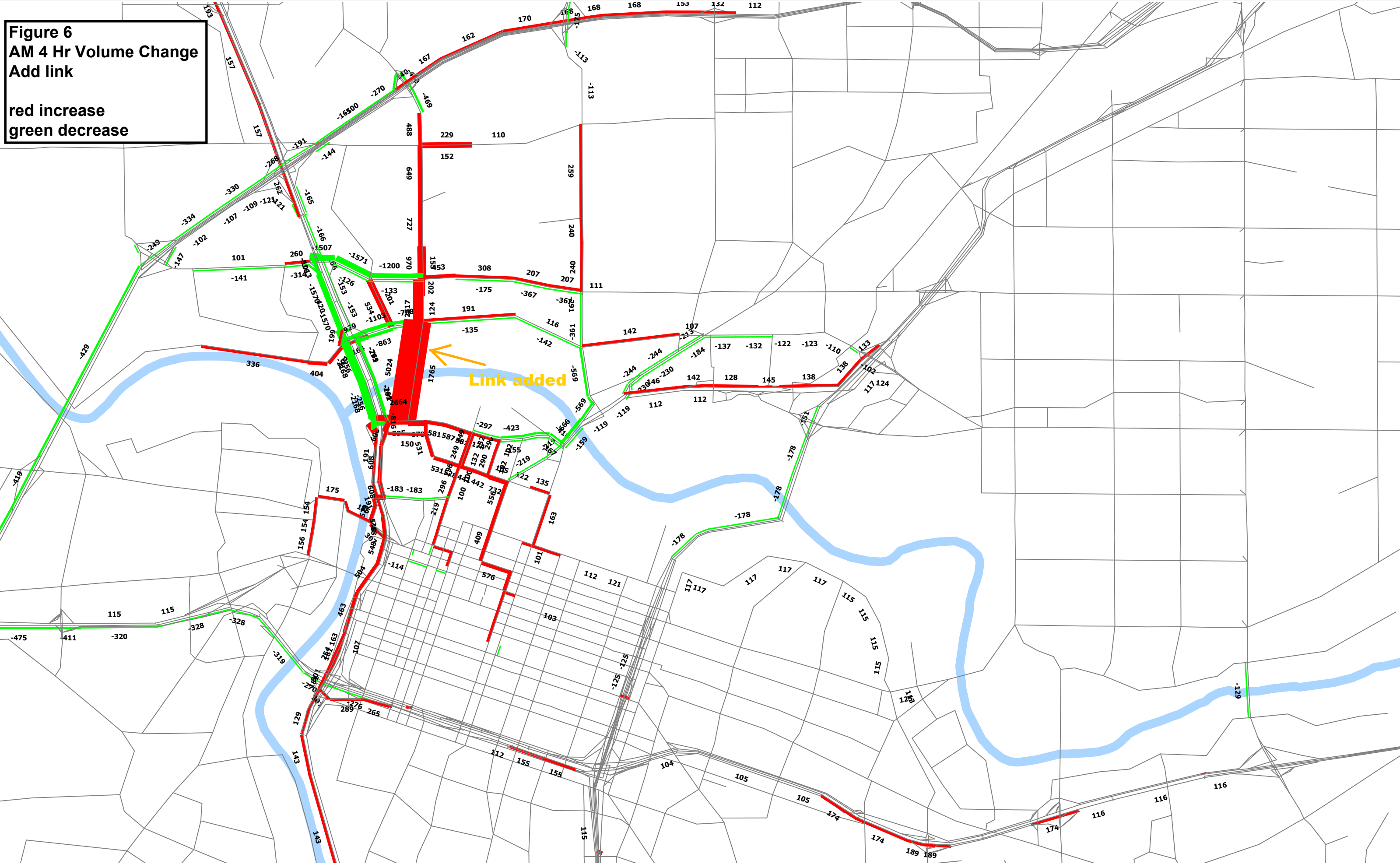


Figure 7
PM 4 Hr Volume Change
Add link

red increase
green decrease

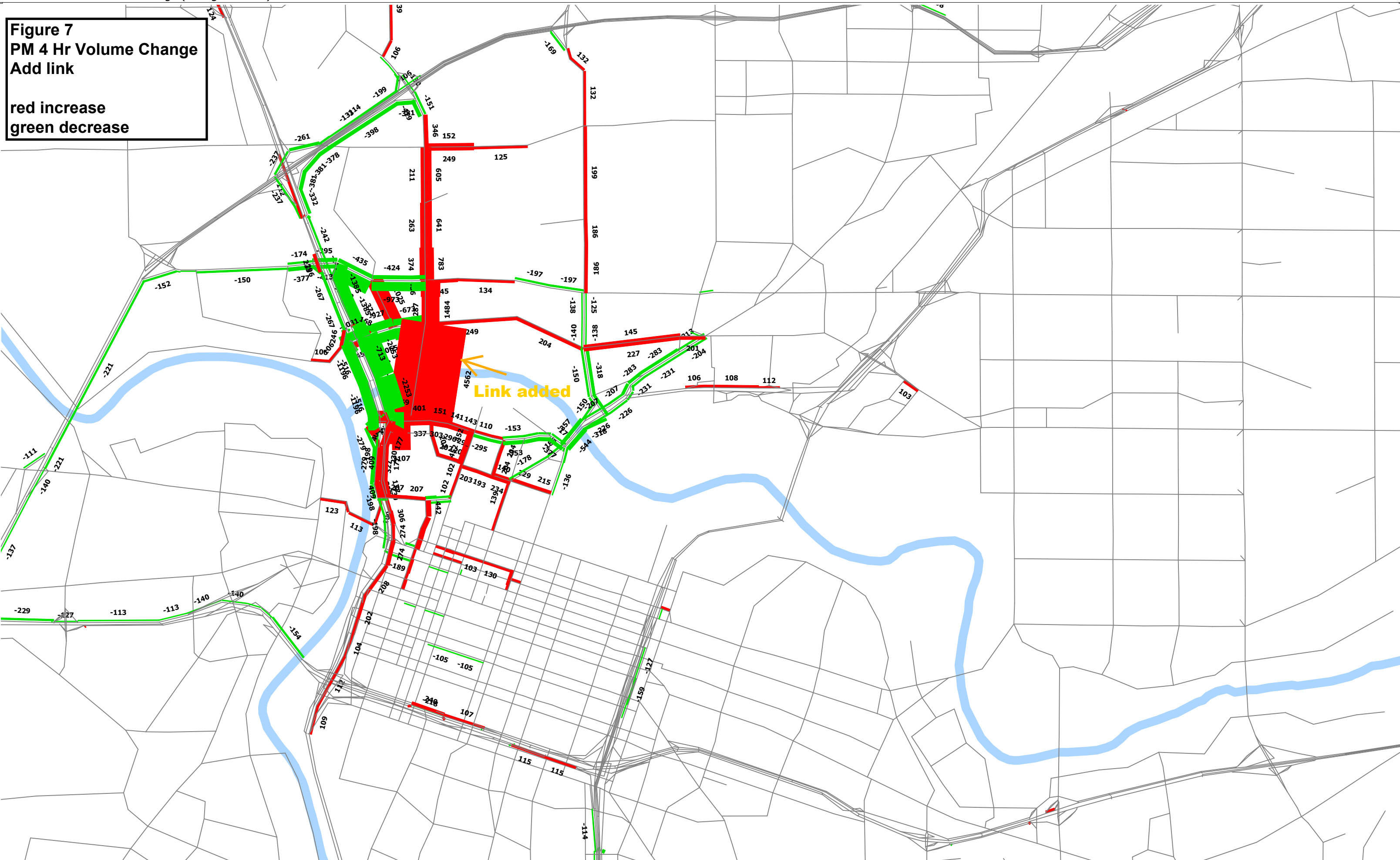


Figure 8
AM 4 Hr Volume Change
Subtract a link

red increase
green decrease

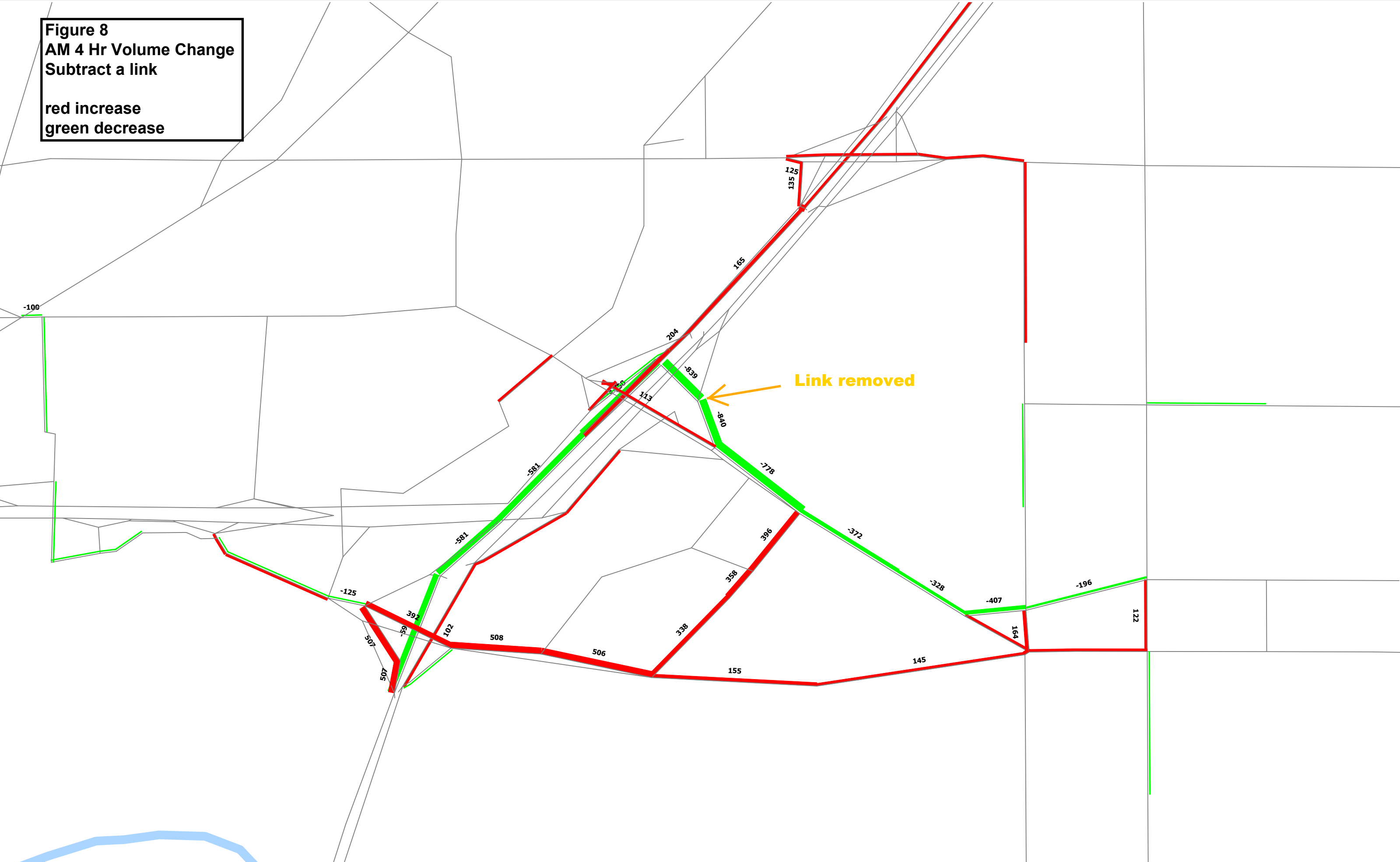
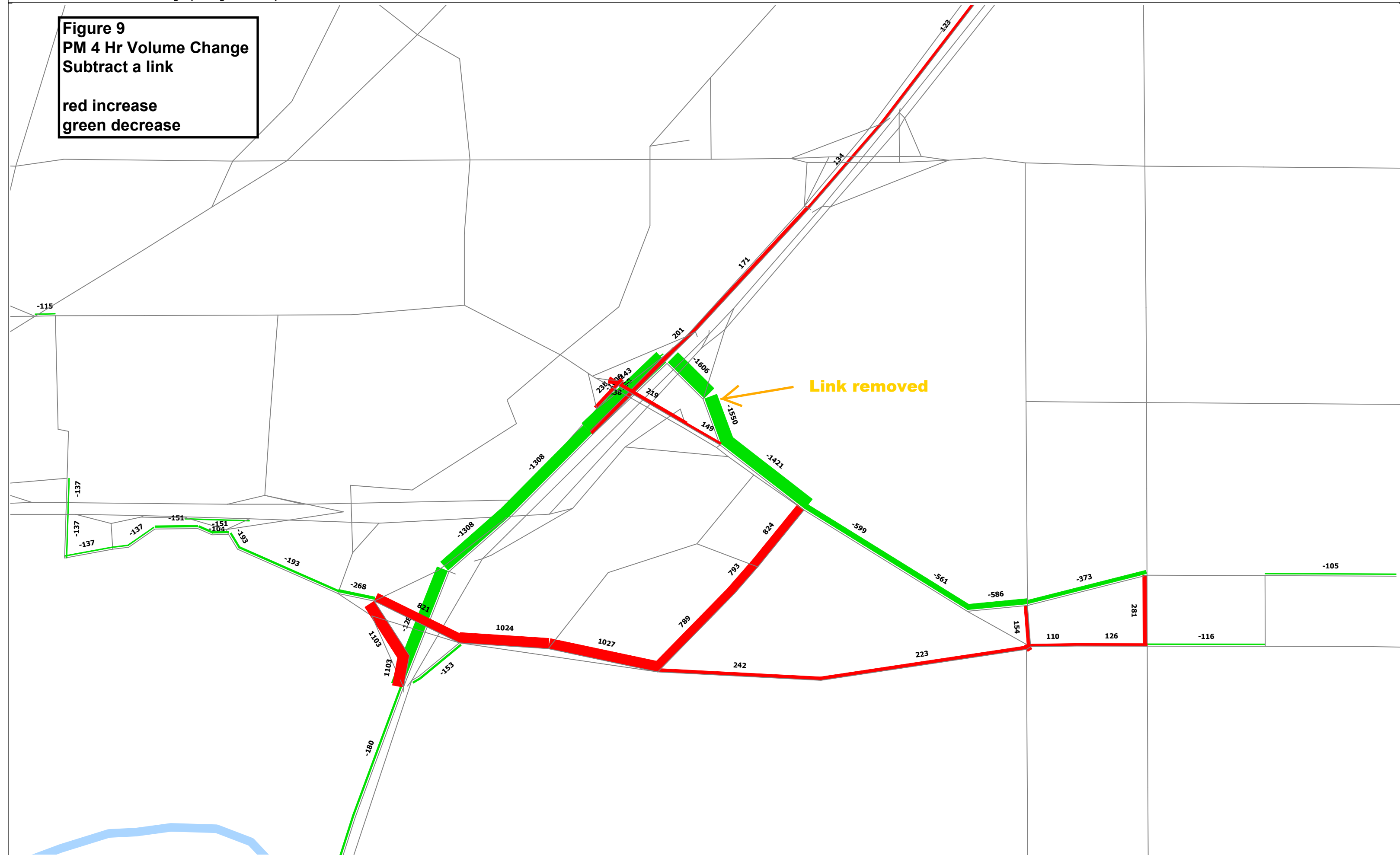


Figure 9
PM 4 Hr Volume Change
Subtract a link

red increase
green decrease





MEMORANDUM

DATE: May 17, 2020

TO: Ryan Kohagura, Cynthia Smith, and James Hoong| Caltrans

FROM: John Gibb, David Tokarski, and Udit Molakatalla| DKS Associates

SUBJECT: I-5 Focus Area Travel Demand Model Calibration & Validation Project #P18128-011
Memo

Caltrans has contracted with DKS Associates to evaluate a range of alternative improvements on Interstate 5 (I-5) between Sutterville Road and the Yolo County line in Sacramento County. The latest available version of SACOG's regional activity-based travel demand model (SACSIM19) will be utilized to develop project forecasts. Regional travel demand models like SACSIM are developed and validated at the regional scale. For corridor level applications, greater model sensitivity, and therefore refinement, is typically considered to ensure the best results. As such, the SACSIM regional model was tailored to fit the specific needs required of this analysis including the need to generate volume forecasts to support the evaluation of I-5 managed lane alternatives. This "focused" version of the regional model was developed to ensure a high level of confidence in the project forecasts to evaluate project alternatives along I-5.

The memorandum describes the validation of a "focused" version of SACOG's SACSIM model to 2018 Base Year conditions based on detailed traffic count data collected on and near I-5 as part of a previous study.

VALIDATION CRITERIA

The performance of the base year model for the 3-hour AM and PM peak periods has been evaluated using both static and dynamic validation tests. The static evaluation uses the following validation criteria outlined in the California Transportation Commission's *"2017 Regional Transportation Plan Guidelines for Regional Transportation Planning Agencies:"*

- At least 75 % of the roadway links with traffic counts should be within the Caltrans deviation threshold, which differs based on magnitude of the count.
- Estimate of correlation between the model estimates and observed counts should be at least 0.88
- Percent root mean square error (RMSE) for the roadway links with counts in the project study area should not exceed 40%.

The Task Order also calls for three dynamic tests: add lanes to a link, add a link, and subtract a link.

INITIAL BASE YEAR MODEL REVIEW AND REFINEMENT

The following steps were taken to prepare an “initial” base year model:

- DKS started with the latest version of SACOG’s SACSIM19 model prepared by SACOG for 2016 Base Year. 
- DKS reviewed SACOG’s network near I-5 and made adjustments to number of lanes and free-flow speeds to reflect existing conditions. This review included the I-5 mainline (HOV, mixed flow and auxiliary lanes) and ramps along I-5, as well as on connecting roadways and  parallel roadways.
- Traffic Analysis Zones (TAZs) were split and detail added to the model roadway network in the study corridor vicinity, to provide better spatial resolution of travel choices on roads tributary to the study corridor interchanges. TAZ splits are shown in **Figure 1**.

VALIDATION RUNS AND MODEL REFINEMENTS

Calibration involved iterations of runs of the base-year model and refinements to bring model-predicted volumes closer to 3-hour and peak-hour volumes, and peak-hour travel times. Refinements focused on model speeds and capacities in the study corridor and proximate roadways, but some refinements covered larger areas, particularly along freeways including I-80 and US 50. Review included the following:

- Reviewed metered on-ramps for correct metered lanes and HOV bypasses throughout Sacramento and beyond. Many metered on-ramps begin and/or merge as one lane but have two metered lanes; such were coded as two lanes to represent the meter delays correctly.
- Reviewed and corrected the connectivity details of the complex freeway-to-freeway interchanges in and near the study area.
- Refined and corrected connections, lanes, and speeds of tributary and parallel arterials and collectors near I-5, including Riverside Blvd., Sutterville Road, Richards Blvd, Garden Highway, W El Camino Ave, Del Paso Road, Truxel Road.
- Reduced the capacities of all freeway links and surface-streets in downtown Sacramento, as is a common practice, to better represent congestion patterns.

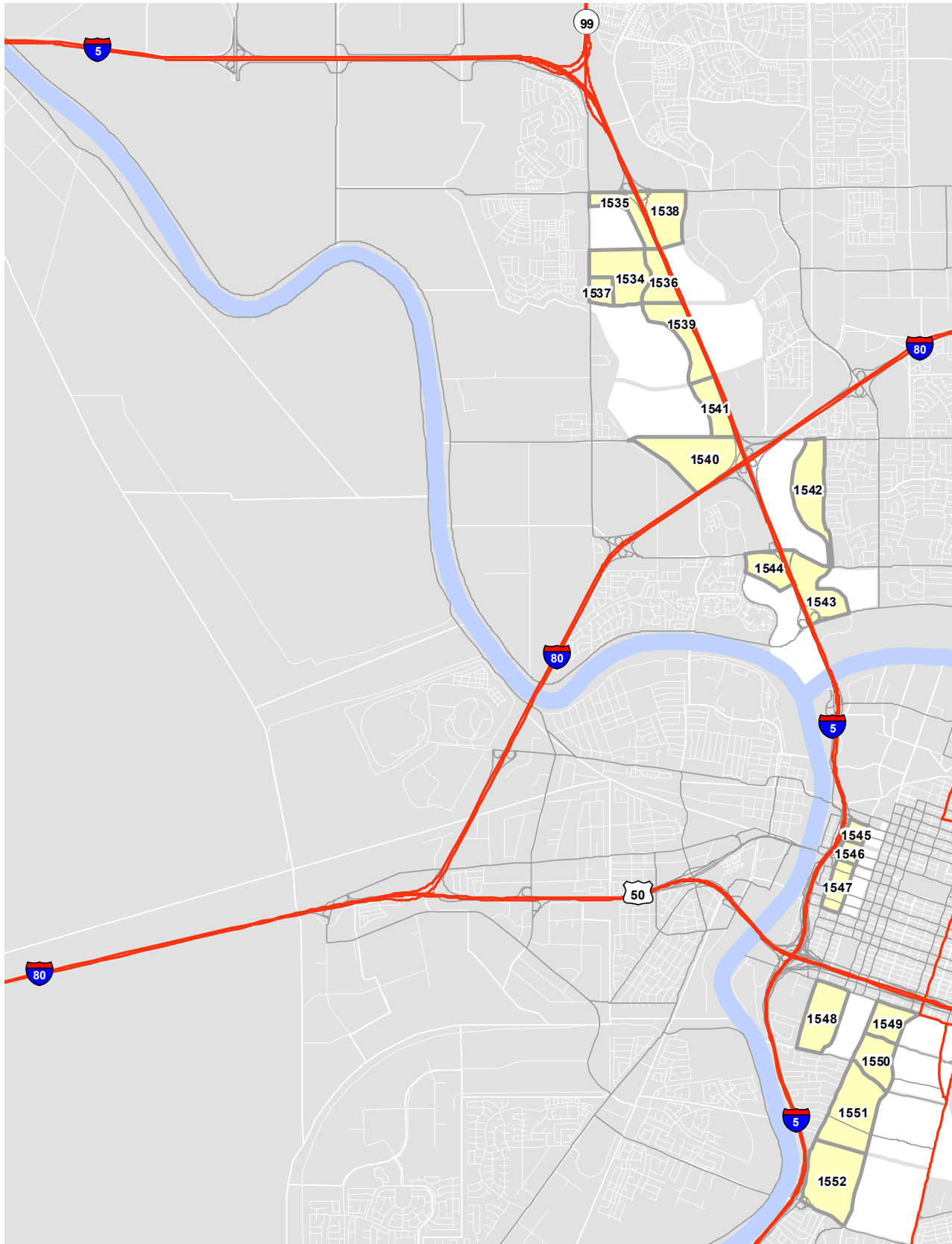


FIGURE 1: TAZ (TRAFFIC ANALYSIS ZONE) SPLITS (ZONES 1534 AND ABOVE)

Additional refinements were made to the general model system, exogenous inputs, and parameters:

- Tested and adjusted a penalty function for demand-flows in excess of capacity, to approximate the vehicle-delays in queued conditions. Additionally, adjusted the model's link delay function for freeways, in order to better approximate the observed differences between congested and free-flowing speeds. Given the need to evaluate managed-lane as part of the I-5 managed lanes alternatives (including toll-lanes), the focus area model was calibrated to reasonably represent the existing delay along the corridor
- Updated the activity-purpose distribution of internal-external travel on all model gateways to a subarea extraction of the California Statewide Travel Demand Model, due to the importance of external travel on the study corridor.
- Updated the time-of-day distribution of internal-external and through auto travel from the respective trips in the 2012 California Statewide Travel Survey
- Updated the time-of-day distribution of internal-external and through truck travel using selected Caltrans PEMS reports.

STATIC VALIDATION RESULTS

Caltrans guidelines for model validation utilize FHWA's "desirable deviation" curve to define thresholds for the model volume deviation from traffic counts. The larger the actual traffic volume, the lower the desirable deviation. The FHWA curve was designed to evaluate daily volumes. The focus of the validation for I-5, however, is the peak periods. DKS used an accepted method to scale the FHWA daily volume curve to a 3-hour volume curve using a ratio of 3-hour to daily volumes.

Figure 2 shows existing travel lanes along I-5 and the locations of the mainline and ramp count locations. **Table 3** and **Table 4** compare model volumes to counts on mainline segments and individual ramps along northbound and southbound I-5, respectively.

Figure 3 shows the deviation of model volumes to counts were compared to the "desirable deviation" curve. Separate symbols are used to show the deviation of mainline volumes versus ramp volumes. **Table 5** presents the key measures for evaluating model validation.



TABLE 3: MODEL TO COUNT COMPARISON: NORTHBOUND

#	LOCATION	3 HOUR COUNT		3 HOUR MODEL VOLUME		MODEL-TO-COUNT RATIO	
		AM	PM	AM	PM	AM	PM
48	NB I-5 to Sutterville Rd Off-Ramp	620	1,030	1,094	700	1.76	0.68
51	NB I-5 Mainline at Sutterville Rd	21,450	15,020	19,527	13,187	0.91	0.88
49	NB I-5 from Sutterville Rd On-Ramp	1,660	1,550	1,717	2,191	1.03	1.41
45	NB I-5 to Broadway Off-Ramp	990	810	660	324	0.67	0.40
37	NB I-5 to EB US-50	5,130	3,330	3,773	2,621	0.74	0.79
38	NB I-5 to WB US-50	3,670	2,670	4,868	3,490	1.33	1.31
30	NB I-5 to Q St Off-Ramp	4,600	1,390	2,501	857	0.54	0.62
39	EB US-50 to NB I-5	2,220	1,300	2,334	1,071	1.05	0.82
41	WB US-50 to NB I-5	9,680	7,010	9,130	9,624	0.94	1.37
44	NB I-5 from W St On-Ramp	600	1,270	574	1,176	0.96	0.93
33	NB I-5 Mainline at North of I-5 /US-50	21,220	17,950	19,600	19,193	0.92	1.07
32	NB I-5 from P St On-Ramp	780	2,570	1,137	2,908	1.46	1.13
25	NB I-5 to J St Off-Ramp	3,790	3,640	3,832	2,465	1.01	0.68
28	NB I-5 from L St On-Ramp	610	2,310	565	2,384	0.93	1.03
27	NB I-5 from I St On-Ramp	1,100	2,890	1,694	4,295	1.54	1.49
22	NB I-5 to Richards Blvd Off-Ramp	2,130	1,230	1,780	2,281	0.84	1.85
23	NB I-5 from Richards Blvd On-Ramp	1,400	3,590	1,604	3,927	1.15	1.09
18	NB I-5 to Garden Hwy Off-Ramp	2,320	1,990	2,990	4,330	1.29	2.18
19	NB I-5 from Garden Hwy On-Ramp	950	2,180	1,237	1,831	1.30	0.84
15	NB I-5 to W El Camino Ave Off-Ramp	2,480	2,250	1,363	1,988	0.55	0.88
12	NB I-5 Mainline at South of I-5/I-80	15,320	22,350	15,870	23,475	1.04	1.05
7	NB I-5 to EB I-80	6,270	8,350	5,546	7,431	0.88	0.89
8	EB I-80 to NB I-5	1,420	3,280	853	1,435	0.60	0.44
9	NB I-5 to WB I-80	320	370	196	2	0.61	0.01
10	WB I-80 to NB I-5	2,760	3,480	2,484	3,224	0.90	0.93
2	NB I-5 b/w I-80 Connectors and Arena Bl	12,910	20,390	13,467	20,701	1.04	1.02
63	NB I-5 to Arena Blvd Off-Ramp	2,040	3,410	2,557	3,863	1.25	1.13
64	NB I-5 from Arena Blvd Loop On-Ramp	330	300	164	133	0.50	0.44
62	NB I-5 at Arena Blvd¹	11,210	17,280	10,911	16,838	0.97	0.97
65	NB I-5 from Arena Blvd Slip On-Ramp	240	520	197	296	0.82	0.57
59	NB I-5 to Del Paso Rd Off-Ramp	2,370	4,300	1,212	2,525	0.51	0.59
60	NB I-5 from Del Paso Rd Loop On-Ramp	380	460	131	130	0.34	0.28
54	NB I-5 at Del Paso Rd	9,460	13,960	10,092	14,840	1.07	1.06
61	NB I-5 from Del Paso Rd Slip On-Ramp	650	960	604	1,058	0.93	1.10
53	NB I-5 b/w Del Paso Rd and SR 99	10,110	14,920	10,827	16,028	1.07	1.07
1	NB I-5 to NB SR-99	3,380	8,170	2,387	6,598	0.71	0.81
4	SB SR-99 to NB I-5	1,840	1,070	1,881	1,480	1.02	1.38
52	NB I-5 b/w SR 99 and Airport Blvd.	8,560	7,830	10,323	10,908	1.21	1.39
44	NB I-5 to Airport Blvd Off-Ramp	2,740	2,310	3,441	2,358	1.26	1.02
45	NB I-5 from Airport Blvd Loop On-Ramp	250	190	196	252	0.78	1.33
46	NB I-5 from Airport Blvd Slip On-Ramp	390	520	269	520	0.69	1.00

Note: Exceeds Maximum Desirable Deviation: **Low, High**

TABLE 4: MODEL TO COUNT COMPARISON: SOUTHBOUND

#	LOCATION	3 HOUR COUNT		3 HOUR MODEL VOLUME		MODEL-TO-COUNT RATIO	
		AM	PM	AM	AM	PM	AM
47	SB I-5 to Airport Blvd Off-Ramp	550	940	627	1,392	1.14	1.48
48	SB I-5 from Airport Blvd Loop On-Ramp	2,040	2,370	1,704	2,903	0.84	1.22
49	SB I-5 from Airport Blvd Slip On-Ramp	-	-	-	-		
50	SB I-5 Mainline at North of I-5/SR-99	6,400	8,910	9,093	11,274	1.42	1.27
3	SB I-5 to NB SR-99 - Connector	690	2,040	999	2,430	1.45	1.19
2	SB SR-99 to SB I-5 - Connector	7,150	4,890	7,392	3,464	1.03	0.71
51	SB I-5 Mainline at South of I-5/SR-99	Count data was inconsistent with adjacent mainline and ramps					
56	SB I-5 to Del Paso Rd Off-Ramp	1,060	1,120	1,073	992	1.01	0.89
57	SB I-5 from Del Paso Rd Loop On-Ramp	2,300	1,970	993	1,068	0.43	0.54
55	SB I-5 at Del Paso Rd	14,090	12,590	14,413	11,316	1.02	0.90
58	SB I-5 from Del Paso Rd Slip On-ramp	1,010	700	741	407	0.73	0.58
67	SB I-5 to Arena Blvd Off-Ramp	870	830	756	559	0.87	0.67
68	SB I-5 from Arena Blvd Loop On-Ramp	1,070	950	2,342	1,571	2.19	1.65
66	SB I-5 at Arena Blvd	Count data was inconsistent with adjacent mainline and ramps					
69	SB I-5 from Arena Blvd Slip On-Ramp	1,790	1,150	1,610	1,275	0.90	1.11
1	SB I-5 Mainline at North of I-5/I-80	17,090	14,550	19,343	15,078	1.13	1.04
3	SB I-5 to WB I-80	2,910	2,110	2,119	919	0.73	0.44
4	SB I-5 to EB I-80	2,800	3,260	2,268	2,325	0.81	0.71
6	WB I-80 to SB I-5	7,130	6,010	6,801	6,881	0.95	1.14
5	EB I-80 to SB I-5	400	410	30	116	0.08	0.28
11	SB I-5 Mainline at South of I-5/I-80	18,880	15,620	21,788	18,832	1.15	1.21
13	SB I-5 from W El Camino Ave Loop On-Ramp	1,630	1,100	1,854	794	1.14	0.72
14	SB I-5 from W El Camino Ave Slip On-Ramp	890	1,710	1,080	1,060	1.21	0.62
16	SB I-5 to Garden Hwy Off-Ramp	1,540	1,570	1,487	1,236	0.97	0.79
17	SB I-5 from Garden Hwy On-Ramp	2,110	2,930	2,277	3,421	1.08	1.17
20	SB I-5 to Richards Blvd Off-Ramp	2,260	2,090	3,809	2,101	1.69	1.01
21	SB I-5 from Richards Blvd On-Ramp	1,230	2,650	1,371	2,777	1.11	1.05
24	SB I-5 to J St Off-Ramp	4,300	2,910	6,409	4,157	1.49	1.43
26	SB I-5 from I St On-Ramp	960	3,210	546	1,924	0.57	0.60
29	SB I-5 to Q St Off-Ramp	1,950	780	2,455	1,389	1.26	1.78
34	SB I-5 Mainline between Q St off and US-50	15,650	19,860	14,756	19,926	0.94	1.00
36	SB I-5 to WB US-50 - Connector	1,140	1,770	617	1,156	0.54	0.65
35	SB I-5 to EB US-50 - Connector	9,770	9,120	7,501	8,524	0.77	0.93
43	SB I-5 to X St Off-Ramp	490	740	1,580	970	3.22	1.31
31	SB I-5 from P St On-Ramp	1,050	3,900	822	2,222	0.78	0.57
42	EB US-50 to SB I-5 - Connector	2,510	4,600	2,550	5,320	1.02	1.16
40	WB US-50 to SB I-5 - Connector	2,270	3,750	2,025	3,844	0.89	1.03
54	SB I-5 from W St On-Ramp	280	2,670	173	1,330	0.62	0.50
52	SB I-5 Mainline at Sutterville Rd	10,340	23,160	9,127	21,084	0.88	0.91
46	SB I-5 to Sutterville Rd Off-Ramp	1,520	1,400	2,029	1,968	1.33	1.41
47	SB I-5 from Sutterville Rd On-Ramp	610	1,330	281	965	0.46	0.73

Note: Exceeds Maximum Desirable Deviation: **Low, High**

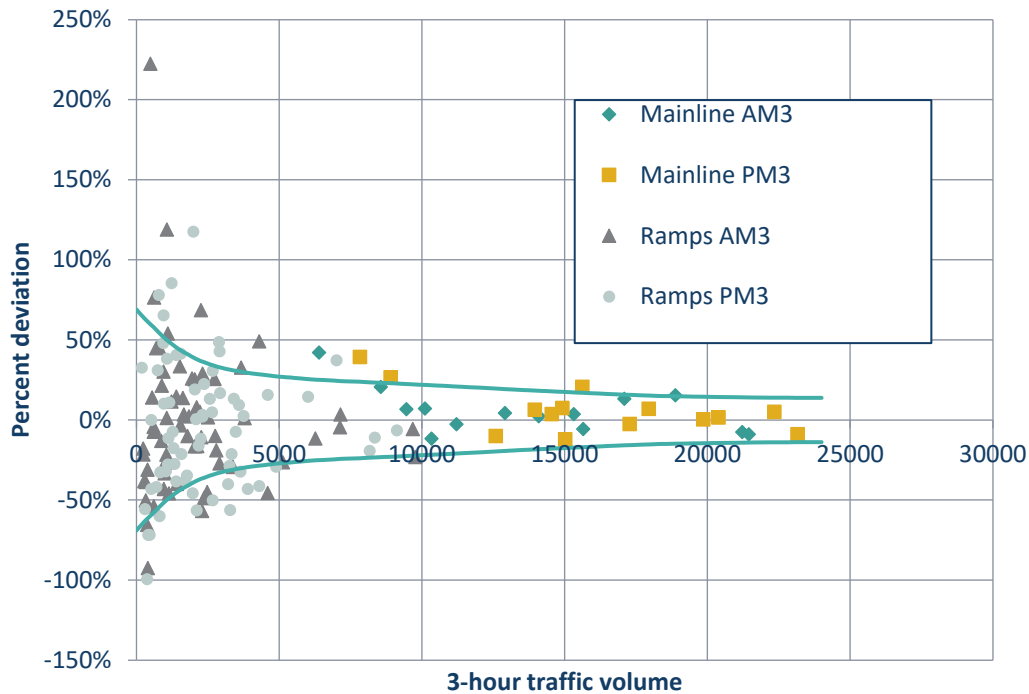


FIGURE 3: 3 HOUR MODEL VOLUME DEVIATION FROM DESIRABLE THRESHOLDS

TABLE 5: KEY VALIDATION MEASURES

MEASURES	AM 3 HOUR	PM 3 HOUR	TARGET
I-5 MAINLINE			
SEGMENTS WITHIN DESIRABLE DEVIATION	12	11	
SEGMENTS OUTSIDE DESIRABLE DEVIATION	2	3	
TOTAL SEGMENTS	14	14	
PERCENT WITHIN	86%	79%	>75%
CORRELATION	0.94	0.93	>0.88
RMSE	11%	11%	<40%
AVERAGE MODEL/COUNT	1.03	1.04	
I-5 RAMPS			
SEGMENTS WITHIN DESIRABLE DEVIATION	52	47	
SEGMENTS OUTSIDE DESIRABLE DEVIATION	13	18	
TOTAL SEGMENTS	65	65	
PERCENT WITHIN	80%	72%	>75%
CORRELATION	0.94	0.91	>0.88
RMSE	34%	35%	<40%
AVERAGE MODEL/COUNT	0.96	0.96	

Conclusions that can be reached from the results of the static validation tests include:

- For mainline I-5, most of the corridor segments are within the desirable deviation during both the AM and PM 3- hour peak period and the percent root mean square error is within acceptable limits. The correlation between the model estimated and observed counts is exceeds the recommended target value of 0.88.
- The percentage of ramps along I-5 that are within the desirable deviation are above the target validation threshold during the AM 3-hour peak period and close to the target validation threshold during the PM 3-hour peak period. The percent root mean square error for ramp are within acceptable limits and the model estimated and observed counts exceeds the recommended target value of 0.88.

Best practice is to use the model to forecast the change in traffic volumes rather than using the forecast volume directly from the model. To account for model error, future year forecasts will be developed using the “delta method” which accounts for error between base year model estimates and observed counts. Based on the above validation statistics, it can be concluded that the I-5 focus area model adequately validates to existing conditions and can be used in the process of forecasting future traffic volumes.

DYNAMIC VALIDATION TEST AND RESULTS

The Task Order calls for three dynamic tests: add lanes to a link, add a link and subtract a link, which are discussed below:

ADD LANES TO A LINK

This test involved adding one general purpose lane in each direction on I-5 where it crosses the American River between Richards Boulevard and Garden Highway. **Figure 4** and **Figure 5** are “delta plots” which show the change in 3-hour AM and 3-hour PM volumes on the roadway network, respectively.

Given current peak period congestion levels on I-5 north of downtown Sacramento, it is expected that additional capacity on this section of I-5 would increase volume on I-5 and in turn cause some reductions on other facilities such as I-80 and US 50 west of I-5. The two figures show that the model performs as expected.

ADD A LINK

This test involved adding the proposed American River crossing at Truxel Rd. **Figure 6** and **Figure 7** are “delta plots” which show the change in 3-hour AM and 3-hour PM volumes on the roadway network, respectively.

Given the limited number and capacity of river crossings, it expected that this new link would both reduce traffic on other crossings and, due to re-distribution of trips, cause more total traffic to cross the American River. The two figures show that the model performs as expected.

SUBTRACT A LINK

This test involved subtracting the I Street on- ramp to northbound I-5. **Figure 8** and **Figure 9** are “delta plots” which show the change in 3-hour AM and 3-hour PM volumes on the roadway network, respectively.

The on-ramp serves northbound I-5 from downtown Sacramento. It is expected that removal of this ramp would shift traffic from I Street to other parallel roadways such as P Street, L Street, and Richards Boulevard, and those roadways respective on-ramps to northbound I-5. It should be noted that I-5 contains both links for general purpose lanes and auxiliary lanes and the plot shows increases on the general purpose lanes and large decreases on the auxiliary lane between I Street and Richards Boulevard. The two figures show that the model performs as expected.

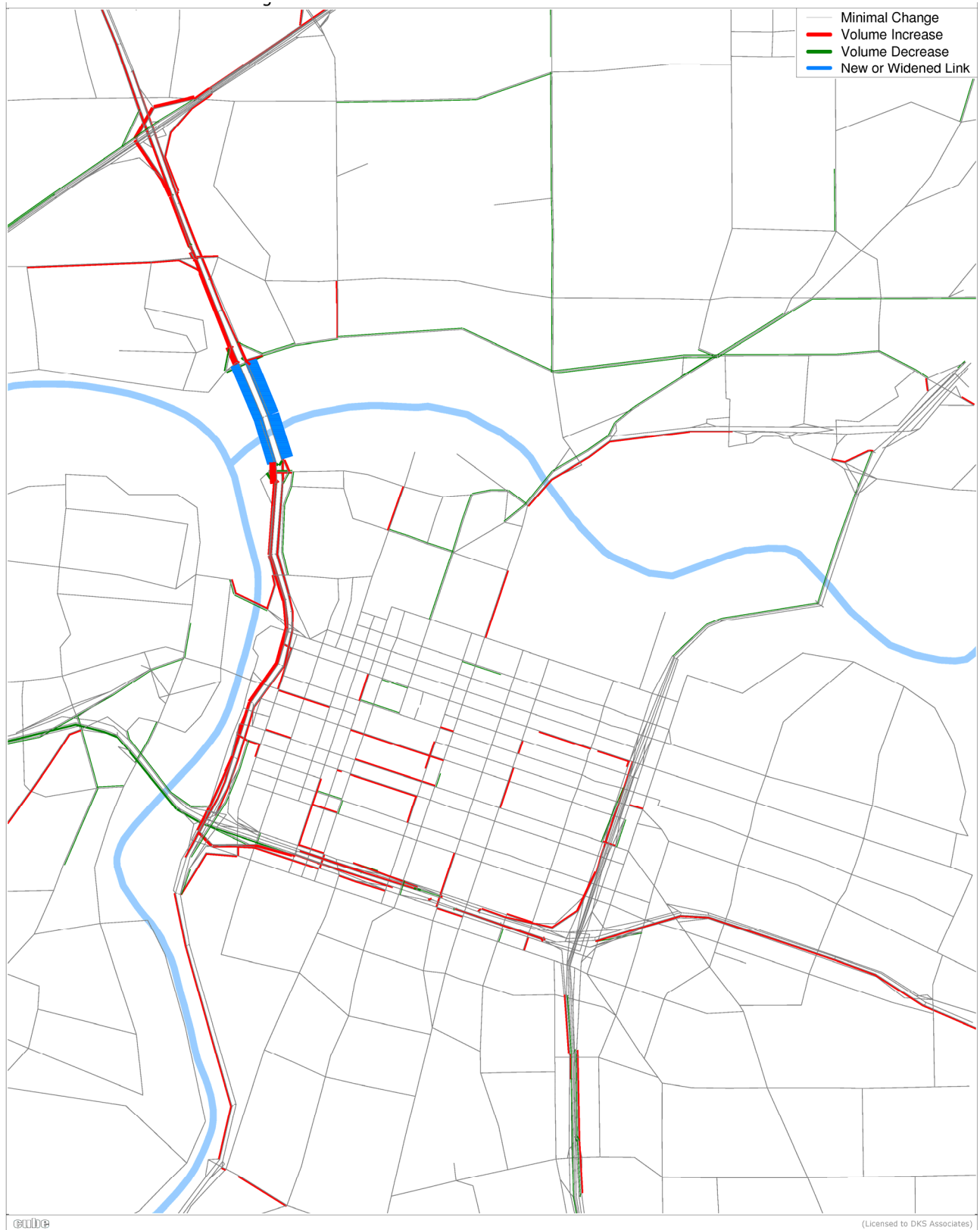


FIGURE 4: ADD LANES SENSITIVITY TEST – AM PEAK PERIOD

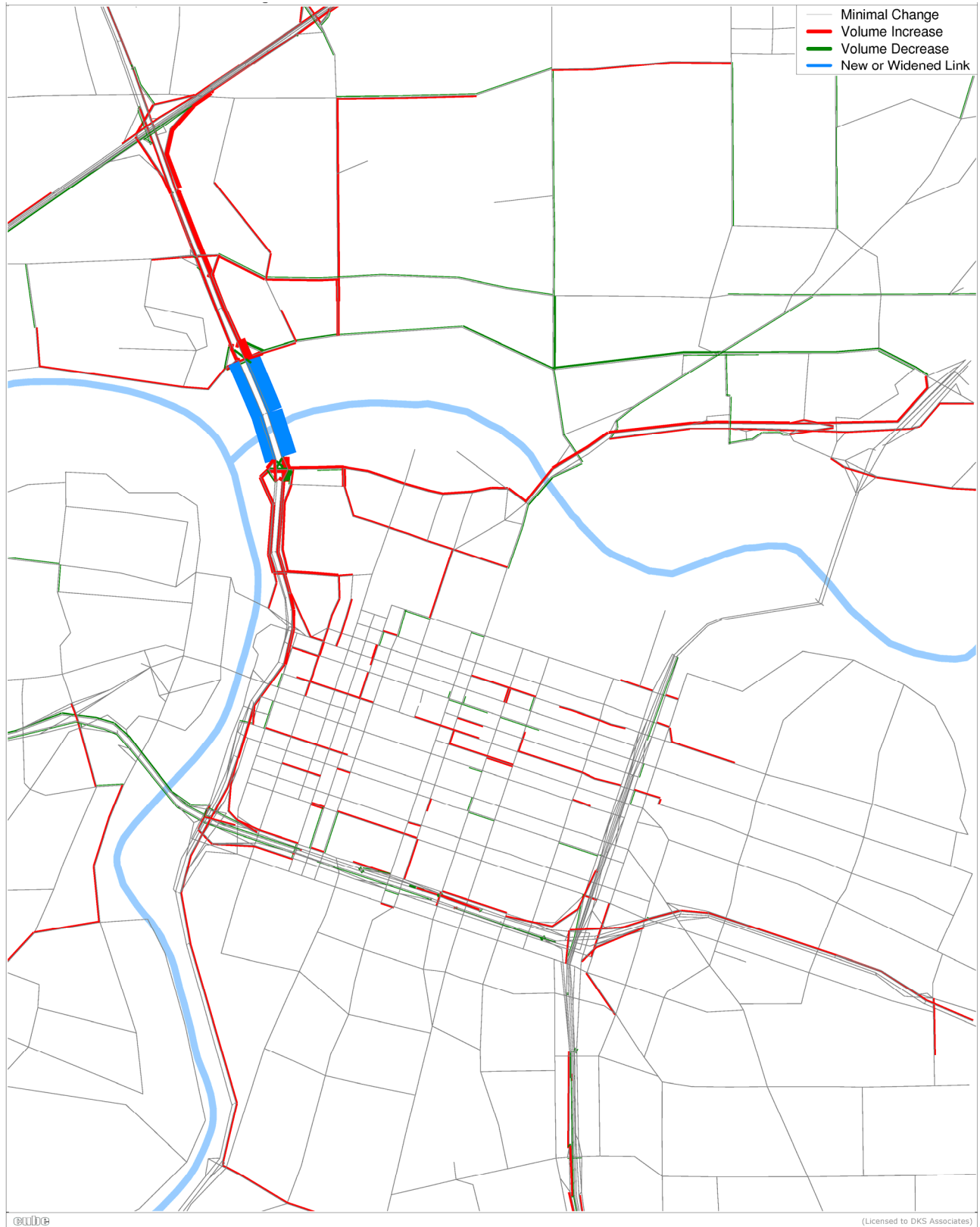


FIGURE 5: ADD LANES SENSITIVITY TEST – PM PEAK PERIOD

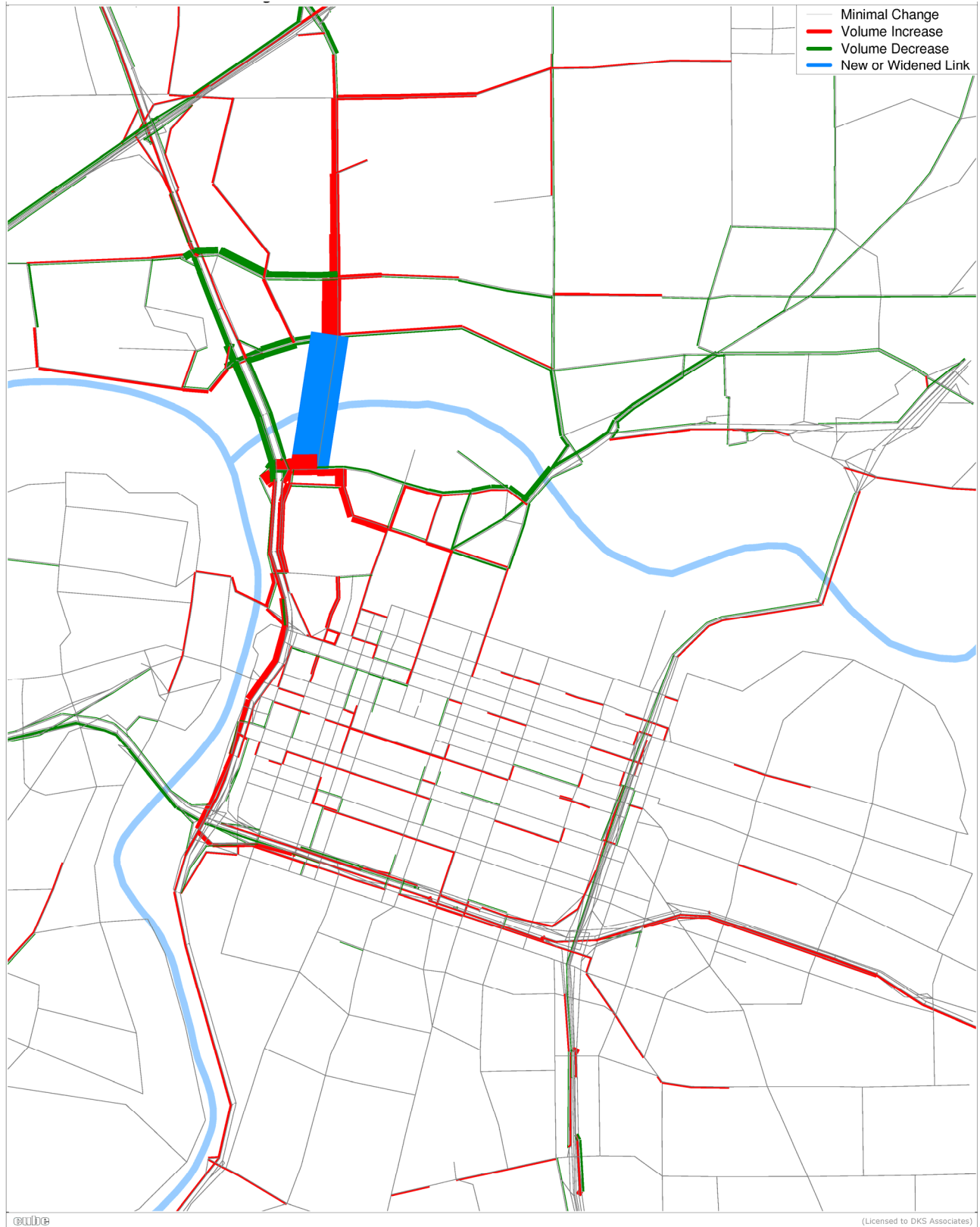


FIGURE 6: ADD LINK SENSITIVITY TEST – AM PEAK PERIOD

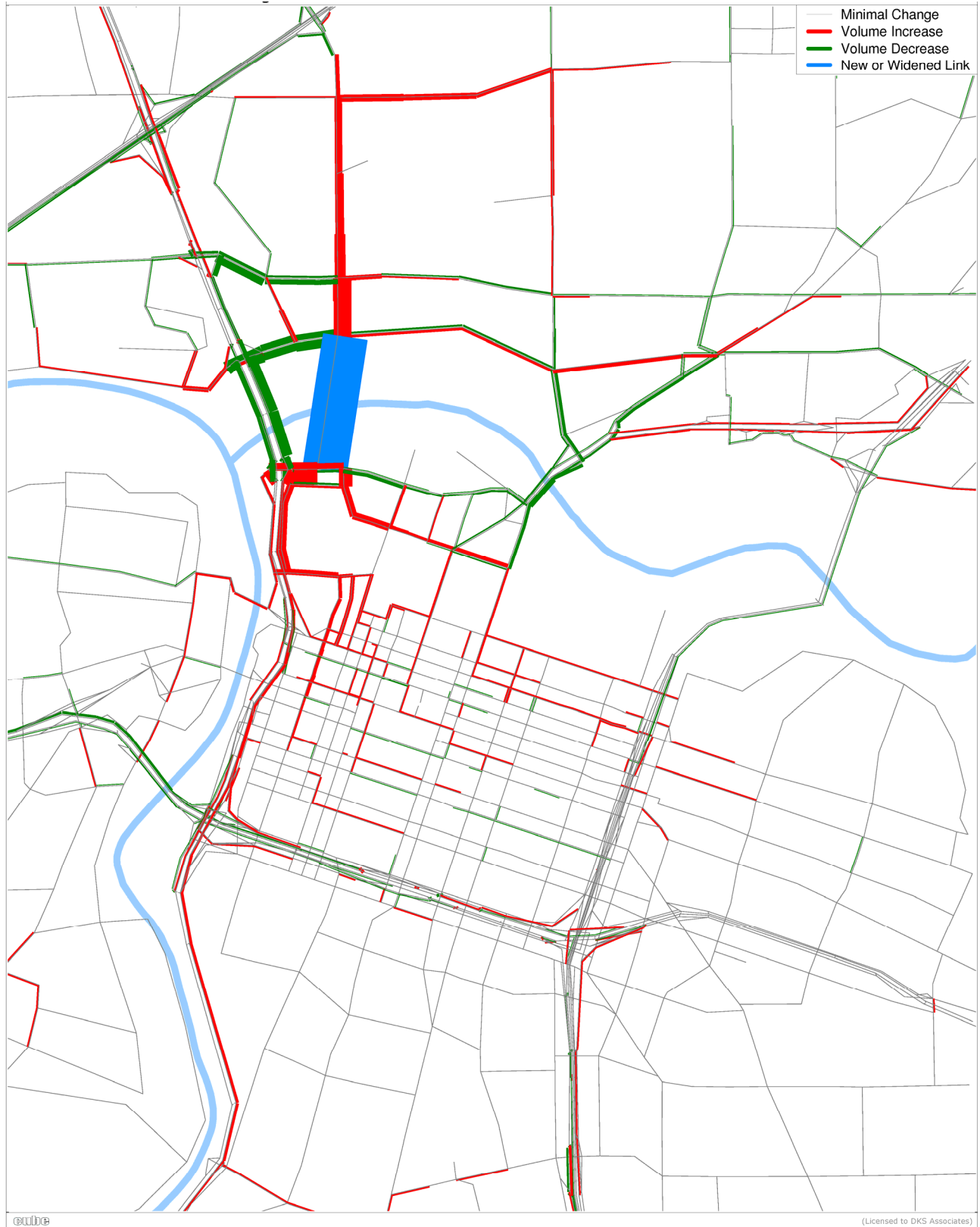


FIGURE 7: ADD LINK SENSITIVITY TEST – PM PEAK PERIOD

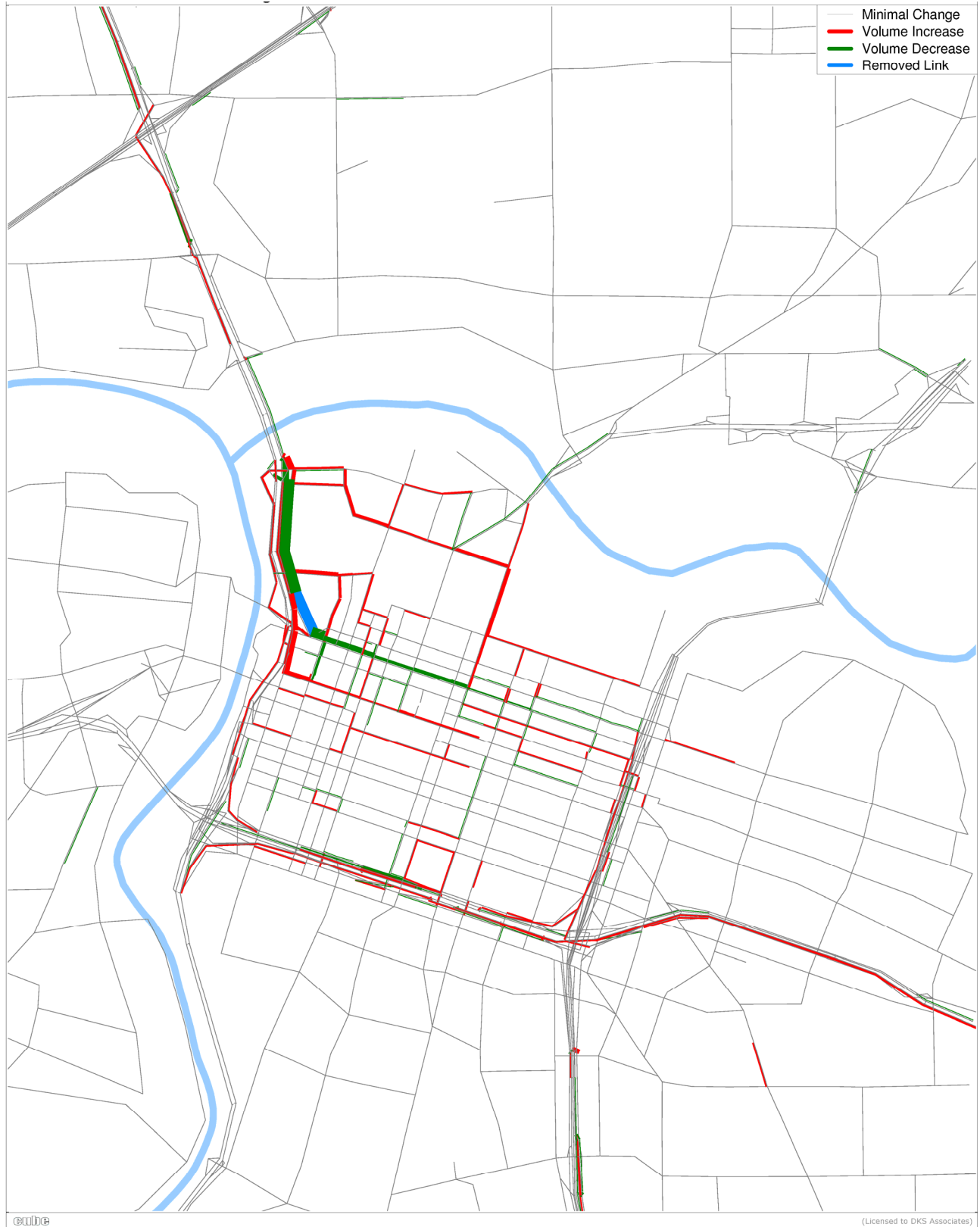


FIGURE 8: REMOVE LINK SENSITIVITY TEST – AM PEAK PERIOD

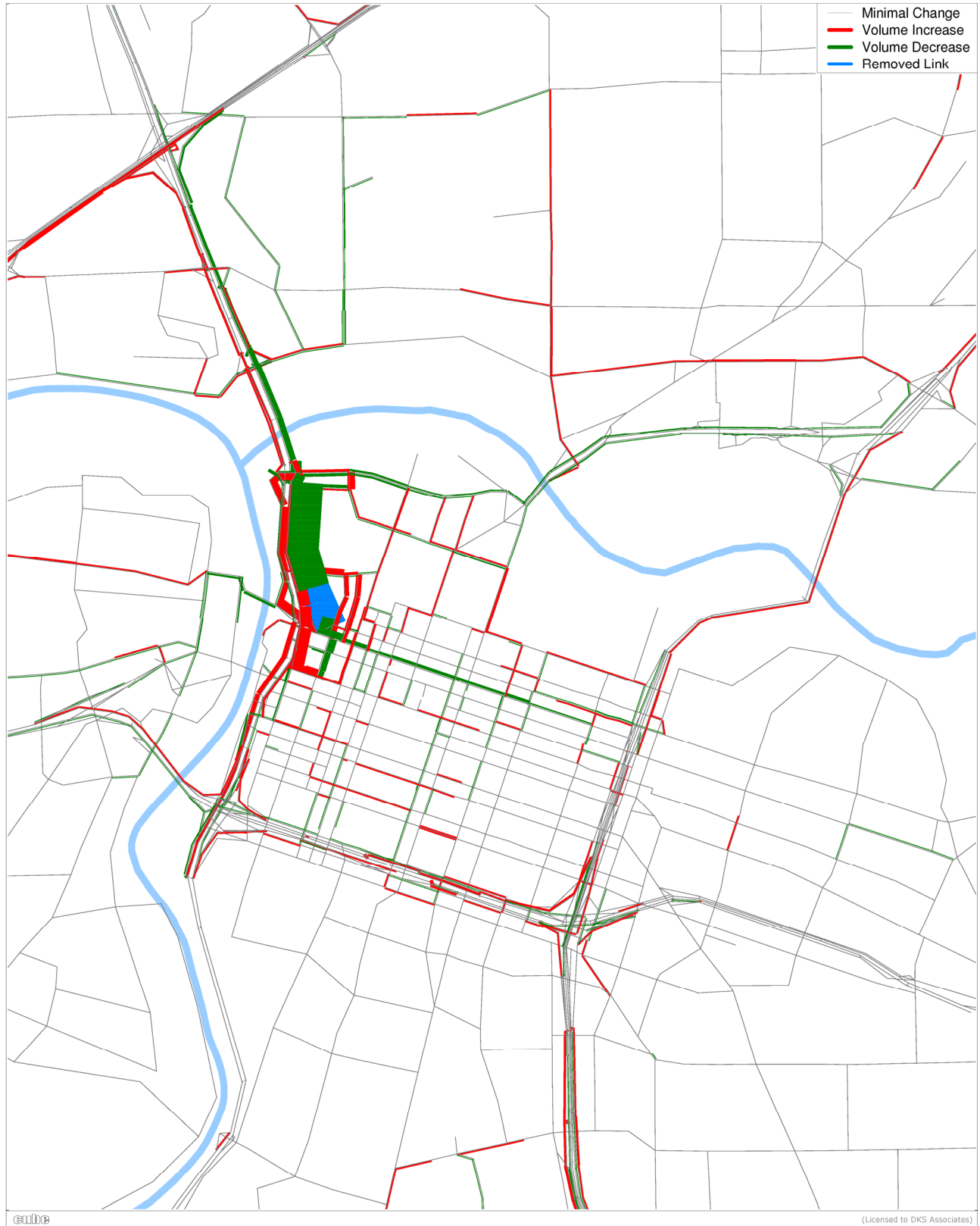


FIGURE 9: REMOVE LINK SENSITIVITY TEST – PM PEAK PERIOD