Evaluation of Renton Ramp Meters on I-405

From the SE 8th St. Interchange in Bellevue to the SR 167 Interchange in Renton

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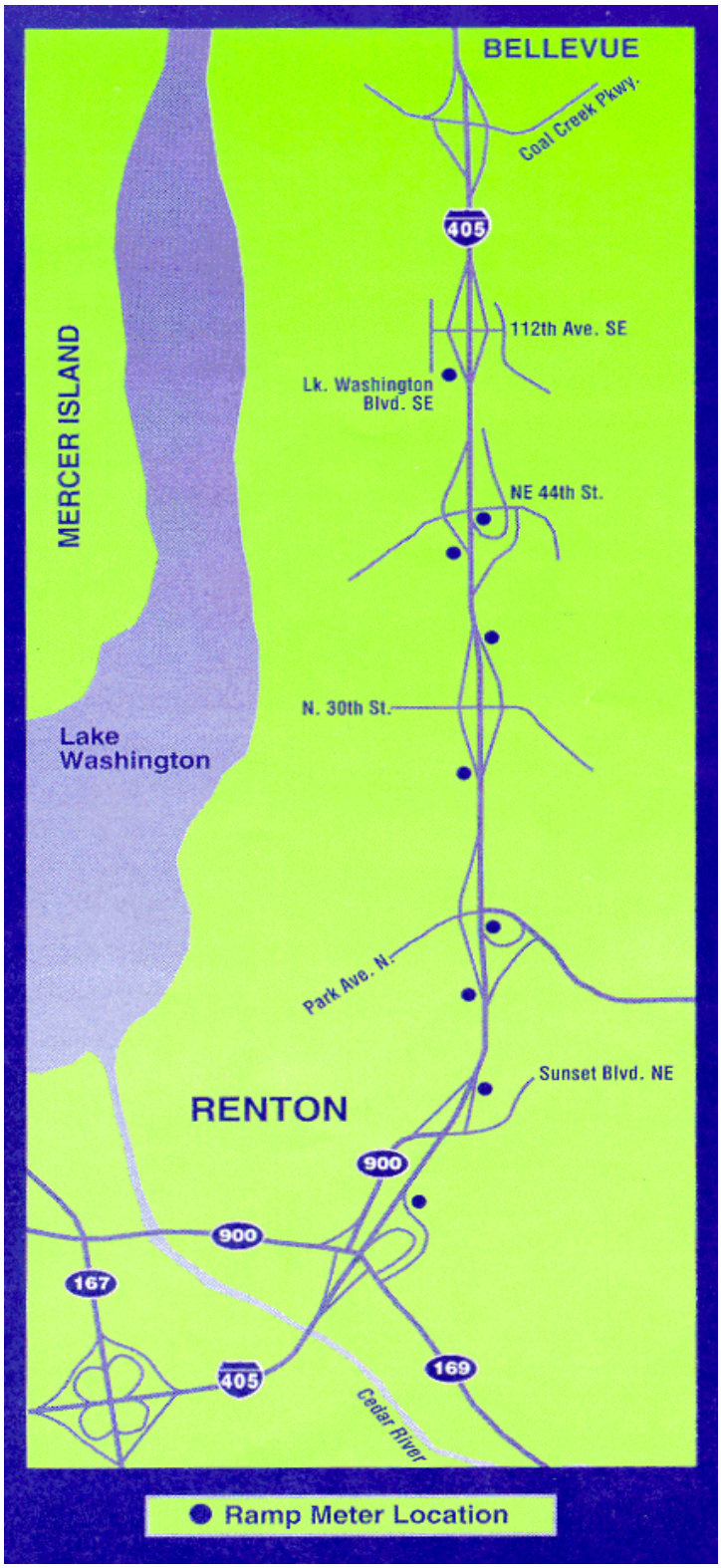

Vicinity Map of study limit and ramp meter locations

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INTRODUCTION

Background

The Washington State Department of Transportation has operated ramp meters in the Seattle area since 1981. Previous before-and-after studies have yielded positive results. A new ramp metering algorithm call "fuzzy logic" was developed in 1999. The effectiveness of the fuzzy logic algorithm was analyzed prior to its large-scale implementation. This evaluation examines the effectiveness of ramp metering with the application of fuzzy logic.

Locations

The locations of the nine ramp meters included in this evaluation are listed below. All ramp meters were initially activated on July 19th, 1999.

Table 1: Ramp Meter Locations

Southbound onramp	I-405 milepost	Northbound onramp	I-405 milepost
112th Ave SE	9.29	SR 169 *	4.00
NE 44th St	7.47	Sunset Blvd NE	4.53
N 30th St	6.51	Park Ave N	5.43
Park Ave N	5.43	N 30th St	6.51
		NE 44th St	7.47

** Metering is not activated for the morning commute due to excessive demand.*

TRAVEL TIME AND SPEED ANALYSIS

Traffic Data Collection

Travel times and speeds were manually recorded by drivers traveling the study corridor in the general-purpose lanes during peak-hour traffic on Tuesdays, Wednesdays, and Thursdays.

To establish a baseline for comparison, *before* data were collected from June 17th to July 1st, 1999. After the ramp meters were activated on July 19th, *after* data were collected from August 17th, 18th, and 19th.

Data Processing

Recorded travel times were filtered in two ways to help determine if the data should be discarded or corrected. First, any data for times with accidents, disabled vehicles, or inclement weather that affected traffic were discarded. The idea was to keep everything else constant with ramp meters being the only variable. Trials covering less than the entire study corridor were also discarded.

Travel times were also checked by dividing them by the distances between interchanges to yield segment speeds. If the resulting speed was over 80 mile per hour, the data were either discarded or checked for error. Most errors arose when drivers incorrectly identified checkpoint locations at one of two confusing intersections. Besides filtering for excessive speeds, another way to check for errors was to examine speeds and travel times on adjacent freeway segments (or from previous and successive runs) for consistency.

Because speeds recorded at travel time checkpoints were not always representative of segment speeds, average calculated speeds were used for all *before* and *after* comparisons. In addition to filtering the data, final computations used median averages, rather than mean averages, in order to mitigate the influence of outlying data.

Analysis Results

Northbound

The travel time and trip speed results are summarized below in Tables 2 and 3.

Table 2: Northbound Total Travel Times

Time of day	*Before* travel time (minutes)	*After* travel time (minutes)	Net time saved (minutes)	Net time saved (percentage)	Number of trials b*efore*	Number of trials *after*
600 to 700	22.01	17.43	**4.58**	***21%***	*6*	*7*
700 to 800	38.62	22.88	**15.74**	***41%***	*6*	*6*
800 to 900	36.53	20.82	**15.72**	***43%***	*6*	*7*
900 to 1000	20.52	12.12	**8.40**	***41%***	*10*	*10*
1000 to 1100	12.97	9.76	**3.21**	***25%***	*5*	*2*
1400 to 1500	9.98	11.29	**-1.31**	***-13%***	*1*	*4*
1500 to 1600	10.33	12.17	**-1.83**	***-18%***	*7*	*5*
1600 to 1700	10.35	10.78	**-0.43**	***-4%***	*9*	*6*
1700 to 1800	10.45	10.61	**-0.16**	***-2%***	*7*	*6*
1800 to 1900	9.90	10.78	**-0.88**	***-9%***	*6*	*8*

Table 3: Northbound Median Speeds

Time of day	*Before* speed (mph)	*After* speed (mph)	Speed improvement (mph)	Speed improvement (percentage)	Number of trials b*efore*	Number of trials *after*
600 to 700	27	34	**7**	**26%**	*6*	*7*
700 to 800	15	26	**11**	**70%**	*6*	*6*
800 to 900	16	28	**12**	**75%**	*6*	*7*
900 to 1000	29	48	**20**	**69%**	*10*	*10*
1000 to 1100	45	60	**15**	**33%**	*5*	*2*
1400 to 1500	59	52	**-7**	**-11%**	*1*	*4*
1500 to 1600	57	48	**-9**	**-15%**	*7*	*5*
1600 to 1700	57	54	**-2**	**-4%**	*9*	*6*
1700 to 1800	56	55	**-1**	**-1%**	*7*	*6*
1800 to 1900	59	54	**-5**	**-8%**	*6*	*8*

The results indicate that ramp meters effectively increase speeds during the morning commute, but not for the evening commute. The low number of trials are insufficient for performing a statistical analysis. Figures 1 and 2 are graphical representations of the above tables. Time periods with the worst congestion prior to ramp metering showed the greatest improvements in both travel times and trip speeds.

Figure 1: Northbound Travel Times

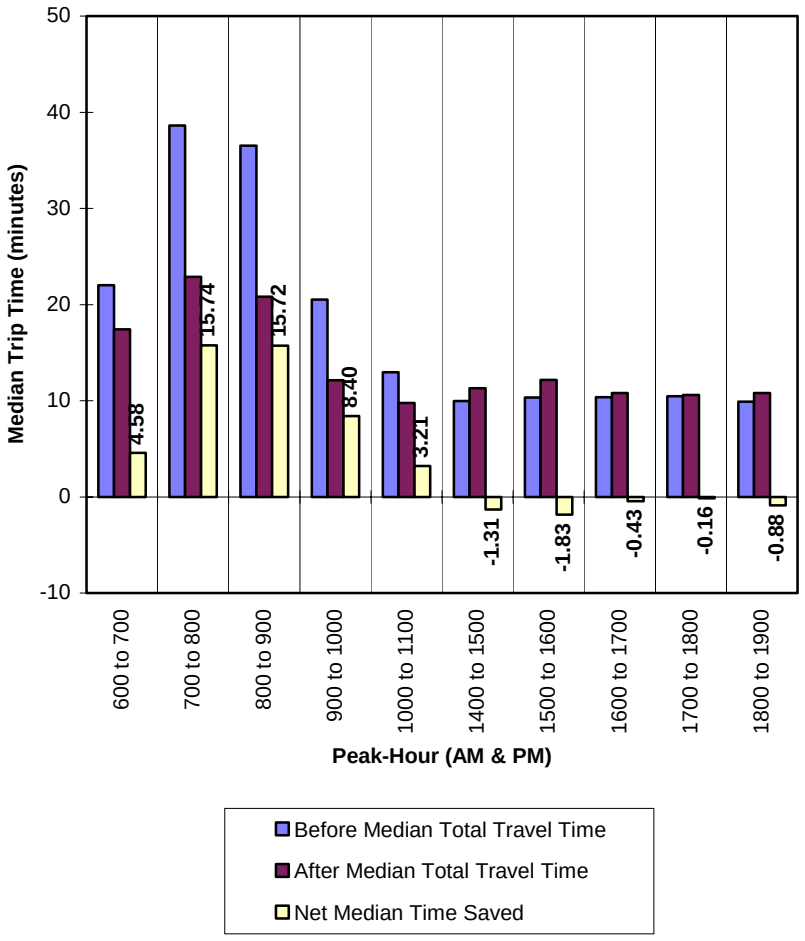
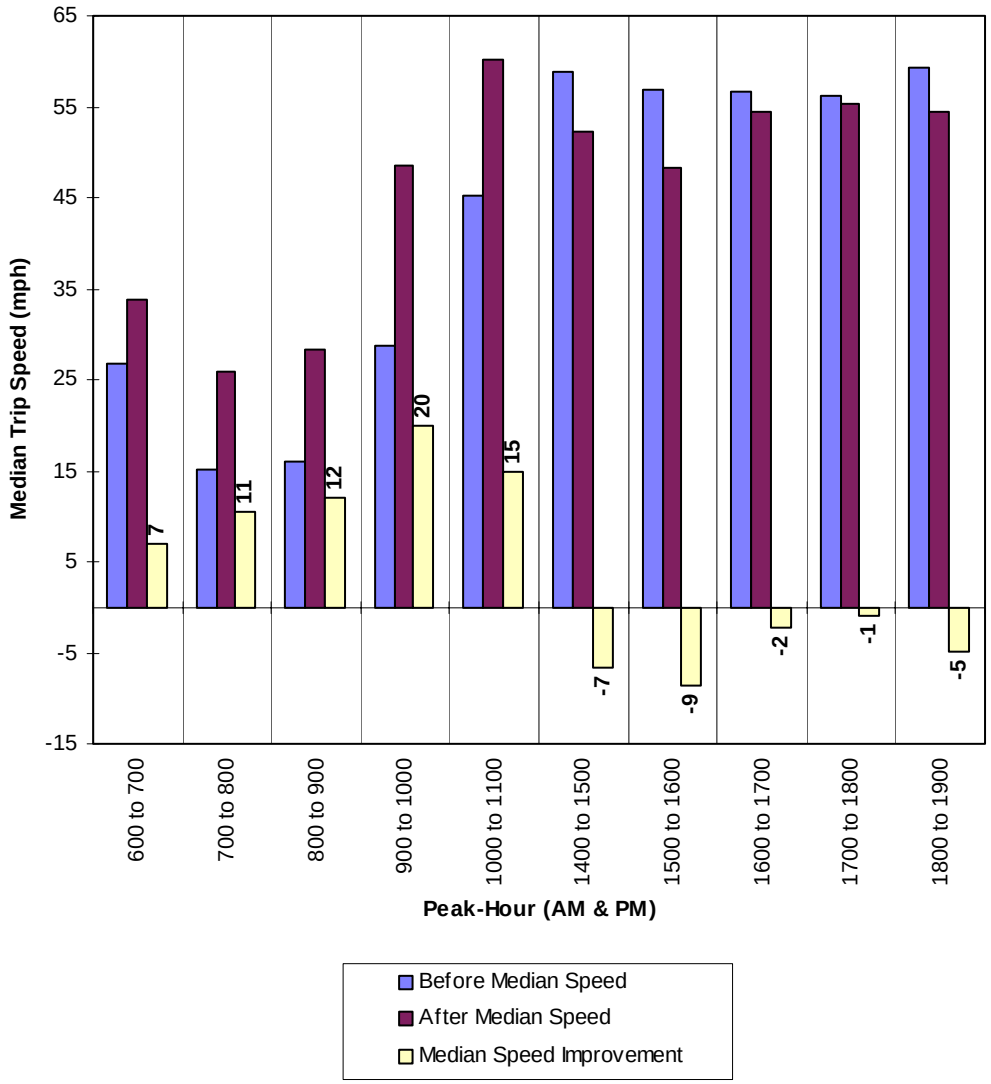


Figure 2: Northbound Median Speeds



Ramp meters are not normally turned on during periods of high freeway speeds, such as the northbound I-405 evening commute.

The percentage of speed improvement is plotted in Figure 3 to show ramp meters' effectiveness at different times throughout the day. Because traffic volumes and patterns will change over time, mainline speeds are better indicators of the most effective time to operate ramp meters than time of day. "Percentage of Speed Improvement" is plotted versus "*Before* Average Trip Speed" in Figure 4 to show at what freeway speeds ramp meters should be activated.

Table 4: *Before* and *After* Speeds of Northbound Traffic

Time of day	***Before*** **average trip speed (mph)**	**Speed improvement (percentage)**	*After* average Trip Speed [not plotted] (mph)
600 to 700	27	***26%***	*34*
700 to 800	15	***70%***	*26*
800 to 900	16	***75%***	*28*
900 to 1000	29	***69%***	*48*
1000 to 1100	45	***33%***	*60*
1400 to 1500	59	***-11%***	*52*
1500 to 1600	57	***-15%***	*48*
1600 to 1700	57	***-4%***	*54*
1700 to 1800	56	***-1%***	*55*
1800 to 1900	59	***-8%***	*54*

Figure 3: Speed Improvement of Northbound Traffic as a Function of Time

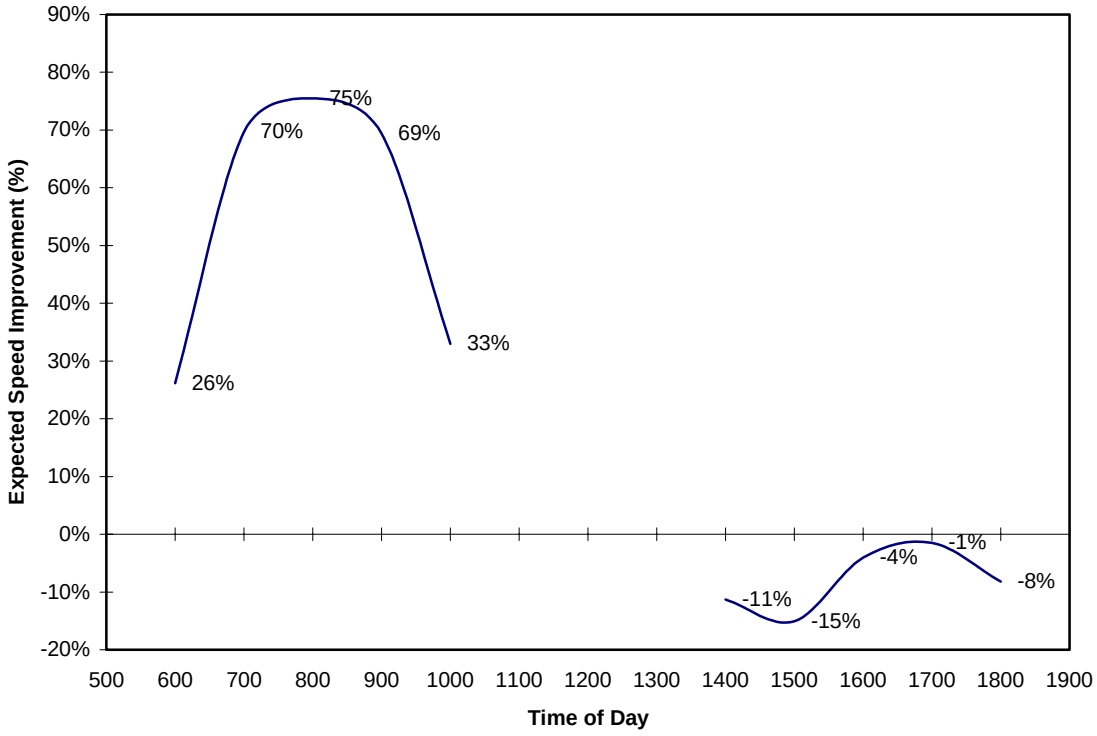


Figure 4: Speed Improvement of Northbound Traffic as a Function of *Before* Speeds

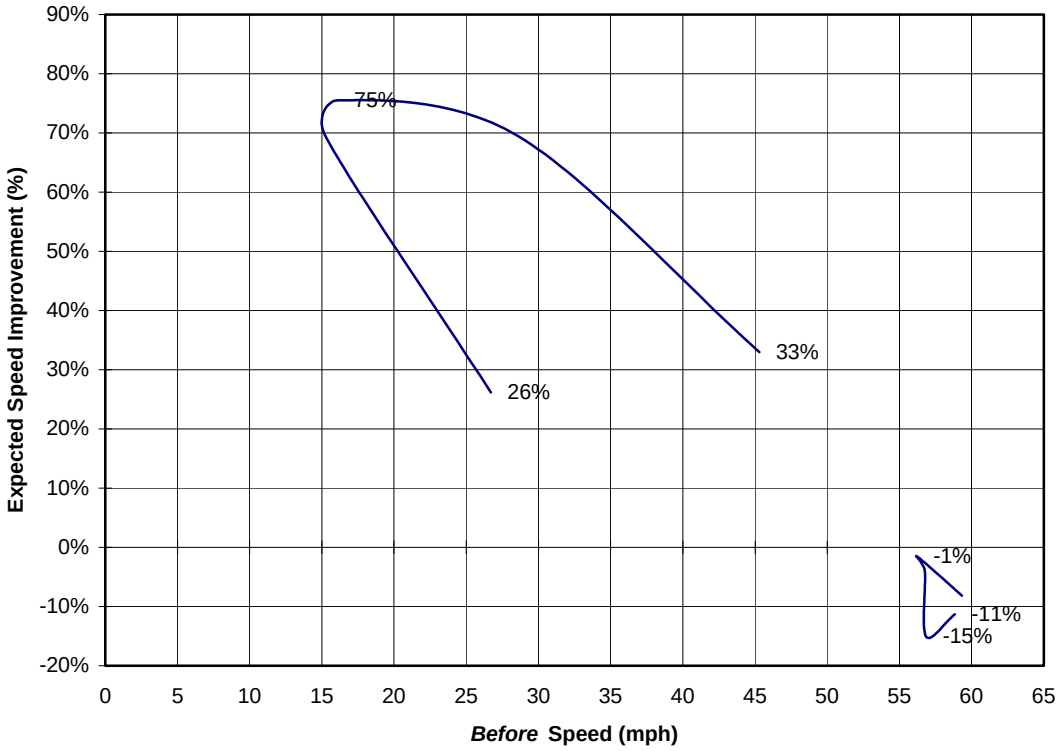


Table 4 and Figure 4 show that ramp meters are effective in the morning commute for the range between 15 and 55 mph (extrapolating). The results suggest that ramp meters should not be activated when average traffic speeds are higher than 55 mph.

Southbound

Similar to northbound, the results shown in Tables 5 and 6 indicate positive results for the morning commute and most of the afternoon commute. Again, there are insufficient data to support a statistical analysis.

Table 5: Northbound Total Travel Times

Time of day	*Before* travel time (minutes)	*After* travel time (minutes)	Net time saved (minutes)	Net time saved (percentage)	Number of trials b*efore*	Number of trials *after*
600 to 700	11.83	10.75	**1.08**	***9%***	*8*	*8*
700 to 800	17.88	13.13	**4.74**	***27%***	*6*	*7*
800 to 900	11.10	9.73	**1.37**	***12%***	*7*	*8*
900 to 1000	10.87	10.00	**0.87**	***8%***	*9*	*11*
1400 to 1500	28.42	19.33	**9.09**	***32%***	*4*	*6*
1500 to 1600	22.63	21.04	**1.59**	***7%***	*5*	*6*
1600 to 1700	19.67	20.20	**-0.53**	***-3%***	*9*	*5*
1700 to 1800	20.70	19.53	**1.17**	***6%***	*3*	*6*
1800 to 1900	17.57	17.97	**-0.40**	***-2%***	*8*	*3*

Table 6: Northbound Median Speeds

Time of day	*Before* speed (mph)	*After* speed (mph)	Speed improvement (mph)	Speed improvement (percentage)	Number of trials b*efore*	Number of trials *after*
600 to 700	50	55	**5**	**10%**	*8*	*8*
700 to 800	33	45	**12**	**36%**	*6*	*7*
800 to 900	53	61	**7**	**14%**	*7*	*8*
900 to 1000	54	59	**5**	**9%**	*9*	*11*
1400 to 1500	21	31	**9**	**43%**	*4*	*6*
1500 to 1600	26	28	**2**	**8%**	*5*	*6*
1600 to 1700	30	29	**-1**	**-3%**	*9*	*5*
1700 to 1800	28	30	**2**	**6%**	*3*	*6*
1800 to 1900	34	33	**-1**	**-2%**	*8*	*3*

Table 7 and Figures 5 and 6 show the effective range of ramp meters on southbound traffic.

Table 7: *Before* and *After* Speeds of Southbound Traffic

Time of day	*Before* average trip speed (mph)	Speed improvement (percentage)	*After* average Trip Speed [not plotted] (mph)
600 to 700	50	***10%***	*55*
700 to 800	33	***36%***	*45*
800 to 900	53	***14%***	*61*
900 to 1000	54	***9%***	*59*
1400 to 1500	21	***43%***	*31*
1500 to 1600	26	***8%***	*28*
1600 to 1700	30	***-3%***	*29*
1700 to 1800	28	***6%***	*30*
1800 to 1900	34	***-2%***	*33*

Figure 5: Speed Improvement of Southbound Traffic as a Function of Time

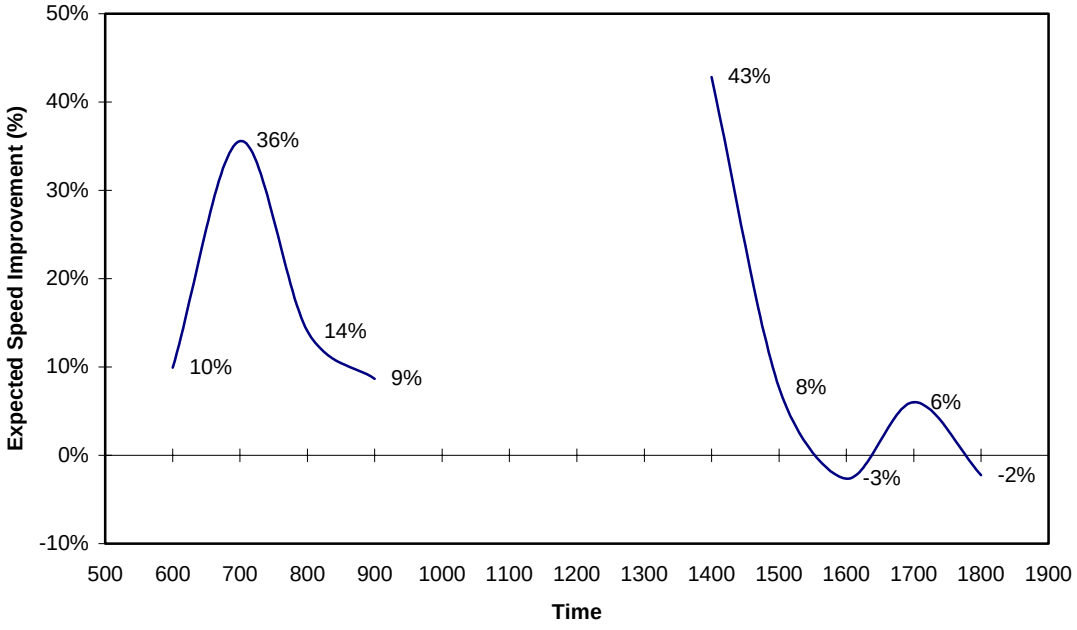
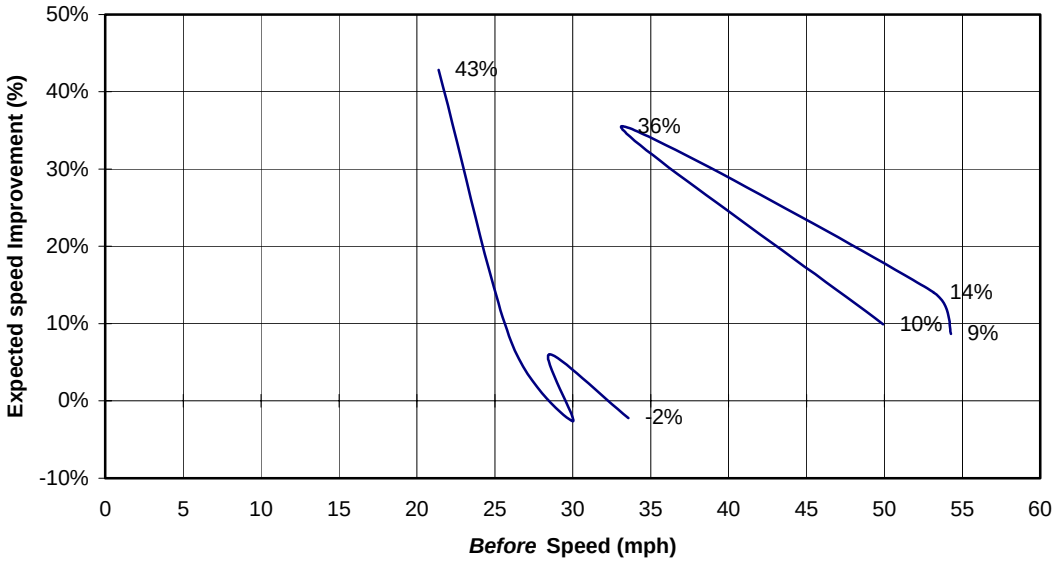


Figure 6: Speed Improvement of Southbound Traffic as a Function of *Before* Speeds



Ramp meters are effective from 33 to 55 mph during the morning commute. Although there are no data to for speeds less than 33 mph because southbound morning volumes are light, meters are probably also effective at lower speeds.

Similarly, the effective range for the afternoon commute tops out at 30 mph and could go higher, but there are no data to support it.

Since the ramp meters' effective range for southbound traffic is limited in one way or another, the effective range derived from the northbound calculation is more acceptable.

CONCLUSIONS AND RECOMMENDATIONS

According to the travel time study, the Renton ramp meters provide a travel time savings of 3 to 16 minutes depending on time of day, with traffic speeds increasing by 7 to 20 mph.

Although the meters are currently most effective between the hours of 6 and 10 AM, they should be activated whenever freeway speeds drop below 55 mph.

APPENDIX: I-405 Travel Time Study Summary

By Paul Neel

Ramp metering began on I-405 in the Renton area on July 19, 1999. Affected ramps included: SR 169 to NB (PM only), Sunset to NB, Park to NB and SB, NE 30th to NB and SB, NE 44th to NB and SB, and SE 112th to SB. A premetering travel time study was conducted during the last half of June with runs being made between SE 8th St. in Bellevue and SR 167. From August 17th to 19th the runs were repeated to find out how ramp metering affected travel times through the corridor. The numbers below were arrived at by averaging the travel times together for one hour time periods.

Preliminary results of the study show overall a significant decrease in travel times with ramp metering in place. A number of time slices show reductions upwards of 40%. However, caution should be taken in interpreting these results. We were able to gather only about 4 days before ramp metering and 3 days after ramp metering due to time and staffing constraints. With this small sample size just a day or two of abnormal traffic could alter the outcome.

Northbound I-405 during the morning commute showed the largest reductions in travel times. Southbound I-405 during the same time period showed moderate reductions. In the afternoon northbound actually showed a slight increase in travel times while southbound showed large decreases in the early afternoon and slight decreases through the rest of the evening.

	Northbound				Southbound			
Time	Before	After	Change	% Change	Before	After	Change	% Change
6:00	20:30	17:26	3:04	-15%	13:48	11:04	2:44	-20%
7:00	44:41	24:07	20:34	-46%	20:09	13:08	7:01	-35%
8:00	37:43	21:25	16:18	-43%	13:14	9:55	3:19	-25%
9:00	21:09	12:20	8:49	-42%	11:50	9:56	1:54	-16%
10:00	12:31	9:45	2:46	-22%	11:31	NA	NA	NA
14:00	NA	13:08	NA	NA	34:02	17:56	16:06	-47%
15:00	11:06	13:29	2:23	21%	26:52	20:11	6:41	-25%
16:00	11:38	12:20	0:42	6%	21:44	20:30	1:14	-6%
17:00	10:44	10:55	0:11	2%	23:22	20:05	3:17	-14%
18:00	10:19	10:21	0:02	0%	18:19	17:09	1:10	-6%
19:00	NA	10:00	NA	NA	NA	NA	NA	NA