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November 30, 2006

Rick Nys, P.E.
Clackamas County Dept. of Transportation & Development
Traffic Engineering
9101 S.E. Sunnybrook Boulevard
Clackamas, OR 97015

Dear Mr. Nys:

Attached is the report entitled *Evaluation & Recommendation for Signalized Intersection of Beavercreek and Meyers Road* that Dr. Monsere assigned us to write in September of 2006.

As you requested, the report explores the complaint from Oregon City High School officials regarding the Beavercreek Road left turn lane signal phasing. The focus of the report is on analyzing the flow of the intersection under three different left turn phasings: permitted, permitted-protected, and protected. Recommendations are provided regarding improving the traffic flow of the intersection.

Our group at Portland State hopes this report meets your needs and proves useful to the Clackamas County Department of Transportation. Let us know if you have any questions or concerns.

Sincerely,

Catherine Wilson

Catherine Wilson, Project Leader
Portland State University
Encl. Report on Evaluation & Recommendation for Signalized Intersection of Beavercreek and Meyers Road

Department of Civil and Environmental Engineering

CE454 Urban Transportation Systems

Final Report

Evaluation & Recommendation for Signalized Intersection of Beavercreek and Meyers Road (Clackamas County)

PROJECT TEAM #3

Stephen Eagar

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November 30, 2006

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ACKNOWLEDGEMENTS

We would like to recognize, acknowledge and thank those who helped make this learning experience possible. Namely, Richard Nys, P.E., Traffic Engineer with the Clackamas County Department of Transportation, who willingly responded to our numerous phone calls, emails and readily shared his working knowledge and resources regarding this transportation project. Your guidance and suggestions were much appreciated. Special thanks to Matt Dorado for his time, humor and willingness to share with us his expertise in TrafficWare's Synchro software.

DISCLAIMER

This report is the result of an academic exercise. The results are based on a traffic volume count taken on October 18, 2006, and the recommendations are the opinions of the student authors only.

INTRODUCTION

This project was created in response to a complaint received by the Clackamas County Transportation Department regarding the signal phasing at the three-way county intersection of Beavercreek and Meyers Road (see Figure 1 below.) The complaint received was from officials of the newly remodeled Oregon City High School (population 2,200), which occupies the northwest corner of this signalized intersection. The school expressed concern over the appropriateness, safety and queue storage of the 'permissive' left turn lane from Beavercreek northwest bound onto Meyers Road. The objective of this project was to collect data necessary to evaluate and recommend possible phasing modifications, based upon the intersection analysis.

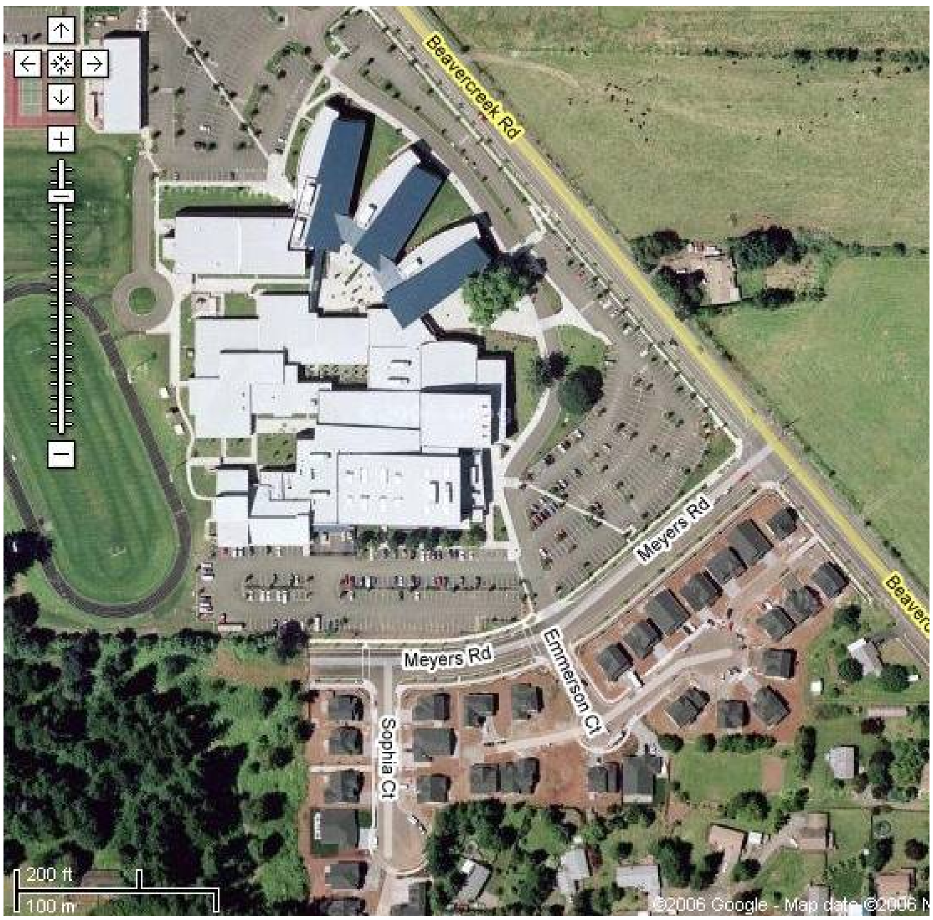


Figure 1: Aerial view of site

The intersection's configuration, known as a T-intersection, is comprised of both a major (Beavercreek) and minor (Meyers) road with three approaches each containing its own signal and pedestrian crossing. Beavercreek Road is a major thoroughfare, with access to Highway 213 and Interstate 205. Meyers Road allows access to the Oregon City High School and a small housing development adjacent to the school. NOTE: At the time of the field data collection for this study, a barricade across the entire width of Meyers Road existed just beyond the access points to the high school and housing development. This extension of Meyers Road had recently been paved and will eventually access another arterial thoroughfare, thereby impacting this intersection's capacity. In addition, a large, empty field occupies land northeast of the Beavercreek/Meyers Road intersection. This area has not yet been incorporated into the Urban Growth Boundary plan; however, Oregon City has recently posted signs informing the public as to the creation of the Beavercreek Road Concept Plan (Appendix Figure A.1.).

The northwest Beavercreek approach consists of a through lane (NWT) and an exclusive left turn lane (NWL), approximately 95 feet in length. The southeast Beavercreek approach consists of a shared lane which serves both through traffic and traffic turning right onto Meyers Road (SET/SER). The northeast approach from Meyers Road consists of an exclusive left turn lane (NEL), a bicycle lane and an exclusive right turn lane (NER). The timing of the intersection is fully-actuated and operated in a dual-ring configuration. Video cameras mounted atop each of three signal masts are used to detect vehicles. The intersection is at a slight grade, but is well-illuminated and has adequate sight-distance. In addition, the signal is operating in an uncoordinated mode, which allows it to operate independently from intersections either preceding or succeeding the Meyers/Beavercreek Road approach.

The following are observations made during the field study which give context to the problem at hand:

- The high school has two access points, an entrance off of Beavercreek Road, northwest of the intersection, and an entrance off of Meyers Road, requiring passing through the intersection.
- The Beavercreek Road entrance to the high school can only be accessed from the southeast bound lane of traffic due to grade separation. Therefore, northwest bound traffic must utilize the signalized intersection for access to the high school.
- Traffic flow on the school premises flows from north to south, which, in turn, further increases traffic through the intersection (Appendix Figure A.2).

REASONS FOR EXISTING PROBLEM

Due to the fact that this intersection lies within a school crossing zone (speed limit of 20 mph during the hours of 7am-5pm) warrants signalization according to the 2003 Manual of Uniform Traffic Control Devices. The permitted left turn from the northwest approach, however, requires turning vehicles to yield the right-of-way to the opposing stream of traffic and wait for gaps (Appendix Figure A.3). During peak hour traffic, queues begin to form when gaps from opposing traffic are insufficient and do not allow the bay of left-turning vehicles to empty during that phase. The painted median was observed to act as an extension of the left-turn bay. However, conflict arises when the queued vehicles from the overflowing left-turn bay and painted median block the through lane of traffic, a result known as spillover. As of November 17, 2007, there have been no reported vehicular and/or pedestrian accidents at this intersection.

METHODOLOGY

The analysis of traffic flow at this intersection included evaluating the existing capacity of each approach. The capacity was partially based on traffic counts taken during a field study conducted between 6-8am and 3-5pm on Wednesday, October 18, 2006. This data was later compiled on a spreadsheet (Appendix Table A.1) and analyzed for the peak intervals. In the afternoon, the Beavercreek northwest left turn lane was lightly used, due to the fact that most of the traffic was departing the school grounds, so only the morning peak hour was analyzed. The peak hour in the morning was determined to be 7:00-8:00 am.

Directional flow rates of the individual lanes and peak hour factors for both the lanes and the intersection as a whole were then determined (Appendix Table A.2). This data, along with the signal timing data for the intersection provided by the Clackamas County Department of Transportation, were inputted into Trafficware's Synchro 6 modeling software. To measure performance, Synchro utilizes the level-of-service (LOS) concept, whereby control (signal) delay is the measure of service. Signal delay represents the total delay experienced by a driver within a lane group (approach) due to both uniform and random arrivals, as well as signal control influences on the arrival pattern. The delay LOS criteria for signalized intersections are specified in the Highway Capacity Manual [Transportation Research Board 2000.] Clackamas County currently accepts no less than a 'D' LOS, which corresponds to a delay between 35 and 55 seconds. The intersection was analyzed using three different scenarios for the Beavercreek northwest left turn signal: permitted, permitted-protected, and protected.

RESULTS

The Synchro 6 analysis of the Beavercreek and Meyers Road intersection provided a level of service determination for each of the traffic approaches. Under the prevailing permitted phase, the LOS for the southeast approach was found to be A, the northwest approach, B, and the northeast approach, C. When the Beavercreek left turn phasing was changed to permitted-protected, the Beavercreek southeast approach dropped to a B and the left turn delay only marginally decreased. The intersection level of service was B for both cases. This further confirms the negative impact of changing the left turn phasing from its present permitted state.

The results of this analysis (Appendix Tables A.3-A.5) show that any change from the current permitted left turn signal phasing would not substantially reduce the delay experienced by drivers turning left onto Meyers Road from Beavercreek Road. Changing the phasing from a permitted to a permitted-protected phasing decreases the level of service (LOS) of the Beavercreek southeast through lane, but the LOS for the Beavercreek northwest left turn lane remained unchanged. Changing the phasing to a fully protected phase causes the LOS of the Beavercreek left turn lane to drastically decrease from a LOS of B to an F. Synchro simulations show that, due to the short protected turning phase allowed, a massive queue builds up, causing spillover onto the Beavercreek northwest through lane. Increasing the protected left turn phase time lengthens the intersection cycle time, thereby significantly decreasing the LOS on all other approaches.

RECOMMENDED SOLUTIONS

Based upon observations made in mid-October, changing the left turn signal phase from permitted to fully-protected is not advisable.

In order to address the concerns of the school officials, however, the following solutions are offered:

1. Change left turn phasing from permitted to permitted-protected. This solution will decrease the delay (0.5 seconds) experienced by the drivers accessing the school.
2. Adjust phasing to accommodate only peak hour (7:00-8:00 am) traffic, thereby reducing driver anxiety. Due to the shortened green time, this will result in a level of service for the Beavercreek southeast through lane to decrease, however, traffic in that direction is very light during that peak morning hour.
3. Change striping to allow more queue store in the Beavercreek left turn lane. As it stands now, the queue spills into the Beavercreek northwest through traffic, especially during the 7:30-8 am time period.

Since conducting the October 18th traffic counts, further expansion of housing developments have occurred on Meyers Road thereby increasing the flow of traffic utilizing the northeast approach. From these observations and Synchro analysis, the real problem seems to be the formation of large queues on the northeast Meyers Road left turn lane. This new development coupled with traffic exiting Oregon City High School during the morning and afternoon commute, causes large queues in the Meyers Road left turn lane (Appendix Figure A.4). A temporary solution to the increased Meyers Road traffic would be to increase green time for that approach. According to the signal timing plan, the initial green time, minimum gap, and yellow time are much less for this approach than what is allowed for the other approaches. These times could be increased, to reflect the increasingly heavy traffic volume turning left from Meyers Road onto Beavercreek Road.

Finally, developable land lies adjacent to this intersection. In the future, the whole intersection may have to be expanded and re-phased. Increased land development may eventually warrant restructuring and widening in order to insure the safety of the people accessing and leaving the high school under the resulting higher traffic volumes. The Beavercreek Road area, including the Beavercreek/Meyers Road intersection, is currently under study regarding these changes.

REFERENCES

[1] Fred L. Mannering, et al., *Principles of Highway Engineering and Traffic Analysis*, 3rd ed., John Wiley & Sons, 2005.

[2] David Husch, *Synchro 6*, Trafficware, 2003.

[3] “Manual on Uniform Traffic Control Devices”, 2003 edition.

APPENDIX

Figure A.1 – Future changes to intersection are possible.

Figure A.2 – Newly remodeled Oregon City High School.

APPENDIX

Figure A.3 – Left turn bay on Beavercreek Road

Figure A.4 – Meyers Road Approach to Beavercreek Road

APPENDIX

Table A.1- Traffic counts

Morning Counts						
Movement	**NWL**	**NWT**	**NEL**	**NER**	**SET**	**SER**
6:30 AM	18	183	25	6	35	9
6:45 AM	14	176	22	4	33	7
7:00 AM	23	207	44	11	40	10
7:15 AM	50	160	80	20	59	15
7:30 AM	63	165	87	29	95	32
7:45 AM	37	169	79	26	59	20
8:00 AM	8	156	18	4	27	5
Afternoon Counts						
Movement	**NBL**	**NBT**	**EBL**	**EBR**	**SBT**	**SBR**
3:00 PM	6	82	97	32	102	48
3:15 PM	7	87	32	11	139	17
3:30 PM	9	80	27	7	140	13
3:45 PM	6	78	22	6	169	12
4:00 PM	9	90	16	3	160	7
4:15 PM	13	79	26	5	153	14
4:30 PM	18	85	27	4	181	13
4:45 PM	25	73	23	3	204	11
	Peak=					

APPENDIX

Table A.2- Traffic volumes. V = Volume (veh./hr.) Intersection PHF = .84

Morning	-	-	-	-								
	NWL	**V**	**NWT**	**V**	**NEL**	**V**	**NER**	**V**	**SET**	**V**	**SER**	**V**
6:30 AM	18	72	183	732	25	100	6	24	35	140	9	36
6:45 AM	14	56	176	704	22	88	4	16	33	132	7	28
7:00 AM	23	92	207	828	44	176	11	44	40	160	10	40
7:15 AM	50	200	160	640	80	320	20	80	59	236	15	60
7:30 AM	63	252	165	660	87	348	29	116	95	380	32	128
7:45 AM	37	148	169	676	79	316	26	104	59	236	20	80
8:00 AM	8	32	156	624	18	72	4	16	27	108	5	20
Afternoon	-	-	-	-								
	NWL	**V**	**NWT**	**V**	**NEL**	**V**	**NER**	**V**	**SET**	**V**	**SER**	**V**
3:00 PM	6	24	82	328	97	388	32	128	102	408	48	192
3:15 PM	7	28	87	348	32	128	11	44	139	556	17	68
3:30 PM	9	36	80	320	27	108	7	28	140	560	13	52
3:45 PM	6	24	78	312	22	88	6	24	169	676	12	48
4:00 PM	9	36	90	360	16	64	3	12	160	640	7	28
4:15 PM	13	52	79	316	26	104	5	20	153	612	14	56
4:30 PM	18	72	85	340	27	108	4	16	181	724	13	52
4:45 PM	25	100	73	292	23	92	3	12	204	816	11	44
		PHF		PHF		PHF		PHF		PHF		PHF
PEAK V	173	0.69	701	0.85	290	0.83	86	0.74	253	0.67	77	0.60
	Peak Hour =											

APPENDIX

Table A.3 Timing sheet generated by Synchro 6 (Permitted phasing)

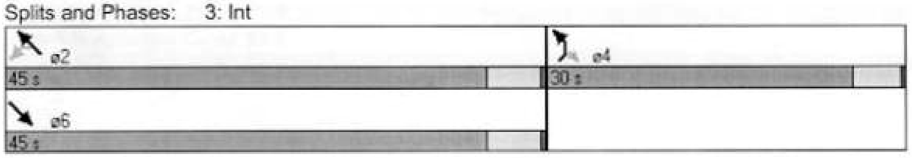
Timings
3: Int 11/17/2006

Lane Group	SET	NWL	NWT	NEL	NER
Lane Configurations					
Volume (vph)	253	173	701	290	86
Turn Type		Perm			Perm
Protected Phases	6		2	4	
Permitted Phases		2			4
Detector Phases	6	2	2	4	4
Minimum Initial (s)	8.0	8.0	8.0	4.0	4.0
Minimum Split (s)	16.0	16.0	16.0	8.5	8.5
Total Split (s)	45.0	45.0	45.0	30.0	30.0
Total Split (%)	60.0%	60.0%	60.0%	40.0%	40.0%
Yellow Time (s)	4.5	4.5	4.5	4.0	4.0
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5
Lead/Lag					
Lead-Lag Optimize?					
Recall Mode	Max	Max	Max	None	None
Act Effct Green (s)	42.9	42.9	42.9	18.9	18.9
Actuated g/C Ratio	0.61	0.61	0.61	0.27	0.27
v/c Ratio	0.35	0.39	0.73	0.72	0.20
Uniform Delay, d1	6.0	6.8	9.4	23.0	0.0
Control Delay	8.1	11.1	16.0	26.0	4.9
Queue Delay	0.0	0.0	0.4	0.0	0.0
Total Delay	8.1	11.1	16.4	26.0	4.9
LOS	A	B	B	C	A
Approach Delay	8.1		15.4	21.2	
Approach LOS	A		B	C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 69.8
Natural Cycle: 55
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.73
Intersection Signal Delay: 15.2 Intersection LOS: B
Intersection Capacity Utilization 59.6% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 3: Int



APPENDIX

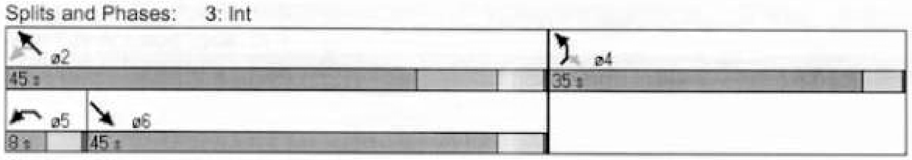
Table A.4 Timing sheet generated by Synchro 6 (Permitted-protected phasing)

Timings
3: Int 11/17/2006

Lane Group	SET	NWL	NWT	NEL	NER
Lane Configurations					
Volume (vph)	253	173	701	290	86
Turn Type		pm+pt			Perm
Protected Phases	6	5	2	4	
Permitted Phases		2			4
Detector Phases	6	5	2	4	4
Minimum Initial (s)	8.0	4.0	8.0	4.0	4.0
Minimum Split (s)	16.0	8.0	16.0	8.5	8.5
Total Split (s)	45.0	8.0	45.0	35.0	35.0
Total Split (%)	51.1%	9.1%	51.1%	39.8%	39.8%
Yellow Time (s)	4.5	3.5	4.5	4.0	4.0
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5
Lead/Lag	Lag	Lead			
Lead-Lag Optimize?	Yes	Yes			
Recall Mode	Max	None	Max	None	None
Act Effct Green (s)	41.3	49.3	49.3	20.8	20.8
Actuated g/C Ratio	0.53	0.63	0.63	0.27	0.27
v/c Ratio	0.41	0.42	0.71	0.73	0.21
Uniform Delay, d1	10.3	6.0	9.6	26.1	0.0
Control Delay	13.2	10.5	15.7	29.4	5.3
Queue Delay	0.0	0.0	0.0	0.0	0.0
Total Delay	13.2	10.5	15.7	29.4	5.3
LOS	B	B	B	C	A
Approach Delay	13.2		14.7	23.9	
Approach LOS	B		B	C	

Intersection Summary
Cycle Length: 88
Actuated Cycle Length: 78.1
Natural Cycle: 55
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.73
Intersection Signal Delay: 16.6 Intersection LOS: B
Intersection Capacity Utilization 59.6% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 3: Int



APPENDIX

Table A.5 Timing sheet generated by Synchro 6 (Protected phasing)

Timings
3: Int 11/17/2006

Lane Group	SET	NWL	NWT	NEL	NER
Lane Configurations					
Volume (vph)	253	173	701	290	86
Turn Type		Prot			Perm
Protected Phases	6	5	2	4	
Permitted Phases					4
Detector Phases	6	5	2	4	4
Minimum Initial (s)	8.0	4.0	8.0	4.0	4.0
Minimum Split (s)	16.0	8.0	16.0	8.5	8.5
Total Split (s)	36.0	8.0	49.0	26.0	26.0
Total Split (%)	48.0%	10.7%	65.3%	34.7%	34.7%
Yellow Time (s)	4.5	3.5	4.5	4.0	4.0
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5
Lead/Lag	Lag	Lead			
Lead-Lag Optimize?	Yes	Yes			
Recall Mode	Max	None	Max	None	None
Act Effct Green (s)	37.1	4.0	45.1	18.1	18.1
Actuated g/C Ratio	0.52	0.06	0.63	0.25	0.25
v/c Ratio	0.41	2.08	0.71	0.77	0.21
Uniform Delay, d1	9.6	33.6	8.7	24.5	0.0
Control Delay	12.0	538.6	13.9	31.4	5.8
Queue Delay	0.0	0.0	0.5	0.0	0.0
Total Delay	12.0	538.6	14.4	31.4	5.8
LOS	B	F	B	C	A
Approach Delay	12.0		118.1	25.5	
Approach LOS	B		F	C	

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 71.3
Natural Cycle: 55
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 2.08
Intersection Signal Delay: 73.9 Intersection LOS: E
Intersection Capacity Utilization 59.6% ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 3: Int