M E M O R A N D U M

To: Janelle Fowlds, Traffic Engineer, MNDOT District 4 - Detroit Lakes

From: Shawn Birst, Associate Research Fellow, UGPTI-ATAC

Date: January 16, 2003

Re: **Nokomis Street Evaluation (Alexandria, MN)**

1.0 INTRODUCTION

This study was conducted for the Minnesota Department of Transportation(MNDOT) by the Advanced Traffic Analysis Center (ATAC) to examine traffic operations in Alexandria, MN. Concerns have been expressed from some Alexandria citizens about traffic problems, especially related to the side-streets of Nokomis Street, also known as Trunk Highway 29. This study will evaluate the operations of the Nokomis corridor, using video detection equipment and traffic analysis tools.

2.0 OBJECTIVES

The purpose of this study is to assist MNDOT in developing effective traffic operation strategies for the Nokomis St corridor in Alexandria, MN. The main objectives of this study are summarized as follows:

- evaluate traffic operations at the intersection of Lake View Avenue and Nokomis St, with special emphasis on side-street traffic during the morning peak period,

- examine traffic operations at the intersection of CSAH 42 and Nokomis St, emphasizing the afternoon peak period, and

- evaluate traffic operations at the intersection of 3rd Ave and Nokomis St, with special emphasis on the afternoon peak period.

3.0 METHODOLOGY

The study examines ftraffic operation for the existing conditions of the analysis area, (shown in Figure 1) as well as the effects of various traffic control and road geometry modifications. This study will collect traffic data and perform several traffic analyses, including traffic signal warrant analysis, field delay measurements, and traffic simulation analysis. The following sections will discuss these topics in more detail.

3.1 Data Collection

Traffic data were collected at the intersections of Nokomis St and 3rd Ave, Lake View Ave, and CSAH 42. To observe various traffic conditions, data were collected for 12 hours (7:00 am - 7:00 pm) on a Thursday and Friday throughout the later part of August and early September, 2002. A video detection system was used to gather the field data and assisted in presenting the existing conditions and calibrating the analysis tools. The video tapes from the detection system were reviewed manually to determine turning movement counts at all three intersections and control delay at Nokomis St and Lake View Ave. Appendix A contains the results of the turning movement counts.

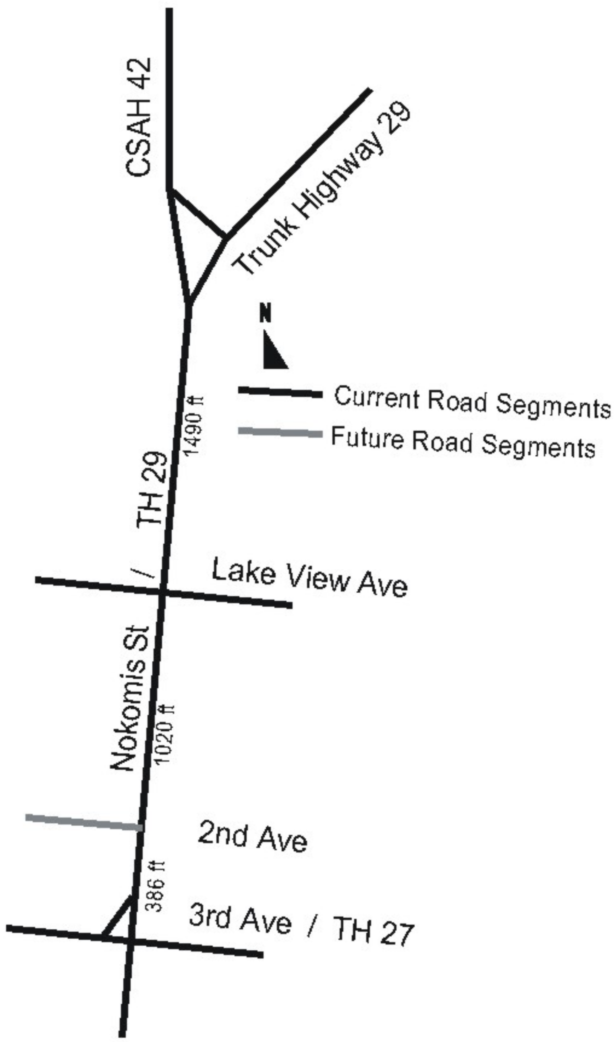

Figure 1. Analysis Network

3.2 Traffic Signal Warrant Analysis
A warrant analysis was performed on the intersection of Nokomis St and Lake View Ave. The 2001 Minnesota Manual on Uniform Traffic Control Devices (MN-MUTCD) was used for the warrant analysis. Eight traffic signal warrants are available for analysis, however, based on the gathered field data, three signal warrants were analyzed for this study:

- Warrant 1, 8-Hour Vehicular Volume,
- Warrant 2, 4-Hour Vehicular Volume, and
- Warrant 3, Peak-Hour.

The 2000 Census reported a population of 8,820 for Alexandria, MN. Therefore, the warrant analysis used 70% of the original criteria based on this population, causing the required traffic volume needed to meet the warrant to be reduced by 30%. The reduction may be used where the population of the built-up area of an isolated city is less than 10,000. Although the surrounding lake area consists of several thousand additional people, the reduction was used for the analysis. The complete results of the warrant analysis are shown in Appendix B, while the remaining sections provide a summary of the analysis.

3.2.1 Warrant 1, 8-Hour Vehicular Volume

Warrant 1 consists of two conditions: A) minimum vehicle volume and B) interruption of continuous traffic. Condition A is intended to evaluate intersections that experience large traffic volumes. Condition B is for intersections whose major-street volume is so large that the minor street suffers extreme delay when attempting to cross or enter the major street. The standard for this warrant is to meet either condition or meet 80% of both conditions.

Based on the field data, Warrant 1 was not met. Although, major-street volume thresholds were satisfied, the side-street volumes were too low for either condition. Condition A required 105 vehicles per hour on the higher-volume-minor-street for eight hours of the day, while Condition B required 53 vehicles. However, the volumes observed on the side street for the highest 8 hours ranged from 27 to 37 vehicles per hour.

3.2.2 Warrant 2, 4-Hour Vehicular Volume

Warrant 2 is intended to evaluate the operation of the intersecting traffic. Using the 70% factor, the required higher-volume-minor-street must encounter 60 vehicles per hour for 4 hours for major-street volumes greater than 950 vehicles per hour. Similar to Warrant 1, the major-street volume requirements were met, however, the side-street volumes, ranging from 29 to 37 vehicles per hour, were less than the required amount.

3.2.3 Warrant 3, Peak-Hour

Warrant 3 is used in special cases when traffic conditions for a minimum period of one hour are such that the side-street traffic suffers undue delay when entering or crossing the major street. Two categories must be met for this warrant. Category A consists of three conditions for an average day:

- stop delay of one minor-street approach is four hours or greater,
- higher-volume-minor-street approach must have 100 vehicles or more, and
- intersection volume must be 800 vehicles or more.

Category B requires the higher-volume-minor-street approach to have at least 75 vehicles when the major-street volume is greater than 1300 vehicles. Based on the field data, only one of the conditions of Category A was met and Category B was not met. Therefore, this warrant was not met.

The analysis concluded that a traffic signal at the intersection of Nokomis St and Lake View Ave does not meet signal warrants. It should be pointed out that the major-street volumes of Nokomis St exceeded the threshold for all three warrants by a considerable amount, however, the minor-street volumes were significantly lower than the threshold even when using the 70% factor.

3.3 Control Delay Analysis

Control delay measurements provide insight on the time motorists of a particular movement, approach, or intersection are delayed as a result of a traffic control device. Motorists may perceive a high delay time while crossing or entering a major street, but typically the actual delay time is significantly less than the perceived time. Several factors may influence driver perception, but one factor most relevant to a two-way stop-control (TWSC) intersection is the uncertainty of having an adequate gap to complete the turning maneuver. This issue may not be a factor (at least not to the same extent) at intersections with four-way stop-control or signal control.

Delay time measurements were performed for the westbound approach (higher-volume-minor-street approach) of the Nokomis St and Lake View Ave intersection. The measurements determined the length of time each vehicle waited to enter or cross Nokomis St during the three peak periods (AM, midday, and PM) over two days (Thursday and Friday). The complete results of the control delay analysis are shown in Appendix C. The following table illustrates the average control delay time values.

Table 1. Average Control Delay for the Westbound Approach of Lake View

Day of Week	Peak Period	Avg. Control Delay (sec./veh.)
Thursday	AM (7:00 am - 9:00 am)	22.2
	Midday (11:00 am - 1:00 pm)	29.1
	PM (4:00 pm - 6:00 pm)	34.3
Friday	AM (7:00 am - 9:00 am)	20.7
	Midday (11:00 am - 1:00 pm)	34.6
	PM (4:00 pm - 6:00 pm)	31.0

Although the average values are not extremely high, ranging from 22.2 to 34.6 seconds/vehicle, approximately 15% (7 to 12) of the motorists for each peak period encountered delay time greater than 60 seconds. In addition, the maximum delay time values ranged from 83 to 142 seconds/vehicle. These values are excessive, however, the occurrence is too infrequent to warrant a signal based on delay time.

3.4 Simulation Analysis

Traffic simulation was used to compare the existing conditions of the corridor to various traffic control alternatives during different peak-hour periods. Traffic simulation models mimic the behavior of a transportation system given different types of interaction among its components or entities, i.e., roadway networks, drivers, and traffic control devices. These models integrate the behavior and interactions among these separate entities to measure their impact on the system's operations and performance.

The CORSIM microscopic traffic simulation program was used for the analyses. CORSIM provides useful visual and numerical output. The visual output (animation) is useful for presenting the traffic operations to those interested, while the numerical output is used for evaluating performance measures, such a travel time, delay time, speed, etc.

The Synchro traffic signal optimization program was used to develop signal plans for the three potential signalized intersections and to update the current signalized intersection (Nokomis St and 3rd Ave) when needed. The proposed/modified signal plans were evaluated in CORSIM. Several input parameters were needed for the simulation and signal timing analysis, which include the following:

- Road Geometry - intersection location, street length, lane geometry, speed limit
- Traffic Control - phases, green and intergreen time, actuated settings
- Traffic Volume - turning movement counts

Several scenarios were compared in the simulation analysis, with the main objective to determine the effects of adding signalized control to one intersection. Several measures of effectiveness (MOE) were extracted from CORSIM, including delay time, control delay, and throughput. The MOE were then compared among different scenarios. Since CORSIM is a stochastic model, which is based on random processes, 30 runs were performed for each scenario and the average values were used for the comparisons. Four groups of scenarios were compared using various peak periods, traffic control, and geometry, which include the following:

- AM Thursday (Existing Geometry)
  1. Existing Conditions
  2. CSAH 42 Signal Installation
  3. Lake View Ave Signal Installation

- PM Thursday (Existing Geometry)
  4. Existing Conditions
  5. CSAH 42 Signal Installation
  6. Lake View Ave Signal Installation
  7. Lake View Ave X 2 Signal Installation (Doubled the Lake View volume)

- PM Friday (Existing Geometry)
  8. Existing Conditions
  9. CSAH 42 Signal Installation
  10. Lake View Ave Signal Installation

- PM Thursday (Construction of 2nd Ave and Reconstruction of 3rd Ave)
  11. Unsignalized Operation of 2nd Ave (Using 20% of 3rd Ave EBL volume)
  12. Signalized Operation of 2nd Ave (Using 20% of 3rd Ave EBL volume)
  13. Unsignalized Operation of 2nd Ave (Using 10% of 3rd Ave EBL volume)
  14. Signalized Operation of 2nd Ave (Using 10% of 3rd Ave EBL volume)

It should be noted that a 70-second cycle length was used for Lake View Ave and CSAH 42 during all time periods, operating under actuated-uncoordinated control. For the 2nd Ave scenarios with signalized control, a 85-second cycle length was used for 2nd Ave and 3rd Ave and operated under actuated-coordinated control to reduce the delay between the two intersections.

4.0 SIMULATION RESULTS
The results of the 14 scenarios were grouped for the 3 respective intersections, as well as the overall network. The summary of the results are discussed in the following sections.

4.1 Lake View Avenue
Modifying the traffic control from unsignalized to signalized was evaluated in four scenarios using traffic simulation. Each of the four scenarios provided benefits to both Lake View Ave approaches, as shown in Table 2. The critical approach (westbound) achieved savings from the signalized control ranging from 21 to 34 seconds/vehicle. Although Lake View Ave received benefits from signalized control, it does not experience a high enough volume to counteract the delay caused to the traffic on Nokomis St. One scenario doubled the existing Lake View Ave traffic, however, the Lake View Ave delay did not significantly increase and intersection delay experienced a significant increase under signalized control. Although the average vehicle delay at the intersection is not excessive in terms of delay time per vehicle with signalized control, intersection control delay increased significantly, ranging from 238 to 348%.

Table 2. Comparison of Traffic Control at Lake View Ave.

	Eastbound Approach		Westbound Approach		Northbound Approach		Southbound Approach	
Thursday AM Peak	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)
Unsignalized Control	13.9	7.5	37.8	27.2	.3	444.6	.7	930.2
Signalized Control	10.0	7.5	11.2	27.1	3.4	445.2	5.5	930.3
Change in Intersection Control Delay	265% {1.4 sec/veh (unsignalized) to 5.0 sec/veh (signalized)}							
Thursday PM Peak	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)
Unsignalized Control	26.1	15.2	34.2	25.1	.4	1001.0	.7	693.6
Signalized Control	13.1	15.1	13.1	25.0	5.7	1001.0	4.8	694.5
Change in Intersection Control Delay	348% {1.2 sec/veh (unsignalized) to 5.5 sec/veh (signalized)}							
Thursday PM Lake View Traffic X 2	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)
Unsignalized Control	32.4	31.3	43.7	50.6	.4	996.4	.6	692.5
Signalized Control	13.4	31.2	14.8	50.5	8.1	997.3	6.7	692.5
Change in Intersection Control	244% {2.3 sec/veh (unsignalized) to 7.8 sec/veh (signalized)}							
Friday PM Peak	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)
Unsignalized Control	34.8	15.1	46.7	39.0	.4	985.0	.7	691.9
Signalized Control	12.51	15.2	14.5	38.7	6.5	981.8	5.4	693.3
Change in Intersection Control Delay	238% {1.9 sec/veh (unsignalized) to 6.3 sec/veh (signalized)}							

Note: Intersection control delay is the weighted average of the approach control delay values.
The change in intersection control delay was based on three significant digits.

4.2 CSAH 42

Three scenarios were compared to evaluate changing the traffic control from unsignalized to signalized. Unlike Lake View Ave, this analysis focused on providing assistance to a movement on the main street (Nokomis St), specifically the northbound left-turn movement during the afternoon periods. The signalized scenario incorporated a northbound left-turn phase. Since the eastbound demand from CSAH 42 is low, the control delay increases as a result of incorporating a traffic signal, as shown in Table 3. This observation can be explained by the fact that the eastbound traffic can enter Nokomis St without any difficultly; however, a signal would inhibit traffic since they would have to wait until a green indication is provided.

The northbound approach experienced delay improvements only during the Thursday PM scenario. During the other two periods, the northbound left-turning traffic receives sufficient gaps from the opposing southbound traffic under unsignalized control and the signalized control would provide green to the eastbound approach which would interrupt the northbound and southbound traffic. Although the average vehicle delay at the intersection is not excessive with signalized control, the intersection control delay increased from 46 to 189%.

Table 3. Comparison of Traffic Control at CSAH 42.

	Eastbound Approach		Westbound Approach		Northbound Approach		Southbound Approach	
Thursday AM Peak	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)
Unsignalized Control	11.8	18.8	-	-	3.1	437.9	.2	512.9
Signalized Control	15.7	19	-	-	3.6	438.1	5.8	513.0
Change in Intersection Control Delay	189% {1.7 sec/veh (unsignalized) to 5.0 sec/veh (signalized)}							
Thursday PM Peak	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)
Unsignalized Control	13.9	20.7	-	-	3.4	967.9	.3	397.3
Signalized Control	17.5	22.7	-	-	2.5	967.5	6.5	397.2
Change in Intersection Control	46% {2.7 sec/veh (unsignalized) to 3.9 sec/veh (signalized)}							
Friday PM Peak	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)
Unsignalized Control	13.9	20.8	-	-	3.2	1103.5	.3	353.5
Signalized Control	21.7	20.7	-	-	3.9	1104.0	8.8	353.0
Change in Intersection Control	100% {2.7 sec/veh (unsignalized) to 5.3 sec/veh (signalized)}							

Note: Intersection control delay is the weighted average of the approach control delay values.
The change in intersection control delay was based on three significant digits.

4.3 2nd Avenue

The intersection of Nokomis St and 2nd Ave will be constructed in the summer of 2003. This intersection will provide motorists with an additional route to travel east/west and will divert some of the traffic off 3rd Ave. In addition, the intersection of Nokomis St and 3rd Ave will be reconstructed in 2004. The construction will provide an additional eastbound left-turn lane and northbound through lane between 3rd Ave and 2nd Ave. The additional northbound lane would drop a few hundred feet north of 2nd Ave.

In the field, traffic will be distributed between 2nd Ave and 3rd Ave based on the delay encountered. If motorists observed excessive delay at 2nd Ave with unsignalized control, they would divert to 3rd Ave. Since 2nd Ave does not have any new developments currently under construction, it is difficult to project the traffic volume that would use the street. Therefore, the traffic volume used for this study is a portion of the eastbound left-turn traffic currently on 3rd Ave. To provide a range of traffic conditions a 10% and 20% portion of the Thursday PM traffic was used for the eastbound approach of 2nd Ave, resulting in approach volumes of 54 and 93 vehicles per hour, respectively. The turning percentages used for this approach were 85% left turning traffic and 15% right turning traffic. For the two traffic levels, comparisons between unsignalized and signalized traffic control were performed.

It was observed that CORSIM could not accurately model the lane drop north of 2nd Ave. Typically, traffic that is familiar with the area would realize the lane drop in advance and try to merge into the proper lane between 3rd Ave and 2nd Ave. However, CORSIM evenly splits traffic between available lanes, which resulted in traffic merging north of 2nd Ave. Therefore, CORSIM's queue length and delay time for the northbound approach of 2nd Ave during signalized operation are very conservative.

The simulation results, shown in Table 4, suggest a traffic signal is not needed at 2nd Ave. Signalized control provided minimal delay benefits to the eastbound approach for the 20% scenario, while creating additional delay for the 10% scenario. The additional delay is the result of traffic waiting longer for a green indication from the traffic signal compared to finding an adequate gap under stop control. Although the average vehicle delays for the 20% and 10% scenarios were not excessive under either traffic control, incorporating a traffic signal increased intersection control delay by 329% and 467%, respectively.

Since the distance between 2nd Ave and 3rd Ave is only 400 feet, traffic operations between the intersections could be adversely affected during peak periods. The traffic sent to 2nd Ave from 3rd Ave primarily originates from the eastbound left and northbound through movements. Therefore, the northbound queue at 2nd Ave may extend back to 3rd Ave, adversely affecting the intersection's traffic operations and safety. Most transportation agencies have guidelines related to the spacing of signalized intersections to ensure the efficient and safe movement of traffic. MNDOT recommends signalized intersection spacing greater than 1/4 mile (1320 feet). Therefore, to comply with those standards, 2nd Ave should operate as unsignalized.

Table 4. Comparison of Traffic Control at 2nd Ave.

	Eastbound Approach		Westbound Approach		Northbound Approach		Southbound Approach	
Thursday PM Peak 20%	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)
Unsignalized Control	24.9	92.9	-	-	.1	913.0	.4	660.5
Signalized Control	23.7	93.3	-	-	4.6	914.9	7.6	661.3
Change in Intersection Control Delay	329% {1.6 sec/veh (unsignalized) to 6.9 sec/veh (signalized)}							
Thursday PM Peak 10%	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)	Control Delay (sec/veh)	Throughput (veh)
Unsignalized Control	21.5	53.7	-	-	.1	955.5	.4	660.9
Signalized Control	19.3	53.4	-	-	4.4	955.6	4.9	660.0
Change in Intersection Control Delay	467% {.9 sec/veh (unsignalized) to 5.1 sec/veh (signalized)} 19.3							

Note: Intersection control delay is the weighted average of the approach control delay values.
The change in intersection control delay was based on three significant digits.

4.4 Overall Network

Modifying traffic control affects intersection operations, as well as the operation of the total corridor or network. The CORSIM simulations also provided numerical information related to network performance in terms of vehicle-hours of delay. Signalized operation increased network delay for every comparison. Delay caused by signalizing Lake View Ave increased 6% to 13%, CSAH 42 increased 2% to 6%, and 2nd Ave increased 9% to 12%.

Table 5. Effects of Traffic Control to Overall Network

Intersection with Nokomis St		Unsignalized	Signalized	Difference
Lake View Ave	AM Thursday	15.5	17.5	13%
	PM Thursday	27.8	30.5	10%
	PM Thur. (2XLakeView)	29.5	32.7	11%
	PM Friday	29.6	31.4	6%
CSAH 42	AM Thursday	15.5	16.5	6%
	PM Thursday	27.8	28.3	2%
	PM Friday	29.6	30.9	4%
2nd Ave (20%)	PM Thursday	24.7	27.6	12%
2nd Ave (10%)	PM Thursday	23.3	25.3	9%

Note: Intersection control delay is the weighted average of the approach control delay values.
The change in intersection control delay was based on three significant digits.

5.0 SUMMARY/RECOMMENDATIONS

This study evaluated the traffic operation of Nokomis St between 3rd Ave and CSAH 42. Several tasks were performed to determine the existing conditions and several traffic control alternatives, including a warrant analysis, field delay analysis, and traffic simulation analysis. Since Lake View Ave was identified as the critical intersection, most of the tasks focused on this intersection. The signal warrant analysis, which often is the only traffic study performed for an intersection, determined that a traffic signal is not justified at Lake View Ave. The field delay analysis determined that the Lake View Ave delay is not excessive overall, however, about 15% of the traffic experienced delay greater than one minute. The simulation analysis determined the potential effects of modifying traffic control. Although some benefits are realized for the side-street approaches, the adverse affects to the major-street approaches and total network significantly outweigh those benefits. In addition, MNDOT has indicated that Lake View Ave has experienced only a few crashes over the past several years.

Based on our analyses, it is recommended to maintain CSAH 42 and Lake View Ave as unsignalized intersections and to implement unsignalized control at 2nd Ave after construction. If traffic volumes continue to increase along Nokomis St and Lake View Ave, it is also recommended to reevaluate the intersection operation.

APPENDIX A: Turning Movement Counts

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Fargo, ND 58105

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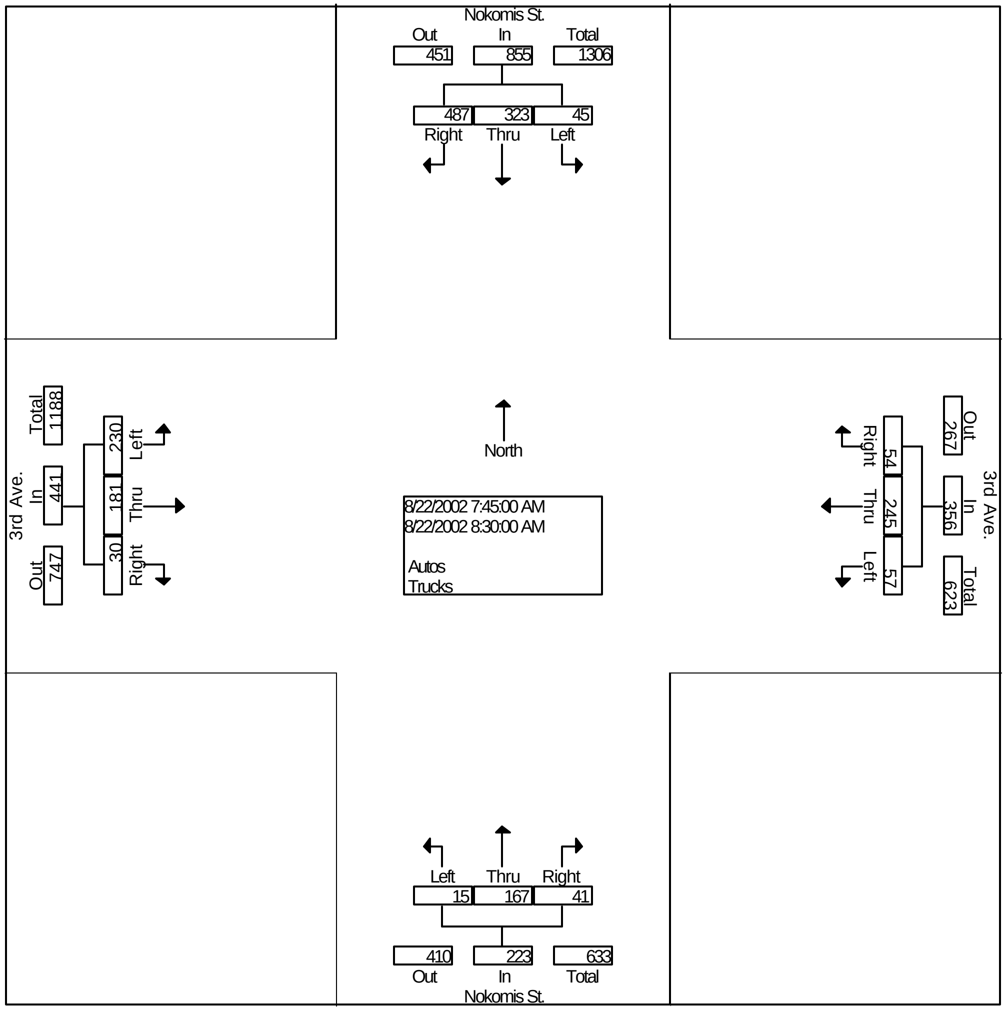

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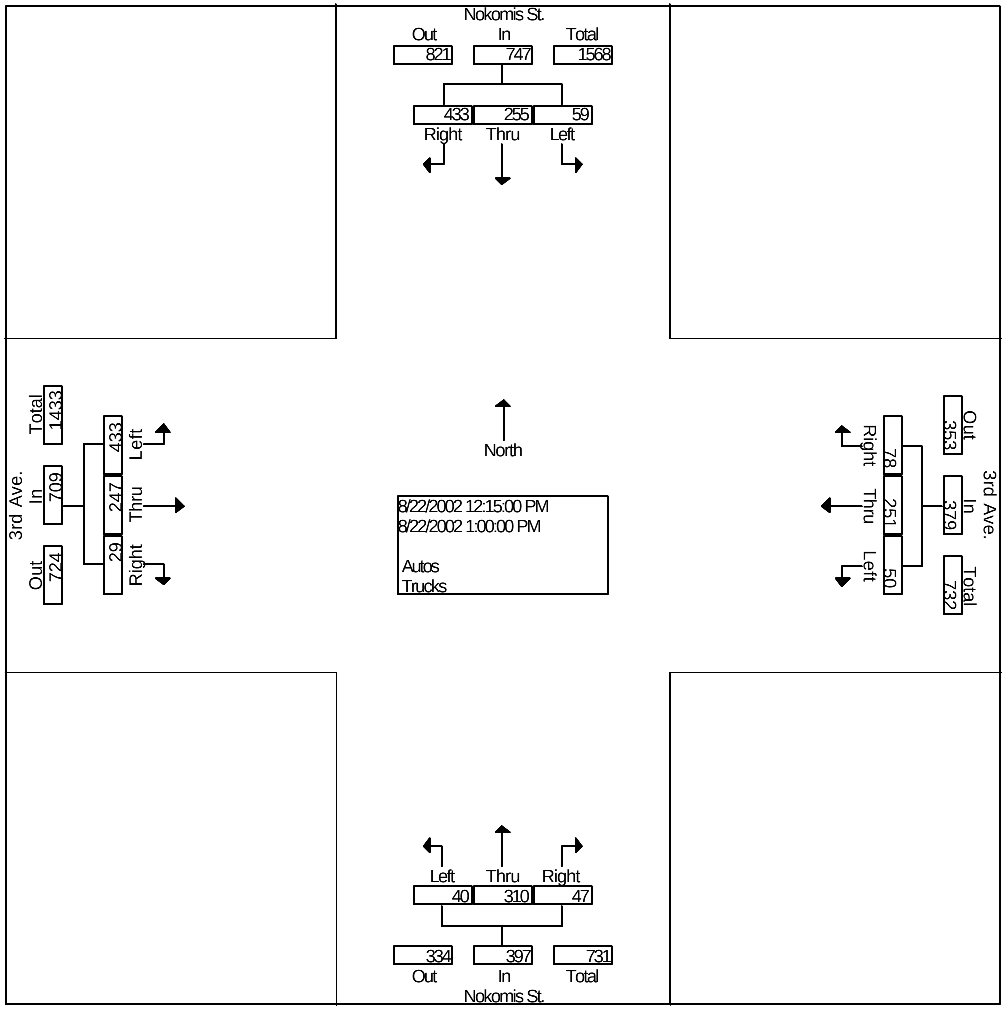

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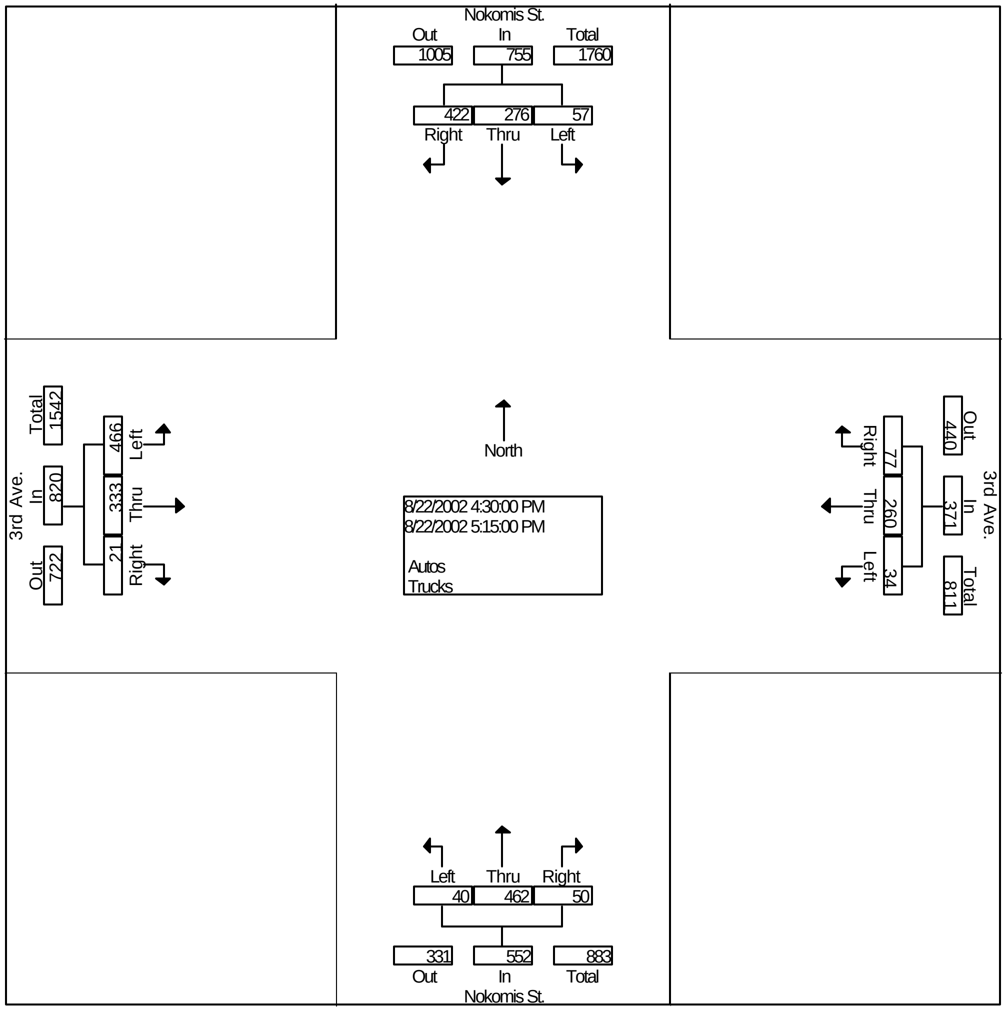

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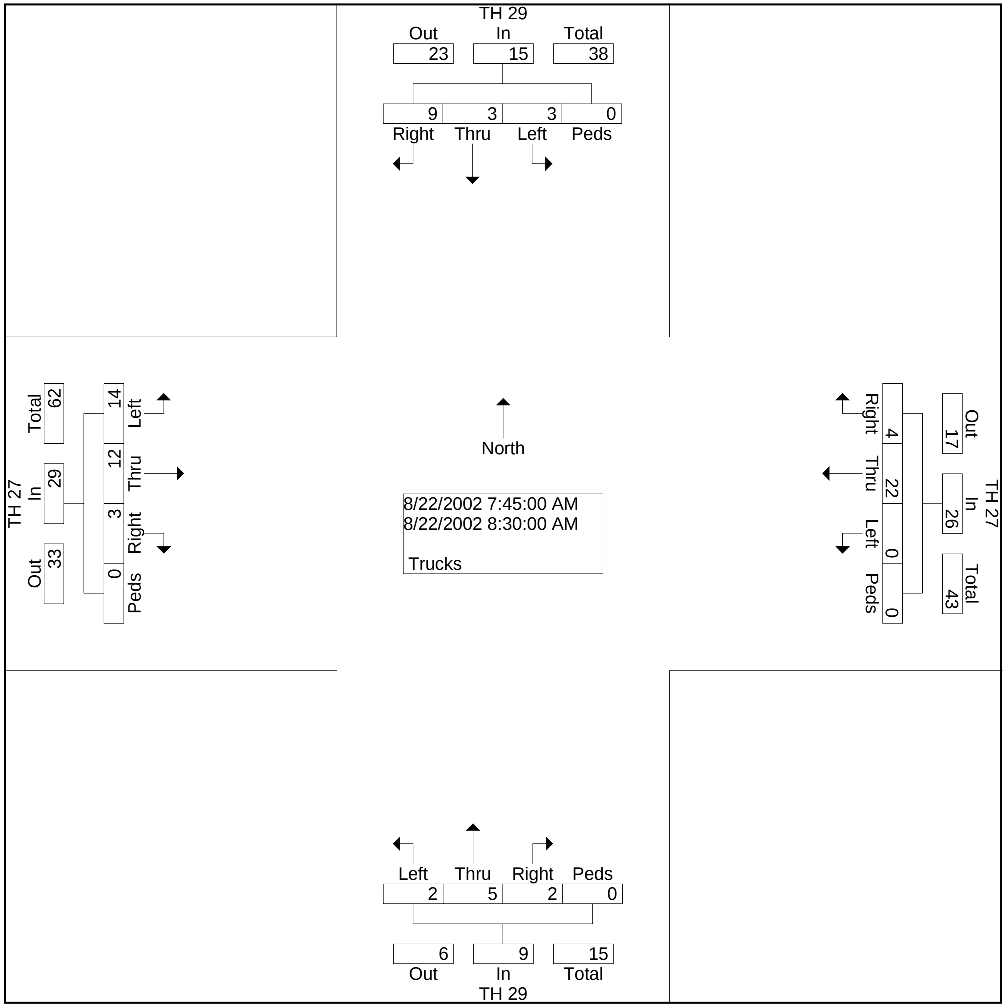

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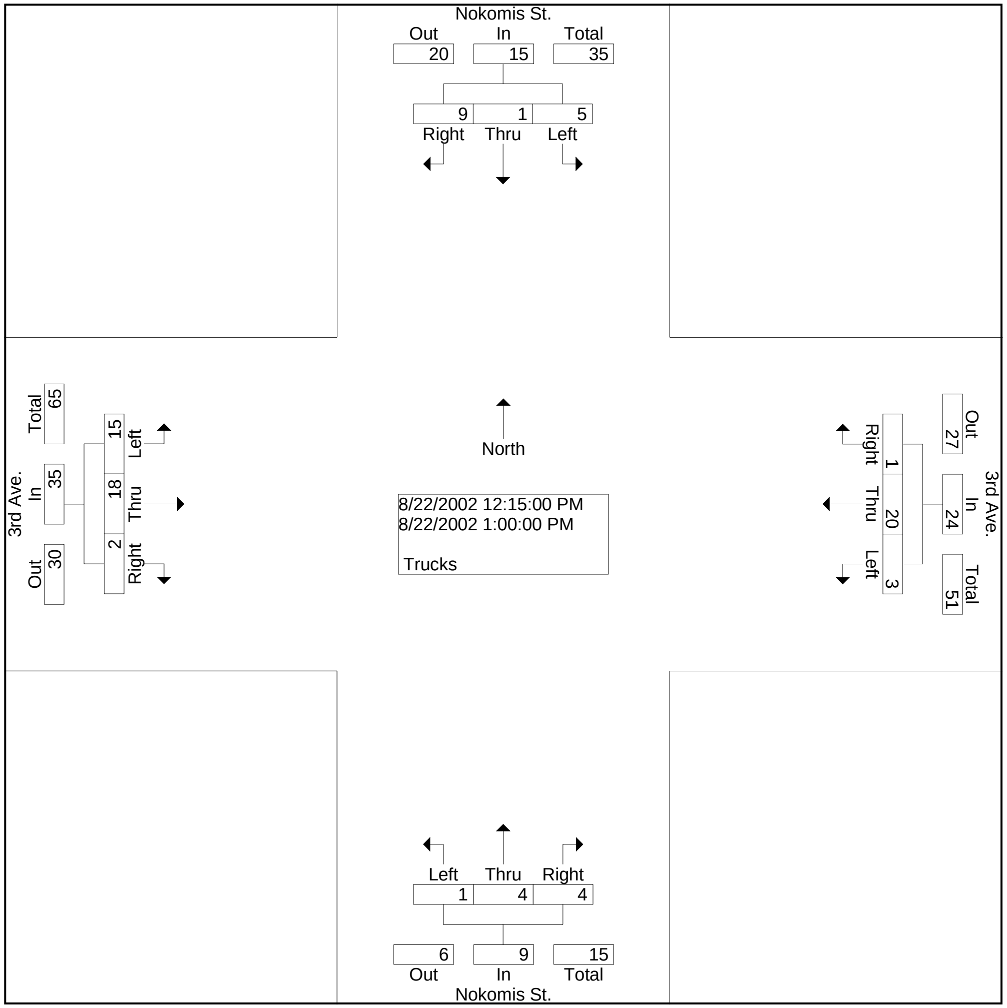

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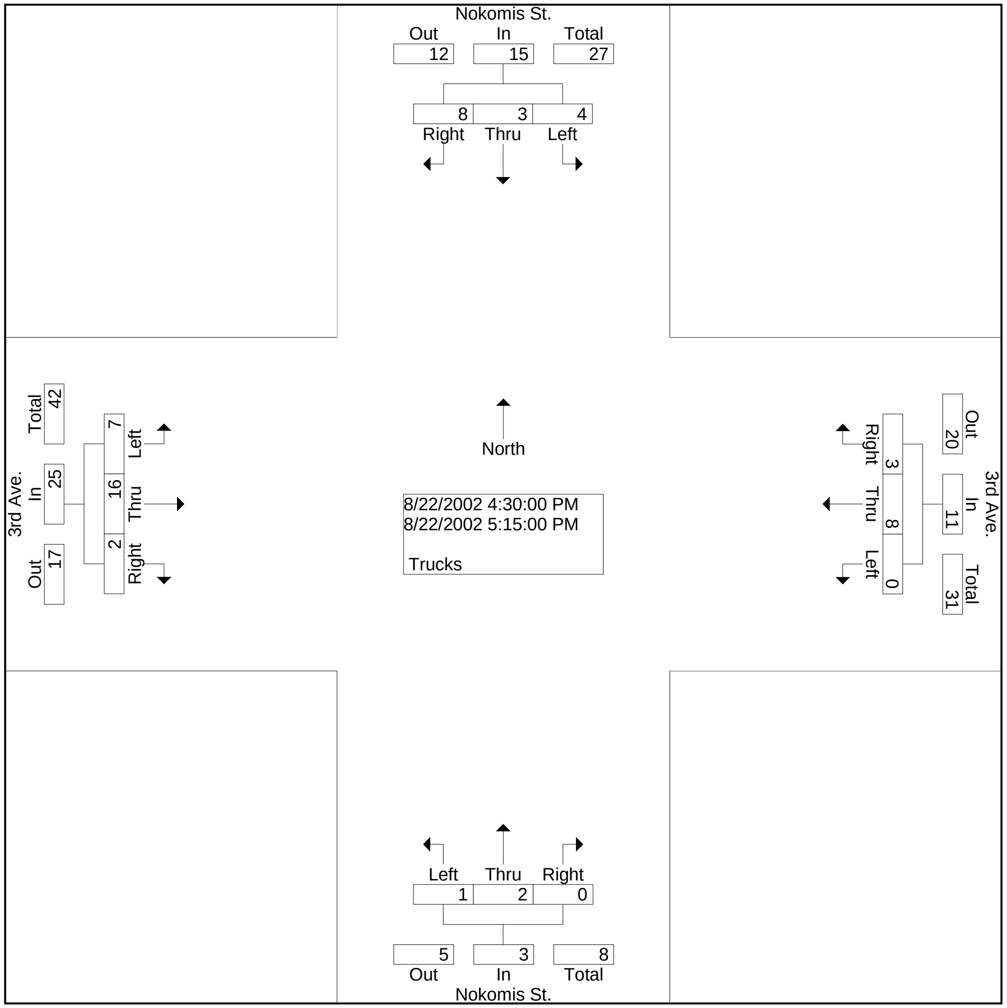

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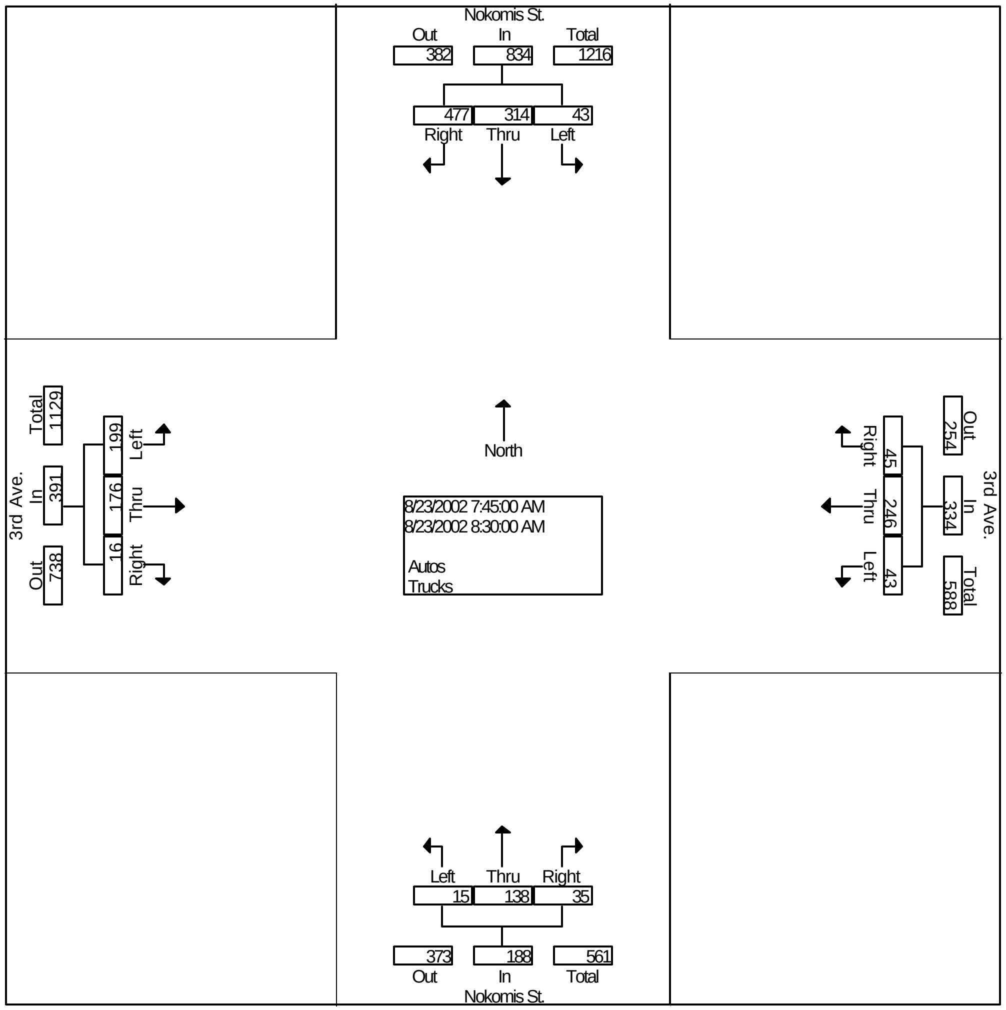

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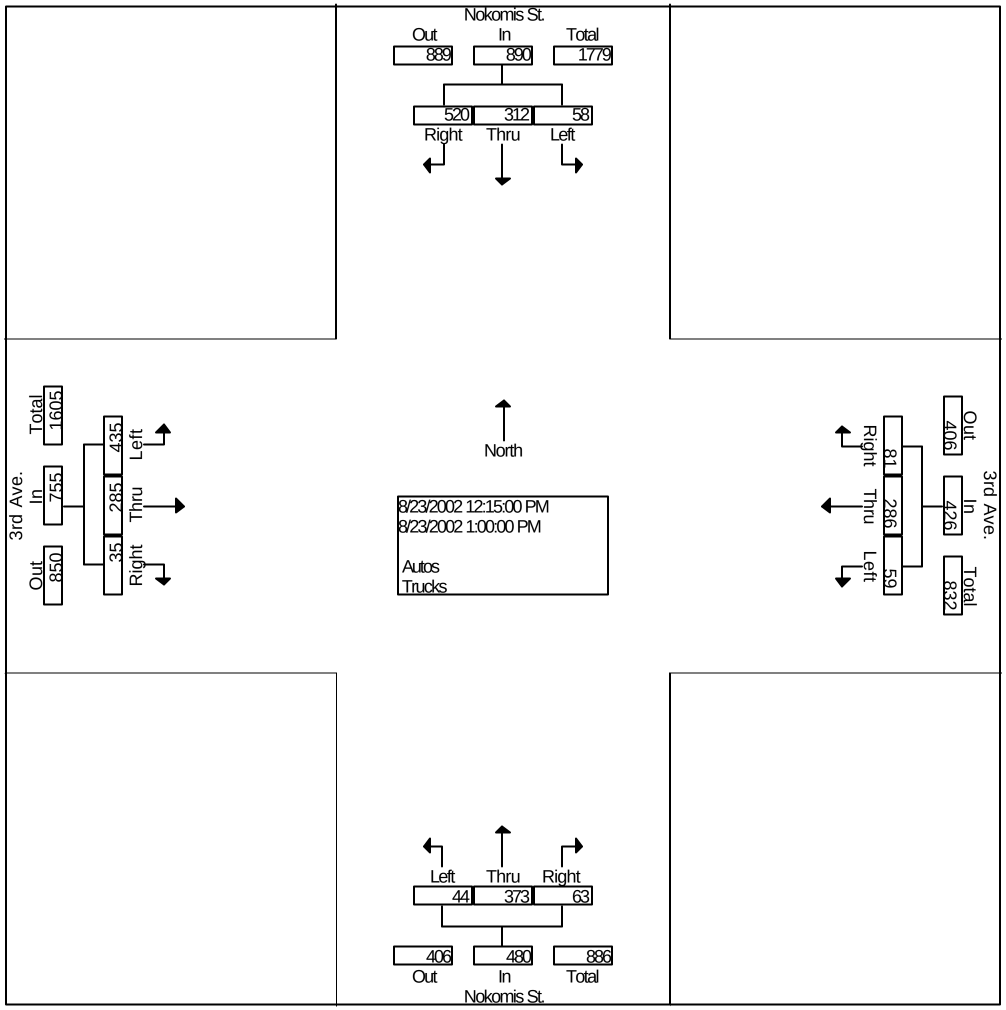

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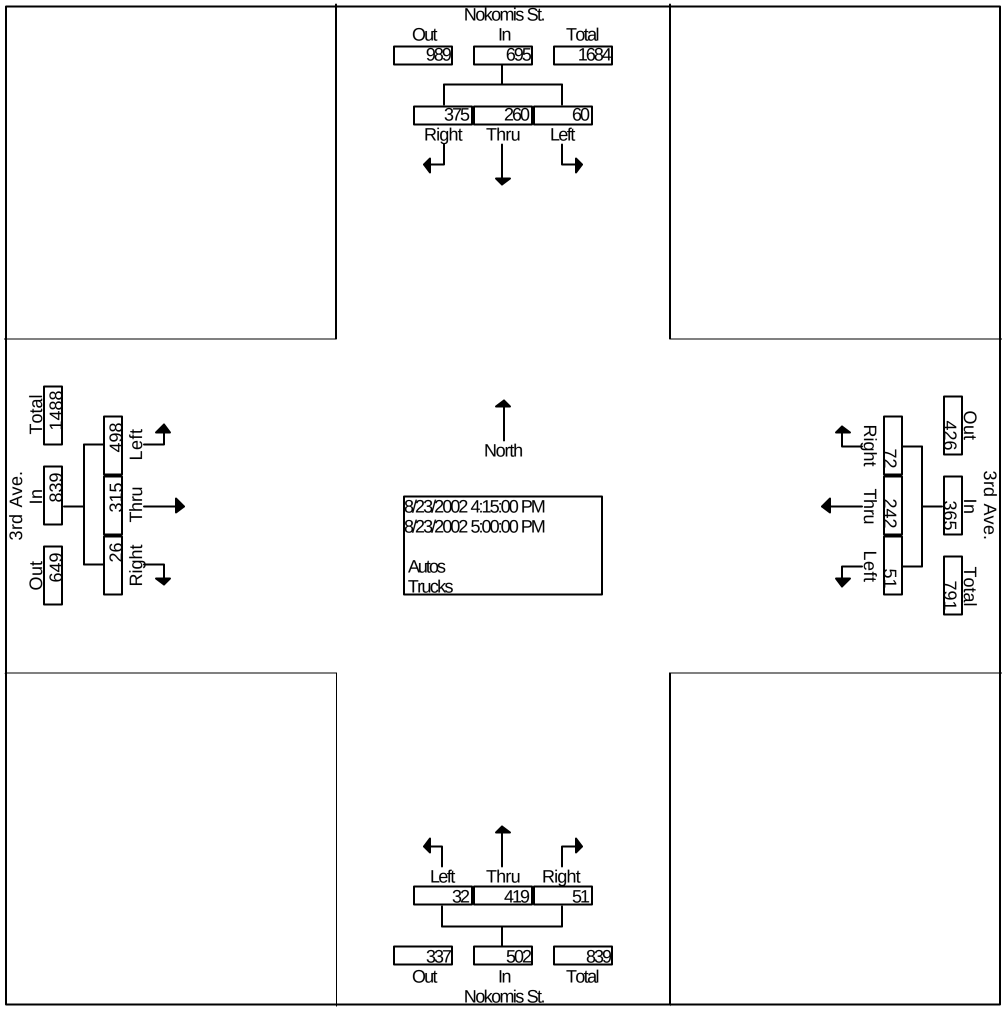

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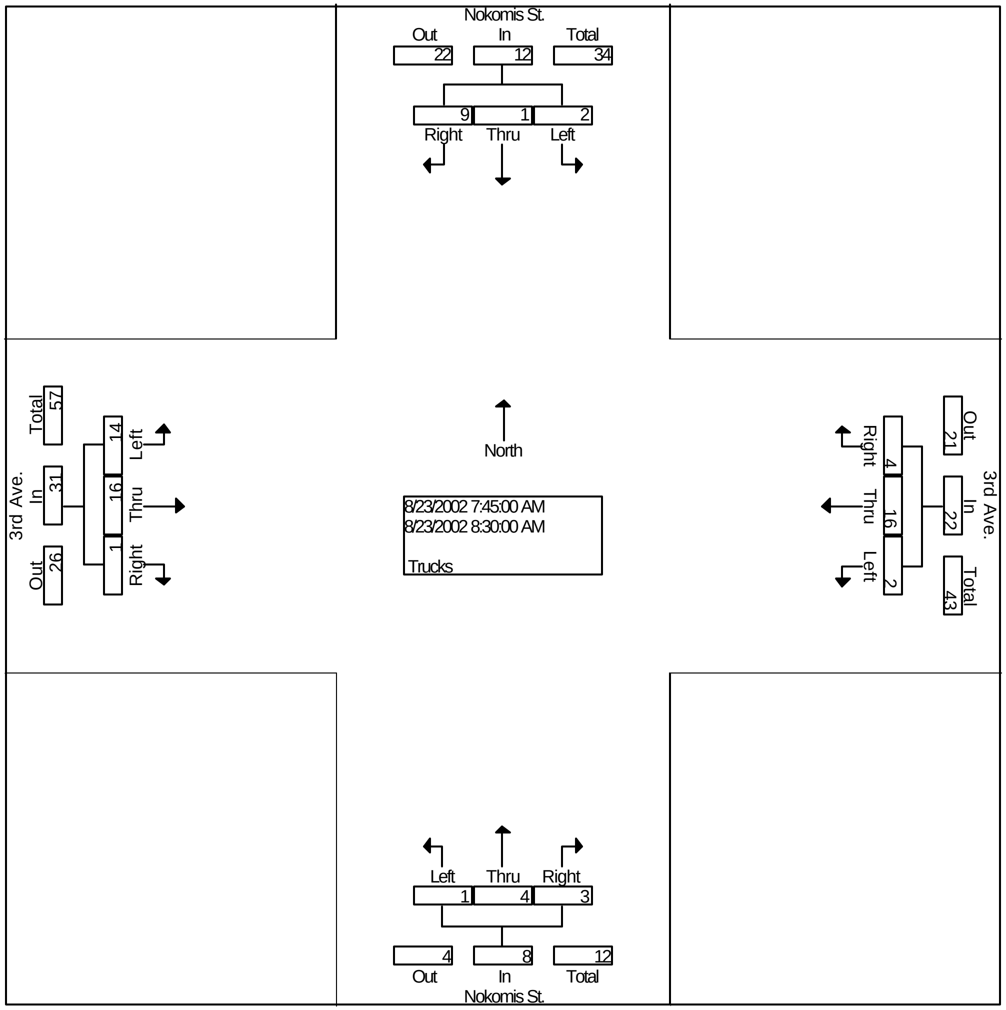

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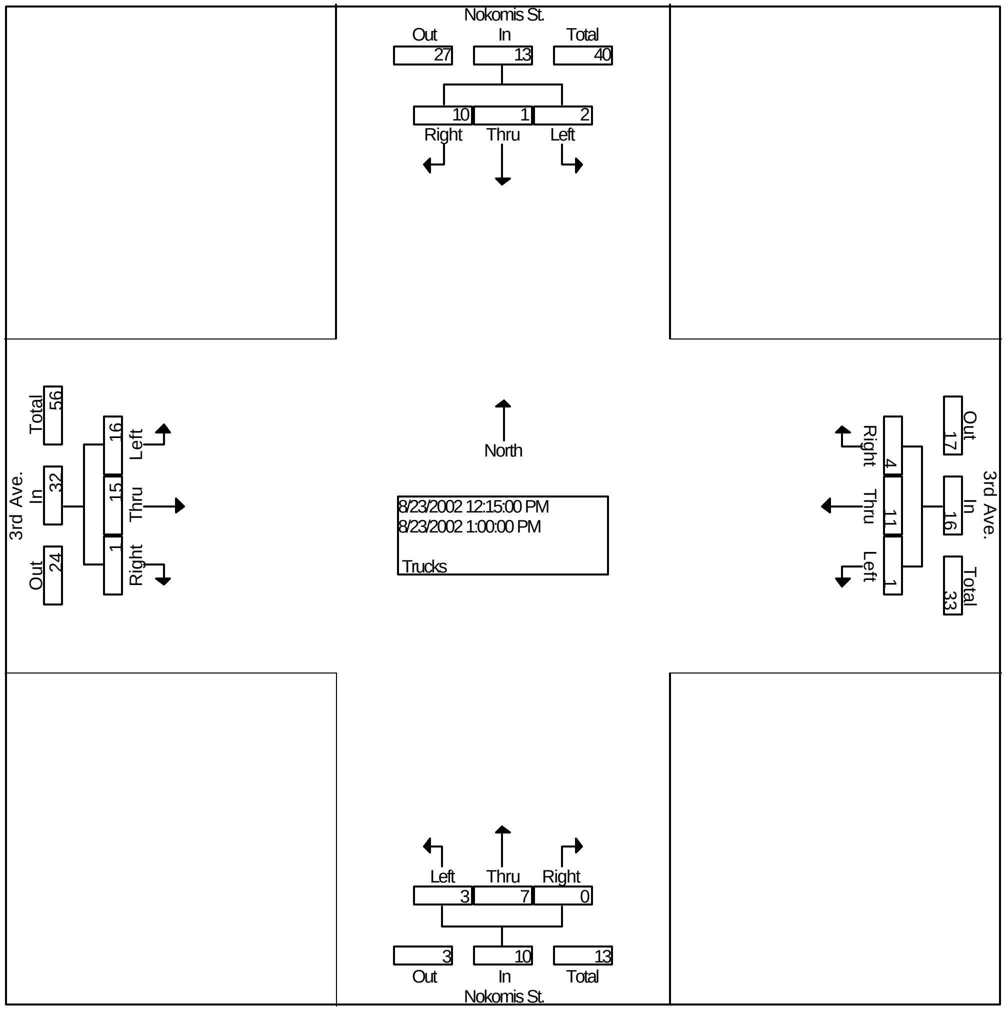

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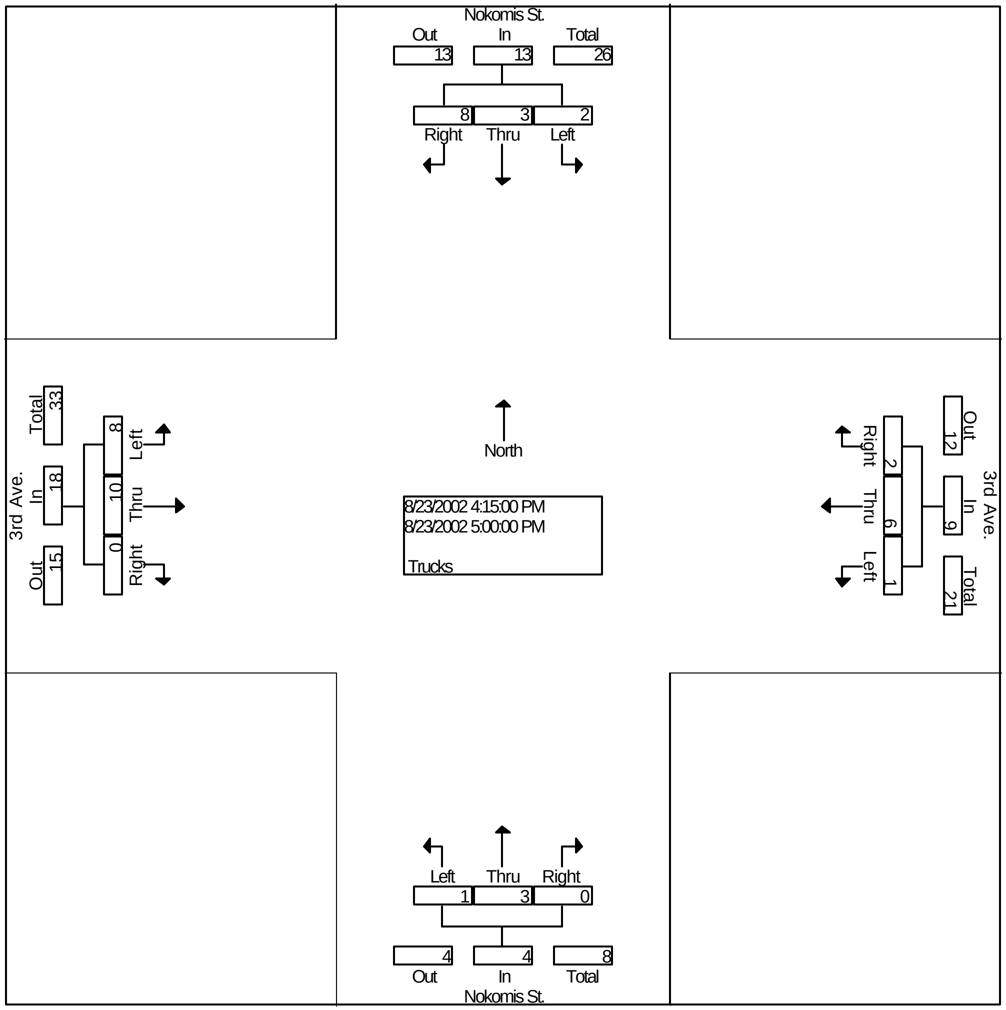

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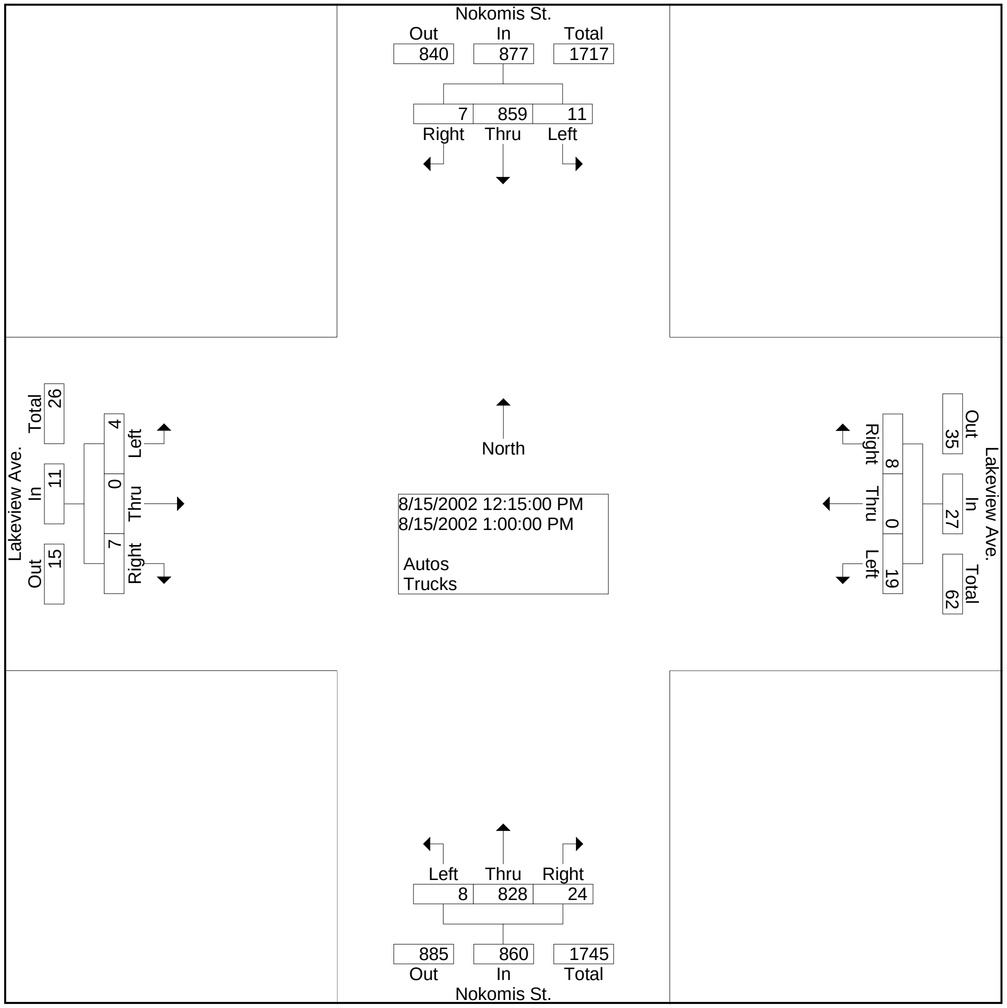

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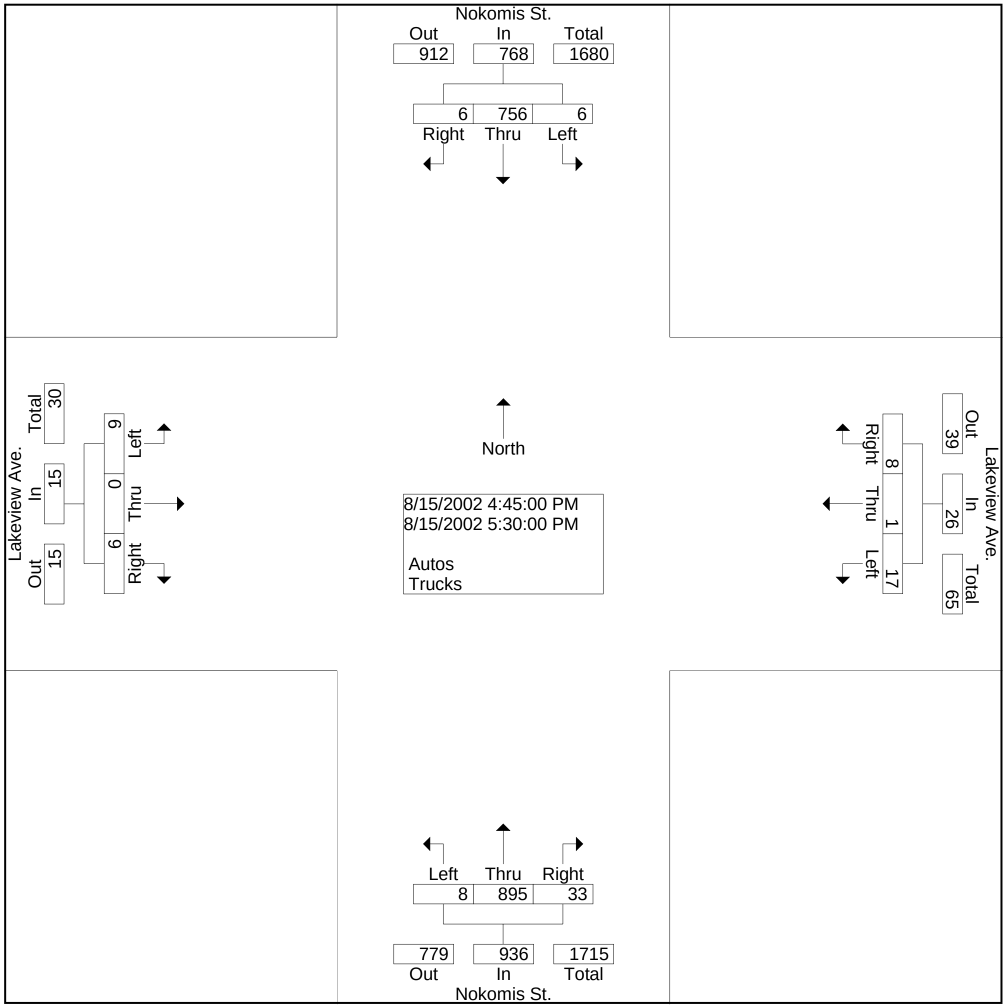

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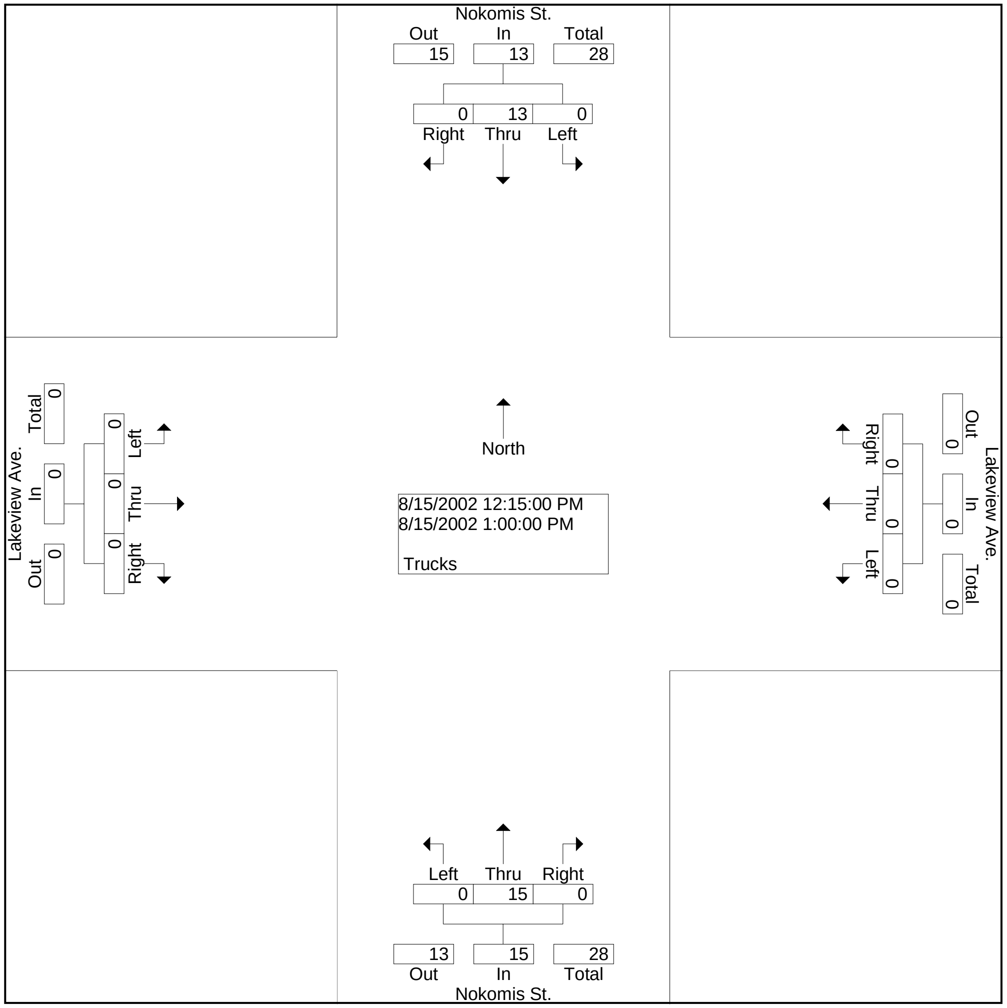

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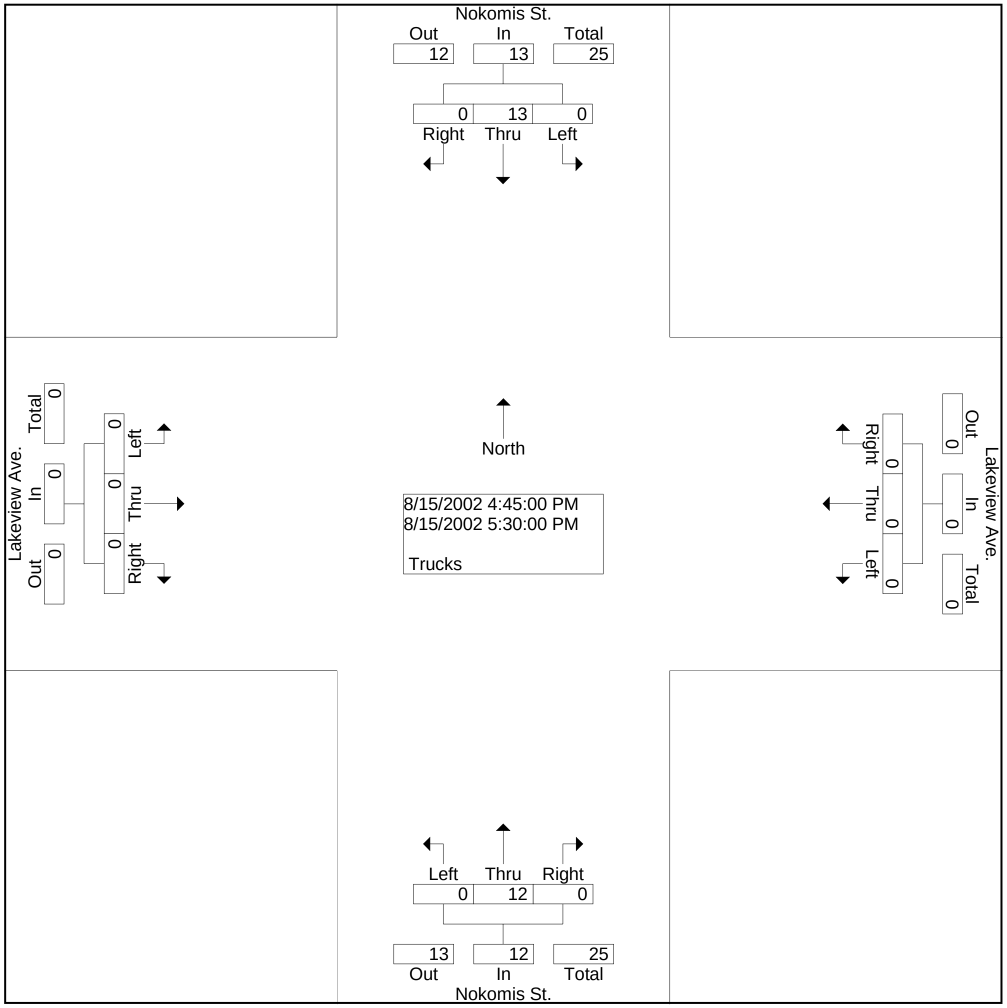

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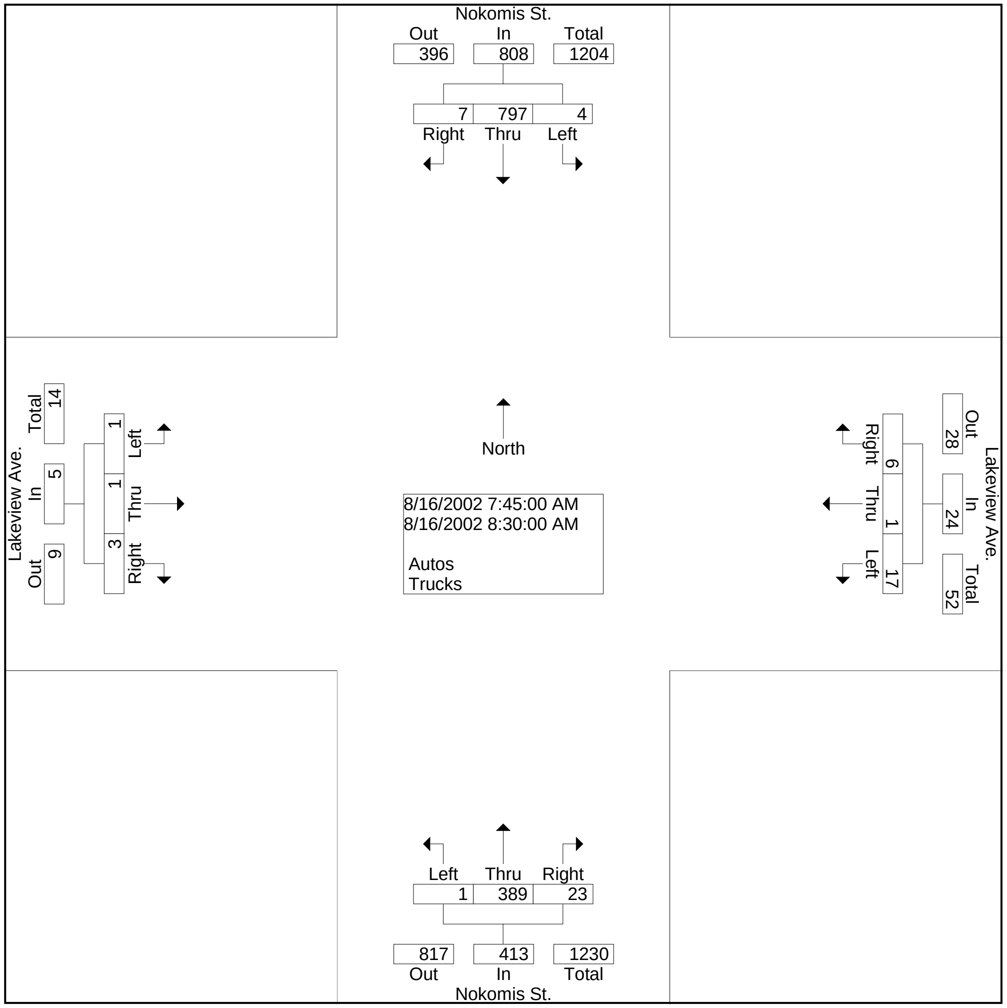

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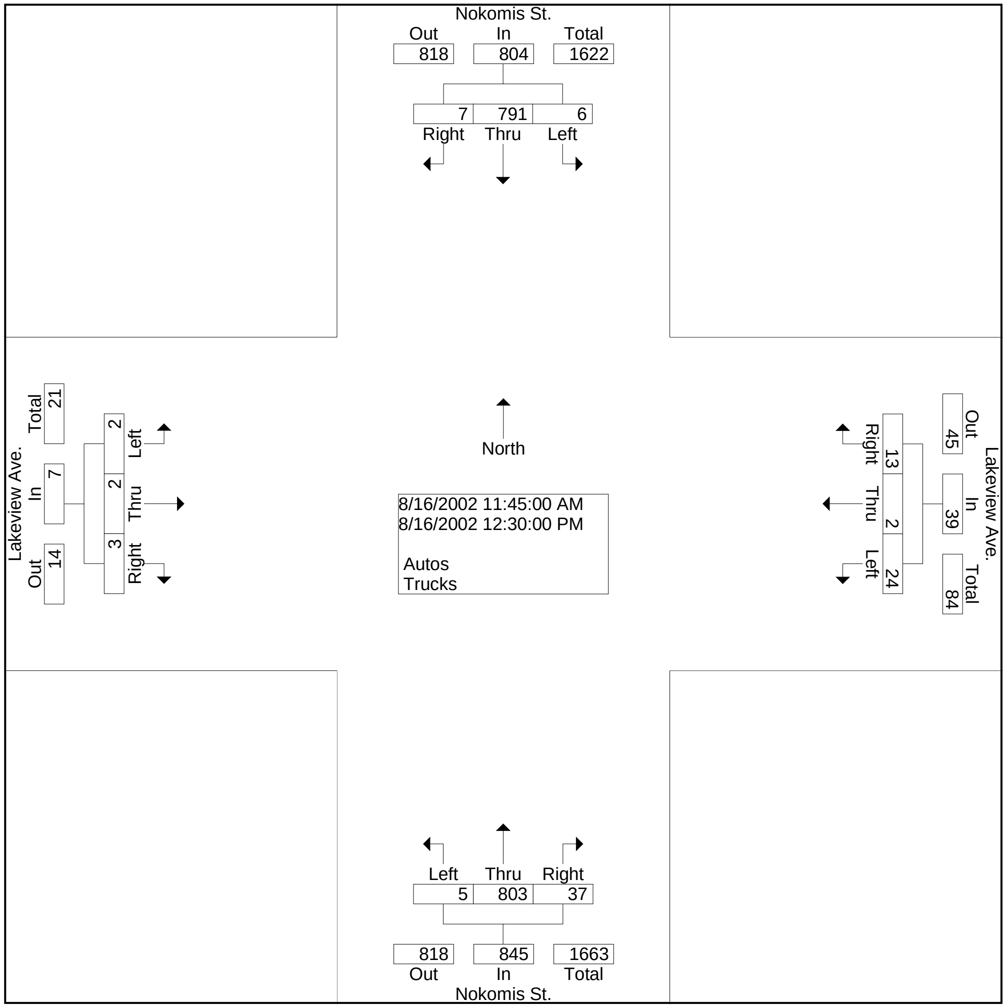

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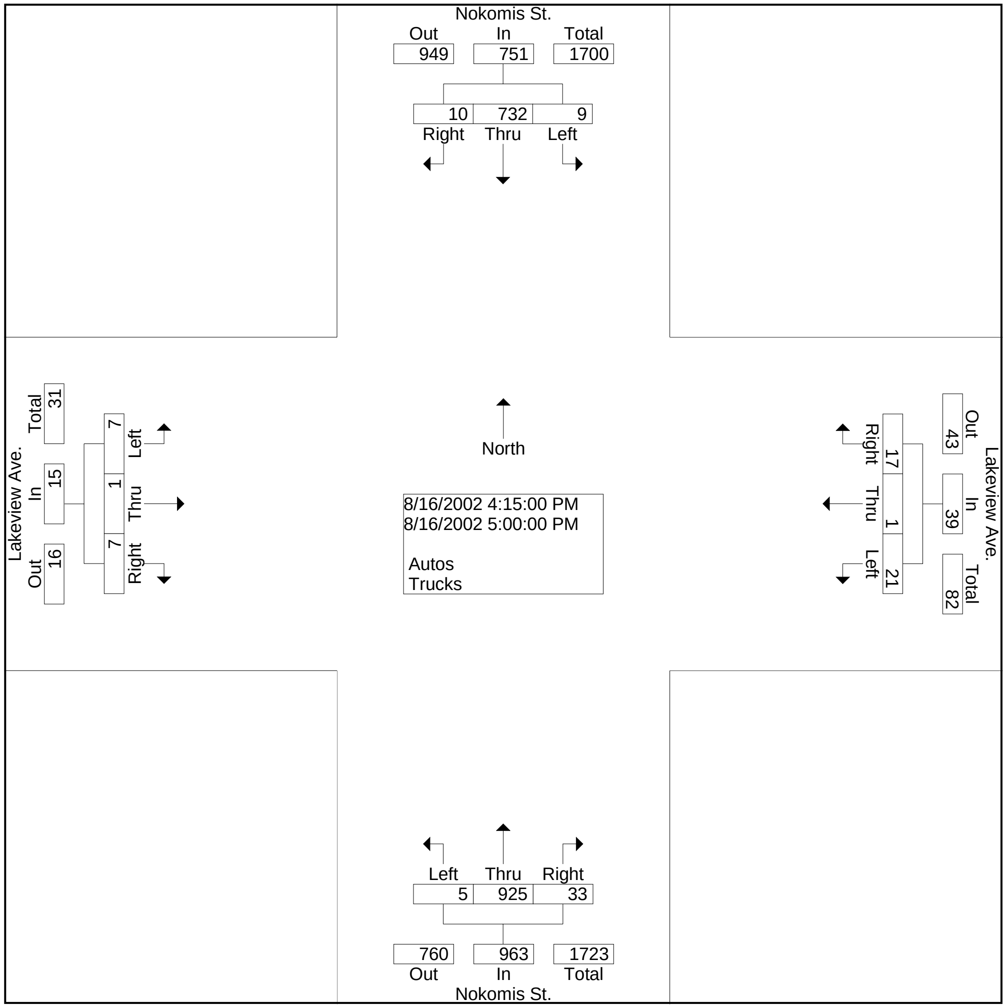

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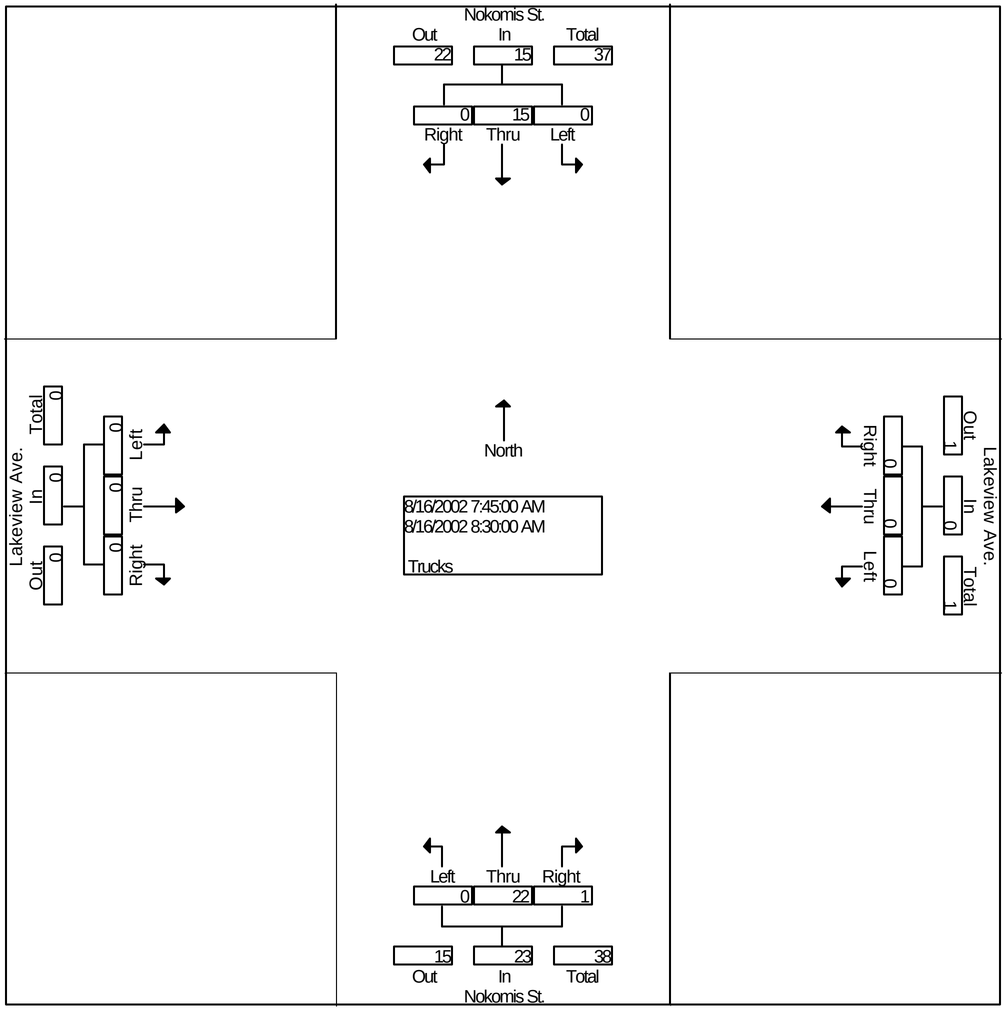

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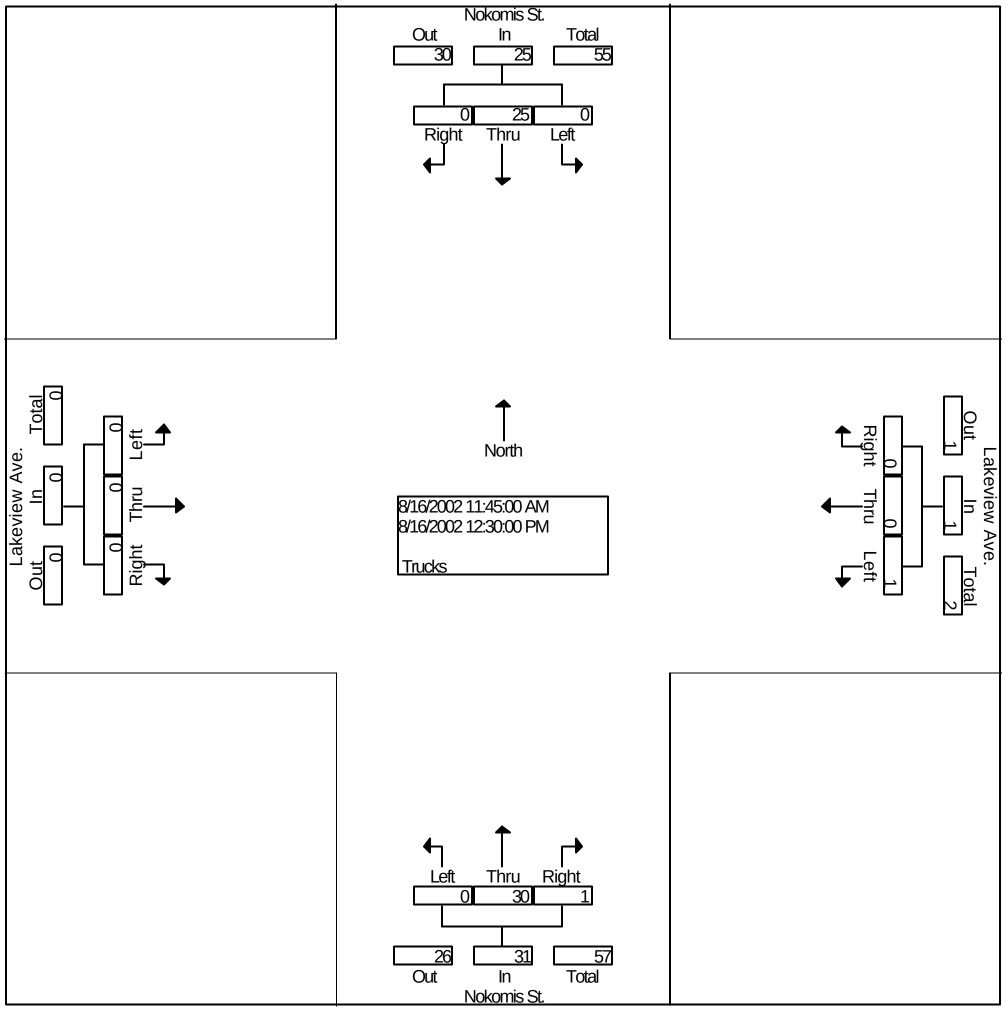

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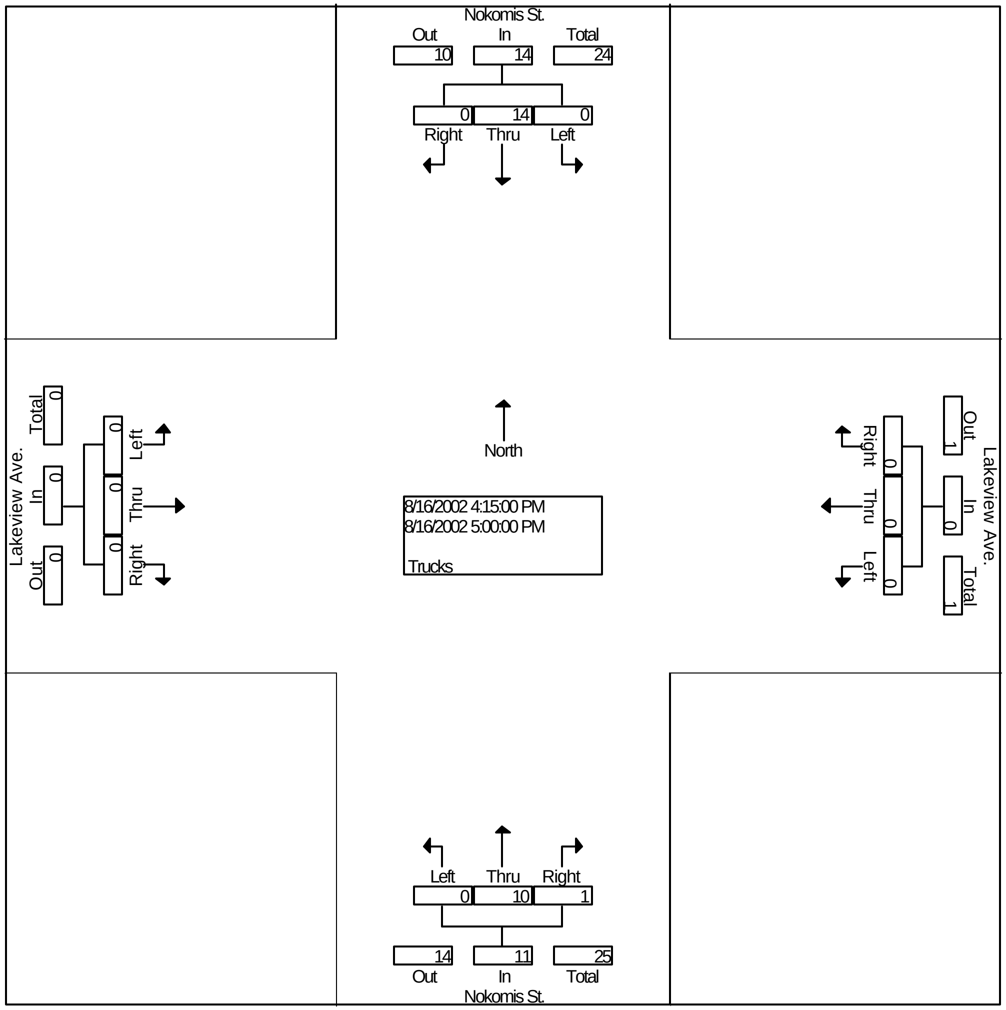

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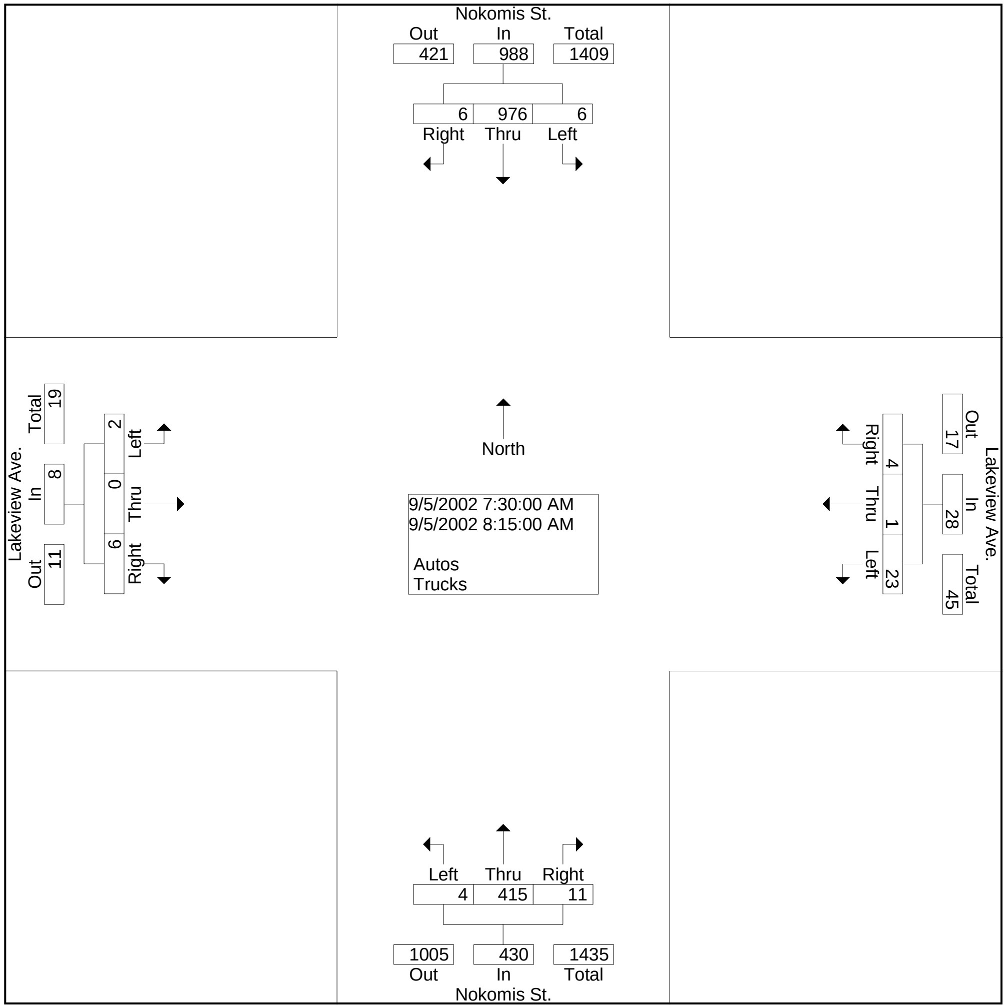

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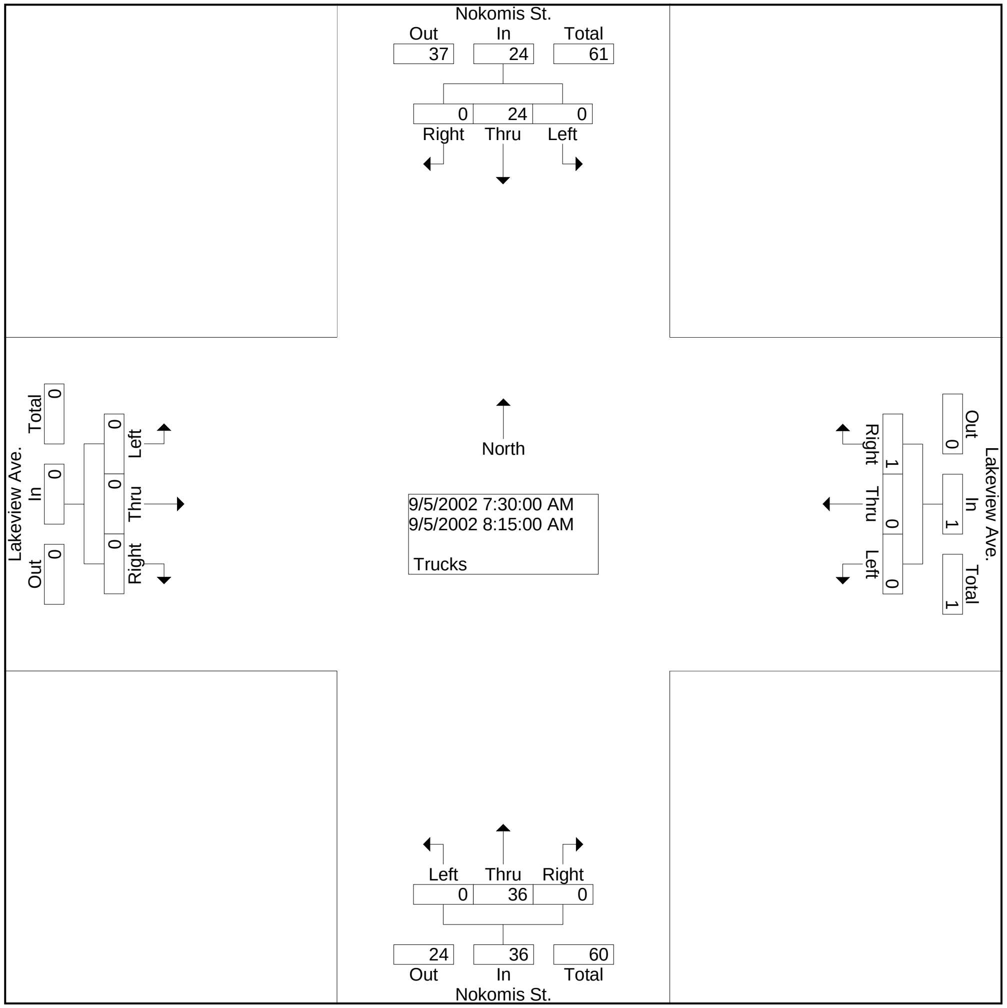

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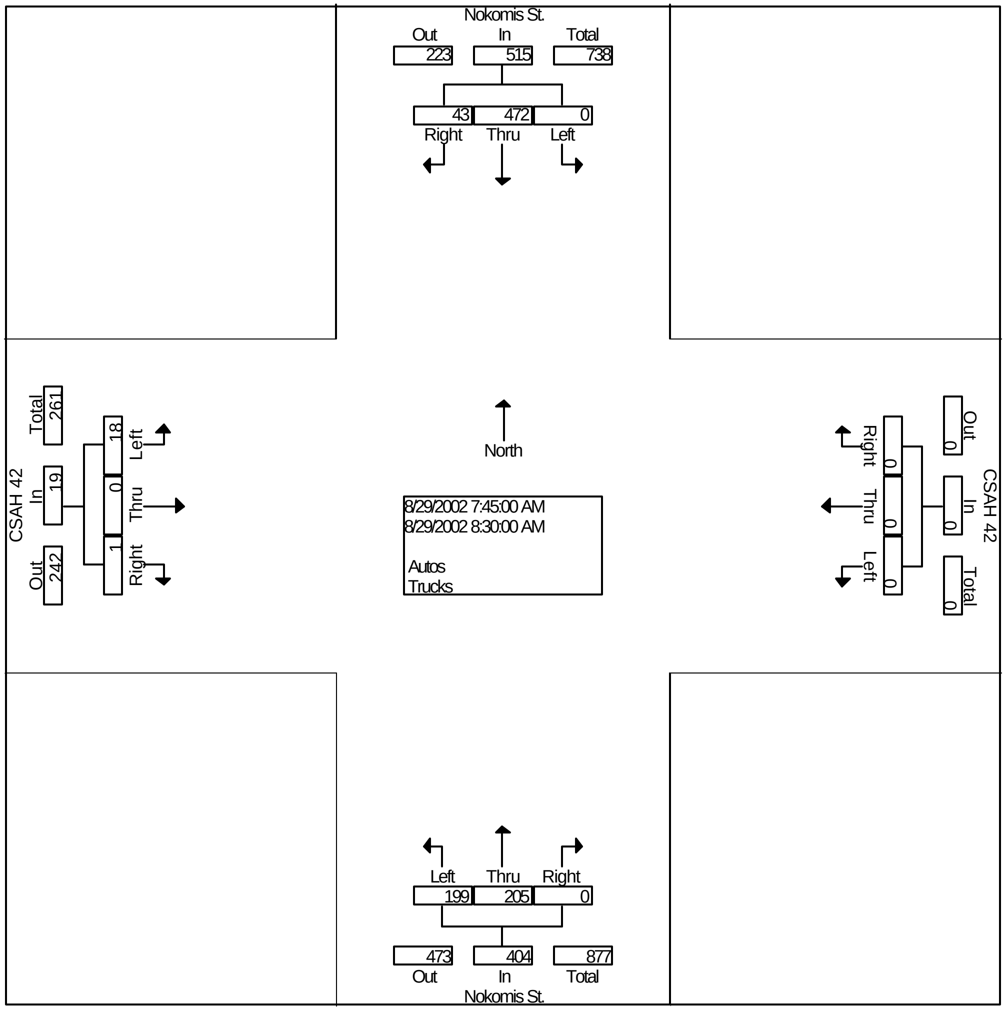

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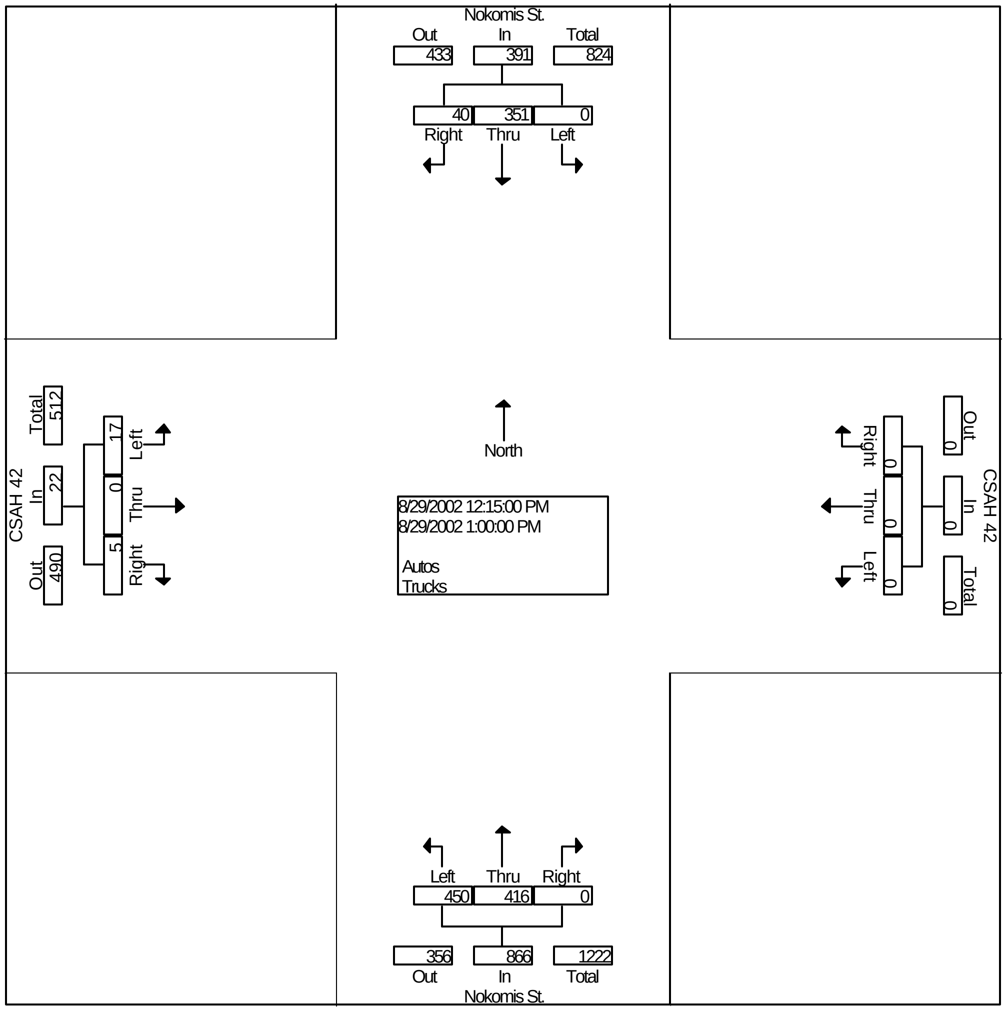

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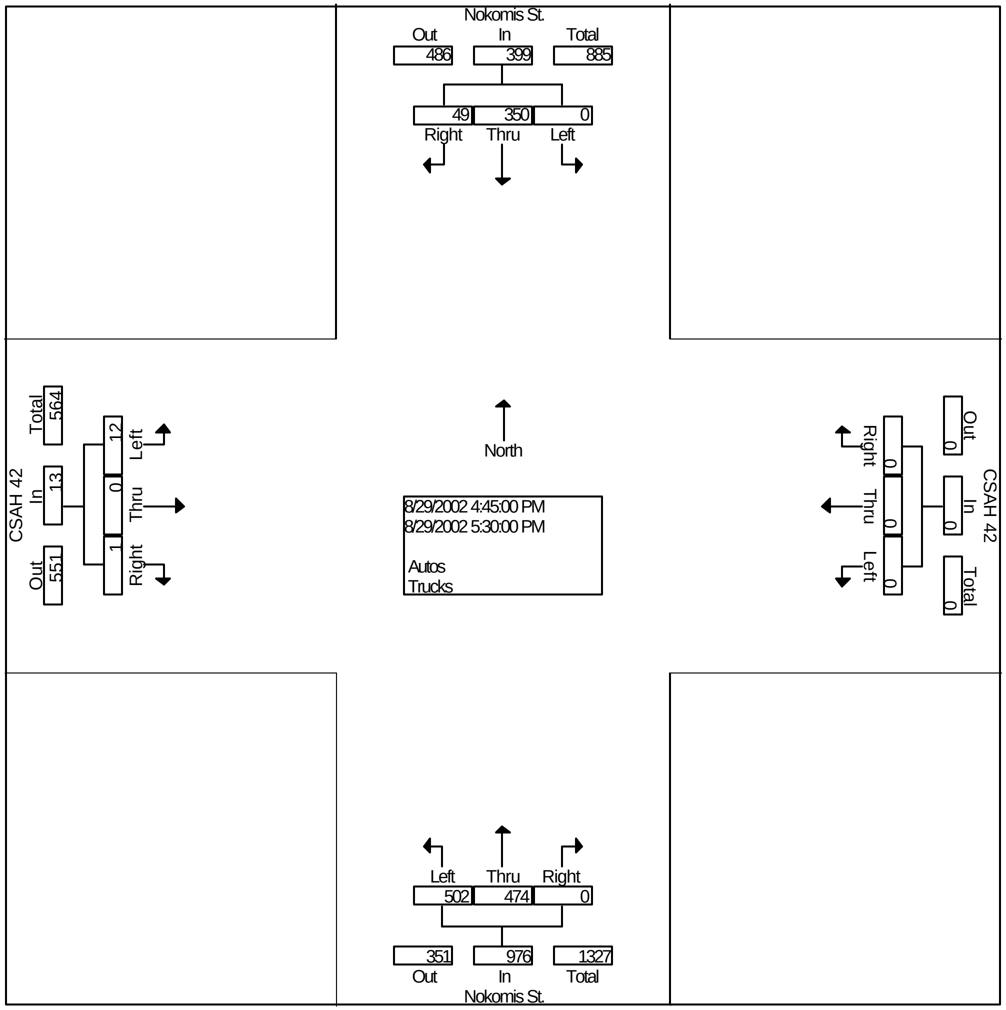

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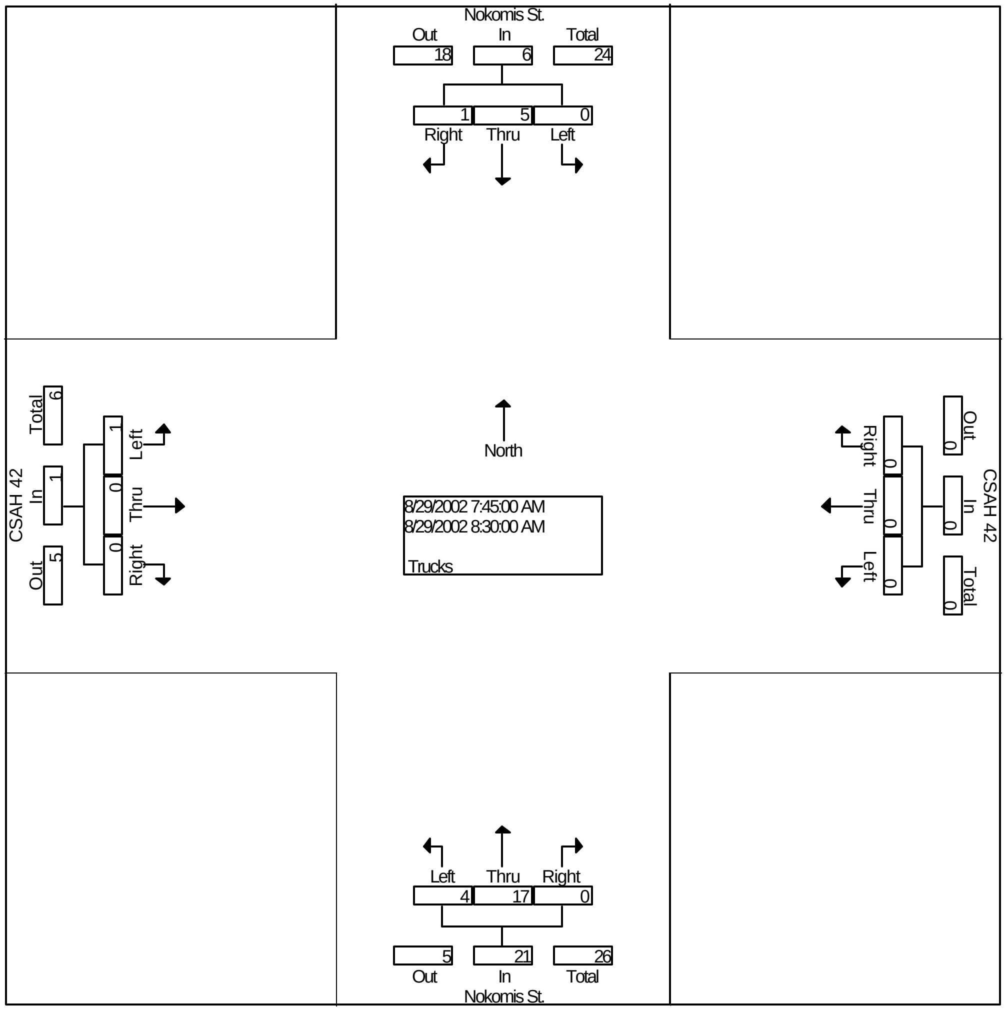

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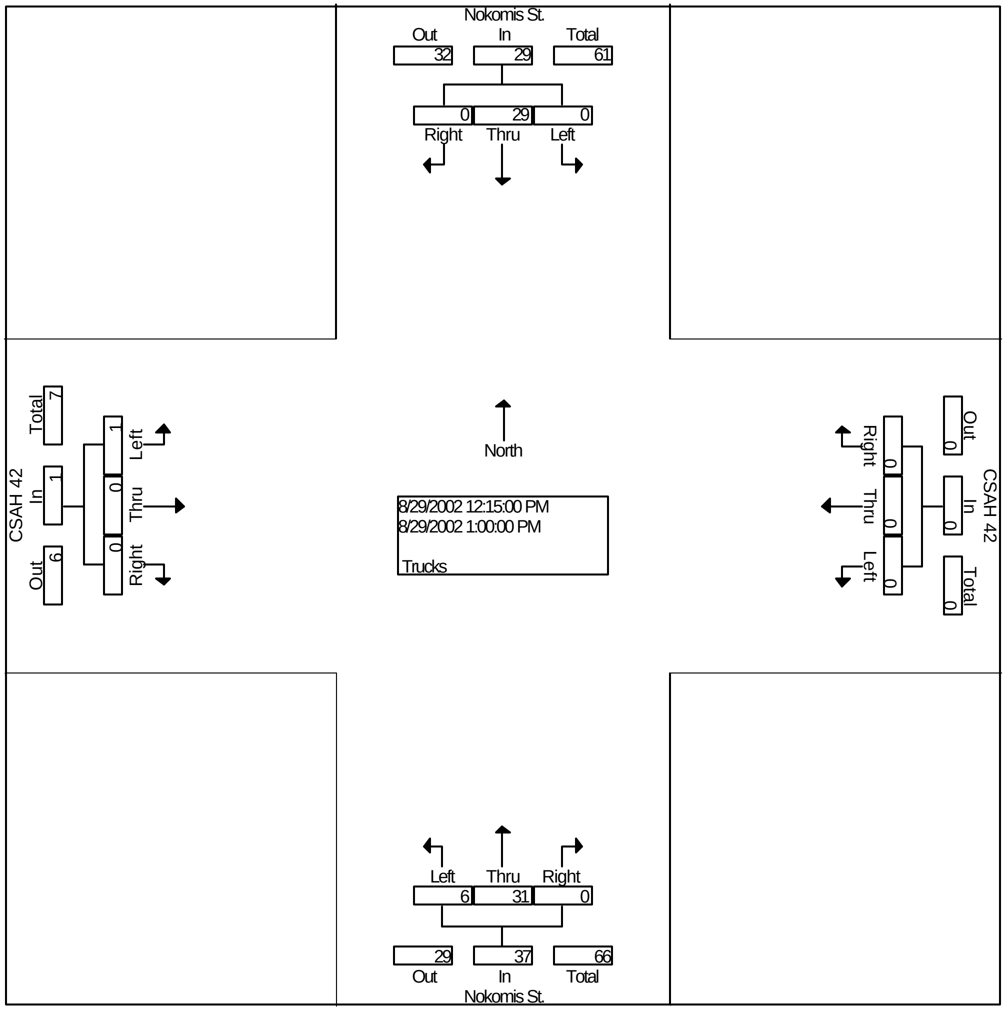

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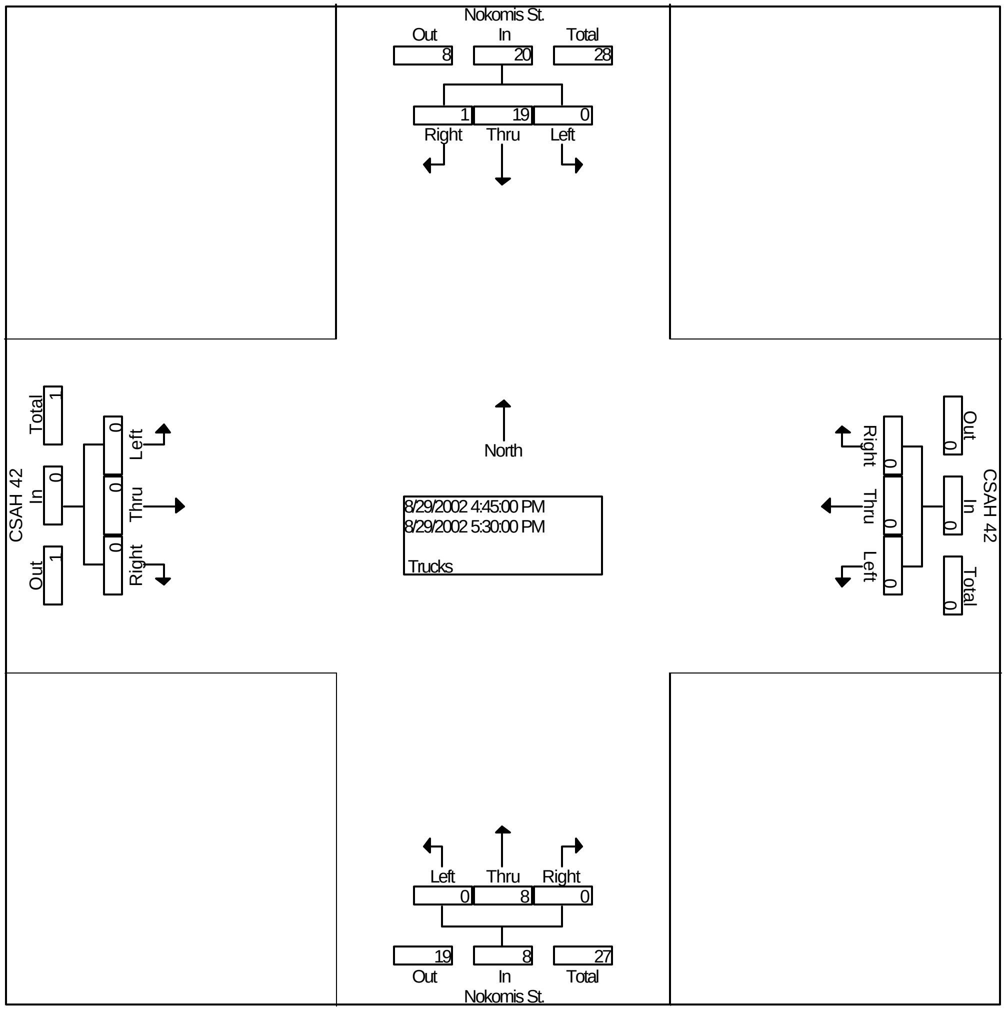

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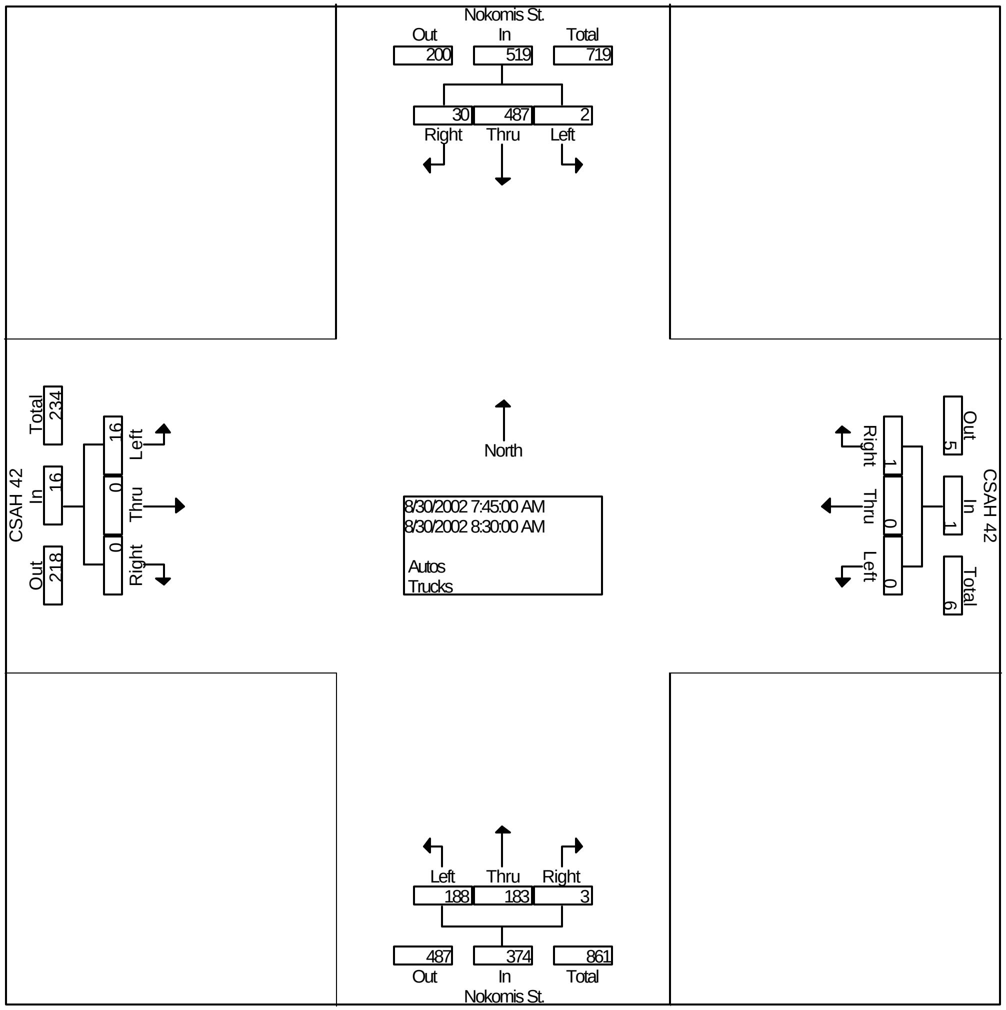

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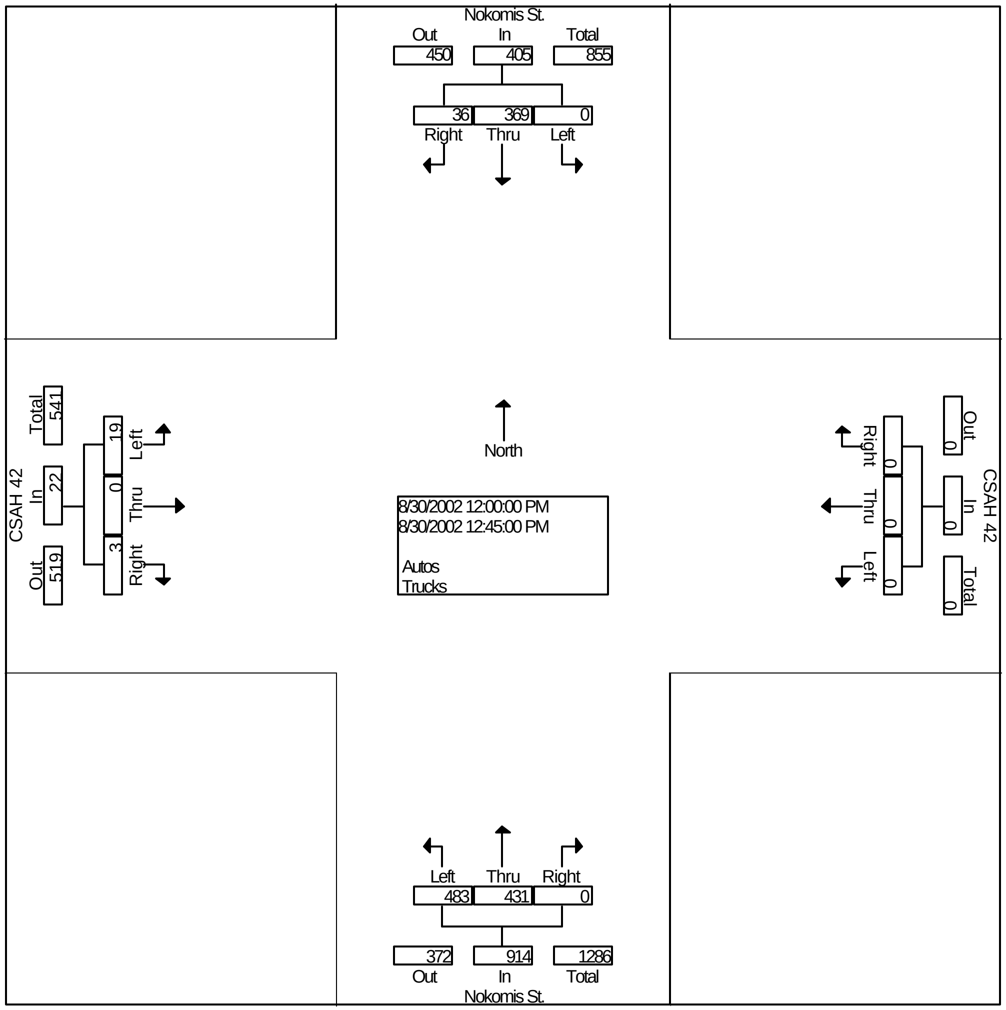

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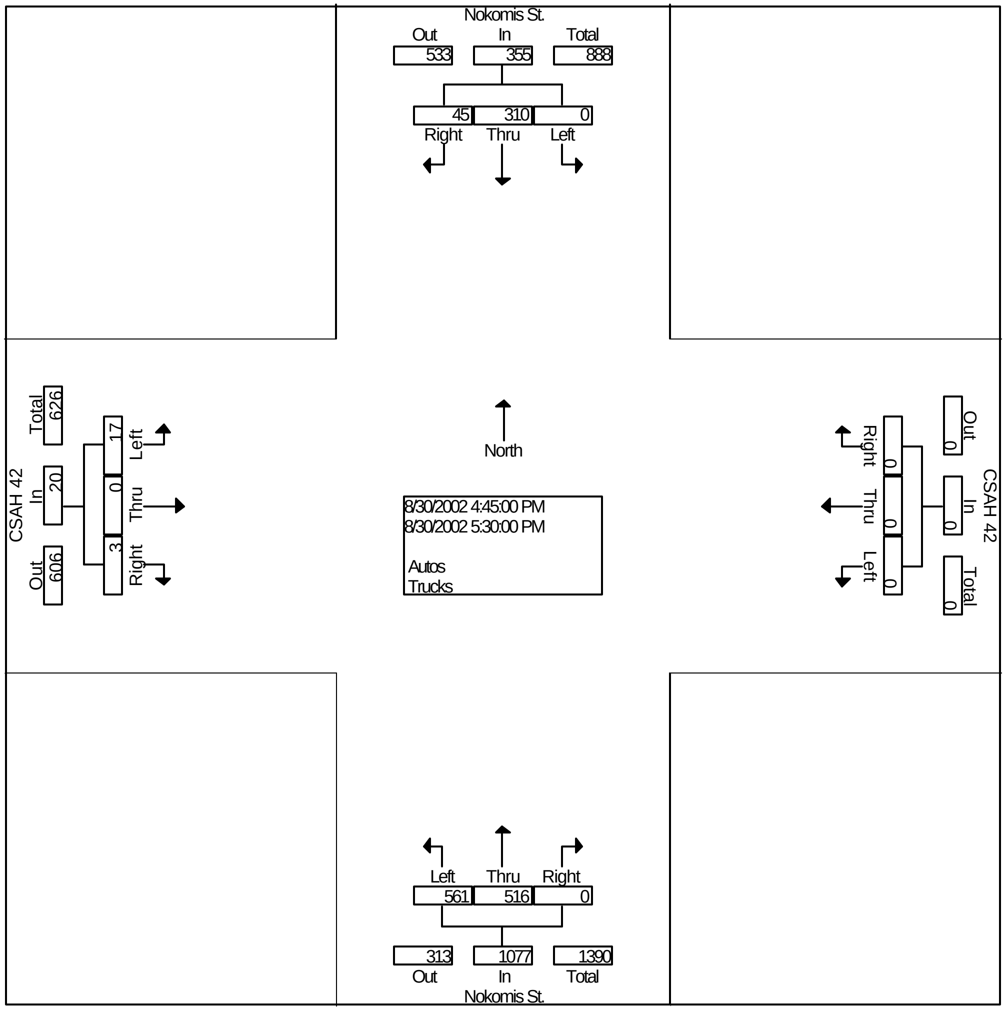

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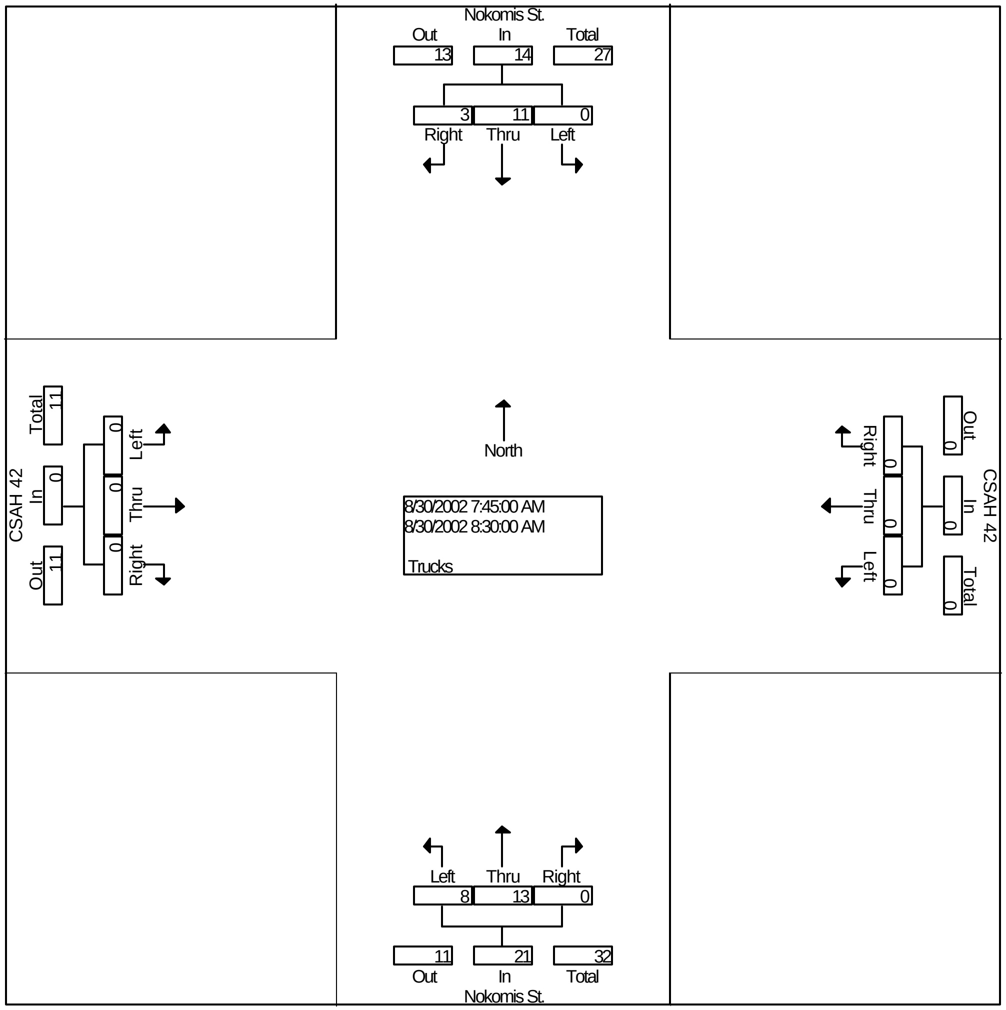

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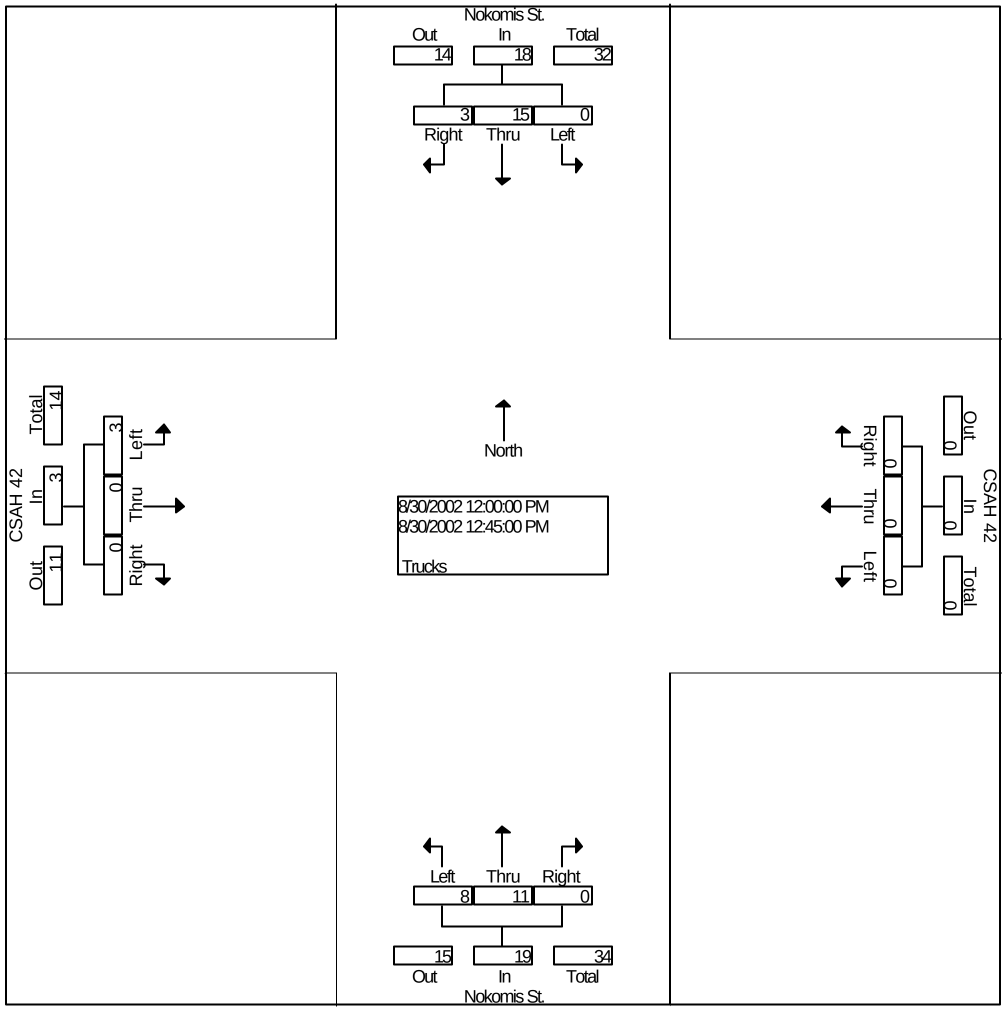

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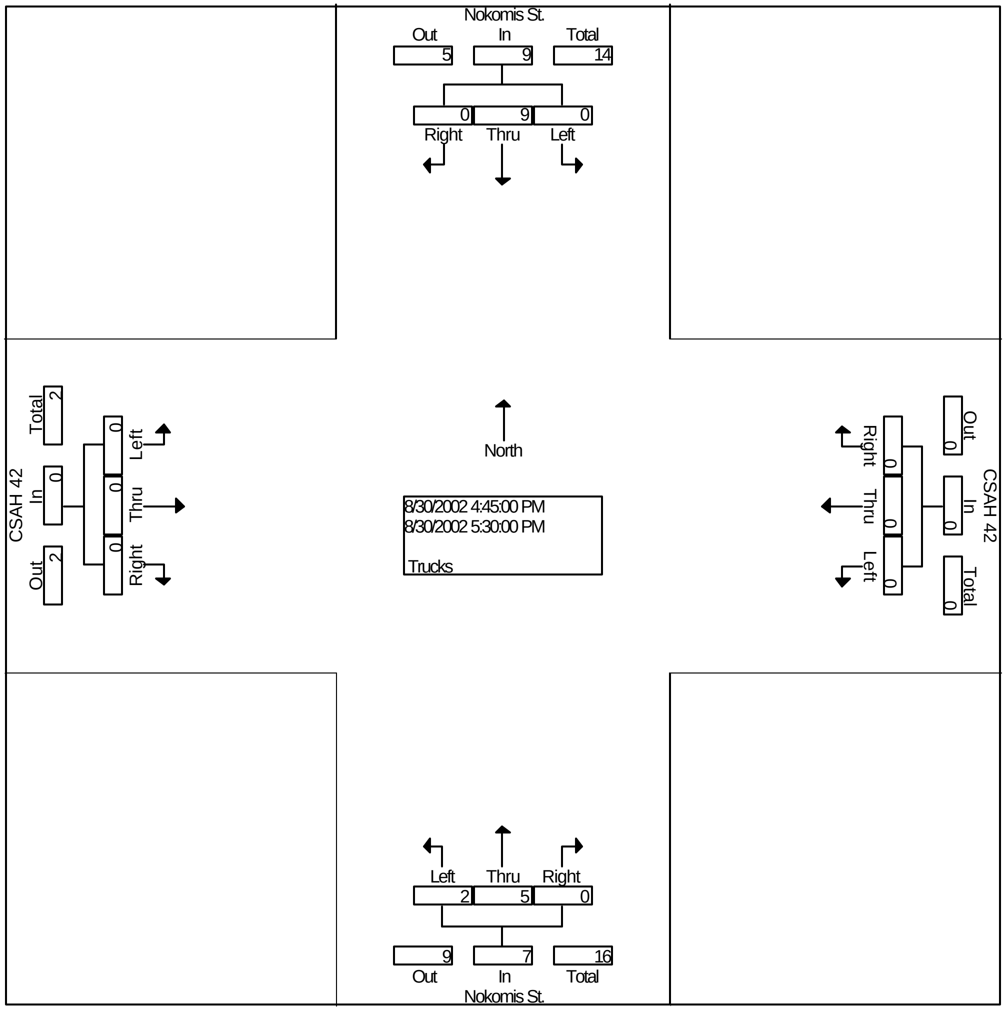

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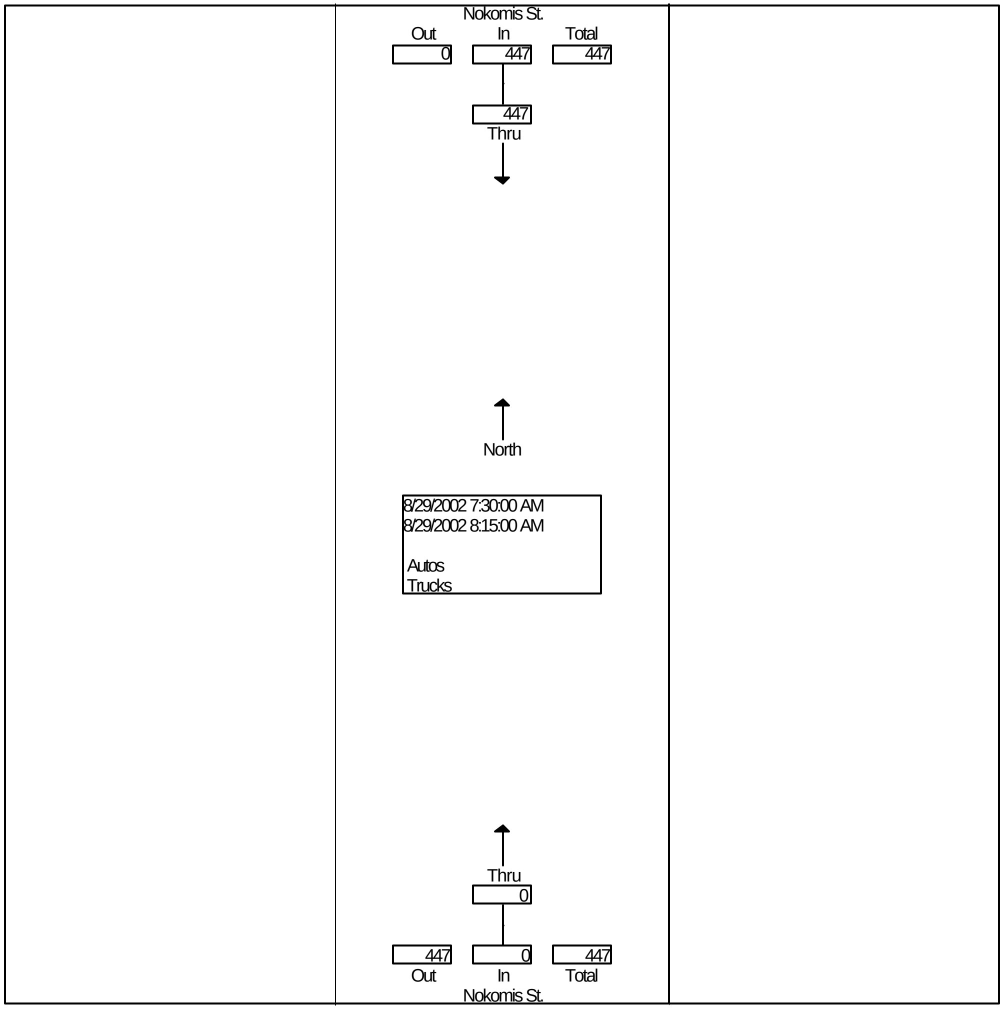

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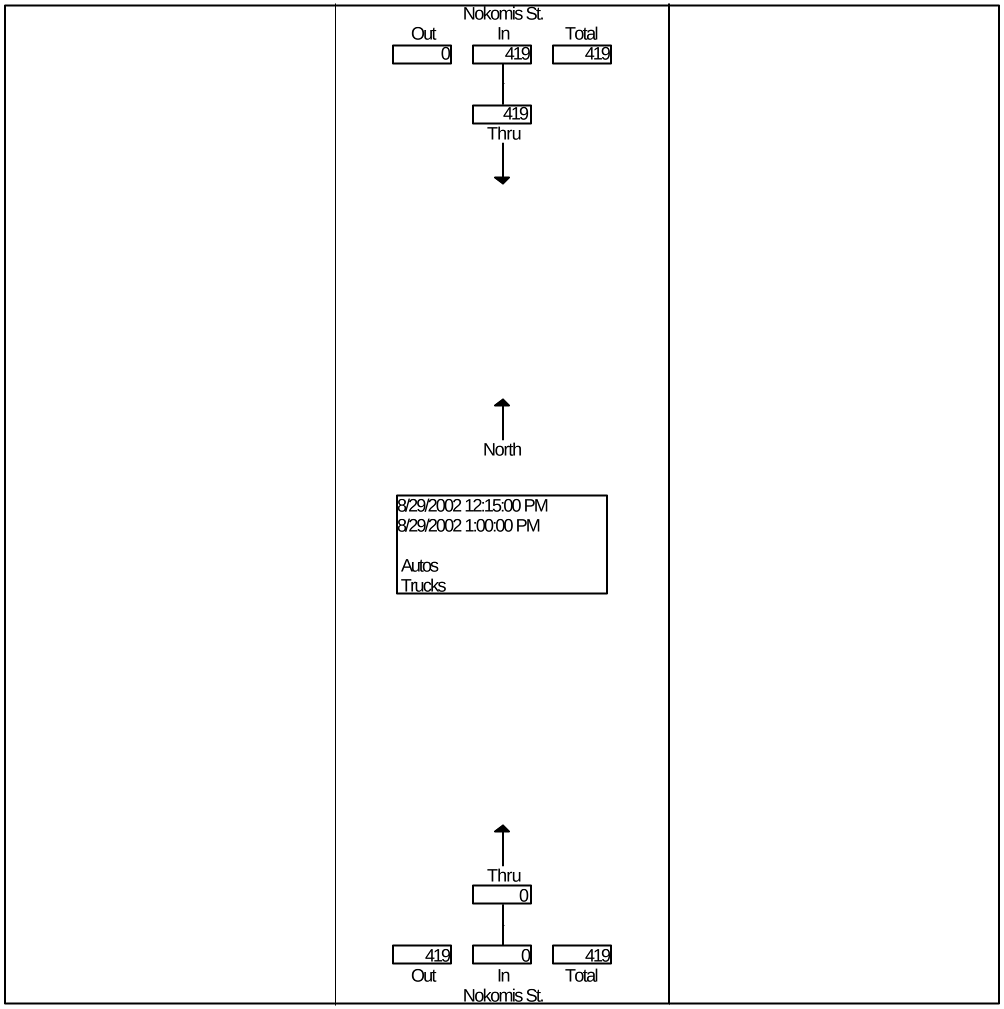

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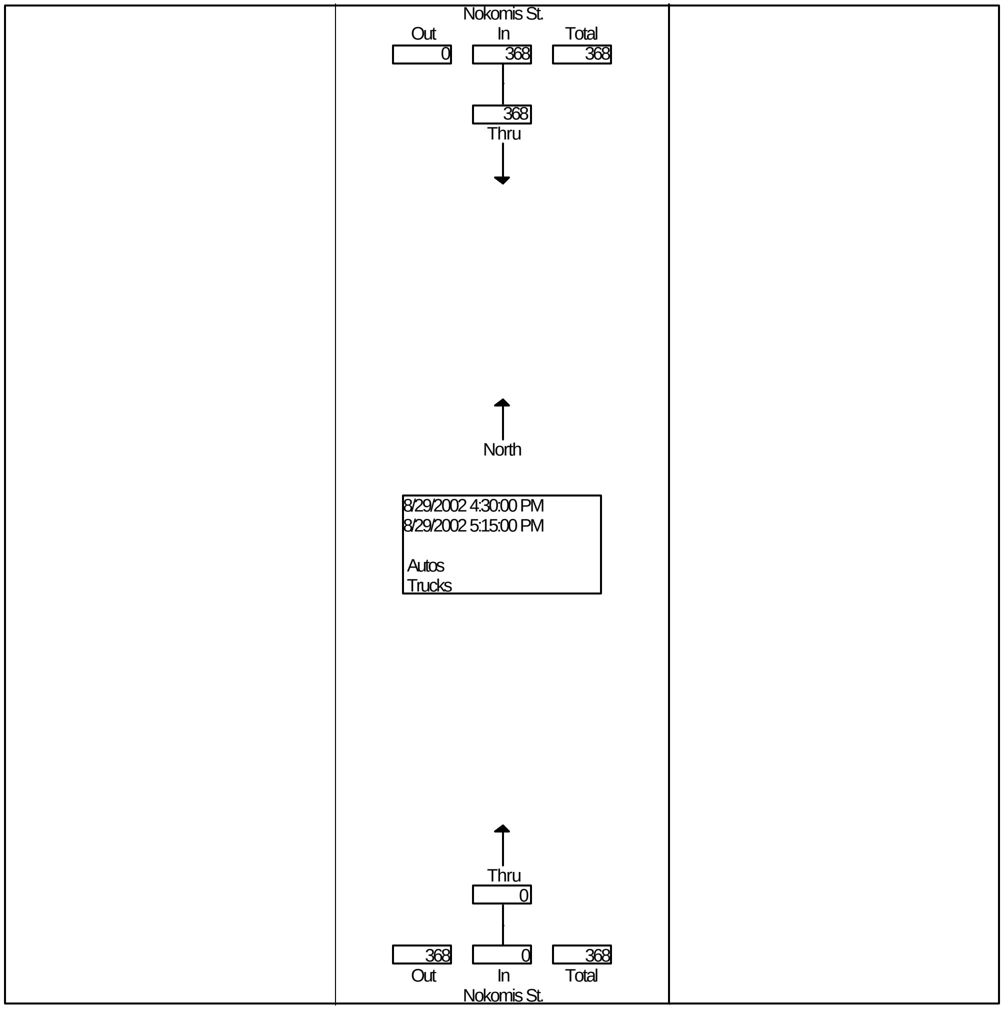

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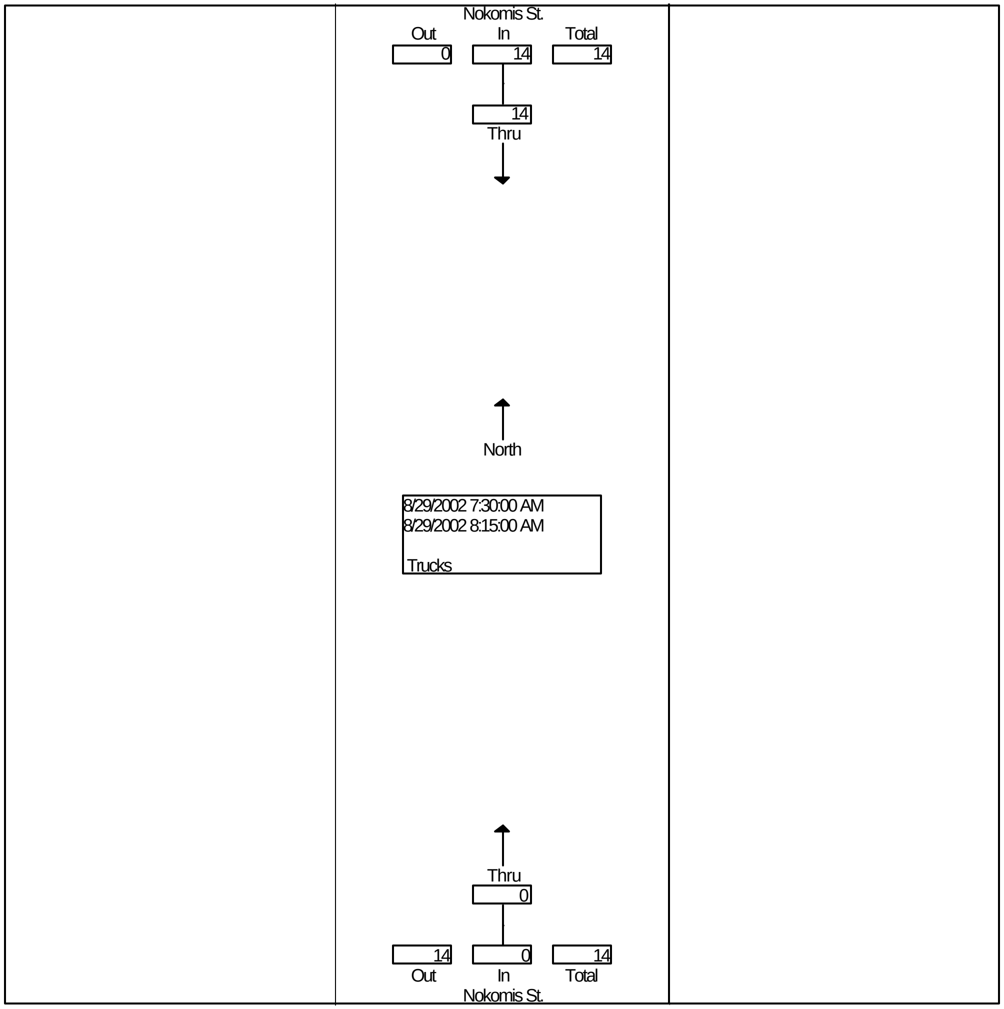

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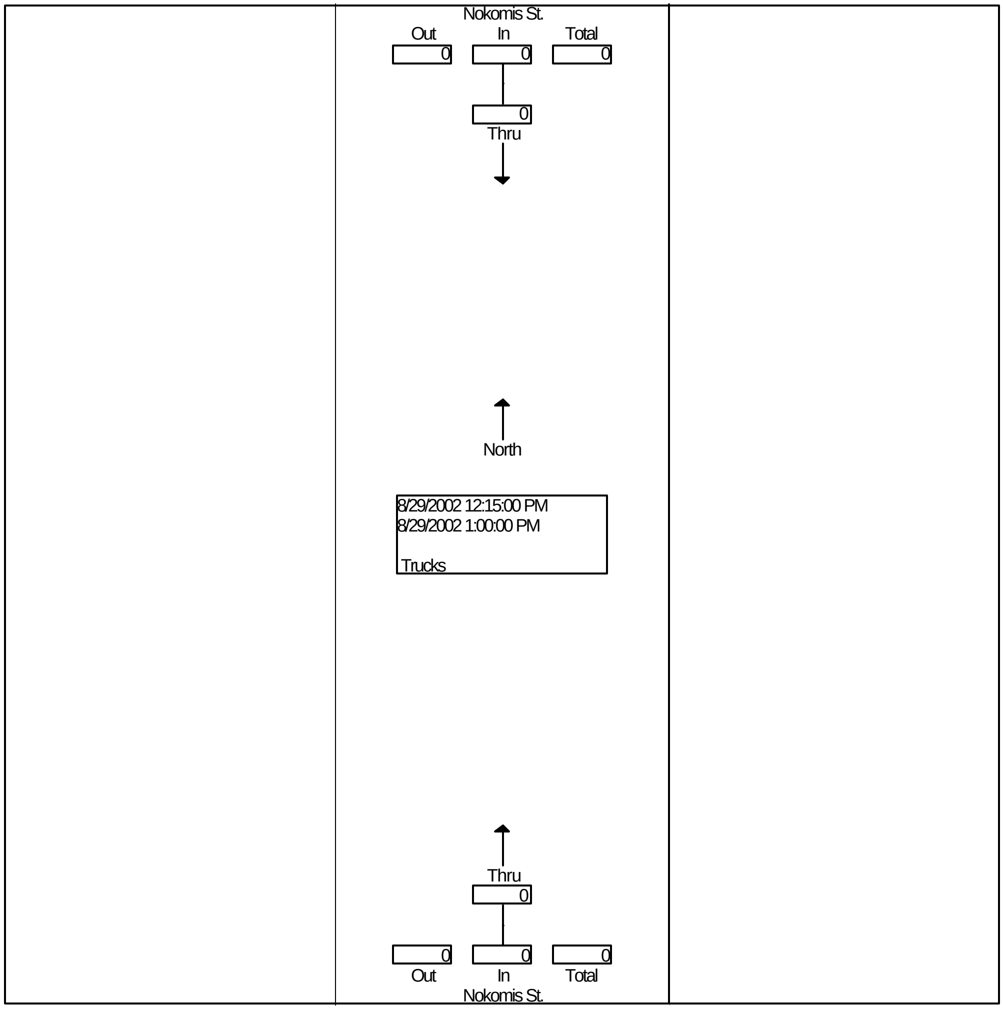

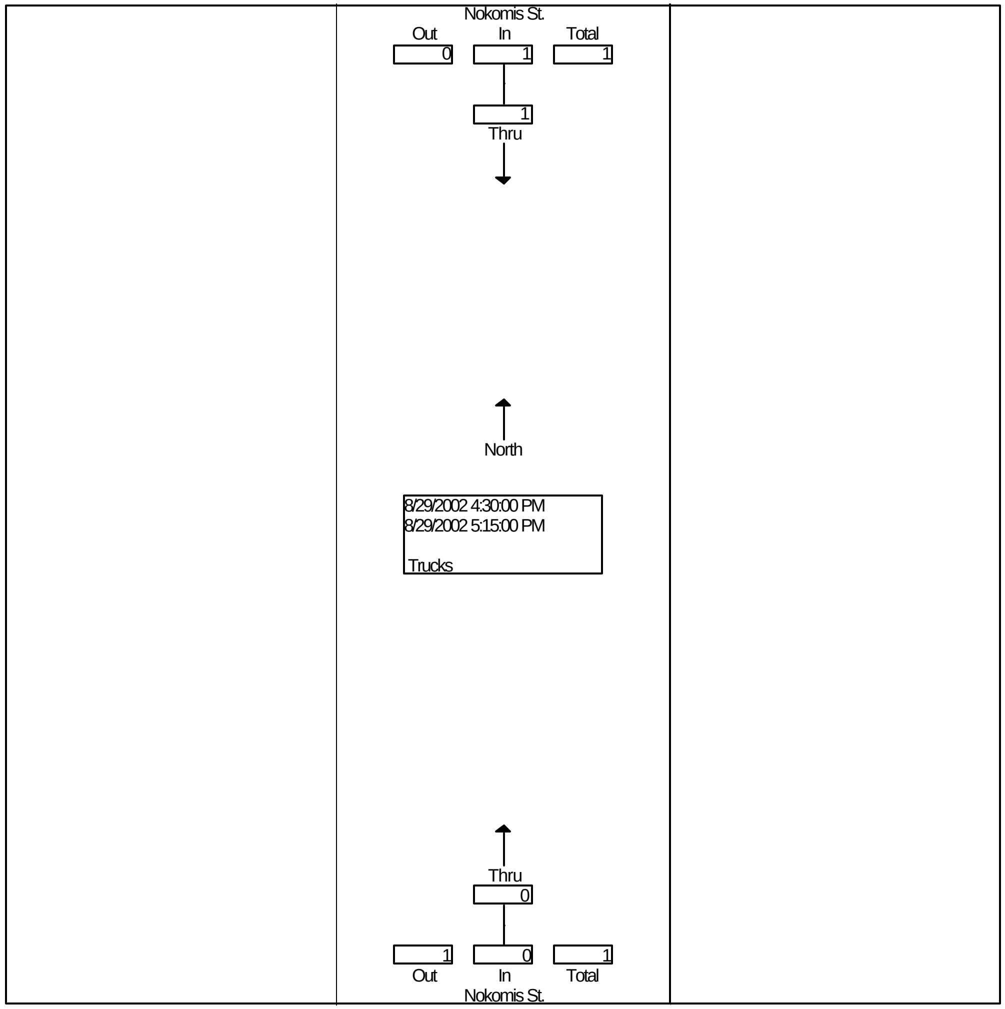
Nokomis St.
Out
In
Total
0
1
1
1
Thru
North
8/29/2002 4:30:00 PM
8/29/2002 5:15:00 PM
Trucks
Thru
0
1
0
1
Out
In
Total
Nokomis St.

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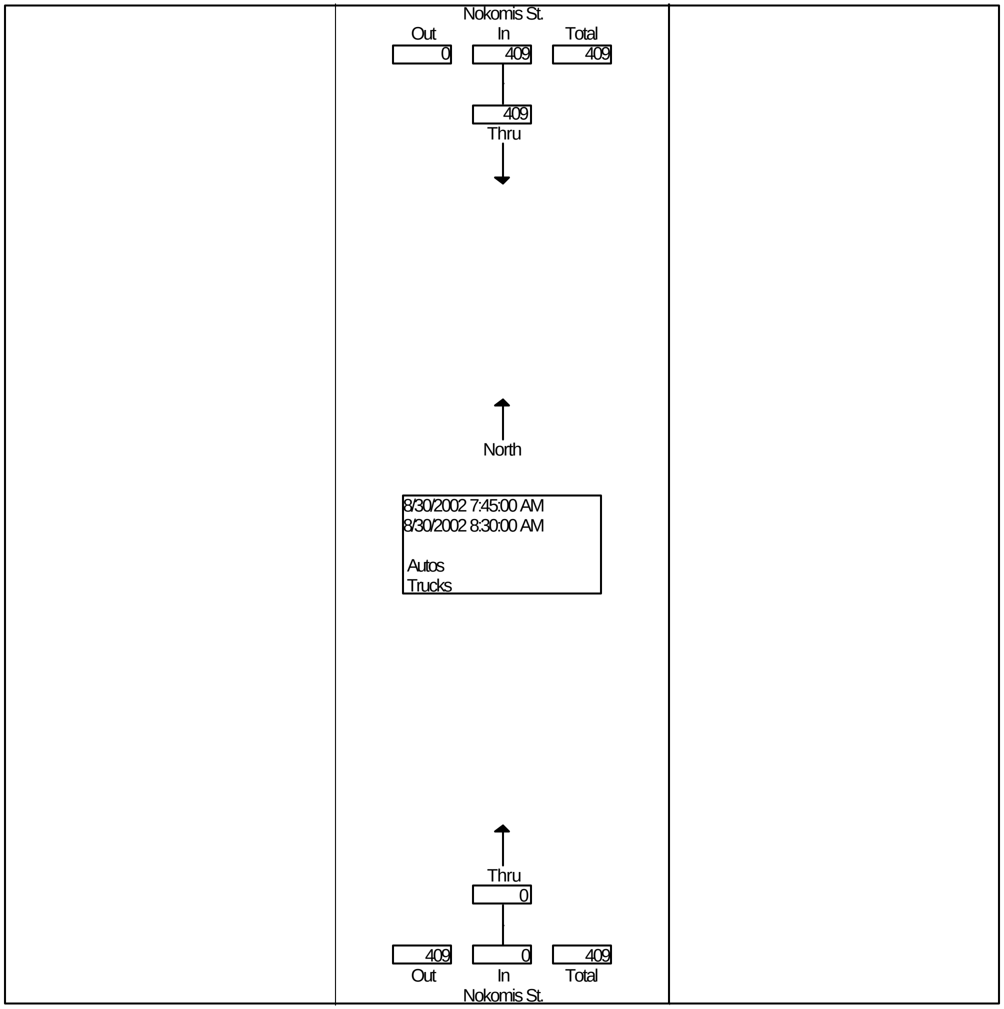

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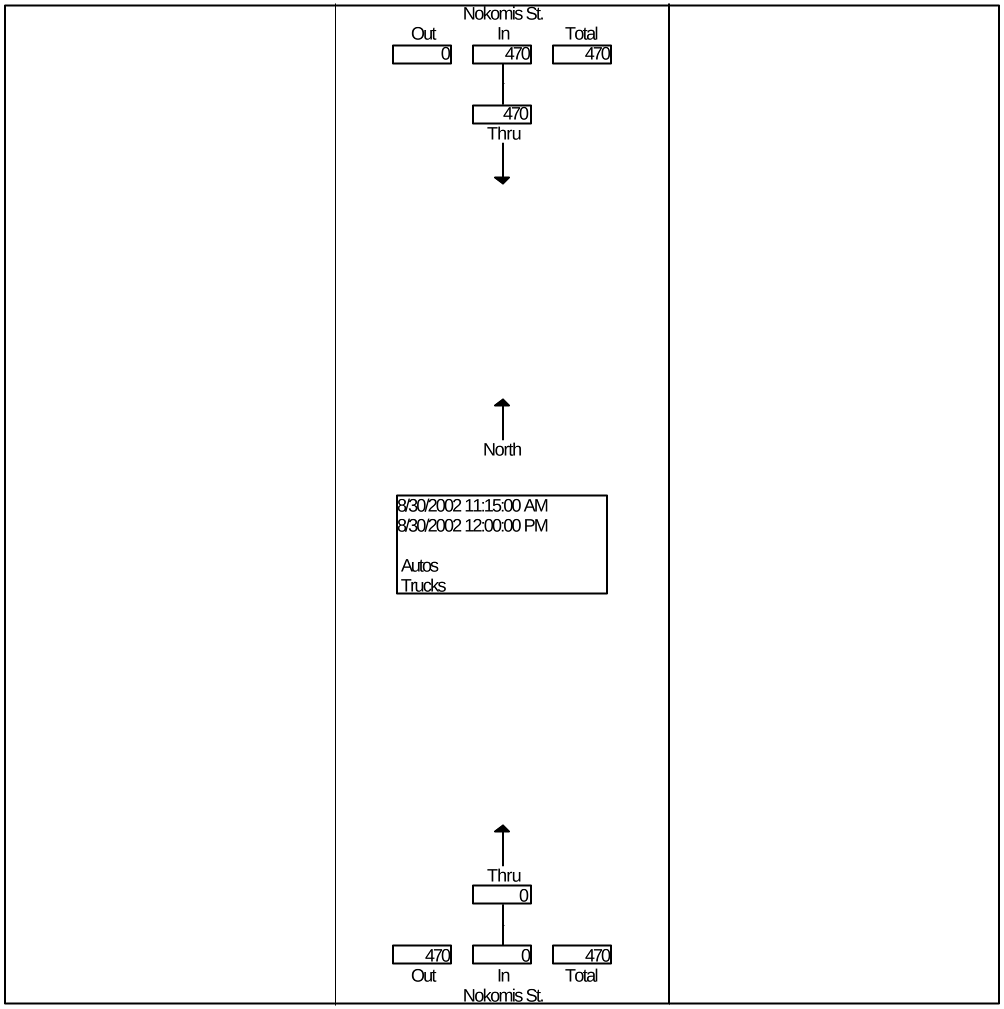

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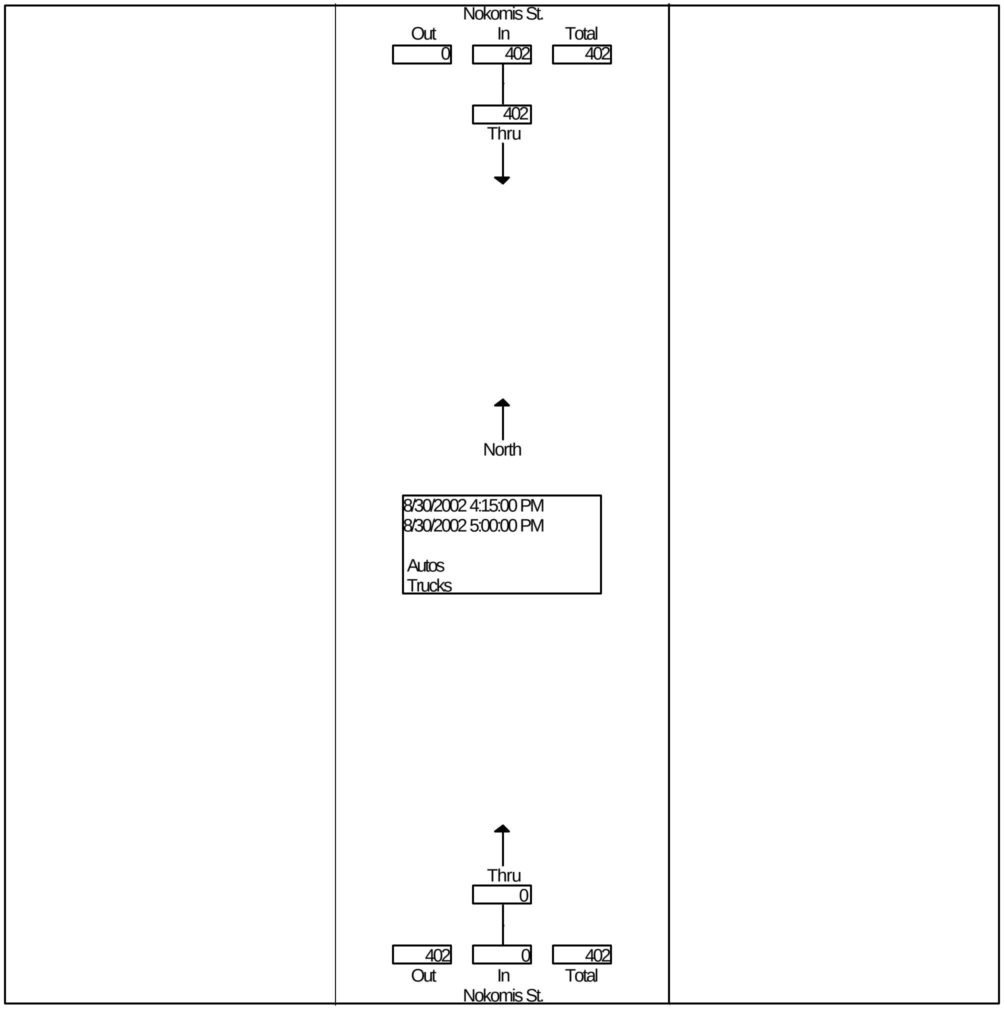

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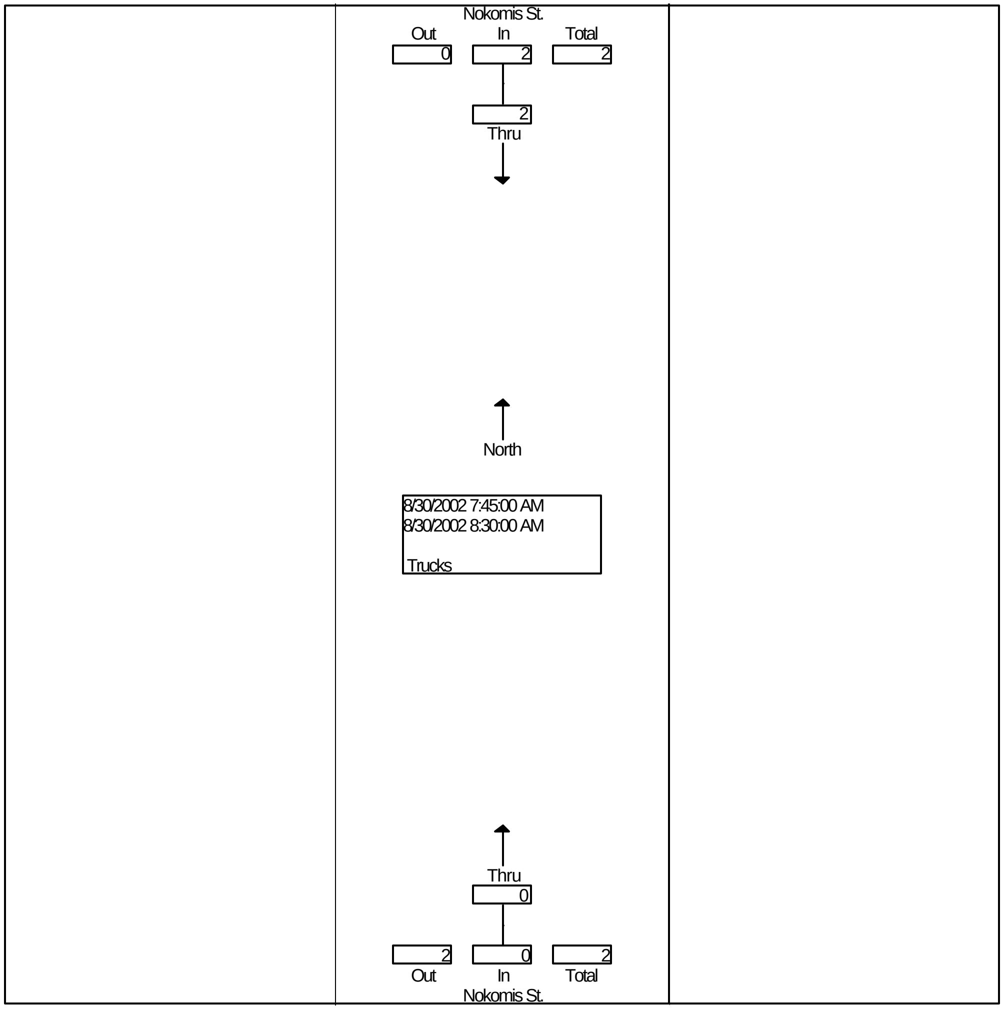

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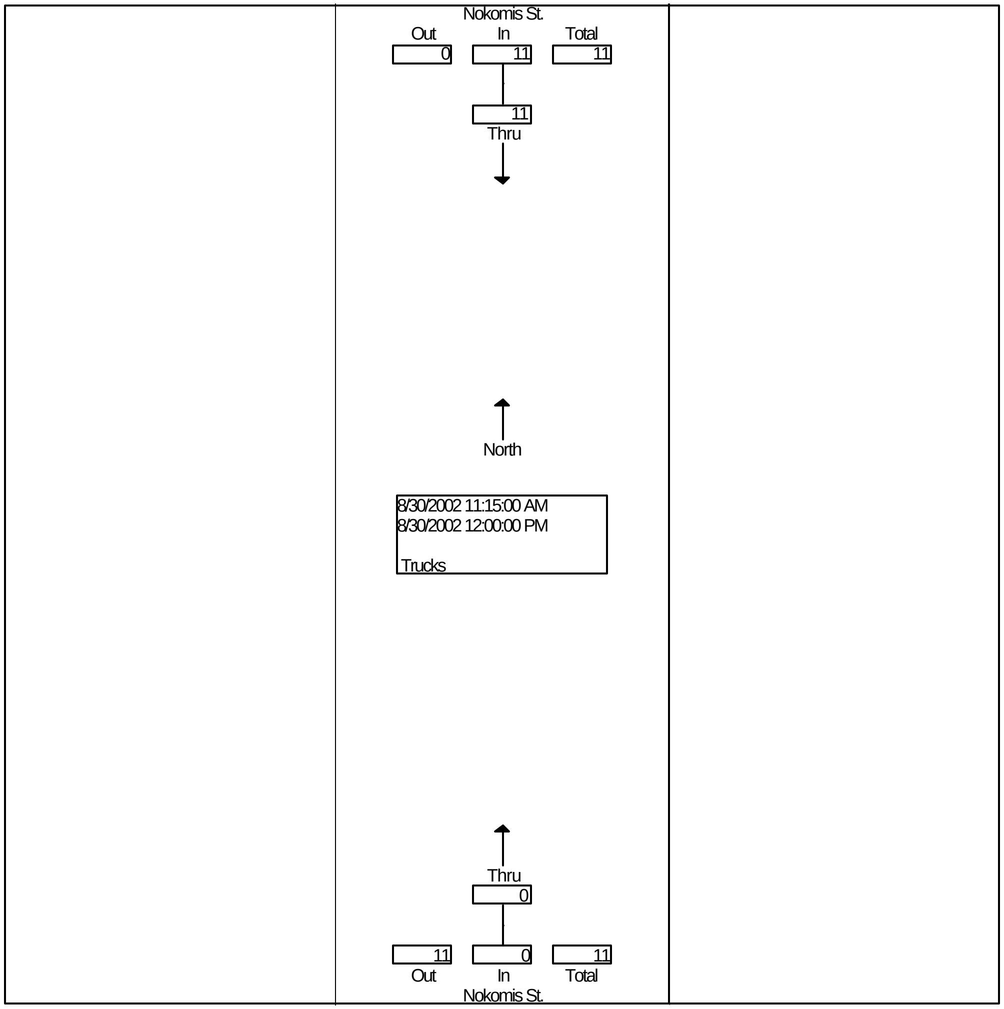

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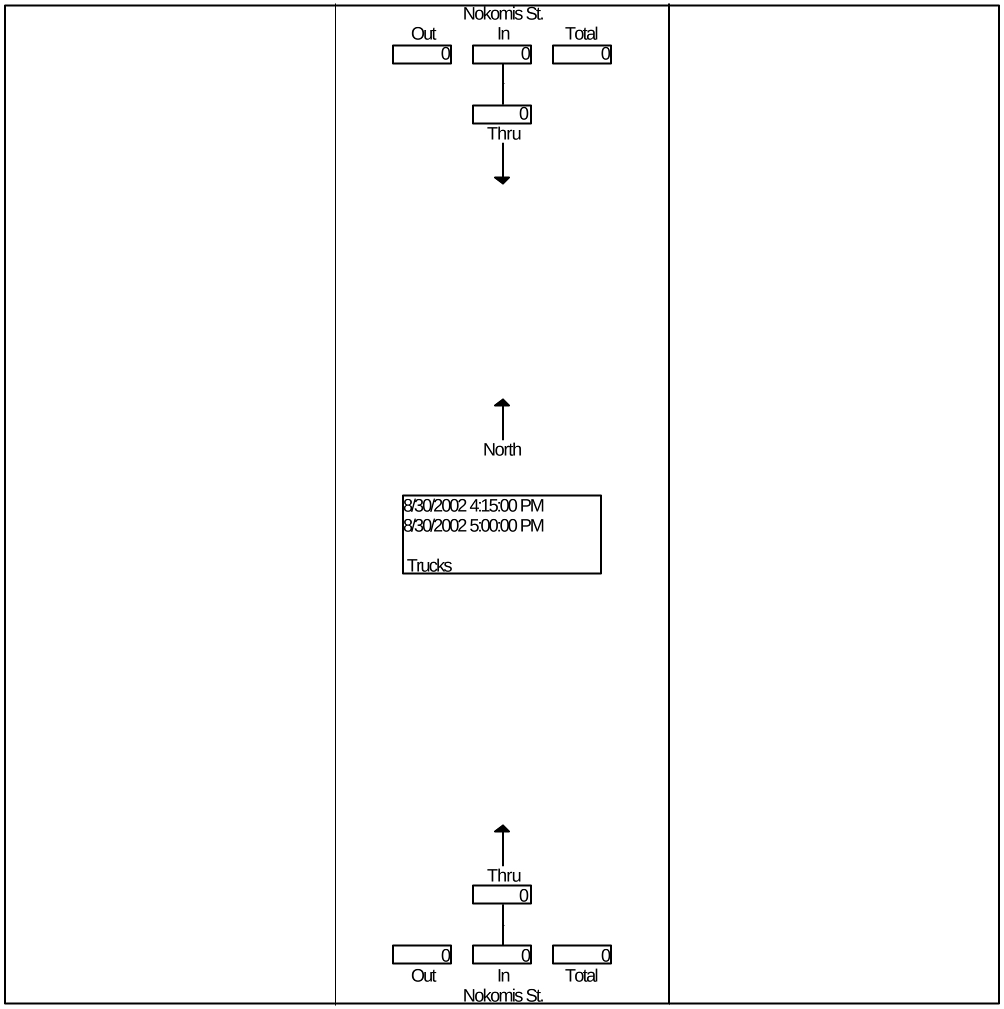


APPENDIX B: Traffic Signal Warrant Analysis

Warrant 1, Eight-Hour Vehicular Volume

Major Street: TH 29 (Nokomis St.) - 2 lanes
Minor Street: Lake View Ave. - 1 lane
Approach Speed: 30 mph
Population: 8820
Based on population, use 70% of base volumes

Condition A - Minimum Vehicle Volume			Condition B - Interruption of Continuous Traffic		
Minimum Base Volumes:	**420**	**105**	**Minimum Base Volumes:**	**630**	**53**
Time Period	**VPH on major street**	**VPH on higher-volume minor street**	**Time Period**	**VPH on major street**	**VPH on higher-volume minor street**
8:00-9:00	1579	37	8:00-9:00	1579	37
13:00-14:00	2390	32	13:00-14:00	2390	32
14:00-15:00	2421	29	14:00-15:00	2421	29
11:00-12:00	2209	29	11:00-12:00	2209	29
7:00-8:00	1692	28	17:00-18:00	2410	28
17:00-18:00	2410	28	7:00-8:00	1692	28
9:00-10:00	1628	27	12:00-13:00	2567	27
12:00-13:00	2567	27	9:00-10:00	1628	27
10:00-11:00	1911	24	10:00-11:00	1911	24
18:00-19:00	1847	22	18:00-19:00	1847	22
16:00-17:00	2591	20	16:00-17:00	2591	20
15:00-16:00	2513	15	15:00-16:00	2513	15

(shaded values do not meet criteria **(shaded values do not meet criteria)**

Warrant Conditions:
One of the following conditions must exist for any 8 hours of an average day
Condition A - Minimum Vehicle Volume (420 on major street and 105 on higher-volume minor street)
Condition B - Interruption of Continuous Traffic (630 on major street and 53 on higher-volume minor street)

Final Conclustion: Warrant 1 is not met since neither Condition A or B were met.

Warrant 2, Four-Hour Vehicular Volume

Major Street: TH 29 (Nokomis St.) - 2 lanes
Minor Street: Lake View Ave. - 1 lane
Approach Speed: 30 mph
Population: 8820
Based on population, use 70% of base volumes

Minimum Base Volumes:	**950**	**60**
Time Period	**VPH on major street**	**VPH on higher-volume minor street**
8:00-9:00	**1579**	**37**
13:00-14:00	**2390**	**32**
14:00-15:00	**2421**	**29**
11:00-12:00	**2209**	**29**
17:00-18:00	2410	28
7:00-8:00	1692	28
12:00-13:00	2567	27
9:00-10:00	1628	27
10:00-11:00	1911	24
18:00-19:00	1847	22
16:00-17:00	2591	20
15:00-16:00	2513	15

(**Bold** values represent the four highest hours for the highest minor-street approach, shaded values do not meet criteria)

Warrant Conditions:
Any four hours must meet the following conditions:
Major street volume greater than 950 and higher minor street volume greater than 60 vph.

(The highest observed value for the highest minor street was 37 VPH.)

Final Conclusion: Warrant 2 is not satisfied for any 4 hours.

Warrant 3, Peak Hour

Major Street: TH 29 (Nokomis St.) - 2 lanes
Minor Street: Lake View Ave. - 1 lane
Approach Speed: 30 mph
Population: 8820
Based on population, use 70% of base volumes

1 hour period End Time	SUM of NB & SB (Major Movement)	WB approach (Highest Minor)	Total VPH For all Approaches
8:00	1692	28	1728
8:15	1776	28	1812
8:30	1707	30	1742
8:45	1632	38	1674
9:00	1579	37	1619
9:15	1588	41	1634
9:30	1615	32	1653
9:45	1595	20	1621
10:00	**1628**	**27**	**1661**
10:15	1678	25	1707
10:30	1741	27	1772
10:45	1784	26	1813
11:00	**1911**	**24**	**1938**
11:15	2001	24	2031
11:30	2114	24	2145
11:45	2224	23	2254
12:00	**2209**	**29**	**2248**
12:15	2347	34	2390
12:30	2411	32	2452
12:45	2464	35	2509
13:00	**2567**	**27**	**2605**
13:15	2570	24	2606
13:30	2542	27	2583
13:45	2464	30	2512
14:00	**2390**	**32**	**2439**
14:15	2312	31	2359
14:30	2299	31	2342
14:45	2343	29	2381
15:00	**2421**	**29**	**2457**
15:15	2502	28	2538
15:30	2512	24	2546
15:45	2529	18	2555
16:00	**2513**	**15**	**2537**
16:15	2482	14	2502
16:30	2506	16	2530
16:45	2577	18	2608
17:00	**2591**	**20**	**2625**
17:15	2627	20	2665
17:30	2616	26	2657
17:45	2594	32	2637
18:00	**2410**	**28**	**2448**
18:15	2186	26	2219
18:30	2012	21	2040
18:45	1823	18	1848
19:00	**1847**	**22**	**1848**

(shaded values do not meet the criteria for part A2 or part B)

Warrant Conditions:
Either Category must be met to warrant a traffic signal
A. Must meet all three conditions:
1. The total stop-time delay on one minor-street approach must equal or exceed 4 vehicle-hours.
2. The highest minor street approach must have traffic equal to or greater than 100 VPH.
3. The 4 approach intersection must have traffic equal to or greater than 800 VPH.

B. The highest minor street approach must exceed 75 VPH for any given 1-hour period, when the sum of the major movement for that hour exceeds 1300 VPH.

Analysis Summary:

Condition A1: During the PM peak ***2-hour*** period, a ***total*** of 49 vehicles were observed, having a *total* stop-time delay of ***.468*** vehicle-hours. Therefore, A1 is not met even with the total from the ***2-hour*** period.

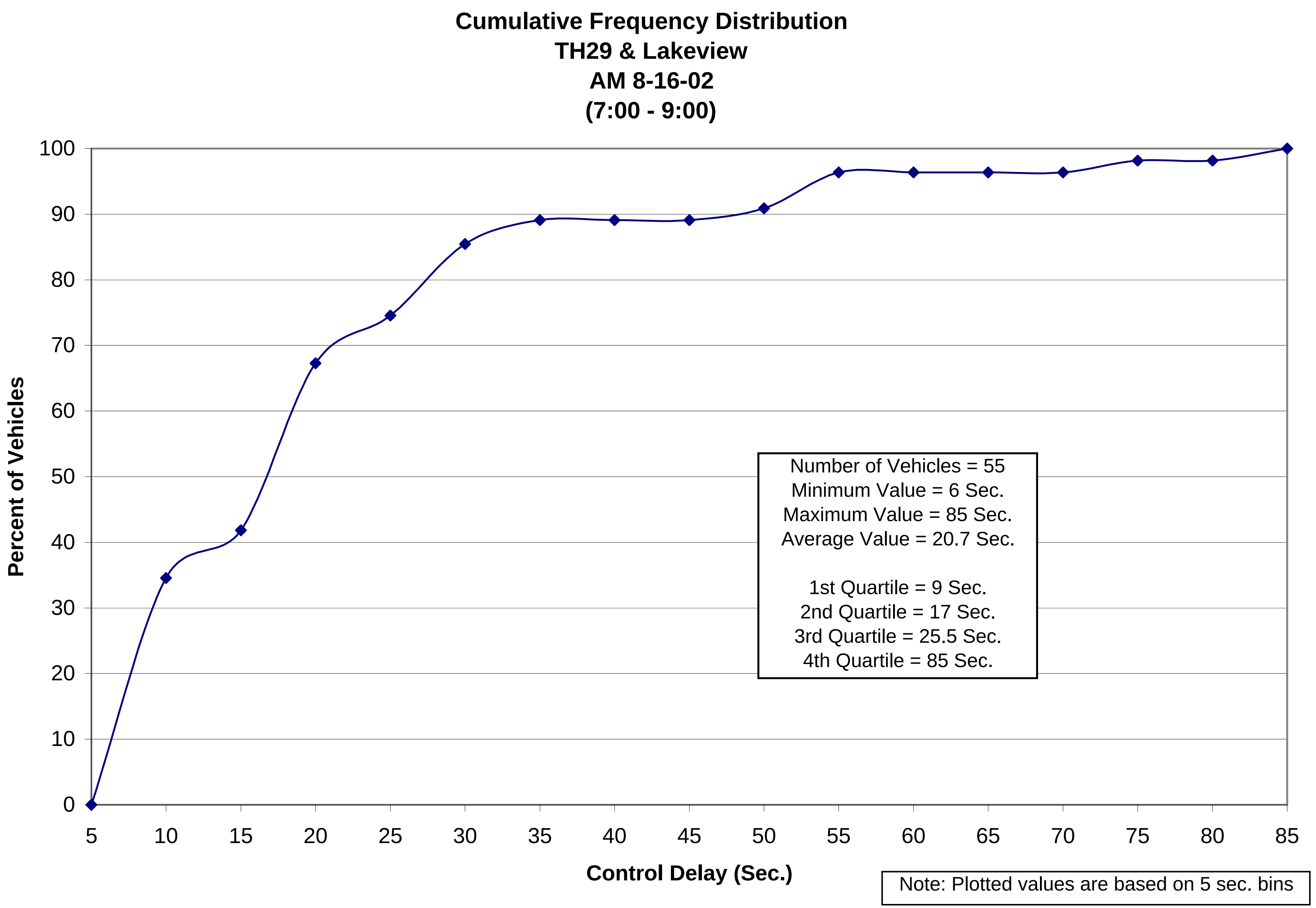
Condition A2: This condition is not met during any hourly period.

Condition A3: This condition is met during all hourly periods.

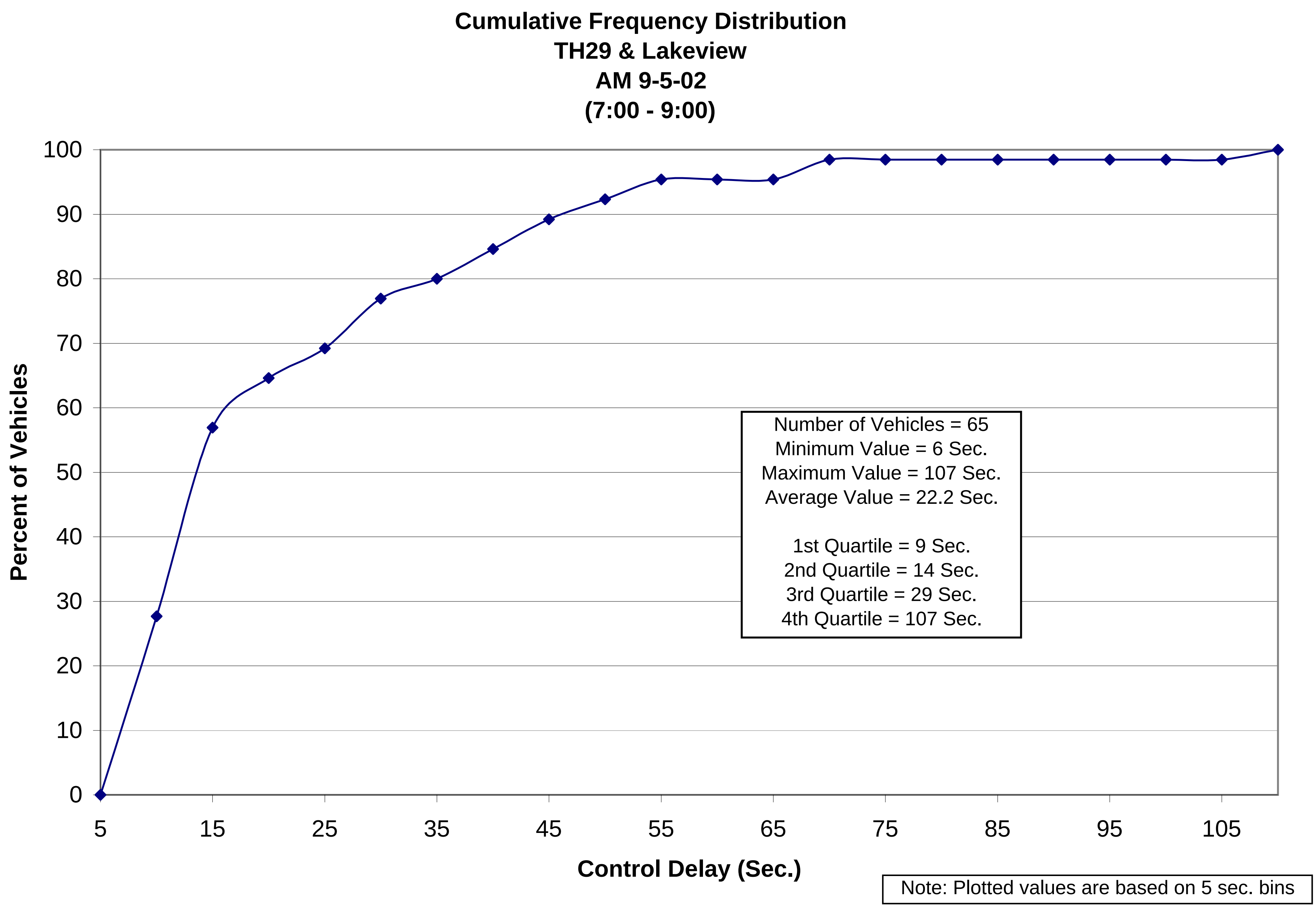
Condition B: This condition is not met during any hourly period.

Final Conclusion: Warrant 3 is not satisfied for any 4 consecutive 15 min. periods.

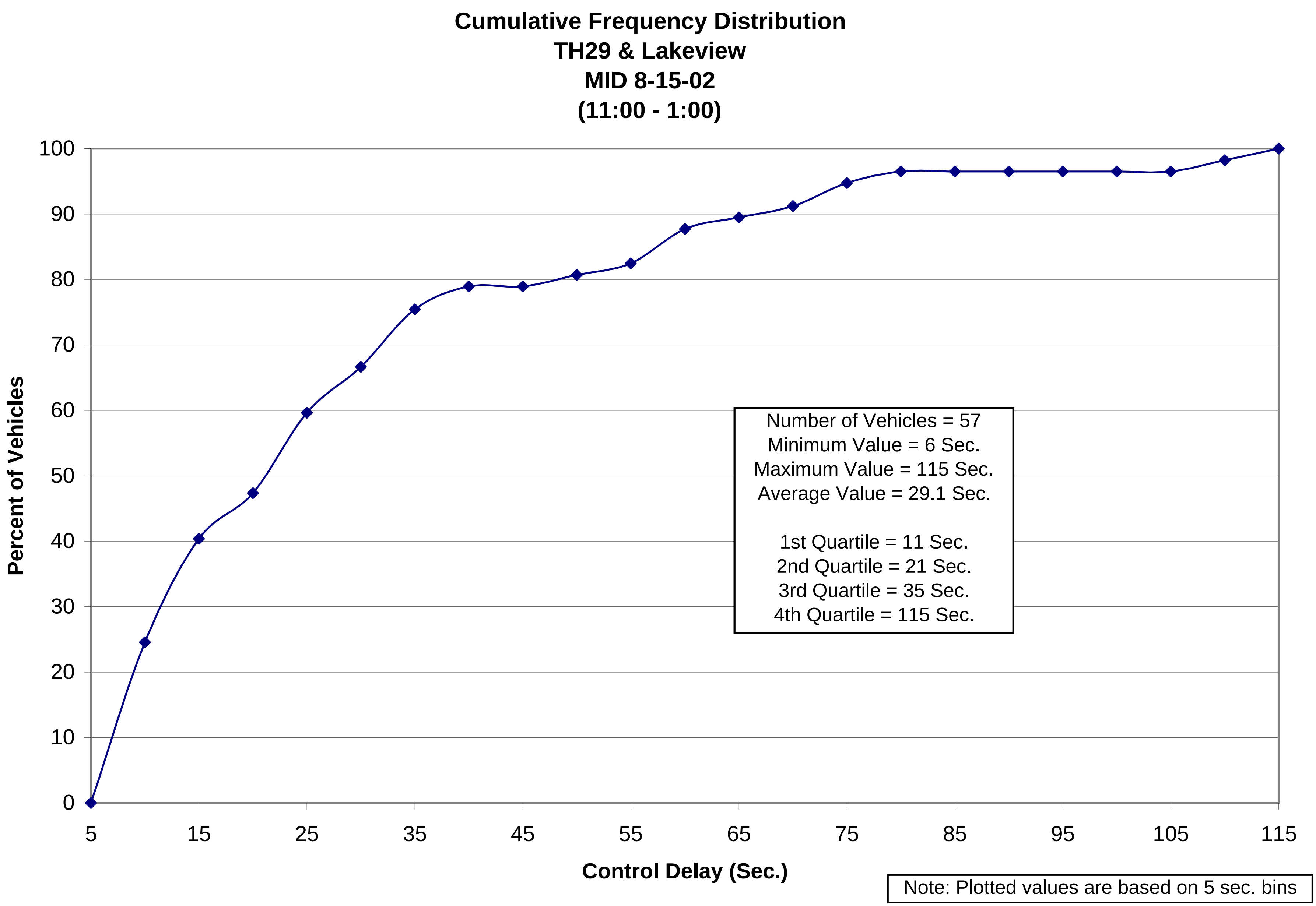
APPENDIX C: Control Delay of Lake View Ave (WB Approach)

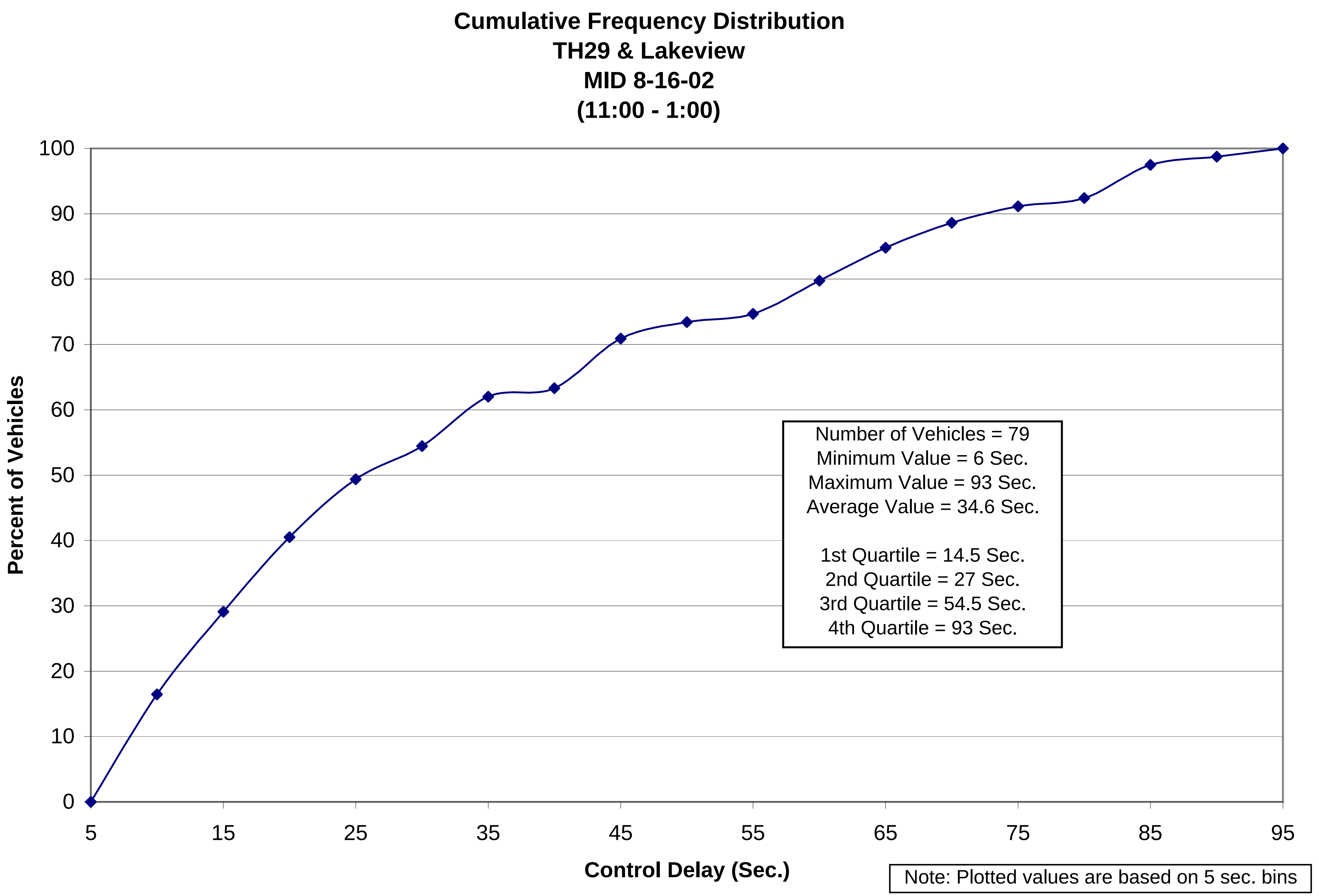


Cumulative Frequency Distribution
TH29 & Lakeview
AM 8-16-02
(7:00 - 9:00)
Percent of Vehicles
Control Delay (Sec.)
0
10
20
30
40
50
60
70
80
90
100
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
Number of Vehicles = 55
Minimum Value = 6 Sec.
Maximum Value = 85 Sec.
Average Value = 20.7 Sec.
1st Quartile = 9 Sec.
2nd Quartile = 17 Sec.
3rd Quartile = 25.5 Sec.
4th Quartile = 85 Sec.
Note: Plotted values are based on 5 sec. bins

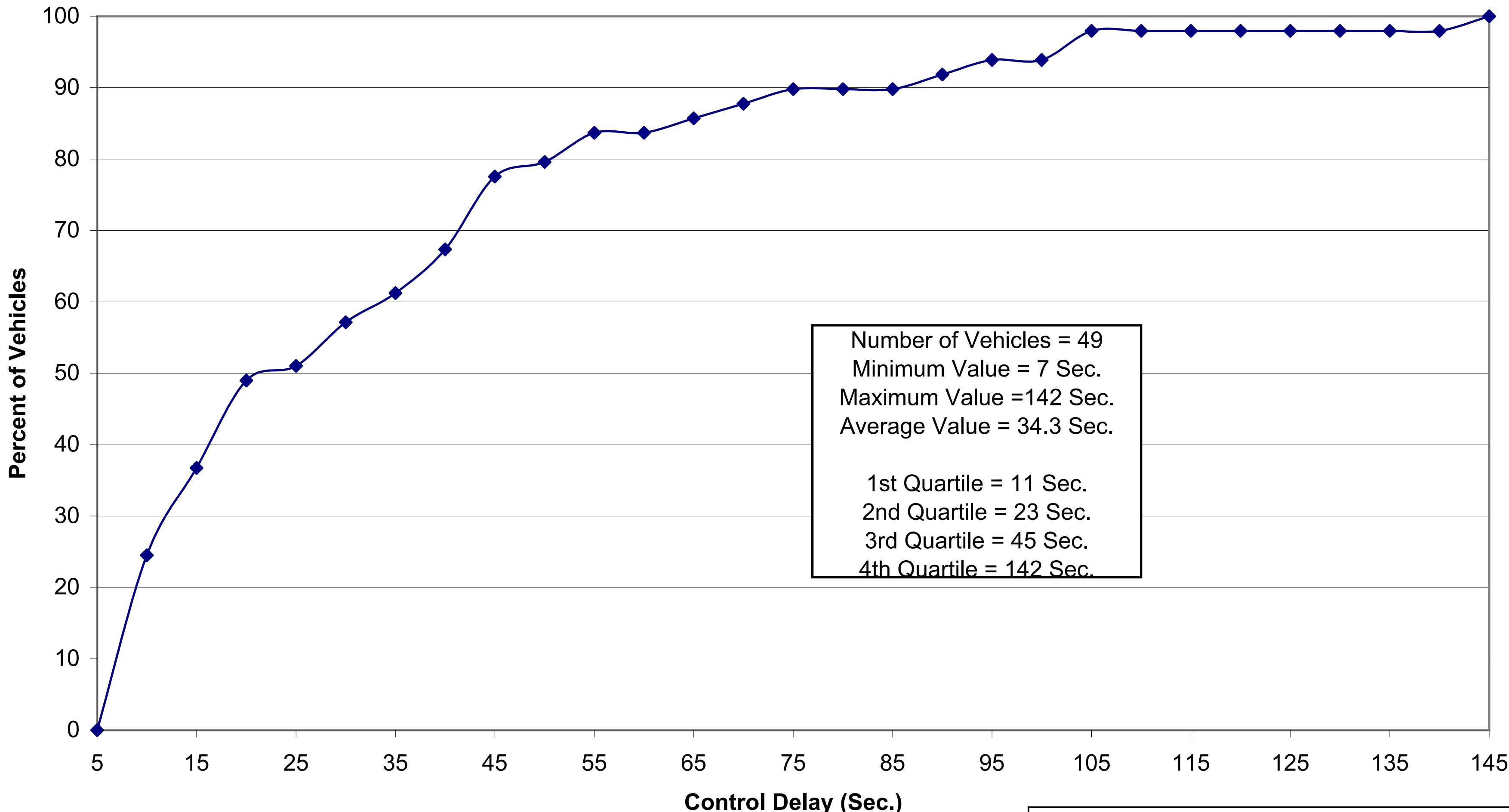


Cumulative Frequency Distribution
TH29 & Lakeview
AM 9-5-02
(7:00 - 9:00)
Percent of Vehicles
0
10
20
30
40
50
60
70
80
90
100
5
15
25
35
45
55
65
75
85
95
105
Control Delay (Sec.)
Number of Vehicles = 65
Minimum Value = 6 Sec.
Maximum Value = 107 Sec.
Average Value = 22.2 Sec.
1st Quartile = 9 Sec.
2nd Quartile = 14 Sec.
3rd Quartile = 29 Sec.
4th Quartile = 107 Sec.
Note: Plotted values are based on 5 sec. bins

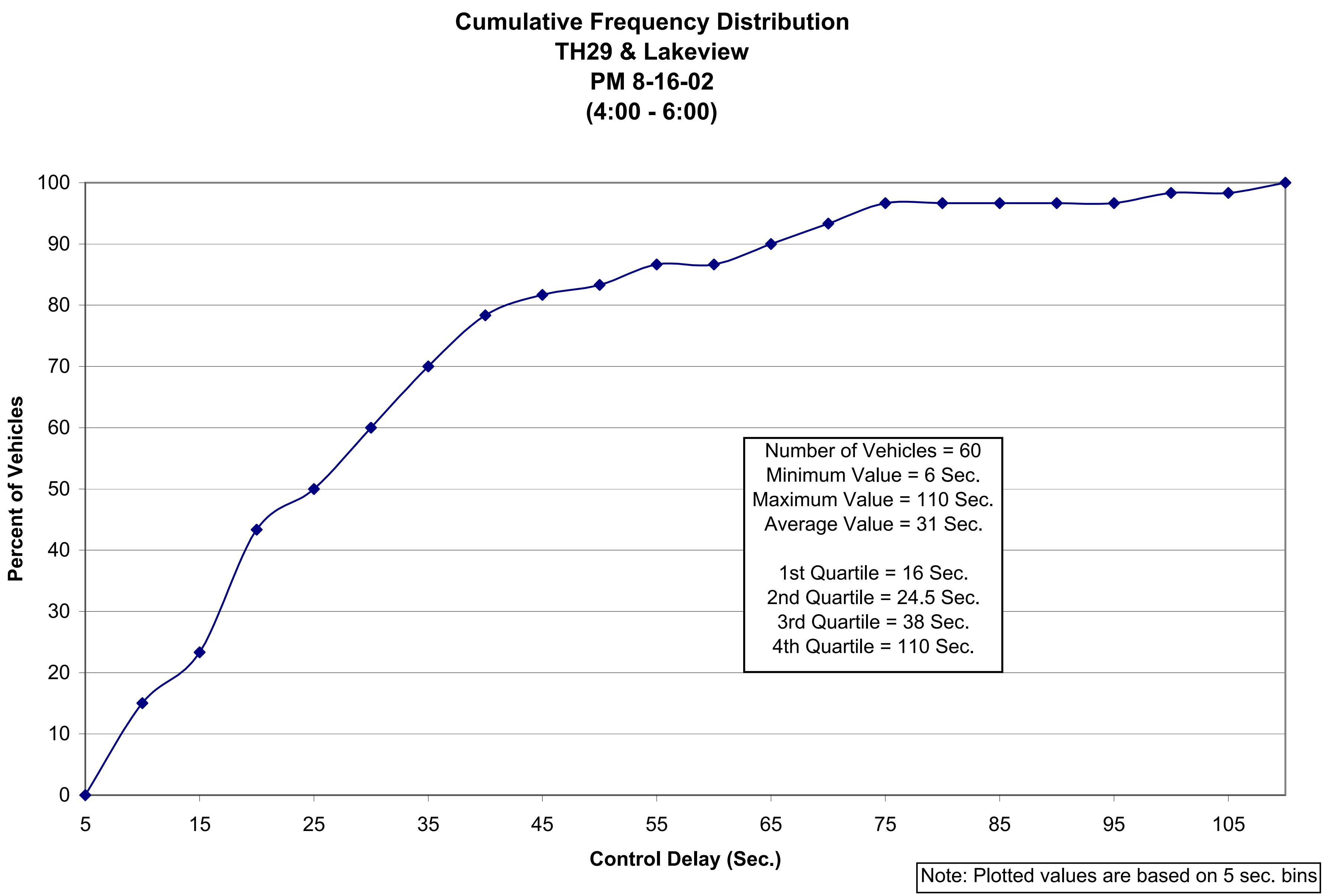

Cumulative Frequency Distribution
TH29 & Lakeview
MID 8-15-02
(11:00 - 1:00)
Percent of Vehicles
100
90
80
70
60
50
40
30
20
10
0
5
15
25
35
45
55
65
75
85
95
105
115
Control Delay (Sec.)
Number of Vehicles = 57
Minimum Value = 6 Sec.
Maximum Value = 115 Sec.
Average Value = 29.1 Sec.
1st Quartile = 11 Sec.
2nd Quartile = 21 Sec.
3rd Quartile = 35 Sec.
4th Quartile = 115 Sec.
Note: Plotted values are based on 5 sec. bins


Cumulative Frequency Distribution
TH29 & Lakeview
MID 8-16-02
(11:00 - 1:00)
Percent of Vehicles
0
10
20
30
40
50
60
70
80
90
100
5
15
25
35
45
55
65
75
85
95
Control Delay (Sec.)
Number of Vehicles = 79
Minimum Value = 6 Sec.
Maximum Value = 93 Sec.
Average Value = 34.6 Sec.
1st Quartile = 14.5 Sec.
2nd Quartile = 27 Sec.
3rd Quartile = 54.5 Sec.
4th Quartile = 93 Sec.
Note: Plotted values are based on 5 sec. bins

Cumulative Frequency Distribution
TH29 & Lakeview
PM 8-15-02
(4:00 - 6:00)



Note: Plotted values are based on 5 sec. bins


Cumulative Frequency Distribution
TH29 & Lakeview
PM 8-16-02
(4:00 - 6:00)
100
90
80
70
60
50
40
30
20
10
0
Percent of Vehicles
5
15
25
35
45
55
65
75
85
95
105
Control Delay (Sec.)
Number of Vehicles = 60
Minimum Value = 6 Sec.
Maximum Value = 110 Sec.
Average Value = 31 Sec.
1st Quartile = 16 Sec.
2nd Quartile = 24.5 Sec.
3rd Quartile = 38 Sec.
4th Quartile = 110 Sec.
Note: Plotted values are based on 5 sec. bins