SEH

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for All of Us®

March 21, 2017

RE: Ramsey, Minnesota
CSAH 83 at Sunwood Drive/147th Avenue NW Signal System
Flashing Yellow Arrow Considerations
SEH No. RAMSY 141224

Mr. Bruce Westby, PE
City Engineer
City of Ramsey
7550 Sunwood Drive Northwest
Ramsey, Minnesota 55303

Dear Mr. Westby:

As requested, we reviewed the intersection of CSAH 83 (Armstrong Boulevard) and Sunwood Drive/147th Avenue Northwest with regards to proposed modification of the existing intersection traffic signal left turn operations. Recently, the City has received requests to have flashing yellow arrow operation installed and activated at this intersection. In response to these requests, the City had SEH perform an analysis of the intersection to determine if flashing yellow arrow operation can be utilized here. The analysis would include review of the feasibility, cost, and safety of the intersection for flashing yellow arrow operations. Following is the results of our analysis.

This 4-legged intersection was signalized in January 2013 (prior to when the adjacent Trunk Highway 10-CSAH 83 intersection was reconstructed with an interchange), with protected left turn phasing installed for all approaches. The posted speed limit on CSAH 83 is 55 mph, while both Sunwood Drive and 147th Avenue Northwest are posted at 30 mph. The northbound and southbound CSAH 83 approaches and the eastbound 147th Avenue Northwest approaches each have a single left turn lane, while the westbound Sunwood Drive approach has a dual left turn lane. Single through lanes and separate right turn lanes exist on the side street approaches, while each CSAH 83 approach has two separate through lanes and a separate right turn lane approaching the intersection. The intersection is located approximately ¼ mile east of the Trunk Highway 10/CSAH 83 interchange area, with a significant east-to-south horizontal curve for northbound CSAH 83 traffic from the interchange area to where a full left turn lane exists for traffic approaching Sunwood Drive/147th Avenue Northwest.

SEH obtained peak hour turning movement traffic counts on September 29, 2016, several months after the Trunk Highway 10-CSAH 83 interchange area was opened and area traffic patterns were able to stabilize, in order to properly analyze existing traffic conditions. SEH

performed AM peak hour (6-9 am), mid-day (11-1 pm), and PM peak hour (3-7 pm) turning movement traffic counts to determine typical weekday traffic patterns at this intersection.

SEH also obtained crash data for the intersection for the 5 year period of 2011-2015 from the State's crash website. SEH then completed a brief field review of the signal system to confirm that the existing traffic signal plans correspond to the current installation of the signal system and take into account the current intersection geometrics. SEH also reviewed traffic signal cabinet components to determine if additional electrical equipment would be required to be provided in order to allow for flashing yellow arrow operation to be used.

As part of the signal system installation, each intersection approach was set up to operate with protected left turn phasing (3-section RLA-YLA-GLA signals). The intersection has a newer Econolite ASC-3 controller unit and Reno MMU-1600-GE conflict monitor, both of which are fully compatible with upgraded left turn (i.e. flashing yellow arrow) operations. The controller cabinet has sufficient load switch bays available to accommodate flashing yellow arrow operations. Thus, the existing controller and cabinet have the capacity and capability to accommodate future flashing yellow arrow operations for all four intersection approaches without requiring this equipment to be significantly upgraded or revised.

As part of our analysis, SEH utilized the Minnesota Department of Transportation's (MnDOT) flashing yellow arrow installation criteria from their "*Traffic Signal Timing and Coordination Manual*" to analyze extended usage of flashing yellow arrow operations for each intersection approach. A copy of this criteria is attached for your information. Based on comparison of available data with the MnDOT criteria, the following can be inferred:

> The design of this signal system included the initial recommendation of protected left turn phasing for each intersection approach due to the higher posted speed limit of 55 mph on CSAH 83 (as is typical Anoka County practice) and the presence of a dual left turn lane for the westbound Sunwood Drive approach.
>
> With regards to utilizing Flashing Yellow Arrow operations for each left turn movement, the following should be noted:
>
> - According to the current edition of the *AASHTO Geometric Design of Highways and Streets* manual, left-turning drivers "need sufficient sight distance to decide when it is safe to turn left across the lanes used by opposing traffic." This stopping sight distance along CSAH 83 for the design/posted speed of 55 mph is at least 495 feet of clear sight distance to the north and south. For both Sunwood Drive and 147th Avenue Northwest, the recommended stopping sight distance at 30 mph is as least 200 feet to the east and west. Based on a field review of intersection geometrics, the southbound, eastbound, and westbound intersection approaches are straight for several hundred feet in each direction with no impediments to the sight distance (other than possible sun issues for eastbound

traffic in the AM peak hour and for westbound traffic in the PM peak hour during fall-winter months).

For northbound CSAH 83, sight distance is somewhat limited due to a sweeping north-to-west horizontal curve that begins approximately 300 feet north of the intersection. However, there are no impediments to sight distance in the median area and no trees or other topography exist to the north on either side of the roadway that limit sight distance for northbound left turning traffic at the intersection (northbound left turning traffic can see oncoming traffic clearly for at least the minimum stopping sight distance required at the posted 55 mph speed limit).

Based on this information, **available stopping sight distance meets this criteria for each intersection approach**.

- Based on the recent crash history at this intersection, no crashes were reported on the State of Minnesota's crash web site between 2011 and 2015. **Thus, there does not appear to be a safety concern at this intersection with the presence of signalized operation**.

- One of the recommendations from the *MnDOT Traffic Signal Timing and Coordination Manual* is to utilize protected left turn phasing only either for situations where the posted speed limit exceeds 45 mph and the peak hour left turning volume is greater than 240 vehicles per hour, or for when the cross product between left turning traffic volume and opposing through traffic volume exceeds 80,000. With regards to the most recent available traffic counts:

  a. Between the hours of 4:00 pm-5:00 pm of the most recent traffic counts, westbound Sunwood Drive left turn volumes were near 130 vehicles per hour. No other intersection approach exceeded 65 left turning vehicles per hour during the PM peak period.

  b. For the midday and AM peak hour counts, no intersection approach had left turning traffic volumes that exceeded 70 vehicles per hour.

  c. The cross product between left turn traffic volumes and opposing through traffic volumes never exceeded 25,000 for any hour counted in 2016.

Following up against the flashing yellow arrow criteria from the *MnDOT Traffic Signal Timing and Coordination Manual:*

1. Left turn lanes line up well for each intersection approach with sufficient turning room in the intersection so that left turn paths were not conflicting. This was observed specifically for the westbound dual left turn lane/eastbound single left turn

movement, where protected left turn phasing was run together for these movements with no conflicts between either direction's left turn movements. Left turn movements are offset far enough such that no conflicts in left turn paths are occurring.

2. As mentioned, the westbound approach has two left turn lanes. For this approach, the MnDOT Manual suggests that protected operation be utilized during the higher volume periods of the day with Engineering judgment being used to determine if flashing yellow operation could be used for all other times of the day.

3. There are less than 3 opposing lanes of through traffic facing each intersection approach.

4. The intersection does not have a high crash rate and there is no significant history of right angle crashes involving left turning traffic.

In summary, as there is no significant crash history for left turning traffic and traffic volumes are likely lower for the entire intersection (outside of the peak traffic periods), the City should be able to consider using Flashing Yellow Arrow operations at this intersection throughout much of a typical weekday and throughout the weekend. In addition, any changes to the operation of the left turn signal phases are not anticipated to impact overall operations of the intersection in a negative way (and delays for left turning traffic will decrease with flashing yellow arrow operations which will improve the overall operation of the intersection). For peak traffic periods though (and for when sun becomes an issue for eastbound and westbound traffic), protected left turn operation is strongly recommended to be implemented.

Some modifications to the existing signal system installation will be required to revise the operation of this signal system and add flashing yellow arrows for each intersection approach. Both overhead end mounted and far left pole mounted left turn signals for each intersection approach will required having 3-section RLA-YLA-GLA signal heads replaced with 4-section RLA-YLA-FYLA-GLA signal heads. For the westbound approach (due to the dual left turn lane), a 5-foot extension will be required to be added to the mast arm facing this approach so that two 4-section overhead signals can be installed and centered on each left turn lane (requirement that each approaching left turn lane have its own flashing yellow arrow signal centered on each left turn lane). No additional through signal heads will be required to be installed facing any of the four approaches, as there are already separate through (RYG) signal heads centered on each through lane. Some additional cabling (6/c#14) will be required to be installed to operate new flashing yellow arrow signal heads on all four intersection approaches based on a review of the field wiring diagram. No new conduit will be required to be installed to accommodate installation of these new cables.

With regards to left turn lane detection, the *MnDOT Traffic Control Signal Design Manual* recommends that either four loop detectors be installed for proper detection (at 5', 20' 35' and 50' from the stop bar or crosswalk) or that two separately wired loop detectors be installed for

existing signal system retrofits at 10' and 40' from the stop bar or crosswalk. Recent County practice has been to have the four separate loop detectors installed in each left turn lane in order to be able to operate the left turn lanes on non-lock operation. For this signal system, left turn lane detection was installed at 10' and 40' from the stop bar for the northbound, southbound, and westbound approaches (each wired separately), while the eastbound approach has four loop detectors installed in the left turn lane. To meet current County practice, additional loop detectors will be required to be furnished and installed 25 feet and 55 feet from the stop bar in the northbound and southbound left turn lanes as well as in both westbound left turn lanes (for a total of 8 new loop detectors). No additional 2/c#14 cables or controller cabinet loop detector cards will be required to operate these new loop detectors since existing loop detectors are already wired separately in each left turn lane.

To allow for flashing yellow arrow operation, we estimate that these modifications (completed by an electrical signal contractor) will cost approximately $40,000. A detailed preliminary engineer's estimate of costs is attached to this letter for your information.

Overall, we do not see any issues with installation and operation of flashing yellow arrows for each intersection approach. However, should the City and County implement flashing yellow arrow modifications to this signal system, **we recommend that the signal system initially operate with protected left turns during both the AM peak period (6:00-9:00 am) and the PM peak period (3:00-7:00 pm) due to higher traffic volumes, higher posted speeds, and the presence of dual left turn lanes through this area**. For all other hours of the day and for all weekend hours, the City and County should be able to consider using flashing yellow arrow operations.

Note that any changes in the operation of this signal system should be monitored by the City and County, including annual review of crash data to ensure that crash frequency does not increase due to modified left turn signal operations.

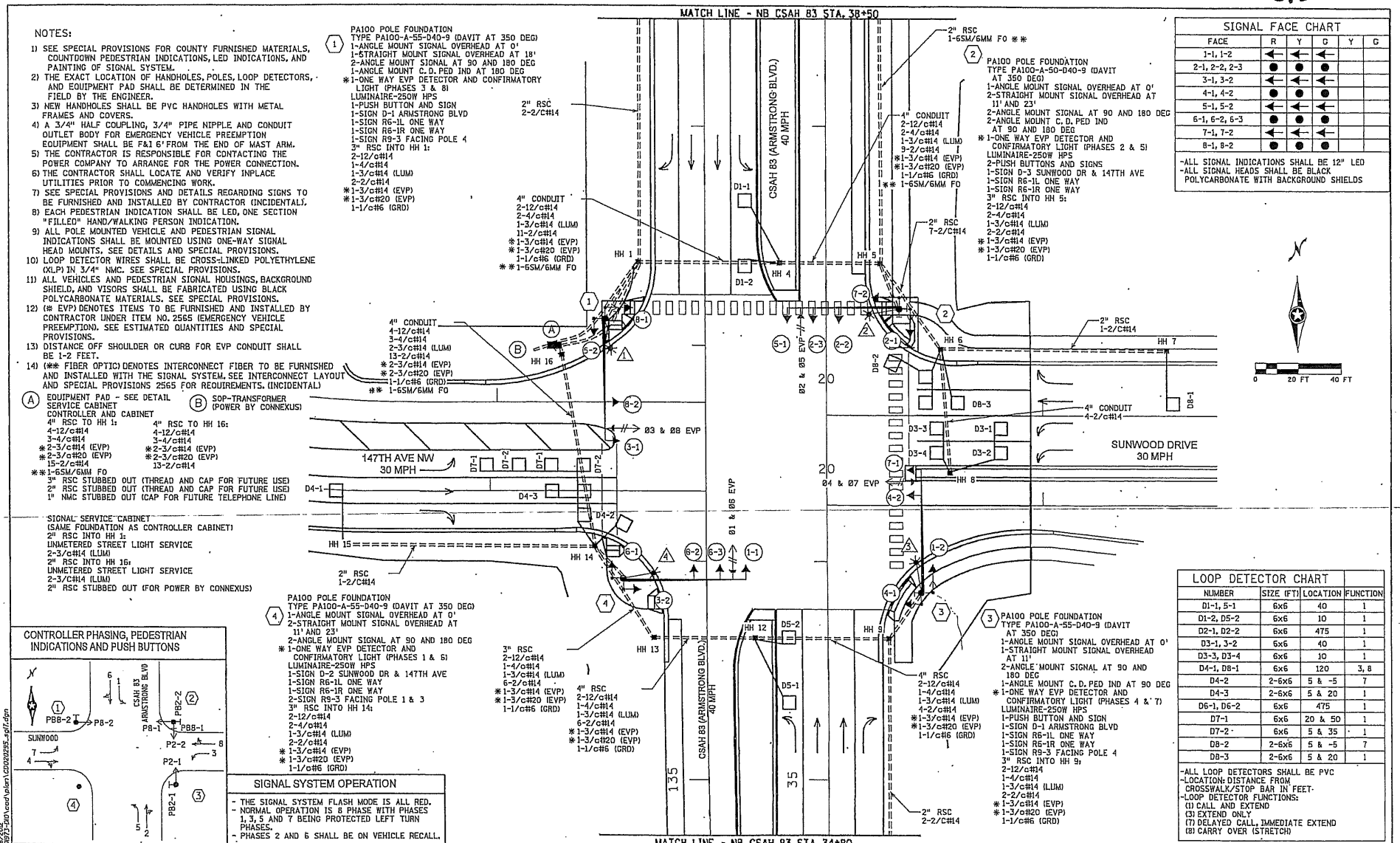
Please review our analysis and feel free to contact me at 651.490.2073 with any questions or concerns that you may have related to our analysis.

We hope that this information provides you with insight needed to help evaluate and implement the appropriate left turn operations for this intersection.

Sincerely,
SHORT ELLIOTT HENDRICKSON INC.

John M. Gray, PE
Project Engineer

Enclosures
c: Jane Rose, Anoka County Highway Department



NOTES:

1) SEE SPECIAL PROVISIONS FOR COUNTY FURNISHED MATERIALS, COUNTDOWN PEDESTRIAN INDICATIONS, LED INDICATIONS, AND PAINTING OF SIGNAL SYSTEM.
2) THE EXACT LOCATION OF HANDHOLES, POLES, LOOP DETECTORS, AND EQUIPMENT PAD SHALL BE DETERMINED IN THE FIELD BY THE ENGINEER.
3) NEW HANDHOLES SHALL BE PVC HANDHOLES WITH METAL FRAMES AND COVERS.
4) A 3/4" HALF COUPLING, 3/4" PIPE NIPPLE AND CONDUIT OUTLET BODY FOR EMERGENCY VEHICLE PREEMPTION EQUIPMENT SHALL BE F&I 6' FROM THE END OF MAST ARM.
5) THE CONTRACTOR IS RESPONSIBLE FOR CONTACTING THE POWER COMPANY TO ARRANGE FOR THE POWER CONNECTION.
6) THE CONTRACTOR SHALL LOCATE AND VERIFY INPLACE UTILITIES PRIOR TO COMMENCING WORK.
7) SEE SPECIAL PROVISIONS AND DETAILS REGARDING SIGNS TO BE FURNISHED AND INSTALLED BY CONTRACTOR (INCIDENTAL).
8) EACH PEDESTRIAN INDICATION SHALL BE LED, ONE SECTION "FILLED" HAND/WALKING PERSON INDICATION.
9) ALL POLE MOUNTED VEHICLE AND PEDESTRIAN SIGNAL INDICATIONS SHALL BE MOUNTED USING ONE-WAY SIGNAL HEAD MOUNTS, SEE DETAILS AND SPECIAL PROVISIONS.
10) LOOP DETECTOR WIRES SHALL BE CROSS-LINKED POLYETHYLENE (XLP) IN 3/4" NMC. SEE SPECIAL PROVISIONS.
11) ALL VEHICLES AND PEDESTRIAN SIGNAL HOUSINGS, BACKGROUND SHIELD, AND VISORS SHALL BE FABRICATED USING BLACK POLYCARBONATE MATERIALS. SEE SPECIAL PROVISIONS.
12) (* EVP) DENOTES ITEMS TO BE FURNISHED AND INSTALLED BY CONTRACTOR UNDER ITEM NO. 2565 (EMERGENCY VEHICLE PREEMPTION). SEE ESTIMATED QUANTITIES AND SPECIAL PROVISIONS.
13) DISTANCE OFF SHOULDER OR CURB FOR EVP CONDUIT SHALL BE 1-2 FEET.
14) (** FIBER OPTIC) DENOTES INTERCONNECT FIBER TO BE FURNISHED AND INSTALLED WITH THE SIGNAL SYSTEM. SEE INTERCONNECT LAYOUT AND SPECIAL PROVISIONS 2565 FOR REQUIREMENTS. (INCIDENTAL)

(A) EQUIPMENT PAD - SEE DETAIL
SERVICE CABINET
CONTROLLER AND CABINET
4" RSC TO HH 1:
4-12/c#14
3-4/c#14
*2-3/c#14 (EVP)
*2-3/c#20 (EVP)
15-2/c#14
**1-6SM/6MM FO
4" RSC TO HH 16:
4-12/c#14
3-4/c#14
*2-3/c#14 (EVP)
*2-3/c#20 (EVP)
13-2/c#14
3" RSC STUBBED OUT (THREAD AND CAP FOR FUTURE USE)
2" RSC STUBBED OUT (THREAD AND CAP FOR FUTURE USE)
1" NMC STUBBED OUT (CAP FOR FUTURE TELEPHONE LINE)

(B) SOP-TRANSFORMER
(POWER BY CONNEXUS)

SIGNAL SERVICE CABINET
(SAME FOUNDATION AS CONTROLLER CABINET)
2" RSC INTO HH 1:
UNMETERED STREET LIGHT SERVICE
2-3/c#14 (LUM)
2" RSC INTO HH 16:
UNMETERED STREET LIGHT SERVICE
2-3/c#14 (LUM)
2" RSC STUBBED OUT (FOR POWER BY CONNEXUS)

(1) PA100 POLE FOUNDATION
TYPE PA100-A-55-D40-9 (DAVIT AT 350 DEG)
1-ANGLE MOUNT SIGNAL OVERHEAD AT 0°
1-STRAIGHT MOUNT SIGNAL OVERHEAD AT 18'
2-ANGLE MOUNT SIGNAL AT 90 AND 180 DEG
1-ANGLE MOUNT C.D. PED IND AT 180 DEG
*1-ONE WAY EVP DETECTOR AND CONFIRMATORY LIGHT (PHASES 3 & 8)
LUMINAIRE-250W HPS
1-PUSH BUTTON AND SIGN
1-SIGN D-1 ARMSTRONG BLVD
1-SIGN R6-1L ONE WAY
1-SIGN R6-1R ONE WAY
1-SIGN R9-3 FACING POLE 4
3" RSC INTO HH 1:
2-12/c#14
1-4/c#14
1-3/c#14 (LUM)
2-2/c#14
*1-3/c#14 (EVP)
*1-3/c#20 (EVP)
1-1/c#6 (GRD)
2" RSC
2-2/C#14
4" CONDUIT
2-12/c#14
2-4/c#14
1-3/c#14 (LUM)
11-2/c#14
*1-3/c#14 (EVP)
*1-3/c#20 (EVP)
1-1/c#6 (GRD)
**1-6SM/6MM FO
4" CONDUIT
4-12/c#14
3-4/c#14
2-3/c#14 (LUM)
13-2/c#14
*2-3/c#14 (EVP)
*2-3/c#20 (EVP)
1-1/c#6 (GRD)
**1-6SM/6MM FO

(2) PA100 POLE FOUNDATION
TYPE PA100-A-50-D40-9 (DAVIT AT 350 DEG)
1-ANGLE MOUNT SIGNAL OVERHEAD AT 0°
2-STRAIGHT MOUNT SIGNAL OVERHEAD AT 11' AND 23'
2-ANGLE MOUNT SIGNAL AT 90 AND 180 DEG
2-ANGLE MOUNT C.D. PED IND AT 90 AND 180 DEG
*1-ONE WAY EVP DETECTOR AND CONFIRMATORY LIGHT (PHASES 2 & 5)
LUMINAIRE-250W HPS
2-PUSH BUTTONS AND SIGNS
1-SIGN D-3 SUNWOOD DR & 147TH AVE
1-SIGN R6-1L ONE WAY
1-SIGN R6-1R ONE WAY
3" RSC INTO HH 5:
2-12/c#14
2-4/c#14
1-3/c#14 (LUM)
2-2/c#14
*1-3/c#14 (EVP)
*1-3/c#20 (EVP)
1-1/c#6 (GRD)
2" RSC
1-6SM/6MM FO **
4" CONDUIT
2-12/c#14
2-4/c#14
1-3/c#14 (LUM)
9-2/c#14
*1-3/c#14 (EVP)
*1-3/c#20 (EVP)
1-1/c#6 (GRD)
**1-6SM/6MM FO
2" RSC
7-2/C#14
2" RSC
1-2/C#14
4" CONDUIT
4-2/c#14

(3) PA100 POLE FOUNDATION
TYPE PA100-A-55-D40-9 (DAVIT AT 350 DEG)
1-ANGLE MOUNT SIGNAL OVERHEAD AT 0°
1-STRAIGHT MOUNT SIGNAL OVERHEAD AT 11'
2-ANGLE MOUNT SIGNAL AT 90 AND 180 DEG
1-ANGLE MOUNT C.D. PED IND AT 90 DEG
*1-ONE WAY EVP DETECTOR AND CONFIRMATORY LIGHT (PHASES 4 & 7)
LUMINAIRE-250W HPS
1-PUSH BUTTON AND SIGN
1-SIGN D-1 ARMSTRONG BLVD
1-SIGN R6-1L ONE WAY
1-SIGN R6-1R ONE WAY
1-SIGN R9-3 FACING POLE 4
3" RSC INTO HH 9:
2-12/c#14
1-4/c#14
1-3/c#14 (LUM)
2-2/c#14
*1-3/c#14 (EVP)
*1-3/c#20 (EVP)
1-1/c#6 (GRD)
4" RSC
2-12/c#14
1-4/c#14
1-3/c#14 (LUM)
4-2/c#14
*1-3/c#14 (EVP)
*1-3/c#20 (EVP)
1-1/c#6 (GRD)
2" RSC
2-2/C#14

(4) PA100 POLE FOUNDATION
TYPE PA100-A-55-D40-9 (DAVIT AT 350 DEG)
1-ANGLE MOUNT SIGNAL OVERHEAD AT 0°
2-STRAIGHT MOUNT SIGNAL OVERHEAD AT 11' AND 23'
2-ANGLE MOUNT SIGNAL AT 90 AND 180 DEG
*1-ONE WAY EVP DETECTOR AND CONFIRMATORY LIGHT (PHASES 1 & 6)
LUMINAIRE-250W HPS
1-SIGN D-2 SUNWOOD DR & 147TH AVE
1-SIGN R6-1L ONE WAY
1-SIGN R6-1R ONE WAY
2-SIGN R9-3 FACING POLE 1 & 3
3" RSC INTO HH 14:
2-12/c#14
2-4/c#14
1-3/c#14 (LUM)
2-2/c#14
*1-3/c#14 (EVP)
*1-3/c#20 (EVP)
1-1/c#6 (GRD)
3" RSC
2-12/c#14
1-4/c#14
1-3/c#14 (LUM)
6-2/c#14
*1-3/c#14 (EVP)
*1-3/c#20 (EVP)
1-1/c#6 (GRD)
4" RSC
2-12/c#14
1-4/c#14
1-3/c#14 (LUM)
6-2/c#14
*1-3/c#14 (EVP)
*1-3/c#20 (EVP)
1-1/c#6 (GRD)

SIGNAL FACE CHART

FACE	R	Y	G	Y	G
1-1, 1-2	←	←	←		
2-1, 2-2, 2-3	●	●	●		
3-1, 3-2	←	←	←		
4-1, 4-2	●	●	●		
5-1, 5-2	←	←	←		
6-1, 6-2, 6-3	●	●	●		
7-1, 7-2	←	←	←		
8-1, 8-2	●	●	●		

-ALL SIGNAL INDICATIONS SHALL BE 12" LED
-ALL SIGNAL HEADS SHALL BE BLACK POLYCARBONATE WITH BACKGROUND SHIELDS

LOOP DETECTOR CHART

NUMBER	SIZE (FT)	LOCATION	FUNCTION
D1-1, 5-1	6x6	40	1
D1-2, D5-2	6x6	10	1
D2-1, D2-2	6x6	475	1
D3-1, 3-2	6x6	40	1
D3-3, D3-4	6x6	10	1
D4-1, D8-1	6x6	120	3, 8
D4-2	2-6x6	5 & -5	7
D4-3	2-6x6	5 & 20	1
D6-1, D6-2	6x6	475	1
D7-1	6x6	20 & 50	1
D7-2	6x6	5 & 35	1
D8-2	2-6x6	5 & -5	7
D8-3	2-6x6	5 & 20	1

-ALL LOOP DETECTORS SHALL BE PVC
-LOCATION: DISTANCE FROM CROSSWALK/STOP BAR IN FEET.
-LOOP DETECTOR FUNCTIONS:
(1) CALL AND EXTEND
(3) EXTEND ONLY
(7) DELAYED CALL, IMMEDIATE EXTEND
(8) CARRY OVER (STRETCH)

CONTROLLER PHASING, PEDESTRIAN INDICATIONS AND PUSH BUTTONS

SIGNAL SYSTEM OPERATION

- THE SIGNAL SYSTEM FLASH MODE IS ALL RED.
- NORMAL OPERATION IS 8 PHASE WITH PHASES 1, 3, 5 AND 7 BEING PROTECTED LEFT TURN PHASES.
- PHASES 2 AND 6 SHALL BE ON VEHICLE RECALL.

NO.	DATE	BY	CHK	REVISIONS

Design By: SD
Plan By: MAS
Checked By: NEH
Approved By: SD

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.
CERTIFIED BY: [signature]
LYDOKEN PROFESSIONAL ENGINEER - SEAL OR STAMP, PE
DATE: 04/03/12 LIC. NO# 40948

WSB & Associates, Inc.
701 Xenia Avenue South, Suite 300
Minneapolis, MN 55416
www.wsbeng.com
INFRASTRUCTURE • ENGINEERING • PLANNING • CONSTRUCTION

City of RAMSEY
Armstrong Blvd at Sunwood Drive
City of Ramsey, Minnesota

CITY OF RAMSEY, MINNESOTA
TRAFFIC CONTROL SIGNAL SYSTEM INTERSECTION LAYOUT
SIGNAL PLAN
S.A.P. 199-020-010 / C.P. 12-20

SHEET 125 OF 153 SHEETS

Date Printed: 6/25/2012
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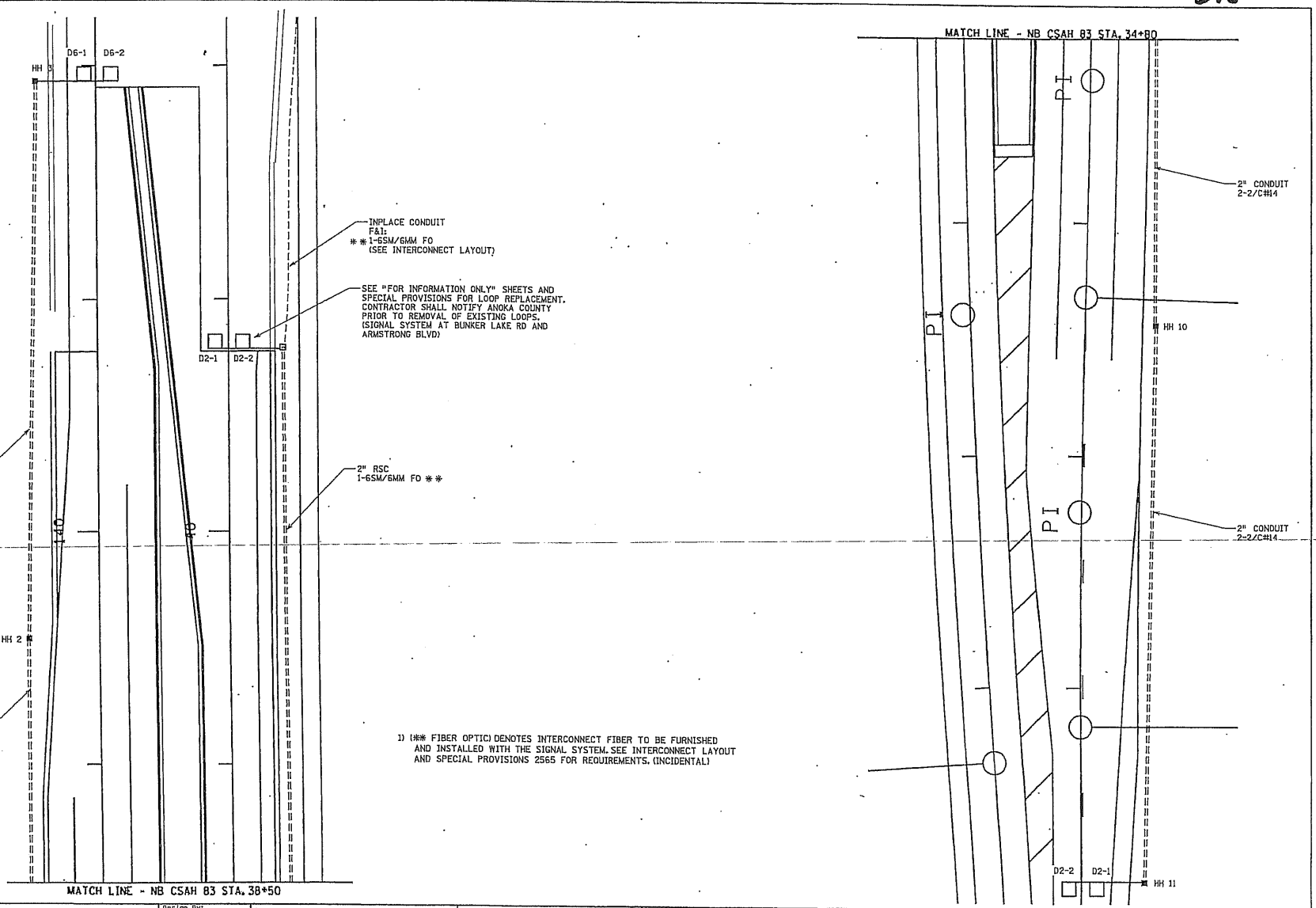

1) (**) FIBER OPTIC) DENOTES INTERCONNECT FIBER TO BE FURNISHED AND INSTALLED WITH THE SIGNAL SYSTEM. SEE INTERCONNECT LAYOUT AND SPECIAL PROVISIONS 2565 FOR REQUIREMENTS. (INCIDENTAL)

NO.	DATE	BY	CHK	REVISIONS

Design By: SD
Plan By: MAS
Checked By: NEH
Approved By: SD

I HEREBY IDENTIFY THIS ITEM PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

CERTIFIED BY: _____ LICENSED PROFESSIONAL ENGINEER - SEAL ON FILE, PE
DATE: 04/03/18 LIC. NO.: 40245

WSB & Associates, Inc.
701 Xenia Avenue South, Suite 300
Minneapolis, MN 55416
www.wsbeng.com
763-541-4800 Fax 763-541-1700
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City of RAMSEY
Armstrong Blvd at Sunwood Drive
City of Ramsey, Minnesota

CITY OF RAMSEY, MINNESOTA
TRAFFIC CONTROL SIGNAL SYSTEM MATCH LINE
SIGNAL PLAN
S.A.P. 199-020-010 / C.P. 12-20

SHEET 126 OF 153 SHEETS

Date Printed: 6/26/2018
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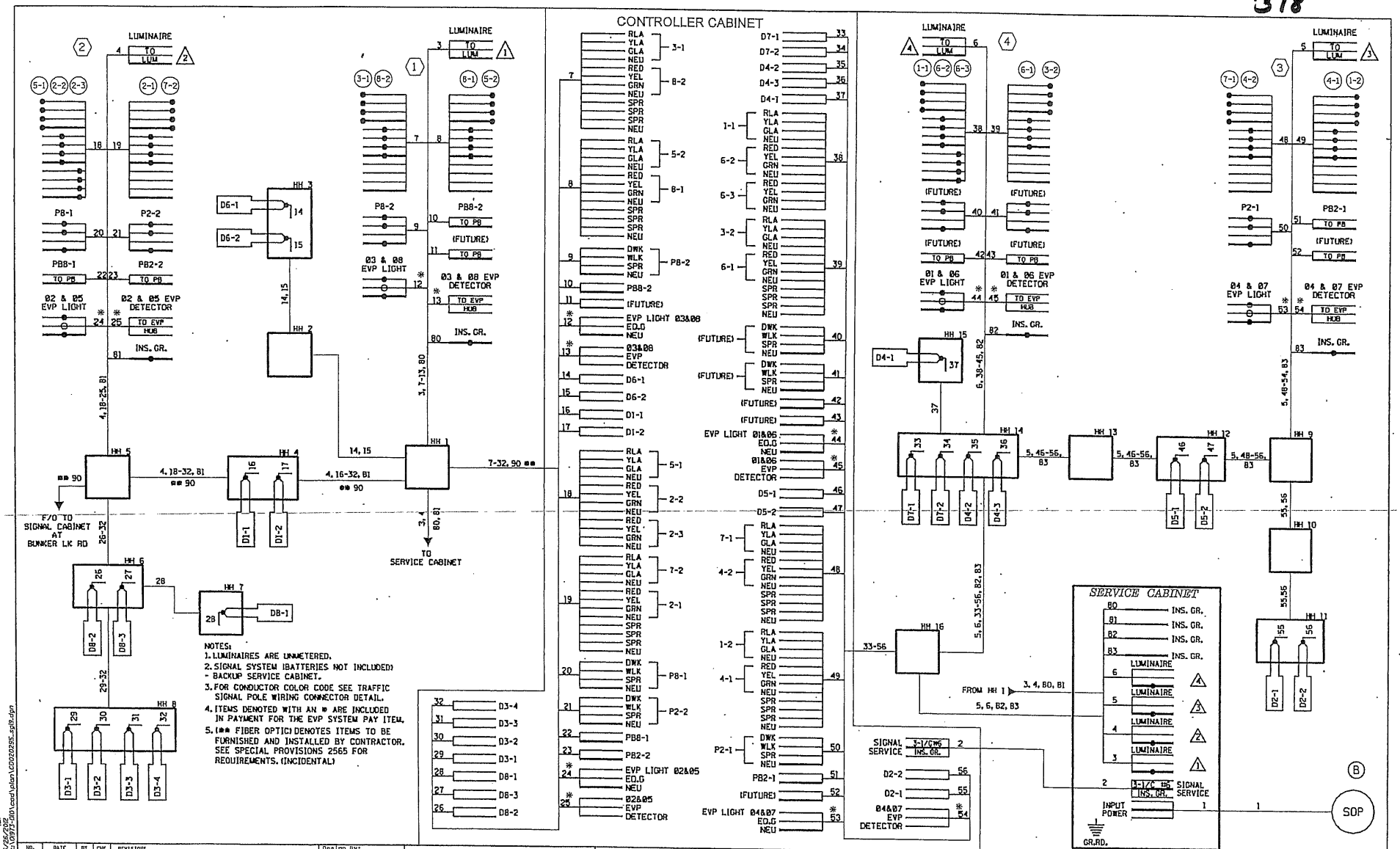

NO.	DATE	BY	CHK	REVISIONS

Design By: SD
Plan By: MAS
Checked By: NEH
Approved By: SD

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

CERTIFIED BY: [signature] LUCINDA J. JOHNSON, P.E. - SEAL REQUIRED
DATE: 04/03/13 Lic. NO: 40545

WSB & Associates, Inc.
701 Xenia Avenue South, Suite 300
Minneapolis, MN 55416
www.wsbeng.com
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City of RAMSEY
Armstrong Blvd at Sunwood Drive
City of Ramsey, Minnesota

CITY OF RAMSEY, MINNESOTA
TRAFFIC CONTROL SIGNAL SYSTEM WIRING DIAGRAM
SIGNAL PLAN
S.A.P. 199-020-010 / C.P. 12-20

SHEET 127 OF 153 SHEETS

Date Printed: 4/2/2013 7:25:37 AM
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Estimated Costs and Quantities
Revise Signal System (FYA Modifications)
CSAH 83 at Sunwood Drive/147th Avenue NW
Prepared by JMG (SEH) on March 21, 2017

Item	Estimated Quantity	Estimated Unit Cost	Estimated Total Cost
Remove 3-Section Signals	8	$300	$2,400
4-Section Signals (with LED)	9	$900	$8,100
5-Foot Extension	1	$2,500	$2,500
Strap-on Mid Mast Arm Mount	1	$1,000	$1,000
R10-X12 Sign Panels	4	$500	$2,000
Controller Cabinet Modifications	1	$2,000	$2,000
6 x 6 NMC Loop Detectors	8	$1,500	$12,000
6/c#14 Cable (to poles 1, 2, 3, 4)	800'	$2	$1,600
EVP detector modifications	1	$500	$500
Traffic Control	1	$2,500	$2,500
Sub Total			$34,600
Miscellaneous	approx. 15%		$5,400
Total Estimated Revise Signal System Costs			$40,000

Short Elliott Hendrickson Inc.

3535 Vadnais Center Drive
St. Paul, MN, 55110
Building a Better World for All of Us

2016 Anoka County Counts
Armstrong Blvd at Sundown Dr/147th St
AM Peak
Ramsey, MN

File Name : 1-CSAH 83 (Armstrong Blvd) at Sundown Drive_147th Avenue 6AM-9AM.ASF
Site Code :
Start Date : 9/29/2016
Page No : 1

Groups Printed- Cars + - Trucks

	Armstrong Blvd From North						Sundown Drive From East						Armstrong Blvd From South						147th Street From West						
Start Time	Right	Thru	Left	UTrn	Peds	App. Total	Right	Thru	Left	UTrn	Peds	App. Total	Right	Thru	Left	UTrn	Peds	App. Total	Right	Thru	Left	UTrn	Peds	App. Total	Int. Total
BREAK																									
06:00 AM	0	74	10	0	0	84	3	0	7	0	0	10	10	11	0	0	0	21	0	0	0	0	0	0	115
06:15 AM	0	64	11	0	0	75	2	0	6	0	0	8	12	19	0	0	0	31	1	0	0	0	0	1	115
06:30 AM	0	77	12	0	0	89	2	1	5	0	0	8	9	21	0	0	0	30	0	0	0	0	0	0	127
06:45 AM	0	50	23	0	0	73	3	0	11	0	1	15	22	25	3	0	0	50	0	0	0	0	0	0	138
Total	0	265	56	0	0	321	10	1	29	0	1	41	53	76	3	0	0	132	1	0	0	0	0	1	495
07:00 AM	0	57	13	0	0	70	4	0	9	0	0	13	20	20	3	0	0	43	3	0	0	0	0	3	129
07:15 AM	0	65	18	0	0	83	5	0	9	0	1	15	40	24	0	0	0	64	0	0	0	0	0	0	162
07:30 AM	1	48	15	0	0	64	4	0	5	0	0	9	47	48	0	0	0	95	0	0	0	0	0	0	168
07:45 AM	1	57	18	0	0	76	3	0	11	0	0	14	38	30	1	0	0	69	0	0	1	0	0	1	160
Total	2	227	64	0	0	293	16	0	34	0	1	51	145	122	4	0	0	271	3	0	1	0	0	4	619
08:00 AM	1	32	19	0	0	52	8	0	13	0	0	21	24	18	0	0	0	42	2	0	0	0	0	2	117
08:15 AM	0	57	9	0	0	66	8	0	11	0	0	19	14	17	2	0	0	33	0	1	1	0	0	2	120
08:30 AM	0	46	15	0	0	61	7	1	12	0	1	21	18	21	1	0	0	40	0	0	0	0	0	0	122
08:45 AM	0	33	13	0	0	46	9	0	7	0	0	16	29	20	2	0	0	51	0	0	0	0	0	0	113
Total	1	168	56	0	0	225	32	1	43	0	1	77	85	76	5	0	0	166	2	1	1	0	0	4	472
Grand Total	3	660	176	0	0	839	58	2	106	0	3	169	283	274	12	0	0	569	6	1	2	0	0	9	1586
Apprch %	0.4	78.7	21	0	0		34.3	1.2	62.7	0	1.8		49.7	48.2	2.1	0	0		66.7	11.1	22.2	0	0		
Total %	0.2	41.6	11.1	0	0	52.9	3.7	0.1	6.7	0	0.2	10.7	17.8	17.3	0.8	0	0	35.9	0.4	0.1	0.1	0	0	0.6	
Cars +	2	650	172	0	0	824	57	2	101	0	2	162	271	258	12	0	0	541	5	1	1	0	0	7	1534
% Cars +	66.7	98.5	97.7	0	0	98.2	98.3	100	95.3	0	66.7	95.9	95.8	94.2	100	0	0	95.1	83.3	100	50	0	0	77.8	96.7
Trucks	1	10	4	0	0	15	1	0	5	0	1	7	12	16	0	0	0	28	1	0	1	0	0	2	52
% Trucks	33.3	1.5	2.3	0	0	1.8	1.7	0	4.7	0	33.3	4.1	4.2	5.8	0	0	0	4.9	16.7	0	50	0	0	22.2	3.3

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2016 Anoka County Counts
Armstrong Blvd at Sundown Dr/147th St
Mid-Day Peak
Ramsey, MN

File Name : 2-CSAH 83 (Armstrong Blvd) at Sundown Drive_147th Avenue 11AM-1PM.ASF
Site Code :
Start Date : 9/29/2016
Page No : 1

Groups Printed- Cars + - Trucks

	Armstrong Blvd From North						Sundown Drive From East						Armstrong Blvd From South						147th Street From West						
Start Time	Right	Thru	Left	UTrn	Peds	App. Total	Right	Thru	Left	UTrn	Peds	App. Total	Right	Thru	Left	UTrn	Peds	App. Total	Right	Thru	Left	UTrn	Peds	App. Total	Int. Total
BREAK																									
11:00 AM	1	23	8	0	0	32	14	0	11	0	0	25	19	20	0	1	0	40	1	0	0	0	0	1	98
11:15 AM	1	19	11	0	0	31	10	1	17	0	0	28	24	19	1	0	0	44	1	0	0	0	0	1	104
11:30 AM	0	22	8	0	0	30	12	0	15	0	1	28	17	28	0	0	0	45	0	1	0	0	0	1	104
11:45 AM	0	16	12	0	0	28	11	0	8	0	0	19	20	16	1	0	0	37	0	1	0	0	0	1	85
Total	2	80	39	0	0	121	47	1	51	0	1	100	80	83	2	1	0	166	2	2	0	0	0	4	391
12:00 PM	0	27	11	0	0	38	12	0	12	0	0	24	22	31	0	0	0	53	0	0	0	0	0	0	115
12:15 PM	1	17	6	0	0	24	22	2	16	0	0	40	24	34	2	0	0	60	2	1	1	0	0	4	128
12:30 PM	0	24	9	0	0	33	11	0	15	0	0	26	33	18	5	0	0	56	0	1	2	0	0	3	118
12:45 PM	1	22	11	0	0	34	15	0	12	0	0	27	22	28	0	0	0	50	2	0	0	0	0	2	113
Total	2	90	37	0	0	129	60	2	55	0	0	117	101	111	7	0	0	219	4	2	3	0	0	9	474
Grand Total	4	170	76	0	0	250	107	3	106	0	1	217	181	194	9	1	0	385	6	4	3	0	0	13	865
Apprch %	1.6	68	30.4	0	0		49.3	1.4	48.8	0	0.5		47	50.4	2.3	0.3	0		46.2	30.8	23.1	0	0		
Total %	0.5	19.7	8.8	0	0	28.9	12.4	0.3	12.3	0	0.1	25.1	20.9	22.4	1	0.1	0	44.5	0.7	0.5	0.3	0	0	1.5	
Cars +	3	161	75	0	0	239	105	3	102	0	1	211	176	186	8	1	0	371	6	4	3	0	0	13	834
% Cars +	75	94.7	98.7	0	0	95.6	98.1	100	96.2	0	100	97.2	97.2	95.9	88.9	100	0	96.4	100	100	100	0	0	100	96.4
Trucks	1	9	1	0	0	11	2	0	4	0	0	6	5	8	1	0	0	14	0	0	0	0	0	0	31
% Trucks	25	5.3	1.3	0	0	4.4	1.9	0	3.8	0	0	2.8	2.8	4.1	11.1	0	0	3.6	0	0	0	0	0	0	3.6

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2016 Anoka County Counts
Armstrong Blvd at Sundown Dr/147th St
PM Peak
Ramsey, MN

File Name : 3-CSAH 83 (Armstrong Blvd) at Sundown Drive_147th Avenue 3PM-7PM.ASF
Site Code :
Start Date : 9/29/2016
Page No : 1

Groups Printed- Cars + - Trucks

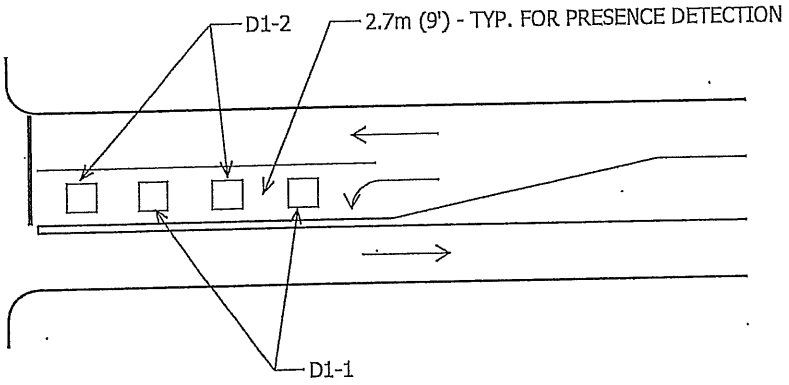
	Armstrong Blvd From North						Sundown Drive From East						Armstrong Blvd From South						147th Street From West						
Start Time	Right	Thru	Left	UTrn	Peds	App. Total	Right	Thru	Left	UTrn	Peds	App. Total	Right	Thru	Left	UTrn	Peds	App. Total	Right	Thru	Left	UTrn	Peds	App. Total	Int. Total
BREAK																									
03:00 PM	0	27	10	0	0	37	23	0	14	0	1	38	29	36	0	1	0	66	0	0	0	0	0	0	141
03:15 PM	0	26	16	0	0	42	20	0	24	0	0	44	17	49	1	0	0	67	5	0	0	0	0	5	158
03:30 PM	0	47	17	0	0	64	31	0	22	0	0	53	30	57	2	0	1	90	0	0	0	0	1	1	208
03:45 PM	0	34	19	0	0	53	26	0	10	0	0	36	41	53	0	2	0	96	1	0	1	0	0	2	187
Total	0	134	62	0	0	196	100	0	70	0	1	171	117	195	3	3	1	319	6	0	1	0	1	8	694
04:00 PM	0	46	7	0	0	53	35	0	30	0	0	65	27	54	0	0	0	81	0	0	0	0	0	0	199
04:15 PM	1	29	22	0	0	52	33	0	29	0	0	62	29	58	0	0	0	87	0	0	1	0	0	1	202
04:30 PM	0	52	10	0	0	62	45	0	41	0	0	86	31	65	0	1	1	98	1	0	0	0	0	1	247
04:45 PM	1	33	18	0	0	52	32	1	29	0	0	62	32	73	1	0	0	106	1	0	0	0	0	1	221
Total	2	160	57	0	0	219	145	1	129	0	0	275	119	250	1	1	1	372	2	0	1	0	0	3	869
05:00 PM	2	38	20	0	0	60	47	0	23	0	0	70	35	73	0	1	0	109	4	0	0	0	0	4	243
05:15 PM	0	45	9	0	0	54	37	0	22	0	0	59	36	64	0	0	0	100	0	0	0	0	0	0	213
05:30 PM	0	49	14	0	0	63	34	0	20	0	2	56	26	56	2	0	0	84	1	0	1	0	0	2	205
05:45 PM	1	38	14	0	0	53	26	0	7	0	1	34	31	68	1	2	0	102	0	0	2	0	0	2	191
Total	3	170	57	0	0	230	144	0	72	0	3	219	128	261	3	3	0	395	5	0	3	0	0	8	852
06:00 PM	0	46	15	0	0	61	41	0	17	0	1	59	32	49	1	1	0	83	0	0	1	0	0	1	204
06:15 PM	0	38	16	0	0	54	34	0	19	0	3	56	24	54	0	1	0	79	0	0	0	0	0	0	189
06:30 PM	0	41	12	0	4	57	20	0	21	0	5	46	25	47	0	0	0	72	1	0	0	0	0	1	176
06:45 PM	0	24	17	0	0	41	25	0	13	0	0	38	26	31	0	0	0	57	0	0	0	0	0	0	136
Total	0	149	60	0	4	213	120	0	70	0	9	199	107	181	1	2	0	291	1	0	1	0	0	2	705
Grand Total	5	613	236	0	4	858	509	1	341	0	13	864	471	887	8	9	2	1377	14	0	6	0	1	21	3120
Apprch %	0.6	71.4	27.5	0	0.5		58.9	0.1	39.5	0	1.5		34.2	64.4	0.6	0.7	0.1		66.7	0	28.6	0	4.8		
Total %	0.2	19.6	7.6	0	0.1	27.5	16.3	0	10.9	0	0.4	27.7	15.1	28.4	0.3	0.3	0.1	44.1	0.4	0	0.2	0	0	0.7	
Cars +	5	602	233	0	0	840	508	1	339	0	2	850	460	866	4	9	1	1340	14	0	6	0	0	20	3050
% Cars +	100	98.2	98.7	0	0	97.9	99.8	100	99.4	0	15.4	98.4	97.7	97.6	50	100	50	97.3	100	0	100	0	0	95.2	97.8
Trucks	0	11	3	0	4	18	1	0	2	0	11	14	11	21	4	0	1	37	0	0	0	0	1	1	70
% Trucks	0	1.8	1.3	0	100	2.1	0.2	0	0.6	0	84.6	1.6	2.3	2.4	50	0	50	2.7	0	0	0	0	100	4.8	2.2

Exhibit 4-6 Protected Permissive and FYA Left Turn – Separate Left Turn Lane

LOOP DETECTOR PLACEMENT

PROTECTED/PERMISSIVE AND FLASHING YELLOW LEFT TURN

SEPARATE LEFT TURN LANE



LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND

NUMBER	FUNCTION	SIZE	LOCATION
D1-1	1	2 - 1.7 x 1.7m (6' X 6')	6m (20') & 15m (50')
D1-2	1	2 - 1.7 x 1.7m (6' X 6')	1.5m (5') & 11m (35')

LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

NOTES:

1) CONTROLLER PHASE AND DETECTOR FUNCTION SHALL BE NON-LOCK MEMORY WITH NO RECALL.
2) USE BACK UP PROTECTION TO PREVENT LEFT TURN TRAP IF THERE ARE OPPOSING LEFT TURNS.
3) DESIGN SPEED IS 25 MPH.
4) EACH NUMBERED LOOP DETECTOR SHALL HAVE A SEPARATE LEAD-IN CABLE AND SEPARATE AMPLIFIER.
5) IF USING NMC LOOPS, A SINGLE LARGER LOOP CAN REPLACE THE DUALS.
6) DETECTOR CROSS SWITCHING MAY BE USED.
7) USE THIS FIGURE IF INSTALLING A FLASHING YELLOW ARROW (FYA).

FIGURE 5

Metric				US Customary			
		Intersection sight distance				Intersection sight distance	
		Passenger cars				Passenger cars	
Design speed (km/h)	Stopping sight distance (m)	Calculated (m)	Design (m)	Design speed (mph)	Stopping sight distance (ft)	Calculated (ft)	Design (ft)
20	20	30.6	35	15	80	121.3	125
30	35	45.9	50	20	115	161.7	165
40	50	61.2	65	25	155	202.1	205
50	65	76.5	80	30	200	242.6	245
60	85	91.7	95	35	250	283.0	285
70	105	107.0	110	40	305	323.4	325
80	130	122.3	125	45	360	363.8	365
90	160	137.6	140	50	425	404.3	405
100	185	152.9	155	55	495	444.7	445
110	220	168.2	170	60	570	485.1	490
120	250	183.5	185	65	645	525.5	530
130	285	198.8	200	70	730	566.0	570
				75	820	606.4	610
				80	910	646.8	650

Note: Intersection sight distance shown is for a passenger car making a left turn from an undivided highway. For other conditions and design vehicles, the time gap should be adjusted and the sight distance recalculated.

Exhibit 9-67. Intersection Sight Distance—Case F—Left Turn from Major Road

If stopping sight distance has been provided continuously along the major road and if sight distance for Case B (stop control) or Case C (yield control) has been provided for each minor-road approach, sight distance will generally be adequate for left turns from the major road. Therefore, no separate check of sight distance for Case F may be needed.

However, at three-leg intersections or driveways located on or near a horizontal curve or crest vertical curve on the major road, the availability of adequate sight distance for left turns from the major road should be checked. In addition, the availability of sight distance for left turns from divided highways should be checked because of the possibility of sight obstructions in the median.

At four-leg intersections on divided highways, opposing vehicles turning left can block a driver's view of oncoming traffic. Exhibit 9-98, presented later in this chapter, illustrates intersection designs that can be used to offset the opposing left-turn lanes and provide left-turning drivers with a better view of oncoming traffic.

Varying Between Protected, Protected/Permissive, and Permissive Operation

As discussed above, the FYA can be considered a variable operation signal indication. Consider the following items:

- ✓ All FYA signals may vary operation between protected, protected/permissive, and permissive operation at various times of the day and night.
- ✓ Each signal approach will need to be analyzed individually to determine the time-of-day FYA operation by considering the following criteria:
  - a) Cross-product volumes of left turns and opposing throughs at various times of day
  - b) Speed limit
  - c) Sight distance limitations
  - d) Number of opposing through lanes
  - e) Double left turn lanes or single left turn lanes
  - f) Opposing left turn lane offset
  - g) Cross street or mainline approach
  - h) Comprehensive left turn crash analysis of approaches with similar characteristics

Test for Protected Only Operation 24 Hours per Day

In some cases, the left turn indication should run in the most restrictive Protected-Only mode 24 hours per day. Refer to Exhibit 3-13 for the Protected Only Left Turn Operation Guidelines. If the answer to question 1 or 2 is "yes", then protected operation should be used throughout the day.

Exhibit 3-13 Part 1: Protected-Only Left Turn Operation 24 Hours per Day

Part 1: Protected Only Operation - 24 hrs/day Guidelines

Question 1: Conflicting Left Turns

Do the opposing left turn paths conflict?

○ Yes
○ No

> If the answer is Yes, then use Protected Operation 24 hours/day.
> If the answer is No, proceed to the next question.

Question 2: Limited Sight Distance

Does the left turner have very limited sight distance as defined in the current AASHTO "A Policy on Geometric Designs of Highways and Streets"?

○ Yes
○ No

> If the answer is Yes, then use Protected Operation 24 hours/day.
> If the answer is No, proceed to part 2 to check for FYA by TOD.

> If the Answer is Yes to Question 1 or 2, use Protected Operation 24 hours/day
> If the Answer is No to all of the above, proceed to Part 2.

If the answer is "yes" to any of the questions in Part 1, then Protected-Only operation is suggested throughout the day. If the answer to all of the questions is "no", then proceed to Part 2 (Exhibit 3-14) to check for permissive FYA operation by time of day.

Test for FYA Operation by Time of Day

Part 2 (Exhibit 3-14) should be performed for each time of day interval. Typically, the evaluation would be for 4 or more intervals throughout the day (AM Peak, Mid-day Peak, PM Peak and Off Peak). Other intervals can be evaluated as warranted.

For the Cross-Product (Question 6) use the highest hourly cross product during the interval evaluated.

Exhibit 3-14 Part 2: Permissive FYA Operation by Time of Day

Part 2: Time of Day Operation of FYA

_____ Start Time

_____ End Time

Question 3: Number of Left Turn Lanes

Does the left turn have two (2) or more lanes?

○ Yes
> If the answer is **Yes**, Protected Operation is **suggested** during the **high** volume times of the day (use Engineering Judgment if Decision to run FYA by TOD).

○ No
> If the answer is **No**, proceed to the next question.

Question 4: Number of Opposing Through Lanes

Does the left turn face three (3) or more opposing through lanes?

○ Yes
> If the answer is **Yes**, Protected Operation is **suggested** during the **high** volume times of the day (use Engineering Judgment if Decision to run FYA by TOD).

○ No
> If the answer is **No**, proceed to the next question.

Question 5: Crash History

Is protected/permissive operation in place and is there a high number of left turn related collisions during this time interval over a 3-year period susceptible to correction by protected only phasing?

○ Yes
> If the answer is **Yes**, Protected Operation is **suggested** for this TOD.

○ No
> If the answer is **No**, proceed to the next question.

Question 6: Speed and Cross Product

Is the Speed 45 MPH or greater and the Peak Hour left turn volume greater than 240 vph or is the peak hour cross product greater than 80,000 (100,000 if 2 opposing lanes)?

○ Yes
> If the answer is **Yes**, Protected Operation is **suggested** for this TOD.

○ No
> If the answer is **No**, FYA may be possible during this time period.

> If the answer is **Yes** to all Questions, Protected Only Operation is **Suggested** during this TOD (use Engineering Judgment if Decision to run FYA by TOD).

> If the answer is **No** to all Questions, FYA may be used during this TOD.

If the answer to all of the questions in Part 2 are "yes", protected only operation is suggested. Use engineering judgment if a decision to run FYA for the evaluated time period.

Question 6 does include a threshold volume of 240 vph for the subject left turn. However, if the opposing through volume is low, apply engineering judgment to determine if FYA operation could be used even if the left turn volume exceeds 240 vph.

If permissive FYA operation is allowed, protected/permissive operation may be investigated. The decision to use protected/permissive operation should be based on a capacity analysis.

Definitions

- ✓ **Protected only left turn operation:** signal phasing that allows left turn movements to only be made on an exclusive phase (green arrow).
- ✓ **Conflicting Left Turn Paths:** At some locations geometric constraints at the intersection cause the paths of opposing left turn vehicles to cross as overlap creating a conflict. An example is an approach that crosses a divided roadway with a wide median. In these locations, it may be necessary to operate the left turns in a lead-lag sequence or a split phase sequence, not allowing simultaneous opposing left turns. This operation will require protected left turns.
- ✓ **Opposing through lane (conflict):** The opposing through lanes are the lanes across from, and in conflict with, the left turning vehicle. Multiple lanes make it difficult for a driver to evaluate gaps in oncoming traffic. An opposing separate right turn lane will typically not be counted with opposing through lanes unless engineering judgment indicates that the lane configuration and number of right turns will cause conflicts with the left turn movement.
- ✓ **Limited Sight Distance (Requirements):** The minimum sight distance values necessary for the design vehicle volume to complete the turn movement. Distance should be calculated from the stop bar for the mainline left turning vehicle. Measurement is based on travel path, speed, and acceleration vehicle height. Both the sight distance for passenger vehicles and trucks should be checked using heights and distance requirements per the AASHTO Geometric Design Guide. The current reference at time this manual was prepared is the 2004 Guide, Chapter 9, Exhibit 9-67).
- ✓ **Dual Left Turn Lanes:** Multiple left turn lanes may consist of exclusive left turn lanes or a combination of exclusive left turn lanes and lanes that are shared by through and left turning traffic. Both the dual lane and the left turn lane opposing this operation are suggested to operate with protected phasing. Left turn lanes without opposing traffic, such as left turns off of a one- way street, does not require protected only phasing based upon this criteria. It might also be possible to run the FYA in permissive mode during low volume times of the day.
- ✓ **Protected/permissive left turn operation:** signal phasing that provides an exclusive phase (green arrow) followed by a permissive phase (flashing yellow arrow), time during the signal cycle where left turning traffic may make a left turn after yielding to oncoming traffic.
- ✓ **Left Turn Related Collisions:** These are Collisions that could be corrected by protected only phasing, such as those between those involving a left turning vehicle and an opposing through vehicle. At higher speeds the accidents collisions are likely to be more severe. Therefore, a lower number of collisions might be used as the parameter for consideration for high-speed approaches. Because of the variations in collisions overtime, an average number of collisions per year over a 3- year period should be used if the data is available.
- ✓ **Speed:** Because it can be difficult for a driver to accurately judge available gaps in traffic approaching at high speeds, the engineer must exercise discretion when considering permissive or protected permissive left turn phasing with opposing speeds of 45 MPH or above.

Use of posted speed limit is recommended. Non-arterial approaches may have lower speeds than the posted speed limit because they are often in a stop condition upon the arrival of traffic. Grades affect the acceleration rate of the left turner and the stopping distance and speed of the opposing through traffic and are therefore considered in conjunction with speeds.

✓ **Cross Product:** The left turn volume multiplied by the opposing through volume. The cross product values used are taken from the Wisconsin Department of Transportation (WisDOT) Traffic Signal Design Manual discussion on left turn conflicts analysis, Chapter 2, Section 3, Subject 4. Cross product used represents a high frequency of conflicts for left turners looking for gaps in through traffic.

FYA during Free Operation

With the variable-phasing operation of the FYA head, free operation will no longer have an assigned fixed phasing operation. Therefore, standard free operation will need to be set up in the signal controller so technicians can put signals quickly to FREE with a standard phasing operation desired at the specific time. Here is an example of the standard FREE operations that will need to be set up in the signal controller:

1. All left turns protected
2. All left turns protected/permissive
3. All left turns permissive
4. Mainline protected, cross street protected permissive
5. Mainline protected, cross street permissive
6. Mainline protected/permissive, cross street protected
7. Mainline protected/permissive, cross street permissive
8. Mainline permissive, cross street protected
9. Mainline permissive, cross street protected/permissive Minimum Green Times

Minimum Green Times

Mn/DOT currently sets the minimum green time based on the type of phasing operation where protected lefts have a 7 second minimum green and protected/permissive lefts have a 5 second minimum green. Given the FYA head is a variable phasing operation head, a decision will need to be made as to if there should be more than one minimum green value that changes with the phasing operation; or if a universal minimum green should apply to all phasing operations.

If one minimum green is used, and if a left turn phase will ever run protected, the left turn minimum green should be set at 7 seconds. If a left turn will never run protected (i.e. only run protected/permissive or permissive), then the left turn minimum green should be set at 5 seconds.

EVP Preemption Operation under FYA

A. Protected-only Operation

✓ When the FYA is not allowed (protected only), the pre-emption will bring up the protected left turn and the adjacent through phase. The opposing FYA will not be allowed during preemption (refer to Exhibit 3-15).