

APPENDIX A  
FLAGSTAFF REGIONAL WINTER STORM HISTORY

**WINTER STORM SUMMARY – FLAGSTAFF  
SIX PROJECT WINTERS: 1997 - 2003**

<b>Winter Season (October - May)</b>	<b>Storm Events</b>	<b>Seasonal Snowfall - Inches</b>	<i>Snow In Caltrans- 3M Tests</i>	<b>ATRC Research Project Phases</b>
1997-98	27	<b>108"</b>	-	<i>Pre-Planning Stage</i>
1998-99	13	<b>72"</b>	5.4"	Caltrans
1999-2000	18	<b>74"</b>	16.8"	Caltrans
2000-01	25	<b>125"</b>	30.6"	Caltrans & 3M
2001-02	10	<b>39"</b>	<i>None</i>	Caltrans & 3M
2002-03	14	<b>55"</b>	-	Bendix & Eaton VORAD
<b>Six Year Average Winter Season:</b>	<b>18</b>	<b>79"</b>		
<i>*Flagstaff 30 Year Historical Average:</i>		<b>107"</b>		<i>(1997-2003)</i>
<i>*Flagstaff 105 Year Historical Average:</i>		<b>84"</b>		<i>(1898-present)</i>

- Storms Greater than One Inch of Snow at Flagstaff
- Recorded at Pulliam Airport / WX Observation Station

**NUMBER OF DAYS SNOWFALL EXCEEDED 1 INCH FOR FLAGSTAFF**

<b>Calendar Year</b>	<b>Jan</b>	<b>Feb</b>	<b>Mar</b>	<b>Apr</b>	<b>May</b>	<b>Oct</b>	<b>Nov</b>	<b>Dec</b>	<b>Total Days</b>	<b>Total Snow</b>
<b>1997</b>	6	2	0	4	0	0	1	4	<b>17</b>	<b>113</b>
<b>1998</b>	4	8	7	3	0	0	2	2	<b>26</b>	<b>123</b>
<b>1999</b>	1	1	2	5	0	0	0	0	<b>9</b>	<b>56</b>
<b>2000</b>	3	5	9	1	0	2	3	1	<b>24</b>	<b>101</b>
<b>2001</b>	7	5	2	5	0	0	2	6	<b>27</b>	<b>131</b>
<b>2002</b>	0	0	2	0	0	0	1	5	<b>8</b>	<b>30</b>
<b>2003</b>	0	3	4	1	0	0	0	0	<b>8</b>	<b>33</b>
<b>7 Cal Yr Average</b>	<b>3.0</b>	<b>3.4</b>	<b>3.7</b>	<b>2.7</b>	<b>0.0</b>	<b>0.3</b>	<b>1.3</b>	<b>2.6</b>	<b>17.0</b>	<b>84</b>

*\*Full Calendar Year averages - through December 2003.*

Courtesy of National Weather Service, Flagstaff

## FLAGSTAFF REGIONAL WINTER STORM HISTORY: 1973-2003

### Number of Days Snowfall Exceeded 1 inch for Flagstaff, AZ

Year	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec	Total
1973	6	9	15	4	1	0	4	1	40
1974	5	0	2	1	0	3	1	4	16
1975	7	6	8	6	2	0	3	5	37
1976	1	4	3	5	1	0	0	2	16
1977	3	2	2	2	1	0	1	1	12
1978	8	7	8	3	1	0	4	4	35
1979	10	4	5	1	1	0	1	3	25
1980	8	7	9	2	0	2	0	3	31
1981	3	3	10	2	0	0	3	1	22
1982	7	7	7	1	0	0	3	7	32
1983	3	5	8	4	0	0	4	2	26
1984	1	1	0	2	0	0	3	11	18
1985	6	5	7	2	0	0	5	1	26
1986	0	6	5	1	0	0	1	3	16
1987	7	5	4	0	0	0	1	6	23
1988	4	2	1	5	0	0	4	3	19
1989	3	2	4	0	0	0	0	1	10
1990	6	7	4	2	1	0	2	6	28
1991	1	2	11	0	0	1	4	5	24
1992	6	5	8	1	0	0	1	7	28
1993	15	11	3	1	0	0	5	3	38
1994	1	5	3	6	0	1	4	2	22
1995	7	1	2	5	1	0	0	3	19
1996	1	3	1	0	0	5	4	0	14
1997	6	2	0	4	0	0	1	4	17
1998	4	8	7	3	0	0	2	2	26
1999	1	1	2	5	0	0	0	0	9
2000	3	5	9	1	0	2	3	1	24
2001	7	5	2	5	0	0	2	6	27
2002	0	0	2	0	0	0	1	5	8
2003	0	3	4	1	0	0	0	0	8
<b>Average</b>	<b>4.3</b>	<b>4.3</b>	<b>5.0</b>	<b>2.4</b>	<b>0.3</b>	<b>0.5</b>	<b>2.2</b>	<b>3.3</b>	<b>22.5</b>

Courtesy of National Weather Service, Flagstaff

APPENDIX B

I-40 CORRIDOR SNOWFALL BY DATE: WINTER 2002-03

Intelligent Vehicles / ADOT Snowplow Research								
Daily Snowfall - Winter 2002 - 2003								
Plow No.	F277	F326	F235	F342	F291	F340	F269	Notes
ORG	Kingman	Seligman	Ltl Antelope	Gray Mtn	Flagstaff	Winslow	Chambers	ADOT Maint Site
WEATHER	Diamond		Pulliam	Sunset	Walnut	Blue	Sanders	
SITE	M Ranch	Seligman	Airport	Crater	Canyon	Ridge	POE	WX Site Loc'n
ROUTE	I-40	I-40	I-17	S 89	I-40	SR 87	I-40	
MP Loc'n	91	121	337	430	204	300	339	WX Site Approx MP Loc'n
Summary of Dates w/ Snowfall Total								
10/02/02		R			R			R - Rain
10/03/02	R	R		T	R	R		T - Trace Snow to 0.5"
10/04/02					R			Snowfall > 0.5"
10/16/02							R	
10/17/02		R		R	R	R	R	
10/18/02	R			R	R			
10/21/02					R			
10/22/02	R					R		
10/23/02	R	R		R	R			
10/24/02				R	R	R		
10/25/02				R	R			
10/26/02	R							
10/27/02	R	R	0.3	R	R			
10/28/02	R			R	R	R		
11/08/02	R							
11/09/02		R		R	R			
11/10/02				R	R			
11/12/02						R		
11/26/02	R		3.0		R			
11/30/02	R	R		R	R			
12/01/02	(missing Dec)	R		R	R			
12/02/02						R		
12/03/02							R	
12/04/02				R				
12/08/02				0.5				
12/17/02		R	4.3	3.0	3.0	2.0		
12/18/02		T	7.2	1.5	4.0	3.0		
12/19/02			0.3	T	T	T		
12/20/02		1.7						
12/21/02			2.5	0.5	2.0			
12/23/02				3.0	2.5			
12/24/02			2.7	1.0	2.8			
12/29/02		R						
12/30/02			2.6	1.5	2.0			
01/01/03			T					
01/03/03	T							
01/06/03		R	0.5	10.0	4.0	1.0		
01/07/03				0.3				
01/08/03	R	R						
01/09/03	R			R	R			
01/11/03				R				
01/19/03							R	
01/20/03							R	
01/21/03		R			R			
ORG	Kingman	Seligman	Ltl Antelope	Gray Mtn	Flagstaff	Winslow	Chambers	
02/08/03			T	0.5				
02/09/03			1.0	R	0.9	2.0		
02/10/03						2.0		
02/12/03	R			R				
02/13/03	R	R		R	R	R		
02/14/03	R	R		R	R	R	R	
02/15/03				R				
02/16/03					R			
02/18/03			T			R		
02/25/03	R	R	T	0.3	T	R	R	
02/26/03	2.5	1.0	5.0	0.5	1.0	4.0	R	
02/27/03	T	1.4	2.0	T	2.0	3.0	R	
02/28/03	4.0	R	9.0	0.6	5.0	10.0	R	
03/01/03	T	1.1	1.0	0.3	T		R	
03/02/03	3.0	0.5	5.2	1.0	1.5		R	
03/03/03	T			0.3		R		
03/04/03						1.0		
03/05/03	1.2		2.0		0.5	1.0		
03/06/03			1.0					
03/16/03	R	R	T	R	R			
03/17/03	R	0.2	1.3	R	0.7	7.0		
03/18/03	R	R	2.0	0.3	T	R	R	
03/19/03				0.3				
03/21/03	R		T	0.3		1.0		
04/06/03			T	T	R			
04/15/03	2.0	0.5	2.0	1.0	3.5	2.0		
04/16/03	R			0.5	T			
04/19/03	T	R	T	0.3				
04/20/03			T					
04/22/03						R		
04/23/03	R		T	T	R			
04/24/03				T				
<b>SUM</b>	<b>12.7</b>	<b>6.4</b>	<b>54.9</b>	<b>27.5</b>	<b>35.4</b>	<b>39.0</b>	<b>0.0</b>	Snow Totals - Season
WEATHER	Diamond M		Pulliam	Sunset	Walnut	Blue	Sanders	NOTE: Daily records from
SITE	Ranch	Seligman	Airport	Crater	Canyon	Ridge	POE	12AM to 12AM
ROUTE	I-40	I-40	I-17	S 89	I-40	SR 87	I-40	Shaded Dates Missing:

APPENDIX C

SNOWPLOW ACTIVITY BY WINTER STORM CODES: ALL SITES

Snowplow Activity: Winter Storm Codes – All Sites									
Project 473 Winter 2002 – 2003									
PECOS DATA	F277	F326	F235	F342	F291	F340	F269	Notes	
MAINT ORG:	Kingman	Seligman	Ltl Antelope	Gray Mtn	Flagstaff	Winslow	Chambers	Activities: 171,172,173, 1607	
Reports	12	13	72	61	33	40	16	247	
System:	XVision	Radar	XVision	Radar	Radar	XVision	Radar		
Std Hwy	I-40	I-40	I - 17	US 89	I-40	SR 87	I-40		
MP's	54 – 72	121–146	335-340	420-440	185-230	317-290	347-360		
Installed	03-Dec-02	22-Jan-03	07-Feb-02	21-Sep-01	14-Jan-03	03-Dec-02	04-Feb-03		
Dates / Miles Summary									
10/26/02			141						
10/27/02			25						
11/25/02			305						
11/26/02			193						
11/30/02			134						
12/01/02			149						
12/07/02				49					
12/08/02				140					All XVision opn'l
12/17/02						284			
12/18/02			269	321		348			
12/19/02			323	404		257			
12/20/02	356		232	253		153			
12/21/02	249		307	285		182			
12/22/02			244	196		315			
12/23/02			671	764		604			
12/24/02			321	325		328			
12/29/02			231	277		124			
12/30/02			333	275		352			Odo failed F342
01/06/03			349	BO		182			
01/08/03			51	130					
01/09/03			71						
01/10/03				63					
01/11/03				111					
02/08/03			589		162	411	31		All radars opn'l
02/09/03			182			118	165		
02/11/03				50					
02/12/03			109	297	72				
02/13/03			260	281	87	268			
02/14/03		116		117	68	104			
02/15/03					95				
02/16/03					266				
02/18/03							150		
02/24/03			67	55	73				
02/25/03	143	143	523	562	235	425			
02/26/03	269	377	714	350	288	604	717		
02/27/03	320	249	686	602	608	656	344		
02/28/02	392	128	658	363	706	463	414		Dash short F340
03/01/03		266	353	658	431		404		
03/02/03		172	363	248	147	163	303		
03/04/03			290	217	151		125		
03/05/03		28	267	92	144	139			
03/16/03			283	121	236				
03/17/03		123	101	398	305	383	186		
03/18/03				221	147		182		
03/20/03			56	114					
03/21/03			17	145					
04/15/03		228	354		103				
04/18/03			278						
04/22/03			132						
04/23/03			240		128				
SUM	1,729	1,830	10,871	8,484	4,452	6,863	3,021		37,250
Use-Days:	6	10	39	32	20	22	11		
	<b>F277</b>	<b>F326</b>	<b>F235</b>	<b>F342</b>	<b>F291</b>	<b>F340</b>	<b>F269</b>		
ORG	Kingman	Seligman	Ltl Antelope	Gray Mtn	Flagstaff	Winslow	Chambers		

APPENDIX D

SNOWPLOW ACTIVITY BY SNOWFALL DATES: ALL SITES

Intelligent Vehicles / Snowplow Guidance Research														
Project 473 Winter 2002 – 2003														
MAINT ORG:	F277	F326	F235	F342	F291	F340	F269	Notes						
Kingman	Seligman	Ltl Antelope	Gray Mtn	Flagstaff	Winslow	Chambers	Activities:		171,172,173, 1607					
WEATHER SITE:	Diamond M Ranch	Seligman	Pulliam Airport	Sunset Crater	Walnut Canyon	Blue Ridge	Sanders POE							
System:	XVision	Radar	XVision	Radar	Radar	XVision	Radar	Shading:						
Std Hwy	I-40	I-40	I - 17	US 89	I-40	SR 87	I-40	RAIN						
MP's	54 – 72	121-146	335-340	420-440	185-230	317-290	347-360	LT SNOW						
Installed	03-Dec-02	22-Jan-03	07-Feb-02	21-Sep-01	14-Jan-03	03-Dec-02	04-Feb-03	HVY SNOW						
Dates / Miles / Snowfall Summary : PECOS														
10/26/02	R		141					*						
10/27/02	R	R	25	0.3	R	R		R						
10/28/02	R				R			R						
11/08/02	R													
11/09/02		R			R	R		*						
11/10/02					R	R		*						
11/12/02							R							
11/25/02			305											
11/26/02	R		193	3.0		R								
11/30/02	R	R	134		R			*						
12/01/02	(No Dec WX)	R	149		R	R		*						
12/02/03	*						R							
12/03/03	*							R	All XVision opn'l					
12/04/03	*				R									
12/07/02	*			49				*						
12/08/02	*			140	0.5			*						
12/17/02	*	R	4.3	3.0	3.0	284	2.0							
12/18/02	*	T	269	7.2	321	1.5	4.0	348	3.0					
12/19/02	*		323	0.3	404	T	T	257	T					
12/20/02	356	*	232	253				153	*					
12/21/02	249	*	307	2.5	285	0.5	2.0	182	*					
12/22/02	*		244	196				315	*					
12/23/02	*		671	764	3.0	2.5	604	*						
12/24/02	*		321	2.7	325	1.0	2.8	328	*					
12/29/02	*	R	231	277			124	*						
12/30/02	(No Dec WX)		333	2.6	275	1.5	2.0	352	*					
01/01/03			T					*						
01/03/03	T													
01/06/03		R	349	0.5	BO	10.0	4.0	182	1.0					
01/07/03						0.3								
01/08/03	R	R	51	130										
01/09/03	R		71		R	R								
01/10/03				63										
01/11/03				111	R			*						
01/19/03								*	R					
01/20/03								*	R					
01/21/03		R				R								
ORG	Kingman	Seligman	Ltl Antelope	Gray Mtn	Flagstaff	Winslow	Chambers							
02/08/03			589	T	0.5	162	411	*	31					
02/09/03			182	1.0	R	0.9	118	2.0	165					
02/10/03							2.0							
02/11/03				50										
02/12/03	R		109	297	R	72								
02/13/03	R	R	260	281	R	87	268	R						
02/14/03	R	116	R	117	R	68	104	R	R					
02/15/03				R	95	R	*							
02/16/03					266	R								
02/18/03							R		150					
02/24/03			67	T	55	73								
02/25/03	143	R	143	R	523	T	562	0.3	235	T	425	R	R	
02/26/03	269	2.5	377	1.0	714	5.0	350	0.5	288	1.0	604	4.0	717	R
02/27/03	320	T	249	1.4	686	2.0	602	T	608	2.0	656	3.0	344	R
02/28/03	392	4.0	128	R	658	9.0	363	0.6	706	5.0	463	10.0	414	R
03/01/03	T	266	1.1	353	1.0	658	0.3	431	T	*	404	R	R	Dash short F340
03/02/03	3.0	172	0.5	363	5.2	248	1.0	147	1.5	163	*	303	R	
03/03/03	T					0.3				R				
03/04/03				290	217		151				1.0	125		
03/05/03	1.2	28		267	2.0	92	144	0.5	139	1.0				
03/06/03				1.0										
03/16/03	R	R	283	T	121	R	236	R		*				
03/17/03	R	123	0.2	101	1.3	398	R	305	0.7	383	7.0	186		
03/18/03	R	R	2.0	221	0.3	147	T		R	182	R			
03/19/03						0.3								
03/20/03			56	114										
03/21/03	R		17	T	145	0.3					1.0			
04/06/03				T	T		R			*				
04/15/03	2.0	228	0.5	354	2.0		103	3.5		2.0				
04/16/03	R					0.5	T							
04/18/03			278							*				
04/19/03	T	R		T		0.3				*				
04/20/03				T										
04/22/03			132						R					
04/23/03	R		240	T		T	128	R						
04/24/03						T								
<b>MILES:</b>	<b>1,729</b>	<b>1,830</b>	<b>10,871</b>	<b>8,484</b>	<b>4,452</b>	<b>6,863</b>	<b>3,021</b>	<b>37,250</b>						
<b>Use-Days:</b>	6	10	39	32	20	22	11	140						
WX SITE w/ Snow Total	Diamond M Ranch	Seligman	Pulliam Airport	Sunset Crater	Walnut Canyon	Blue Ridge	Sanders POE	0.0						
ORG	8650	8651	8553	8552	8550	8751	8755		* Missing WX					

APPENDIX E  
ADOT-ATRC DAILY ACTIVITY REPORT

# **SNOWPLOW RESEARCH '02-'03**

## **DAILY ACTIVITY REPORTS**

***CHAMBERS / WINSLOW / FLAGSTAFF  
GRAY MOUNTAIN / LITTLE ANTELOPE  
SELIGMAN / KINGMAN***

### **ADOT TEAM LEADER - OPERATORS:**

Please fill out one activity report after each shift of operation on the roadway with the Advanced Snowplow Systems in use. These activities may include:

- Radar / Xvision / Guidance / AVL system installs, tests and calibrations,
- Operator training, evaluations and demonstrations, and,
- All normal winter maintenance operations on your route.

These shift reports are needed to record the time and distance logged using the advanced snowplow systems, the weather and surface conditions, and problems. This is very valuable data to analyze the performance and value to ADOT of the several technologies being tested in this study.

These reports should take less than a minute to complete after a normal shift. But, if there is a problem with any of the systems on the snowplow, please take the time to fully describe the problem and when, where and how it occurred.

\*\*The Org operating the Advanced Snowplow should copy these reports for the ATRC (MailDrop 075R) and keep the originals in a binder.

ADOT SNOWPLOW RESEARCH 2002-2003
DAILY ACTIVITY REPORT
ADOT OPERATIONAL TESTING

Date: Time Start: Time End: System: Eaton Vorad Rada

Operator's Name: Snowplow: F342 Org No: 8552

CONDITIONS WHILE PLOWING

Table with 5 columns and multiple rows for recording plowing conditions. Rows include: Highway Number (US 89), Route Mileposts (420 - 440), CONDITIONS (Windy?, Wind Speed, Wind From Direction, Snowfall?, Sunny?, Cloudy?, Day or Night), VISIBILITY (circle) (Zero, 50 feet, 100, 200, 300, > 300 ft), ROADWAY (circle) (Icy, Snowpack, Slush, Clear), and ACTIVITY (circle) (Plowing, Spread Sand / Chemical, Test Runs, Operator Training).

Odometer Start of Shift Mileage: End of Shift Mileage:

Truck Status (check one): Good? Problems? (Note below)

System Status (check one): Good? Problems? (Note below)

Problems and / or Comments:

APPENDIX F

ADOT - ATRC INCIDENT REPORT

## **SNOWPLOW RESEARCH '02-'03**

# **WARNING SYSTEM INCIDENT REPORTS**

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### **CHAMBERS - WINSLOW - FLAGSTAFF - SELIGMAN KINGMAN - GRAY MOUNTAIN - LITTLE ANTELOPE**

#### **ADOT TEAM LEADER - OPERATORS:**

Please fill out a Warning Systems Incident Report for any shift of operation on the roadway in which the Advanced Warning System on your snowplow made a difference in the safety and efficiency of your work. These reports are very important to ADOT, and to the system suppliers, to determine their value for future winters.

Your "incident" reports may be either positive or negative. They include:

- A warning of any object, stopped vehicle, person, or animal in the roadway.
- A warning you are rapidly overtaking a vehicle that you can't clearly see.
- Any observations of the road surface or other conditions affecting plowing.
- Any activity when you were able to plow more quickly, more precisely, or with fewer stops, due to visibility assistance information from the system.
- Any incident or situation when the system did not give accurate warnings.
- Any incident or situation when the system did not give any warnings.
- False warnings under specific weather or visibility conditions.
- Any other incident-specific safety or operational problems.
- Any other incident specific benefits to your safety and plowing efficiency.

These reports should only take a few minutes to complete after a normal shift. But, if there is a problem with any of the systems on the snowplow, please take the time to fully describe the problem and when, where and how it occurred. Please inform your Equipment Services contacts and the ATRC of any significant system problems.

Please copy the reports for ATRC (MailDrop 075R) and keep the originals in a binder.

**Questions or problems? Call Steve Owen, ATRC, 602-712-6910**

**EVT-300 RADAR SYSTEM – ADOT COMMENT SHEET FOR INCIDENTS**

PLEASE TAKE A FEW MINUTES TO DESCRIBE ANY SITUATIONS THAT AROSE WHILE DRIVING THAT COULD HAVE BEEN SERIOUS WITHOUT THE **EATON-VORAD RADAR SYSTEM**. *RECORD ANY POTENTIAL COLLISIONS OR NEAR MISS SITUATIONS WITH ANIMALS, AUTOS, PEDESTRIANS, ETC.* COMMENT ON SYSTEM WARNINGS, WEATHER CONDITIONS, INCIDENT AND WHETHER OR NOT IT WAS AN EMERGENCY. THANK YOU!

DRIVER: \_\_\_\_\_ PLOW TRUCK: \_\_\_\_\_ ROUTE: \_\_\_\_\_ MILEPOST: \_\_\_\_\_

DATE	INCIDENT DESCRIPTION	EMERGENCY	NON – EMERGENCY	OUTCOME AND COMMENTS	TIME OF DAY	WEATHER CONDITIONS

ADDITIONAL COMMENTS: *(Return a copy of this form to ATRC at Maildrop 075R)*



**XVISION COMMENT SHEET for Situations - ADOT**

PLEASE TAKE A FEW MINUTES TO RELATE ANY SITUATIONS THAT AROSE WHILE DRIVING THAT COULD HAVE BEEN SERIOUS WITHOUT THE **BENDIX XVISION SYSTEM**. *RECORD ANY POTENTIAL COLLISIONS OR NEAR MISS SITUATIONS WITH ANIMALS, AUTOS, PEDESTRIANS, ETC.* COMMENT ON SCREEN POSITION, WEATHER CONDITIONS, INCIDENT AND WHETHER OR NOT IT WAS AN EMERGENCY. THANK YOU!

ADOT DRIVER: \_\_\_\_\_ PLOW TRUCK \_\_\_\_\_ ROUTE \_\_\_\_\_ SCREEN POSITION: DASH / VISOR

DATE	INCIDENT DESCRIPTION	EMERGENCY	NON – EMERGENCY	OUTCOME /COMMENTS	TIME OF OCCURANCE	WEATHER CONDITIONS

ADDITIONAL COMMENTS: *(Return a copy of this form to ATRC at Maildrop 075R)*



## DRIVERS' EVENT & ACTIVITY REPORT COMMENTS

### 1. EVT-300 radar comments submitted by four Eaton VORAD project snowplow crews.

Date	Incident Description	Outcome & Comments	Time of Day	Weather Conditions
1-29-03	Drove truck to Phoenix	System worked good	Day shift	Fair
2-25-03	Overtook one vehicle in fog, radar responded normally	Radar works well in fog	Night shift	Moderate to heavy ground fog
2-26-03	Came up on a semi truck in very low visibility and heavy snowfall. (Radar) did not pick up the vehicle.	Radar started picked up objects again until it stopped snowing.	Midnight	Heavy snowfall and very low visibility.
2-26-03	Alerts from roadside in fog	Radar gave alerts from bridge and off-ramp sign	Night shift	Medium to heavy fog, visibility 50 ft to 300 ft.
2-28-03	Picked up semi trucks, bridges, and vehicles	OK	Day shift	Snowing off & on, plowing slush
3-01-03	Picked up semi trucks, overpass, vehicles	OK	Day shift	Snowing off & on, slush on road
3-01-03	Emergency - Traffic Accident	Radar picked up a pedestrian in the dark before I had seen him.	7:15 PM	Medium snowfall, snowpacked & icy
3-01-03	Lost some detection range	Caused by snow buildup on antenna	3:00 – 9:00 PM	Medium snowfall, slush & snowpack
4-15-03	Warnings in dips on SR 89	Radar does alarm in deep dips, seems to work OK in light fog.	Day shift	Medium snow, slushy roadway

### 2. Bendix night vision comments submitted by three XVision project snowplow crews.

Date	Incident Description	Outcome & Comments	Time of Day	Weather Conditions
10-26-02	Person walking at side of roadway	Able to see with night vision before headlights	10:15 PM	Partly cloudy
11-25-02	Iced up within a mile, in snowfall, cleaned it 5 times.	(Lens heater) Never cleaned itself.	7:00 PM	Medium to heavy snow, visibility 50-100 ft
11-30-02	Icy road, sanding, no visibility in fog	Heavy fog, could not see anything.	Night shift	Thick fog, zero visibility
12-17-02	Night owl flying; coyote in middle of road 200 feet ahead	Able to see with night vision before with the headlights.	7:30 & 8:15 PM	Partly cloudy
12-18-02	Working well	Worked great – lens hot!	Night shift	Light snowfall
12-22-02	With XVision I could see wheel paths from oncoming traffic		8:30 PM	Medium snowfall

<b>Date</b>	<b>Incident Description</b>	<b>Outcome &amp; Comments</b>	<b>Time of Day</b>	<b>Weather Conditions</b>
12-22-02	While it was snowing I could see better where I had already plowed		8:30 PM	Medium snowfall
12-22-02	Erratic heater, road film baked on hot lens	½ time lens too hot to touch, ½ time ice cold.	Night shift	Light-medium snow, snowpack
12-23-02	When snowing, I could see elk at the side of the shoulder better		1:30 AM	Light flurries
12-23-02	Saw elk eating on side of roadway	System is working	9:00 PM	Light snow
12-24-02	When doing cleanup of roadway, can see where you just plowed	Still need a good storm	1:00 AM	Light snow
12-29-02	Saw a rabbit	Saw it ahead of (lights)	9:00 PM	Light snow
1-06-03	Snow packed in lens		Day shift	Med snow, slush
2-08-03	Jackrabbit, elk & coyote	Could see them running across road	10-12 PM	Clear
2-09-03	Fog	Could see a lot better ahead; lens iced up on day shift		Clear
2-13-03	Rain	XVision fuzzy when raining hard.	1:00 AM	Rain
2-13-03	Rain & Fog	Light rain & fog; can still see good.	4:30 AM	Rain & fog
2-25-03	Ice, slush – plowing	Stop twice to clean lens	Night shift	Medium snow – 50 ft visibility
2-25-03	Iced up – air temp 34	Ice formed on lens, no heat apparent	Day shift	Light snow, 200 ft
2-26-03	Snowpack – plowing	Clean the lens 5 times	Day shift	Medium snow – 200 ft visibility
2-26-03	Iced up, turned off	Would not restart	Day shift	Medium snow & 50 ft vis
2-26-03	Ice, slush – plowing	Clean lens three times	Night shift	Med snow – 200 ft
2-27-03	Snowpack, slush - plowing	Clean XVision 18 times	Day shift	Heavy snow – 50 ft visibility
2-27-03	Snowpack, slush - worked great	No problems plowing	11:00 AM - 1:00 PM	Heavy snow, & 200 ft visibility
2-27-03	Storm patrol, clear roads, fog & rain	System worked excellent in foggy conditions; poor screen image when raining	Night shift	Some fog, and rain
2-28-03	Snowpack, slush, windy - plowing	Clean lens 3 times	Night shift	Light snow, 200 ft
4-15-03	Plowing, slush & medium snow	Lens was snowpacked all day	Day shift	Med. Snow, 100 foot visibility

APPENDIX G

ADOT - ATRC DRIVER SURVEYS: RADAR

# EATON VORAD EVT-300 RADAR - Long-Term Evaluation Response Summary 2002-03

## Overview:

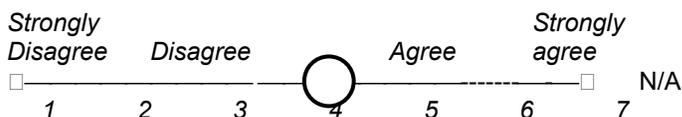
This survey was administered twice to most of the project snowplow drivers – in mid-winter and at the end of the season. All four Eaton VORAD systems were installed by 04 February 2003.

Because of the very limited number of participants, the responses and scores are listed for each topic, and also averaged. Individual field sites are not identified. Not all of the same drivers took both surveys. All responses below are grouped into mid-winter (March) and end-of-winter (June) perspectives.

## Part 1.

The statements listed below address key evaluation goals for the EVT-300 system. Each plow operator has marked the numeric scale as best represents his opinion of the system, and any comments to explain the ratings are shown also. With 4 as the scale's midpoint, scores from 3.6 to 4.4 show a *Neutral* rating.

Example: I could more effectively complete my driving tasks.



**1. I would buy an EVT-300 radar system, if I owned my own truck.**

- a. Mid-winter: 2, 4.5, 4, 5, 4, 5, 3, 2.5, 3.5 = Avg 3.7 - *Neutral*
- b. Post-season: 4, 3, 4, 4, 1, 3, 1, 6, 1 = Avg 3.0 - *Disagree*

**2. My safety on the road is significantly improved when I use the EVT-300 radar.**

- a. Mid-winter: 2, 4, 4, 5, 4, 5, 3, 2.5, 4.5 = Avg 3.8 - *Neutral*
- b. Post-season: 4, 3.5, 5, 4, 3, 1, 2, 6, 4 = Avg 3.6 - *Neutral*

**3. I feel my ability to detect and react to objects in the road is significantly improved with the EVT-300 radar system.**

- a. Mid-winter: 3.5, 5, 5, 5, 4, 5, 3, 4, 4.5 = Avg 4.3 - *Neutral*
- b. Post-season: 4, 3.5, 5, 4, 3, 2, 2, 6, 4 = Avg 3.7 - *Neutral*

**4. I feel my overall driving ability is significantly improved with the EVT-300 radar system.**

- a. Mid-winter: 4, 5, 4, 4, 4, 5, 3, 2.5, 4.5 = Avg 4.0 - *Neutral*
- b. Post-season: 4, 4.5, 4, 4, 3, 3, 1, 5, 5 = Avg 3.7 - *Neutral*

**5. I feel my ability to use the EVT-300 radar system is significantly reduced by noise in the cab, from other systems, rough road conditions or when the truck vibrates.**

- a. Mid-winter: N/A, 5.5, 5, N/A, N/A, 3, N/A, N/A = Avg 4.5 - *Agree*
- b. Post-season: N/A, 4, N/A, N/A, 3, N/A, 1, 2, 4 = Avg 2.8 - *Disagree*

**6. After the long night of driving with the EVT-300 radar system, I felt that fatigue significantly reduced my driving ability.**

- a. Mid-winter: N/A, N/A, 4, 4, 3, 1, 3, 3.5, 3.5 = Avg 3.1 - *Disagree*
- b. Post-season: 4, 5, 5, 5, 6, 3, 1, 2, 5 = Avg 4.0 - *Neutral*

**7. I feel the EVT-300 system warnings are clear and effective for object detection.**

- a. Mid-winter: 3.5, 4.5, 5, 5, 5, 4, 4.5, 4 = Avg 4.5 - *Agree*
- b. Post-season: 4, 5, 5, 5, 3, 4, 2, 6, 4 = Avg 4.2 - *Neutral*

**8. I could easily focus on the road without becoming distracted by the EVT-300**

- a. Mid-winter: 3.5, 5, 4, 5.5, 5, 5, 4, 3.5, 4.5 = Avg 4.4 - *Neutral*  
b. Post-season: 5, 5, 5, 5, 3, 4, 5, 6, 7 = Avg 5.0 - *Agree*

**Part 2. General Preferences**

1. List the two things you liked most about the EVT-300 radar, and describe why.
- a. Mid-winter:
- Beeps when someone is in front of you.
  - Radar was helpful when I was plowing the fast lane – vehicles would at times be in a blind spot alongside the plow.
  - It detects vehicles on your right side (blind spot).
  - Not obtrusive; warning bells do make you alert.
  - When plowing in the left lane, the side sensor helps to let you know when a vehicle is passing or is in your blind spot.
- b. Post-season:
- The right side sensor is pretty handy – alerts you when vehicle is in your blind spot on right side.
  - It alerts you when coming upon a slow-moving vehicle.
  - The detection of vehicles or other objects along the right side.
  - Ease of operation – always on when using the truck.
  - Low maintenance – just keep sensors clean and check wires.
  - I was not using the equipment as much as expected.
  - The advance warning.
  - The ability to see cars in the blind spot on the right side of the truck.
2. List the two things you disliked most the EVT-300 radar, and describe why.
- a. Mid-winter:
- Hard to see warning lights during daytime.
  - System display mounted behind steering wheel.
  - System picked up bridge columns causing me to focus ahead quickly, which took my eye off the traffic behind me.
  - Mounting on dash – would like to have display mounted above windshield, more in line of sight.
  - When it sounds off it's very alarming and startles you most of the time.
- b. Post-season:
- The beeper goes off when going under bridges; you begin to ignore the system.
  - The mounting of the sensor display unit is in the wrong place. The steering wheel is in the way, and you can't see the lights until it beeps.
  - The detection of bridge columns.
  - Main display location would be better mounted at top of windshield, more normal driving view.
  - Will startle you.
  - Warning system doesn't come on soon enough.
  - It gives false signals both by going off when there is nothing there, and not going off when an object is ahead of you.

**Part 3. Open-ended Questions**

1. With regard to fatigue, describe how you felt at the end of your shift. Do you feel your state (tiredness, attention span) was affected for better or worse by using EVT-300 radar? Do you feel that fatigue affected your performance?

- a. Mid-winter:
    - Attention span (divided between) roadway and system.
    - I was not very tired after using the radar because the beeping it produced kept me more alert.
    - No change from normal.
    - It does help keep me more alert watching the contact distances.
    - No difference.
  - b. Post-season:
    - My overall state was not affected and my performance was not affected by the EVT-300.
    - At the end of my shift I didn't feel tired, this is probably due to the system. When the system was activated, I was ready to slow down.
    - It was about the same.
    - I feel that in hard-to-see conditions the EVT-300 did help out considerably.
    - Fatigue always affects your abilities, the radar does not change this.
    - The time I spent on the truck was not sufficient to answer.
    - Worse, all the false alarms make it hard to drive.
    - I felt the same as without it, but it did help when my attention span was low.
    - Fatigue has not been a factor because we have had no real snow.
2. Preferred radar range. Do you feel the current range is acceptable? If not, how far out in front of the truck would you like the system to "see"?
- a. Mid-winter:
    - Right now it's 300 feet – change to 500 feet.
    - Radar range is okay. Many times passing trucks would move back into the driving lane and the radar would beep.
    - Range is acceptable at 310 feet but the alarm needs to be set when the red light first comes on.
    - So far the range seems to be OK.
    - No, it needs to warn you further out.
  - b. Post-season:
    - The system range is acceptable.
    - The radar range is far enough. At times vehicles passing will turn back into the travel lane and will activate the system.
    - The range seems to be good right now.
    - Yes – acceptable.
    - 500 feet would be better.
    - No, not acceptable.
    - The range is good. If it went out any further it would be going off too much.
    - I really agree with the range.
- c. Preferred system warnings. Was the audible or the visual alarm more effective for target warning information? Did any of the system elements interfere with your driving? Would you have preferred more adjust in the setting?
- a. Mid-winter:
    - Audible warning was effective. The only interference was the false warning of bridge columns.
    - The alarm comes on a little too late. May need to adjust where the alarm comes on earlier.
    - The two alarms together are working well.
    - Audible is more noticeable, but when you're tired it is startling.
  - b. Post-season:
    - Everything is OK, but the mounting for the visual alarm needs to be relocated.
    - The alarms seem to be effective in getting the warning across.
    - Both warnings seem to work well. There has been no interference, the settings work fine.

- I feel it did fine.
  - No interference, and no more adjustments.
  - Both together work good.
  - Settings are good.
4. Please make any further comments regarding advantages and disadvantages of the EVT-300 radar system below.
- a. Mid-winter:
- I have not needed the system currently as visibility is pretty good; the least is about ½ mile.
  - So far the system seems to be working well.
- b. Post-season:
- Still had to use my own skills to do my job.

**Part 4. Your Overall Recommendations – Post-Season:**

1. Your summary of storm experience on average for the entire winter - how useful was the Eaton VORAD EVT-300 for you in:

- a. Fog?
- Good warning.
  - Worked well.
  - Helped out in hard-to-see conditions.
- b. Rain?
- Good warning.
  - Worked well.
- c. Light Snow?
- Average.
  - Good warning.
  - Worked well.
- d. Heavy Snow / Whiteouts?
- Sometimes useful and sometimes not.
  - Warning slightly altered because of buildup of snow on system (antenna).
  - Worked well, as long as buildup is not severe.
  - Worked good.
  - Worked well in all aspects of weather; you just need to clean the radar antenna in heavy snow.
2. Is the system useful for you in any other operations apart from night plowing? Please describe:
- It is useful in daytime driving and warns you when you are coming upon a slow-moving vehicle.
  - No, snow plowing is the only operation that the system is useful (3 “no” replies).
  - It works just as well when driving in heavy traffic.
  - Works great for the passenger-side blind spot.
  - City driving during snow, it helps with cars pulling in front of you.
3. How many other snowplow operators in your Org have driven or ridden in your truck? What comments on the system did they have?
- (Chambers) Two other drivers, with no comments.
  - (Seligman) One other - did not like the alarms; he did not understand what all it was telling him.
  - (Flagstaff) None.
  - (Gray Mountain) Four or five people. No comments as they didn’t use the system.

4. Are there any other plow routes in your Org where this system would also be useful? If so, how many plow trucks, and roughly how many plow route miles?
- (Chambers) There are other routes all along I-40 that should have this system or a similar system installed.
  - (Seligman) All seven routes, about 620 plow miles.
  - (Flagstaff) Not really; N/A.
  - (Gray Mountain) This system would not work for snow activities elsewhere in our area.
5. Based on your experience with this research project, should ADOT purchase more of these systems for those snowplow routes where impaired visibility is a frequent and serious problem?
- I think ADOT should put the systems in all snowplow trucks.
  - ADOT should purchase additional systems where severe storms occur. The other additional places that might need this system are where there are high volume traffic areas.
  - This product is very useful for over-the-road trucks. A plow truck has too many things in the way.
  - The VORAD system would work better if used for summer driving.
  - If it snowed more it would be useful but visibility (this season) has always been good.
  - Yes, this system works without being too intrusive.
  - Yes.
  - No (2 replies).

NOTES:

- Not all of the nine primary operators completed Part 4 of the survey.
- The final survey included one new driver with very limited training.
- The four EVT-300 snowplows were normally in use on SR 89 and I-40.
- The number of shifts using the system that 7 drivers reported were 7, 6, 6, 5, 2, 30, and 2.
- Due to install dates and varying weather conditions, maintenance and weather records indicate that the EVT-300 system was actively in use over the winter for plowing and storm patrol as follows:
  - Seligman – 9 days, with 6.4 total inches of snow on the assigned plow route.
  - Flagstaff – 20 days, with 35 inches of snow on the route (Walnut Canyon weather site).
  - Gray Mountain – 32 days, with 27.5 inches of snow on the route (Sunset Crater).
  - Chambers – 12 days, with no snow recorded on the route (Sanders POE).

APPENDIX H

ADOT - ATRC DRIVER SURVEYS: NIGHT VISION

## BENDIX XVISION - Long-Term Evaluation Response Summary 2002-03

### Overview:

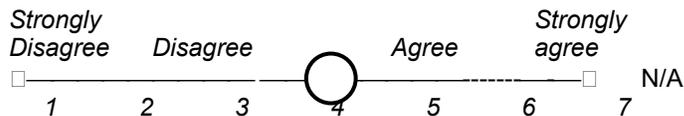
This survey was administered as many as three times to the drivers – in early winter, mid-winter and at the end of the season. All XVision systems were installed by 03 December 2002.

Due to the very limited number of participants, the responses and scores are listed for each topic, and also averaged. Individual field sites are not identified. Not all of the same drivers took both surveys. Responses are grouped into pre-, mid-, and end-of-winter perspectives (December, February, & May).

### Part 1.

The statements listed below address key evaluation goals for the XVision system. Each plow operator has marked the numeric scale as best represents his opinion of the system, and any comments to explain the ratings are shown also. With 4 as the scale's midpoint, scores from 3.6 to 4.4 show a *Neutral* rating.

Example: I could more effectively complete my driving tasks.



#### **1. I would buy an XVision system, if I owned my own truck.**

- a. Pre-winter (December '02): 4, 7, 4, 6, 7, 6 = Avg 5.7 - *Agree*
  - I really enjoy seeing all objects both on and off the highway.
- b. Mid-winter (February '03): 7, 5, 7, 4.5, 1, 6 = Avg 5.1 - *Agree*
- c. Post-season (May '03): 4, 7, 1, 7, 4.5, 6 = Avg 4.9 - *Agree*

#### **2. My safety on the road is significantly improved when I used the XVision system.**

- a. Pre-winter: 5, 5, 5.5, 6, 7, 7 = Avg 5.9 - *Agree strongly*
  - I really like the system, especially seeing around curves.
- b. Mid-winter: 7, 3, 5, 4.5, 1, 6 = Avg 4.4 - *Neutral*
  - Except in snow.
- c. Post-season: 6, 2.5, 6, 1, 5, 3 = Avg 3.9 - *Neutral*

#### **3. My ability to detect and react to objects in the road is significantly improved with the XVision system.**

- a. Pre-winter: 6, 4, 6, 5.5, 6, 7 = Avg 5.8 - *Agree*
- b. Mid-winter: 4, 3, 5, 5, 1, 7 = Avg 4.2 - *Neutral*
- c. Post-season: 3, 6, 1, 7, 5.5, 6 = Avg 4.75 - *Agree*

#### **4. My overall driving ability is significantly improved with the XVision system.**

- a. Pre-winter: 7, 6, 4, 5, 5, 5.5 = Avg 5.4 - *Agree*
  - I don't think Xvision could improve my driving – just make me more aware of surroundings.
- b. Mid-winter: 1, 2, 3, 4.5, 1, 6 = Avg 2.9 - *Disagree*
  - Not in snow.
- c. Post-season: 3, 5, 1, 6, 1.5, 5 = Avg 3.6 - *Neutral*

#### **5. I feel my ability to use the XVision system is significantly reduced on rough road conditions or when the truck vibrates.**

- a. Pre-winter: 6, 4, 2, N/A, 3, 3 = Avg 3.6 - *Neutral*
  - The LCD screen is very stationary, and does not move.

- b. Mid-winter: N/A, 2, 3, N/A, 3, 5 = Avg 3.25 - *Disagree*  
 c. Post-season: 3, 4, N/A, 6, 3.5, 4 = Avg 4.1 - *Neutral*

**6. After a long shift of driving with the XVision system, I felt that eye fatigue significantly reduced my driving ability.**

- a. Pre-winter: N/A, 4, 2, 4, 5, 1 = Avg 3.2 - *Disagree*  
 b. Mid-winter: N/A, 3, 3, 4.5, 5, 4 = Avg 3.9 - *Neutral*  
 c. Post-season: 4, 6, N/A, 5, 2.5, 4 = Avg 4.3 - *Neutral*

**7. I feel the image resolution was adequate for object detection.**

- a. Pre-winter: 7, 7, 4, 4, 4, 6 = Avg 5.3 - *Agree*  
 b. Mid-winter: N/A, 3, 5, 4.5, 1, 6 = Avg 3.9 - *Neutral*  
 c. Post-season: 4, 4.5, 6, 1, 6, 3 = Avg 4.1 - *Neutral*

**8. I feel I could easily focus on the road without becoming distracted by the XVision system.**

- a. Pre-winter: 7, 7, 7, 4, 3, 5 = Avg 5.5 - *Agree*  
 • I barely have to adjust my sight to see the screen where it is located.  
 b. Mid-winter: N/A, 3, 6, 4.5, 1, 6 = Avg 4.1 - *Neutral*  
 c. Post-season: 3, 6, 1, 3, 6, 5 = Avg 4.0 - *Neutral*

**Part 2. General Preferences**

1. List the two things you liked most about the XVision system, and describe why.

a. Pre-winter:

- Seeing around curves.
- See better.
- See roadway better, and curves and trees.
- See a long way down the road.
- Seeing people, animals and cars.
- Safety.
- Helps you see more of what's ahead of you.
- Picks up anything with a heat source.

b. Mid-winter:

- Still could see objects in fog; see around curves.
- Detects objects on shoulder of road.
- Could see better at night - see animals a lot better.

c. Post-season:

- Helps seeing things at night a lot better.
- See around curves; see through fog.
- See better generally, especially see objects better in roadway.
- Able to see elk hazards; able to see cars and people.
- When it was not snowing I could pick out objects .

2. List the two things you disliked most the XVision system, and describe why.

a. Pre-winter:

- The lens plugs up.
- Ice build-up around the lens.
- Need better adjustments on unit to see more clearly – for LCD display contrast.
- Ices up all the time in snow conditions and salt buildup, both make it unusable.
- Sunset – screen was blurred.
- Vehicles changing lanes in front of me look closer than they are.

- b. Mid-winter:
  - Iced up.
  - Rain conditions – blurred screen.
  - Screen not clear, fuzzy most of the time.
  - Camera lens cover when wet, you can't see or focus on objects on screen.
  - I do not like it - hard to see; snow packs on the camera.
  - When it's raining it gets fuzzy.
  - The XVision should move with the roadway.
- c. Post-season:
  - It always plugs up when it's snowing.
  - Did not work in snow!!
  - Snow on the system – hard to see.
  - Cleaning the lens during winter storms.
  - Fuzzy when raining a lot.
  - Rain conditions.
  - Too fuzzy on the screen – needs to be more clear.

### **Part 3. Open-ended Questions**

1. With regard to fatigue, describe how you felt at the end of your typical plow shift. Do you feel your state (tiredness, attention span) was compounded by using XVision? Do you feel fatigue affected your performance?

- a. Pre-winter:
  - N / A
  - At first, but now I've gotten used to the system
  - It gave me something to look at when I wanted to see way up the road, I looked at the screen and didn't have to strain my eyes.
  - With headlamps of oncoming cars, I can look at the screen and have less eyestrain.
  - Some eye fatigue after 10 to 12 hours of driving.
- b. Mid-winter:
  - No fatigue, no effect on performance (2 replies).
  - After a 12-hour shift at my age (59) I am tired, but with regard to the XVision, I do not see any more fatigue due to this system.
- c. Post-season:
  - Tired & fatigued after 12-hour shifts, but not from XVision.
  - I feel the XVision had nothing to do with tiredness. Fatigue did not affect my performance.
  - When I first used the system I felt fatigue, but when I got used to it I felt better using the system.
  - The same as any (other ) shift.
  - No, I could watch the screen and then the road. I didn't have to stare just at the road.

2. Preferred camera range. Is the current range acceptable? Is the field of view (side to side, up and down) acceptable? If not, what changes would improve the usefulness of the system to "see"?

- a. Pre-winter:
  - Yes (2)
  - I love the way my lens is set.
  - I feel the camera range is great.
- b. Mid-winter:
  - Yes, everything is good.
  - For myself the current range is acceptable.

- Yes (2 replies).
- c. Post-season:
- Yes – acceptable (2 replies).
  - Current range is great.
  - Range is just fine – view just right for distance, and up and down too.
  - Need more side-to-side range.
3. Preferred screen contrast and brightness level. Was the adjustment range on the units adequate for target detection? Did it interfere with your driving?
- a. Pre-winter
- Contrast setting was a great help; adjusted for my preference. Nothing interfered with my driving.
  - Contrast was adequate, no interference, no need to adjust settings.
  - Prefer being able to adjust settings somewhat.
  - Contrast setting was good.
- b. Mid-winter:
- No – no interference (3replies).
  - Yes, adequate contrast, no interference.
  - Need adjustments for this setting, and any others.
- c. Post-season:
- Most of the time, did not interfere with my driving.
  - Yes (adequate), did not interfere with driving.
  - It was just fine – did not interfere (2 replies).
  - It was very adequate.
4. Please make any further comments regarding advantages and disadvantages of the XVision system.
- a. Pre-winter:
- A washer system would be a lot better for melting ice buildup, on or around the lens housing, wiring, etc. – need to try different deicer fluids if not corrosive to lens.
  - Need more time with the unit to comment more on it.
  - I think XVision is better than (other tests with) radar and Caltrans system (magnet guidance).
  - Let's get the heater situation worked out and you should have a great system.
  - I think it will help greatly, and am glad to have the opportunity to run it.
- b. Mid-winter:
- Everything good for now.
  - Disadvantage when wet, can't make out what's on the screen.
- c. Post-season:
- Need good heating system on the camera.
  - Wish it would have worked during snow.
  - Hard to focus on it.
  - Snow gets on the camera and you cannot see.
  - Very pleased with the system, but snow blowback from the plow dirties the lens a lot.
  - When wet, raining or wet snow, hard to make out what's on screen because of wetness.
  - The system is a great help – I look forward to next year.

**Part 4. Your Overall Recommendations – Post-Season:**

1. Your summary of storm experience on average for the entire winter - how useful was XVision for you in:

- a. Fog?
    - N/A (2)
    - Was OK.
    - Excellent.
  - b. Rain?
    - N/A
    - It was fuzzy.
    - Poor.
    - Not very useful when wet.
  - c. Light Snow?
    - As long as lens didn't get wet, XVision was most useful.
    - Excellent.
    - Worked really good.
  - d. Heavy Snow / Whiteouts?
    - Did not have any whiteouts.
    - Excellent.
    - We didn't get much snow here this year – about two storms only.
2. Is the system useful for you in any other operations apart from night plowing? Please describe:
    - You are able to see more what's on the shoulder and road, which I think makes it more safe.
    - No.
    - Daytime too, could see roadway better and objects clearer.
    - All day.
  3. How many other snowplow operators in your Org have driven or ridden in your truck? What comments on the system did they have?
    - (Little Antelope) One other – no comments noted.
    - (Winslow) One other – he doesn't like the system too much.
    - (Kingman) One other – had about the same comments as I did (positive except rain issues).
  4. Are there any other plow-routes in your Org where this system would also be useful? If so, how many plow trucks, and roughly how many plow-route miles?
    - (Kingman) It would be useful on US 93, and SR 66 (57–123); that would mean two more trucks.
    - (Winslow) Need to try system on I-40 to see how it works with more traffic and slideoffs.
  5. Based on your experience with this research project, should ADOT purchase more of these systems for those snowplow routes where impaired visibility is a frequent and serious problem?
    - No (2 replies plus 1 blank).
    - Yes I do!!!!!!
    - Yes – useful in winter weather.
    - Sure!

NOTES:

- Not all six primary operators responded to Part 4 of the survey.
- The plows were normally in use on I-17, SR 87, and I-40.
- The number of shifts that four drivers reported using the system were: 10, 25+, 15, and 20.
- Due to install dates and varying weather conditions, maintenance and weather records indicate that XVision was actively in use over the winter as follows:
  - Kingman – 5 days, with 13 total inches of snow on the assigned plow route.
  - Little Antelope – 37 days, with 55 inches of snow on the route.
  - Winslow – 22 days, with 39 inches of snow on the route.

APPENDIX I

EATON VORAD SMARTCRUISE EVALUATION RESULTS

## EVT-300 RADAR SYSTEM – SMARTCRUISE EVALUATION

### PART 1 – OBJECTIVE

Criteria	Measurements	Notes & Comments
Preset Speed Control – Accuracy	The Mack cruise control was effective in holding speeds within 1 mph, slight variation on grades. (SmartCruise will override factory cruise control)	Plow F342, with manual transmission, was able to hold speed accurately on its factory cruise control. There was no apparent loss of accuracy with the VORAD SmartCruise engaged to “hook up” with and follow the target vehicle.
Following Distance – Consistency	Following distance varied from 250 ft to 310 ft, as based on travel speed vs the time interval setting. Ranges varied slightly, +/- 10 to 15 ft, while tracking a target vehicle.	SmartCruise will follow at from 2.25 to 3.25 seconds separation, based on real-time speed of the vehicles. Even in hilly terrain, SmartCruise did maintain a fixed following distance for long periods. Any variations seemed to be primarily due to speed fluctuations of the target vehicle.
Following Speed and Distance – Accuracy	Normal ProLink readings consistently differed by only +/- 0.2 to 0.5 mph . Readings varied more, up to +/-1.5 mph, on grades. Ranges varied +/- 15 ft.	The ProLink diagnostic tool with VORAD card produced excellent following-speed results. Larger variations in hilly areas indicate that the target vehicle probably could not exactly maintain a steady speed, even if they had cruise control.
Effect Of Vehicle Sizes – Following	No significant issues – had consistent results with several different vehicle types.	Vehicles tracked included a Ford Contour sedan, a Chevy S-10 pickup, and two 18 wheelers – a cargo trailer and a gas tanker.

## EVT-300 RADAR SYSTEM – SMARTCRUISE EVALUATION

### PART 2 – SUBJECTIVE

Criteria	Notes & Comments
Smoothness – Engagement / Disengagement	The operator reported no problems with SmartCruise engaging the normal Mack cruise control. It engaged smoothly to both accelerate and decelerate the truck to “hook up” with the target vehicle. Application or cutting back of the throttle and engine brake were apparent but not obtrusive.
Positive Driver Overrides – Brake & Accelerator	Any overrides simply acted on the basic Mack cruise control system, and were not a problem for the driver. The SmartCruise is transparent in this aspect.
Operation In Curves	The ProLink often showed a brief target loss of one to two seconds when entering a curve. This is the normal timeframe for the yaw sensor to read the curve and adjust the beam pattern. The driver did not perceive a loss of cruise control in curves, however, as the system recaptured the target immediately.
Operation On Grades	The effect of Interstate-standard grades on the Mack cruise control was minor. Some target vehicles, especially those without cruise, showed variations, which the SmartCruise was able to deal with.
False Warnings From Roadside Objects	On the I-40 test route, no problems were noted.
Response To Vehicle Cutting In	Vehicles generally cut in at least 120 feet ahead, and were immediately acquired by the system. If they continued at a faster pace, the SmartCruise did not respond but the warning lights did. If they cut in and slowed, the SmartCruise acted to decelerate.
Effect Of Vehicle Size – Cutting In	The vehicle size did not seem to be a factor in warning response or in the SmartCruise tracking & following performance.
Effects Of Inclement Weather - Dust / Fog / Rain / Snow / Mud / Heat / Cold	Not tested in this case.
Warnings – Type and Intensity	The system performed normally in testing. The operator was familiar with all warning modes and had no problems or concerns.
Operator Confidence Level	This operator had not used SmartCruise on a regular basis since the installation on March 10 <sup>th</sup> -11 <sup>th</sup> . At the end of the test session, he was comfortable with the system. He felt confident that it was working as designed and did improve performance and safety.
Operator Fatigue Factors	The SmartCruise should provide real safety benefits for long-haul trips where driver fatigue, inattention and distraction can be factors.
Overall Satisfaction – Suitability for Driving Tasks	Based on the test performance and the consistent results, the SmartCruise appears to be a valuable safety feature for long trips.

## EVT-300 RADAR SYSTEM – SMARTCRUISE EVALUATION

Snowplow: F342  
 Site: I-40: MP 204-230

**Test Instruments:**

- ProLink Engine Diagnostic System  
 With Eaton VORAD system cartridge
- Stalker Speed Radar Gun
- Bushnell Lytespeed 400 Infrared Rangefinder

Test Runs	Test Conditions	ProLink – VORAD Diagnostics	Rangefinder & Speed Radar
1	Target: Red S-10 Pickup Speedometer: 55 mph  EB gradual downgrade	Speed: 55 +/- 0.5 mph Distance: 265 ft +/- 10 ft	Speed: 55 +/- 1 mph Distance: 93 yd / 279 ft
2	Target: 18 wheel cargo Speedometer: 65 mph  WB gradual upgrade	Speed: 65 +/- 1.5 mph Distance: 300 ft +/- 10 ft  (target dropped to 55 mph) (distance: 255 ft +/- 5 ft)	Speed: 63 mph Distance: 100 yd / 300 ft  (distance 93 yd / 279 ft)
3	Target: 18 wheel tanker Speedometer: 65 mph  EB gradual downgrade	Lost ProLink Connection	Speed: 64 mph Distance: 107 yd / 321 ft
4	Target: Ford Contour Speedometer: 65 mph  WB gradual upgrade	Lost ProLink Connection	Speed: 65 mph Distance: 98 yd / 294 ft

**NOTES:**

1. SmartCruise can be set for 2.25 to 3.25 seconds of separation at any cruise speed:

Design Following Distance - 55 mph: 182 to 262 feet  
 Design Following Distance - 60 mph: 198 to 286 feet  
 Design Following Distance - 65 mph: 214 to 309 feet

2. The maximum range for both cruise target capture and obstacle warning is 350 feet.

3. Hand-held readings provided a check on the ProLink, but were less precise.

APPENDIX J

TECHNICAL ADVISORY COMMITTEE

PROJECT OPINION SURVEY RESULTS: JUNE 2002

*(NEW PROJECT DIRECTION FOR PHASE THREE – 2002-03)*

**IVI / SNOWPLOW GUIDANCE RESEARCH PROJECT No. 473  
TECHNICAL ADVISORY COMMITTEE**

**TAC OPINION SURVEY RESULTS: JUNE 2002**  
**PROJECT RESULTS & PROJECT DIRECTION**

Introduction – Since late 1997 this project has studied advanced vehicle topics, to identify the advantages of ITS to help ADOT improve the function and safety of the state highway system. ADOT has installed magnetic media in two Arizona highways, and has acquired new systems to the point that we now have access to three Advanced Snowplows in the Flagstaff area.

After four years of field research, we have answered some basic questions, and learned a great deal about some ITS systems. And, we have just begun to work with others. Now, ATRC has surveyed the TAC members on where ADOT and partners should go with this research project.

This short survey asked for the TAC's views on each major ITS system that the project has deployed for testing and evaluation. It also asked what the TAC feels has been achieved, and what the project can practically do next, with our budget and available ADOT resources.

\* \* \* \* \*

**BACKGROUND – CURRENT PROJECT STATUS:**

3M – Magnetic Tape is in place for 5 miles of US 89 (10 lane miles) at Sunset Crater. Since 2000 (3M Corp. is on hold, but will still provide new mat'ls and repairs). Truck System installed and supported (off warranty - repairs at ADOT's cost).

Caltrans – Magnets are in place for 6 lane-miles of US 180 at Kendrick Park. Since 1998 (the IGA is open for another year, to June 03). ASP System is available to ADOT for future winter evaluations (\*radio required).

F342 3M and Collision Warning Radar – Both Installed and operating, over the past winter. Support by 3M for repairs has been prompt and efficient – \*our costs from now on. Radar tech support & service has been spotty / Eaton hasn't invoiced, nor been paid.

F235 Night vision System – Installed & functional on I-17 plow route / truck cab issues. Evaluation agreement at no cost / no tests or demos done yet / need different truck?

AVL GreyLink Vehicle Tracking System – two units – F342 and portable - both functional. Flagstaff Snow Desk workstation / needs dedicated phone line, modem, and PC. Problem areas: phone service / cell coverage / shared line / training materials.

\*\* Responses – 14 – TAC Members and Snowplow Operators-Team Leaders \*\*

**A. SYSTEM CONCEPT PROS AND CONS? HOW IMPORTANT TO ADOT?**

• **Caltrans Roadway-Magnet Guidance System?**

Position	Org	Comments
State Manager	Phoenix	I think this is an interesting technology. I think it might have merit for further deployment. Unfortunately, given budget shortfalls, this will not be a high priority in the near future. We are doing good right now just to keep snowplows running.
State Manager	Phoenix	Issue is cost / versus benefit to the state.
State Eqpt Mgr	Phoenix	This appears to be old technology relative to progress in other areas.
Maint Engineer	I-40 Dist	The infrastructure (embedded magnets) appears impractical for use on rural asphaltic concrete roadways. Application seems appropriate for PCCP. Low importance for ADOT.
Maint / District Engineer	I-40 Dist	The best system for guidance, but most labor intensive to install. Not fully developed to point of production. Most favored by drivers.
District Engineer	I-40 Dist	Pro: it is a positive control system with the magnets, truck system seems a little complicated but may be possible to modify to meet local needs in the future. Con: expensive to install in both roadway and truck, magnet life may be limited by future maintenance actions on the paved surface, system may be only limited to those areas that require the positive control, is dedicating truck to the one site reasonable?
Superintendent	I-40 Dist	N / C
Superintendent	I-40 Dist	The system seems to work well but it can only be tested when we have the Caltrans truck plus it would be unrealistic to try and install this type of system for at a large scale.
Dist Eqpt Mgr	I-40 Dist	Very interesting, however I feel we will never have the resources to purchase and install this elaborate a system.
Org Supervisor	I-40 Dist	The system has proven itself, with some changes – it all depends on money.
Org Supervisor	I-40 Dist	According to my crew, it's a little different from F342 (3M) but agree with magnet system and would help them out during snowstorms.
Operator	I-40 Dist	Fairly good idea. But cost and installation is too much to think about a longer area.
Operator	I-40 Dist	Some places we do need it.
Operator	I-40 Dist	Will work good during whiteouts.
ATRC		Caltrans says the 3 RoadView plows are successful, but the data is too poor to support more deployments now. Will work to improve hardware, but focus will be on rotary plows. Only Alaska and AZ have partnered. Caltrans plow available next winter.

• **3M Tape – Lane Awareness System?**

Position	Org	Comments
State Manager	Phoenix	I think this is an interesting technology. I think it might have merit for further deployment. Unfortunately, given budget shortfalls, this will not be a high priority in the near future. We are doing good right now just to keep snow plows running.
State Manager	Phoenix	Cost / installation. Maintenance of the tape ?
State Eqpt Mgr	Phoenix	A good product but the business failed. Practical where it can be overlaid one or more times.
Maint Engineer	I-40 Dist	Good potential due to concept and ability to sustain function after rehabilitation (overlays). Concern over product availability. Importance to ADOT – Moderate.
Maint / District Engineer	I-40 Dist	Good basic system. Concerns over lack of support from 3M due to them getting out of the business.
District Engineer	I-40 Dist	Pro: another positive control system with the tape, truck system seems a little less complicated then the magnet system Con: similar to the magnet system with the exception that the limitation on the number of trucks equipped to read the system may not apply.
Superintendent	I-40 Dist	Seems like this is a dying product.
Superintendent	I-40 Dist	This system seems to also work well and is more feasible to set up in a larger scale.
Dist Eqpt Mgr	I-40 Dist	If we were to pursue any system, this appears to be the one most compatible with our limited resources.
Org Supervisor	I-40 Dist	Is very costly and has some concerns on other pavement jobs going over the top.
Org Supervisor	I-40 Dist	My crew sure likes it. If only they had put 3M tape on both lanes, going southbound too.
Operator	I-40 Dist	The use of this is fairly simple. Everyone that I trained on it could run it their first try. Tape was a good idea but now that it is no longer made what good is it to keep testing unless we combine the different systems pros, to create a new system that works for everyone. But cost is an issue.
Operator	I-40 Dist	Works good.
Operator	I-40 Dist	Works good but tape goes on too small a section of road – need southbound 89 also.
ATRC		3M reports that there is no corporate interest in reopening the marketing of the tape product, although more material or hardware can be obtained. This snowplow is fully operational as regards the 3M system, US 89 NB.

• **Eaton VORAD Collision Warning Radar?**

Position	Org	Comments
State Manager	Phoenix	This has merit for warning snowplow operators of potential problems. As we begin to purchase new snowplows, we should consider including this as a standard item.
State Manager	Phoenix	I think this is more important than above items
State Eqpt Mgr	Phoenix	Good product that is soon to be OEM on more heavy trucks.
Maint Engineer	I-40 Dist	Not familiar with details of performance. Importance of application – high.
Maint / District Engineer	I-40 Dist	Great concept, but am not convinced that we have sold the idea to the drivers.
District Engineer	I-40 Dist	Pro: interesting concept that could help even in clear and dry weather in the future Con: I'm not sure we know where we're headed at this point and that Eaton has been somewhat non-responsive to our questions.
Superintendent	I-40 Dist	N / C
Superintendent	I-40 Dist	Most operators seem to like this system but it kind of gives you false impression of the obstacles that are out there.
Dist Eqpt Mgr	I-40 Dist	Let's take it to its limits before we judge.
Org Supervisor	I-40 Dist	Very helpful and can be used any time other than winter – Good Deal.
Org Supervisor	I-40 Dist	According to my operators the radar is a good system, it really helps when you need it. The question is will it really work during a whiteout snowstorm.
Operator	I-40 Dist	I like every part of this because we ,the operators, can use this all year round. I have used this and found that it increases the time for you to avoid a collision with an object that is in front of you. It also has the capabilities to record 20 seconds of an accident, that could be used in court or for equipment services.
Operator	I-40 Dist	Gives warnings ahead of you.
Operator	I-40 Dist	Warning system works good, we could use it.
ATRC		Radar worked well, within its design limits, in the second winter, but without snow. Several storms are needed for a valid test. The plan to test the SmartCruise feature should proceed, we have the funds and the vendor is interested in doing this.

• **GreyLink Automatic Vehicle Logging/Tracking (AVL) System?**

Position	Org	Comments
State Manager	Phoenix	Additional research should be done in the area of AVL. The technology seems to be catching on throughout the US, but Arizona does not have a lot of experience with this technology. AVL is more prevalent in the emergency services industry.
State Manager	Phoenix	Low priority
State Eqpt Mgr	Phoenix	A good resource for management, operational responsibility always lies with the driver.
Maint Engineer	I-40 Dist	Not satisfied with benefits or intention of utilization; concern with liability aspects. Importance to ADOT – low.
Maint / District Engineer	I-40 Dist	The AVL concept is good. However from what I have seen so far, the Greylink product is less than what I had envisioned and hoped it would accomplish. We need a system that an end user can operate easily, with little or no training and data is easily read and understood.
District Engineer	I-40 Dist	Pro: this is another system that would help during not only winter storms but during the clear and dry weather as well; system has possibilities in monitoring material usage, etc. in the future. Con: I'm not sure we totally know what technology infrastructure is required and how the way we do business fits with this device.
Superintendent	I-40 Dist	May need to go to satellite phone system for truck.
Superintendent	I-40 Dist	I don't see us using this system much until we have a more reliable phone system. It makes more sense trying to get the operators equipment that will make it safer for them to operate the equipment, than in tracking them with the limited funds we have.
Dist Eqpt Mgr	I-40 Dist	No real feel for this – no comment.
Org Supervisor	I-40 Dist	This can be very good for quick response to incidents, and if the truck needs help.
Org Supervisor	I-40 Dist	I've seen some papers on the tracking system (AVL). I agree with the research going on.
Operator	I-40 Dist	This is some what of a good idea but with being hooked up to a cell phone doesn't really give us a reliable way of communicating between that computer and AVL. There are other AVL that can be accessed through the internet that could be easier to communicate.
Operator	I-40 Dist	Works good, would use it.
ATRC		The concept of AVL seems very valuable to local & state fleet managers. This system, and support, has improved since the purchase, but is not so rural-user-friendly. Combined with phone and modem problems it has not proven out yet. Research can fund better hardware for SnowDesk, can upgrade the software again, and get more training. A test of this AVL or a different system <u>in Phoenix</u> may also answer our questions.

• **Bendix X-Vision Night vision Camera?**

Position	Org	Comments
State Manager	Phoenix	Could use some additional testing and demonstrations.
State Manager	Phoenix	Important – especially in those blizzard type of situations
State Eqpt Mgr	Phoenix	A good product, no chance to use it yet.
Maint Engineer	I-40 Dist	Potential for deployment is high – but mounting location and vibration concerns need more work.
Maint / District Engineer	I-40 Dist	This could be as important to ADOT as the snowplow guidance system, although I'll be the first to admit that I only know a little about the concept – that's all - don't know enough to comment.
District Engineer	I-40 Dist	Pro: It's really nice to know what is ahead of you before your headlights find it. Con: Do we really need it?
Superintendent	I-40 Dist	Need to do the tests and demo. Use existing truck if we can and new one if necessary.
Superintendent	I-40 Dist	I am hoping this will provide the operators with better vision of what they can't see with their eyes thus making it safer for the operators to perform their work.
Dist Eqpt Mgr	I-40 Dist	We need to fully test this, then evaluate.
Org Supervisor	I-40 Dist	N / C
Org Supervisor	I-40 Dist	My people said they really like it. They agree with the night vision system, it should help them during snowstorms.
Operator	I-40 Dist	This system is still new. I have used it during dry conditions and I thought it worked great but I would like to see how it would work under snow or rainy conditions.
Operator	I-40 Dist	Great distance vision.
Operator	I-40 Dist	Works good, I would use it.
ATRC		This unit deserves a full winter's testing to determine how it performs in various storm conditions. A summer partner is unlikely now, and snow is the key issue. We could move this to other snowplows every month or six weeks, to get a better cross-section of users and conditions.

**B. THIS PROJECT'S FUTURE DIRECTIONS?**

• **WHAT HAVE WE LEARNED?**

Position	Org	Comments
State Manager	Phoenix	The technology has potential benefits. There are still many issues around who will market this technology, and what is the business case?
State Manager	Phoenix	Not sure... delegated to others at district – thus do not feel comfortable answering this
State Eqpt Mgr	Phoenix	N / C
Maint Engineer	I-40 Dist	In my opinion, the 3M guidance, Bendix, and Vorad should be considered for expansion. The 3M system needs additional testing in a heavy winter.
Maint / District Engineer	I-40 Dist	We learned a lot about teamwork. We've learned a lot about 2 different guidance systems. We've received a lot of feedback on other things we should be studying. We've also learned that funding is a big issue and overshadows much of what we want to do. We learned a little about AVL.
District Engineer	I-40 Dist	The positive control systems have potential despite the initial costs in saving on equipment accidents, etc. There is a high cost in constructing positive control systems. There might be greater opportunities in focusing on the individual vehicle systems that are not totally tied to some hardwired or positive control systems.
Superintendent	I-40 Dist	There are a lot of things out there technically that should make it safer for the operators to perform their work. It is not feasible to implement some of the new systems.
Dist Eqpt Mgr	I-40 Dist	3M System works, radar works but not fully tested, the night vision works but value uncertain.
Org Supervisor	I-40 Dist	That it takes a lot of time and effort to research all that has been done. We have learned a lot about vendors that are out there, materials, and ways to use them.
Org Supervisor	I-40 Dist	My crew are saying IF only it would snow really bad to see if the systems really would help them.
Operator	I-40 Dist	We have learned that there are ways of keeping us and the public safe during a snow storm. But also we have found out the cost of that and it is more than people are willing to spend.
Operator	I-40 Dist	More safety on the road at night.
Operator	I-40 Dist	Need more snow and whiteouts to use the systems.
ATRC		We have learned a lot about the state of the art in guidance and warning systems. We've learned that rural AZ conditions, even in a mild winter, can limit the use of some of these systems. We have also learned what ITS systems may be most valuable, considering ADOT's slim resources. We have learned the costs, benefits, and limits, of both guidance systems.

• **WHAT HAVE WE NOT LEARNED YET?**

Position	Org	Comments
State Manager	Phoenix	Would be nice to have more time and experience in live winter conditions.
State Manager	Phoenix	N / C
State Eqpt Mgr	Phoenix	What is the ideal snowplow (blade system) design? What is the ideal snowplow truck, and, what is feasible?
Maint Engineer	I-40 Dist	N / A
Maint / District Engineer	I-40 Dist	Implementation plan. Night vision. Other AVL product possibilities.
District Engineer	I-40 Dist	The cost/benefit of the different systems, mainly due to the fact that we have not been able to compare data of accidents, closures, delays due to plow downtime that these systems would impact. How the data collected will inter-relate with the data from the free agent vehicle systems to provide choices between hardwired and free agent approaches.
Superintendent	I-40 Dist	N / C
Superintendent	I-40 Dist	How to provide more vision for our operators through wipers/lighting.
Dist Eqpt Mgr	I-40 Dist	Radar and night vision – usefulness.
Org Supervisor	I-40 Dist	How to get things at a lower price. Are there other vendors out there?
Org Supervisor	I-40 Dist	Don't know at this time, but what information we have should help us.
Operator	I-40 Dist	We have to learn how to make things safe with out increasing the cost that people are willing to spend.
Operator	I-40 Dist	N/C
Operator	I-40 Dist	N/C
ATRC		We have not learned <u>how much</u> any specific system can help our plow operators and supervisors. We can't measure improvements or benefits, especially in mild winters. We know costs and driver satisfaction levels, but not the specific benefits on the roadway or at the District office.  We still have specific on-board systems waiting to be evaluated.

• **WHAT ELSE COULD THE I.T.S. SNOWPLOW PROJECT STUDY EFFECTIVELY?**

Position	Org	Comments
State Manager	Phoenix	More work on AVL and night vision would be a good idea. Also, more work on cost benefit analysis.
State Manager	Phoenix	N / C
State Eqpt Mgr	Phoenix	N / C
Maint Engineer	I-40 Dist	No new concepts with this study.
Maint / District Engineer	I-40 Dist	Two-way communication between the plow and the 'Central office'. Would probably require satellite communications. Could tie AVL and a number of other concepts and functions for data collection.  GPS Guidance could be studied.
District Engineer	I-40 Dist	Cost/benefit possibilities to determine what system should be used. Can this research be tied to the individual vehicle telematics being developed in private industry? How can this research be applied to the way ADOT does business?
Superintendent	I-40 Dist	GrayLink with satellite phone
Superintendent	I-40 Dist	We need to see what the night vision system does and what is out there, that will help all the operators see better at night, and when you have white outs.
Org Supervisor	I-40 Dist	Collision radar and night vision.
Org Supervisor	I-40 Dist	I think we have enough equipment to work with at this time. I don't know about the cost.
Operator	I-40 Dist	I think lighting on plows, wipers, and plow sizes could be a good start. I think studying the use of training personnel to see if it also increases safety.
Operator	I-40 Dist	N/C
Operator	I-40 Dist	Lights on snowplows.
ATRC		This effort can coordinate with Maintenance Research, which has been funded in the past for lighting, visibility and AVL studies. This project has pretty limited resources for the next winter, depending on TAC decisions regarding Caltrans and also NAU.

• **SHOULD THIS PROJECT DO MORE NEXT WINTER, AND IF SO, WHERE?**

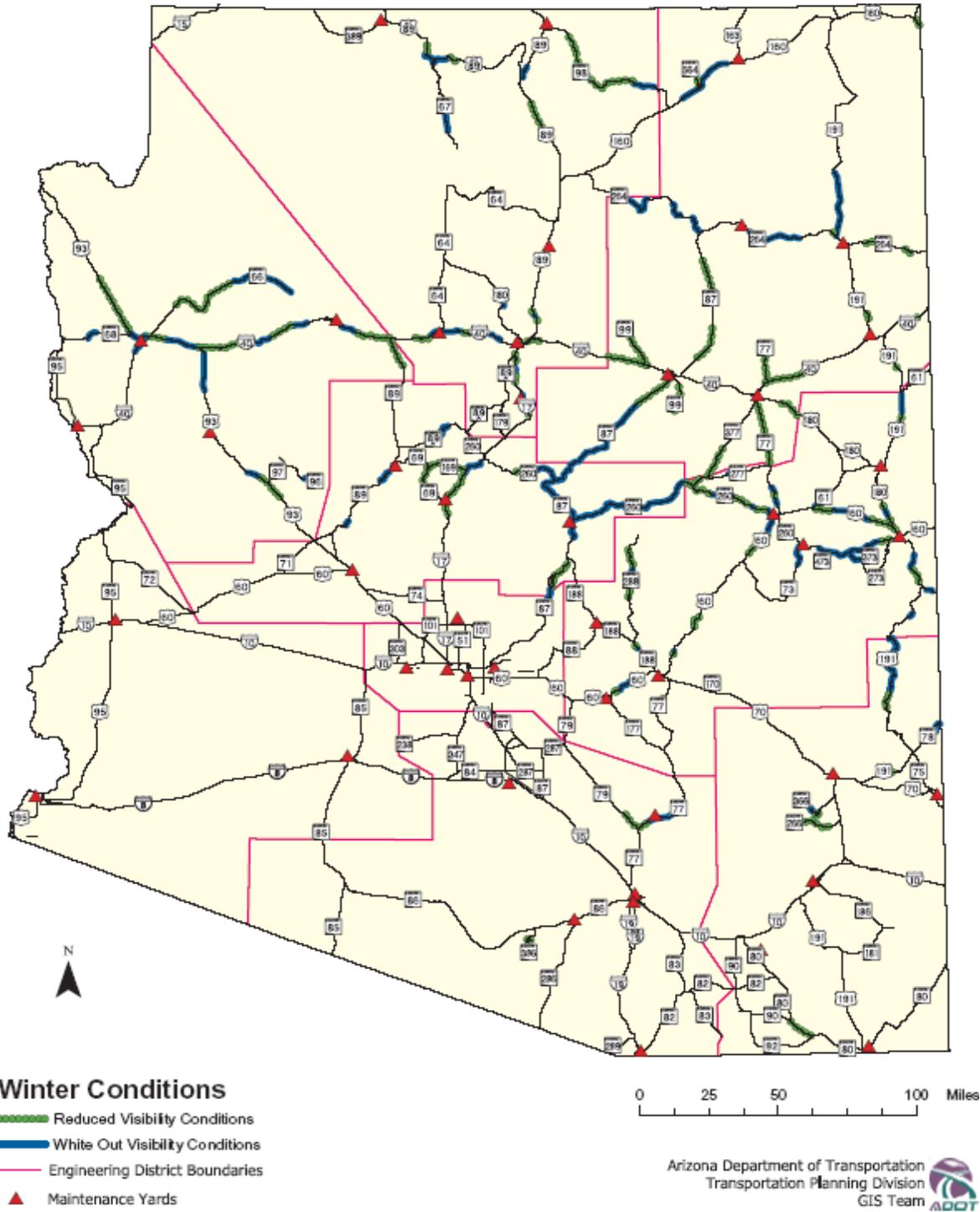
Position	Org	Comments
State Manager	Phoenix	Given the need to better assess live winter conditions, I think it is very important that additional work be done next year.
State Manager	Phoenix	No – I think the focus now should be – what does Maint. want – in regards to safety features, enhancements to their vehicles to support them
State Eqpt Mgr	Phoenix	Yes, on specific on-board systems.
Maint Engineer	I-40 Dist	Additional 3M testing, CalTrans plow does not need to return
Maint / District Engineer	I-40 Dist	<p>I think there are at least 2 ways to approach this:</p> <ol style="list-style-type: none"> <li>1. See what kind of support you receive from the District to continue. Without it, we are not going to go very far and it will be very frustrating.</li> <li>2. Discuss the results with the TAC for input. You may get the same or differing opinions between 1 and 2.</li> </ol> <p>Do we have enough data to finish up the snowplow guidance portion of the study? If not, what is left undone that needs follow up next winter season?</p> <p>The answers to these questions are essential to being able to determine an answer to your question above. I believe you will find that the District, most likely, thinks we squeezed out all we can regarding the snowplow guidance system beyond finding the funding to implement and fine tune the system. So if there are things left undone that you need to study, then we need to make that case to the District.</p>
District Engineer	I-40 Dist	We should reach out and possibly start introducing the technology in the Prescott, Globe, and Holbrook Districts, starting with the introduction of some of the individual vehicle devices rather than the positive control systems.
Superintendent	I-40 Dist	Finish test on the night vision.
Superintendent	I-40 Dist	We probably should not do anymore with the Magnets, 3M tape or AVL but we should see what the night vision is going to do and what else is out there that can help the operator see at night and when it is snowing.
Org Supervisor	I-40 Dist	Collision radar and night vision.
Org Supervisor	I-40 Dist	I think it is working now, we should wait until we have a good snowstorm.
Operator	I-40 Dist	With the state budget the way it is I think that we should look into the cost of bringing the plow from Cal Trans to see if we have enough information to make a good enough project analysis from it. I feel as some of the operators are not into the different projects and don't want to continue writing all the reports and taking time out their work schedule to train the different people on the equipment. I feel it should be up to the managers to see if there is money and time to keep up the different projects. The 3M project can keep going on next year since there is really no cost in using the equipment because it is already going to be out on the road.
Operator	I-40 Dist	Yes
Operator	I-40 Dist	Yes
ATRC		<p>We have big gaps in our knowledge of our new systems in severe winter weather. Primarily these are night vision, collision radar, &amp; 3M performance.</p> <p>As to training, there are not any new aspects of the 3M or Caltrans systems.</p>

APPENDIX K

ARIZONA WINTER VISIBILITY SURVEY BY ROUTE MILES: 2003

# ADOT Engineering Districts

## Winter Conditions Visibility Survey by Route Corridor Miles



**ADOT Winter Visibility Survey: Highway Corridor (Milepost) Distances**

<b>ADOT Maintenance District</b>	<b>White-Out Visibility Miles Total<sup>(1)</sup></b>	<b>Reduced Visibility Miles Total<sup>(1)</sup></b>	<b>Total Extent w/ Impaired Visibility</b>	<b>Total of Plow Route Miles in District</b>	<b>Total of All Highway Miles in District</b>	<b>Impaired Percent of Plow Route Miles</b>	<b>Impaired Percent of All Route Miles</b>
Flagstaff	63	97	160	776	776	21%	21%
Globe	117	179	296	804	919	37%	32%
Holbrook	130	215	345	833	833	41%	41%
Kingman	100	140	240	385	530	62%	45%
Phoenix	6	0	6	20	379	30%	2%
Prescott	146	78	224	387	572	58%	39%
Safford	47	48	95	675	804	14%	12%
Tucson	11	18	29	112	840	26%	3%
Yuma	0	0	0	0	562	0%	0%
<i>State-wide Totals</i>	<i>620</i>	<i>775</i>	<i>1,395</i>	<i>3,992</i>	<i>6,216</i>	<i>35%</i>	<i>22%</i>

<sup>(1)</sup> **White-Out Visibility Conditions:** Unable to continue plowing; cannot see beyond the hood or make out any surroundings. May last 15 to 20 minutes or more. Occurs 3 or more times each winter season: Oct 15 - Apr 15.

<sup>(2)</sup> **Reduced Visibility Conditions:** Plows have to slow significantly, even occasionally stop. May last 15 to 20 minutes or more, but is not bad enough to be considered a "white-out". Occurs 3 or more times each winter season: Oct 15 - Apr 15.

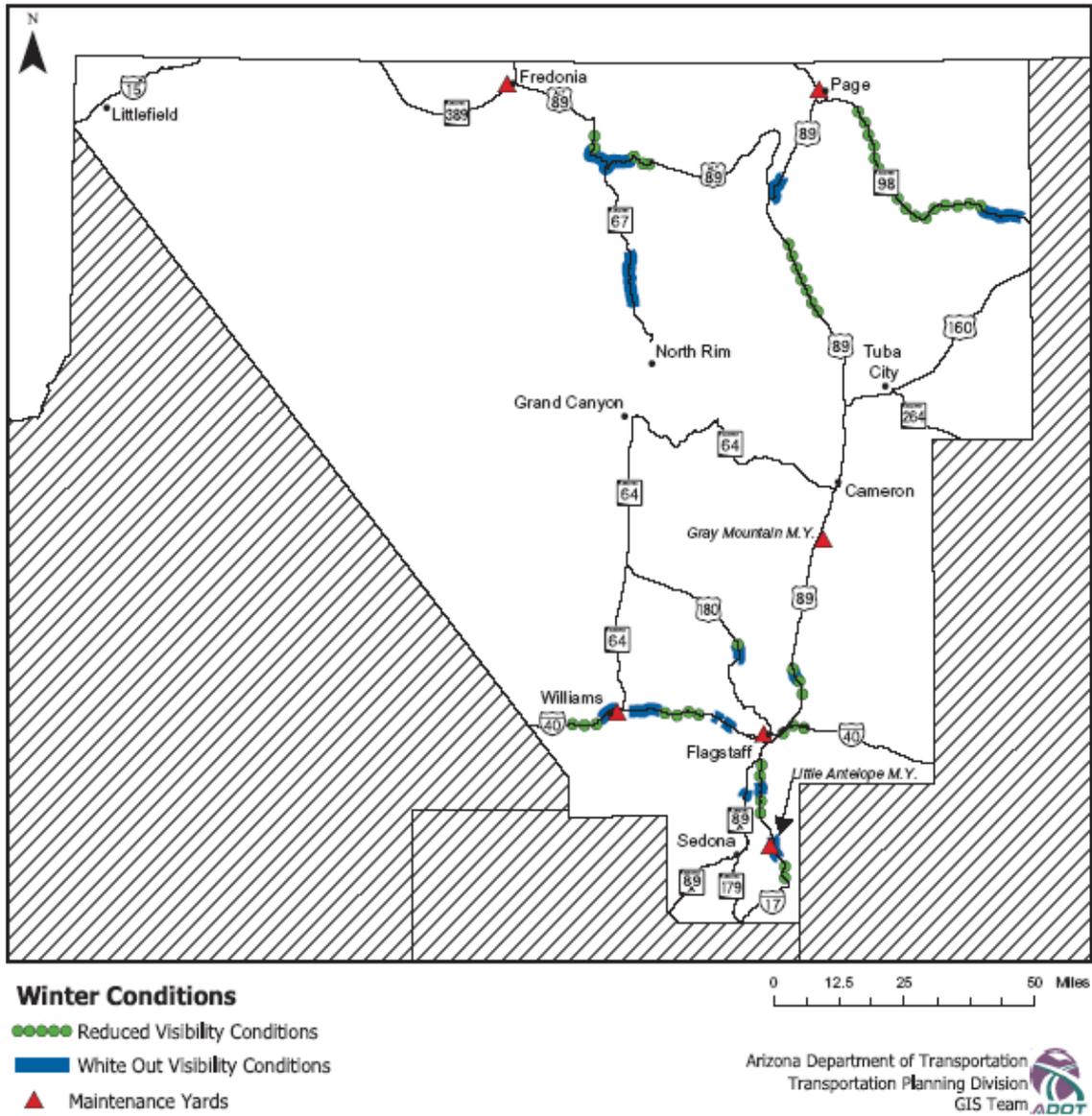
Notes - Route or Corridor miles are the total length of the low- or zero-visibility section of the corridor, as defined by the starting and ending mileposts. Plow Route miles are the normal patrol route segments where plows are always assigned for an expected storm.

Survey data was updated & verified by ATRC during the months of June & August 2003.

Rev:  
08-15-03

# Flagstaff District

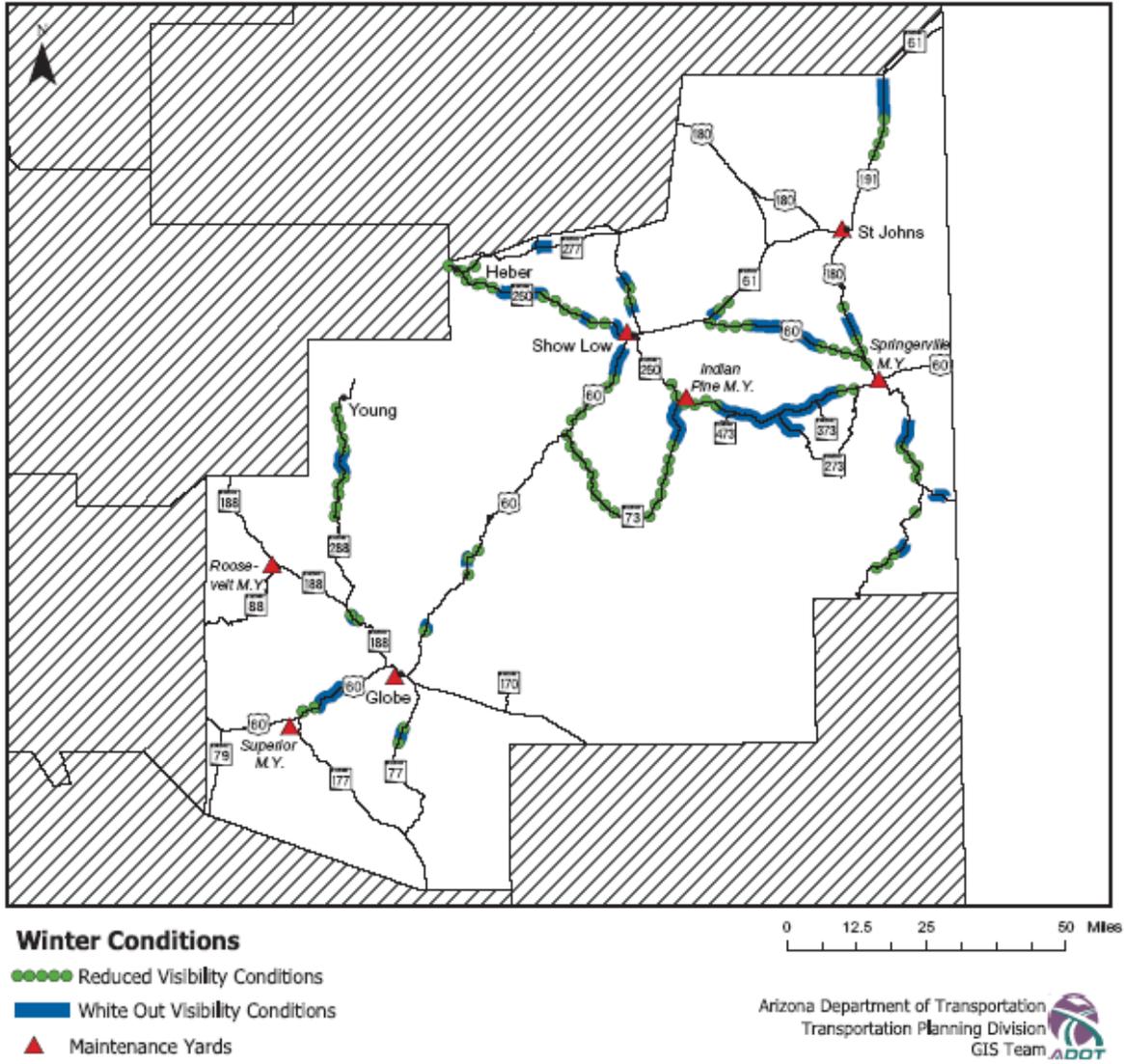
## Winter Conditions Visibility Survey by Route Corridor Miles



<b>FLAGSTAFF District</b>							
<b>Winter Conditions Visibility Survey by Route Corridor Miles</b>							
<b>JUNE 2003</b>							
<b>A - White-Out Visibility Conditions</b>							
<b>Route Corridor Miles - Milepost Distances</b>							
<b>Orgs--&gt;</b>	Flagstaff	Williams	Gray Mtn	Ltl Antelope	Page	Fredonia	
<b>Org Number--&gt;</b>	8550	8551	8552	8553	8554	8555	
<b>Route &amp; Location</b>							<b>Lanes *Check:Ln-Mi</b>
I40, MP 186-188	2						4 8
I40, MP 167-173		6					4 24
I40, MP 184-185		1					4 4
I40, MP 161-165		4					4 16
I17, MP 317-321				4			4 16
I17, MP 330-332				2			4 8
89A, MP 389-391				2			2 4
89, MP 428 to 430			2				4 8
89, MP 525-530					5		2 10
98, MP 342-350					8		2 16
SR 67, 599-610						11	2 22
89A, MP 573-586						13	2 26
180, MP 235-238	3						2 6
<b>Org Totals--&gt;</b>	<b>5</b>	<b>11</b>	<b>2</b>	<b>8</b>	<b>13</b>	<b>24</b>	
<b>District Total for White-out Conditions (corridor route miles)--&gt;</b>						<b>63.00</b>	(Sum L-M) 168
<b>B - Reduced Visibility Conditions</b>							
<b>Route Corridor Miles - Milepost Distances</b>							
<b>Orgs--&gt;</b>	Flagstaff	Williams	Gray Mtn	Ltl Antelope	Page	Fredonia	
<b>Org Number--&gt;</b>	8550	8551	8552	8553	8554	8555	
<b>Route &amp; Location</b>							<b>Lanes *Check:Ln-Mi</b>
I40, MP 199-204	5						4 20
I40, MP 155-160		5					4 20
I40, MP 174-181		7					4 28
I17, MP 312-315				3			4 12
I17, MP 333-337				4			4 16
I17, MP 326-330				4			4 16
89, MP 425 to 428			3				4 12
89, MP 430-432			2				4 8
89, MP 500-514					14		2 28
98, MP 304-342					38		2 76
89A, MP 567-573						6	2 12
89A, MP 586-590						4	2 8
180, MP 238-240	2						2 4
<b>Org Totals--&gt;</b>	<b>7</b>	<b>12</b>	<b>5</b>	<b>11</b>	<b>52</b>	<b>10</b>	
<b>District Total for Reduced Visibility Conditions (corridor route miles)--&gt;</b>						<b>97.00</b>	(Sum L-M) 260
<b>District Total for Both Impaired-Visibility Conditions (corridor route miles)--&gt;</b>						<b>160.00</b>	(Sum L-M) 428
<b>ALL Plow Route Miles in Org--&gt;</b>	<b>106.78</b>	<b>107.33</b>	<b>154.24</b>	<b>102.39</b>	<b>165.01</b>	<b>139.91</b>	
<b>*Source: Meeting w/ Danny Russell</b>						<b>Total of Plow Route Miles in District--&gt;</b>	<b>775.66</b>
<b>ALL Milepost Distance Miles in Org--&gt;</b>	<b>106.78</b>	<b>107.33</b>	<b>154.24</b>	<b>102.39</b>	<b>165.01</b>	<b>139.91</b>	
<b>*Source: Org Boundary Log</b>						<b>Total of ALL Highway Miles in District--&gt;</b>	<b>775.66</b>
A - White-Out Visibility Conditions: Unable to continue plowing; cannot see beyond the hood or make out any surroundings. May last 15 to 20 minutes or more. Occurs 3 or more times each winter season: Oct 15 - Apr 15.							
B - Reduced Visibility Conditions: Plows have to slow down significantly, and even occasionally stop. May last 15 to 20 minutes or more, but is not bad enough to be considered a "white-out". Occurs 3 or more times each winter season: Oct 15 - Apr 15.							

# Globe District

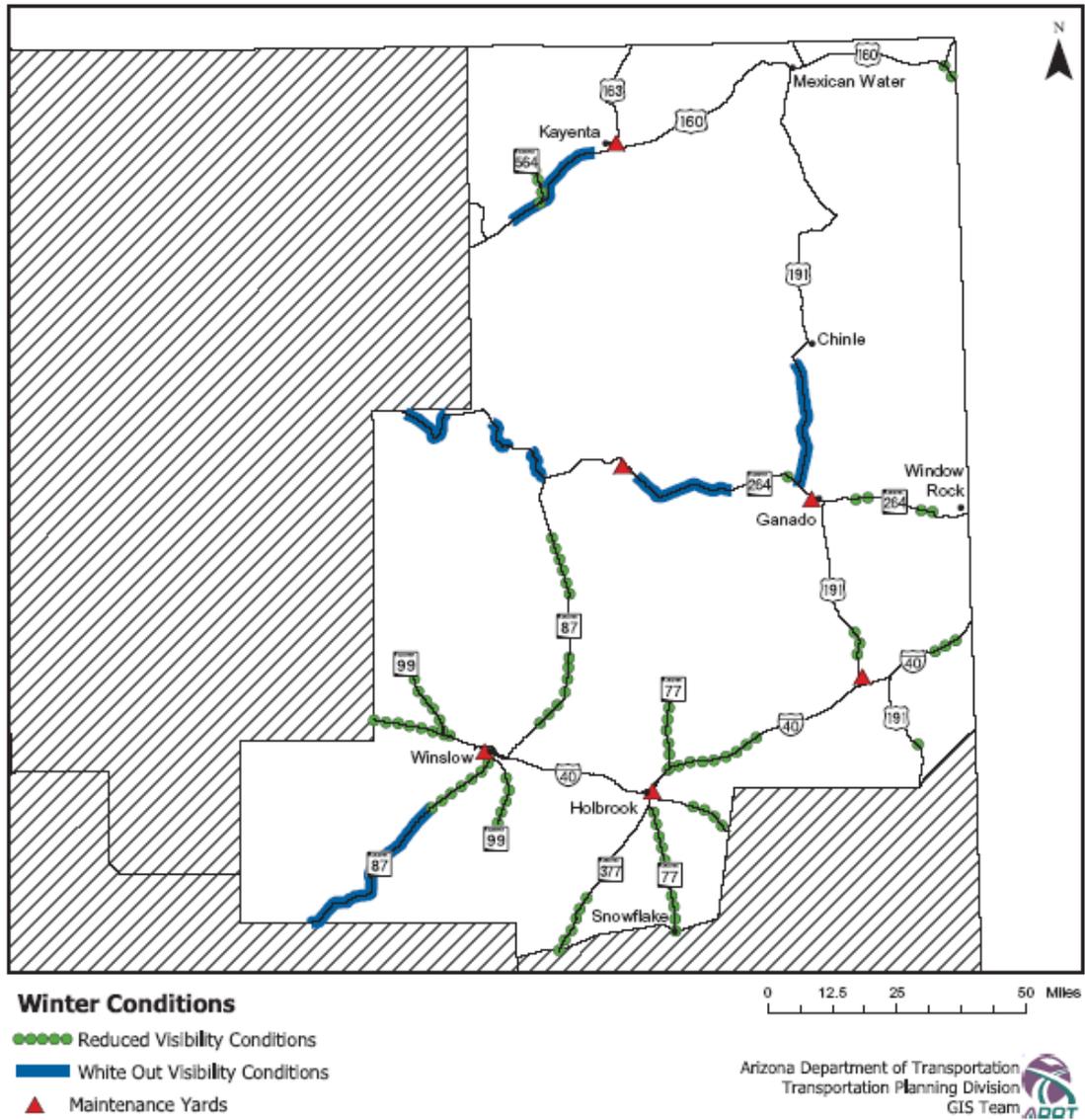
## Winter Conditions Visibility Survey by Route Corridor Miles



GLOBE District										
Winter Conditions Visibility Survey by Route Corridor Miles										
JUNE 2003										
A - White-Out Visibility Conditions										
Route Corridor Miles - Milepost Distances										
Orgs-->	Globe	Roosevelt	Superior	Show Low	St Johns	Springerville	Indian Pine			
Org Number-->	8350	8352	8353	8354	8355	8356	8357			
Route & Location								Lanes	*Check:Ln-Mi	
US 60, MP 261.5 - 262.5	1							3	3	
US 60, MP 279.5-281.5	2							2	4	
SR 77, MP 160-162	2							2	4	
SR 288, MP 290-295		5						2	10	
SR 188, MP 227-228		1						2	2	
US 60, MP 231.5-238.5			7					3	21	
US 60, MP 333-338				5				2	10	
SR 77, MP 346-348				2				2	4	
SR 77, MP351-353				2				4	8	
SR 260, MP 314-322				8				2	16	
SR 260, MP 330-332				2				2	4	
SR 260, MP 336-338				2				4	8	
SR 277, MP 321-324				3				2	6	
SR 61, MP 355-357					2			2	4	
US 180, MP 386-390					4			2	8	
US 191, MP 337-344					7			2	14	
US 60, MP 362-376						14		2	28	
US 180, MP 412-417						5		2	10	
US 180, MP 429-431						2		2	4	
SR 260, MP 377.4-390						12.6		2	25.2	
US 191, MP 238.3-240.4						2.1		2	4.2	
SR 260, MP 365-378.7							13.7	3	41.1	
SR 73, MP 350-357.7							7.7	3	23.1	
SR 273, MP 377.8-383							5.2	2	10.4	
<b>Org Totals--&gt;</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>24</b>	<b>13</b>	<b>35.7</b>	<b>26.6</b>		(Sum L-M)	
	<b>District Total for White-out Conditions (corridor route miles)--&gt;</b>							<b>117.3</b>		272
B - Reduced Visibility Conditions										
Route Corridor Miles - Milepost Distances										
Orgs-->	Globe	Roosevelt	Superior	Show Low	St Johns	Springerville	Indian Pine			
Org Number-->	8350	8352	8353	8354	8355	8356	8357			
Route & Location								Lanes	*Check:Ln-Mi	
US 60, MP 261-261.5 & 262.5-263	1							3	3	
US 60, MP 278-279.5 & 281.5-284	4							2	8	
SR 77, MP 159-160 & 162-163	2							2	4	
SR 288, MP 280-290 & 295-305		20						2	40	
SR 188, MP 226-227 & 228-229		2						2	4	
US 60, MP 228-231.5 & 238.5-242			7					3	21	
US 60, MP 321-333				12				3	36	
SR 77, MP 348-351				3				2	6	
SR 260, MP 302.7-310				7.3				4	29.2	
SR 260, MP 310-314				4				4	16	
SR 260, MP 322-330 & 332-336				12				2	24	
SR 277, MP 306-310				4				2	8	
SR 61, MP 357-360					3			2	6	
US 180, MP 384-386 & 390-394					6			2	12	
US 191, MP 330-337					7			2	14	
US 60, MP 355-362						7		2	14	
US 60, MP 376-387						11		2	22	
US 180, MP 417-425						8		2	16	
SR 260, MP 390-394						4		2	8	
SR 373, MP 388-390.2						2.2		2	4.4	
US 191, MP 233-238.3						5.3		2	10.6	
US 191, MP 248-249						1		2	2	
SR 260, MP 354-365							11	2	22	
SR 73, MP 335-350							15	3	45	
SR 73, MP 310-330							20	2	40	
<b>Org Totals--&gt;</b>	<b>7</b>	<b>22</b>	<b>7</b>	<b>42.3</b>	<b>16</b>	<b>38.5</b>	<b>46</b>		(Sum L-M)	
	<b>District Total for Reduced Visibility Conditions (corridor route miles)--&gt;</b>							<b>178.8</b>		415.2
	<b>District Total for Both Impaired-Visibility Conditions (corridor route miles)--&gt;</b>							<b>296.1</b>		(Sum L-M) 687.2

# Holbrook District

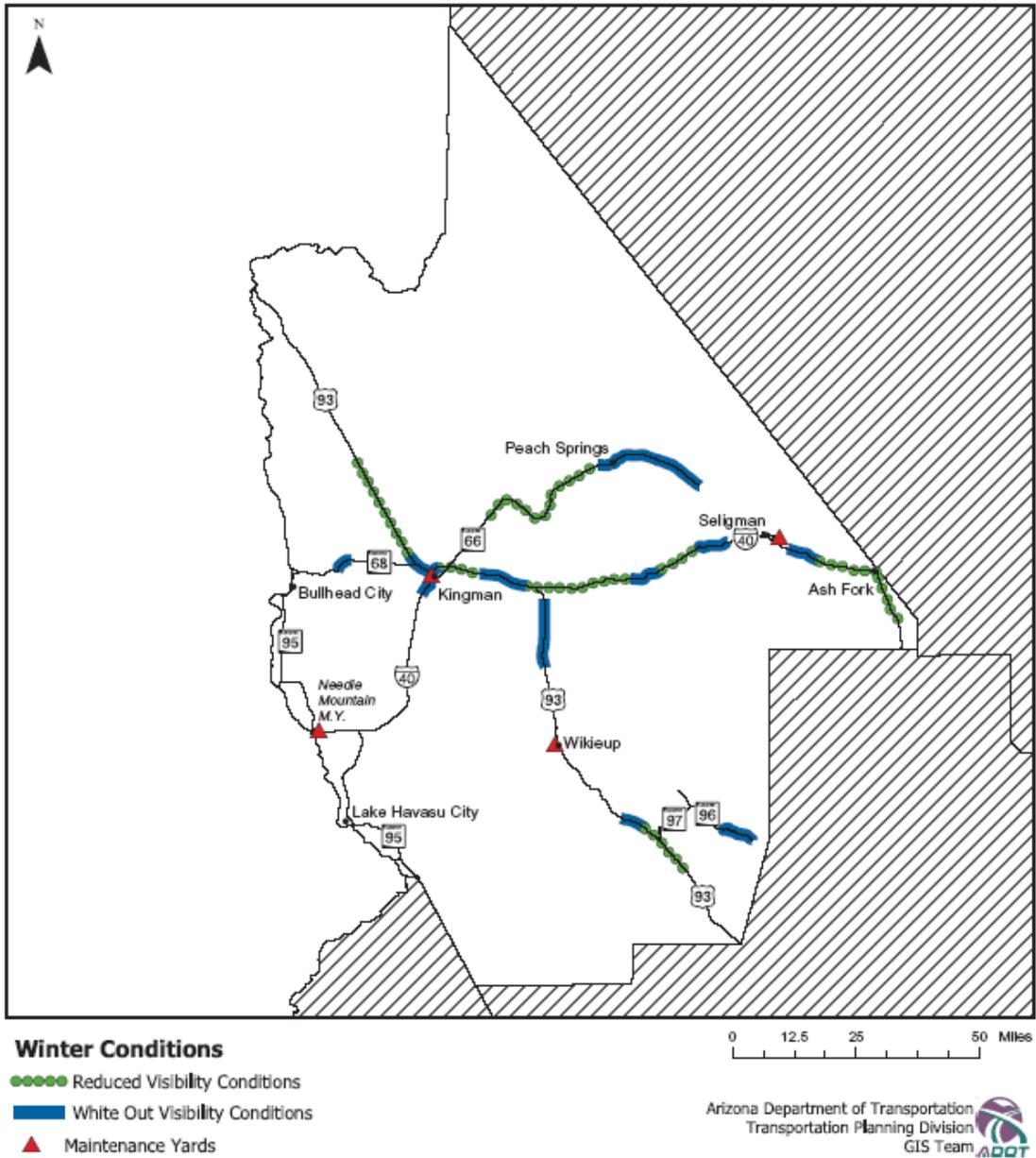
## Winter Conditions Visibility Survey by Route Corridor Miles





# Kingman District

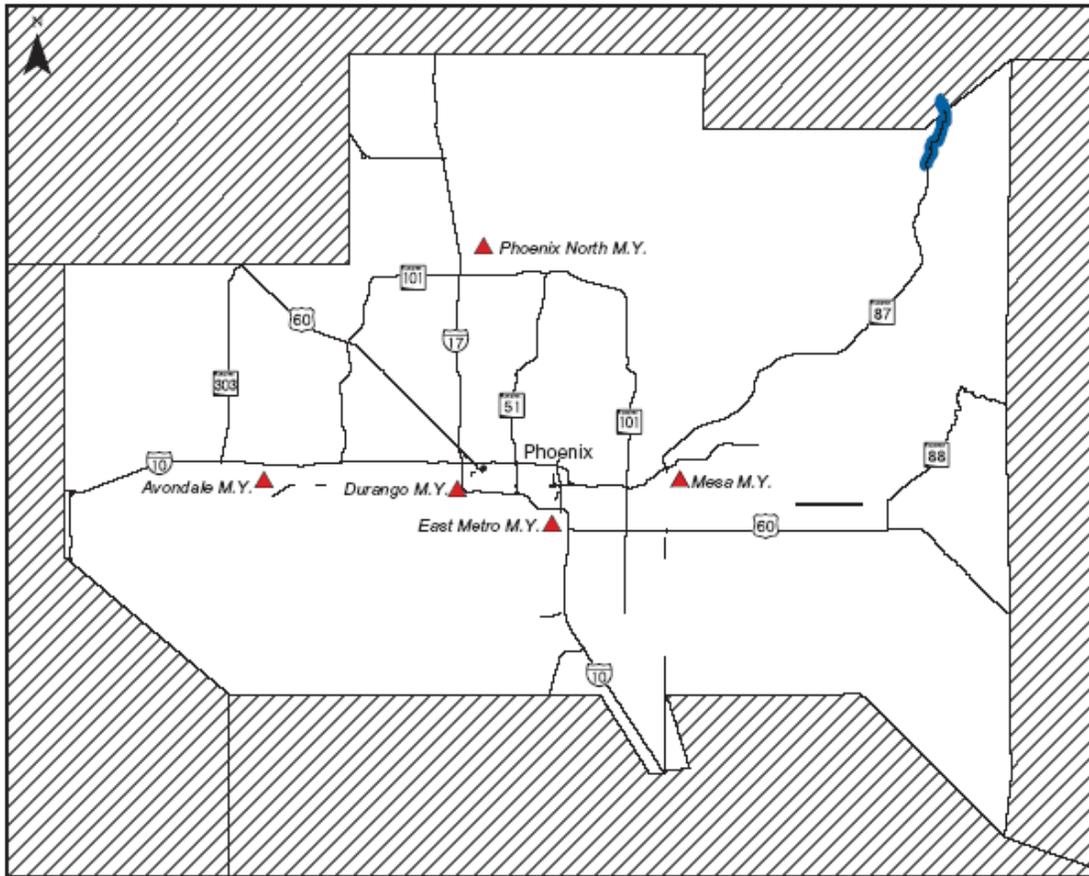
## Winter Conditions Visibility Survey by Route Corridor Miles





# Phoenix District

## Winter Conditions Visibility Survey by Route Corridor Miles



### Winter Conditions

- Reduced Visibility Conditions
- White Out Visibility Conditions
- ▲ Maintenance Yards

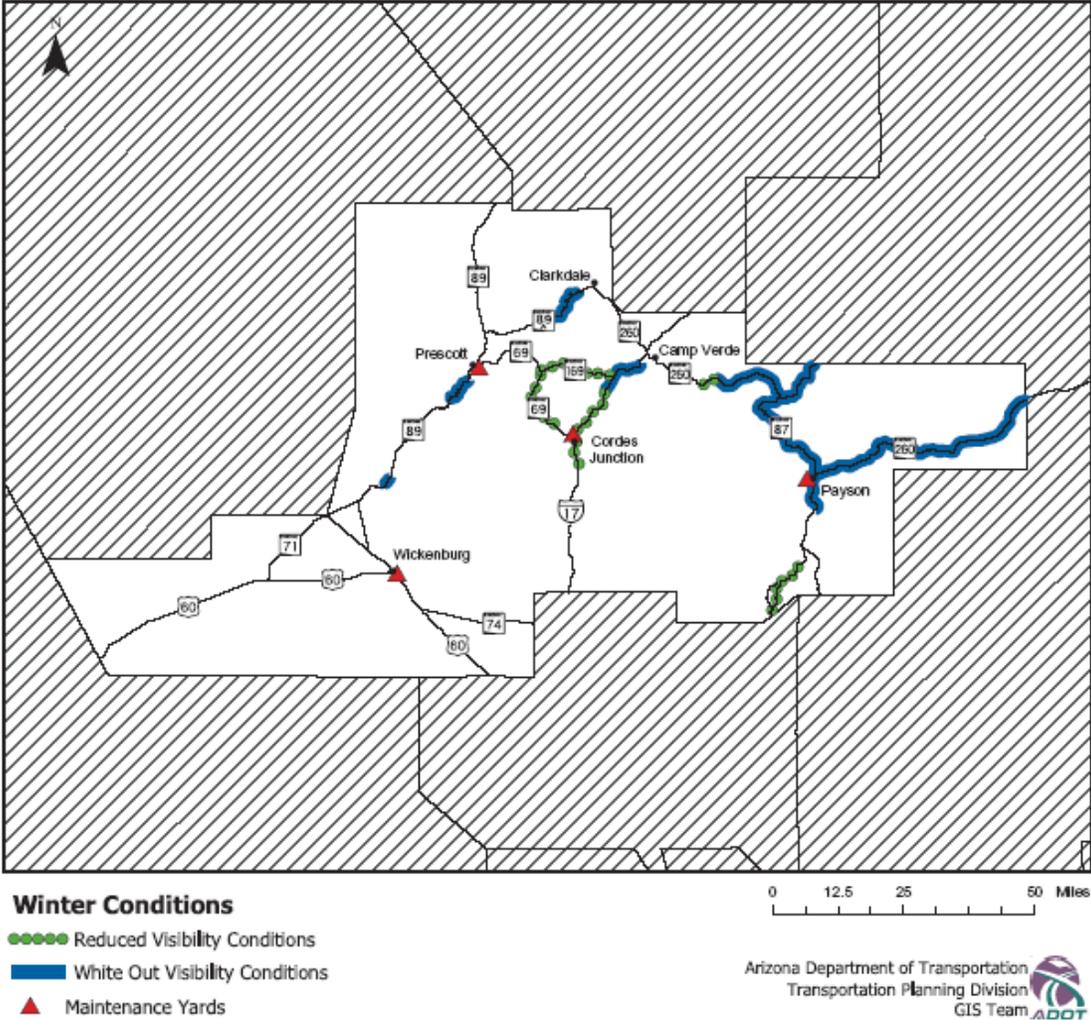
0 5 10 20 Miles

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# Prescott District

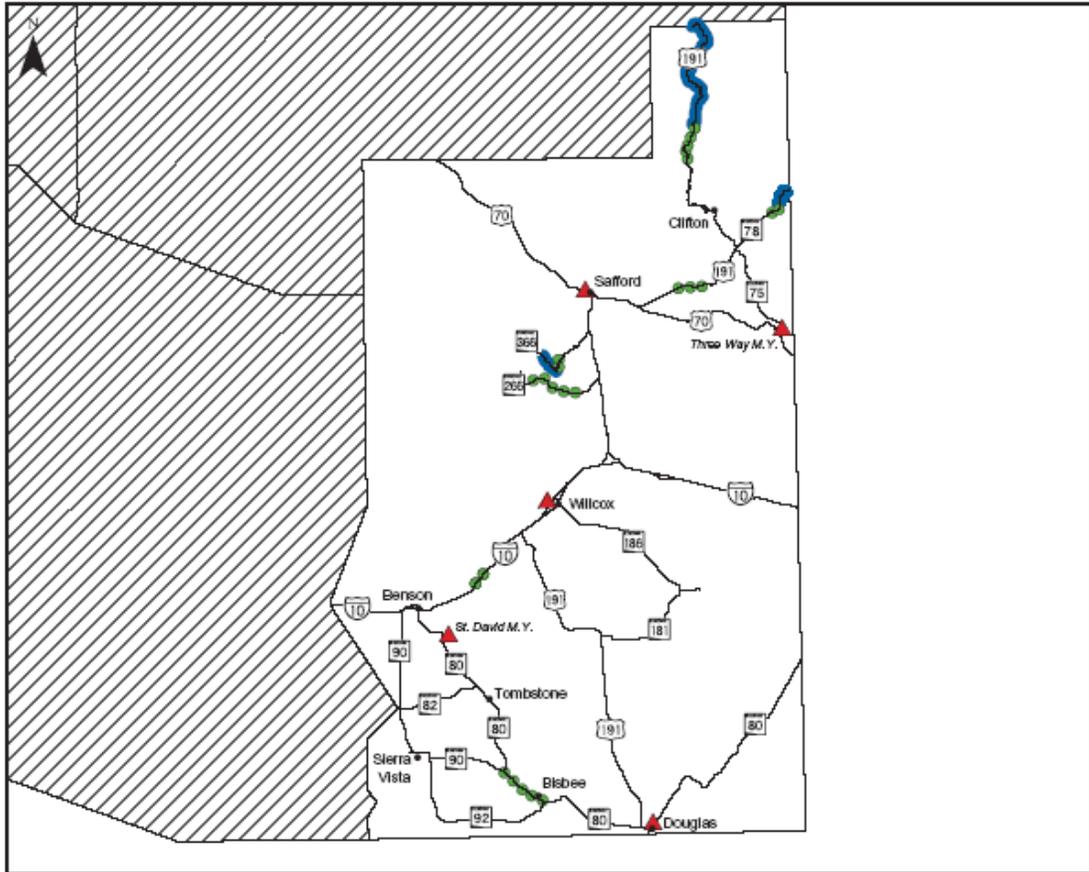
## Winter Conditions Visibility Survey by Route Corridor Miles



<b>PRESCOTT District</b>							
<b>Winter Conditions Visibility Survey by Route Corridor Miles</b>							
<b>JUNE 2003</b>							
<b>A - White-Out Visibility Conditions</b>							
Route Corridor Miles - Milepost Distances							
Orgs-->	Prescott Valley	Cordes Jct	Wickenburg	Payson			
Org Number-->	8850	8851	8852	8853			
Route & Location						Lanes	Check:Ln-M
I-17 MP 275 - 285		10				4	40
SR 87 MP 244 - 254				10		4	40
SR 87 MP 254 - 290				36		2	72
SR 89 MP 276 - 278			2			4	8
SR 89 MP 300 - 308	8					2	16
SR 89A MP 331 - 344	13					2	26
SR 260 MP 236 - 243		7				2	14
SR 260 MP 243 - 282				39		4	156
SR 260 MP 282 - 303				21		2	42
							0
							0
							0
							0
							0
<b>Org Totals--&gt;</b>	<b>21</b>	<b>17</b>	<b>2</b>	<b>106</b>			(Sum L-M)
	<b>District Total for White-out Conditions (corridor route miles)--&gt;</b>					<b>146.00</b>	<b>414</b>
<b>B - Reduced Visibility Conditions</b>							
Route Corridor Miles - Milepost Distances							
Orgs-->	Prescott Valley	Cordes Jct	Wickenburg	Payson			
Org Number-->	8850	8851	8852	8853			
Route & Location						Lanes	Check:Ln-M
I-17 MP 258 - 275		17				4	68
SR 69 MP 268 - 281		13				4	52
SR 69 MP 281 - 296	15					4	60
SR 87 MP 218 - 233				15		4	60
SR 169 MP 0 - 15		15				2	30
SR 260 MP 233 - 236		3				2	6
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
<b>Org Totals--&gt;</b>	<b>15</b>	<b>48</b>	<b>0</b>	<b>15</b>			(Sum L-M)
	<b>District Total for Reduced Visibility Conditions (corridor route miles)--&gt;</b>					<b>78.00</b>	<b>276</b>
	<b>District Total for Both Impaired-Visibility Conditions (corridor route miles)--&gt;</b>					<b>224.00</b>	<b>690</b>
<b>*Fill Out For Each ORG:</b>							
<b>ALL Plow Route Miles in Org--&gt;</b>	<b>122</b>	<b>117</b>	<b>3</b>	<b>145</b>			
*Source: MSLT file edits: Bob Lajeunesse	<b>Total of Plow Route Miles in District--&gt;</b>					<b>387.00</b>	
<b>ALL Milepost Distance Miles in Org--&gt;</b>	<b>120.65</b>	<b>136.69</b>	<b>170.68</b>	<b>144.34</b>			
*Source: Org Boundary Log	<b>Total of ALL Highway Miles in District--&gt;</b>					<b>572.36</b>	
A - White-Out Visibility Conditions: Unable to continue plowing; cannot see beyond the hood or make out any surroundings. May last 15 to 20 minutes or more. Occurs 3 or more times each winter season: Oct 15 - Apr 15.							
B - Reduced Visibility Conditions: Plows have to slow down significantly, and even occasionally stop. May last 15 to 20 minutes or more, but is not bad enough to be considered a "white-out". Occurs 3 or more times each winter season: Oct 15 - Apr 15.							

# Safford District

## Winter Conditions Visibility Survey by Route Corridor Miles



### Winter Conditions

- Reduced Visibility Conditions
- White Out Visibility Conditions
- ▲ Maintenance Yards

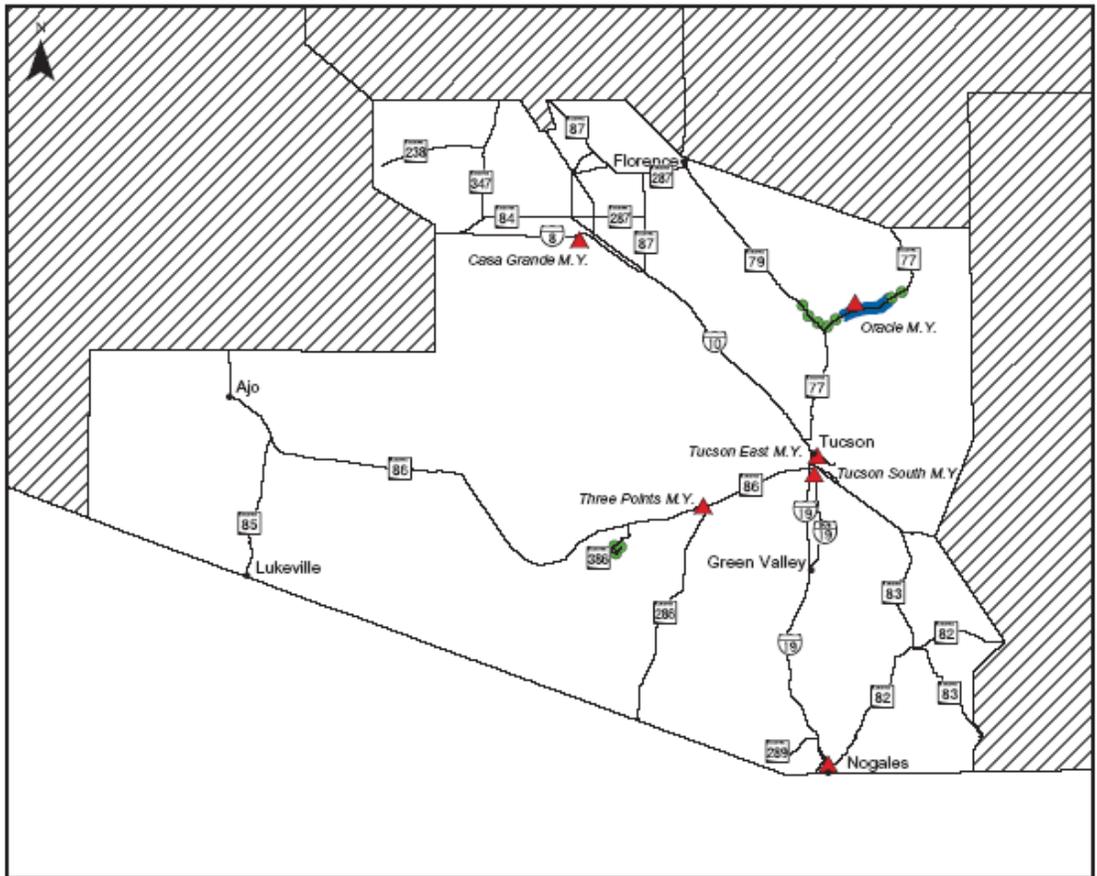
0 12.5 25 50 Miles

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# Tucson District

## Winter Conditions Visibility Survey by Route Corridor Miles



### Winter Conditions

- Reduced Visibility Conditions
- White Out Visibility Conditions
- ▲ Maintenance Yards

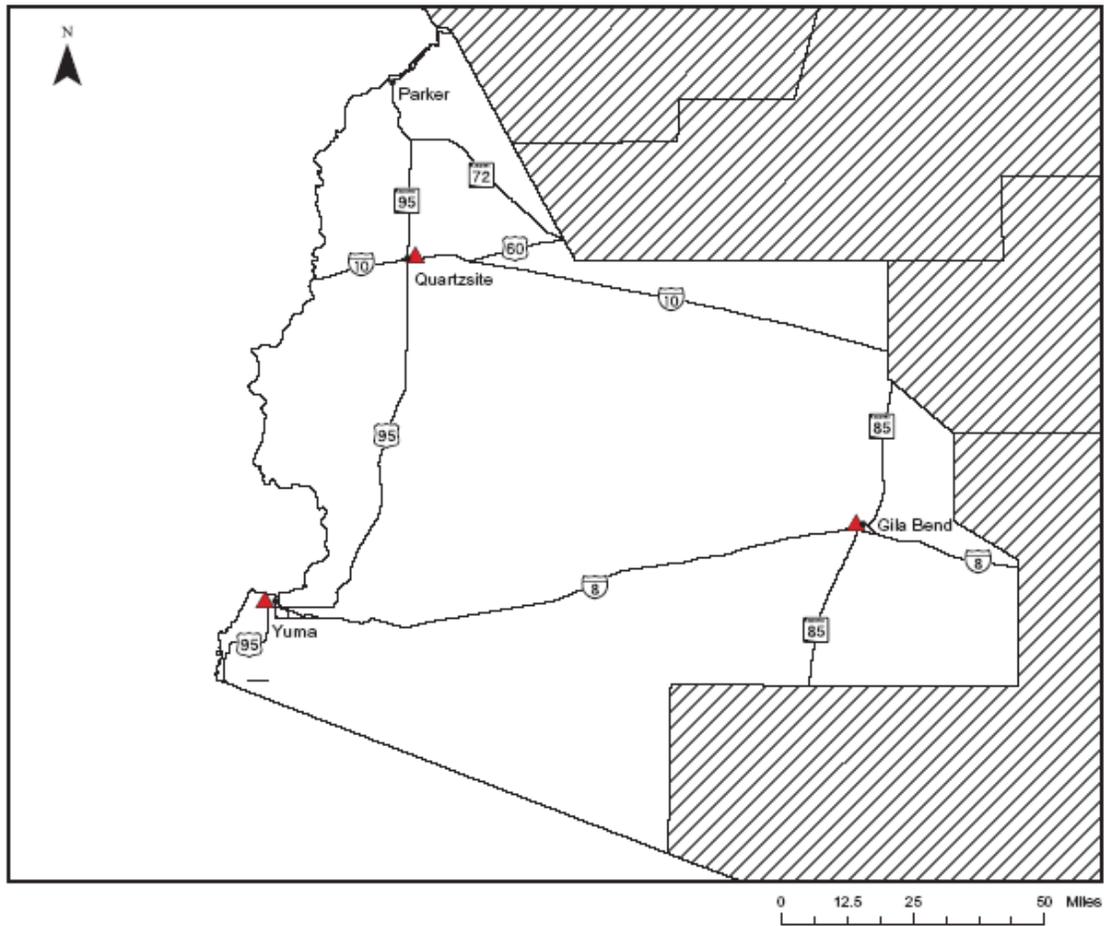
0 12.5 25 50 Miles

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<b>TUCSON District</b>								
<b>Winter Conditions Visibility Survey by Route Corridor Miles</b>								
<b>JUNE 2003</b>								
<b>A - White-Out Visibility Conditions</b>								
<b>Route Corridor Miles - Milepost Distances</b>								
<b>Orgs--&gt;</b>	<b>Tucson W.</b>	<b>Tucson E.</b>	<b>3 Points</b>	<b>Nogales</b>	<b>Oracle</b>	<b>Casa Grande</b>		
<b>Org Number--&gt;</b>	<b>8150</b>	<b>8151</b>	<b>8152</b>	<b>8153</b>	<b>8154</b>	<b>8155</b>		
<b>Route &amp; Location</b>							<b>Lanes</b> <b>*Check:Ln-Mi</b>	
SR 77: MP 96 - 107					11		2    0 22 0 0 0 0 0 0 0 0 0 0 0 0	
<b>Org Totals--&gt;</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>11</b>	<b>0</b>	<b>(Sum L-M)</b> 22	
<b>District Total for White-out Conditions (corridor route miles)--&gt;</b>							<b>11.00</b>	<b>22</b>
<b>B - Reduced Visibility Conditions</b>								
<b>Route Corridor Miles - Milepost Distances</b>								
<b>Orgs--&gt;</b>	<b>Tucson W.</b>	<b>Tucson E.</b>	<b>3 Points</b>	<b>Nogales</b>	<b>Oracle</b>	<b>Casa Grande</b>		
<b>Org Number--&gt;</b>	<b>8150</b>	<b>8151</b>	<b>8152</b>	<b>8153</b>	<b>8154</b>	<b>8155</b>		
<b>Route &amp; Location</b>							<b>Lanes</b> <b>*Check:Ln-Mi</b>	
SR 386: MP 7 - 12			5				2    0 10	
SR 77: MP 92 - 96					4		2    8	
SR 77: MP 107 - 110					3		2    6	
SR 79: MP 93 - 99					6		2    12 0 0 0 0 0 0 0 0 0	
<b>Org Totals--&gt;</b>	<b>0</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>13</b>	<b>0</b>	<b>(Sum L-M)</b> 36	
<b>District Total for Reduced Visibility Conditions (corridor route miles)--&gt;</b>							<b>18.00</b>	<b>36</b>
<b>District Total for Both Impaired-Visibility Conditions (corridor route miles)--&gt;</b>							<b>29.00</b>	<b>58</b>
<b>*Fill Out For Each ORG:</b>								
<b>ALL Plow Route Miles in Org--&gt;</b>	<b>12</b>	<b>15</b>	<b>15</b>	<b>25</b>	<b>45</b>	<b>0</b>		
<b>*Source: MSLT followup w/ Cliff Riley</b>	<b>Total of Plow Route Miles in District--&gt;</b>						<b>112.00</b>	
<b>ALL Milepost Distance Miles in Org--&gt;</b>	<b>62.68</b>	<b>94.17</b>	<b>209.82</b>	<b>155.74</b>	<b>157.49</b>	<b>160.3</b>		
<b>*Source: Org Boundary Log</b>	<b>Total of ALL Highway Miles in District--&gt;</b>						<b>840.20</b>	
A - White-Out Visibility Conditions: Unable to continue plowing; cannot see beyond the hood or make out any surroundings. May last 15 to 20 minutes or more. Occurs 3 or more times each winter season: Oct 15 - Apr 15.								
B - Reduced Visibility Conditions: Plows have to slow down significantly, and even occasionally stop. May last 15 to 20 minutes or more, but is not bad enough to be considered a "white-out". Occurs 3 or more times each winter season: Oct 15 - Apr 15.								

# Yuma District

## Winter Conditions Visibility Survey by Route Corridor Miles



▲ Maintenance Yards

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