

65-3136

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

SIGNAL HEAD COLOR STUDY

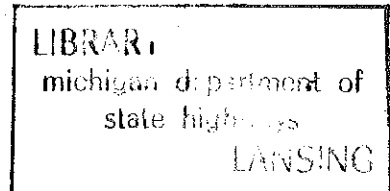
Conducted Jointly by the

MDSH TRAFFIC DIVISION
TRAFFIC RESEARCH SECTION

and

THE CITY OF DETROIT
DEPARTMENT OF STREETS AND TRAFFIC

in Cooperation with the
U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS



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Lansing, Michigan

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

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CONTENTS

	<u>Page</u>
SYNOPSIS	1
STUDY PROCEDURES	3
STUDY RESULTS	16
CONCLUSIONS	26

LIST OF TABULATIONS

Table 1: Accidents on Woodward Avenue	5
Table 2: Woodward Avenue Signal Observance	10
Table 3: Accidents on Grand River Avenue	13
Table 4: Grand River Avenue Signal Observance	17
Table 5: Summary of Results	23
Table 6: Grand River Avenue Thru-on-Red Counts During Non-Congestion Periods	25
Table 7: Statistically Significant Changes	27
Table 8: Study Results by Individual Intersections	28

SYNOPSIS

A difference between the specifications of the Michigan Department of State Highways and the City of Detroit for paint color used on the outside of traffic signal heads prompted the initiation of a study of the relative merits of dark green versus highway yellow color on signals. The study was conducted jointly by the two above mentioned administrations, and it was agreed that all the signals on Woodward and Grand River Avenues in Detroit, which were originally painted a dark green, would be painted in the regular yellow color as part of the study procedures. Both of these avenues are part of the state trunkline system within the city.

Signal observance surveys were taken at five intersections on Woodward Avenue and on six intersections on Grand River Avenue before and after changing the paint. In these six-hour surveys, vehicles going through the intersection illegally on red signal indication, entering the intersection on amber indication, and abnormal or panic stops were counted. Accident experience at all signalized intersections on each of the trunklines (30 intersections on Woodward Avenue and 58 on Grand River Avenue) were studied for a year before painting and a year after painting.

After analyses for statistical significance, the study results failed to provide conclusive evidence to favor either the dark green or the yellow color. The results that were considered statistically significant were: an increase in vehicles entering on red signal on Grand River Avenue after the signals were painted yellow, a decrease in abnormal stops on both trunklines, a decrease in total accidents on Woodward Avenue, and an increase in daylight right-angle accidents on Grand River Avenue. Even these statistically significant changes are believed to have other causative factors than signal head colors, which makes any evaluation of color in this study virtually impossible.

STUDY PROCEDURES

Reason for the Study

The Michigan Department of State Highways specifications require that traffic signal heads be painted highway-yellow on the outside. The City of Detroit Department of Streets and Traffic, however, painted their signals a dark green color. This practice included signals on those city arteries which are part of the State Trunkline System that are maintained by the City through agreement with the Department of State Highways. In 1960, with the aim of obtaining uniformity throughout the trunklines, the Department of State Highways requested that the signal heads be painted in the regulation yellow color. The City contended that their experience led them to favor the dark color because the lens colors were more readily visible against a dark signal-head color. The Department of State Highways believed, however, that it was more important that the motorist quickly note the presence of a traffic signal, at which range the relative visibility of lens colors against the signal background is not critical. These differing opinions were the reasons for initiating a study on the relative merits of the two colors.

The Department of State Highways and the City of Detroit Department of Streets and Traffic agreed to conduct, jointly, studies on Woodward Avenue, which is part of U.S. Route 10,

and on Grand River Avenue which is designated as Interstate Route 96 Business Spur. The study envisaged a before-and-after evaluation of the effects of changing the color of the paint from dark green to yellow. The two study parameters adopted were accident experience and drivers' behavior and observance of the traffic signals.

Woodward Avenue Study

There are two separate sections of Woodward Avenue in the City of Detroit, a third intermediate section falling within the limits of the City of Highland Park. For the accident part of the study, all the signalized intersections of this thoroughfare within the City of Detroit were considered. There are 30 such intersections (Table 1). For the driver behavior and signal observance surveys 5 intersections were selected which were considered to be representative of the various traffic and environmental characteristics throughout the whole stretch of this city street. These intersections are State Fair Entrance, 6 Mile Road, Chicago (Fig. 1), Warren, and Montcalm (Fig. 2).

To compare the behavior of drivers at the five intersections before and after changing the color of the paint, surveys were made for a period of 6 hours (9-11AM, 12N-2PM and 2:30-4:30PM) to count the number of vehicles that entered the intersection illegally during the red phase of the signals, the number that entered during the amber phase, and the number that made abnormal or panic stops both before the stop bars, which are

Table 1

ACCIDENT EXPERIENCE ON WOODWARD AVENUE
BEFORE AND AFTER CHANGING SIGNAL-HEAD PAINT

Location	Oct. 1, 1959 through Sept. 30, 1960 (Signals Painted Green)			Jan. 1, 1961 through Dec. 31, 1961 (Signals Painted Yellow)		
	Right-Angle Accidents		Total Accidents	Right-Angle Accidents		Total Accidents
	Daylight	Dark		Daylight	Dark	
State Fair Parking Lot Entr.	0	0	11	0	0	18
State Fair + Bus Loop	2	2	56	0	3	56
Golden Gate	0	0	9	0	0	12
Savannah	0	0	15	1	4	25
Merril Plaisance	2	2	25	1	3	31
McNichols (6 Mile Road)	11	1	50	9	3	41
Calvert-Trowbridge	2	0	12	1	1	8
Chicago-Arden Park	4	1	23	1	2	20
Clairmount-Owen	2	0	73	0	3	73
Hazelwood-Holbrook	1	1	18	1	0	24
Euclid	3	1	30	0	0	25
Seward-Marston	0	0	27	1	1	33
Bethune	0	0	17	0	0	13
Grand Blvd.	3	3	76	6	0	59
Milwaukee	2	1	33	2	1	29
Baltimore	4	0	33	1	2	33
Medbury-Antoinette	1	1	7	0	1	9
Kirby	1	0	30	1	0	25
Putnam-Farnsworth	0	1	26	1	0	19
Warren	2	3	57	5	1	39
Forest	2	1	53	0	2	39
Canfield	1	1	30	1	2	21
Alexandrine	0	2	33	0	1	30
Mack-Davenport	1	2	25	0	0	11

Table 1 - (Page 2)

ACCIDENT EXPERIENCE ON WOODWARD AVENUE
BEFORE AND AFTER CHANGING SIGNAL-HEAD PAINT

Location	Oct. 1, 1959 through Sept.30, 1960 (Signals Painted Green)			Jan. 1, 1961 through Dec. 31,1961 (Signals Painted Yellow)		
	Right-Angle Accidents		Total Accidents	Right-Angle Accidents		Total Accidents
	Daylight	Dark		Daylight	Dark	
Eliot-Stimson	0	3	19	1	0	16
Adelaide-Sibley	0	0	16	1	0	24
Vernor	3	5	53	1	1	31
Montcalm	2	0	11	1	2	10
Columbia	3	1	22	1	0	19
Elizabeth	1	1	8	2	0	5
Total	53	33	898	39	33	798

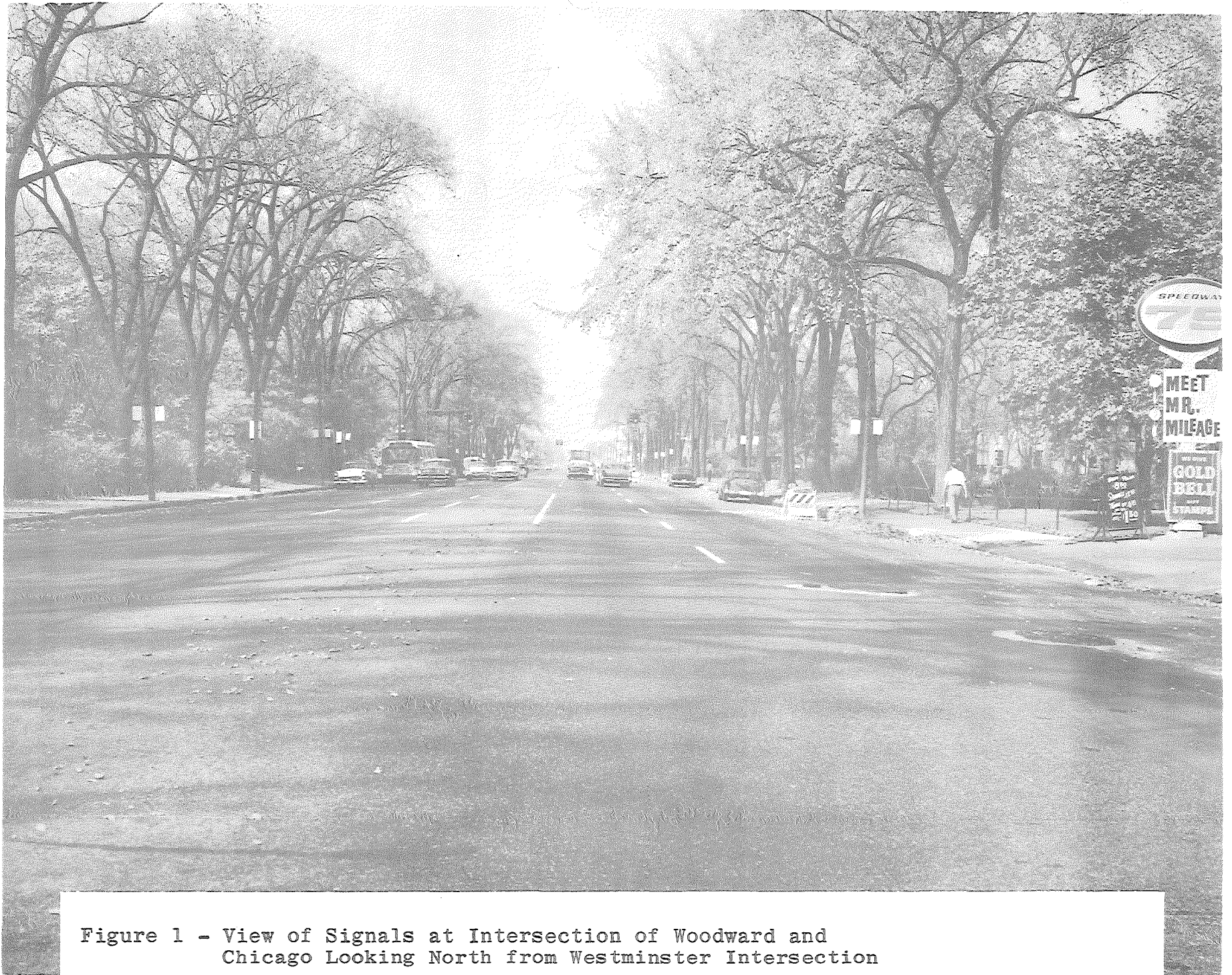


Figure 1 - View of Signals at Intersection of Woodward and
Chicago Looking North from Westminster Intersection



Figure 2 - View of Signals at Intersection of Woodward and Montcalm Looking South from Winder Intersection

painted on the pavement, or after these bars. After the signal heads were painted yellow, these surveys were repeated. The results are indicated in Table 2. Traffic volume counts were also taken during these surveys.

The City of Detroit provided accident data for one year prior to changing the paint color and one year after. Comparison of the accident data is shown in Table 1.

Grand River Avenue Study

This phase of the study was started almost two years after the Woodward Avenue phase. For accident studies, all of the 58 signalized intersections on Grand River Avenue in Detroit were examined (Table 3). For the driver behavior and signal observance surveys, 6 intersections were selected to reflect the variations in the character of traffic and environment conditions along this trunkline. These intersections are McIntyre, Greenfield, Ward, Grand, Warren, and Second.

Driver behavior surveys similar to those taken on Woodward Avenue were conducted before and after painting the signals in the yellow color. The results indicated what seemed to be a big increase in the total number of vehicles going through on red signal after the painting. While there were 47 such vehicles during the "before" survey, 229 were reported for the "after" survey. This shed doubts on the accuracy of this first "after" survey. A possible reason for inaccuracy was that the survey takers probably were not properly instructed

Table 2

WOODWARD AVENUE
SIGNAL OBSERVANCE SURVEY

Location	Survey Period	Number of Cycles		Entering on Red		Entering on Amber		Abnormal Stops	
		Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow
N.W. of State Fair Main Gate #5	9 - 11A	141	140	13	10	271	118	8	19
	12N - 2P	141	140	13	2	187	121	4	13
	2:30 - 4:30P	112	110	39	11	150	103	19	7
	6 hr. total	394	390	65	23	608	342	31	39
	S.E. of State Fair Main Gate #5	9 - 11A	144	140	2	0	52	12	0
	12N - 2P	138	140	0	2	76	28	1	1
	2:30 - 4:30P	112	110	9	4	100	24	3	1
	6 hr. total	394	390	11	6	228	64	4	2
N.W. of 6 Mile Rd.	9 - 11A	144	144	11	16	150	225	5	1
	12N - 2P	144	144	4	12	116	117	0	1
	2:30 - 4:30P	114	114	8	8	98	110	3	9
	6 hr. total	402	402	23	36	364	452	8	11
	S.E. of 6 Mile Rd.	9 - 11A	140	144	3	2	67	88	0
	12N - 2P	142	144	2	13	61	131	3	0
	2:30 - 4:30P	113	114	1	18	105	227	3	1
	6 hr. total	395	402	6	33	233	446	6	1

10

Table 2 - (Page 2)

WOODWARD AVENUE
SIGNAL OBSERVANCE SURVEY

Location	Survey Period	Number of Cycles		Entering on Red		Entering on Amber		Abnormal Stops	
		Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow
N.W. of Chicago Blvd.	9 - 11A	136	135	1	18	29	117	11	11
	12N - 2P	143	146	1	7	58	92	11	4
	2:30 - 4:30P	115	114	2	4	24	43	2	1
	6 hr. total	394	395	4	29	111	252	24	16
S.E. of Chicago Blvd.	9 - 11A	134	134	1	0	32	18	0	1
	12N - 2P	144	145	3	1	33	25	5	1
	2:30 - 4:30P	115	111	10	0	128	25	2	1
	6 hr. total	393	390	14	1	193	68	7	3
N.W. of Warren	9 - 11A	150	136	8	31	109	201	19	3
	12N - 2P	142	144	9	11	173	159	8	2
	2:30 - 4:30P	106	113	4	12	132	124	14	3
	6 hr. total	398	393	21	54	414	484	41	8
S.E. of Warren	9 - 11A	125	136	0	1	30	30	1	0
	12N - 2P	152	143	2	3	48	47	2	0
	2:30 - 4:30P	120	115	0	1	87	102	1	0
	6 hr. total	397	394	2	5	165	179	4	0

Table 2 - (Page 3)

WOODWARD AVENUE
SIGNAL OBSERVANCE SURVEY

Location	Survey Period	Number of Cycles		Entering on Red		Entering on Amber		Abnormal Stops	
		Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow
On Warren N.E. of Woodward	9 - 11A	134	Not Available	5	2	33	89	16	1
	12N - 2P	143	"	3	4	50	84	10	8
	2:30 - 4:30P	109	"	0	3	55	68	6	2
	6 hr. total	386	"	8	9	138	241	32	11
N.W. of Montcalm	9 - 11A	110	115	1	8	46	52	0	0
	12N - 2P	116	116	6	15	51	41	2	0
	2:30 - 4:30P	107	107	4	7	29	33	2	1
	6 hr. total	333	338	11	30	126	126	4	1
S.E. of Montcalm	9 - 11A	111	115	6	16	60	108	3	2
	12N - 2P	118	116	7	15	111	145	1	2
	2:30 - 4:30P	108	107	2	8	72	50	1	0
	6 hr. total	337	338	15	39	243	303	5	4
Totals for all Intersections		4223	Not Available	180	265	2823	2957	166	96

Table 3

ACCIDENT EXPERIENCE ON GRAND RIVER AVENUE
BEFORE AND AFTER CHANGING SIGNAL-HEAD PAINT

Location	Jan. 1, 1962 through Dec. 31, 1962 (Signals Painted Green)			Nov. 1, 1963 through Oct. 31, 1964 (Signals Painted Yellow)		
	Right-Angle Accidents		Total Accidents	Right-Angle Accidents		Total Accidents
	Daylight	Dark		Daylight	Dark	
McIntyre	0	0	9	1	0	14
Lahser	8	6	49	3	4	44
Bentler	0	1	3	0	0	0
Trinity	1	2	13	4	1	24
Evergreen	2	3	31	6	6	23
Outer Drive	5	3	31	2	0	6
Warwick	2	0	22	2	1	16
Fenkell-Southfield-Ashton	4	2	49	2	3	25
Biltmore-Lindsay	0	0	15	1	0	11
St. Mary's	0	1	13	0	0	12
Prevost	1	0	16	3	1	18
Greenfield	5	4	51	8	2	70
Whitcomb	4	1	20	1	3	22
Robson	1	1	6	0	0	9
Hubbell	2	2	13	8	1	26
Freeland	1	1	3	2	1	8
Stansbury	1	0	18	4	0	19
Schaefer	3	2	33	4	2	29
Ward	1	0	10	2	1	20
Meyers	1	0	19	6	1	24
Birwood	1	0	6	0	0	4
Wyoming	6	4	32	6	4	37
Ohio	1	0	11	2	2	18
Plymouth-Cloverlawn	2	2	16	3	1	19
Oakman	0	1	52	1	2	59
Detroit RR (Term) W. of Cloverdale	3	2	23	0	0	14
American	0	0	17	2	0	20
Monica	0	2	17	1	1	20

Table 3- (Page 2)

ACCIDENT EXPERIENCE ON GRAND RIVER AVENUE
BEFORE AND AFTER CHANGING SIGNAL-HEAD PAINT

Location	Jan. 1, 1962 through Dec. 31, 1962 (Signals Painted Green)			Nov. 1, 1963 through Oct. 31, 1964 (Signals Painted Yellow)		
	Right-Angle Accidents		Total Accidents	Right-Angle Accidents		Total Accidents
	Daylight	Dark		Daylight	Dark	
Livernois	8	4	66	8	13	98
Chicago	2	0	29	3	1	42
Joy	1	4	65	2	4	59
Beverly-Hillsboro	2	0	10	0	0	24
Firwood-Kimberly	1	0	10	0	0	4
Maplewood-Quincy	0	1	26	2	1	50
Vicksburg	0	0	15	1	0	14
Allendale-Hogarth	0	0	9	1	2	26
Larchmont-Lothrop	1	1	21	1	1	41
Grand Blvd.-Dexter-Vinewood	1	1	66	3	1	82
Roosevelt	1	0	23	2	0	21
Wreford	3	0	16	2	2	23
McGraw	7	1	32	7	3	57
Ford Freeway	5	1	18	4	5	32
Linwood	0	0	26	1	1	11
Warren-Sixteenth	3	4	39	5	5	56
Fifteenth-Hancock	1	0	12	1	1	13
Fourteenth	1	0	21	1	1	8
Buchanan-Canfield	1	1	11	1	0	13
Twelfth	1	1	25	1	1	9
National	0	0	3	0	0	1
Trumbull	0	1	13	1	2	29
Ash	0	0	5	2	0	6
Lodge Freeway	2	2	34	3	2	21
Fifth	1	0	5	1	0	5
Third-Henry	1	0	21	4	3	19
Vernor	1	1	13	2	0	26
Second	2	1	8	4	0	6

Table 3 - (Page 3)

ACCIDENT EXPERIENCE ON GRAND RIVER AVENUE
BEFORE AND AFTER CHANGING SIGNAL-HEAD PAINT

Location	Jan. 1, 1962 through Dec. 31, 1962 (Signals Painted Green)			Nov. 1, 1963 through Oct. 31, 1964 (Signals Painted Yellow)		
	Right-Angle Accidents		Total Accidents	Right-Angle Accidents		Total Accidents
	Daylight	Dark		Daylight	Dark	
Elizabeth	2	0	11	0	0	4
Cass	0	1	7	3	0	7
Total	103	65	1258	140	86	1418

and consequently made errors in their tally. It was decided to repeat the after phase of the signal observance survey. But, because the first survey was taken in November of 1963, the repeat survey was postponed to the following Spring to be conducted under better controlled conditions.

The results of the signal observance surveys, comparing the "before" and the second "after" conditions, are shown in Table 4. Volume counts were also taken at these intersections for statistical evaluation of the results. Unfortunately, errors were made in the "before" volume counts for the southeast-bound traffic northwest of Grand Boulevard. For this reason, signal observance survey data for this approach leg of the Grand Boulevard intersection have been excluded from the analyses of the results.

The City compiled accident data for the period before the signals were painted yellow and for the two "after" periods as explained above. Table 3 includes only the second "after" period. The first "after" data indicate a total of 1440 accidents which is not much different from the total of 1418 obtained during the second period.

STUDY RESULTS

Woodward Avenue

Accident study and signal observance survey results are shown in Tables 1 and 2. These results have been analyzed statistically for significance of the indicated changes in the criteria examined.

Table 4

GRAND RIVER AVENUE
SIGNAL OBSERVANCE SURVEY

Location	Survey Period	Number of Cycles		Entering on Red		Entering on Amber		Abnormal Stops	
		Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow
N. W. of McIntyre	9 - 11A	90*	120	3	2	61	44	6	3
	12N - 2P	120	120	3	2	60	49	1	6
	2:30 - 4:30P	120	120	2	4	74	71	8	4
	6 hr. total	330	360	8	8	195	164	15	13
S. E. of McIntyre	9 - 11A	88*	120	5	7	72	26	5	0
	12N - 2P	120	120	2	5	117	62	10	0
	2:30 - 4:30P	120	120	8	8	166	79	14	0
	6 hr. total	328	360	15	20	355	167	29	0
N. W. of Greenfield	9 - 11A	80	80	1	2	28	45	4	9
	12N - 2P	80	80	0	1	18	23	0	6
	2:30 - 4:30P	80	80	0	0	24	16	2	5
	6 hr. total	240	240	1	3	70	84	6	20
S.E. of Greenfield	9 - 11A	80	80	0	0	20	13	5	2
	12N - 2P	80	80	0	1	18	12	3	5
	2:30 - 4:30P	80	80	0	1	52	64	3	4
	6 hr. total	240	240	0	2	90	89	11	11
*Light was out at 10:28A									

Table 4 - (Page 2)

GRAND RIVER AVENUE
SIGNAL OBSERVANCE SURVEY

Location	Survey Period	Number of Cycles		Entering on Red		Entering on Amber		Abnormal Stops	
		Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow
N. W. of Ward	9 - 11A	80	80	0	0	38	14	3	1
	12N - 2P	80	80	0	0	11	34	1	4
	2:30 -4:30P	80	80	1	0	8	21	1	1
	6 hr. total	240	240	1	0	57	69	5	6
S. E. of Ward	9 - 11A	80	80	1	1	48	41	2	0
	12N - 2P	80	80	4	4	103	129	14	1
	2:30 -4:30P	80	80	4	5	116	129	9	0
	6 hr. total	240	240	9	10	267	299	25	1
N. W. of Grand**	9 - 11A	(80)	(80)	0	0	(60)	(50)	(7)	(13)
	12N - 2P	(80)	(80)	0	(2)	(40)	(53)	(3)	(21)
	2:30 -4:30P	(80)	(80)	0	0	(62)	(86)	(11)	(11)
	6 hr. total	(240)	(240)	0	(2)	(162)	(189)	(21)	(45)
S. E. of Grand	9 - 11A	80	80	2	9	25	33	2	0
	12N - 2P	81	80	0	0	1	2	0	0
	2:30 -4:30P	80	80	2	24	27	76	4	0
	6 hr. total	241	240	4	33	53	111	6	0

**Values for this approach leg are not included in the totals and in the statistical analyses because the "before" volume counts were inaccurate

Table 4 -(Page 3)

GRAND RIVER AVENUE
SIGNAL OBSERVANCE SURVEY

Location	Survey Period	Number of Cycles		Entering on Red		Entering on Amber		Abnormal Stops	
		Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow
N.W. of Warren	9 -11A	115	114	0	0	30	9	5	3
	12N - 2P	120	120	0	1	10	24	1	5
	2:30 -4:30P	107	108	0	1	20	21	3	7
	6 hr. total	342	342	0	2	60	54	9	15
S.E. of Warren	9 - 11A	114	115	0	3	16	22	0	0
	12N - 2P	120	120	0	1	18	18	2	1
	2:30 -4:30P	107	108	0	0	12	18	0	1
	6 hr. total	341	343	0	4	46	58	2	2
N.W. of Second	9 - 11A	115	115	3	4	36	31	1	4
	12N - 2P	120	120	1	1	17	8	0	1
	2:30 -4:30P	107	108	3	1	23	24	1	1
	6 hr. total	342	343	7	6	76	63	2	6
S.E. of Second	9 - 11A	116	115	0	1	28	14	3	4
	12N - 2P	120	120	2	2	39	50	8	6
	2:30 -4:30P	106	108	0	3	22	32	3	3
	6 hr. total	342	343	2	6	89	96	14	13

Table 4 - (Page 4)

GRAND RIVER AVENUE
SIGNAL OBSERVANCE SURVEY

Location	Survey Period	Number of Cycles		Entering on Red		Entering on Amber		Abnormal Stops	
		Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow	Signals Painted Green	Signals Painted Yellow
On Second S. of Grand River	9 - 11A	80	115	0	0	10	18	0	1
	12N - 2P	120	120	0	1	10	9	2	2
	2:30 - 4:30P	110	108	0	2	23	22	3	0
	6 hr. total	310	343	0	3	43	49	5	3
20 Totals for all intersections		3536	3634	47	97	1401	1303	129	90

The decrease in the total number of accidents from 898 to 798 is thus found to be statistically significant. According to this analysis, the average number of accidents per intersection before the color change was 29.93, and reduced to 26.60. This decrease has a probability level between 0.02 and 0.03. However, the City reported that this decrease, which is 11.1%, is not much different from the 9.8% city-wide reduction during the same period.

It is reasonable to assume that the accident type which would be directly related to the inconspicuousness of a signal head color is the right angle collision. Also, daylight conditions are more meaningful than night time. An examination of the accident data is therefore made to single out the right-angle daylight accidents, and this shows a reduction from 53 to 39. But, a statistical analysis indicates that the level of probability is between 0.11 and 0.12 and that this reduction is not significant.

An inspection of Table 2, representing the results of the signal observance surveys, shows that there was an increase in the total vehicles entering the intersections on red signal after the paint change. However, this was statistically not significant (probability between 0.1 and 0.2). A similar and statistically insignificant ($P > 0.9$) increase is also found in the total vehicles entering on amber signal. The only statistically significant change (probability level between 0.02 and 0.05) in the signal observance survey was found in the number of abnormal stops.

A summary of the above changes and whether or not these are statistically significant is contained in Table 5.

Grand River Avenue

Basic summaries of the study and survey results are shown in Tables 3 and 4. As explained under STUDY PROCEDURES, all "after" figures refer to the second time, since the first "after" data were considered inaccurate. Again, all numerical findings were analyzed for statistical significance.

An increase is observed from 1258 total accidents in 1962, before yellow paint was applied to the signals, to 1418 accidents for a one-year period after painting. This is an increase of 160 or 12.7% but statistically not significant ($0.08 > P > 0.07$). During this time, from 1962 to 1964, increase in average daily traffic was 1.5% so that the traffic growth should not have much bearing on the increase in accidents. Of the total 58 intersections, 34 show increase in the "after" period, 18 show decrease and 6 show no change. There are some distinct areas along Grand River within which a great majority of the consecutive signalized intersections indicate worsening of the accident situation, with a few showing no change. There are three such areas: one from Ford Freeway to Maplewood, containing 9 intersections; another from Chicago to Monica, containing 8 intersections; and a third from Stansbury to St. Mary's, containing 8 intersections. These three areas are responsible for a total rise of 157 accidents. Possible causes of these area-wide worsenings of the accident picture should

Table 5

SUMMARY OF RESULTS USED IN EVALUATING
 THE EFFECT OF SIGNAL HEAD COLOR CHANGE
 FROM GREEN TO YELLOW

<u>Criteria</u>	<u>On Woodward Avenue</u>		<u>On Grand River Avenue</u>	
	<u>Change</u>	<u>Statistical Significance</u>	<u>Change</u>	<u>Statistical Significance</u>
<u>Signal Observance</u>				
Entering on Red	Increase	No	Increase	Yes
Entering on Yellow	Increase	No	Decrease	No
Abnormal Stops	Decrease	Yes	Decrease	Yes
<u>Accidents</u>				
Total	Decrease	Yes	Increase	No
Right-Angle Daylight	Decrease	No	Increase	Yes

perhaps be checked into, but this is considered outside the scope of the present study.

Again, if one may reason that right-angle collisions during daylight would be a better indication of the effectiveness of signal head color, it is seen that such accidents have increased from 103 to 140. This is a rise of 36% and is statistically significant ($0.02 > P > 0.01$). Exclusion from the before-and-after comparison those areas of distinct worsening as pointed earlier would leave 43 right-angle accidents during daylight in the "before" period and 61 in the "after". This would be a rise of 18 accidents or 42%.

The results of the signal-observance surveys indicate a rise in the total vehicles entering on red signal, from 47 in the "before" period to 97 in the "after". This change is found to be statistically significant ($P > 0.000033$). Red-signal violation southeast of Grand Boulevard alone has changed from 4 to 33. It is very probable that this had other causes. If this intersection were entirely eliminated from the comparison, red-signal violations "before" would be 43 and "after" would be 64.

Signal violation would be a better indicator of the effect of signal head color if the observance survey did not include congested traffic periods, because during these periods there arise situations where signal violations may somewhat be condoned due to long queues waiting to clear the intersection and vehicles

Table 6

GRAND RIVER AVENUE

COMPARISON OF "THRU-ON-RED" COUNTS DURING
NON-CONGESTION PERIODS

Intersection	Direction	Hours When Volumes Are Less Than 50% of Peak Traffic	Vehicles Going Thru on Red	
			Signals Painted Green	Signals Painted Yellow
McIntyre	S. E. Bound	10 - 11 A	1	1
	"	12 N - 1 P	1	2
	N. W. Bound	9 - 11 A	5	2
	"	12 N - 2 P	2	5
Greenfield	N. W. Bound	9 - 11 A	0	0
	"	12 N - 2 P	0	1
	"	2:30 - 4 P	0	0
Ward	S. E. Bound	9 - 11 A	0	0
	"	12 N - 2 P	0	0
	"	2:30 - 4:30 P	1	0
	N. W. Bound	9 - 11 A	1	1
	"	12 N - 2 P	4	4
	"	2:30 - 4 P	1	3
Grand	N. W. Bound	9 - 11 A	2	9
	"	12 N - 2 P	0	0
	"	2:30 - 4 P	2	14
Warren	S. E. Bound	10 - 11 A	0	0
	"	12 N - 2 P	0	0
	"	2:30 - 4:30 P	0	1
	N. W. Bound	9 - 11 A	0	3
	"	12 N - 2 P	0	0
	"	2:30 - 4 P	0	0
Second	S. E. Bound	1 - 2 P	1	0
	N. W. Bound	9 - 11 A	0	1
	"	12 N - 2 P	2	2
On Second	N. Bound	9 - 11 A	0	0
	"	12 N - 2 P	0	1
	"	2:30 - 4 P	0	2
Total			23	52

following each other with minimal headways. An attempt was therefore made to examine the situation if heavy traffic periods were excluded from the survey results. To do this, hourly approach volumes for each direction were inspected and those volumes which are higher than 50% of the peak hour volume (1964 counts) were discarded (see Table 6). The signal-observance data on hand is of course confined to the basic six hours, so that these results by no means reflect the entire off-peak periods. Under this condition, the number of vehicles going through on red signal before the signals were painted was 23 and increased to 52. This is not materially different from the results of the complete 6-hour tally which showed a doubling in the number of violations.

Total change in the number of vehicles entering on amber signal indication was from 1401 to 1303. This decrease, however, was found to be statistically insignificant ($0.26 > P > 0.25$). The only statistically significant decrease was in the number of abnormal stops from 129 to 90 ($0.02 > P > 0.01$).

CONCLUSIONS

Considering only those differences in the results of the before-and-after comparisons which are statistically significant, the criteria listed in Table 5 reduce to the following:

Table 7

Statistically Significant Changes in Criteria
for Evaluation of the Effect of Signal Color

<u>Criteria</u>	<u>Changes After Painting Signals Yellow</u>
1. Vehicles entering on red signal	: Increased on Grand River Ave.
2. Abnormal stops at signals	: Decreased on both avenues
3. Total accidents	: Decreased on Woodward Avenue
4. Daylight right-angle accidents	: Increased on Grand River Ave.

The above results derive from total figures obtained for all the intersections where surveys were made. A further examination of the individual study-intersections was made, using the same criteria of signal observance and accident experience, to explore the possibility of detecting any revealing facts on the relative merits of the two colors for signal heads. This effort is presented in Table 8. If equal weight may be assigned to the five criteria selected, it is seen that on the Woodward Avenue intersections, 4 out of 5 intersections indicate greater number of decreases in the adverse criteria. On Grand River Avenue, however, all of the 6 intersections indicate greater number of increases in the adverse criteria. It should be remembered, of course, that there is a time lapse of almost two years between the "after" surveys on Woodward and Grand River Avenues, and this time factor may have made comparisons less reliable.

Under the general traffic conditions prevailing on the trunklines considered, the effect of other factors outweigh any small effect the color of the signals may have. For example, looking at the

Table 8

COMPARISON OF STUDY RESULTS BEFORE AND AFTER PAINTING

GREEN SIGNAL-HEADS TO YELLOW

CONDITIONS AT INDIVIDUAL STUDY INTERSECTIONS

Woodward Avenue

	Signals Painted Green	Signals Painted Yellow	Increase (+) or Decrease (-)	Increase (+) or Decrease (-) in Majority of Criteria
<u>State Fair Gate</u>				
Vehicles entering on red	76	29	-	-
" " " amber	836	406	-	-
Abnormal stops	35	41	+	
Total accidents	56	56	0	
Right-angle daylight accid.	2	0	-	

6 Mile Road

Vehicles entering on red	29	69	+	
" " " amber	597	898	+	
Abnormal stops	14	12	-	
Total accidents	50	41	-	
Right-angle daylight accid.	11	9	-	

Chicago

Vehicles entering on red	18	30	+	
" " " amber	304	320	+	
Abnormal stops	31	19	-	
Total accidents	23	20	-	
Right-angle daylight accid.	4	1	-	

Warren

Vehicles entering on red	23	59	+	
" " " amber	579	663	+	
Abnormal stops	45	8	-	
Total accidents	57	39	-	
Right-angle daylight accid.	2	5	+	

Montcalm

Vehicles entering on red	26	69	+	
" " " amber	369	429	+	
Abnormal stops	9	5	-	
Total accidents	11	10	-	
Right-angle daylight accid.	2	1	-	

Table 8 - (Page 2)

Grand River Avenue

	<u>Signals Painted Green</u>	<u>Signals Painted Yellow</u>	<u>Increase (+) or Decrease (-)</u>	<u>Increase (+) or Decrease (-) in Majority of Criteria</u>
<u>McIntyre</u>				+
Vehicles entering on red	23	28	+	
" " " amber	550	331	-	
Abnormal stops	44	13	-	
Total accidents	9	14	+	
Right-angle daylight accid.	0	1	+	

Greenfield

<u>Greenfield</u>				+
Vehicles entering on red	1	5	+	
" " " amber	160	173	+	
Abnormal stops	17	31	+	
Total accidents	51	70	+	
Right-angle daylight accid.	5	8	+	

Ward

<u>Ward</u>				+
Vehicles entering on red	10	10	0	
" " " amber	324	368	+	
Abnormal stops	30	7	-	
Total accidents	10	20	+	
Right-angle daylight accid.	1	2	+	

Grand Boulevard

<u>Grand Boulevard</u>				+
Vehicles entering on red (*)	4	33	+	
" " " amber (*)	53	111	+	
Abnormal stops (*)	6	0	-	
Total accidents	66	82	+	
Right-angle daylight accid.	1	3	+	

Warren

<u>Warren</u>				+
Vehicles entering on red	0	6	+	
" " " amber	106	112	+	
Abnormal stops	11	17	+	
Total accidents	39	56	+	
Right-angle daylight accid.	3	5	+	

Second

<u>Second</u>				+
Vehicles entering on red	9	12	+	
" " " amber	165	159	-	
Total accidents	8	6	-	
Abnormal stops	16	19	+	
Right-angle daylight accid.	2	4	+	

(*) Northwest-bound only 29

accident situation on Grand River Avenue, the statistically significant increase in the right-angle collisions during daylight may not in fact be significant at all for purposes of this study, considering the fact that right-angle collisions during dark hours also increased from 65 to 86, and that the color of signal paint at night should not have any bearing whatever on being easily spotted. This would certainly indicate other major causes for accident aggravation than the effect of signal-head color.

Examining again the results in Table 7 and assuming equal weight for each of the criteria considered, there are 3 decreases, on both thoroughfares, against 2 increases. This may perhaps be interpreted as a favorable point for the yellow color. Considering all the available evidence, however, this study does not provide sufficient data to distinguish clearly between the merits of dark green and yellow paint on traffic signals on the two city trunklines.

It is a fact, of course, that yellow as a light-reflective tone is superior to dark green; and if it is agreed that, to a driver approaching an intersection from a distance, to be able to notice that a signal assembly exists at all is more important than to distinguish which lens indication is on, yellow color should be considered preferable. Further effort to prove this point by expanding the research so that statistically more reliable test parameters could be set up was not deemed justifiable, and it was decided to conclude the study.