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Final Report

WRONG-WAY MOVEMENTS ON PARTIAL CLOVERLEAF RAMPS

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16. Abstract <p>The purposes of this study were: 1) to evaluate the new ramp design (exit and entrance ramps combined into one paved surface separated only by a double yellow line) using actual counts of wrong-way movements and comparing them to data collected in previous research, and 2) To make counts of wrong-way movements on about ten other combined ramps to determine if any have problems.</p> <p>A total of 17 ramps were monitored under this study. Three ramps were considered to have serious wrong-way count problems. On all three ramps, countermeasures were taken to reduce the wrong-way movements.</p> <p>Final conclusions are that the combined ramp geometry does reduce the number of wrong-way movements. But alternate forms of signing and marking may be needed.</p>			
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I. INTRODUCTION

Accidents caused by wrong-way movements account for less than one-half of one percent of all freeway accidents, yet this low percentage of accidents accounts for up to 10% of freeway fatalities. The high fatality rate is due to the severity of wrong-way driving accidents. In California, 18% of wrong-way movements result in fatalities, another 46% produce injuries.¹

A great deal of research has been done by California on wrong-way driving, and much data is available from them on wrong-way accidents and the wrong-way driver. The weekend is the peak time for wrong-way incidents and the peak time of day is from 2-3 AM and from 9-10 PM.¹ Fifty-four percent of wrong-way drivers had been drinking and 63% of wrong-way drivers involved in accidents had been drinking.² Wrong-way driving generally occurs on problem ramps. Based on 796 ramps studied in California³, 85% experienced two moves or less per month, and 12 ramps had from 16 to 86 moves per month. It stands to reason then that a significant number of fatalities can be prevented by identifying problem ramps and taking steps to reduce the number of wrong-way injuries at these ramps.

In Georgia wrong-way movements had been a problem on several partial cloverleaf ramps in the Atlanta area. GDOT Research Project No. 7703, "Wrong-Way Traffic Movements on Freeway Ramps"⁴, identified remedial countermeasures to reduce them, but the movements were not eliminated.

One recommendation from Research Project 7703 was that the on and off ramps from partial cloverleaf interchanges be widely separated so that individual signing can eliminate the confusion at these ramps; however, separating the ramps does increase problems with capacity and traffic. It also requires purchase of additional right of way and signalized locations would require two individual signals at each ramp. This was not feasible in the metro Atlanta area where a major interstate widening program was underway to relieve already

crowded freeways and major arterials. The Connecticut DOT informally experimented with a design in which close exit and entrance ramps would be combined into one paved surface separated only by a double yellow line. The theory of this design is to appeal to the driver's habit of keeping to the right of the yellow line. This design was of great interest to GDOT design engineers, and it was decided to try this design in Georgia. After ten such ramps were designed in the Atlanta area, this study was initiated. Since that time more combined ramps have been designed and constructed and as of this writing it is standard design practice in urban areas.

The objectives of this study were: 1) to evaluate the new ramp design using actual counts of wrong-way movements and comparing them to data collected under Project 7703, and 2) to make counts of wrong-way movements on about ten other combined ramps to determine if any have problems.

II. WRONG-WAY COUNTER

In 1966 the California Department of Transportation developed a wrong-way vehicle detection counter for monitoring freeway ramp locations in that state. In 1977, Georgia Tech purchased 18 of these wrong-way counters from California and initiated a study for the Georgia DOT to monitor 44 Atlanta-area freeway ramps of various configurations.

The device consists of two pneumatic road tubes, A and B, connected to air switches in the cabinet. The circuitry of the device is such that a wrong-way sequence (B-A) will actuate the device. This advances the digital counter and shoots a picture with an instamatic-type snapshot camera.

Counter Use

In order to give a representative idea of the wrong-way rate, an adequate time of study must be used. This, of course, will depend on the rate observed to some extent. A location with a high rate can probably be adequately studied in 30 days. On the other hand, at more normal ramps (which will constitute the vast majority of ramps) wrong-way movements will be very sporadic events, if they occur at all. A short study may happen to include the only movement in a much longer period, but the conclusion would be that there is an inflated wrong-way movement rate. Usually 60 days of "good" data is necessary to establish the wrong-way rate at a location. "Good" data is considered to be counts that are verified by photos. In this study, all counts included in the data base were verified with a photo.

Counter Location

Generally, a location on the tangent part of the ramp is preferred to make it easier to align the road tubes perpendicular to traffic. It is also desirable to locate the camera unit in such a place that it can be chained to a sign, light standard or a guardrail. On some partial cloverleaf ramps it is necessary to locate the road tubes on a curve. If so, the tubes should be placed

perpendicular to the center of the wheel path: It is also preferable to locate the inboard end of the tube on the outside of the curve which results in stronger pulses because the outside wheels tend to carry a higher load.

Finally, it should be noted that the position of the device along the ramp will influence the results. The counter should not be located too close to the cross street. If it is within about 100 feet there may be high counts due to vehicles pulling into the ramp, realizing their mistake, and backing out. The counter should be located far enough along the ramp so that vehicles detected are committed to the wrong-way movement. A suggested distance is 400 feet. In conditions of heavy traffic, queues may form on the ramps. Typically in this situation, some vehicles will roll back over the road tubes and cause an actuation. The farther down the ramp the tubes are located, the less likelihood there is of this happening. Sites which may have heavy traffic should be observed and the counter located beyond the longest peak-hour queues.

Road Tube Installation

After initial setup of warning signs and other safety-related procedures, the next step is to install the road tubes. This can be done by either one or two people and can usually be done in about 20-30 minutes with experience.

An appropriate length of half round or standard round 1/4" I.D. road tube should be measured out by laying it across the roadway. The half round road tube with 1/4" ID is available from The John C. Hemberger Co. of San Diego, California. This is the only supplier known to the author. The round tube is the same as that used by the Department's Planning Data Services Bureau for traffic counts.

There are three different ways to anchor the tubes (Figure 1). Each consists of using a 2½" Parker-Kalon (P-K) masonry nail. When the tubes are secured, there should be enough tension between the anchoring points to keep the tubes from overlapping. On very hot days, this process also causes the

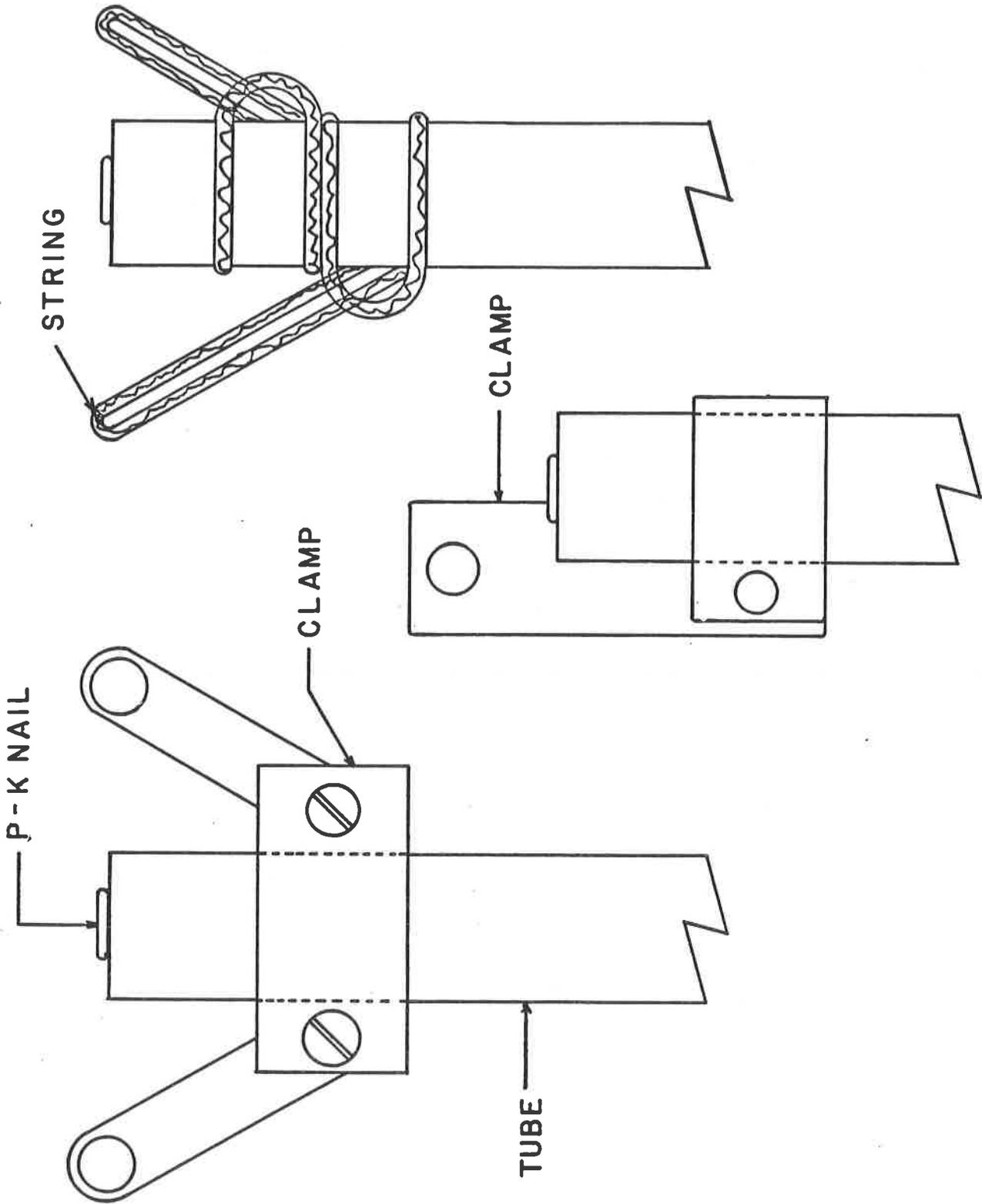


FIGURE 1

nails to pull out of the asphalt. Six inch gutter spikes may have to be used for anchoring. The far end of the road tubes should be sealed to insure a stronger pulse and also to help prevent the infiltration of water into the tubes. Good results can be had using a P-K nail inserted in the tube; however, some water still gets into the tubes occasionally after heavy rains, and they can be blown out with compressed air.

Clamps or string and nails are used to secure the road tube to the roadway. For asphalt roadways, the installation can be done with P-K nails. They can easily be driven with a 3- or 4- pound hammer. During winter a 2" nail is sufficient; however, as the pavement warms up and softens in the summer, short nails will not hold well, even if 2-1/2" or 3" nails are used. In high traffic locations the tubes may be pulled out of the pavement especially by large trucks; therefore, if a concrete curb and gutter is available, the clamps should be secured in it. It is virtually impossible to drive a P-K nail in concrete. In this case, a stud gun can be used for anchoring the tube clamps.

If the roadway is wide (greater than 2 lanes) or there are many turning movements, then a center clamp (Figure 1) should be installed to reduce the stress on the road tubes. The middle of or between traffic lanes is the best place for the clamp.

Counter Installation

Once the road tubes are in place, the wrong-way counter is set up. To install the battery, remove the screws holding down the base for the electronics and camera, remove base plate and put the battery in. There are two battery lead wires; red is positive and white is negative.

After the battery is installed, the air switches should be set. Turn the counter to "ON" and "TEST" (with the two toggle switches on the electronics unit) and then turn the contact adjustments on the air switches (the scaled brass dials) until the light for the corresponding switch comes on; this means the switch is closed. Loosen the screw and turn the dial to 0 and tighten.

The "A" switch should be set to .005"-.006" clearance and the "B" switch should be set to .010" to .014" clearance. Having the "A" switch more sensitive insures that an "A" pulse is not missed. Otherwise the "B" pulse is first and then an "A" pulse on the heavier rear axle registers a false actuation. This is especially a problem with motorcycles.

After the air switches are set, connect the tubes and check the pulses by observing traffic crossing the tubes ("A" tube is the first one hit by right-way traffic). Be sure both tubes are reading. The wrong-way circuit can be checked by reversing the tubes so a right-way vehicle will be "seen" by the counter as wrong-way. Switch the tubes back the right way and make sure the unit doesn't count this way. The counter has a "non-repeat" feature so that after an actuation, the counter cannot be actuated again until 5 seconds have passed without an "A" actuation. False actuations will result if this feature is not functioning correctly. The rotary switch on the electronics unit should be set to the predominant speed of right-way traffic. If in doubt, use a slower speed.

Finally, the camera should be installed, slip the spring behind it and push the solenoid down to make sure it pushes the trigger. The solenoid should be adjusted if necessary. Remove the camera, put in film, wind the frame advance tight and reinstall the camera. Aim the camera so that the tubes are in view. The camera unit should be approximately 40 feet from the tubes to give a clear view of the entire lane(s).

During previous monitoring, there were counter malfunctions. Parts and battery changes were made to solve these problems. Electronic parts were upgraded to function well in high temperatures and moisture conditions that might occur inside the counter. The batteries which were initially used were 7½ volt non-rechargeable lantern batteries. After data was collected, at S.R. 54 and Central Avenue, these were replaced with two 6 volt gel-cell

rechargeable batteries wired in series to give a total of 12 volts. Counter circuitry was modified to be compatible with 12 volt supply. By using 12 volts, under normal conditions, monitoring for 30 days without recharging was possible.

III. RAMPS STUDIED

During the course of this project, a total of 17 ramps were monitored by the Georgia Department of Transportation. Fifteen of these ramps were in the Metro Atlanta Area. Two of the 17 ramps were monitored before and after they were converted to combined ramps. These ramps were I-75 (North) at Jonesboro Road (SR 54) and I-75 (North) at Central Avenue (East).

I-75 North and S.R. 54

The SR 54 partial cloverleaf interchange was known to have a problem with wrong-way movements. A number had been witnessed and people who had accidentally made that movement were known. This location originally had a grass median approximately 25' wide. The grass had been killed by repeated traffic crossing from the exit ramp to the entrance ramp to correct their wrong-way entry. Counts made at this location during widening of Jonesboro Road with standard construction signing in place were 73.3 per 30 day for night and 13.4 per 30 day for day giving a total of 86.7 wrong-way movements per 30-day month.* Construction to combine the ramps was completed in September of 1982. The grass median was eliminated and the exit and entrance ramps were both widened to two lanes each (Figure 2). After reconstruction, the ramps were signed as follows: large pavement arrows in each of the two entrance and exit ramps; double yellow line separating the two ramps, and continued for a distance of 420' down the ramps before the ramps separated; "I-75" trail-blazer signs at the intersection; a "RIGHT LANE YIELDS" sign; and a "KEEP RIGHT" sign at the split of the ramps. Two sets of "WRONG-WAY" and "DO NOT ENTER" signs were located at the exit ramp after the two ramps split. S.R. 54 also has a 4" median to channelize the left turning traffic into the on-ramp. A drawing of the new interchange geometry at SR 54 is shown in Figure 2 and results of the counts are shown in Table 1.

* Wrong-way movements per 30-day month are a combination of day and night movements.

A

JONESBORO ROAD AND I-75 NORTH

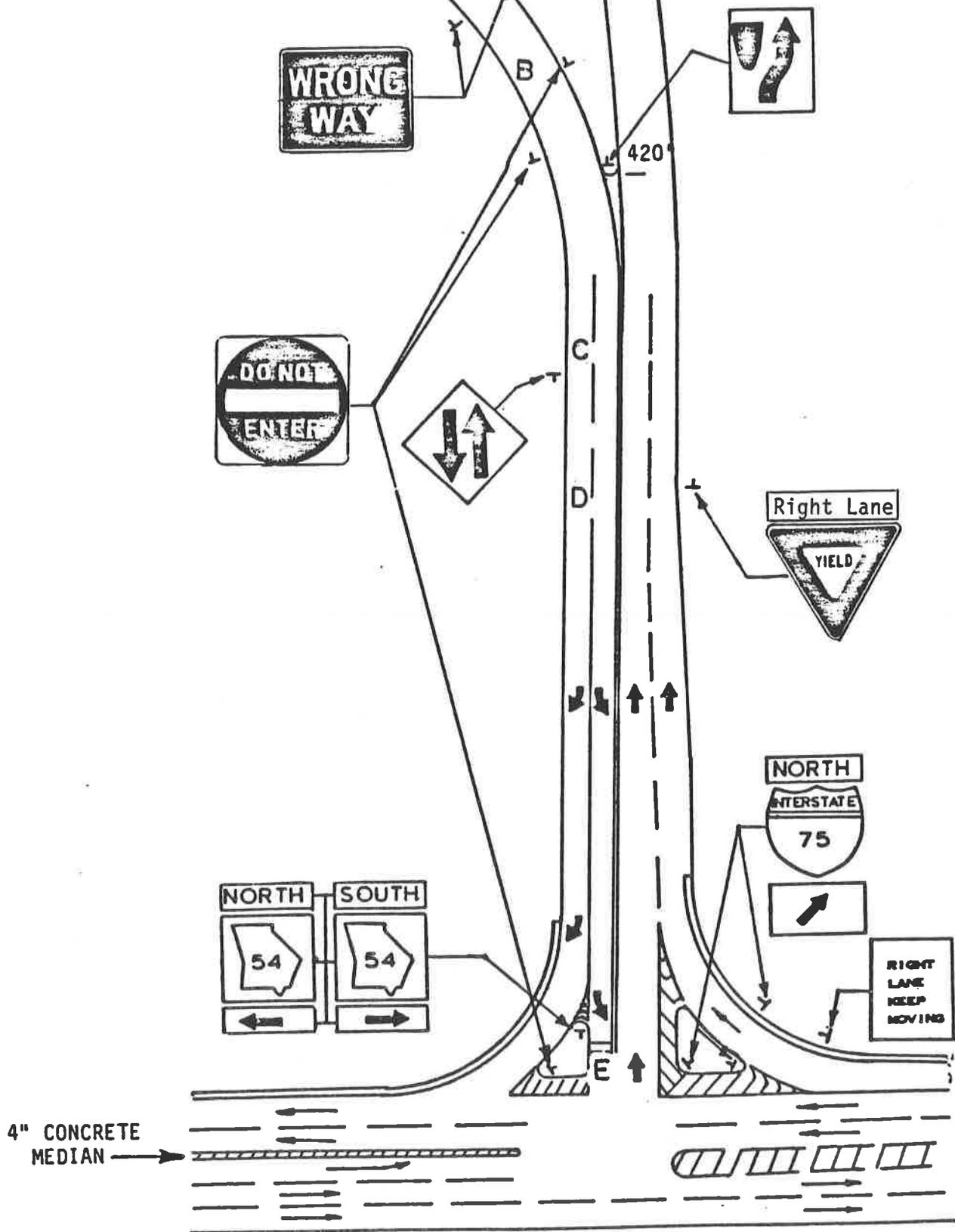


FIGURE 2

TABLE 1

Dates Studied From	To	Location		Wrong-Way Movements	Days Monitored	Rate Per Month
Jonesboro Road (SR 54) at I-75 (North)						
(Counts made before ramps were combined)						
		Location	Countermeasures			
2-79	4-79	A ³	GDOT Standard ¹	6	62	2.9
2-81	3-81	C ³	Jonesboro Road widening under construction. Traffic cones and wrong-way signs	11	24	13.8
3-81	3-81	C ³	Construction complete. Cones removed, signs and striping in place	26	9	86.7
3-81	5-81	C ³	4" concrete median	19	64	8.9
7-81	10-81	C ³	Added 18' pavement arrows, stop bar, raised reflectors	14	56	7.5
5-82	7-82	E ³	Same as above	14	52	8.1
(Counts made after ramps were combined)						
9-82	12-82	B ³	Same as drawing except on-ramps merging. See figure 2	13	119	3.3
10-82	12-82	D ³	Same as drawing except on-ramps merging.	7 ²	78	2.7
1-83	6-83	D ³	Same as drawing - Right Lane yields	1 ²	116	0.3
3-83	6-83	A ³	Same as drawing - Right Lane yields	1	100	0.3

Notes:

1. GDOT Standard Countermeasures: Two DO NOT ENTER signs; one KEEP RIGHT sign at intersection; two WRONG-WAY signs at Point C; an I-75 NORTH sign across SR-54; two 9' pavement arrows (nearly obscure)
2. Does not include actuations caused by vehicles 1-3 feet over the centerline.
3. See locations on Figure 2.

Results

Results from Table 1 show that when the ramps were separated and normal signing installed, a rate of 0.5 per day and 7.0 for night per month was recorded, giving a total of 7.5 per month. After the ramps were combined, the only countermeasures taken were to make the on-ramps merge, which dropped the wrong-way rate to 3.3, and to make the right lane yield, which dropped the rate to 0.3. This location was no longer considered to be a problem location since the rate was now below 3 per 30 day month. After a few weeks of erratic movements, traffic using the location had accepted the new geometry and it performs well. Later, the "RIGHT LANE YIELDS" was removed once motorists were familiar with the location. One author of this report and one other Department employee providing input to this project use this interchange daily. No problems have been noted in the ensuing 5½ years.

I-75 North and Central Avenue

Central Avenue was also singled out for special work because of a known problem with wrong-way movements. Part of the research done at Central Avenue was done as part of Project 7703 and part of the research was conducted in 1979 as a special study entitled "Central Avenue Wrong-Way Movement Study".⁵ Initial counts at Central Avenue showed a very high rate of 88.6 wrong-way movements per 30-day month, 75 per month for days and 13.6 per month for night (Table 2). This location had a very narrow four-foot median of curb and grass between the ramps to and from I-75 northbound. There was a railroad track on the opposite side of the interchange. The original sign package at this location consisted of a "KEEP RIGHT" sign in the median and two sets of "DO NOT ENTER - WRONG WAY" signs on the ramp. Signing and marking improvements were made to this interchange over a period of time and the counters recorded the improvements as individual phases of improvements were made. Changes at Central Avenue include an "I-75 NORTH" trailblazer sign installed to direct left turning traffic onto the on-ramp; "WRONG WAY" and "DO NOT ENTER" signs

TABLE 2

Dates Studied		Location	Wrong-Way Movements	Days Monitored	Rate Per Month	
From	To					
Central Avenue (East) at I-75 (North)						
Original Design						
		Phase	Countermeasures			
4-77	5-78		Before (Original Signing Plan)	65	22	88.6
		1	I-75 Trailblazer and extend centerline	22	15	44
		2	Lowered "DO NOT ENTER" and "WRONG-WAY" signs	15	14	32
		3	Remove above and install 18" stop bar	81	21	44
		4	Remove above and install 8" yellow ceramic buttons to Central Avenue centerline	3	44	2.0
Ramps Combined						
8/85	1/86		Construction complete temporary signing & marking	11	41	8.0
1/86	3/86		Permanent signing & marking installed	15	37	12.1
4/86	5/86		"Chicken Tracks" installed	11	15	22.0
5/86	6/86		Temporary "WRONG-WAY" sign removed	18	14	38.6
6/86			Delineators in Central Avenue Median Installed	14	14	30.0

located on the ramp median were lowered to 18" above the pavement in order to place them more directly in the path of headlight beams at night; an 18" wide stop line was added in the off-ramp; yellow ceramic buttons of 8" diameter were installed on the extension of the centerline of Central Avenue to aid in channelizing left turning traffic; and a long (18') arrow was painted on the off-ramp where it could be seen by Central Avenue. The results of these countermeasures showed a reduction in wrong-way movements from 88 to 2.

The results at Central Avenue prompted a recommendation to the Department to adopt the use of a signing package which includes a trailblazer sign, 18" wide stop line, and an 18' long painted pavement arrow. In addition, 8" ceramic buttons are recommended where wrong-way movements are known to be a problem. Except for the ceramic buttons, all of the above countermeasures are used as standard practice by the Georgia DOT at the present time.

Over two years later, I-75 was widened and the Central Avenue ramps were moved about 200' east of their previous location. Actual ramp construction was completed and opened in July 1983; however, bridge construction to widen Central Avenue was not complete and traffic was required to pass through construction across the bridge at a number of different locations as the construction phases were completed.

Results

Counts at the new ramp location were made from July until December of 1983 and the results are shown in Table 2. The new geometry of Central Avenue Location is shown in Figure 3. After reconstruction and temporary arrows were installed, the wrong-way rate was 8.0, 5.1 day and 2.9 night. Once permanent signing and marking was in place this number rose to 12.1, 5.7 day and 6.5 night. On April 11, 1986 "Chicken Tracks"* were installed on Central Avenue leading onto the ramp. This countermeasure also increased the wrong-way rate

* "Chicken Tracks" are paint strips that lead turning vehicles onto the ramp.

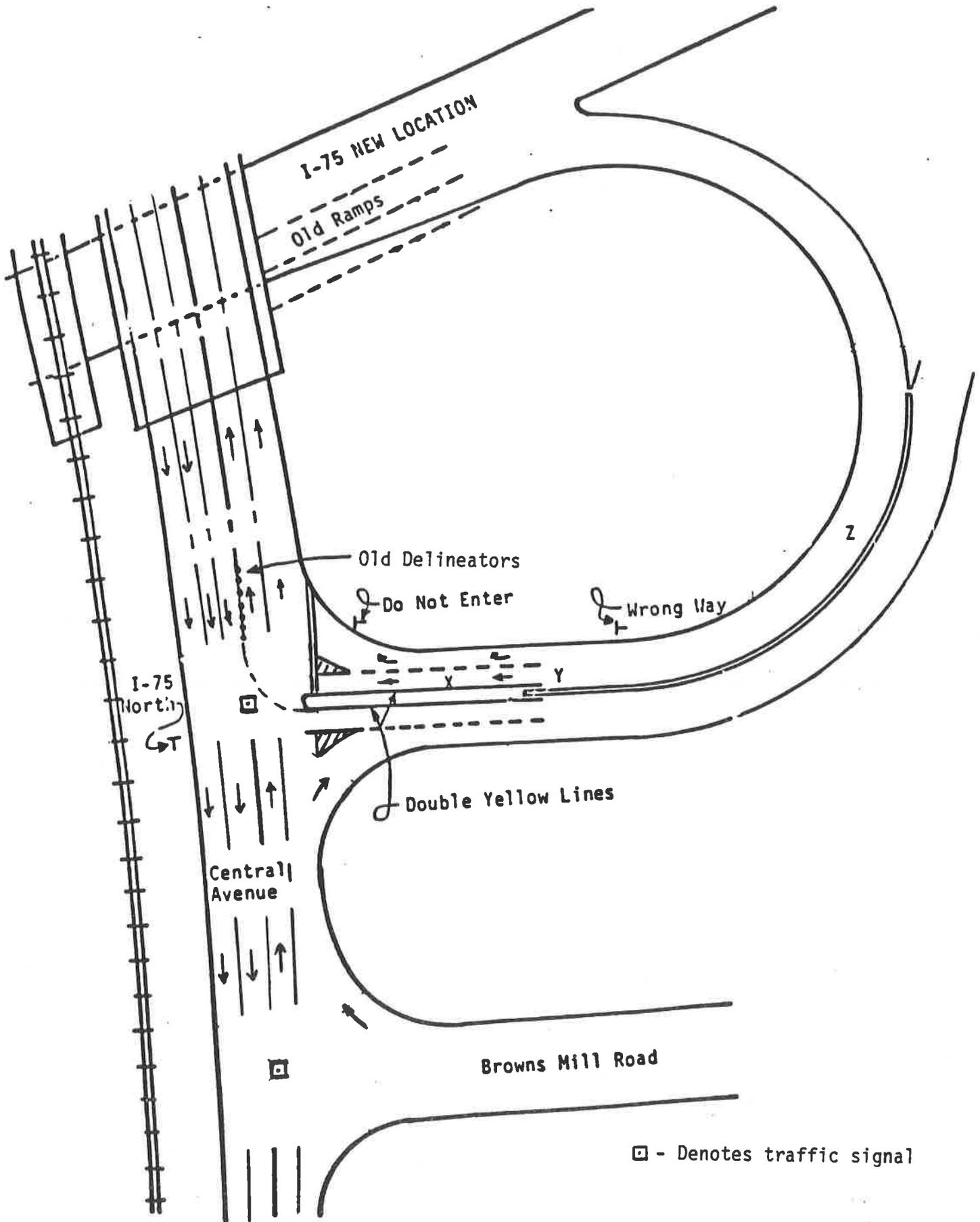


FIGURE 3

an additional 45% to 22.0 per 30 day month, 4.0 day and 18.0 night. When removing the temporary "WRONG WAY" signs, the rate climbed to its highest since reconstruction, 38.6, 19.3 day and 19.3 night. The last countermeasure was to install delineators in the median of Central Avenue. The delineators were intended to keep motorists, making left turns onto the ramp, from turning too soon and possibly turning into the off-ramp. This last measure caused a 22% drop in the wrong-way rate. The rate was now 30.0, 21.4 day and 8.6 night, which was extremely high. Monitoring continued for only 14 days after the delineators were installed due to counter malfunctions.

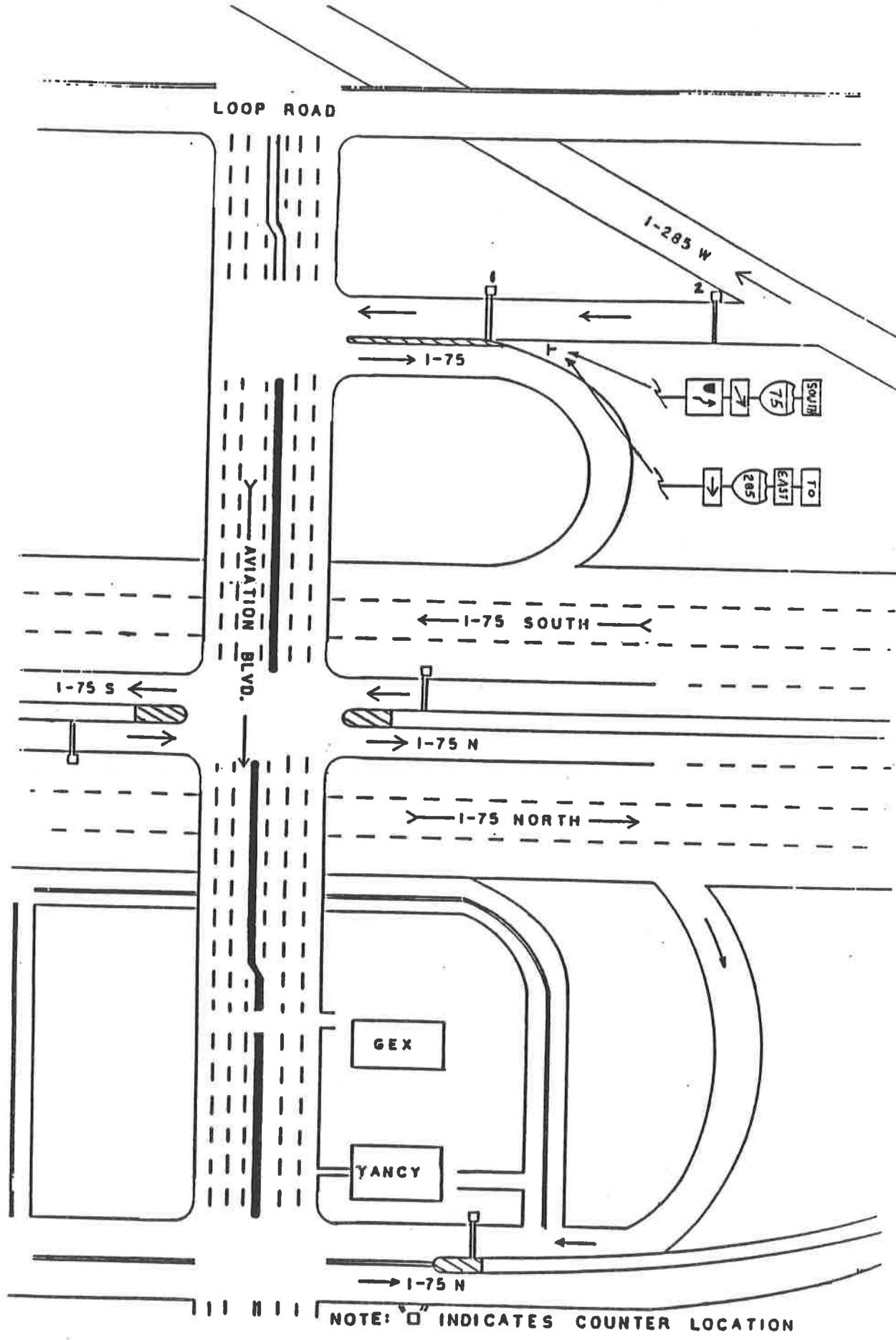
Other Ramps Studied

The mixed results of the two previously mentioned ramps showed the need to monitor additional locations. The study was modified in 1987 to monitor 15 additional combination ramps. The following is a listing of those ramps:

<u>Location</u>	<u>Type</u>
I-285 (East) and Old Dixie Highway	Partial Cloverleaf
I-285 (West) and Old Dixie Highway	Partial Cloverleaf
I-75 (North) and Aviation Blvd.*	Median Entrance/Exit Ramps**
I-75 (South) and Aviation Blvd.*	Median Entrance/Exit Ramps**
I-75 (North) and Aviation Blvd.*	Partial Cloverleaf
I-75 (South) and Central Avenue (West)	Partial Cloverleaf
I-75 (South) and Aviation Blvd.*	Partial Cloverleaf
I-75 (North) and Henry Ford, II Dr. (East)	Partial Cloverleaf
I-75 (South) and Henry Ford, II Dr. (West)	Partial Cloverleaf
I-75 (North) and Northside Dr.	Partial Cloverleaf
I-75 (North) and Northside Dr.	Median Entrance/Exit Ramps**
I-75 (North) and Moores Mill Rd.	Partial Cloverleaf
I-75 (South) and Moores Mill Rd.	Partial Cloverleaf
North Columbus Bypass (S.R. 22 East) and S.R. 219 (River Rd.)	Partial Cloverleaf
North Columbus Bypass (S.R. 22 West) and S.R. 219 (River Road)	Partial Cloverleaf

* See Figure 4

** These ramps presently open to all traffic were designed for future access by high occupancy vehicles to the median lanes when so designated.



NOTE: □ INDICATES COUNTER LOCATION

FIGURE 4

Of these 15 ramps, 11 had zero wrong-way counts and 2 had counts of less than 3 each (See Table 3). These ramps are discussed below. A rate of 3 movements or less per month is considered to be incidental.⁴

I-75 North and Aviation Blvd. (Right-Hand Exit) had a wrong-way count rate of 4.8 per 30 day month. This location was monitored for 62 days and there were a total of 10 wrong-way counts, which were all day time movements. Four of the counts were recorded within the first 10 days of operation. The remaining 6 counts were recorded in the remaining 52 days yielding a rate of 3.2. Observation of the accompanying photos suggest that motorists were traveling the wrong-way deliberately as a short cut to the adjacent Yancey Caterpillar Equipment Company. It was decided that the ramp itself was not the reason for the wrong-way movements and that the rate was falling as people learned their way around the newly reconstructed roadway.

Aviation Blvd. and I-75 South (Right-Hand Exit, at Intersection of Ramp and Aviation Blvd.)(Figure 4) had the worst wrong-way count rate of any of the ramps that were studied during this project. There were a total of 365 confirmed wrong-way counts, 268 day and 97 night, in 226 days of monitoring.* These counts were collected with the ramps original signing and after two separate temporary changes were made. The original signing within the median is shown in Figure 5. With the original signing there were 126 wrong-way counts in 68 days which was a wrong-way rate of 55.6 per 30 day month. It was found that the interstate directional signs on this ramp were different (Figure 5a). These signs were misleading due to the fact that the same ramp is used to get to both I-75 and I-285. It was suspected that motorists were traveling in the right lane (Figure 4) and that they were switching to the left lane because of the direction of the arrows. The I-75 arrow (Figure 5a)

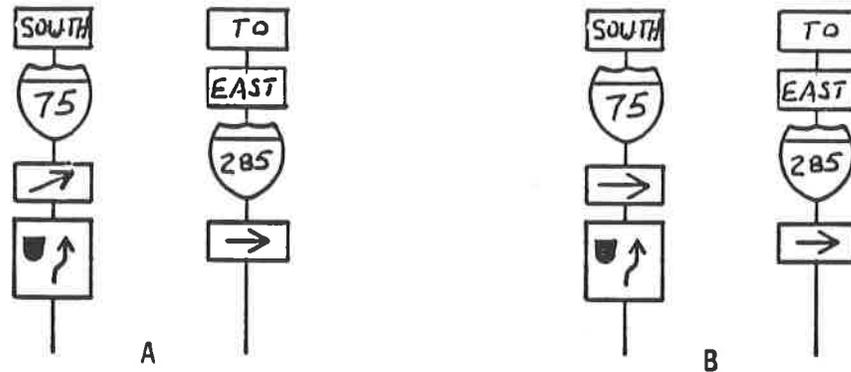
* There were several counts that were not used in the data due to the fact that there were not any photos to confirm these counts.

TABLE 3

Dates Studied From	To	Location	Wrong-Way Movements	Days Monitored	Rate Per Month
3-87	5-87	1. I-285 (East) and Old Dixie Highway	0	32	0.0
4-87	5-87	2. I-285 (West) and Old Dixie Highway	0	53	0.0
4-87	5-87	3. I-75 (North) and Aviation Blvd. (High Occupancy Vehicle)	0	31	0.0
4-87	5-87	4. I-75 (South) and Aviation Blvd. (HOV)	0	41	0.0
4-87	6-87	5. I-75 (North) and Aviation Blvd. (Right-Hand Exit)	10	62	4.8
6-87	7-87	6. I-75 (South) and Central Avenue (West)	0	36	0.0
		7. I-75 (South) and Aviation Blvd. Right-hand exit, at Intersection of Ramp & Aviation Blvd.			
4-87	6-87	a. Standard signing	126	68	55.6
6-87	8-87	b. Interstate directional signs changed	123	56	65.9
8-87	12-87	c. Temporary pavement arrows	116	102	34.1
		I-75 (South) and Aviation Blvd. Right-hand exit, further down ramp at fork			
6-87		a. Standard signing	9	12	22.5
6-87	8-87	b. Interstate directional arrows changed	19	46	12.4
8-87	12-87	c. Temporary pavement arrows	23	78	8.8
7-87	8-87	8. I-75 (North) and Henry Ford, II Dr.	2	31	1.9
7-87	12-87	9. I-75 (South) and Henry Ford, II Dr.	4	61	2.0
10-87	11-87	10. I-75 (North) and Northside Dr.	0	28	0.0
10-87	11-87	11. I-75 (North - HOV) and Northside Dr.	0	28	0.0
10-87	11-87	12. I-75 (North) and Moores Mill Rd.	0	34	0.0
10-87	11-87	13. I-75 (South) and Moores Mill Rd.	0	27	0.0
9-87	12-87	14. S.R. 22 (East) and S.R. 219	0	83	0.0
9-87	12-87	15. S.R. 22 (West) and S.R. 219	0	83	0.0

was replaced with a straight arrow (Figure 5b).

Figure 5

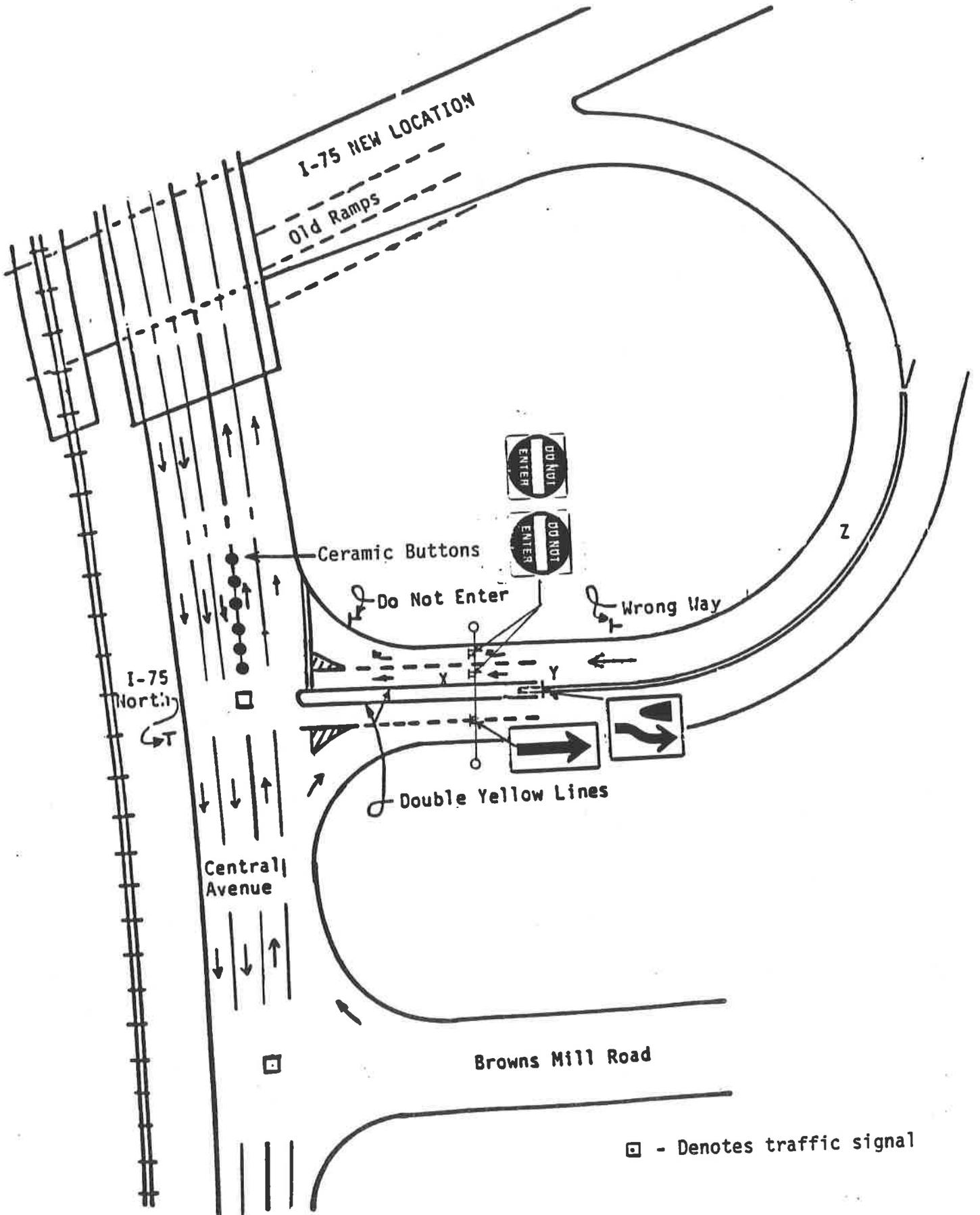


The sign change increased the wrong-way rate from 55.6 to 65.9. GDOT monitored this location after the sign change for 56 days and recorded 123 wrong-way counts. On August 8, 1987, temporary Pavement Arrows were placed on both the On-Ramp and the Off-Ramp to determine if this would help alleviate the confusion. The wrong-way rate dropped to 34.1. It was also recommended that the Interstate Sign Assembly be relocated to the right side of the On-Ramp. The sign assembly has not been relocated to date.

Approximately two months after monitoring began on the same ramp, a second counter was installed approximately 700 feet further down the ramp (Figure 4). The purpose was to determine the number of motorists that were proceeding the full distance to the I-285 ramp. The initial rate before any signing changes were made was 22.5 per 30 day month. 40.5% of the motorists entering the wrong way were continuing on. After the directional signs were changed, this rate dropped to 12.4 per 30 day month. It was unusual that this rate dropped considering that the counter 700 feet up the ramp showed over a 15% increase. Once the temporary arrows were placed, the 30 day rate dropped to 8.8 which was 25.8% of the wrong-way motorists entering the ramp. This number is still high number for vehicles traveling this distance. Once the motorists passed the second counter, it is not known whether they continued, turned around, or took a short cut to I-285 West (Figure 4).

V. RECOMMENDATIONS

1. Add an 18-foot by 9-foot solid head thermoplastic arrow in each lane of each exit ramp within five feet of the stop bar. Where the arrow conflicts with lane-use arrows, enlarge and move the lane-use arrows up to within five feet of the stop bar.
2. Wrong way movements should be monitored at all partial cloverleaf ramps to determine if problems exist.
3. Add eight inch yellow ceramic buttons along the cross street centerline, if all other countermeasures do not work. This will keep motorists from making premature left turns.
4. A minimum distance of 300' is recommended before the beginning of a barrier wall. This will give motorists adequate time to correct their mistake.
5. There should be a continued use of combined ramps in urban areas. Separating the ramp does increase problems with capacity and traffic. It also requires purchase of additional right of way and signalized locations would require two individual signals at each ramp. With proper signing and marking, combined ramps can work.
6. The following countermeasures should be added at Central Avenue (see page 24):
 - . Delineators replaced with eight inch yellow ceramic buttons.
 - . The "Keep Right" sign on top of the barrier wall facing on-ramp traffic to I-75 N.B. should be replaced.
 - . Install overhead directional signs on signal wires for I-75 and Browns Mill Road.
 - . Add two (2) "DO NOT ENTER" signs on the back of existing signs located on Overhead Span Wire structure - facing On-Ramp Traffic.
 - . Add a "Straight Ahead" lane designation sign on the existing Overhead Span Wire structure to be located over the on-ramp to I-75 N.B.



□ - Denotes traffic signal

IV. REFERENCES

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3. Estep, A. C., Wrong-Way Driving on California Freeways 1961-1972. Presentation given at the American Association of State Highway Officials 1972 Summer Meeting of the Operating Subcommittee of Traffic Engineering.
4. Parsonson, Peter S. and Marks, James R., Wrong-Way Traffic Movements on Freeway Ramps, GDOT Research Project 7703, Final Report, Office of Materials and Research, Georgia Department of Transportation, Atlanta, GA, September 1979, 97 pages.
5. Middlebrooks, Percy B. and Parsonson, Peter S., Central Avenue Wrong-Way Movement Study, Special Report, Office of Materials and Research, Georgia Department of Transportation, Atlanta, GA, December, 1979, 13 pages.