Wrong-Way Driving Prevention Methods

Requested by
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October 2, 2015

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Executive Summary

Background

Caltrans' Division of Traffic Operations would like to identify effective methods used by other transportation agencies for reducing wrong-way driving incidents and accidents. Caltrans is interested in learning what wrong-way improvements are used by other agencies to reduce wrong-way crashes, such as detection systems, warning signage, freeway interchange designs and enhanced enforcement for driving under the influence (DUI).

To assist Caltrans in identifying methods for preventing wrong-way crashes, CTC & Associates:

- Gathered information on state practices through a phone survey of selected state DOTs.
- Conducted a literature search on wrong-way driving countermeasures, focusing on those resources that relate to the topics covered in the survey questions, the role of driver age, and the role of lack of familiarity in wrong-way driving incidents.

Summary of Findings

Overall, both the consultation with state DOTs and the literature review showed that there are a large number of resources related to preventing wrong-way driving.

Illinois and Texas seem to be at the forefront of wrong-way driving research, and Florida DOT and Michigan DOT are also engaged in ongoing wrong-way driving pilot projects. While no states use enhanced lighting as a countermeasure or have conducted public awareness campaigns, and most do not vary countermeasures by ramp type, most states are investigating the use of countermeasures beyond pavement signs and markings. This includes the deployment of TAPCO devices (which use radar detection of wrong-way drivers to trigger flashing LEDs around wrong-way signs) as well as Texas DOT's exploration of the use of TraffiCalm devices, which employ two radar systems and a camera to remedy the problem of false alarms seen with TAPCO devices. Texas DOT also provided useful information on real-time warnings to drivers and coordination of response to incidents, and Texas A&M Transportation Institute is developing a connected vehicle testbed that can be used for wrong-way driving.

The literature review results indicate that there is an ongoing, widespread interest in wrong-way driving countermeasures, including a recent wrong-way driving summit, an ongoing NCHRP project, and pilot projects in Arizona and Florida. There seems to be ample evidence that partial cloverleaf exchanges are particularly problematic, and that the largest factors in wrong-way driving incidents are age and cognitive impairment (due to alcohol or some other factor). There is some evidence that lowering warning sign heights or using LEDs and TAPCO devices may reduce wrong-way driving incidents. However, detection systems may require further development in order to eliminate false positives before DOTs are comfortable using them on a large scale.

CTC conducted interviews with seven states concerning their wrong-way driving countermeasures: Florida, Illinois, Maine, Michigan, Montana, Texas and Washington. Their responses are summarized below.

Consultation with State Departments of Transportation

- **Documents and research:**
    - All states except Maine provided details on their wrong-way driving countermeasures (see Appendices A-1 to F-5).
    - Illinois and Texas have both done a significant amount of research on the effectiveness of wrong-way driving countermeasures, and Illinois hosted the 2013 National Wrong-Way Driving Summit. Florida DOT and Michigan DOT are engaged in ongoing pilot projects related to wrong-way driving. Illinois research pinpointed problematic ramp types (such as the partial cloverleaf), and Texas research showed a 38 percent reduction in incidents after LED-embedded TAPCO signs were implemented.
    - Florida DOT shared its wrong-way driving monitoring reports and information on crash characteristics.
    - Several states are exploring the use of intelligent transportation systems (ITS) to target wrong-way driving (see **Expansion of countermeasures** below).
    - No states have conducted research based on interviews with wrong-way drivers.
- **Varying countermeasures by ramp type:** Only Washington varies its countermeasures by ramp type: Systems are different for loop and diamond ramps. Michigan is targeting new countermeasures for partial cloverleaf interchanges.
- **Enhanced lighting as a countermeasure:** No states use enhanced lighting as a countermeasure, but Florida is adopting a statewide practice of having lighting at all exit ramps in three to five years.
- **Incidents by ramp type:** All states but Montana said partial cloverleaf or cloverleaf ramps were problematic. Michigan and Illinois have confirmed this with their own research. None of the interviewed states uses carpool drop ramps.
- **Expansion of countermeasures beyond signage and pavement markings:**
    - All states but Montana and Michigan have explored the use of TAPCO devices with radar detection of wrong-way drivers that triggers flashing LEDs around wrong-way signs. These devices can also take pictures of cars as they pass and send automatic alerts to traffic management centers. However, the devices appear to have problems with false alerts.
    - Texas, which seems to be the most active state in this area, is exploring newer devices from TraffiCalm Systems that aim to minimize false alarms by incorporating two radar systems (one pointing down-ramp and another pointing up-ramp) along with a camera for confirmation (see Appendix D-8). Texas A&M Transportation Institute is also contracted with Texas DOT to develop the concept of operations and functional requirements for a connected vehicle testbed that can be used for wrong-way driving.
    - Maine DOT is making use of rectangular rapid flashing beacons.
- **Public awareness campaigns:** No states have public awareness campaigns for wrong-way driving, but several states mentioned the relevance of campaigns against drunk driving, since wrong-way drivers are often intoxicated.

- **Real-time warnings to drivers:** Only Texas DOT uses changeable message signs to alert drivers to wrong-way incidents. It does so based on 911 calls monitored by traffic management center operators. See Appendix D-10 for a media report of a motorist who moved out of the way of a wrong-way driver because of a dynamic message sign (DMS) warning, and see Appendix D-11 for message sign details.
- **Coordination of response to incidents:** All states except Illinois have some coordination with police via dispatch centers. In Florida and Washington, the traffic management centers are collocated with the states' highway patrol offices. In San Antonio, Texas, the city police dispatcher sits next to the operations officer. When a 911 call comes in, an e-tone is triggered if the incident involves a wrong-way driver. Police give the location of the incident, and the operator puts up DMS messages and looks for cameras in the area.
- **Interest in pooled fund study:** Maine DOT is not interested in a pooled fund study; staff at Illinois, Michigan, Montana and Texas DOTs might be; and Florida DOT and Washington State DOT are definitely interested. Our contact at Florida DOT was very enthusiastic about this possibility, and offered to help write the project scope.

Related Resources

National Guidance and Research

- The 2013 National Wrong-Way Driving Summit included several presentations on countermeasures.
- A 2012 NTSB study includes a description of countermeasures and case studies of nine wrong-way driving incidents.

Research in Progress

- NCHRP Project 03-117 is exploring the "type(s), number and location(s) of traffic control devices required on freeway and expressway ramps" and other locations.
- Arizona DOT is evaluating wrong-way driving detection and warning systems.
- The ENTERPRISE pooled fund study is conducting research on wrong-way driving countermeasures that will include a survey of DOTs concerning active deployments.
- Florida DOT is using a driving simulator to evaluate the effectiveness of countermeasures, Florida's Turnpike Enterprise is evaluating wrong-way driving incidents and countermeasures, and Minnesota DOT is examining the use of directional rumble strips to prevent wrong-way driving.

Research by Topic

Countermeasures

- A 2015 study assessed information gathered during the 2013 National Wrong-Way Driving Summit. (See page 19.) The study found that:
    - Adding a second identical sign on the left side of the roadway and increasing the size of wrong-way signs are the most acceptable and beneficial countermeasures.
    - Caltrans' case study justified the application of lower-mounted signs, which reduced wrong-way driving incidents by about 90 percent.

    - TxDOT experienced a 30 percent reduction in wrong-way driving incidents after adding LEDs to the borders of Do Not Enter and Wrong Way signs.
    - Pavement marking applications and improvements at problem locations showed promising outcomes, reducing wrong-way incidents by 40 percent for the North Texas Tollway Authority.
- Illinois DOT's *Guidelines for Reducing Wrong-Way Crashes on Freeways* provides comprehensive guidance on wrong-way driving countermeasures.
- France is experimenting with a new wrong-way warning sign consisting of a no-entry symbol on a yellow background (see page 22).

Detection and Warning

- Florida has an ongoing pilot deployment of a wrong-way driving detection and prevention system. The system consists of radar detection devices that trigger red flashing beacons.
- A 2013 Arizona study examined five different detection technologies on freeway exit ramps: microwave sensors, Doppler radar, video imaging, thermal sensors and magnetic sensors. The study showed that "wrong-way vehicles can be detected using easily deployable equipment that is currently available on the market. While each system tested over the trial period had missed or false calls, none of the systems were installed under the vendors' ideal conditions."
- A 2015 German study tested a cost-efficient, "energy self-sufficient system based on low power radio technology." New Zealand and Japan have also evaluated wrong-way driving detection systems.

Characteristics of Incidents

- A 2012 Illinois study (see page 28) is a major source of information for wrong-way driving characteristics: "A large proportion of wrong-way crashes occurred during the weekend from 12 midnight to 5 a.m. Approximately 60% of wrong-way drivers were DUI drivers. Of those, more than 50% were confirmed to be impaired by alcohol [and] 5% were impaired by drugs." This study also shows partial cloverleaf interchanges to be problematic, and was cited by several interviewees for this Preliminary Investigation.
- A 2014 Texas DOT study (see page 20) yielded similar conclusions, finding that wrong-way driving crashes typically occur between midnight and 5 a.m., with a peak around 2 a.m., with driving under the influence a "primary contributing factor."
- A study of French divided roads from 2008 to 2012 showed that wrong-way driving crashes are more likely to occur at night and involve drivers that are older and intoxicated. A Dutch study also found alcohol and age to be significant factors in wrong-way driving incidents.
- Michigan research found that 60 percent of crashes for which the wrong-way entry point was known involved a partial cloverleaf exchange.

Gaps in Findings

- There is limited research on ITS solutions beyond TAPCO devices, and the more advanced features of the devices seem to be in limited use by DOTs because of false positives. The TraffiCalm system being tested in Texas appears to be a more robust emerging technology.
- CTC was unable to arrange interviews with Arizona DOT and Rhode Island DOT, which are both active in evaluating wrong-way driving countermeasures.
- There was no research available concerning driver accounts of why they went the wrong way up ramps. Such research would require obtaining police reports, which only Washington seems to have attempted to do (without success). A series of Dutch studies concluding in 2000 made some use of police reports; see page 32.

Next Steps

Moving forward, Caltrans could consider:

- Following up with Florida, Michigan and Texas concerning their ongoing pilot and research projects.
- Initiating research based on police reports of wrong-way driving accidents in order to determine what led drivers to go the wrong way.
- Contacting the North Texas Tollway Authority for information on the effectiveness of using 2-foot sign elevations.
- Investigating newer devices from TraffiCalm Systems that incorporate dual radar systems and a camera in an effort to minimize false alarms in detecting wrong-way vehicles.

Detailed Findings

Consultation with State Departments of Transportation

To gather information on wrong-way driving prevention methods used by other states, CTC conducted phone interviews with representatives of the following state DOTs: Florida, Illinois, Maine, Michigan, Montana, Texas and Washington. CTC also contacted Arizona, Minnesota, New York and Rhode Island DOTs, but was unable to schedule interviews with these states. Interview questions were as follows:

1. Please share the following documents related to wrong-way driving, if available:
    - Standard plans and guidance for wrong-way driving countermeasures in your state.
    - Any research on the effectiveness of your state's wrong-way driving countermeasures. Caltrans is especially interested in studies of wrong-way driving-related crashes before and after changes to ramps.
    - Wrong-way driving monitoring reports or reporting criteria for your state.
    - Any research on the application of Intelligent Transportation Systems to wrong-way driving in your state.
    - Any information your agency has on the causes of wrong-way driving incidents based on interviews with drivers involved in them. Caltrans is interested in drivers' accounts of why they went the wrong way up a ramp, where they were when they realized they were going the wrong way, and what specifically made them aware they were going the wrong way (for example, a sign, or seeing oncoming traffic).
2. Does your agency use different kinds of wrong-way warning systems for different kinds of ramps (e.g., diamond vs. loop ramps)?
3. Have you used enhanced lighting as a countermeasure for wrong-way driving?
4. Do you know of any research indicating that certain types of interchanges or ramps have higher numbers of wrong-way driving incidents? Are drop ramps serving carpool lanes especially problematic?
5. Is your agency involved in incrementally improving its wrong-way driving countermeasures, to expand beyond signage and pavement markings?
6. Does your agency conduct public awareness campaigns concerning wrong-way driving?
7. Do you have methods for providing real-time warning to other drivers about wrong-way driving incidents, for instance by using changeable message signs?
8. How do agencies in your state coordinate responses to wrong-way driving incidents when they are in progress?
9. Would your agency be interested in joining a pooled fund study investigating methods for reducing the rate of wrong-way driving incidents?

Florida Department of Transportation

Raj Ponnaluri, Arterial Management System Engineer, 850-410-5418,
raj.ponnaluri@dot.state.fl.us.

1. Documents and research

- See Appendices A-1 and A-2 for minimum sign and pavement marking requirements.
- See Appendix A-3 for a presentation on Florida's statewide Wrong-Way Driving initiative.
- For wrong-way driving monitoring reports, see https://firesportal.com/Pages/Public/QuickStats.aspx
- Because Florida DOT doesn't have video recordings of wrong-way driving incidents, it's difficult to know what drivers correct, and when. FDOT does have the technology to take pictures of both the front and back of vehicles when they are detected going the wrong way on a ramp, but the agency does not save them because of public records issues.

2. Do countermeasures vary by ramp type?
No. FHWA has approved two experimental measures in Florida: the use of LED raised pavement markers as a warning (see http://safety.fhwa.dot.gov/intersection/resources/techsum/fhwasa09007/) and the use of rectangular rapid flashing beacons (see Appendix A-3). The latter are being used at six locations in the Tampa Bay area. LED raised pavement markers have not yet been deployed, but FDOT believes this may be one of the best countermeasures, since an impaired driver's cone of vision drops horizontally.

3. Use enhanced lighting as a countermeasure?
No, but lighting is a significant cause for concern, and helps. Florida is adopting a statewide practice of having lighting at all exit ramps in three to five years.

4. Incidents by ramp type
Illinois DOT has done significant work in this area. One of their conclusions is that semi-cloverleaf ramps have a higher rate of wrong-way driving incidents, since the exit and entry ramps are next to each other. Florida does not have drop ramps.

5. Expansion of countermeasures beyond signage and pavement markings?
Yes. Florida is interested in warning systems on exit ramps, including TAPCO devices (see http://www.tapconet.com/solar-led-division/wrong-way-warning-detection-and-alert-system). These devices include LEDs around the wrong-way sign, and radar to detect drivers and initiate the flashing of LEDs. The device can also take a picture of the back of the car as it passes, and send an automatic alert to a traffic management center. Florida is using these devices on a pilot basis in several locations.

6. Public awareness campaigns?
Not directly, but Florida DOT interacts with the media on a regular basis concerning driving under the influence, which is a factor in wrong-way driving.

7. Real-time warnings to other drivers?
No. Florida has the ability, but doesn't do so regularly and doesn't have a standard operating procedure for this. Information from Texas seems to suggest that it is a mistake to tell drivers which lane a wrong-way driver is in, because the wrong-way driver might change lanes. So

there needs to be caution about what information to give to other drivers. Wrong-way driving incidents move so quickly that by the time they are detected and the message is passed to a traffic management center, they are already over.

8. Coordination of response to incidents
Florida DOT's travel management center is collocated with the Florida Highway Patrol, so coordination is very good.

9. Interested in a pooled fund study?
Yes. Florida DOT is looking for tangible, realistic, implementable actions. Ponnaluri would be happy to assist in writing the project scope. He suggested that the scope should focus on making good decisions using available crash data, not just on pavement markings and signage but also other technology solutions.

Illinois Department of Transportation

Tim Sheehan, Safety Design Unit Chief, 217-782-3568, Tim.Sheehan@illinois.gov.

1. Documents and research
Illinois DOT initiated a wrong-way driving investigation through the Illinois Center for Transportation in 2010, with several phases. A 2012 report looked at 10 locations for trends, including which types of ramps were more prevalent, and IDOT published mitigation guidance in 2014. The department engaged in mitigation via signage and pavement markings for 420 interchanges on freeways using standard details provided to all districts (see Appendices F-1 to F-5). A future report will look at the effectiveness of these mitigation measures. Documents include:

- *Investigation of Contributing Factors Regarding Wrong-Way Driving on Freeways*, 2012.
  http://cetrans.isg.siue.edu/wwd/FHWA-ICT-12-010.pdf
  See page 28 of this Preliminary Investigation for details.
- *Guidelines for Reducing Wrong-Way Crashes on Freeways*, 2014.
  https://www.ideals.illinois.edu/bitstream/handle/2142/48998/FHWA-ICT-14-010.pdf?sequence=2
  See page 21 of this Preliminary Investigation for details.

Illinois also hosted the National Wrong-Way Driving Summit in 2013; see https://www.ideals.illinois.edu/handle/2142/49045. See page 16 of this Preliminary Investigation for details.

2. Do countermeasures vary by ramp type?
No. Wrong-way driving incidents are concentrated on partial cloverleaf ramps, and Illinois DOT uses additional signage and pavement markings on these.

3. Use enhanced lighting as a countermeasure?
No.

4. Incidents by ramp type
Partial cloverleaf ramps have more wrong-way driving incidents. See *Investigation of Contributing Factors Regarding Wrong-Way Driving on Freeways*, 2012 (http://cetrans.isg.siue.edu/wwd/FHWA-ICT-12-010.pdf).

5. Expansion of countermeasures beyond signage and pavement markings
Illinois DOT deployed a TAPCO flashing warning sign at one problem location, and is looking for other solutions.

6. Public awareness campaigns?
No. There was some coverage of Illinois' National Wrong-Way Driving Summit.

7. Real-time warnings to drivers?
No.

8. Coordination of response to incidents
Police respond to 911 calls. Illinois DOT does not coordinate with police during incidents, but works with them on reconstructing wrong-way driving accidents.

9. Interested in a pooled fund study?
Maybe, depending on the cost and goals.

Maine Department of Transportation

Duane Brunell, Safety Office, 207-624-3278, Duane.Brunell@maine.gov.

1. Documents and research
Maine DOT has no formal research in the area of wrong-way driving incidents. Anecdotally, problem ramps are cloverleaf and partial cloverleaf locations. Maine doesn't have a huge Interstate system compared to other states, and so doesn't have many wrong-way driving incidents. Nevertheless, Maine DOT is looking at upgrading its wrong-way warning systems. Maine DOT uses the Manual on Uniform Traffic Control Devices (MUTCD) for standard plans and guidance.

2. Do countermeasures vary by ramp type?
No.

3. Use enhanced lighting as a countermeasure?
No.

4. Incidents by ramp type
Cloverleaf and partial cloverleaf ramps are most problematic. Incidents usually involve the elderly or the intoxicated.

5. Expansion of countermeasures beyond signage and pavement markings
Maine DOT is looking at TAPCO systems with LED lights surrounding signs, which flash after radar detection of a vehicle. The system can also send electronic alerts to DOT dispatch and state police via email or text. Maine DOT's pilot unit is also connected to a digital camera that can send five still frames, so operators can see if the vehicle is continuing onto the freeway rather than self-correcting. Maine DOT is still working on technology issues with this system (and is not using alerts). The department is also making a request to FHWA to use rectangular rapid flashing beacons (RRFBs) on an experimental basis. Because these devices are solar powered and Maine is a winter state, it is unclear if they will maintain their charge. (Rhode

Island has just completed a major effort with RRFBs). Maine DOT is also looking at low-cost solutions, such as turn lane skips and further use of ENTER HERE signs.

6. Public awareness campaigns?
No.

7. Real-time warnings to drivers?
No. Maine does not have the density of DMSes that would make this approach effective. The department is looking at a major DMS upgrade along its Interstates, and once that happens may use them to alert motorists of wrong-way drivers.

8. Coordination of response to incidents
Coordination with the Department of Public Safety occurs through the DOT's dispatch capabilities.

9. Interested in a pooled fund study?
Probably not. Brunell indicated that Maine DOT is a minor player in this area.

Michigan Department of Transportation

Tracie Leix, Supervising Engineer, 517-335-2233, LeixT@michigan.gov.

1. Documents and research
From 2010 to 2011, Michigan DOT conducted an effort analyzing 110 wrong-way crashes that occurred between 2005 and 2009 (see Appendix B-4). As a consequence of the study, the department is implementing several countermeasures (see pages 5 to 7 of Appendix B-4; for details of countermeasures, see Appendices B-1, B-2 and B-3). Regions have until 2019 to install these countermeasures. Michigan DOT has no research on ITS or driver accounts of why they went the wrong way.

2. Do countermeasures vary by ramp type?
Michigan DOT's target ramp style for new countermeasures is the partial cloverleaf interchange (on/off ramps parallel to each other and perpendicular to the cross street) and similar designs (trumpet, etc.). Michigan DOT has an estimated 161 interchanges that it is targeting with seven low-cost countermeasures (see pages 5 to 7 of Appendix B-4). Other interchanges in the state will require two of the seven countermeasures: lowered bottom height of the Wrong Way/Do Not Enter signs, and reflective sheeting on signposts.

3. Use enhanced lighting as a countermeasure?
No.

4. Incidents by ramp type
Michigan DOT's research indicates that partial-cloverleaf-style interchanges are susceptible to wrong-way movements. It does not have drop ramps for carpool lanes.

5. Expansion of countermeasures beyond signage and pavement markings?
No. Michigan DOT is always seeking to improve its systems, but has not installed any countermeasures beyond signing and pavement markings/delineation.

6. Public awareness campaigns?
No.

7. Real-time warnings to drivers?
Michigan DOT is currently discussing this internally. For more information, contact Hilary Owen at owenh2@michigan.gov.

8. Coordination of response to incidents
When possible, the dispatch center contacts MDOT Operations for coordination.

9. Interested in a pooled fund study?
Maybe. Please contact Mark Bott, Engineer of Traffic and Safety, at bottm@michigan.gov.

Montana Department of Transportation

Ivan Ulberg, Traffic Design Engineer, Traffic and Safety Bureau, 406-444-6217, iulberg@mt.gov.

1. Documents and research
Montana DOT is engaged in a statewide upgrade of all ramp signage using standard treatments, including red delineators, redundant wrong-way signs, dropping the height of signs to 4 feet, using words rather than symbols, and painting arrows on ramps. See Appendix C for details. The department has not conducted before-and-after studies, and has only one to seven wrong-way crashes a year, making it difficult to analyze trends.

2. Do countermeasures vary by ramp type?
No.

3. Use enhanced lighting as a countermeasure?
No. Montana DOT lights all its ramps.

4. Incidents by ramp type
Montana sees more incidents at urban interchanges. Drivers are usually tired, elderly or under the influence.

5. Expansion of countermeasures beyond signage and pavement markings
Montana DOT has no formal plan to expand beyond signage and pavement markings, but is open to this possibility for interchanges with repeated incidents.

6. Public awareness campaigns?
No. Public awareness campaigns focus on drinking and driving and buckling seatbelts. Wrong-way accidents are a small percentage of crashes.

7. Real-time warnings to drivers?
No.

8. Coordination of response to incidents
Coordination occurs by phone and radio.

9. Interested in a pooled fund study?
Maybe.

Texas Department of Transportation

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- John Gianotti, Transportation Engineer, Texas DOT, 210-731-5240, John.Gianotti@txdot.gov.
- Melisa Finley, Research Engineer, Traffic Operations and Roadway Safety Division, Texas A&M Transportation Institute, 979-845-7596, M-Finley@tti.tamu.edu.

1. Documents and research

- See Appendices D1 to D3 for the details of Texas DOT's San Antonio district's initiative on wrong-way signs and radar detectors. Other localities in Texas have asked for these details, since San Antonio is a leader in wrong-way driving countermeasures. See Appendices D4 to D6 for examples of how Texas DOT added wrong-way detection devices to a construction project.
- A 2014 Texas DOT study (*Assessment of the Effectiveness of Wrong Way Driving Countermeasures and Mitigation Methods*, http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-6769-1.pdf) examined the effectiveness of countermeasures using wrong-way driving events in San Antonio (see Chapter 4, page 90, for data). Results showed a 38 percent reduction in wrong-way driving incidents from 2007 to 2011 on Interstate 281 after LED-embedded TAPCO signs were implemented. More recent data from 2012 to 2015 shows a 29 percent reduction (see Appendix D-7). The difference in rates of reduction is due in part to more recent data relying only on Texas TransGuide operator logs rather than a combination of TransGuide data and San Antonio Police Department data. (TransGuide is an Intelligent Transportation System developed by the San Antonio District of Texas DOT; see http://www.transguide.dot.state.tx.us/SAT/sat.htm.) For information on the effectiveness of using 2-foot sign elevations, contact Eric Hemphill of the North Texas Tollway Authority at 214-224-2166 or ehemphill@ntta.org.
- Texas DOT does not have statewide criteria for wrong-way driving monitoring reports. San Antonio and Houston track incidents via 911 calls. The state's crash reporting includes a way to flag wrong-way driving via a number of different variables, and Texas DOT relies on the police to code these. Houston is starting to work with police and 911 logs to mark wrong-way driving events.
- Texas DOT doesn't have information on driver accounts of why they went the wrong way, but the San Antonio Police Department might. Interviewees were not aware of a formal way for processing wrong-way drivers.

2. Do countermeasures vary by ramp type?
No.

3. Use enhanced lighting as a countermeasure?
No. Roadways are continuously illuminated.

4. Incidents by ramp type
There is no data from Texas. See Illinois DOT's research and guidance:

- *Investigation of Contributing Factors Regarding Wrong-Way Driving on Freeways,* 2012. http://cetrans.isg.siue.edu/wwd/FHWA-ICT-12-010.pdf
  See page 28 of this Preliminary Investigation for details.
- *Guidelines for Reducing Wrong-Way Crashes on Freeways,* 2014. https://www.ideals.illinois.edu/bitstream/handle/2142/48998/FHWA-ICT-14-010.pdf?sequence=2
  See page 21 of this Preliminary Investigation for details.

5. Expansion of countermeasures beyond signage and pavement markings
Texas DOT uses two types of radar, one for ramps (TAPCO) and one for mainlines. TAPCO devices have not worked optimally as an intelligent transportation system. In theory the devices can send alerts for wrong-way driving incidents, which should allow operators to bring the incident up on camera more quickly than is possible now. Another type of radar that is connected to fiber optics is used to send alerts for wrong-way driving incidents on mainlines. Texas uses dynamic message signs to alert drivers to incidents, but these are not linked directly to the radar systems. TAPCO systems are also supposed to be able to do this, but Texas DOT has not used them this way yet. Instead, operators put up messages manually. TAPCO devices currently use single radars and have problems with false alarms. Newer devices by TraffiCalm Systems use two radar systems (one pointing down-ramp and another pointing up-ramp) along with a camera for confirmation; see Appendix D-8. Melisa Finley's contact at TraffiCalm is Karen Hentemann, National Sales Manager, 208-691-0102. Finley noted that TraffiCalm is also in contact with Arizona DOT and other state DOTs.

Texas A&M Transportation Institute is also contracted with Texas DOT to develop the concept of operations and functional requirements for a connected vehicle testbed that can be used for wrong-way driving (see Appendix D-9). Phase I will end in December, and Phase II will involve purchasing a system and conducting a proof of concept over about 12 to 18 months for one location in Texas.

6. Public awareness campaigns?
No. Public service announcements via the media and social media are common for drinking and driving, but not wrong-way driving specifically. The media contacts Texas DOT when there is a cluster of wrong-way driving incidents.

7. Real-time warnings to drivers?
Warnings are not provided in real time. But operators can put up warnings on dynamic message signs based on 911 calls monitored by traffic operations. See Appendix D-10 for a media report of a driver who moved out of the way of a wrong-way vehicle because of a DMS warning. See Appendix D-11 for message sign details. For recommendations made by Texas A&M Transportation Institute to Texas DOT regarding their DMS warning messages, see the 2014 study mentioned above (http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-6769-1.pdf).

8. Coordination of response to incidents
Incidents are coordinated via the TransGuide operations room, which has cameras throughout San Antonio. The San Antonio Police Department dispatcher sits to the left of the operations officer. When a 911 call comes in, an e-tone is triggered if the incident involves a wrong-way driver. Police give the location of the incident, and the operator puts up DMS messages and looks for cameras in the area. Having the dispatcher next to the operator is invaluable.

9. Interested in a pooled fund study?
Maybe. See also NCHRP Project 03-117, which is ongoing: http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3856. (For more details, see page 17 of this Preliminary Investigation.)

Washington State Department of Transportation

Rick Mowlds, Signing Engineer, 360-705-7988, mowldsr@wsdot.wa.gov.

1. Documents and research
See Appendices E-1 to E-6 for Washington State DOT details for wrong-way driving countermeasures. WSDOT has not conducted research on the effectiveness of countermeasures or ITS systems, or driver accounts (this would require getting information from police reports, which WSDOT has attempted to do without success). The department does have information on specific interchanges that are problematic (cloverleaf ramps—see Appendices E-1 to E-6). WSDOT is making some changes to signage and striping, but does not know yet if these changes are effective.

2. Do countermeasures vary by ramp type?
Systems are different for loop and diamond ramps (see Appendices E-1 to E-6).

3. Use enhanced lighting as a countermeasure?
No.

4. Incidents by ramp type
Cloverleaf ramps are problematic. Drop ramps have not been a problem.

5. Expansion of countermeasures beyond signage and pavement markings
WSDOT has not had the funding for intelligent transportation system applications. An assistant regional administrator did put an LED flashing beacon on wrong-way signs on a pilot basis.

6. Public awareness campaigns?
No.

7. Real-time warnings to drivers?
No. WSDOT is not using changeable message signs.

8. Coordination of response to incidents
State patrol responds to 911 calls, and traffic management centers (TMCs) are alerted when this happens. In an urban area the TMC may have a camera that can assist state patrol. The TMC is in the same building as the district state patrol office. Wrong-way incidents also trigger a subsequent investigation into signage and markings.

9. Interested in a pooled fund study?
Yes. Illinois' National Wrong-Way Driving Summit was very useful.

Related Resources

National Guidance and Research

Proceedings of the 2013 National Wrong-Way Driving Summit, 2013 National Wrong-Way Driving Summit, Federal Highway Administration, May 2014.
https://www.ideals.illinois.edu/handle/2142/49045
This report details the proceedings of the 2013 National Wrong-Way Driving Summit in Illinois, which provided "a platform for practitioners and researchers to exchange ideas, evaluate current countermeasures, and develop best practices to reduce WWD crashes and incidents through a 4E's approach (Engineering, Education, Enforcement, and Emergency Response)." See page 7 of the report for a list of effective countermeasures. The remainder of the report contains slides from attendee presentations:

- "Wrong-Way Driving: Study Findings and Objectives," Deborah Bruce, National Transportation Safety Board (NTSB).
- "Wrong-Way Driving: Renewed Emphasis on a Familiar Problem," Brian Fouch, FHWA Office of Safety.
- "Investigation of Contributing Factors Regarding Wrong-Way Driving on Freeways," Huaguo Zhou, Southern Illinois University.
- "California Wrong-Way Driving Monitoring Program," Chiu Liu, Caltrans.
- "North Texas Tollway Authority Wrong-Way Driving Program," Yang Ouyang, North Texas Tollway Authority.
- "Older Drivers: Wrong-Way Driving Study and Countermeasures," Duane Brunell, Maine DOT.
- "Law Enforcement Approach to Preventing Wrong-Way Driving Incidents," Lt. Brian Windle, Illinois State Police.
- "Engineering Strategies for Reducing Wrong-Way Driving Crashes," David Morena, FHWA, Michigan Division; Kim Ault, Michigan DOT.
- "Law Enforcement Approach for Wrong-Way Detection and Correction," Captain Terry Thurman, Harris County Toll Road Authority, Texas.
- "Wrong-Way Driving Mitigation Through Intelligent Transportation Systems and Traffic Engineering," Brian Fariello and Michael Chacon, Texas DOT Traffic Incident Management; John Benda, Illinois Toll Highway Authority.

Wrong Way Driving Road Safety Audit Prompt List, FHWA, 2013.
http://safety.fhwa.dot.gov/intersection/wwd/wwdrsa/
This document contains a Road Safety Audit prompt list intended to focus specific attention on wrong-way driving issues and contributing factors.

Highway Special Investigation Report: Wrong-Way Driving, National Transportation Safety Board (NTSB), 2012.
http://www.ntsb.gov/safety/safety-studies/Documents/SIR1201.pdf
This study investigates wrong-way driving incidents and makes recommendations for preventing them. See Table 1 (pages 5 to 6) for a timeline of wrong-way driving related research, and Table 2 (page 7) for wrong-way collision data. Most incidents involve alcohol-related impairment

(pages 8 to 9), and drivers over 70 are also overrepresented. See pages 12 to 29 for NTSB case studies of nine wrong-way driving incidents. The report also includes a description of countermeasures.

Research in Progress

"Traffic Control Devices and Measures for Deterring Wrong-Way Movements," NCHRP Project 03-117, completion expected in September 2017.
http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3856
From the project description:

> The objectives of this research are to (1) determine the type(s), number, and location(s) of traffic control devices required on freeway and expressway ramps, cross streets, frontage roads, intersection approaches, and emergency cross-overs in order to improve safety and deter wrong-way movements; (2) evaluate the impact of varying median widths on wrong-way movement signing and marking requirements on low- and high-speed rural and urban divided highways; (3) identify inconsistencies in the MUTCD pertaining to median widths used to determine whether medians are treated as one or two intersections for traffic control purposes; and (4) propose for adoption to the Regulatory and Warning, and Markings Technical Committees of the NCUTCD and to the NCUTCD appropriate definitions, text, and figure changes where applicable in Parts 1, 2, 3 and 4 of the MUTCD.

"Detection and Warning Systems for Wrong-Way Driving," Arizona DOT, original end date July 2015.
http://trid.trb.org/view/1357354
Project description:

> Wrong-way driving results from drivers making wrong-way entries onto freeways or other controlled-access highways, or making mainline maneuvers that result in driving the wrong way/direction. Collisions from wrong-way drivers continue to be a problem on the nation's highways, including Arizona's controlled-access highways. Although infrequent, the consequences of wrong-way driving crashes are much more serious than other types of collisions. The department continues to review different access control measures, including the design of on/off ramp approaches and signage, looking for possible changes or additions that can impact wrong-way entries. In addition, the department seeks to explore the potential benefits of detecting wrong-way incidents and providing timely warnings; to the wrong-way driver, to relevant authorities, and to other motorists in the area (where appropriate), as an additional mitigation tool for select highway locations. To this end, this research will focus on establishing the magnitude and characteristics of the problem, identifying the most effective detection systems, evaluating and selecting warning systems/protocols that will work best within existing infrastructure and law enforcement capacities, creating a plan for a pilot deployment at select locations, and developing a post-installation monitoring plan for the identified systems. A matrix of key performance criteria will be developed to evaluate detection systems and warning protocols. The aim will be to ensure that only systems meeting an agreed set of minimum requirements are considered for potential deployment. This effort has its own challenges. First, determining highway points of entry by wrong-way drivers is not a simple matter. Information about wrong-way drivers is normally sent in by other drivers after the wrong-way driver has already entered the highway. Thus those calling in and reporting the wrong-way vehicle rarely know where it entered the highway. Another major issue is how to draw the attention of drivers who are

impaired, which happens to be the case for a large proportion of the drivers involved, as determined from cases where incident information and driver status was available. The large number of exit ramps constitutes another challenge. The cost of implementing specific countermeasures at all exit ramp locations can be prohibitive, making it even more critical to identify and prioritize potential problem locations or corridors. It is also important for any measures taken as part of the solution to either comply with the Manual on Uniform Traffic Control Devices (MUTCD), or have a pilot testing exemption.

"Driving Simulator Studies of the Effectiveness of Countermeasures to Prevent Wrong Way Crashes," Florida DOT, completion expected in September 2015.
http://trid.trb.org/view/1311355
Project description:

Objectives of this research project include understanding the effectiveness of wrong way countermeasures with respect to younger and older drivers, provide insight into the decision-making process associated with entering a freeway using an exit ramp, and to provide recommendations based on the results of literature reviews and simulator studies to reduce the likelihood that impaired individuals and older drivers are involved in wrong way crashes.

"Evaluating the Wrong-Way Driving (WWD) Incidents Problem on the Florida's Turnpike Enterprise (FTE) Roadway System," Florida's Turnpike Enterprise, completion expected in November 2015.
http://trid.trb.org/view/2014/P/1364461
Project description:

The goal is to evaluate the wrong way driving (WWD) incidents problem and potential countermeasures on the Florida's Turnpike Enterprise (FTE's) roadway system. This includes data collection on WWD incidents on the FTE road network including a pilot study site on SR821, analysis of WWD trends, identification of typical problem areas and possible causes, designing and conducting a WWD survey for FTE customers, and providing recommendations to mitigate WWD incidents on FTE's roadway network.

"Countermeasures for Wrong Way Driving on Freeways," ENTERPRISE pooled fund study, start date September 2014.
http://enterprise.prog.org/Projects/2013/wrong_way.html
Project description:

ENTERPRISE member agencies have indicated an interest in learning more about countermeasures for wrong way driving, including countermeasures that utilize Intelligent Transportation Systems (ITS) technologies. The project will conduct a literature review of existing countermeasures to identify active countermeasures, then gather details from agencies about these current deployments. By collecting details about wrong way countermeasures from agencies with active deployments, the project aims to understand and document which approaches have the greatest impacts, which are socially acceptable, and which have institutional issues. The overall goal of the project is to provide a repository of relevant information and to help increase the industry's understanding of which wrong way countermeasures are most effective under various conditions.

"Directional Rumble Strips for Reducing Wrong-Way Driving Freeway Entries," University of Minnesota, start date August 2014.
http://www.roadwaysafety.umn.edu/research/search/projectdetail.html?id=2015039%5D
Project description:

> Wrong-way driving (WWD) on highways is a serious traffic safety problem. A recent study of the Fatality Analysis Reporting System (FARS) showed that traffic fatalities caused by WWD were between 300 and 400 annually from 2004 to 2011 in the United States (ATSSA, 2014). This number of fatalities has been consistent even though total traffic fatalities declined by 4% over the 8-year period from 2004 through 2011. In this study, we will develop a new countermeasure (directional rumble strips) for mitigating WWD issues in order to support the focus of the region's Roadway Safety Institute on safety systems and high-risk road users. First, to evaluate the feasibility of using directional rumble strips on freeway exit ramps, the research team conducted an initial field test of what drivers hear and feel, i.e., the sound and vibration that occur when vehicles run over regular transverse rumble strips at normal speed. An instrumented, test vehicle was used to collect field data to help researchers develop a mechanical model of the vibration that passengers feel in their vehicles. Such a mechanical model will be used for concept design and a feasibility study of directional rumble strips based on estimated noise levels and vibration. Based on the estimated vibration frequency and noise ranges generated by different rumble strips, several conceptual designs of directional rumble strips will be recommended for further field evaluation. Each will generate elevated noise and vibration for wrong-way driving, and normal noise and vibration for right-way driving. To evaluate the effectiveness of the proposed directional rumble strips, a field test of noise and vibration will be conducted to verify the models and develop the design guidelines at the National Center for Asphalt Technology (NCAT) at Auburn University.

Research by Topic

Countermeasures

"Current Practices of Safety Countermeasures for Wrong-Way Driving Crashes," Mahdi Pour-Rouholamin, Huaguo Zhou, Jeffrey Shaw and Priscilla Tobias, TRB 94th Annual Meeting, Paper #15-3648, 2015.
http://docs.trb.org/prp/15-3648.pdf
Excerpt from the Abstract:

> Despite employing numerous countermeasures to combat WWD issues in the nation, no recent research has been conducted to investigate the effectiveness and level of acceptance of these countermeasures and current practices. The purpose of this paper is to fill this gap by assessing the information gathered from a survey at the first National WWD Summit held in July 2013 and by studying emerging countermeasures currently employed in various jurisdictions. On the basis of analyzing the survey results and developed countermeasures, an insight into various characteristic aspects of WWD countermeasures is provided.

The researchers conclude (excerpt from page 12 of the paper):

> Various countermeasures have already been developed by agencies to combat WWD issues, among which engineering countermeasures (with 91.7%) are given the top priority.

According to the survey questionnaire, adding a second identical sign on the left-hand side of the roadway and increasing the size of wrong-way related signs, as implemented by the IDOT and the [North Texas Tollway Authority] (NTTA), are the most acceptable and beneficial countermeasures. Caltrans' case study justified the application of lower mounting signs with about 90.0% reduction in WWD incident frequency and the TxDOT experienced a 30.0% reduction in WWD incident frequency after adding LEDs to DNE and WW sign borders; however, it was found that there is a lack of attention to placement of wrong-way signs at frontage roads. Pavement marking applications and improvement at problematic locations show promising outcomes with a decreasing frequency of wrong-way incidents by 40.0% in the NTTA. Access management in the vicinity of an interchange area, using geometric elements, was found to be an efficient method. As perceived to be the most considerable elements by respondents, controlling access to exit ramps was able to eliminate wrong-way entries in one problem exit ramp in Michigan entirely. Lastly, while only one-third of participating agencies claim to deploy ITS technologies, the HCTRA had successful experience, authenticating the use of these devices.

"Mitigating Wrong-Way Movements Near Interchange Areas Using Access Management Techniques," Mahdi Pour-Rouholamin and Huaguo Zhou, TRB 94th Annual Meeting, Paper #15-2276, 2015.
http://docs.trb.org/prp/15-2276.pdf
Abstract:

Past studies indicated that interchange configurations, access control, and geometric design are related to wrong-way driving (WWD), and minor ramp geometric changes can be effective in reducing the number of wrong-way entries onto freeways. In this paper, access management techniques and geometric elements, which are capable of discouraging wrong-way maneuvers, are identified and discussed. Additionally, every aspect of these elements, including interchange types, exit ramp terminals, frontage roads, raised medians, channelizing islands, and control radius, and their relationship to WWD is investigated. Furthermore, a survey questionnaire was also designed to ask professionals to rank these elements based on the level of attention they received in different 10 jurisdictions. The aforementioned elements should be given special consideration during the design stage of interchanges and intersections.

Assessment of the Effectiveness of Wrong Way Driving Countermeasures and Mitigation Methods, Texas DOT, 2014.
http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-6769-1.pdf
This report reviews the state of the practice for wrong-way driving in the United States and Texas. Researchers conducted a literature review, catalogued Texas countermeasures, and conducted an analysis of wrong-way driving crashes in Texas. They also conducted two closed-course studies on the effectiveness of countermeasures for alcohol-impaired drivers, and analyzed the effectiveness of countermeasures using data from Texas agencies. According to the report (see page 113), they found that:

… the majority of WWD crashes on controlled-access highways occur in major metropolitan areas. These WWD crashes typically happen at night between midnight and 5:00 a.m., with a peak around 2:00 a.m. (the typical time for establishments that serve alcohol to close in Texas). Likewise, driving under the influence was the primary contributing factor of these crashes.

The researchers used the study results to develop recommendations for wrong-way driving countermeasures.

Related resource:

> **Wrong Way Driving Countermeasures**, Texas DOT, 2014.
> http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-6769-S.pdf
> This document is a two-page summary of the final report.

"Cutting the Cost of Wrong Way Driving," *ITS International*, Volume 20, Issue 3, pages 24-25, 2014.
http://www.itsinternational.com/sections/cost-benefit-analysis/features/texas-moves-to-prevent-wrong-way-drivers/
Abstract:

> Wrong way driving collisions are uncommon, but when they do occur, they are highly likely to result in fatalities or serious injury. Concerns about wrong way driving have led transportation agencies to work to improve countermeasures. In 2012, San Antonio's Wrong Way Driving Task Force was established. The task force identified high-risk locations and developed a geographic information system (GIS) map of all sites of reported wrong way incidents. A pilot project was set up on a road identified as high-risk, using radar detection units and illuminated "wrong way" signs. The pilot showed a reduction of wrong way driving incidents of nearly 30%.

Related resource:

> **"Efforts to Reduce Wrong-Way Driving: A Case Study in San Antonio, Texas,"** Steven P. Venglar and Brian G. Fariello, *TRB 93rd Annual Meeting Compendium of Papers,* Paper #14-4371, 2014.
> Abstract at http://trid.trb.org/view/1289343
> This paper details the research described above.

Guidelines for Reducing Wrong-Way Crashes on Freeways, Illinois DOT, 2014.
https://www.ideals.illinois.edu/bitstream/handle/2142/48998/FHWA-ICT-14-010.pdf?sequence=2
This report provides guidance for using wrong-way driving countermeasures. See Chapter 2 for signs, pavement markings and traffic signals; Chapter 3 for geometric elements; and Chapter 4 for advanced technologies, enforcement and education.

Related resource:

> **"Emerging Safety Countermeasures for Wrong-Way Driving,"** H. Hugo Zhou, Auburn University, 2014.
> http://eng.auburn.edu/2014TransConf/EmergingWWDCountermeasures.pdf
> Based on the report above, this presentation covers national trends in wrong-way driving fatalities, crash characteristics and countermeasures.

"Prevention of Wrong Way Accidents on Highways: A Human Factors Approach," Perrine Ruer, Philippe Cabon and Fabrice Vienne, *Transport Research Arena (TRA) 5th Conference: Transport Solutions from Research to Deployment,* 2014.
http://tra2014.traconference.eu/papers/pdfs/TRA2014_Fpaper_19764.pdf

Excerpt from the Abstract:

> Elderly drivers and young drivers are the most prevalent in the wrong way accidents. Two main explanations of these accidents can be identified: violation (the driver [intentionally takes] the wrong way) or error (the driver [does not realize] that he/she is taking a wrong way). This paper focuses on a Human Factors evaluation of two new road signs to prevent wrong way driving. The devices are a light barrier and the standard wrong way signal (B1) on a yellow background (B1Y). This research, carried out in a simulator, aims at evaluating the efficiency of these road signs to prevent errors and violation [in] elderly and young drivers. The results of tests give a qualitative and quantitative evaluation of the wrong way road signs and are discussed regarding their implication for road sign design and human factors evaluation.

"Prevention of Wrong-Way Driving on Highways Using a New Road Sign: A Field Experiment," Catherine Chauvineau, *Transport Research Arena (TRA) 5th Conference: Transport Solutions from Research to Deployment,* 2014.
http://tra2014.traconference.eu/papers/pdfs/TRA2014_Fpaper_18303.pdf
Abstract:

> Every year there are accidents caused by vehicles traveling in the wrong direction on divided roads. While few in number, these accidents are usually very serious and attract considerable media attention. For ten years now studies and experiments have been carried out on France's freeway network, national highways and local roads. An experiment involving a new sign—a no-entry symbol on a yellow background—on exit ramps was carried out on selected roads in two French departments with the authorization of the dedicated short range communications (Road Traffic and Safety Department). The aim was to measure the impact of the new signing on the number of wrong-way incidents on the divided roads concerned. Although the number of infraction reports dropped by almost 40%, the data sample was very small and the results allow for no significant lesson drawing.

"Is There a Right Way?" *Roads & Bridges*, Volume 51, Issue 1, pages 40-42, 2013.
http://www.roadsbridges.com/safety-2013-there-right-way
Abstract:

> This article follows the case of a pilot safety program in Milwaukee, Wisconsin to prevent wrong-way accidents. The steps to setting up the program, including a pilot study, are presented here. San Antonio's efforts on this front are also included, with attention to issues of ramp design, driving while impaired, navigation system alerts and highway signs.

"Wrong-Way Driving on Freeways: Problems, Issues and Countermeasures," Scott A. Cooner and Stephen E. Ranft, *TRB 87th Annual Meeting Compendium of Papers DVD*, Paper #08-2263. 2008.
Abstract at http://trid.trb.org/view/848449
Excerpt from the Abstract:

> … [The] Texas Department of Transportation sponsored a research project to evaluate the most effective traditional and innovative countermeasures throughout the United States to reduce wrong-way movements. Data from previous studies and a detailed study of 4 years of wrong-way crashes on freeways Texas was used to develop a typical wrong-way crash profile. The paper documents best practices nationwide and provides recommended

guidelines for use of the most effective wrong-way countermeasures. A checklist for engineers and field crews to use for reviewing wrong-way entry issues or suspected problem locations is also provided.

"Prevention of Wrong-Way Driving on Freeways," Darja Topolsek, *Promet Traffic-Traffico*, Volume 19, Issue 5, pages 311-321, 2007.
Abstract at http://trid.trb.org/view/841930
Excerpt from the Abstract:

> This paper presents and discusses research based on analysis of traffic accident data caused by wrong-way driving on freeways, while concurrently considering valid technical specifications for the design of roadway connection and junction elements. The thesis presents possible countermeasures for prevention of wrong-way driving and consequential decreases in the number of traffic accidents. The proposed prevention countermeasures to wrong-way driving on freeways could greatly reduce incorrect vehicle movements and enhance traffic safety on these roads.

Countermeasures for Wrong-Way Movement on Freeways: Overview of Project Activities and Findings, Texas DOT, 2004.
http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/4128-1.pdf
Excerpt from the Abstract:

> Several crashes in the Texas Department of Transportation (TxDOT) Fort Worth District have brought attention to the hazard of wrong-way drivers. A search of newspaper articles revealed that the problem of wrong-way driving is not unique to Fort Worth and occurs throughout Texas. Members of the Fort Worth Traffic Management Team identified locations with a history of wrong-way entries and assessed potential countermeasures. During this review process it was determined that research was needed to understand and develop effective countermeasures for wrong-way movements onto freeways and other restricted roads. This research provides TxDOT staff with preventative measures for reducing the frequency and severity of wrong-way entries onto freeway facilities throughout Texas. Researchers performed the following tasks during the project: established state-of-the-practice on safety, design, and operational issues for wrong-way movement on freeways; surveyed state DOTs to get information on typical wrong-way signing and marking and any innovative practices; quantified the frequency, severity, and other important characteristics of wrong-way crashes in Texas based on a review of crash reports and coordination with 911 public safety answering points; identified available countermeasures to reduce wrong-way movements and crashes; evaluated the feasibility and applicability of the available countermeasures to address Texas problems; documented typical situations that were more likely to produce wrong-way entry issues; developed guidelines/recommended practices for application of wrong-way countermeasures and treatments; and developed a checklist for field crews to use for reviewing wrong-way entry issues or suspected problem locations.

Related resources:

> **Countermeasures for Wrong-Way Movement on Freeways: Guidelines and Recommended Practices**, Texas DOT, 2004.
> http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/4128-2.pdf
> These guidelines were developed as part of the same research.

Wrong-Way Driving Countermeasures, Connecticut General Assembly Office of Legislative Research, 2008.
https://www.cga.ct.gov/2008/rpt/2008-r-0491.htm
This report reviews the results of Texas DOT's 2004 study.

Optimizing Arrow Pavement Marking Against Wrong-Way Driving, M.H. Martens and A.R.A. Van Der Horst, 1997.
Abstract at http://trid.trb.org/view/537937
Excerpt from the Abstract (document is in Dutch):

> Several times it has been suggested to place pavement arrow markings on exits to indicate the driving direction in order to prevent wrong-way driving. Under contract with the Netherlands Transport Research Centre (AVV) of the Department of Public Works, the TNO Human Factors Research Institute designed a pavement arrow marking. This marking is expected to be most optimal in reducing the number of wrong-way driving incidents. Attention is paid to the shape of the arrow, its size, the location in longitudinal and transverse profile, and the possible hindrance for traffic that uses the exit in the correct direction. Based on a brainstorm with experts in the area of visual perception, traffic and psychology, an arrow has been selected that bears a resemblance to the standard arrow, but that appears larger and is more pointed, partly due to the characteristic head of the arrow. This arrow is assumed to be the most effective in drawing the attention of wrong-way drivers, since the arrow will keep its characteristic shape under most circumstances. The arrow scores well in terms of conspicuity, characteristic arrow features, distinctness, and clarity.

Prevention of Wrong-Way Accidents on Freeways, California DOT, 1989.
See Appendix G.
This Caltrans report details results of a survey of states on wrong-way driving countermeasures, and recommends prevention measures "in the areas of sign maintenance, annual accident monitoring using a check-list process, ramp and intersection design, and reducing drunk drivers."

Detection and Warning

Wrong-Way Driving Detection and Prevention System: A Pilot Deployment, University of Central Florida, 2015.
http://media.cmgdigital.com/shared/news/documents/2015/02/11/WWD_Slides_for_Media_DRAFT_2-11-2015.pdf
This presentation describes an ongoing pilot deployment of a wrong-way driving detection and prevention system in Florida. The system consists of radar detection devices that trigger red flashing beacons.

"Warnings Designed to Prevent Accidents Caused by Wrong-Way Drivers on Motorways in Germany," T. Volkenhoff, M. Oeser and F. Hennecke, *Advances in Transportation Studies*, Volume 35, pages 103-114, 2015.
Abstract at http://trid.trb.org/view/1356708
This project developed a wrong-way driving detection system than can alert an operational center to provide other drivers with warning messages. The researchers used a driving simulator to validate and optimize warning messages.

"Combating Wrong Way Drivers on Divided Carriageways," Rojina Baisyet and Andrew Stevens, Institution of Professional Engineers New Zealand (IPENZ) Transportation Conference, 2015.
http://conf.hardingconsultants.co.nz/workspace/uploads/paper-stevens-andrew-comb-54f3d517278da.pdf
Excerpt from the Abstract:

> The Auckland Motorway Alliance has successfully tried a Wrong Way detection technology as proof of concept and is now working towards the implementation of a raft of prevention measures. Some of the findings the AMA has learnt are presented in this paper. There are also some helpful hints for all drivers to protect themselves, their families and friends against the risk of them featuring in the statistics as either a perpetrator or an innocent victim of Wrong Way driving.

"Wrong Way Driving on German Motorways—Safety Gain by a Low Cost Detection System," Markus Oeser, Tobias Volkenhoff, Dirk Kemper and Christian Wietfeld, *TRB 94th Annual Meeting Compendium of Papers,* Paper #15-1001, 2015.
Abstract at http://trid.trb.org/view/1336889
Abstract:

> Wrong way drives on motorways are relatively rare, but – in many cases – cause severe accidents often with harmful consequences. Therefore, they acquire a lot of attention in general public. This paper first illustrates occurrence, causes and consequences of wrong way drives on German motorways based on a literature review. Currently, about 2,000 messages are recorded yearly which on average lead to 200 accidents. In Germany, countermeasures consist of avoiding the emergence of wrong way drives by the design of the interchange or the marking. Furthermore, the ambient traffic is to be warned by means of a fast traffic detection. However, no automated detection through technical systems is used so far for this purpose. Such systems need to be very cost-efficient for a comprehensive application in order to work efficiently despite low accident rates. On behalf of the Federal Ministry of Economic Affairs and Energy, the investigation presented in this work thus deals with the development of such a cost-efficient system. This was implemented in the form of an energy self-sufficient system based on low power radio technology. The improvement of detection times was shown in laboratory tests. The necessary high detection rate and the low false alarm rate could be demonstrated in a field study. The investigation of the efficiency of a faster warning was carried out with test persons in a driving simulator laboratory. As a result, it can be stated that the use of low cost technologies for the detection of wrong way drives has promising perspectives.

"Automatically Detecting Wrong-Way Drivers on the Highway System," Sarah Simpson and Reza Karimvand, *TRB 94th Annual Meeting Compendium of Papers,* Paper #15-1299, 2015.
Abstract at http://trid.trb.org/view/1337036
Excerpt from the Abstract:

> This paper explores some of the possibilities of dual functionality using a combination of existing and new field devices coupled with new algorithms to create a wrong-way detection system. The wrong-way detection system is not expected to eliminate all wrong-way crashes. The system is designed to detect wrong-way drivers immediately upon entry; notify the traffic management center and public safety dispatch of the wrong-way entry point; and inform the errant driver of their potentially fatal mistake via visual and/or audible

warnings to prompt drivers into corrective action. Should the errant driver continue onto the highway in the wrong direction, the system tracks the errant vehicle and provides audible updates to the traffic management and dispatch centers in real time of the errant vehicle's location allowing officers additional lead time to respond to the errant driver's actions. The detection system automatically warns right-way mainline drivers in the near vicinity of the on-coming wrong-way vehicle through the use of the existing dynamic message signs and ramp meters.

Next Generation Traffic Data and Incident Detection from Video, ENTERPRISE Pooled Fund Study, 2014.
http://enterprise.prog.org/Projects/2010_Present/nextgenerationvideo/ENT_VideoAnalytics_Report_Sept2014_FINAL.pdf
The ENTERPRISE pooled fund study is looking at various commercially available video analytics systems for a number of different purposes, including wrong-way driving detection. A test of three systems (see pages 22 to 26 of the report) yielded detection of 100 percent during the day and 83 percent at night, with no false alarms during a 44-day test period.

Wrong-Way Vehicle Detection: Proof of Concept, Arizona DOT, 2013.
https://apps.azdot.gov/ADOTLibrary/publications/project_reports/PDF/AZ697.pdf
Excerpt from the Abstract:

> The primary focus of this research was to determine the viability of existing detector systems to identify entry of wrong-way vehicles onto the highway system using five different technologies: microwave sensors, Doppler radar, video imaging, thermal sensors, and magnetic sensors. The devices were installed on freeway exit ramps. Each device was tested in both a controlled environment and in the field under normal traffic operating conditions. During the controlled testing, staged events were conducted to determine whether the devices would accurately detect wrong-way vehicles. The study results of this proof of concept effort verify that wrong-way vehicles can be detected using easily deployable equipment that is currently available on the market. While each system tested over the trial period had missed or false calls, none of the systems were installed under the vendors' ideal conditions.

"Development of a System That Prevents Wrong-Way Driving," Shinobu Matsumoto, Yuichi Mizushima and Hiroki Nagasaki, *20th ITS World Congress, Tokyo 2013: Proceedings,* 2013.
Abstract at http://trid.trb.org/view/1323652
Abstract:

> In Japan, wrong-way driving by inexperienced drivers and head-on collision accidents as a result of this driving have become an issue. To solve this issue, NEXCO EAST and NEXCO Engineering Niigata jointly developed a detection and warning system to prevent wrong-way driving from occurring on highways. We installed this system on various highways in July, 2008. This system consists of a warning provision unit for drivers and the image processing unit that detects wrong-way driving. This system detected five wrong-way driving cases and stopped them by giving a warning to each driver during a six-month period at highway locations where wrong-way driving is a concern. By doing so, this system successfully prevented head-on collision accidents from occurring. When wrong-way driving is detected, this system is also capable of saving images that were shot in the past. This makes it possible to record the behavior of the driver who led to wrong-way driving, and is effective in subsequent analysis of such cases and examination of what fundamental

countermeasures could be taken. This article reports on the development of this system and its operational achievements

Related resources:

"Development and Operation Report of Wrong-Way Driving Prevention Device," Yuichi Mizushima, Masahiro Kobayashi and Koichi Kawakami, *19th ITS World Congress, Vienna, Austria, 22 to 26 October 2012*, 2012.
Abstract at http://trid.trb.org/view/1279698
A prior phase of this research as presented at a previous ITS World Congress.

"Development of the Device to Prevent Wrong-Way Driving," Shinobu Matsumoto and Yuichi Mizushima, *18th ITS World Congress, Orlando, 2011: Proceedings,* 2011.
Abstract at http://trid.trb.org/view/1255608
A prior phase of this research as presented at a previous ITS World Congress.

"Wrong Way Caution System for Motorways Based on Car Navigation System," Masatoshi Takahara, Shogo Sugimoto, Kuniaki Tanaka, Yuya Higuchi and Kiyoshi Tsurumi, *19th ITS World Congress, Vienna, Austria, 22 to 26 October 2012,* 2012.
Abstract at http://trid.trb.org/view/1268199
Abstract:

This paper presents a method for detecting wrong way travel on motorways and a method for warning drivers by using the car navigation system. In Japan, approximately 1,000 wrong way driving incidents are reported annually. Senior drivers older than 65 years old are involved in almost half of these incidents. This phenomenon has become an object of public concern as Japanese society continues to age. To tackle this issue the authors have developed a wrong way travel detection method for motorways using highly accurate location and communication-based map update technologies on the authors car navigation system products.

"A Wrong Way Ramp Detection System," Todd Stiers and Daniel Xing, First International Conference on Transportation Information and Safety (ICTIS), 2011.
Abstract at http://trid.trb.org/view/1111893
Abstract:

A Wrong Way Ramp (WWR) detection system is described. The system is based on (i) in-ground magnetometer sensor grids which wirelessly communicate vehicle detection events to an access point; (ii) algorithms identifying wrong-way events with a high detection rate and low false alarm rate for a variety of vehicle and driver behaviors; (iii) video monitoring and notification; and (iv) Driver alerts. The system design, test issues and resolutions, and field results are presented.

"Stop. You're Going the Wrong Way!" *Public Roads*, Vol. 66, No. 2, September/October 2002.
https://www.fhwa.dot.gov/publications/publicroads/02sep/06.cfm
This article reviews ITS technologies for wrong-way driving, including video cameras and flashing lights triggered by embedded sensors or video detection.

"Automatic Incident Detection: Wrong-Way Vehicle Detection Using Image Processing," M. Forthoffer, S. Bouzar, F. Lenoir, J.M. Blosseville and D. Aubert, *Intelligent Transportation: Realizing the Future. Abstracts of the Third World Congress on Intelligent Transport Systems,* 1996.
Abstract at http://trid.trb.org/view/574555
Abstract:

This paper presents a new function added in an automatic incident detection system. It concerns an algorithm based on image processing able to detect the wrong-way vehicle on the motorway. The algorithm is working in most outdoor conditions (day, night, rain). The principle of the method consists in analysis of the moving vehicles. Each vehicle is tracked in the image and its trajectory is then built. The trajectory is a good criteria to qualify the circulating vehicle direction but in practice, parts of the trajectory include some error due to physical parameters (noise, deformation of objects due to the perspective view, etc.) or to natural phenomena (shadows, glints). A proposed paper presents the following points: a survey of the main difficulties meted in the motion detection field and automatic incident detection; the principle of the method developed by the INRETS; the advantages and drawbacks of the method; and results obtained in field experimentation.

Characteristics of Incidents

Investigation of Contributing Factors Regarding Wrong-Way Driving on Freeways, Illinois DOT, 2012.
http://cetrans.isg.siue.edu/wwd/FHWA-ICT-12-010.pdf
Abstract:

In Illinois, there were 217 wrong-way crashes on freeways from 2004 to 2009, resulting in 44 killed and 248 injured. This research project sought to determine the contributing factors to wrong-way crashes on freeways and to develop promising, cost-conscious countermeasures to reduce these driving errors and their related crashes. A thorough literature review was conducted to summarize the best practices on design, safety, and operational issues related to wrong-way driving on freeways by different states in the United States and abroad. Six-year crash data from the Illinois Department of Transportation were then collected for identifying wrong-way crashes. Out of 632 possible wrong-way crashes identified from the crash database, the 217 actual wrong-way crashes were verified by reviewing hard copies of those crash reports. General statistical characteristics of wrong-way crashes were analyzed, and the findings suggested that a large proportion of wrong-way crashes occurred during the weekend from 12 midnight to 5 a.m. Approximately 60% of wrong-way drivers were DUI drivers. Of those, more than 50% were confirmed to be impaired by alcohol, 5% were impaired by drugs, and more than 3% had been drinking. Causal tables, Haddon matrices, and significance tests were used to identify factors that contribute to wrong-way crashes on Illinois freeways. Alcohol impairment, age, gender, physical condition, driver's experience and knowledge, time of day, interchange type, and urban and rural areas were found to be significant factors. A new method was developed to rank the high-frequency crash locations based on the number of recorded or estimated wrong-way freeway entries. Twelve interchanges were identified for field reviews. Site-specific and general countermeasures were identified for future implementation.

Related resource:

> **"Statistical Characteristics of Wrong-Way Driving Crashes on Illinois Freeways**," TRB 93rd Annual Meeting, Paper #14-4324, 2014.
> http://docs.trb.org/prp/14-4324.pdf
> This TRB paper is based on the same research project.

"Wrong-Way Driving Crashes on French Divided Roads," Emmanuel Kemel, *Accident Analysis & Prevention*, Volume 75, pages 69-76, February 2015.
Abstract at http://trid.trb.org/view/1342159
Excerpt from the Abstract:

> This paper proposes a characterization of wrong-way driving crashes occurring on French divided road on the 2008–2012 period. The objective is to identify the factors that delineate between wrong-way driving crashes and other crashes. Building on the national injury road crash database, 266 crashes involving a wrong-way driver were identified. Their characteristics (related to timing, location, vehicle and driver) are compared to those of the 22,120 other crashes that occurred on the same roads over the same period. The comparison relies on descriptive statistics, completed by a logistic regression. Wrong-way driving crashes are rare but severe. They are more likely to occur during night hours and on non-freeway roads than other crashes. Wrong-way drivers are older, more likely to be intoxicated, to be locals, to drive older vehicles, mainly passenger cars without passengers, than other drivers. The differences observed across networks can help prioritizing public intervention. Most of the identified WW-driving factors deal with cognitive impairment. Therefore, the specific countermeasures such as alternative road signs should be designed for and tested on cognitively impaired drivers. Nevertheless, WW-driving factors are also risk factors for other types of crashes (e.g. elderly driving, drunk driving and age of the vehicle). This suggests that, instead of (or in addition to) developing WW-driving specific countermeasures, managing these risk factors would help reducing a larger number of crashes.

"Characteristics of Wrong-Way Driving on Motorways in Japan," Xing Jian, *IET Intelligent Transport Systems*, Volume 9, Issue 1, pages 3-11, 2015.
Abstract at http://trid.trb.org/view/1342057
Abstract:

> Characteristics of wrong-way incidents and crashes that occurred on the entire motorway network in Japan are analysed in this study with an emphasis on wrong-way crashes. Nearly 40% of vehicles in wrong-way crashes took U-turns on the main carriageway, followed by 20% entering the wrong way at interchanges after passing the tollgate, 18% before passing the tollgate and 12% at rest areas. Wrong entries and suspected dementia were the two main contributing factors for wrong-way crashes, each accounting for nearly 30% of the total number of wrong-way crashes, followed by each 8-10% for confusion with ordinary road, taking U-turns on the main carriageway and driving under the influence of alcohol. Most wrong-way crashes because of wrong entries were caused by older drivers over the age of 60 (61%) and young drivers (22%) and most of those because of confusion with ordinary road were also caused by older drivers (86%). All the wrong-way crashes caused by suspected dementia were by older drivers over the age of 65 and occurred between 4-10 p.m. Finally some applications of recent ITS technologies to prevent wrong-way driving that have been implemented recently on motorways in Japan are briefly introduced.

"Wrong-Way Driving Prevention: Incident Survey Results and Planned Countermeasure Implementation in Florida," Adrian Sandt, Haitham Al-Deek, John H. Rogers Jr. and Ahmad Alomari, *TRB 94th Annual Meeting Compendium of Papers,* Paper #15-2369, 2015.
Abstract at http://trid.trb.org/view/1337596
Excerpt from the Abstract:

> This research developed a first of its kind driver survey to obtain details about unreported WWD events on Central Florida toll roads and freeways. This phone survey asked participants about WWD events either witnessed personally by the participant or by a family member, friend, or acquaintance. The 400 completed surveys showed that State Road (SR) 408 and Florida's Turnpike (SR 91) experienced the most WWD events. Only 14% of the WWD events resulted in a crash, and only 10% of participants who personally witnessed a WWD event reported the event, even though 50% of these participants felt a high risk of danger from the WWD event. Nine percent of the WWD events that were not reported resulted in a crash. These results show that WWD is more frequent than indicated by crashes or 911 calls. Based on these results, the Central Florida Expressway Authority (formerly known as the Orlando-Orange County Expressway Authority) plans to pilot test and evaluate the use of Rapid Rectangular Flashing Beacons (RRFBs) as a WWD countermeasure at 5 ramps along SR 408 and SR 528. This will be the first use of RRFBs to combat WWD. Elsewhere in Florida, Florida's Turnpike Enterprise is installing flashing "Wrong Way" signs along the Homestead Extension (SR 821) and Sawgrass Expressway (SR 869) in South Florida and the Florida Department of Transportation is implementing a variety of WWD countermeasures at I-10 ramps in Tallahassee in North Florida.

"Prediction of Potential Wrong-Way Entries at Exit Ramps of Signalized Partial Cloverleaf Interchanges," Fatemeh Baratian-Ghorghi, Huaguo Zhou, Mohammad Jalayer and Mahdi Pour-Rouholamin, *Traffic Injury Prevention*, Volume 16, Issue 6, pages 599-604, 2015.
Abstract at http://trid.trb.org/view/1347232
Excerpt from the Abstract:

> The focus of this manuscript is to develop a mathematical method to estimate the probability of WWD incidents at exit ramp terminals of this type of interchange. Methods: VISSIM traffic simulation models, calibrated by field data, are utilized to estimate the number of potential WWD maneuvers under various traffic volumes on exit ramps and crossroads. The Poisson distribution model was implemented without field observation and crash data. A comparison between the field data and simulation outputs revealed that the developed model enjoys an acceptable level of accuracy. The proposed model is largely sensitive to left-turn volume toward an entrance ramp (LVE) than stopped vehicles at an exit ramp (SVE). The results indicated that potential WWD events increase when LVEs increase and SVEs decrease. Also, the probability of WWD event decreases as road users are more familiar with the facility. The proposed method can diminish one of the challenges in front of transportation engineers, which is to identify high WWD crash locations due to insufficient information in crash reports. The results are helpful for transportation professionals to take proactive steps to identify locations for implementing safety countermeasures at high risk signalized parclo interchanges.

"Overview of Wrong-Way Driving Fatal Crashes in the United States," Fatemeh Baratian-Ghorghi, Huaguo Zhou and Jeffrey Shaw, *ITE Journal*, Volume 84, Issue 8, pages 41-47, 2014.
Abstract at http://trid.trb.org/view/1323133
Abstract:

> In this study, 8 years (2004-2011) of wrong-way driving (WWD) fatal crash data were extracted from the National Highway Traffic Safety Administration Fatality Analysis Reporting System database. The objectives of this study are to (1) provide an overview of the general trend of WWD fatal crashes in the United States; (2) discuss general characteristics of WWD fatal crashes; and (3) delineate significant contributing factors (e.g., crash location, driver gender, age, and impairment). The results will serve to inform national and state efforts to reduce WWD fatal crashes.

"Characteristics and Countermeasures Against Wrong-Way Driving on Motorways in Japan," Jian Xing, *20th ITS World Congress, Tokyo 2013: Proceedings,* 2013.
Abstract at http://trid.trb.org/view/1323736
Excerpt from the Abstract:

> The characteristics of both wrong-way incidents and crashes that occurred on the entire motorway network in Japan are analyzed in this study with an emphasis on wrong-way crashes. The characteristics of several typical factors resulting in wrong-way crashes are briefly identified and then directions of countermeasures for each factor are suggested. Finally some applications of recent ITS technologies to prevent wrong-way driving that have been successfully implemented on motorways in Japan are briefly introduced.

"Where These Drivers Went Wrong," *Public Roads*, Volume 75, Issue 6, pages 33-41, 2012.
http://www.fhwa.dot.gov/publications/publicroads/12mayjune/05.cfm
Abstract:

> Although crashes caused by wrong-way drivers are rare, they kill or severely injure drivers and passengers at a much greater rate (per crash) than other types of freeway incidents. This paper describes a study conducted by the Federal Highway Administration and the Michigan Department of Transportation (MDOT) regarding wrong-way crashes on freeways. Researchers analyzed 110 wrong-way crashes that occurred on the Michigan freeway system from 2005 to 2009. The researchers restricted their study to vehicles that were known or presumed to have entered the freeway system by traveling the wrong direction on an exit ramp. Findings show that some potential for driver confusion leading to wrong-way entry exists across the entire population, but is amplified in drivers impaired by alcohol or drugs, older drivers and drivers at night. The severity of a wrong-way crash was linked to how far the wrong-way vehicle progressed onto the system. A partial cloverleaf interchange provided the wrong-way ramp entry for 60% of the crashes for which the wrong-way entry point was known. The partial cloverleaf has a feature that appears to be the source of confusion leading to wrong-way freeway entry: a pair of freeway exit/entrance ramps that are adjacent and parallel to each other, and typically meet the crossroad at or near a 90-degree angle. The wrong-way entry mode for a driver is to turn onto the freeway exit ramp, thinking that they are entering onto the freeway entrance ramp. Most of the engineering solutions that can mitigate this problem involve positive cues to showcase the entrance ramp, and negative cues that make the exit ramp appear uninviting. Based on these findings, MDOT staff identified 161 interchanges that exhibit the suspect feature of partial cloverleaf. These interchanges are being targeted for systematic installation of low-cost countermeasures over the next 5 years. The countermeasures include: lowering the bottom

height of DO NOT ENTER and WRONG WAY signs; installing reflective sheeting on the sign supports of these signs; placing stop bars at exit ramps; installing wrong-way pavement marking arrows at exit ramps; installing pavement marking extensions that will guide crossroad left-turning traffic past the exit ramp and safely onto the entrance ramp; painting the island between the exit and entrance ramp for a sufficient distance up the ramp; and placing red delineators along the exit ramp to discourage wrong-way vehicles that are headed up the exit ramp. MDOT has identified the first two of these countermeasures as being cost effective for all ramps, regardless of type. These countermeasures will be installed at the non-targeted interchanges as they come up for routine work.

"Fatal Wrong-Way Collisions on New Mexico's Interstate Highways, 1990–2004," Sarah L. Lathrop, Travis B. Dick and Kurt B. Nolte, *Journal of Forensic Sciences*, Volume 55, Issue 2, pages 432-437, 2010.
Abstract at http://trid.trb.org/view/926076
Abstract:

Medical examiner files from 1990 through 2004 were reviewed to identify fatalities caused by drivers traveling the wrong direction on interstate highways and identify risk factors and prevention strategies. Other fatal nonpedestrian interstate motor vehicle crashes served as a comparison group. Data abstracted included decedent demographics, driver/passenger status, seatbelt use, blood alcohol concentration, weather and light at time of occurrence, and types of vehicles involved. Of 1,171 total fatalities, 79 (6.7%) interstate motor vehicle fatalities were because of drivers traveling against the posted direction in 49 crashes, with 1 to 5 fatalities/crash. Wrong-way collisions were significantly more likely to occur during darkness ($p < 0.0001$) and involve legally intoxicated drivers ($p < 0.0001$). In 29/49 (60%) wrong-way crashes, alcohol was a factor. Prevention strategies aimed at reducing the incidence of driving while intoxicated, as well as improved lighting and signage at ramps, could help reduce the occurrence of fatal wrong-way collisions on interstates.

"Countermeasures Against Traffic Accidents by Wrong Way Driving," Masato Tatsumi and Tomoyuki Adachi, *17th ITS World Congress, Busan, 2010: Proceedings*, 2010.
Abstract at http://trid.trb.org/view/1118519
Abstract:

Wrong way driving on expressways is an event with strong social impact, as it causes serious traffic accidents with causalities including innocent drivers. Recently, increasing numbers of accidents have been reported in mass media such as newspapers. Under these circumstances, we analyzed current statistical records of wrong way driving case on expressways operated by West Nippon Expressway Company Ltd. (NEXCO-West). This paper describes the results of the statistical analysis and various efforts to reduce the number of wrong way driving on expressways.

Heading in the Wrong Direction: Descriptive Research on Wrong-Way Driving on Dutch Motorways: Background, Causes, Liability and Measures, Institute for Road Safety Research, SWOV, 2000.
Abstract at http://trid.trb.org/view/673041
From the Abstract (report is in Dutch):

In this research, the original accident registration sets and the more elaborate official police reports of wrong-way accidents on Dutch motorways were analysed. The accident reports

especially proved to give more insight into the way wrong-way driving begins. Included in the supplementary research was the examination of the factors associated with road design and driver behaviour that could have played a role in wrong-way driving. Therefore, junctions where drivers started wrong-way movements were visited. The supplementary research also examined legal liability in accidents involving wrong-way driving and the effectiveness of (new) measures to prevent wrong-way driving. Analysis of the official police reports showed that about half of the episodes of wrong-way driving began when drivers entered exits, while the other half began when drivers turned their cars (mainly on the main carriageway) or were engaged in similar manoeuvres. The supplementary research focused on situations in which exits were entered unintentionally. This error, made by the largest group, is the simplest to prevent due to its involuntary nature and the locations where it occurs. If the indications found about the characteristics of exits that have been the scene of wrong-way entries are confirmed in further research, complying with the existing specifications for the signing and visibility of these junctions and the maintenance of line markings are amongst the most important measures to be taken to prevent wrong-way driving.

Wrong-Way Drivers and Head-On Collisions on Motorways: Number and Development of Their Threat to Road Safety, in the Period up to 1998, Institute for Road Safety Research, SWOV, 2000.
Abstract at http://trid.trb.org/view/672244
Abstract (report is in Dutch):

This report contains the results of a study into wrong-way drivers. This Dutch study is a sequel to earlier studies in 1981 (See ITRD 258645) and 1997 (See ITRD 491577). The purpose of the study was to gain insight into recent developments in the number of motorway accidents and reports to police stations. At the same time, the quality of the available information about wrong-way driver accidents was examined. Apart from an update of the 1997 study, the report also contains data on other (head-on) collisions on motorways, in which one of those involved were driving in opposite directions. New is the use of detailed official police reports. This data added more insight as to how wrong-way driving occurred. The study used the 1983-1998 accident databases. In order to make a comparison, a selection of all motorway accidents was made. However, this was only possible for 1991-1997. Analysis of the wrong-way driving accidents and victims presents a picture more or less the same as in the 1997 study.

Wrong-Way Drivers on Motorways. Part II: Literature Study, Institute for Road Safety Research, SWOV, 1998.
Abstract at http://trid.trb.org/view/537927
Abstract (report is in Dutch):

In this report an overview is given of the available literature and other sources of information about the extent of wrong-way driving in a number of countries as compared to the total number of accidents/casualties on motorways or (if not available) to national figures concerning accidents/casualties. The following countries are included: Germany, Denmark, United Kingdom, Portugal, Sweden, France, and United States.

Wrong-Way Drivers on Motorways. Part I: The Extent and Development of the Number of Wrong-Way Drivers, and the Road Accidents and Road Casualties Involving Wrong-Way Drivers Prior to the End of 1996, Institute for Road Safety Research, SWOV, 1998.
Abstract at http://trid.trb.org/view/537926
Abstract (report is in Dutch):

This report contains the results of a study into wrong-way driving on motorways and is a follow-up to a previous study conducted in 1981. The objective of the current study was to gain an insight into source files available in the Netherlands that contain information about wrong-way accidents and to determine the quality of that information. The extent, nature and development of wrong-way driving in the Netherlands since 1980 as based on these source files are also discussed. During the 1991 to 1996 period, about 0.1% of all registered road accidents on motorways resulted from wrong-way driving. This percentage indicates that an annual average of 22 wrong-way accidents occurred during this time. Accidents involving wrong-way driving are serious in nature. During the dark, the percentage of wrong-way driving accidents of the total number of accidents on motorways is greater than during the day. Starting at age 55, the percentage of wrong-way drivers involved in road accidents on motorways increases. Alcohol use by wrong-way drivers occurs relatively often, with the exception of the group of drivers aged 70 and older. Regarding the location at which drivers start driving in the wrong direction, little data is available.

Contacts

CTC contacted the individuals below to gather information for this investigation.

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JIM BOXOLD
SECRETARY

ROADWAY DESIGN BULLETIN 15-08
TRAFFIC OPERATION BULLETIN 03-15
(FHWA Approved: April 14, 2015)

DATE: April 15, 2015

TO: District Directors of Transportation Operations, District Directors of Transportation Development, District Design Engineers, District Consultant Project Management Engineers, District Construction Engineers, District Maintenance Engineers, District Geotechnical Engineers, District Structures Design Engineers, District Roadway Design Engineers, District Traffic Operations Engineers, Program Management Engineers

FROM: Michael Shepard, P.E., State Roadway Design Engineer
Mark Wilson, P.E., Director, Office of Traffic Engineering & Operations

COPIES: Brian Blanchard, Tom Byron, David Sadler, Tim Lattner, Trey Tillander, Bruce Dana, John Krause, Robert Robertson, Bob Crim, Rudy Powell, Greg Schiess, Nicholas Finch (FHWA), Jeffrey Ger (FHWA), Chad Thompson (FHWA), Phillip Bello (FHWA)

SUBJECT: **Signing and Pavement Marking Standards at Ramp Intersections**

This bulletin introduces new minimum signing and pavement marking standards for interstate exit ramp intersections throughout the state of Florida to complement the Manual of Uniform Traffic Control Devices (MUTCD), 2009 Edition.

REQUIREMENTS

1. The new standard for signing and pavement marking at exit ramp intersections is illustrated in **Figures 7.8.1** "Diamond Interchange Exit Ramp" and **7.8.2** "Partial Cloverleaf/Trumpet Interchange Exit Ramp" and described as follows:

   A. Include MUTCD "optional" signs
      - Second DO NOT ENTER sign
      - Second WRONG WAY sign
      - ONE WAY signs

   B. Include NO RIGHT TURN and NO LEFT TURN signs

C. Use 3.5 ft. by 2.5 ft. WRONG WAY signs mounted at 4-foot height with retroreflective strip on sign supports (MUTCD, Figure 2A-1[E])
D. Include 2-4 dotted guide line striping for left turns between ramps entrances/exits and cross-streets
E. Include retroreflective paint (yellow) on ramp median nose where applicable
F. Include a straight arrow and route interstate shield pavement marking in left-turn lanes extending from the far-side ramp intersection through the near-side ramp intersection to prevent premature left turns
G. Include a straight arrow and ONLY pavement message in outside lane approaching the ramp exit

COMMENTARY

The FDOT Traffic Engineering and Operations Office conducted a study for wrong-way crashes occurring on interstate freeways and expressways throughout the state of Florida. Over the past years (2009-2013), 280 wrong-way crashes have occurred on Florida's freeways and expressways resulting in more than 400 injuries and 75 deaths. This bulletin requires the use of systemic signing and pavement marking countermeasures to deter wrong-way occurrences.

This bulletin complements design requirements established by the Traffic Engineering Manual (TEM), February 2015 Edition, Section 4.2.4 "Route Shields for Wrong Way Treatment". All signing and pavement markings included in this bulleting have corresponding pay item numbers on the Basis of Estimates Manual, 2015 Edition.

BACKGROUND

Prior to this bulletin the minimum MUTCD signing and pavement marking requirements for exit ramp intersections were accepted as the FDOT Standard. The study conducted has identified the need to provide additional direction to motorists and greater level of warning to errant drivers. The installation of these wrong-way driving countermeasures will provide a safer roadway.

IMPLEMENTATION

The requirements of this bulletin are effective immediately on all design-bid-build projects for which the design development is less than 90% complete (Phase III Submittal). These requirements should be employed on projects beyond 90% complete where implementation will not adversely impact the production schedule.

The requirements of this bulletin are effective immediately on all design-build projects for which the final RFP has not been released. Implementation of this bulletin for Design-build projects for which the final RFP has been released is at the discretion of the District.

CONTACT(s)

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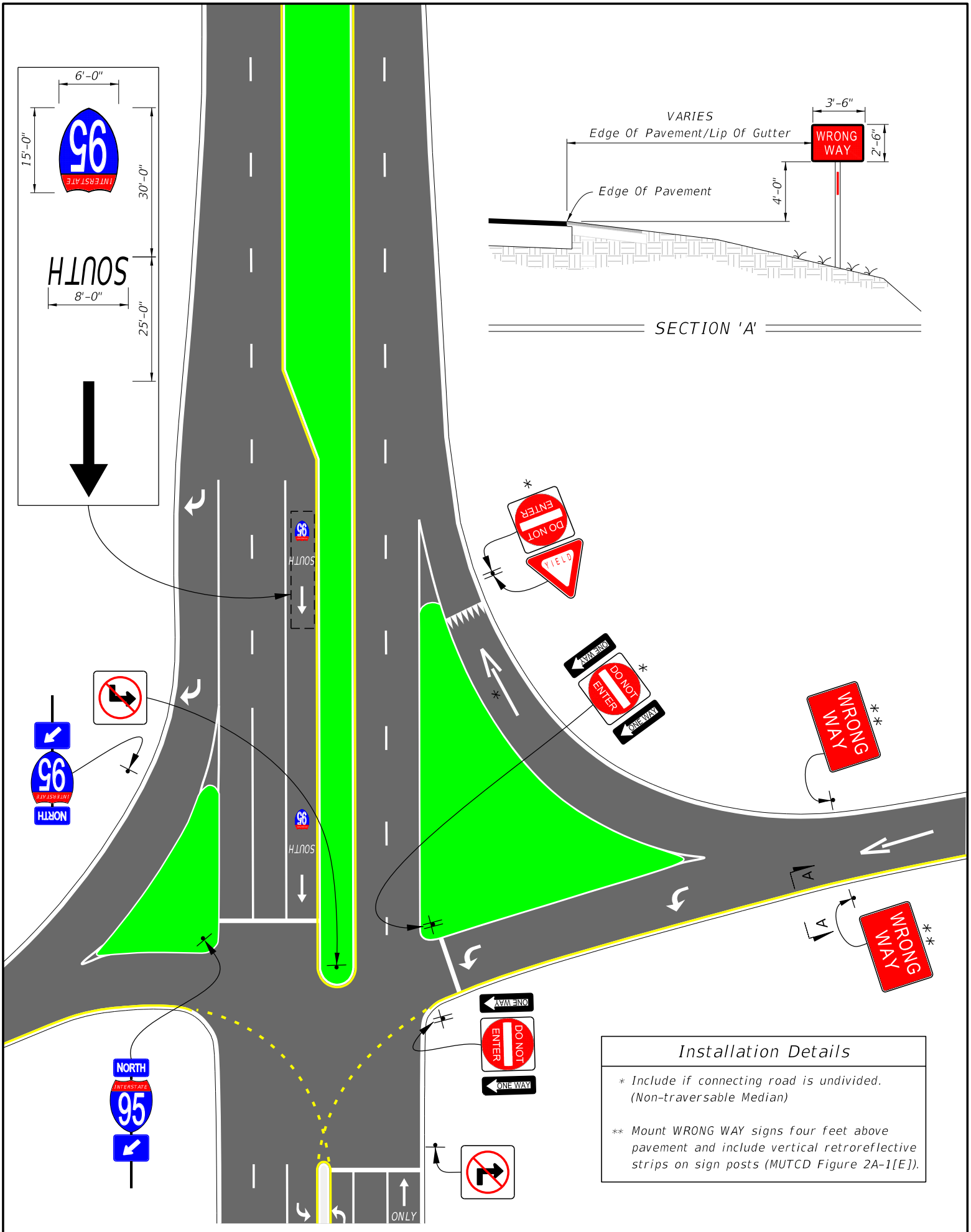

Figure 7.8.1 Diamond Interchange Exit Ramp

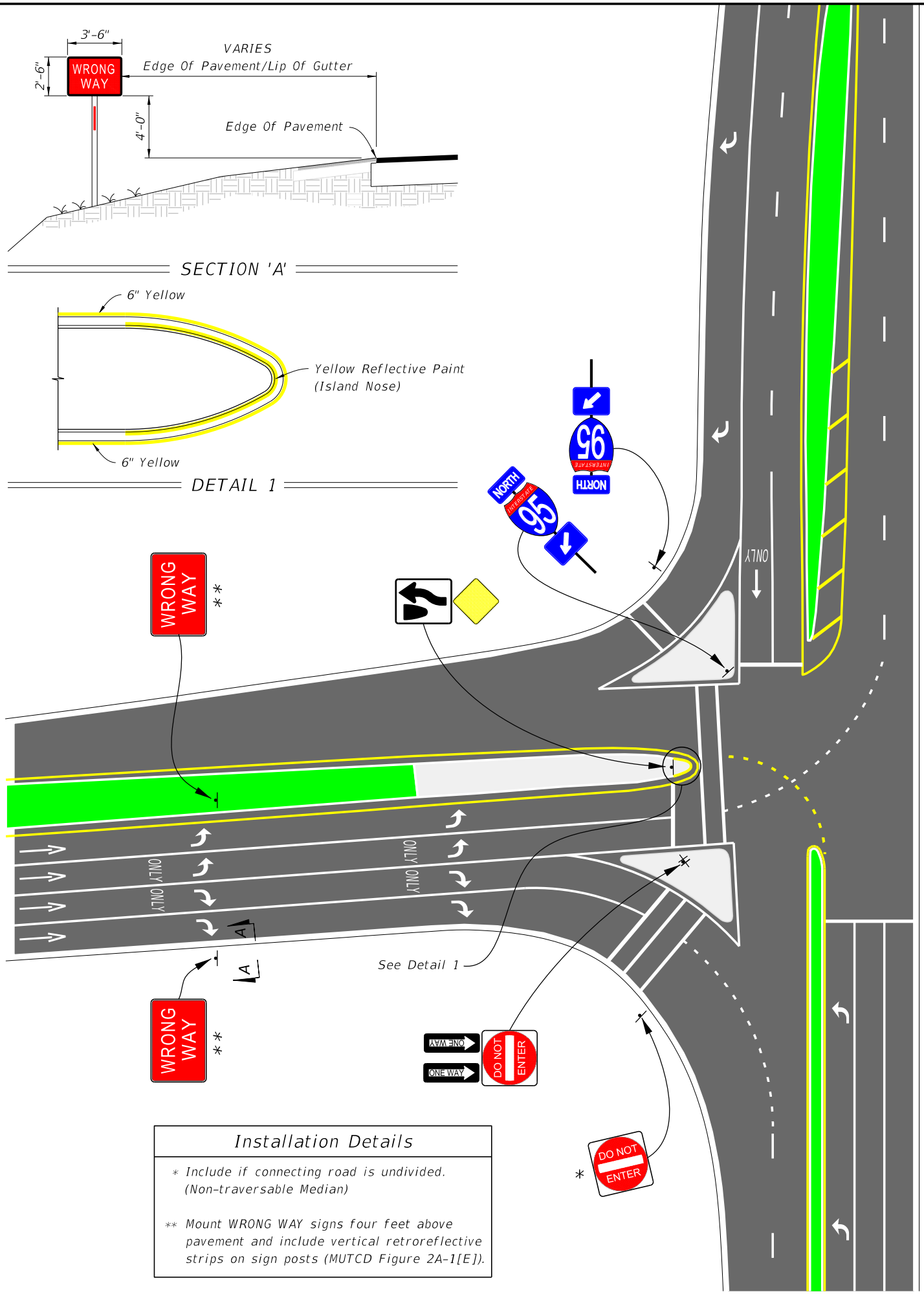

Figure 7.8.2 Partial Cloverleaf/Trumpet Interchange Exit Ramp

Centennial FDOT 1915 ★ 2015

Florida Department of Transportation

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ESTIMATES BULLETIN 15-05
TRAFFIC OPERATIONS BULLETIN 04-15

DATE: July 9, 2015

TO: District Directors of Transportation Operations, District Directors of Transportation Development, District Design Engineers, District Consultant Project Management Engineers, District Construction Engineers, District Maintenance Engineers, District Roadway Design Engineers, District Traffic Operations Engineers, District Specifications Engineers, District Estimates Engineers, Program Management Engineers

FROM: Phillip "Greg" Davis, P.E., State Estimates Engineer
Mark Wilson, P.E., State Traffic Operations Engineer

Trey Tillander for Greg Davis

COPIES: Brian Blanchard, Tom Byron, Tim Lattner, Trey Tillander, David Sadler, Bruce Dana, John Krause, Robert Robertson, Michael Shepard, Bob Crim, Rudy Powell, Greg Davis, Daniel Scheer, Bob Burleson, Greg Schiess, Nicholas Finch (FHWA), Rafiq Darji, Chad Thompson (FHWA), Phillip Bello (FHWA)

SUBJECT: RETROREFLECTIVE STRIPS FOR SIGNS

This bulletin/memo supplements Roadway Design Bulletin 15-08/Traffic Operations Bulletin 03-15 with additional guidance for use of Retroreflective Strips. Specifications Section 700 has been updated to include material requirements, dimensions, measurement and payment information. This specification will be available for the January 2016 e-book.

REQUIREMENTS

1. Show pay item for Retroreflective Strips in the plans (signing pay items) and summarize on the Signing and Pavement Marking Tabulation Sheet.

   NOTE: *Retroreflective strips are required for use on Wrong Way Signs at Ramp Intersections, Rail Road Crossbuck sign blades, and Rail Road Crossbuck sign supports (MUTCD 5F.02 and 8B.03). See implementation plan below for other locations.*

2. Pay item **700- 13- AB Retroreflective Sign Strip, EA** is effective July 1, 2015.

A= Operation

1 (Furnish & Install)

B= Height of Reflective Strip

0 (Back of Rail Road Crossbuck Sign) for back of blades

2 (2') for signs mounted at 4’

5 (5') for signs mounted at 7’, per implementation plan below.

COMMENTARY

Retroreflective Strips are one type of Conspicuity Marking permitted in the MUTCD. The dimensions and material requirements included in the specification are intended to provide a consistent, statewide standard for conspicuity marking products on sign posts. Specific proprietary products are not to be identified in the plans.

While the MUTCD allows for conspicuity markings on other signs, Section 2A.15 also states that “Sign conspicuity improvements can also be achieved by removing non-essential and illegal signs from the right-of-way (see MUTCD Section 1A.08), and by relocating signs to provide better spacing.” Therefore, the Engineer of Record should recognize that the overuse of conspicuity markings could diminish the effectiveness at necessary locations.

The Traffic Engineering Manual (TEM) will be updated with Guidelines for Use of Retroreflective Strips.

BACKGROUND

Refer to Roadway Design Bulletin 15-08/Traffic Operations Bulletin 03-15 for background information on wrong way signs at ramp intersections.

IMPLEMENTATION

For Projects let January 2016 and later:

The Retroreflective strips are approved for use on Wrong Way Signs at Ramp Intersections and Rail Road Crossbucks.

All other locations must be approved by the District Traffic Operations Engineer, and should only be used where additional conspicuity is needed, in accordance with the guidance in the TEM.

Include the pay item(s) in the plans and tabulation sheet, as noted above. The specification will be available in the 2016 e-Book.

For Projects let July 2015 through December 2015:

The Retroreflective strips are approved for use on Wrong Way Signs at Ramp Intersections and Rail Road Crossbucks.

All other locations MUST be approved by the State Traffic Engineering and Operations Office, and should only be used where additional conspicuity is needed.

Include the pay item(s) in the plans and tabulation sheet, as noted above. A Modified Special Provision (MSP) will be available through the District Specifications Office, and must be included with the pay item.

CONTACTS

If you have any questions, please contact:
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Traffic Operations: Raj Ponnaluri, 850-410-5418, Raj.Ponnaluri@dot.state.fl.us

ATTACHMENTS
Modified Special Provision (MSP) for Construction Projects- Highway Signs

ATTACHMENT 1- Modified Special Provision

HIGHWAY SIGNS.
(REV 5-21-15)

ARTICLE 700-2 is expanded by the following:

700-2.1.6 Retroreflective Strips for Signs: Use only on signs where the retroreflective strip is called for in the Plans. Use 0.040 aluminum panels, Type IV or Type XI retroreflective sign sheeting meeting the requirements of Section 994 for the fabrication of the sign strips and stainless steel attachment hardware for the installation. Retroreflective strips must be 2 inches in width and a height of 5 feet for all signs except for WRONG WAY signs, when mounted at 4 feet, the retroreflective strip will be 2 feet in height. For the back of Rail Road Crossbuck signs, the retroreflective strip will be 2 inches wide for the full length of the blade. Match the color of the retroreflective sheeting to the background color of the sign except for YIELD signs and DO NOT ENTER signs, where the color must be red.

SUBARTICLE 700-2.3 is deleted and the following substituted:

700-2.3 Method of Measurement: For single post and multi post sign assemblies, an assembly consists of all the signs mounted on a single structure. The Contract unit price per assembly for ground mounted signs (single post and multi-post), furnished and installed, will include furnishing the sign panels, support structure, foundation, hardware, and labor necessary for a complete and accepted installation.

The retroreflective sign strip will be paid for separately, and the Contract unit price per each will include furnishing the sign strips, hardware and labor necessary for a complete and accepted installation.

For overhead signs, sign panels will be paid separately from support structures. The Contract unit price per each for sign panel, furnished and installed, will include furnishing the sign panels, hardware, and labor necessary for a complete and accepted installation. The Contract unit price for each overhead static sign structure, furnished and installed, will include furnishing the support structure, foundation, hardware, and labor necessary for a complete and accepted installation.

Relocation of signs will consist of removing the existing sign assembly and installing the sign on a new foundation at the location shown in the Plans.

When the Plans call for existing ground-mounted signs to be relocated or removed, after removing the sign panel from the assembly, remove supports and footings. Restore the area of the sign removal or relocation to the condition of the adjacent area.

SUBARTICLE 700-2.4 is deleted and the following substituted:

700-2.4 Basis of Payment: Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 700- 1-	Single Post Sign, per Assembly.
Item No. 700- 2-	Multi Post Sign, per Assembly.
Item No. 700- 3-	Sign Panel, per Each.
Item No. 700- 4-	Overhead Static Sign Structure , per each.
Item No. 700- 13	Retroreflective Strip, per each.

2015 Design Training Expo

Wrong Way Driving: a Statewide Initiative

Raj Ponnaluri, PhD, P.E, PTOE
Traffic Engineering & Operations Office
Florida Department of Transportation

Innovative Solutions for tomorrow's transportation needs

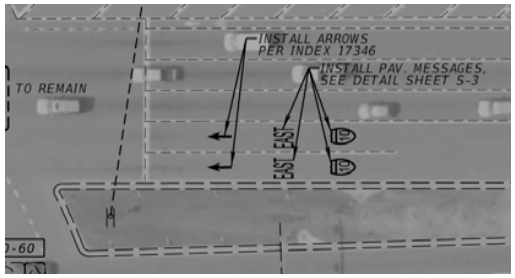
Overview

- CO Traffic Ops developed the statewide effort to address WW incidence.
- Discussions with the District Traffic Engineering and Operations Offices.
- Statewide crash data were analyzed.
- FTE and D3: developed and implemented pilot projects.
- Turnpike began the effort on HEFT; D3 initiated the Tallahassee I-10 Project.
- Several Districts evaluated WW concerns.
- D7 began a District-wide evaluation and implementation.
- Red Rectangular Rapid Flashing Beacons (‘R’RRFB) being tested in D7, Tampa.
- In-road red reflective pavement markers as a stop line will soon be tested in D3.

Pilot Projects – FTE and District 3

- CO with FTE and D3 to develop the pilot projects worked
- 10 interchanges on HEFT; 5 more on Sawgrass Expressway
- Mainly signing and pavement marking (S&PM) countermeasures
- HEFT S&PM effort complete; Sawgrass Expressway pilot being implemented
- D3's implementation with 3 interchanges @ four I-10 ramps in Tallahassee

Pilot Projects in Florida – I-10 (D3)



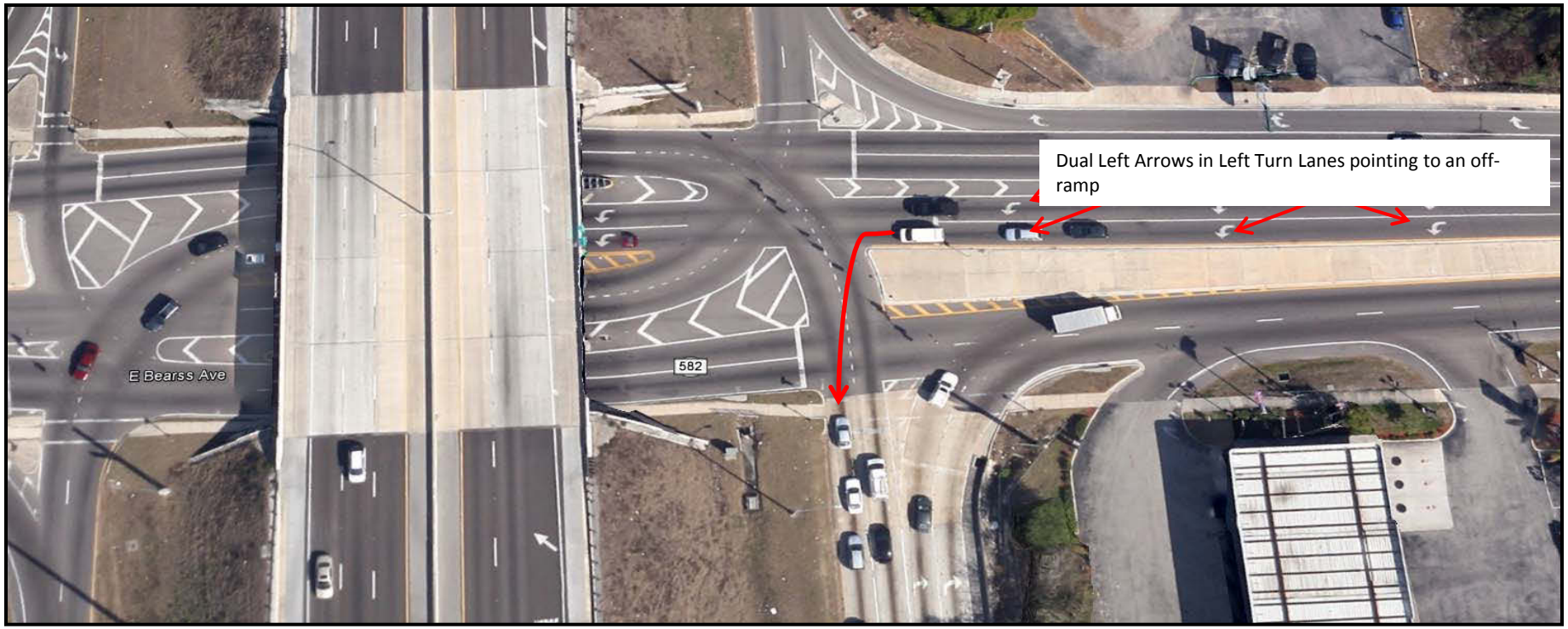
- 4 locations include:
  - SR 263 (Capital Circle NW)
  - SR 63 (US 27/N Monroe St)
  - SR 61 (Thomasville Rd)
  - SR 261 (US 319/Capital Circle NE)
- Installations include:
  - LED-illuminated WRONG WAY signs and vehicle detection
  - Enhanced DO NOT ENTER and static WRONG WAY signage
  - Overhead WRONG WAY signage
  - Enhanced signage (no right-turn, left-turn, no U-turn) and pavement markings on cross streets
  - Median curb extensions to discourage early left-turns
  - Wrong way arrows (RRPMs)

D7 - WWD Crash Treatments

- D7 – District study completed in April 2014; construction project to enhance S&PM along interchanges within Tampa Bay area.
- Per FHP news release (9/7/14), 3 recent fatal crashes involved drunk/drug drivers making U-turn along I-275; drivers entering on correct approach.
- Super short term (2 months) – Traffic service requests to maintenance office to upgrade substandard WW signs
- Short term (5 months) – Use DBPB contract to enhance S&PM @ off-ramps along I-275 corridor in Hillsborough and Pinellas Counties
- Mid tem (12 months) – Use RRFB & wrong way detection technology to create pilot WW detection and awareness
- Long term (12+ months) – Working with CO to develop WW education, enforcement, ramp geometry and ITS treatment

Arterial Treatments : E Bears Ave @ I-275 – Dual Lefts - Current:

Potential Left-Turn Movement into the Off-ramps from I-275



Place Interstate Shied with Straight Arrow, ONLY

No Left Turns; Pavement Shields

-  facing arterial traffic on signal mast arm and post-mounted.

- Pavement shields to designate lane use for on-ramp access.

One Way, Do Not Enter Signs

- ONLY ⇧ arrow in the rightmost arterial lane adjacent to off-ramp.
-  facing arterial traffic at the ramp terminus.
-  and  signs combination at ramp terminus and immediately adjacent to the arterials.

Wrong Way, Large Overhead Signs

- Install WRONG WAY signs on the left and right side of the off-ramp

- Install a large WRONG WAY sign on the backside of an existing overhead structure

Detection-triggered Electronic Signs

- Wrong Way signs with beacons for better visibility at night.
- Turnpike devices which detect wrong way movements
- District 3's devices in Tallahassee

Wrong Way Advisory / Blinker-sign with Detection

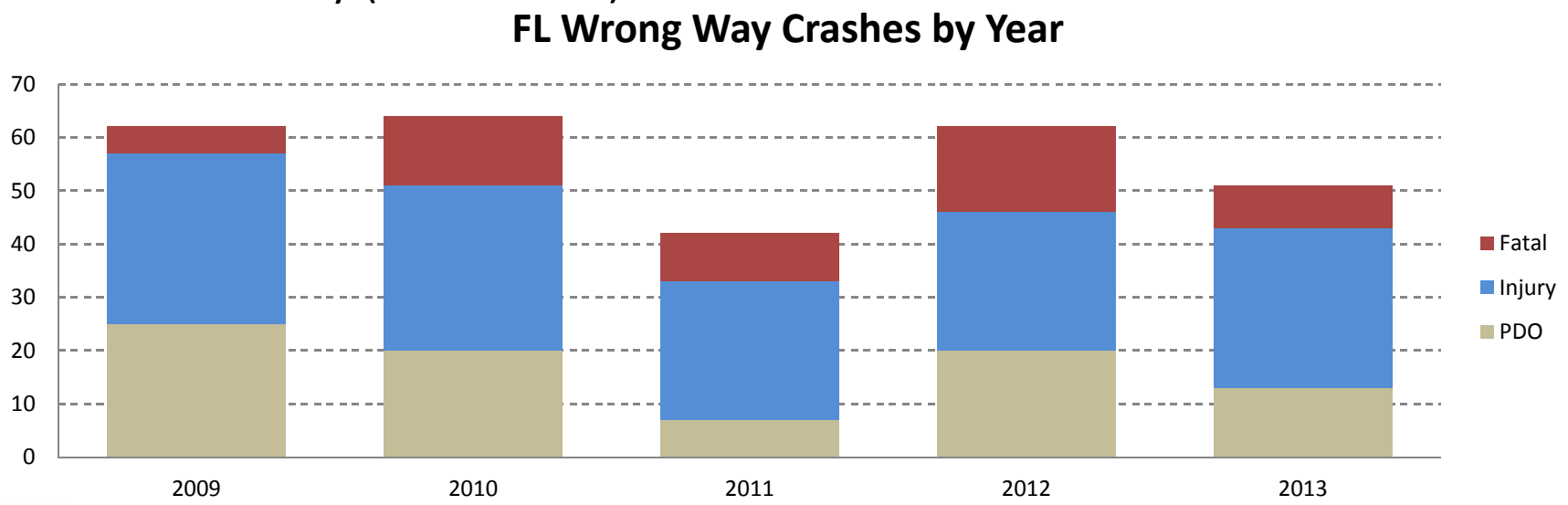
D7 RRFB Video – click to view

Statewide Study

- Statewide Wrong Way Study on limited access off-ramps
- Scope included:
  - Review and analysis of WWD-related crash data
  - Review field conditions at 40 locations
  - Develop countermeasures for implementation
  - Provide recommendation for handling WWD incidence

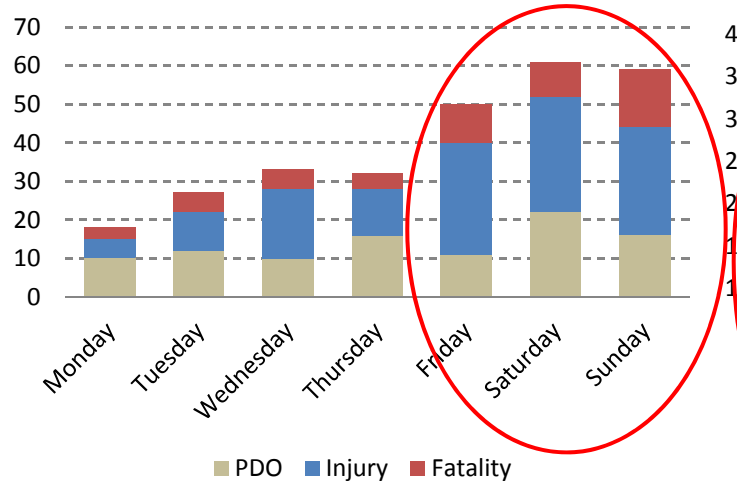
Florida Wrong Way Crash Summary

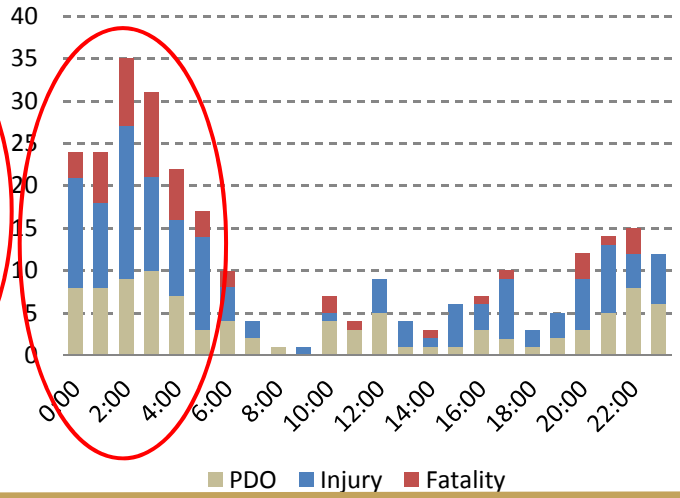
- 280 statewide wrong way crashes (2009-2013)
  - 30% PDO
  - 52% Injury (411 injuries)
  - 18% Fatality (75 fatalities)



Florida Wrong Way Crash Summary

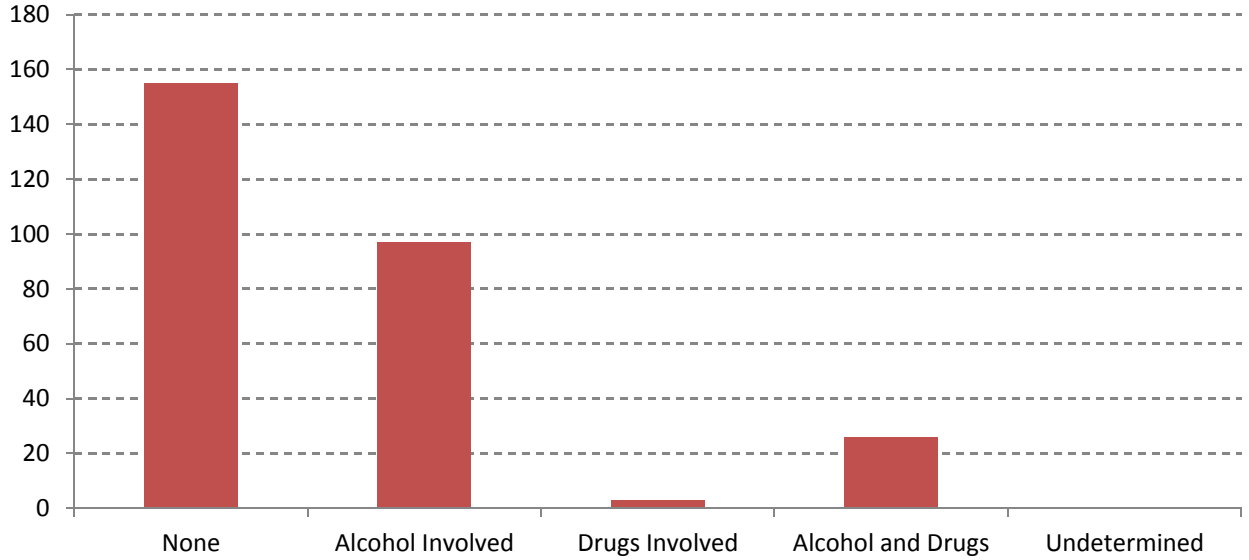
- Wrong way crashes skew toward weekend days
  - 61% occurred Friday through Sunday
  - 1.7 times more than expected on Saturday and Sunday
- Wrong way crashes skew toward early morning hours (12am to 6am)
  - 55% of total wrong way crashes – 4.1 times more than expected
  - 70% of fatal wrong way crashes





Florida Wrong Way Crash Summary

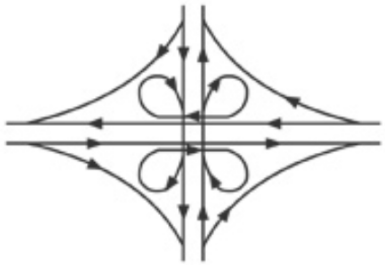
- 45% of wrong way crashes involved alcohol/drugs
  - Consistent with literature review findings (approx. 50%)
  - Proportion 16 times more than all freeway/expressway crashes
  - Potentially under-reported



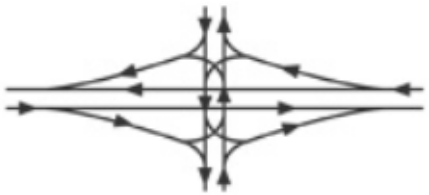
Literature Review – Interchange Types

- Susceptible interchange types:
  - Partial cloverleaf
  - Diamond
  - Left-hand exits
- Full cloverleaf considered most desirable for preventing wrong way movements

Partial Cloverleaf



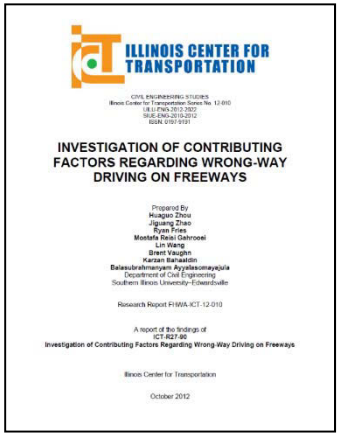
Full Cloverleaf



Diamond

Crash Score Analysis

- Identify interchange locations potentially associated with wrong way entry
- Methodology developed by Illinois Center for Transportation (2012)
  - Identify crashes where vehicle entered the system in wrong direction
    - If entry interchange/ramp was reported, obtain location data
    - If not reported, obtain data for 1st and 2nd upstream interchanges
    - Record interchange locations and interchange types from the RCI database
  - Apply a weighted score to each interchange location and type
    - 1.0 for reported locations/types
    - 0.75 for unreported, 1st upstream location/types
    - 0.25 for unreported, 2nd upstream location/types


ILLINOIS CENTER FOR TRANSPORTATION

INVESTIGATION OF CONTRIBUTING FACTORS REGARDING WRONG-WAY DRIVING ON FREEWAYS

Prepared By
Huagen Zhou
Jiguang Zhao
Ryan Fries
Mostafa Reisi Gahrooei
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Department of Civil Engineering
Southern Illinois University–Edwardsville

Research Report FHWA-ICT-12-010

A report of the findings of
ICT-R27-90
Investigation of Contributing Factors Regarding Wrong-Way Driving on Freeways

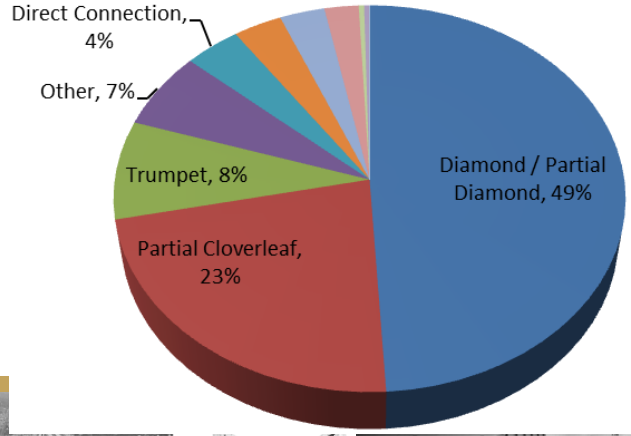
Illinois Center for Transportation

October 2012

Interchange Distribution

- Interchange types with the highest crash scores
  - diamond/partial diamond (crash score of 98)
  - partial cloverleaf (crash score of 45)
  - trumpet (crash score of 17)
- Interchange type with the lowest crash score
  - full cloverleaf (crash score of 1)
- Crash distribution fairly consistent with state's proportion of interchange types

Interchange Type	Statewide Distribution Proportion	Wrong Way Crash Score Proportion
Diamond/Partial Diamond	55.7%	49.1%
2 Quadrant/Partial Cloverleaf	25.5%	22.7%
Trumpet	6.0%	8.3%
Direct Connection Design	5.7%	3.9%
Y Intersection	3.0%	3.1%



Field Review Locations

- 40 Interchange Locations for Field Review
- Considerations
  - Focus on locations linked to wrong way entry
    - High Crash Score (see next slide for methodology)
    - Crash Score per Million Vehicles per Day
  - Statewide district representation
    - Estimated distribution from crash history
      - D1, D3: 3 locations
      - D4, D7: 4 locations
      - D5, D6: 6 locations
      - D2, D8: 7 locations
  - Area type representation (urban vs. rural)
    - Crashes history 76% urban, 24% rural
  - Interchange type representation
    - Diamond, partial diamond, partial cloverleaf, and trumpet

Systemic Wrong Way Countermeasures

- General systemic countermeasures include increasing FDOT's minimum standards to include:
  - MUTCD "optional" signs – 2nd wrong way sign, turn restriction signs, one-way signs
  - Lower (4-ft) mounting height for wrong way signs
  - Add vertical retroreflective strip on sign supports (see MUTCD Figure 2A-1[E]).
  - Type 11 retroreflective sheeting on all wrong way related signs
  - Higher standard of interchange guide signing on crossroad (e.g. overhead v. side-mount, green sign v. shield)
  - 2-ft by 4-ft skip (guide) stripes for left turns between ramps entrances/exits and cross-streets
  - Painted (yellow) median nose
  - Where appropriate, shape median openings to restrict/deter wrong way turning movements (quick curb may be used as needed in retrofit situations)

Level 1a Countermeasures

- Level 1a – MUTCD and FDOT Minimum Requirements
  - Proper signing sequences and level of interchange guide signage on crossroad.
  - Stop bars at end of exit ramps.
  - Keep right signs, as appropriate, on side-by-side exit and entrance ramps
  - Ramp and crossroad lighting (Ref: PPM)
  - WW Arrows on exit ramp (Ref: Std Index 17345)

Level 1b Countermeasures

- Level 1b – Proposed FDOT Minimum Requirements
  - MUTCD "optional" signs – 2nd wrong way sign, turn restriction signs, one-way signs
  - Lower (4-ft) mounting height for wrong way signs
  - Add vertical retroreflective strip on sign supports (see MUTCD Figure 2A-1[E]).
  - Type 11 retroreflective sheeting on all wrong way related signs
  - Higher standard of interchange guide signing on crossroad (e.g. overhead v. side-mount, green sign v. shield)
  - 2-ft by 4-ft skip (guide) stripes for left turns between ramps entrances/exits and cross-streets
  - Painted (yellow) median nose
  - Where appropriate, shape median openings to restrict/deter wrong way turning movements (quick curb may be used as needed in retrofit situations)

Design-TO Joint Bulletin

Centennial FDOT 1915 ★ 2015

Florida Department of Transportation

RICK SCOTT
GOVERNOR

605 Suwannee Street
Tallahassee, FL 32399-0450

JIM BOXOLD
SECRETARY

ROADWAY DESIGN BULLETIN 15-08
TRAFFIC OPERATION BULLETIN 03-15
(FHWA Approved: April 14, 2015)

DATE: April 15, 2015

TO: District Directors of Transportation Operations, District Directors of Transportation Development, District Design Engineers, District Consultant Project Management Engineers, District Construction Engineers, District Maintenance Engineers, District Geotechnical Engineers, District Structures Design Engineers, District Roadway Design Engineers, District Traffic Operations Engineers, Program Management Engineers

FROM: Michael Shepard, P.E., State Roadway Design Engineer
Mark Wilson, P.E., Director, Office of Traffic Engineering & Operations

COPIES: Brian Blanchard, Tom Byron, David Sadler, Tim Lattner, Trey Tillander, Bruce Dana, John Krause, Robert Robertson, Bob Crim, Rudy Powell, Greg Schiess, Nicholas Finch (FHWA), Jeffrey Ger (FHWA), Chad Thompson (FHWA), Phillip Bello (FHWA)

SUBJECT: **Signing and Pavement Marking Standards at Ramp Intersections**

This bulletin introduces new minimum signing and pavement marking standards for interstate exit ramp intersections throughout the state of Florida to complement the Manual of Uniform Traffic Control Devices (MUTCD), 2009 Edition.

REQUIREMENTS

1. The new standard for signing and pavement marking at exit ramp intersections is illustrated in **Figures 7.8.1** "Diamond Interchange Exit Ramp" and **7.8.2** "Partial Cloverleaf/Trumpet Interchange Exit Ramp" and described as follows:

   A. Include MUTCD "optional" signs
      - Second DO NOT ENTER sign
      - Second WRONG WAY sign
      - ONE WAY signs

   B. Include NO RIGHT TURN and NO LEFT TURN signs

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C. Use 3.5 ft. by 2.5 ft. WRONG WAY signs mounted at 4-foot height with retroreflective strip on sign supports (MUTCD, Figure 2A-1[E])
D. Include 2-4 dotted guide line striping for left turns between ramps entrances/exits and cross-streets
E. Include retroreflective paint (yellow) on ramp median nose where applicable
F. Include a straight arrow and route interstate shield pavement marking in left-turn lanes extending from the far-side ramp intersection through the near-side ramp intersection to prevent premature left turns
G. Include a straight arrow and ONLY pavement message in outside lane approaching the ramp exit

COMMENTARY

The FDOT Traffic Engineering and Operations Office conducted a study for wrong-way crashes occurring on interstate freeways and expressways throughout the state of Florida. Over the past years (2009-2013), 280 wrong-way crashes have occurred on Florida's freeways and expressways resulting in more than 400 injuries and 75 deaths. This bulletin requires the use of systemic signing and pavement marking countermeasures to deter wrong-way occurrences.

This bulletin complements design requirements established by the Traffic Engineering Manual (TEM), February 2015 Edition, Section 4.2.4 "Route Shields for Wrong Way Treatment". All signing and pavement markings included in this bulleting have corresponding pay item numbers on the Basis of Estimates Manual, 2015 Edition.

BACKGROUND

Prior to this bulletin the minimum MUTCD signing and pavement marking requirements for exit ramp intersections were accepted as the FDOT Standard. The study conducted has identified the need to provide additional direction to motorists and greater level of warning to errant drivers. The installation of these wrong-way driving countermeasures will provide a safer roadway.

IMPLEMENTATION

The requirements of this bulletin are effective immediately on all design-bid-build projects for which the design development is less than 90% complete (Phase III Submittal). These requirements should be employed on projects beyond 90% complete where implementation will not adversely impact the production schedule.

The requirements of this bulletin are effective immediately on all design-build projects for which the final RFP has not been released. Implementation of this bulletin for Design-build projects for which the final RFP has been released is at the discretion of the District.

New Requirements

I . The new standard for signing and pavement marking at exit ramp intersections is illustrated in Figures 7.8.1 "Diamond Interchange Exit Ramp" and 7.8.2 "Partial Cloverleaf/Trumpet Interchange Exit Ramp" and described as follows:

A. Include MUTCD "optional" signs

• Second DO NOT ENTER sign; • Second WRONG WAY sign; • ONE WAY signs

B. Include NO RIGHT TURN and NO LEFT TURN signs

C. Use 3.5 ft. by 2.5 ft. WRONG WAY signs mounted at 4-foot height with retroreflective strip on sign supports (MUTCD, Figure 2A-1[E])

D. Include 2-4 dotted guide line striping for left turns between ramps entrances/exits and cross-streets.

E. Include retroreflective paint (yellow) on ramp median nose where applicable

F. Include a straight arrow and route interstate shield pavement marking in left-turn lanes extending from the far-side ramp intersection through the near-side ramp intersection to prevent premature left turns

G. Include a straight arrow and ONLY pavement message in outside lane approaching the ramp exit

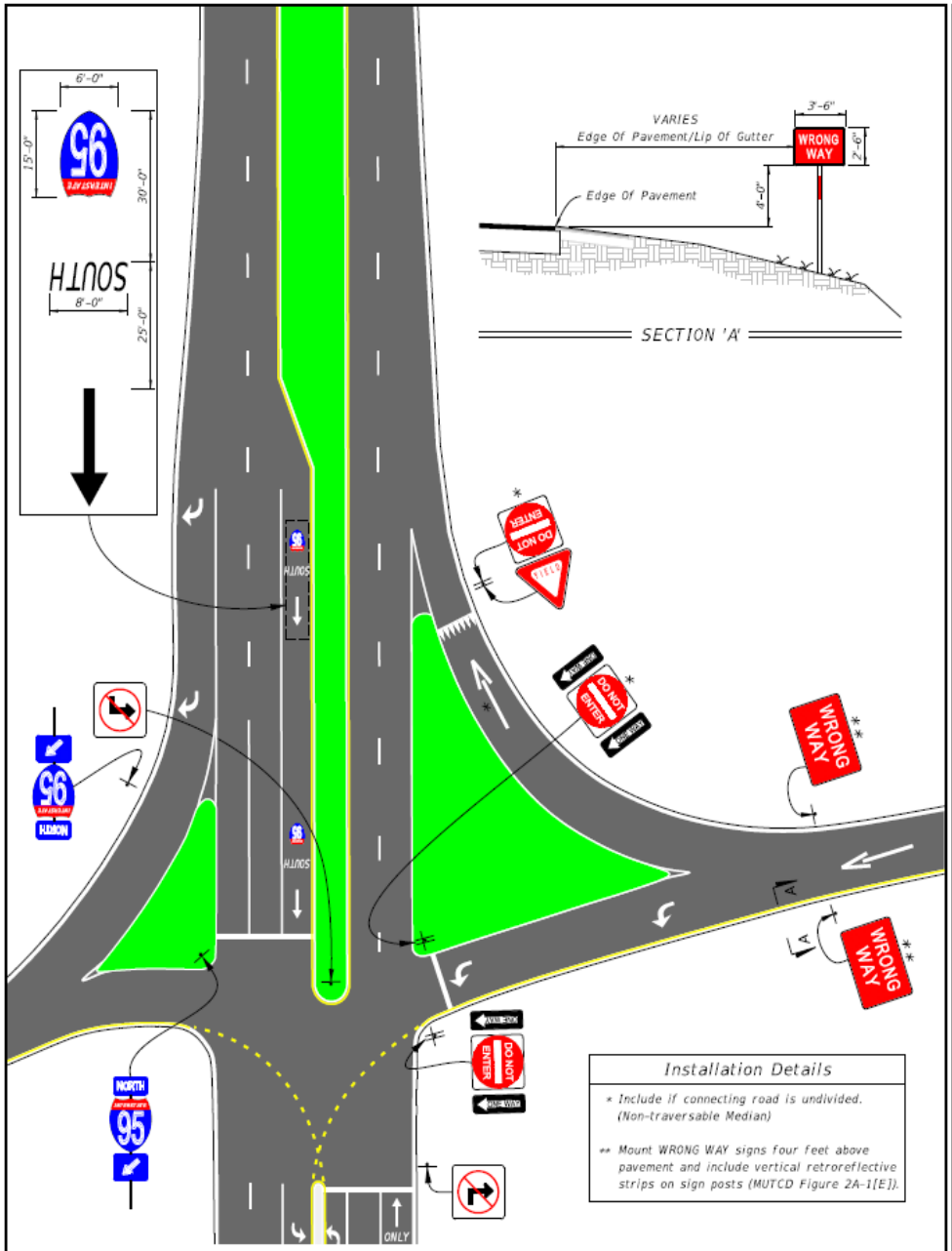


Figure 7.8.1 Diamond Interchange Exit Ramp

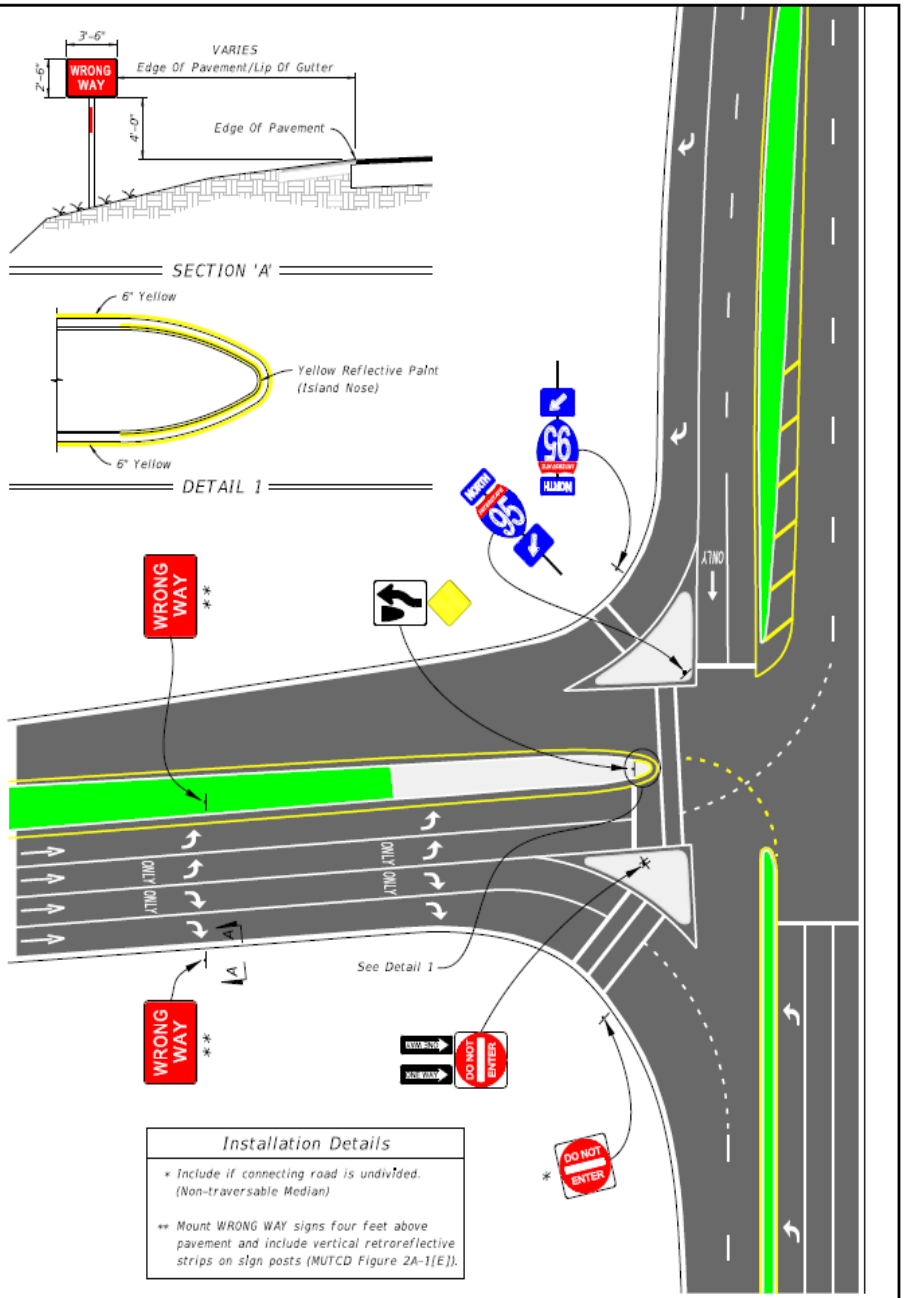


Figure 7.8.2 Partial Cloverleaf/Trumpet Interchange Exit Ramp

Last but not the least…

- Do not forget the 3Es
  - Engineering
  - Education
  - Enforcement

Thank you

FREEWAY AND SERVICE ROAD CONNECTIONS

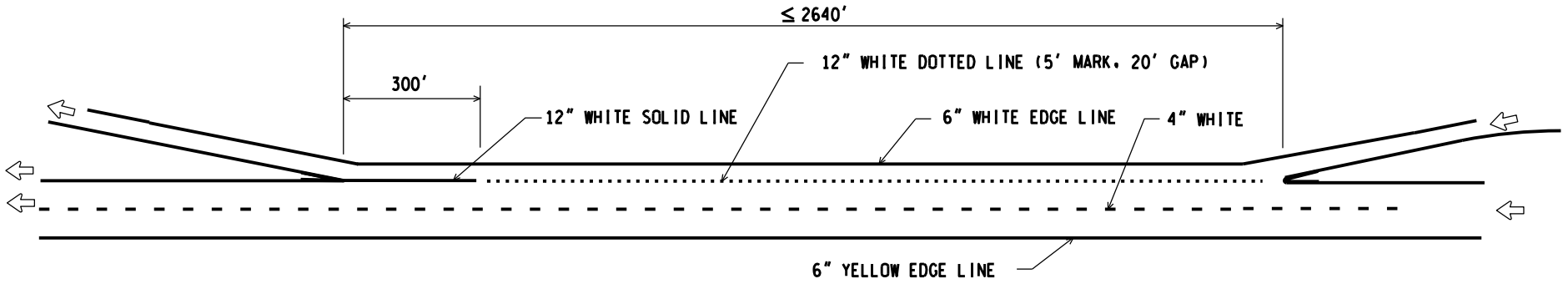
REFER TO NOTES ON SHEET 2.

MDOT Michigan Department of Transportation PREPARED BY DESIGN DIVISION DRAWN BY: LMF CHECKED BY: JGM	DEPARTMENT DIRECTOR Kirk T. Steudle APPROVED BY: _____ DIRECTOR, BUREAU OF FIELD SERVICES APPROVED BY: _____ DIRECTOR, BUREAU OF HIGHWAY DEVELOPMENT	MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR FREEWAY AND RAMP PAVEMENT MARKINGS

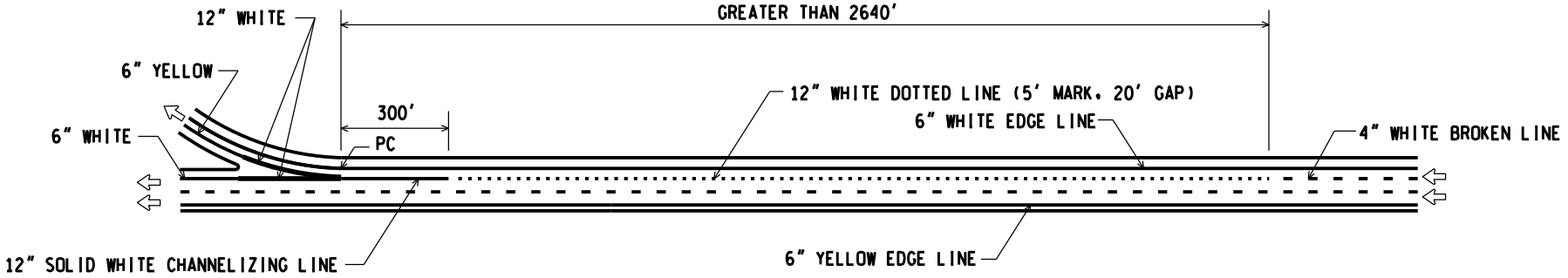
00/00/00	02/10/15	PAVE-925-C	SHEET 1 OF 8
F.H.W.A. APPROVAL	PLAN DATE		

NOTE: THE ORIGINAL SIGNED COPY IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.

NOT TO SCALE



FREEWAY WEAVING LANE



LANE-DROP EXIT GREATER THAN 2640 FT

NOTES:

1. For long weaving lanes (greater than 900 ft) where a RIGHT LANE MUST EXIT sign is normally used, pavement marking should conform to the lane-drop exit treatment shown on this sheet.

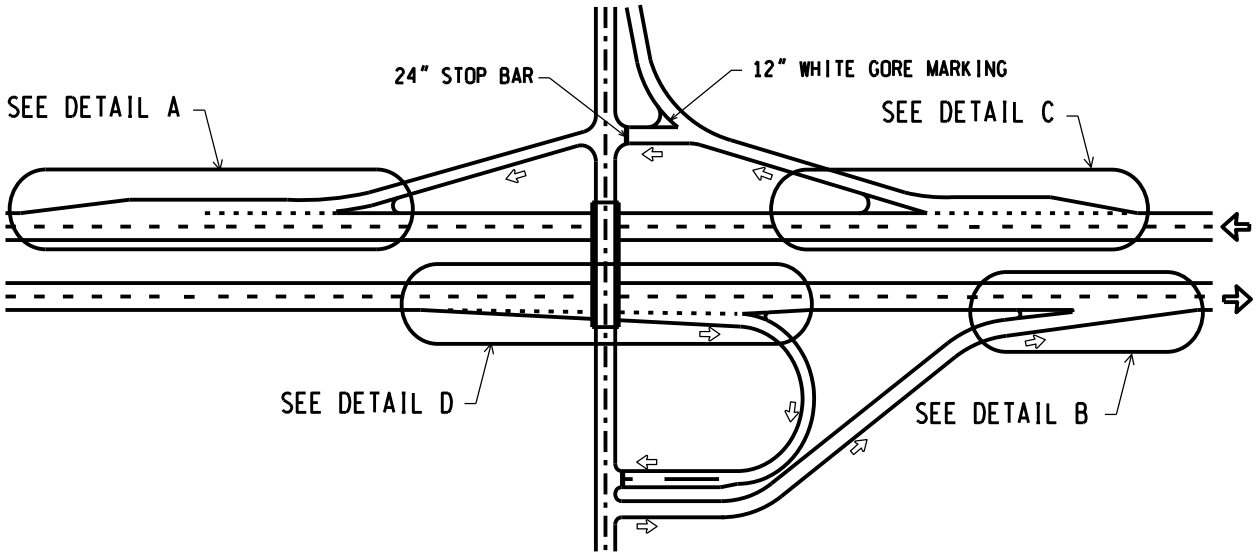
MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN

00/00/00
F.H.W.A. APPROVAL

02/10/15
PLAN DATE

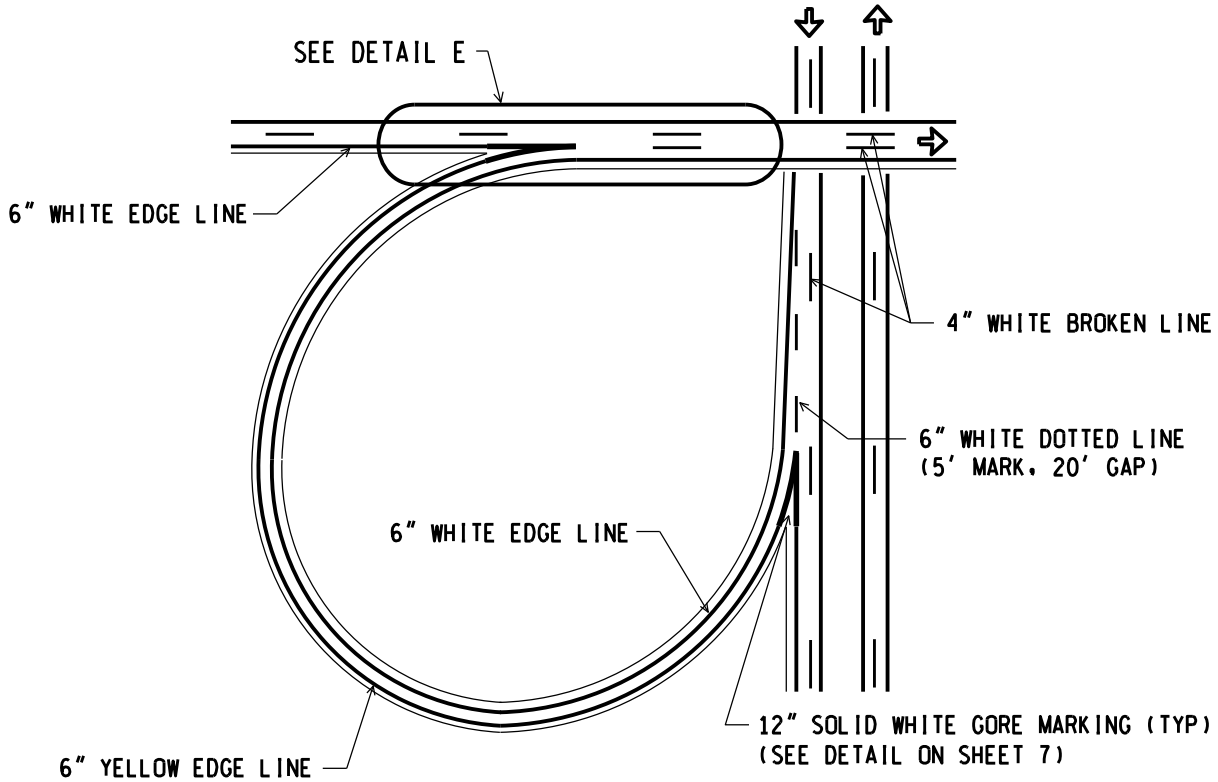
PAVE-925-C

SHEET 2 OF 8



NOTE: For Details A, B, C, D and E see Sheet 4.

ENTRANCE AND EXIT RAMPS



LOOP RAMP

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	00/00/00 F.H.W.A. APPROVAL	02/10/15 PLAN DATE	PAVE-925-C	SHEET 3 OF 8

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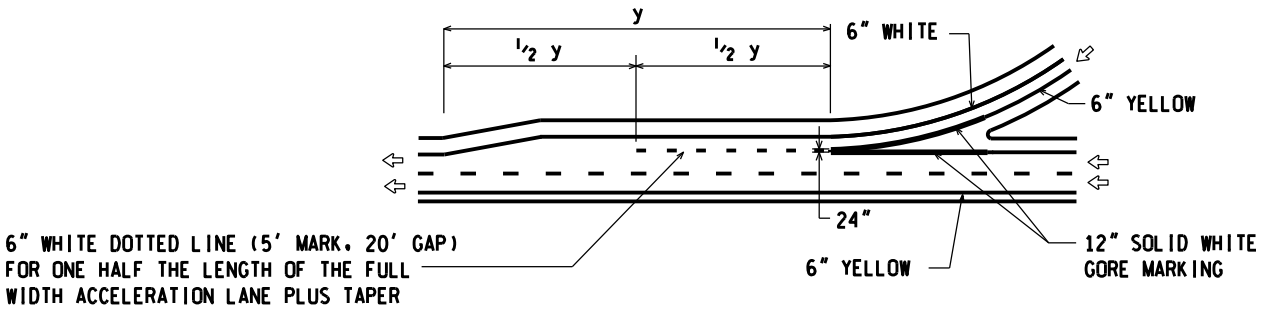
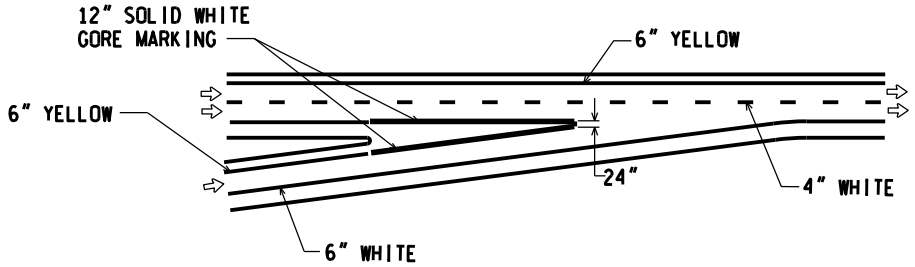
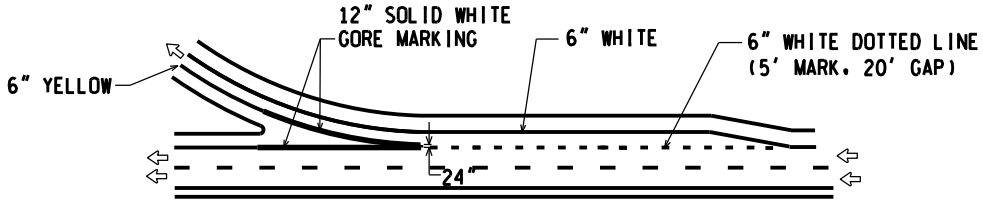


DETAIL A - PARALLEL ACCELERATION LANE



DETAIL B - TAPERED ACCELERATION LANE



DETAIL C - PARALLEL DECELERATION LANE

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	00/00/00 F.H.W.A. APPROVAL	02/10/15 PLAN DATE	PAVE-925-C	SHEET 4 OF 8

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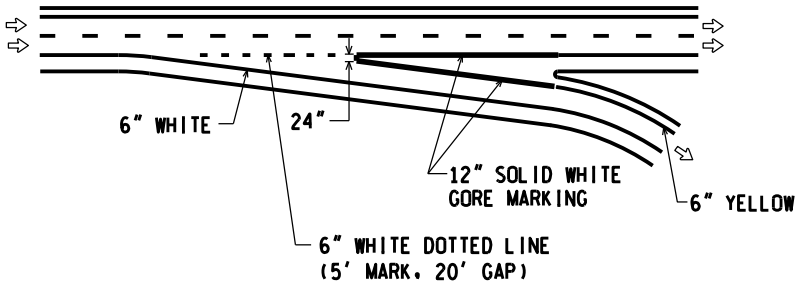
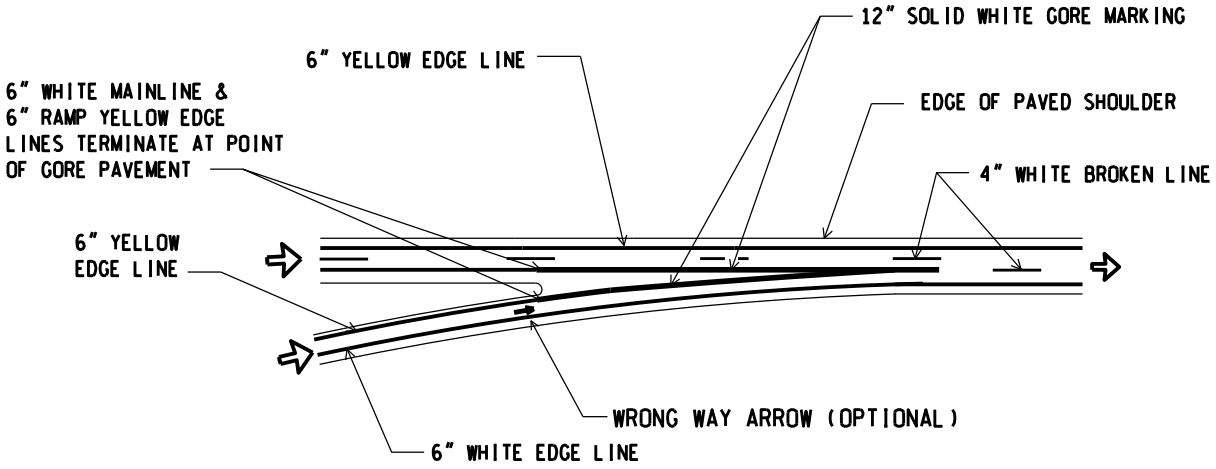


DETAIL D - TAPERED DECELERATION LANE

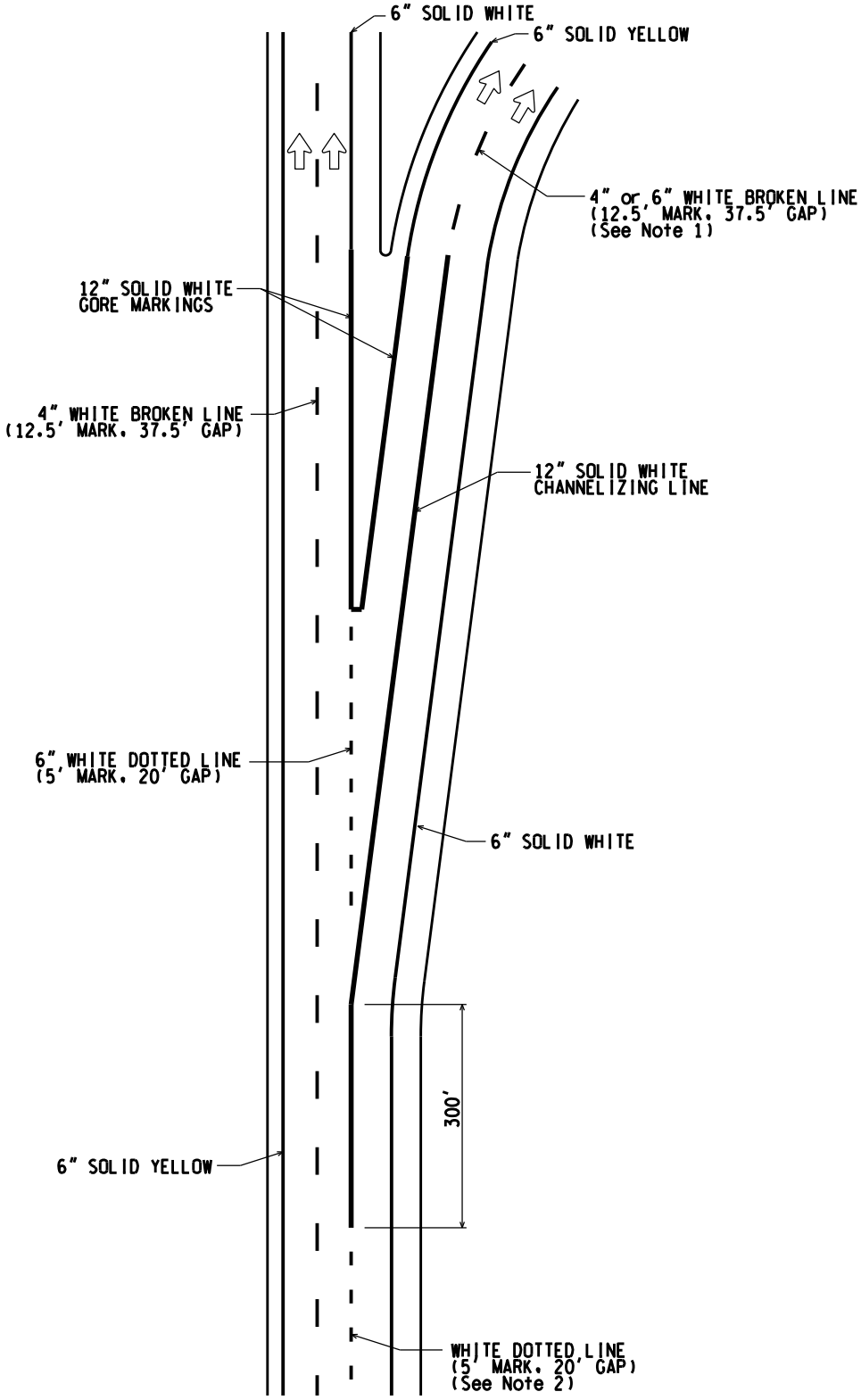


DETAIL E - TAPERED ACCELERATION LANE WITH ADDED LANE

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	00/00/00 F.H.W.A. APPROVAL	02/10/15 PLAN DATE	PAVE-925-C	SHEET 5 OF 8

NOTE: THE ORIGINAL SIGNED COPY IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.



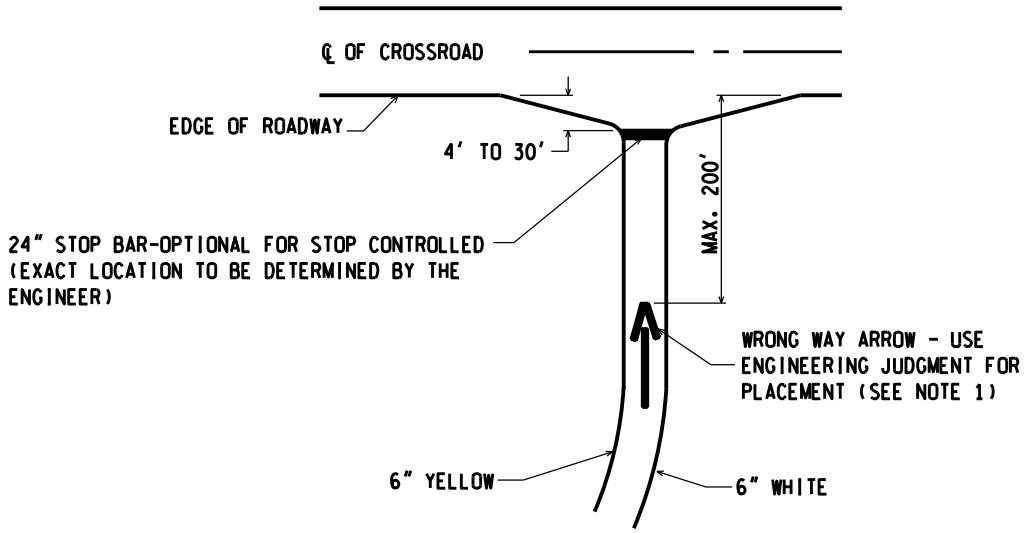
MULTILANE EXIT

NOTES:

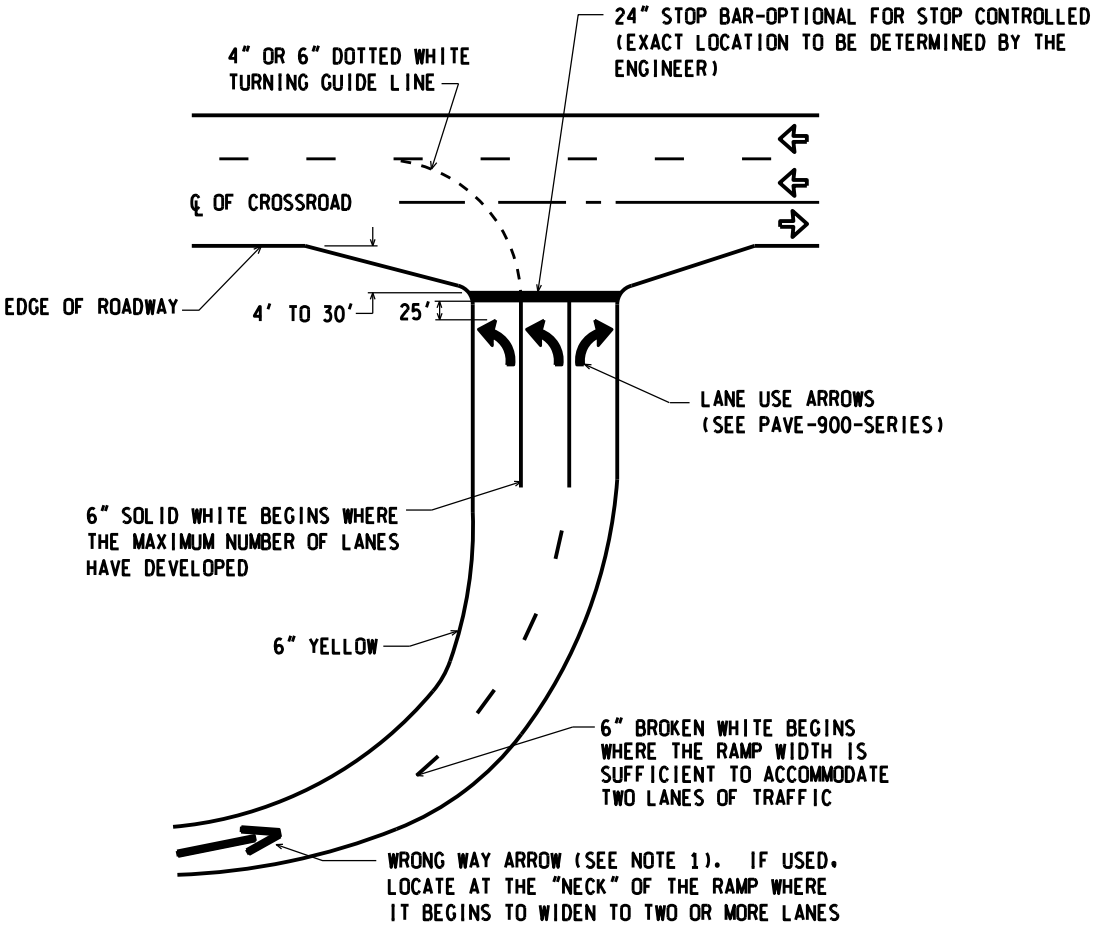
1. On freeway-to-freeway ramps broken lane lines shall be the standard 4" width. On all other ramps, the broken lane line should instead be 6" width for ease of constructability.
2. If the mandatory exit lane is a drop lane, the dotted line in advance of the solid channelizing line shall be 12" width (see Sheet 2). If the mandatory exit lane is a developed lane, the dotted line shall be 6" width (see Sheet 4).

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	00/00/00 F.H.W.A. APPROVAL	02/10/15 PLAN DATE	PAVE-925-C	SHEET 6 OF 8



SINGLE LANE EXIT RAMP TERMINAL

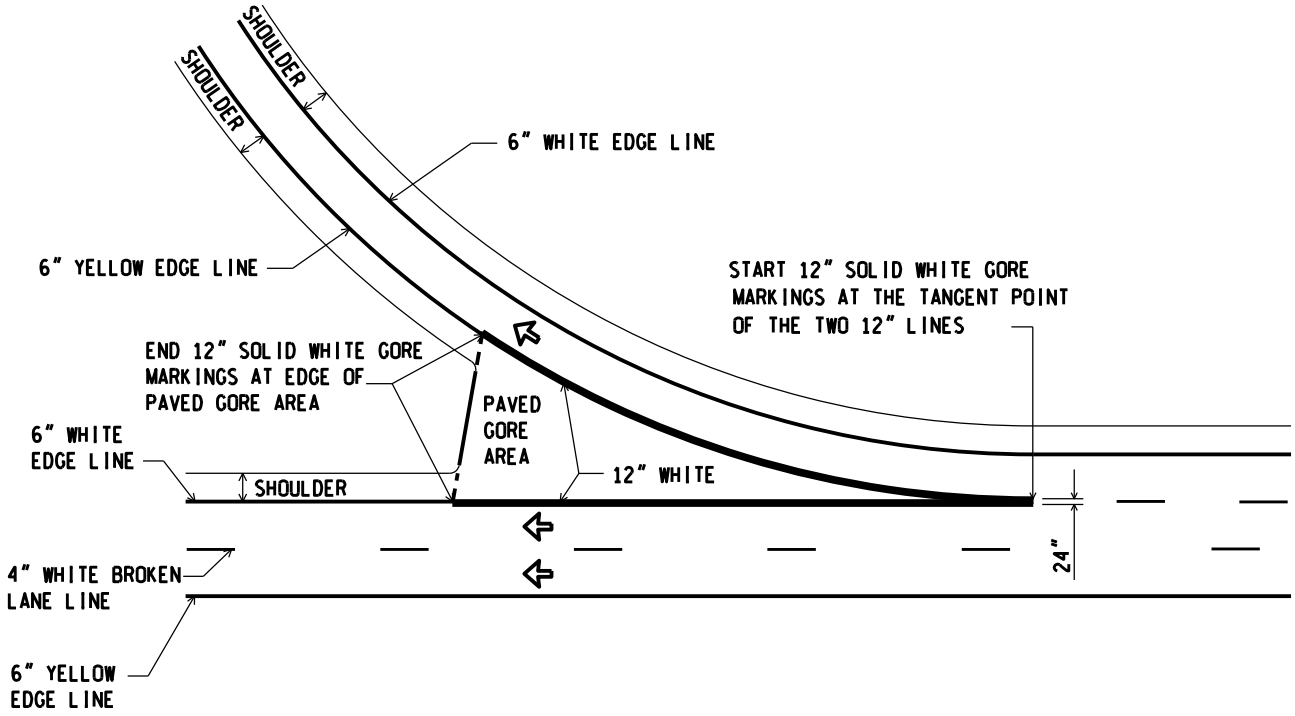


MULTILANE EXIT RAMP TERMINAL

NOTES:

1. Wrong way arrows are optional, EXCEPT when any exit ramp parallels and is adjacent to an entrance ramp at the crossroad terminal (in the same quadrant), regardless of distance between the two ramps.
2. Double-headed arrows may be required where a service road or city street is located opposite a ramp terminal.
3. Include a dotted turning guide line for all double turn movements.

NOT TO SCALE



GORE MARKING DETAIL

EXIT RAMP SHOWN

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	00/00/00 F.H.W.A. APPROVAL	02/10/15 PLAN DATE	PAVE-925-C	SHEET 8 OF 8

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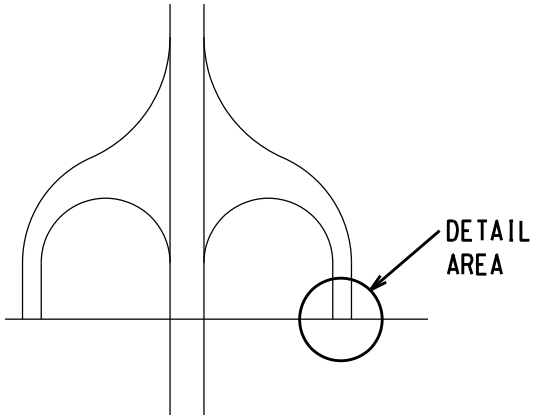
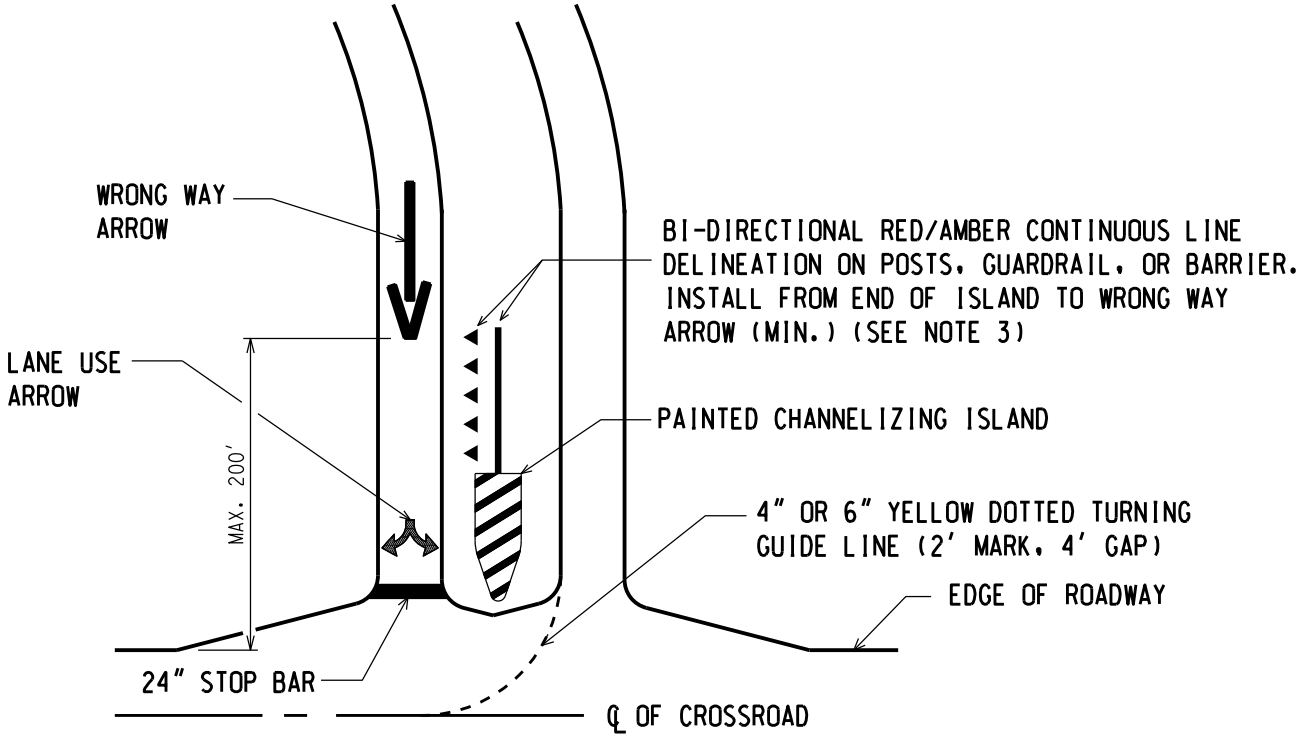


INTERCHANGE LAYOUT

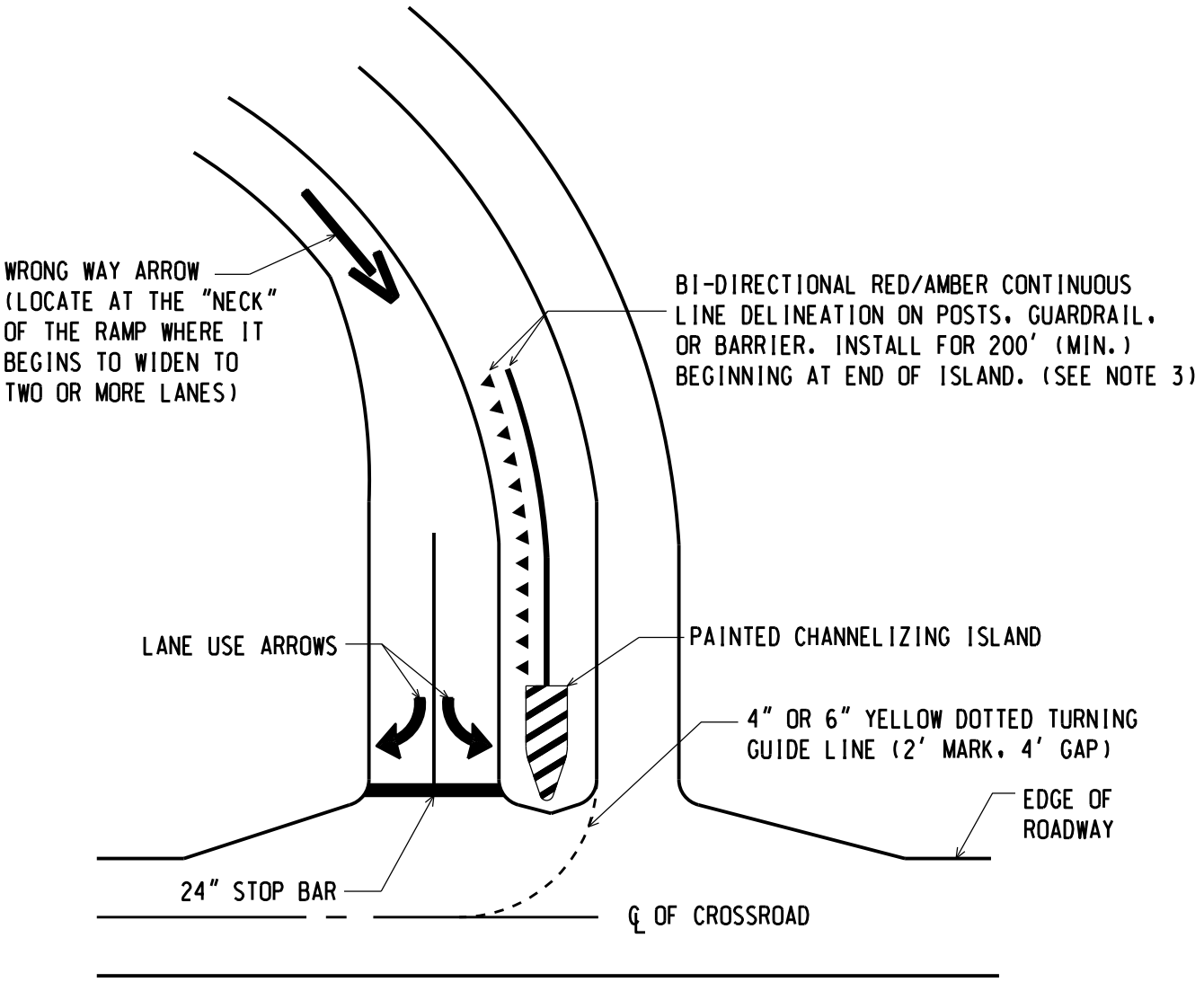


SINGLE LANE PARELLEL EXIT/ENTRANCE RAMP DETAILS

Notes:

1. For additional placement information, see PAVE-900, PAVE-905, PAVE-925, PAVE-940, and R-127.
2. Installation of the wrong way arrow is required. Installation of the stop bar is required at signalized intersections. All other features are optional and shall be installed at the direction of the Engineer.
3. When individual reflectors are used, they shall be placed at 10' maximum spacing. If a proprietary delineation system is used, install per the Manufacturer's recommendations and as directed by the Engineer.

MDOT Michigan Department of Transportation PREPARED BY DESIGN DIVISION DRAWN BY: MKB CHECKED BY: JGM	DEPARTMENT DIRECTOR Kirk T. Steudle APPROVED BY: _____ DIRECTOR, BUREAU OF FIELD SERVICES APPROVED BY: _____ DIRECTOR, BUREAU OF HIGHWAY DEVELOPMENT	MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR PARTIAL CLOVERLEAF TERMINAL MARKINGS			
		00/00/00 F.H.W.A. APPROVAL	12/02/14 PLAN DATE	PAVE-926-A	SHEET 1 OF 2



MULTILANE PARALLEL EXIT/ENTRANCE RAMP DETAILS

Notes:

1. For additional placement information, see PAVE-900, PAVE-905, PAVE-925, PAVE-940, and R-127.
2. Installation of the wrong way and lane use arrows are required. Installation of the stop bar is required at signalized intersections. All other features are optional and shall be installed at the direction of the Engineer.
3. When individual reflectors are used, they shall be placed at 10' maximum spacing. If a proprietary delineation system is used, install per the Manufacturer's recommendations and as directed by the Engineer.

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	00/00/00 F.H.W.A. APPROVAL	12/02/14 PLAN DATE	PAVE-926-A	SHEET 2 OF 2

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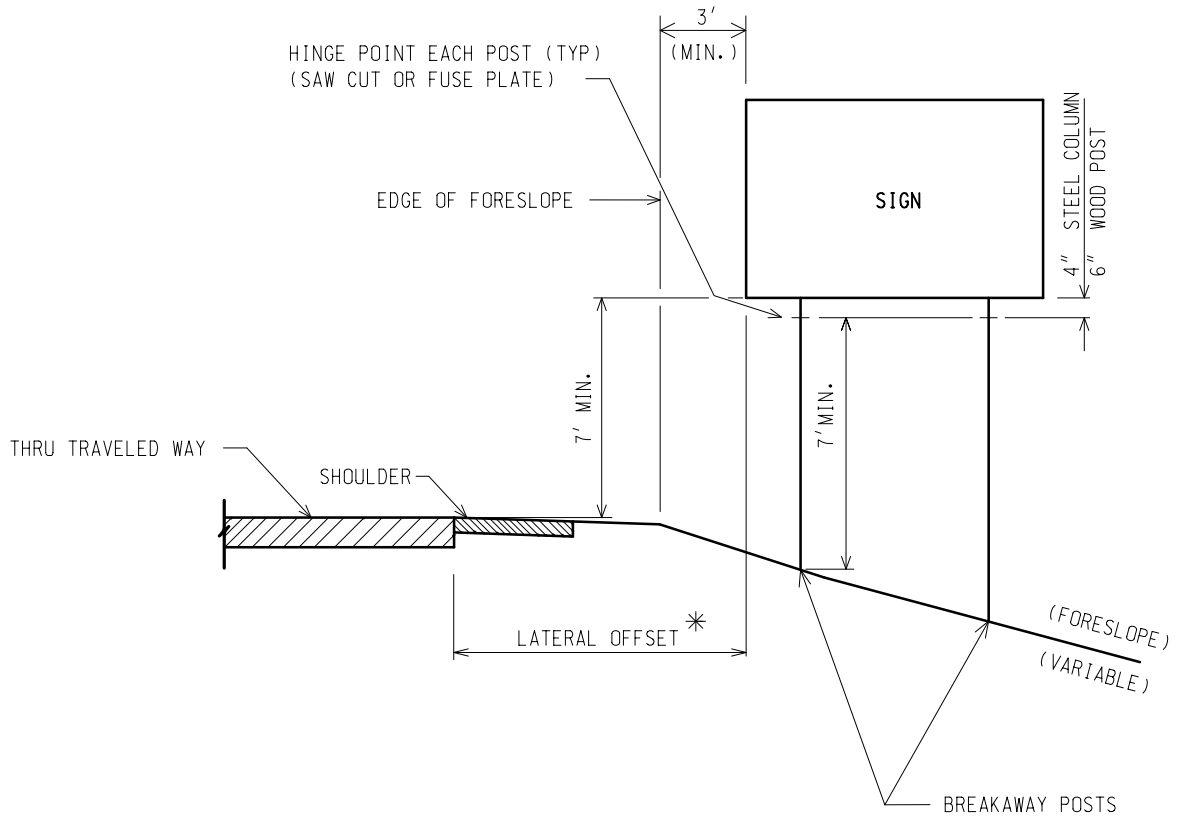
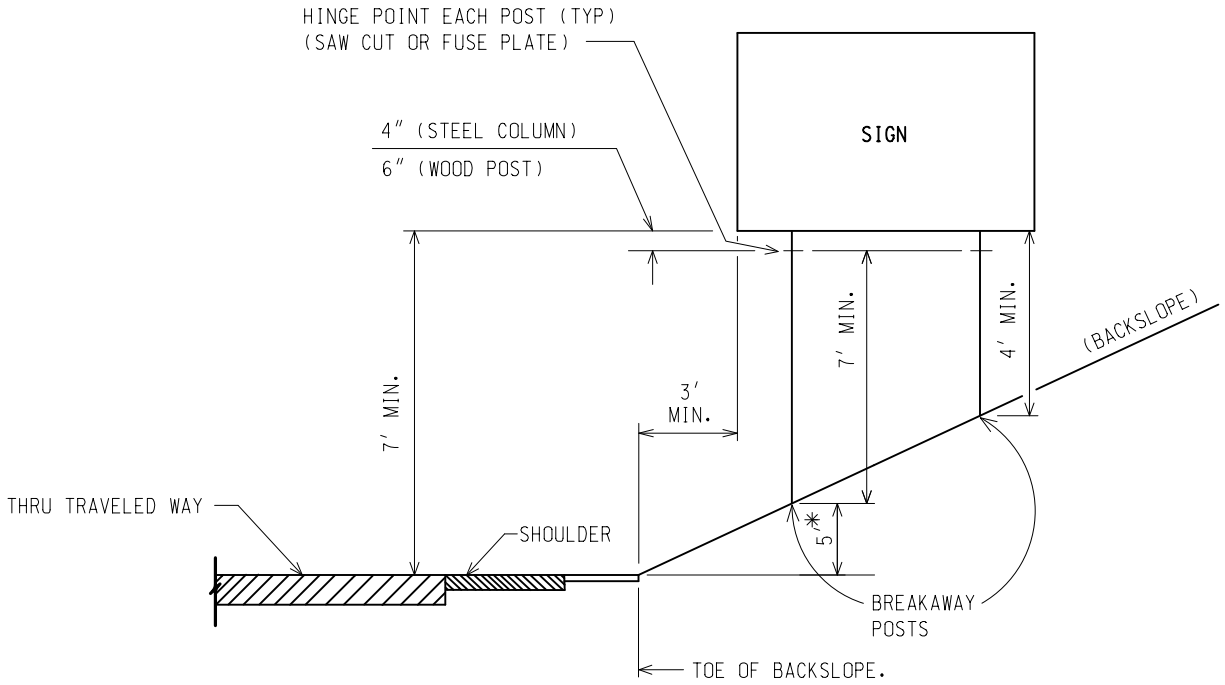


✳ THE LATERAL OFFSET SHALL BE 30′ (MIN.), FOR MAINTENANCE PURPOSES.

SIGN PLACEMENT-ELEVATION VIEW: FREEWAY (FORESLOPE)

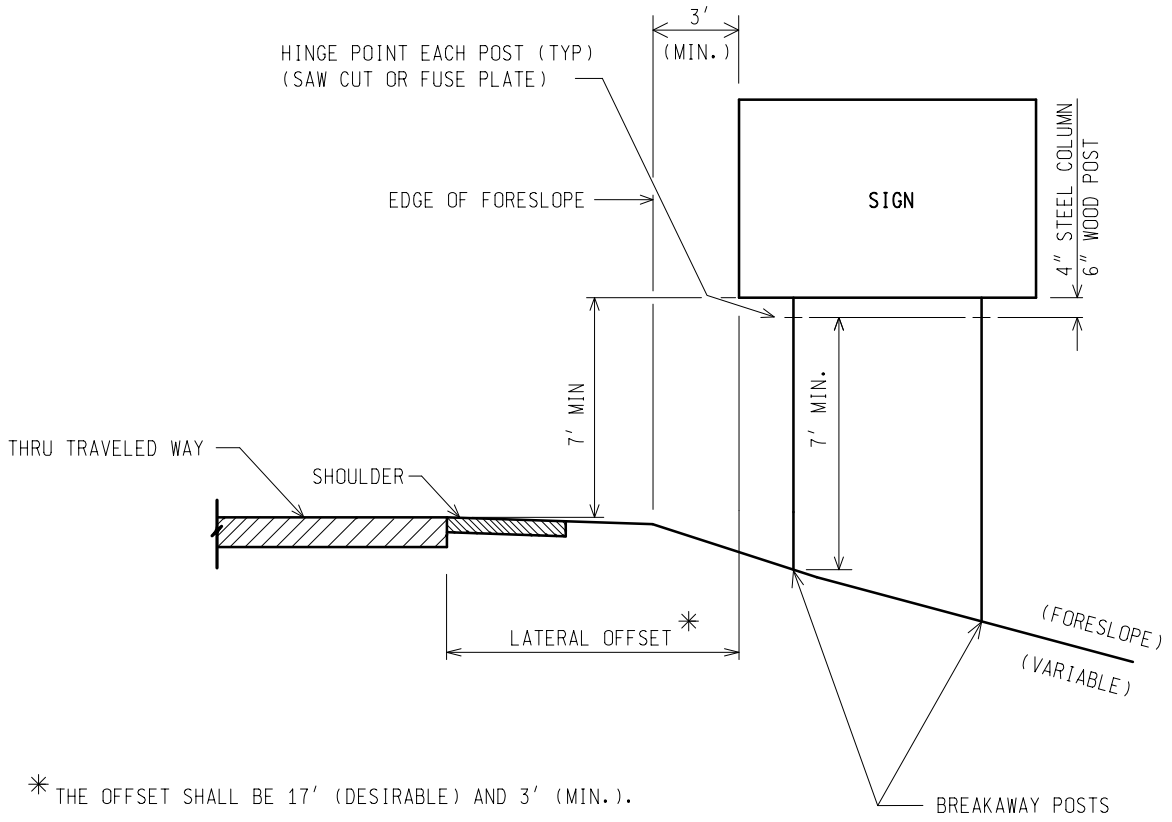
MDOT Michigan Department of Transportation PREPARED BY DESIGN DIVISION DRAWN BY: DHD CHECKED BY: AJU	DEPARTMENT DIRECTOR Kirk T. Steudle APPROVED BY: _____ DIRECTOR, BUREAU OF FIELD SERVICES APPROVED BY: _____ DIRECTOR, BUREAU OF HIGHWAY DEVELOPMENT	MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR ROADSIDE SIGN LOCATIONS & SUPPORT SPACING	12/22/11 F.H.W.A. APPROVAL	12/08/11 PLAN DATE	SIGN-120-D	SHEET 1 OF 8



* IN DEPRESSED SECTIONS WITH 3:1 OR STEEPER BACKSLOPE, IF THE FRONT (TRAFFIC SIDE) POST CANNOT BE LOCATED AT 7' ABOVE SHOULDER ELEVATION, THEN A 3' MINIMUM OFFSET FROM THE TOE OF SLOPE SHALL BE MAINTAINED AND THE SIGN PROTECTED WITH AN APPROVED BARRIER. SEE GENERAL NOTE 5.

SIGN PLACEMENT-ELEVATION VIEW: FREEWAY (BACKSLOPE)

NOT TO SCALE

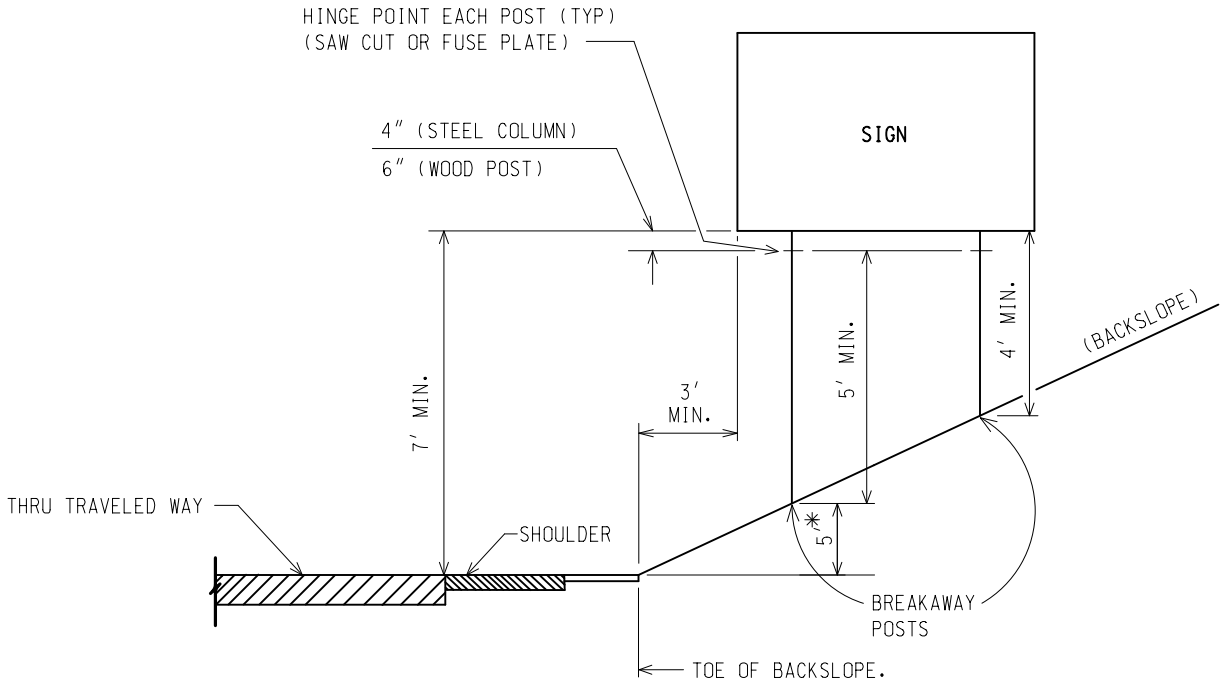


SIGN PLACEMENT-ELEVATION VIEW: NON-FREEWAY (FORESLOPE)

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	12/22/11 F.H.W.A. APPROVAL	12/08/11 PLAN DATE	SIGN-120-D	SHEET 3 OF 8

NOTE: THE ORIGINAL SIGNED COPY IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.



* IN DEPRESSED SECTIONS WITH 3:1 OR STEEPER BACKSLOPE, IF THE FRONT (TRAFFIC SIDE) POST CANNOT BE LOCATED AT 5' ABOVE SHOULDER ELEVATION, THEN A 3' MINIMUM OFFSET FROM THE TOE OF SLOPE SHALL BE MAINTAINED AND THE SIGN PROTECTED WITH AN APPROVED BARRIER. SEE GENERAL NOTE 5.

SIGN PLACEMENT-ELEVATION VIEW: NON-FREEWAY (BACKSLOPE)

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	12/22/11 F.H.W.A. APPROVAL	12/08/11 PLAN DATE	SIGN-120-D	SHEET 4 OF 8

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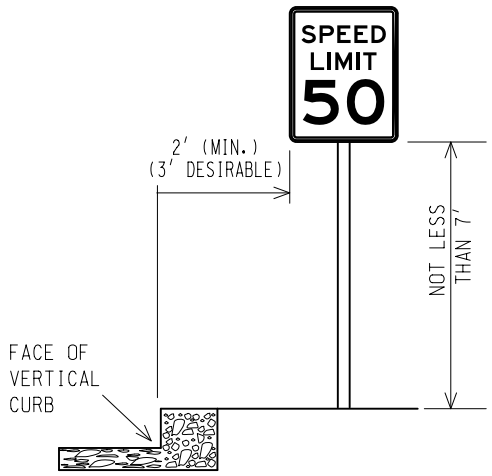
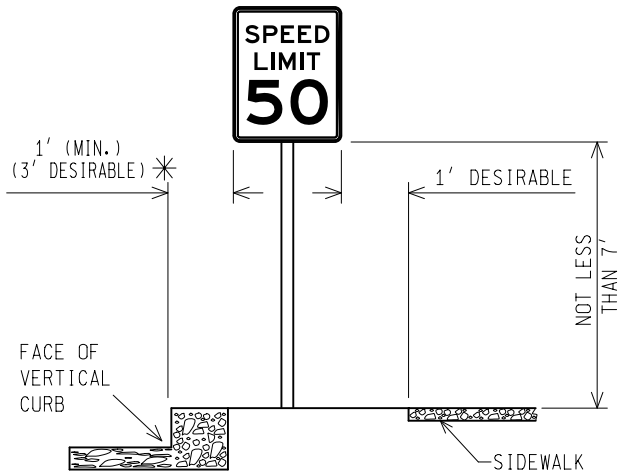


WITHOUT SIDEWALK

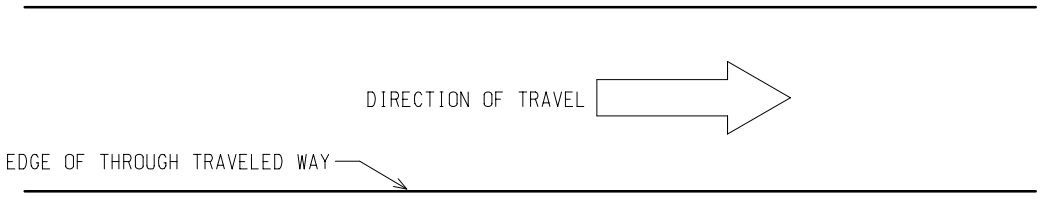


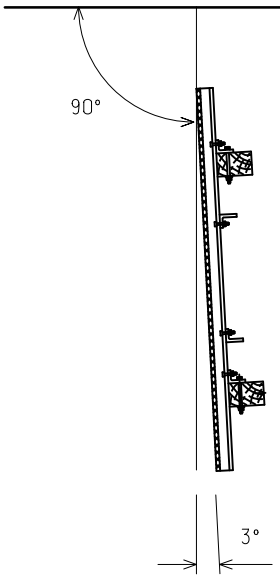
WITH SIDEWALK

✳WHEN DIRECTED BY THE ENGINEER, 1′ IS PERMITTED IN AREAS WHERE SIDEWALK OR UTILITY POLES ARE CLOSE TO CURB PER MMUTCD.

NOTE: SLOPING CURBS SHOULD BE TREATED AS FLAT.

SIGN PLACEMENT ALONG VERTICAL CURB ELEVATION VIEW



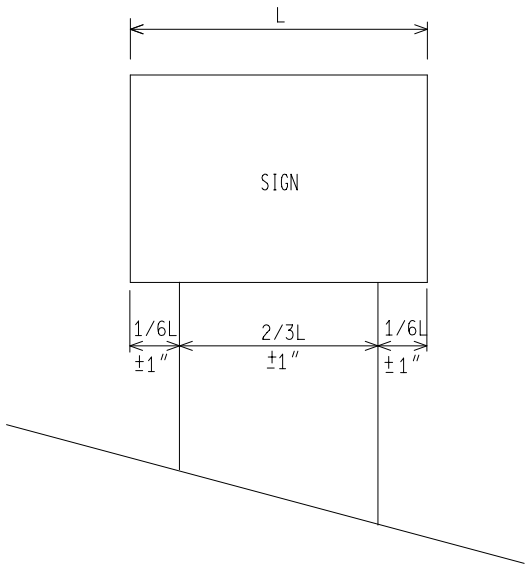


SIGN ORIENTATION

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	12/22/11 F.H.W.A. APPROVAL	12/08/11 PLAN DATE	SIGN-120-D	SHEET 5 OF 8

NOTE: THE ORIGINAL SIGNED COPY IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.



2 POST SIGN SUPPORT SPACING

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	12/22/11 F.H.W.A. APPROVAL	12/08/11 PLAN DATE	SIGN-120-D	SHEET 6 OF 8

NOTE: THE ORIGINAL SIGNED COPY IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.

SIGN BOTTOM HEIGHTS

CONVENTIONAL ROADS

7′- RURAL AREAS

7′- URBAN AREAS

7′- ALL CONDITIONS WHERE SIDEWALKS EXISTS

RAMPS/CROSSROADS

7′- RAMP AND CROSSROAD SIGNING
(WITHOUT VERTICAL CURB)

7′- RAMP AND CROSSROAD SIGNING
(WITH VERTICAL CURB)

7′- ALL CONDITIONS WHERE SIDEWALK EXISTS

4′- DO NOT ENTER AND WRONG WAY SIGNS
(FOR FREEWAY RAMPS)

FREEWAYS/EXPRESSWAYS

7′- ROUTE MARKERS, WARNING AND
REGULATORY SIGNS

7′- ALL OTHER FREEWAY/EXPRESSWAY SIGNS

NOTES:

1. PARKING SIGNS MOUNTED BELOW A PARENT SIGN MAY HAVE A BOTTOM HEIGHT 1′ OR 1.5′ (DEPENDING ON SIGN SIZE) LESS THAN BOTTOM HEIGHTS LISTED FOR PARENT SIGNS.

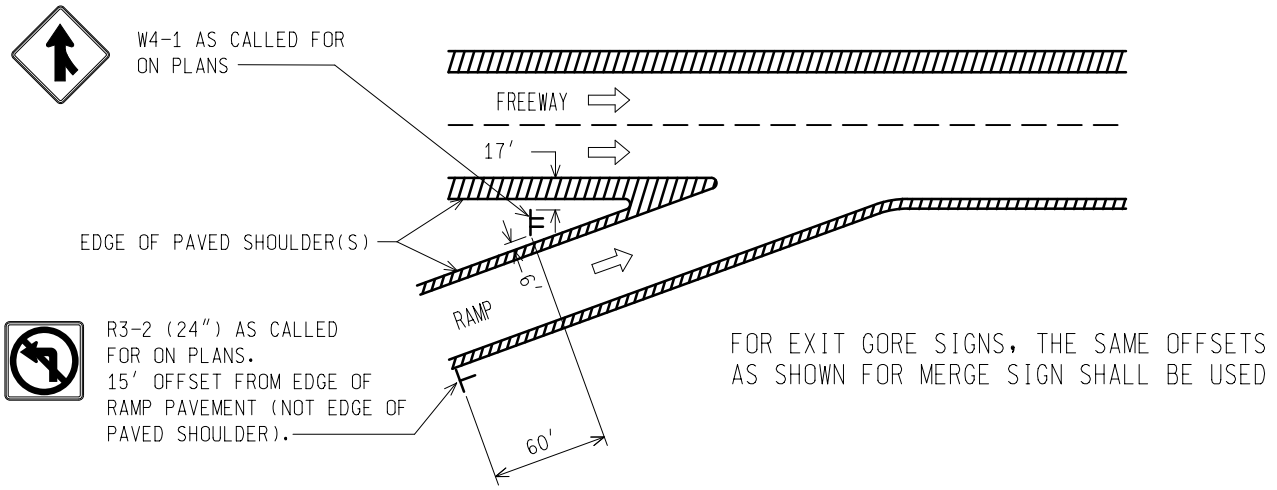
2. BOTTOM HEIGHT OF ALL SIGNS ARE 7′ EXCEPT THE FOLLOWING:
OBJECT MARKERS- 4′
MILE POST MARKERS- 4′
WRONG WAY/DO NOT ENTER (FRWY RAMPS)- 4′

3. CONVENTIONAL ROAD-A STREET OR HIGHWAY OTHER THAN A FREEWAY OR EXPRESSWAY.

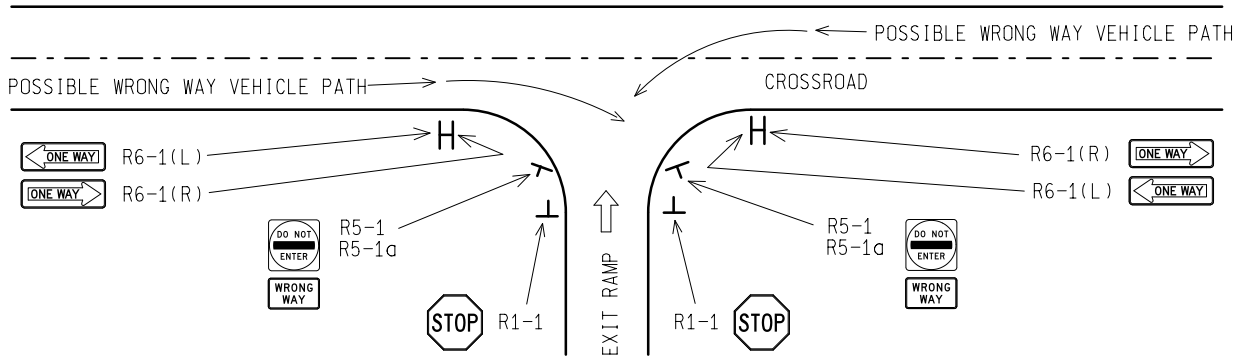
4. EXPRESSWAY-A DIVIDED HIGHWAY WITH PARTIAL CONTROL OF ACCESS.

5. FREEWAY-A DIVIDED HIGHWAY WITH FULL CONTROL OF ACCESS.

NOT TO SCALE



PLACEMENT OF MERGE & NO LEFT TURN SIGNS AT ENTRANCE RAMP



TYPICAL LOCATION OF R5-1 & R5-1a ON EXIT RAMPS. THESE SIGNS SHOULD BE TURNED APPROXIMATELY 20 DEGREES FROM THE CROSSROAD TO FACE THE PATHS OF POSSIBLE WRONG WAY VEHICLE MOVEMENTS.

PLACEMENT OF SIGNS AT EXIT RAMP TERMINALS

GENERAL NOTES:

1. LATERAL OFFSET CLEARANCE OF ALL SIGNS SHALL BE AS INDICATED UNLESS OTHERWISE SHOWN ON CONTRACT SIGN PLAN SHEETS OR IN THE PROPOSAL.
2. THE TERM "SIGN" AS USED ON THIS PLAN MEANS A SINGLE PANEL OR GROUP OF PANELS COMBINED TO FORM ONE INSTALLATION.
3. BOTTOM HEIGHT (BH) SHALL BE AS INDICATED ON SHEET 7 UNLESS OTHERWISE SHOWN ON THE ELEVATION SIGN PLAN SHEET OR IN THE PROPOSAL. BOTTOM HEIGHT IS THE DIFFERENCE IN ELEVATION OF THE NEAREST EDGE OF THE TRAVELED LANE AND BOTTOM OF THE SIGN.
4. SIGN LOCATIONS SHALL BE AS SHOWN UNLESS OTHERWISE SPECIFIED ON CONTRACT SIGN PLAN SHEETS OR IN THE PROPOSAL.
5. WHEN SIGNS ARE TO BE INSTALLED BEHIND CONCRETE BARRIER OR GUARDRAIL, THE NEAR EDGE OF SIGN SHOULD BE SET BACK A MINIMUM OF 3' MEASURED FROM THE BACK OF BARRIER OR GUARDRAIL POSTS. BREAKWAY SIGN POSTS ARE NOT REQUIRED AT THESE LOCATIONS.
6. FOR PLACEMENT OF STOP SIGNS AT CROSSROADS SEE MMUTCD.
7. WRONG WAY AND DO NOT ENTER SIGN SUPPORTS FOR FREEWAY RAMPS SHALL HAVE RED REFLECTIVE SHEETING INSTALLED ON THE SIGN SUPPORTS.

NOT TO SCALE

Where These Drivers Went Wrong

An innovative Michigan study sheds light on engineering strategies to curtail the number and severity of wrong-way crashes on freeways.

by David A. Morena and Tracie J. Leix

Across the country, crashes caused by wrong-way drivers are few and far between, but when they do occur, they often provide fodder for terrifying and heartbreaking headlines. These crashes kill or severely injure drivers and passengers at a much greater rate (per crash) than other types of freeway incidents. It stands to reason that in a wrong-way head-on crash, the highest potential for injury and death occurs on the roads where drivers travel at the highest speeds: the Nation's freeways. For instance, a study published by the California Department of Transportation and Federal Highway Administration (FHWA), *Prevention of Wrong-Way Accidents on Freeways* (FHWA/CA-TE-89-2), found that the fatality rate was 12 times greater for wrong-way crashes compared to all other crashes on California freeways in 1987.

In 2010 and 2011, safety staff with FHWA and the Michigan Department of Transportation (MDOT) analyzed 110 wrong-way crashes that occurred on the Michigan freeway system during the 5-year period from 2005 to 2009. What they found regarding the characteristics of wrong-way drivers corroborated earlier studies, but what they found regarding the road system shed new light on the roadway engineering aspect of wrong-way freeway entries.

The safety researchers restricted their study to vehicles that were known or presumed to have entered the freeway system by traveling the

(Above) This typical treatment at a Michigan freeway exit ramp includes wrong-way signing placed left and right at the mouth of the ramp, lane assignment pavement marking arrows for multilane ramps, and an optional wrong-way arrow pavement marking farther back along the ramp, at the point where the ramp neck backs down to one lane.

Wrong-Way Crashes Make Horrific Headlines

Source: MDOT.

wrong direction on an exit ramp. The team made every effort to exclude cross-median and other crashes in which a vehicle was traveling the wrong way by virtue of the driver losing control of the vehicle. Thus, an accurate description of the incidents researched in this study would be "wrong-way freeway entry" crashes.

The Wrong-Way Driver

The most noticeable characteristics of the wrong-way drivers in this study were their degree of impairment and a tendency toward late-night driving. The 110 crashes in the study included 9 for which the extent of impairment was unknown, either because they involved drive-aways in which the wrong-way driver was not identified, or fatal crashes in which impairment, if any, of the wrong-way driver was not documented.

Looking at the remaining 101 wrong-way drivers for which the extent of impairment was known, nearly 60 percent were under the influence of either alcohol or drugs in their systems when tested: 48 tested positive for alcohol, 7 for drugs, and 5 for both drugs and alcohol. The vast majority of these impaired-driver crashes (54 of 60) occurred at night.

For the full set of wrong-way crashes, the tendency toward night crashes held as well. Of the full 110 wrong-way crashes, a heavy concentration occurred late at night and early in the morning: 57 percent between 11 p.m. and 6 a.m. For comparison, only 16 percent of the total Michigan freeway crashes—wrong-way entry and all others—in 2005–2009 occurred during a similar late-night time period.

The late-night trend was even more pronounced when the researchers examined the 35 serious wrong-way crashes: 71 percent of the fatal and incapacitating wrong-way crashes occurred during the timeframe from 11 p.m. to 6 a.m., compared with only 23 percent for other serious freeway crashes in Michigan between 2005 and 2009.

In total, 78 percent (86 crashes) of the 110 study crashes occurred under conditions of darkness. This statistic makes sense because wrong-way freeway entry is the mistake of a confused driver, and darkness masks many of the roadside cues that are more visible in the daytime.

Driver age was captured for 104 of the wrong-way drivers and showed mostly equal distribution across the range of ages, with a slight concentration toward younger drivers: 18 (17 percent) of the wrong-way drivers were age 65 or older, but 24 (23 percent) of the wrong-way drivers were under the age of 25.

Another way to look at the issue of driver age is to remove the impaired drivers from the population. For the 41 wrong-way drivers who were not impaired at the time of the crash, the distribution of driver age is quite different from the total distribution. This group of 41 unimpaired drivers included 14 drivers age 65 or older (34 percent) and only 2 drivers under the age of 25 (5 percent). Although this is just a small number of crashes, the percentage of older drivers in the unimpaired group does stand out: In general, drivers 65 or older are involved in less than 12 percent of the total crashes in Michigan and approximately 14 percent of crashes that result in serious injury or death.

It appears from this analysis that some general potential for driver confusion leading to wrong-way entry exists across the entire population. This confusion is amplified in younger drivers who are impaired by alcohol or drugs, and amplified as well in older drivers (even without impairment).

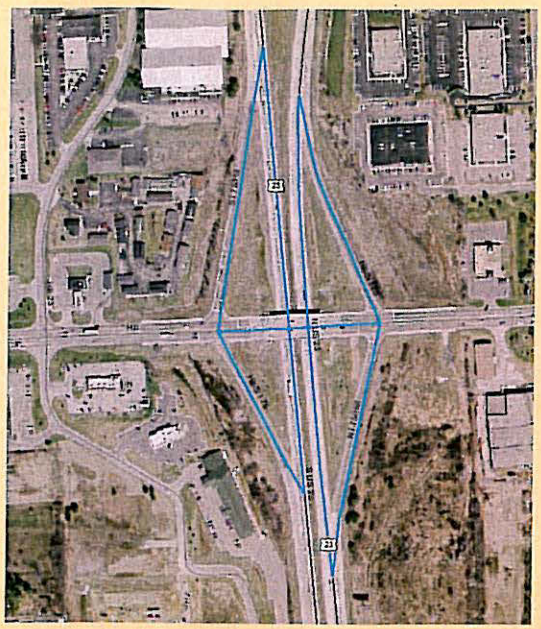
The crash statistics also captured driver gender for 108 of the wrong-way drivers: 75 male, 33 female. This distribution is similar to historical percentages for gender in serious crashes in Michigan.

The Wrong-Way Crash

Not all of the studied crashes occurred on a freeway mainline. Of the 110 crashes, 31 took place on the exit ramp that provided the entry

Severity Depends on the Crash Location

Crash Location	Number of Crashes	Percent of Crashes with a Severe Outcome (Death or Incapacitating Injury)
Mainline freeway	71	42%
Exit ramp	31	6%
Entrance ramp	2	0%
Freeway-to-freeway ramp	6	50%



At a diamond interchange (far left), there is one exit ramp and one entrance ramp for each direction along the freeway. At a trumpet interchange (right), which takes its name from its resemblance to the instrument, all exit and entrance ramps converge into one roadway as shown here. *Photos: MDOT.*

point for the wrong-way vehicle entering from the crossroad. In the 79 remaining crashes, the wrong-way driver reached the freeway mainline and either crashed on the mainline (71), or having traveled for some distance on the mainline, crashed on a freeway-to-freeway ramp (6) or on a freeway entrance ramp (2). In these cases, the researchers assumed that the wrong-way driver entered the freeway system through wrong-way movement on an earlier (but unidentified) exit ramp.

In most of the crashes (96 out of 110), the wrong-way vehicle hit another vehicle that was traveling in the appropriate direction. The remaining crashes were single-vehicle crashes in which the wrong-way vehicle hit a highway barrier (10 crashes), ran into a ditch, or simply overturned.

As a group, these wrong-way crashes were highly severe: 35 (32 percent) resulted in at least one fatality or incapacitating injury. For comparison, only 2 percent of all Michigan freeway crashes in 2005–2009 led to deaths or incapacitating injuries. Together, those 35 severe wrong-way crashes resulted in 30 fatalities and 36 incapacitating injuries—a staggering price to pay for just 35 confused or impaired drivers.

The severity of an individual wrong-way crash was clearly linked to how far the wrong-way vehicle progressed onto the system, most likely due to the speed of the involved vehicles. Only 6 percent of the crashes that occurred on an exit ramp resulted in a death or incapacitating injury, while 42 percent of the mainline crashes resulted in a fatality or incapacitating injury.

This fact has implications for the engineering community. "Although engineering solutions to alert a wrong-way driver are most commonly applied at or near the crossroad—and rightfully so—it seems clear that any successful intervention along the entire length of the exit ramp is likely to be rewarded by a dramatic decrease in crash severity, should a collision occur," says Mark Bott, MDOT traffic and safety engineer.

Could Interchange Design Be an Issue?

Geographically, the locations of the 110 Michigan wrong-way crashes match up fairly well with the pattern and extent of freeway travel throughout the State. Detroit and the surrounding areas, which lay claim to 40 percent of the freeway vehicle

©Google, Inc.

A full cloverleaf interchange contains the diamond configuration but augmented by four loop ramps for a total of eight ramps, providing full access to and from the cross street without requiring any left-turn movement.

miles traveled (VMT) in Michigan, were home to 47 percent (52) of the wrong-way crashes. Similarly, Grand Rapids and the surrounding areas experienced 18 of the crashes, and other areas of the State had smaller numbers, roughly correlating with the extent of their freeway VMT.

Of more interest is the type of interchange through which the wrong-way vehicle gained entry to the system. The purpose of an interchange is to route traffic onto and off the freeway from the crossroad. Freeways have a variety of interchange designs, and apparently not all designs (such as cloverleaf and diamond) are equal in terms of clarity of navigation to the motorist, and particularly to impaired, disoriented, or confused drivers.

Earlier research in California, North Carolina, and Washington State all suggested that the partial cloverleaf design, which puts an exit ramp adjacent to an entrance ramp on the crossroad, might be more conducive to wrong-way entry than other designs. The North Carolina and Washington State research also implicates full cloverleaves, and the California study points to potential navigation problems with full and partial diamond interchanges. Because the exact freeway entry points for the wrong-way drivers were unknown in most crashes investigated in these States, the researchers based their conclusions mainly on systemwide or corridorwide design features, not specific knowledge of individual entry ramps.

For the Michigan study as well, most of the crashes occurred on mainline freeways with no indication of how the wrong-way drivers entered the system. However, the Michigan dataset does contain 31 crashes that occurred on exit ramps, and 4 mainline crashes in which the wrong-way entry point was identified by the reporting police officer. Thus, for those 35 crashes, the wrong-way access ramp was known. Comparing those wrong-way access ramps to the total inventory of Michigan interchanges enabled the researchers to offer educated commentary on the culpability of various types of interchange ramps to the driver confusion that resulted in wrong-way entry.

Michigan has 791 freeway interchanges classified by MDOT as follows: directional (206), partial cloverleaf (163); tight diamond or modified diamond (154); diamond (136); urban diamond (50); trumpet (23); full cloverleaf (20); and others (39).

In the 35 Michigan crashes for which the wrong-way entry point was known, the wrong-way driver entered the freeway system at the following type of interchange: partial cloverleaf (21); trumpet (4); tight diamond (3); urban diamond (3); directional (2); full cloverleaf (1); other (1).

Based on these data, the researchers confirmed the concerns raised in earlier studies about the potential for confusion at partial cloverleaf designs. A partial cloverleaf interchange provided the wrong-way ramp entry for 60 percent of the known wrong-way Michigan

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MDOT

Shown here are two common types of partial cloverleaf interchange designs. In each case, there is at least one exit ramp adjacent to an entrance ramp, running parallel to each other out to the crossroad.

drivers, even though that interchange type accounts for only 21 percent of the interchanges in the State. The trumpet interchange design is implicated as well, hosting 11 percent of the known wrong-way crashes even though trumpets comprise only 3 percent of the State's interchanges.

Another telling statistic is in the geographic spread of the study crashes. The 35 crashes with known wrong-way access points all occurred at different interchanges, with only 2 exceptions: 10 of the crashes occurred at one partial cloverleaf interchange, and 2 crashes occurred at a single trumpet interchange.

The Problem with Parallel Ramps

The primary interchange design implicated in this study—partial cloverleaf—has one predominant feature that appears to be the source of confusion leading to wrong-way freeway entry: a pair of freeway exit/entrance ramps that are adjacent and parallel to each other, and typically meet the crossroad at or near a 90-degree angle.

The wrong-way entry mode, then, for a disoriented, distracted, or otherwise confused driver is to turn onto the freeway exit ramp, thinking that he or she is entering onto the freeway entrance ramp. Although any entering traffic from the crossroad could be subject to confusion, it is the left turner who is presumed to be most susceptible to wrong-way entry in these situations. The left turner has to drive past the wrong ramp to reach the correct one, whereas the right turner encounters the correct ramp immediately. Not surprisingly, most of the engineering solutions that can be brought to bear on this problem involve positive cues to showcase the entrance ramp so that it looks like an entrance ramp, and negative cues that make the exit ramp appear uninviting to a potential wrong-way driver.

The Michigan Strategy

The study results were an eye-opener for MDOT staff. "The first thing I noticed in the data is that the severity of these crashes, as a group, is off the charts," says Bott.

MDOT officials wanted to move quickly but strategically on the issue. Given the design-specific findings from the study, they were able to do so. Of the 791 existing Michigan interchanges, MDOT staff identified 161 interchanges that exhibit the suspect feature of partial cloverleaf—that is, adjacent and parallel ramps extending to the crossroad. These interchanges are being targeted for systematic installation of various low-cost countermeasures at an estimated cost of $2 million over the next 5 years.

Prevention of wrong-way freeway entry is not a new issue for MDOT. The department currently implements the nationally recognized standard approaches to wrong-way prevention: wrong-way marking arrows, DO NOT ENTER/WRONG WAY signing, and other recommended signs and markings to the degree required by the *Manual on Uniform Traffic Control Devices* (MUTCD). However, armed with the knowledge of the frequency and severity of actual wrong-way crashes in the State, MDOT now regards some treatments as mandatory that the MUTCD lists as optional. Also, MDOT is installing other treatments that are considered beyond the current state-of-the-art in wrong-way prevention.

Targeting the Bad Actors

When feasible, MDOT plans to apply the following seven countermeasures to the target ramps at the 161 identified interchanges over the next 5 years, using either State maintenance funds or Federal-aid safety funding as necessary:

- *Lower the bottom height of DO NOT ENTER and WRONG WAY signs to 4 feet (1.2 meters).* These signs typically are set at a bottom height of 7 feet (2.1 meters) to meet standard uniformity concerns regarding crash worthiness and sight distance. Neither of those concerns are paramount on ramps, but visibility of the DO NOT ENTER and WRONG WAY signs is. A lower sign is better positioned to catch a motorist's eye, both at night and during the day. California, Idaho, and Virginia are among the States that have been leading the way with this countermeasure, some of them since the early 1970s.

Where Do Partial Cloverleafs Come From?

It would be inviting to say that if certain types of interchanges have more potential to confuse entering drivers, transportation engineers simply should not build those types. However, the factors that influence choice of interchange design go beyond occasional wrong-way entry to include overall cost, right-of-way restrictions, and capacity to handle projected traffic flow.

The simplest and most common interchange in Michigan and perhaps the Nation is the diamond interchange. This type of interchange gets its name from the shape of the ramp alignment when viewed from above. One off-ramp is provided to the crossroad from each direction of freeway travel, and one on-ramp is provided from the crossroad for each direction. The diamond interchange has sufficient capacity to handle traffic at the majority of interchanges, but operations can break down as ramp volumes increase.

On the other end of the capacity scale is the full cloverleaf design supplemented with collector and distributor roads. This design can accommodate a large amount of exiting and entering traffic by providing two off-ramps and two on-ramps for the crossroad from each direction of freeway travel.

Somewhere between these two extremes is the partial cloverleaf design. This design can come about in several ways, the most prevalent being through a desire to minimize either the cost or the environmental consequences of a right-of-way purchase in one or more quadrants. In yet another scenario, when existing or expected traffic demands exceed the capacity of a diamond interchange, the logical design choice is to add a loop or two to the design to handle the overload of entering or exiting traffic. Often the loops are added to defray either capacity or safety problems resulting from a large amount of left-turning traffic, either onto or off of the crossroad. Thus is born the partial cloverleaf interchange.

- *Install reflective sheeting on the sign supports of DO NOT ENTER and WRONG WAY signs.* Currently, reflective white strips are used in Michigan for additional marking on railroad crossbuck supports (both front and back). Reflective yellow strips have been growing in popularity to emphasize chevron signs and other warning signs, and red strips have been used on STOP signs at selected locations. This countermeasure extends the strategy to include the two sign messages that relate most directly to the prevention of wrong-way entry.
- *Place stop bars at exit ramps.* Current MDOT practice is to place stop bars on exit ramps where the intersection of the ramp and crossroad is signalized; the stop bar is optional at unsignalized intersections under stop control. MDOT will now consider placing stop bars on paired exit ramps in the target group of interchanges, regardless of the type of intersection control, as a further cue that the exit ramp is intended only for traffic leaving the freeway.
- *Install wrong-way pavement marking arrows at exit ramps.* This treatment, like some of the others, is listed as an optional measure in the MUTCD and is regarded as secondary to the more important lane-use pavement markings that are recommended for placement in each lane of an exit ramp, near the crossroad. MDOT had been following MUTCD guidance allowing for optional placement of the wrong-way arrow farther back along the ramp. Moving forward, the department plans to require wrong-way arrows at all target exit ramps, providing a second level of pavement marking warning to wrong-way drivers.
- *Install pavement marking extensions that will guide crossroad left-turning traffic past the exit ramp and safely onto the entrance ramp.* Pavement marking extensions are an established strategy that MDOT and other agencies use to guide traffic into the correct ramps at single-point urban interchanges, or to keep vehicles in their correct lanes during double-left-turn movements at standard intersections. This countermeasure extends the strategy to address what could be the primary failure mode for wrong-way entry at paired exit/entrance ramps—the left turn into the first ramp (the exit ramp).
- *Paint the island between the exit and entrance ramp for a sufficient distance up the ramp.* This positive delineation of the island between the pair of ramps could prove helpful to a confused driver. Delineating an island indicates that there are two ramps, and that might be just enough to prompt driver realization that he or she does not want to be in the ramp to the left of the island.
- *Place red delineators along the exit ramp to discourage wrong-way vehicles that are headed*

MDOT will begin to install DO NOT ENTER/WRONG WAY signs at lower heights than in the past. Shown here is signing in Idaho placed at a bottom height of 4 feet (1.2 meters).

MDOT

Several agencies in Michigan, including MDOT, use retroreflective sheeting strips to emphasize various warning or regulatory signs. MDOT will extend this practice to the lowered and any new DO NOT ENTER/ WRONG WAY signs at freeway exit ramps.

up the exit ramp. This strategy counts on some basic amount of driver recognition that red is used as a discouragement in several forms in the highway environment. Where guardrail is in place on a ramp, the red delineators can be attached to the guardrail either individually or in a continuous delineation system. MDOT already has experimented with several delineation strategies and prefers the continuous design. The bad news is that only a few ramps in the Michigan system have stretches of guardrail near the crossroad where this strategy could be immediately effective in stopping a driver who had just turned onto the ramp. The good news, according to the study's results, is that MDOT could apply this strategy as far up the ramp as the engineers feel is warranted as a means to discourage wrong-way drivers—and ideally capture their attention in time to minimize the severity of wrong-way crashes. Also, in the absence of guardrail, MDOT is considering installing red delineators on delineator posts.

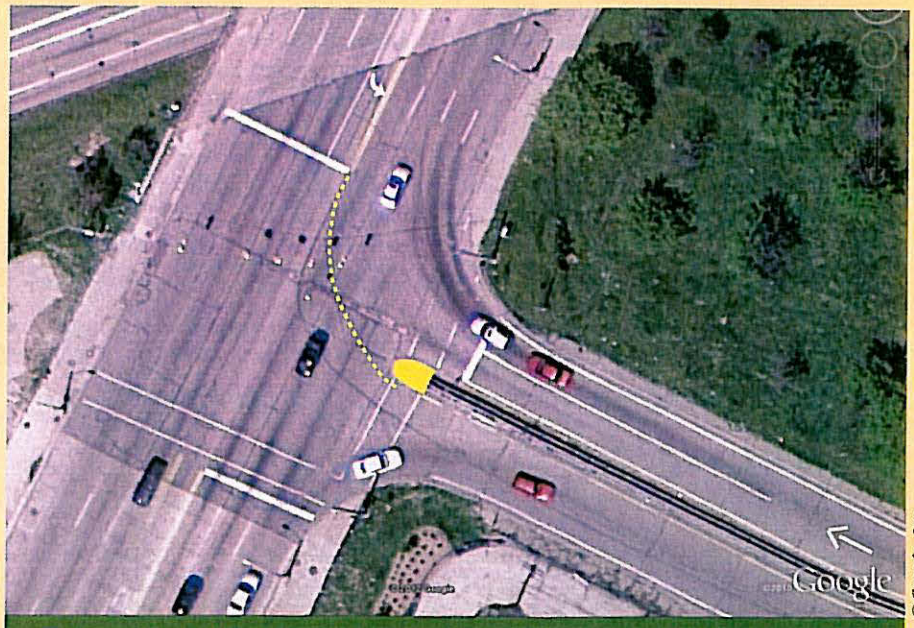
Eventual Improvement To All Interchanges

As MDOT directs resources to the 161 target interchanges it deems the most likely to host wrong-way entry, the agency nonetheless recognizes that the remaining 29 percent of the known freeway wrong-way entries in the study did not result from confusion on paired ramps. Wrong-way entry is a potential danger at *all* ramps, for a variety of driver behavior failure modes.

With that in mind, MDOT identified two of the seven low-cost countermeasures that could be cost effective at all ramps. Specifically, MDOT revised its signing standards to require the lower bottom height and to apply retroreflective sheeting strips to WRONG WAY and DO NOT ENTER signs at all exit ramps. This action will result in field changes at the remaining interchanges as they come up for routine work. Two countermeasures that are being applied to the target ramps—painted medians and pavement marking extensions for left turns—are not likely to be applicable to the nontarget ramps. The option to install the remaining treatments at nontarget ramps will be left as a field decision.

A Close Look at the Big Standout

Of all the interchanges in the State, one stood out in the Michigan study. The interchange of I-94 at Gratiot Avenue in Detroit was the site of 10 of the 35 known wrong-way vehicle entries. And unlike the general set of Michigan's wrong-way crash data, the 10 crashes at this interchange were not primarily at night and did not principally involve impaired drivers. Clearly, other contributing factors must have been involved here, and MDOT conducted a small-scale road safety audit in an attempt to identify what could be causing driver confusion at the two exit ramps of this interchange.



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This aerial photograph shows one existing low-cost countermeasure in place. The photo has been modified to show three others that MDOT intends to place, when feasible, at paired-ramp freeway exits: stop bar placement on the exit ramp, wrong-way pavement marking arrows farther up the ramp, painted island, and left-turn pavement marking extension from the crossroad.

At this interchange, the exit and entrance ramps are in a partial cloverleaf configuration, side by side, and meet the crossroad at a single point, which is under the control of a traffic signal. This design occurs in the northwest and southeast quadrants, so there are two sets of partial cloverleaf ramps, and both quadrants were host to wrong-way vehicle crashes. Each of the two exit ramps carries two lanes to meet the crossroad. The crossroad itself (Gratiot) is five lanes, with a dedicated (and signalized) left-turn lane for traffic turning onto the entrance ramps.

Upon visiting the interchange ramps, the audit group quickly suggested a number of signing and marking treatments that, if implemented, would improve guidance to drivers searching for the entrance ramp and improve deterrence for drivers about to turn onto the exit ramp. These measures were along the lines of the low-cost countermeasures mentioned earlier: painting the median island and installing pavement marking extension lines to guide vehicles turning left from the crossroad, lowering the height of the DO NOT ENTER and WRONG WAY signs, and adding reflective red strips to those sign posts.

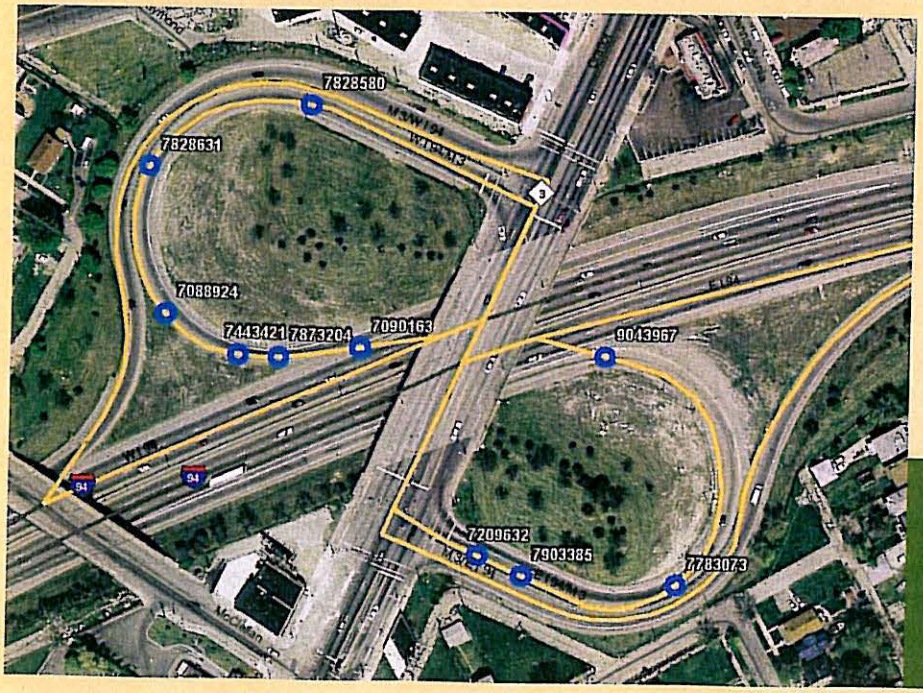
Because these exit ramps carry two lanes, the audit team recommended that lane assignment arrows (rather than wrong-way arrows) be applied to the mouth of the exit ramps. In addition, the group suggested enlarging the existing I-94 directional signs on the crossroad. The group also noted that the southbound stop bar on Gratiot Avenue was pulled back significantly from the intersection which, the audit members surmised, could give drivers the false impression that the left turn should be made into the exit ramp instead of the entrance ramp.

Lucid Systems, Inc.

Delineation capable of showing two different colors back to back can be installed to show red to wrong-direction traffic, as shown here installed at a Michigan exit ramp.

All of these suggested improvements are likely to be helpful, but these countermeasures mostly treat the *symptoms* of the problem at these ramps. That is, they attempt to mitigate the confusion that is already brewing in drivers' minds. The confusion itself, according to the audit team, is an entirely different matter.

The audit group surmised that the wrong-way entries at these exit ramps are being produced in large part by the visual picture that is presented to left-turning crossroad traffic. This visual picture includes a median guardrail that extends nearly entirely to the curb lane. This shuts off a left-turn driver's view of the entrance ramp and distorts the view of the median, which now looks more like a guardrail-aided, right-side curb than a median. Without a clear view of the entrance ramp,



MDOT

Blue circles overprinted on this aerial shot of Gratiot Avenue at I-94 indicate the locations of 10 wrong-way entry crashes that occurred during the 2005–2009 study period.

MDOT

In this street-level view of paired exit and entrance ramps from the viewpoint of a driver turning left from Gratiot Avenue in Detroit onto I–94, the correct path to enter the freeway is to the right of the guardrail.

the driver's impression is that this exit ramp is the only roadway that is available and may be the only roadway connecting to or from the freeway at that point.

Medians typically do not look like this. Normally a driver can easily spot a median as a median, and that perception has something to do with being able to take in the entire set of lanes in one view, including a pavement-level median at the mouth of the terminal. In reviewing the literature, the Michigan researchers found that Washington State had this same issue and came to the same conclusion regarding concrete barriers that extend all the way to the STOP sign at one of the partial cloverleaf interchanges in that State.

In 2012 MDOT is looking at implementing many of the suggested low-cost treatments at the Gratiot ramps. Included are signings and pavement marking improvements, such as painting the median island and installing pavement marking extensions, installing special arrow markings for lane assignments at the mouths of the exit ramps, lowering the height of the DO NOT ENTER and WRONG WAY signs, adding reflective red sheeting to the sign supports, upgrading the existing I-94 directional signs on the crossroad to a larger size, and installing a raised lane separator system that would prohibit left-turning vehicles on Gratiot Avenue from entering the incorrect ramp. An unmaintained street light already has been removed to allow for greater visibility of the entrance ramp. In the longer term, MDOT expects to remove some portion of the guardrail during planned 2014 bridge work and plans to completely reconfigure the current partial cloverleaf ramps to a diamond configuration during a future reconstruction project.

Last Word

From an engineering point of view, reducing wrong-way entries starts with making the correct ramp choices appear inviting, while making the incorrect choices seem uninviting. That is the direction MDOT is taking.

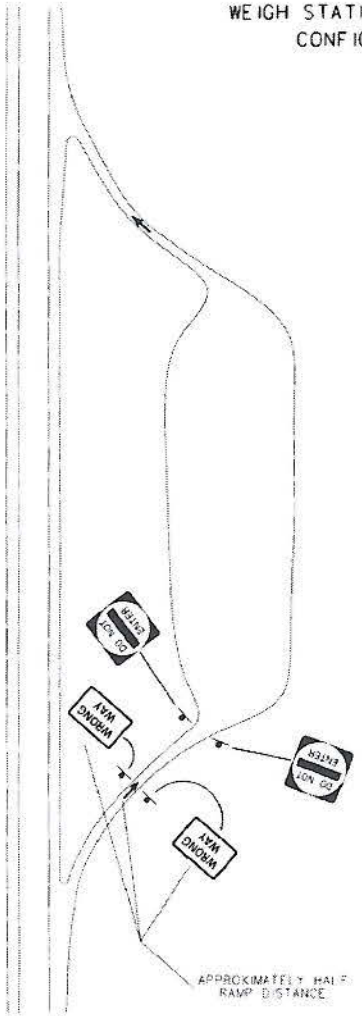
Greg Johnson, MDOT chief operations officer, is pleased with his agency's efforts but takes a realistic view of the task at hand: "We have about 1.3 billion vehicles per year entering our freeway system in Michigan. Some of these entries are made in darkness and under less-than-perfect weather conditions, and some of the drivers are tired, or impaired, or just not as mentally alert as they could be. We don't expect to stop all wrong-way entries. But this research has helped us to better understand the driver failure modes that we are trying to prevent."

David A. Morena has been the highway safety specialist at FHWA's Michigan Division Office in Lansing since 1983. Past and current safety initiatives to which he has contributed, both in Michigan and nationwide, include rumble strips, elderly mobility countermeasures, traffic signal placement, road diets, wrong-way driving countermeasures, and engineering/emergency medical system collaboration. Morena has a B.S. in industrial engineering and an M.S. in traffic engineering from Ohio State University.

Tracie J. Leix, P.E. is the manager of the safety programs unit at MDOT, where she has been since 2005. She holds a degree in civil engineering from Michigan Technological University.

For more information, contact David Morena at 517-702-1836 or dmorena@dot.gov, or Tracie Leix at 517-373-8950 or LeixT@michigan.gov.

WEIGH STATION/REST AREA
CONFIGURATION



Field Notes

LEGEND
RAMP ARROW →
STOP BAR —

MOUNTING HEIGHTS

SIGN	SIGN NUMBER	MOUNTING HEIGHT
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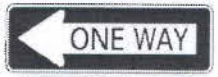
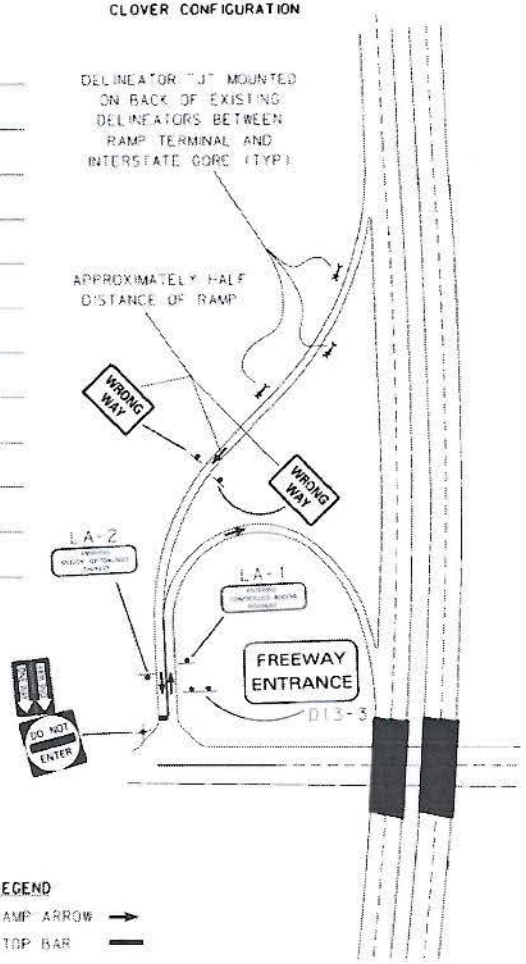
	R6-1L	
	R5-1	4 FT
	R5-1A	4 FT

NOTE:
ALL OTHER SIGNS TO BE MOUNTED ACCORDING TO DETAILED DRAWINGS 619-00 AND 619-08

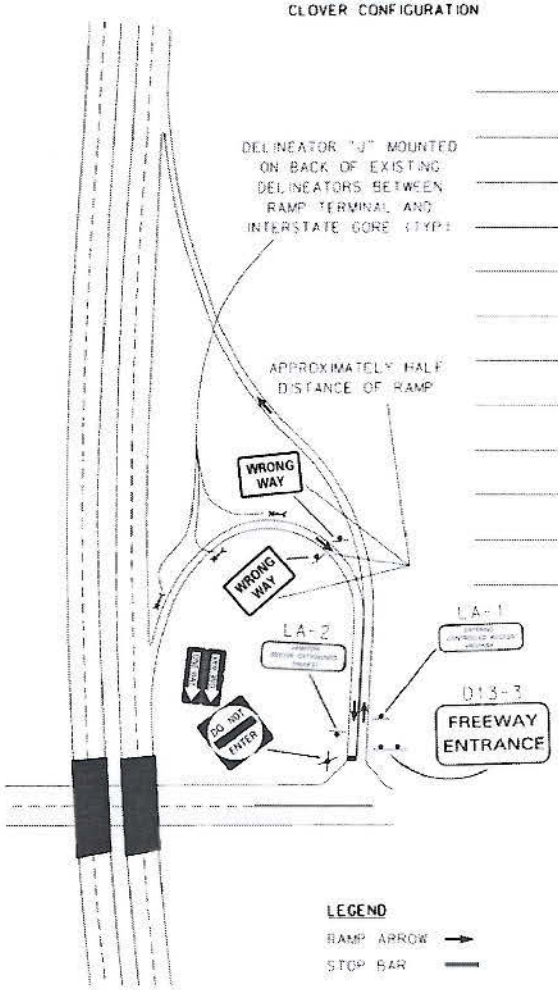
Field Notes

ON-RAMP
CLOVER CONFIGURATION



Field Notes

OFF-RAMP
CLOVER CONFIGURATION



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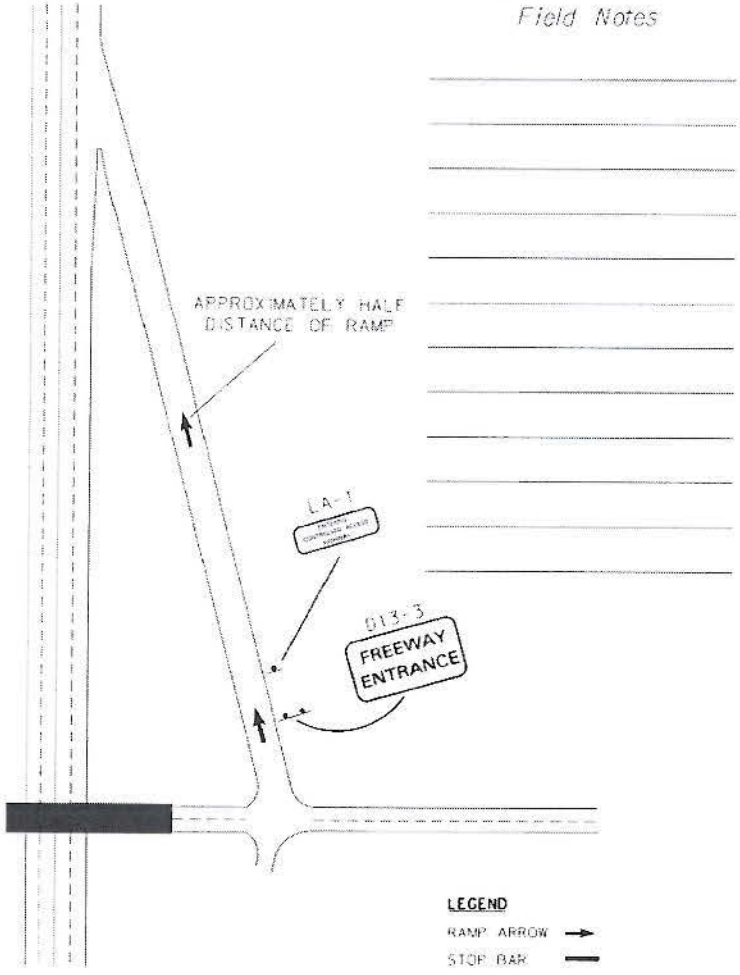
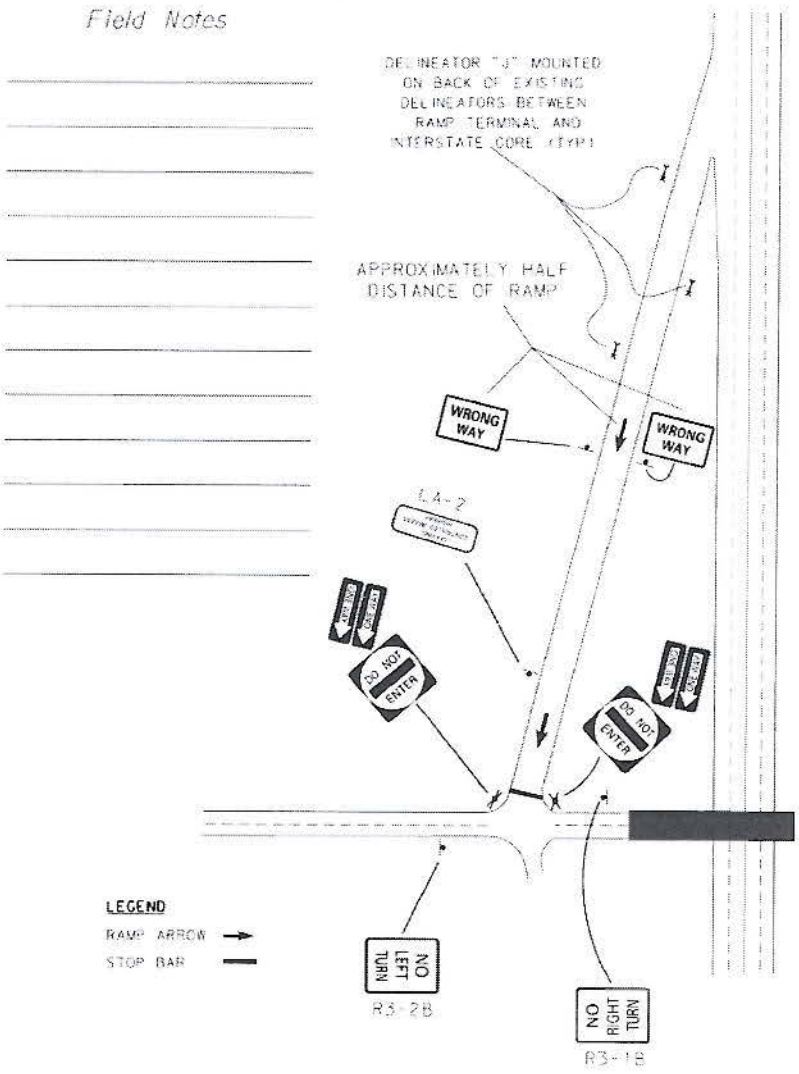
ON-RAMP DIAMOND CONFIGURATION

Field Notes



OFF-RAMP DIAMOND CONFIGURATION

Field Notes



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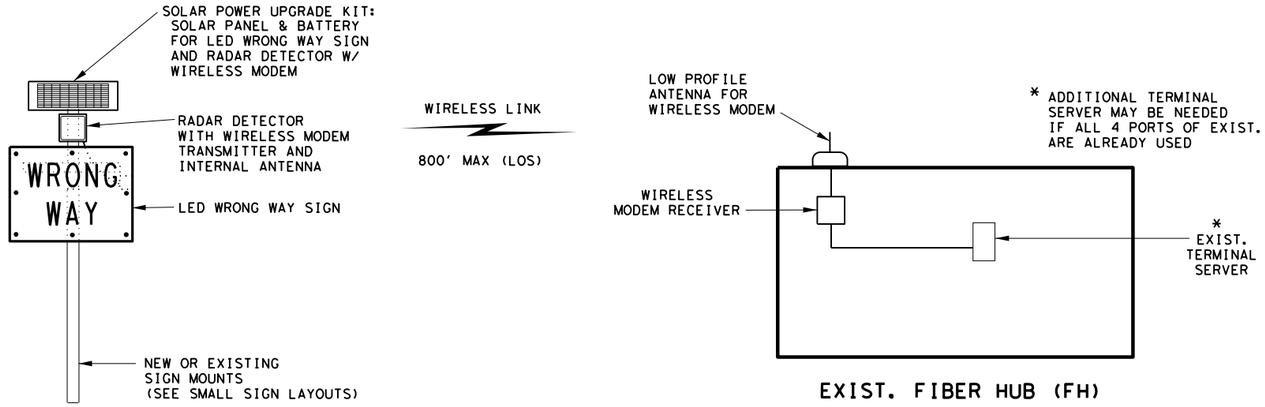
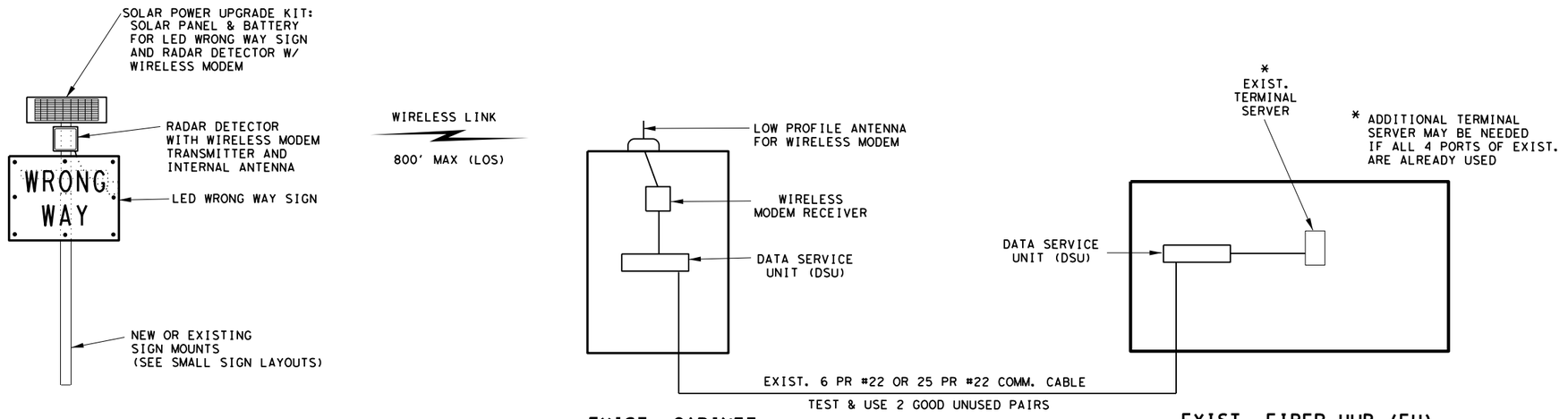
NOTES:
1. PROVIDE AND INSTALL ALL MATERIALS THAT ARE NOT SUPPLIED BY TXDOT IN ORDER TO MAKE ALL WRONG WAY RADAR DETECTORS OPERATIONAL.
2. REVISE EXISTING SCHEMATICS AT FIBER HUB OR CABINET LOCATIONS TO SHOW NEW WRONG WAY RADAR DETECTOR HARDWARE AND CIRCUIT(S).
3. NEW SIGN MOUNTS FOR WRONG WAY SIGNS WILL BE PROVIDED BY CONTRACTOR (AS SHOWN ON SMALL SIGN LAYOUTS)



WRONG WAY RADAR DETECTOR CONNECTION TO EXIST. FIBER HUB



WRONG WAY RADAR DETECTOR CONNECTION TO EXIST. COMM, DMS, OR LCS CABINET

STATE OF TEXAS
JOHN P. GIANOTTI
79730
REGISTERED PROFESSIONAL ENGINEER

John P. Gianotti, P.E. _____ DATE

LED WRONG WAY SIGN & WIRELESS RADAR DETECTOR SCHEMATIC

Texas Department of Transportation
© 9YEAR#xDOT

SHEET 1 OF 1

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
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TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
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6:24:28 PM
4/9/2015
T:\TMS\410-0521-04-274 (IH 410-SH 151 Interchange)\STANDARDS\LED WWS & WRD SCH.dgn

DMS Wrong Way Driver Warning Message – May 2011

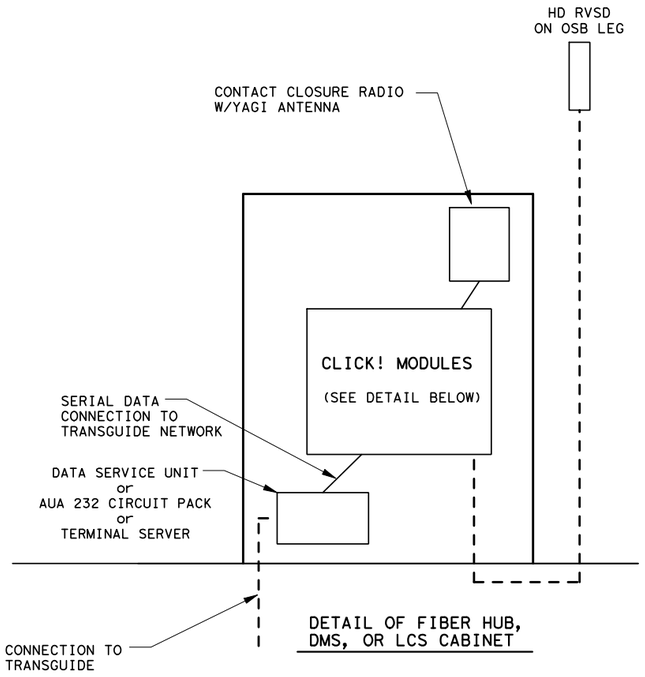
- No lane instructions given
- Message displayed first, then operator searches for vehicle using cameras
- Displayed Until:
  1) WWD stopped, 2) Accident found, *or* 3) SAPD cancels Alert

2012-14 TTI WWD Study – Warning Message Recommendations

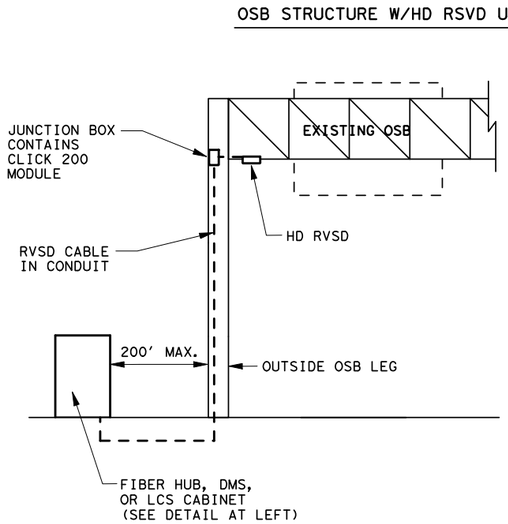
- Recommended warning messages

WARNING WRONG WAY DRIVER REPORTED	WARNING WRONG WAY VEH REPORTED
> 15 characters per line	< 15 characters per line

- Activate beacons when warning message displayed
  - Catch attention of motorists
  - Distinguish from other messages
- What if the sign does not have beacons?
  - Can flash entire message
  - Do not flash one line
- Post when wrong way driver reported
- Displayed in both directions of travel



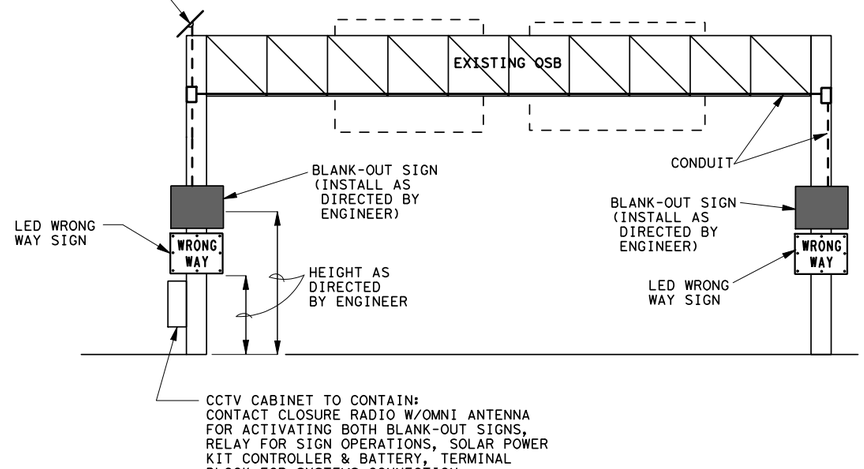
DETAIL OF FIBER HUB, DMS, OR LCS CABINET



OSB STRUCTURE W/HD RSVD UNIT

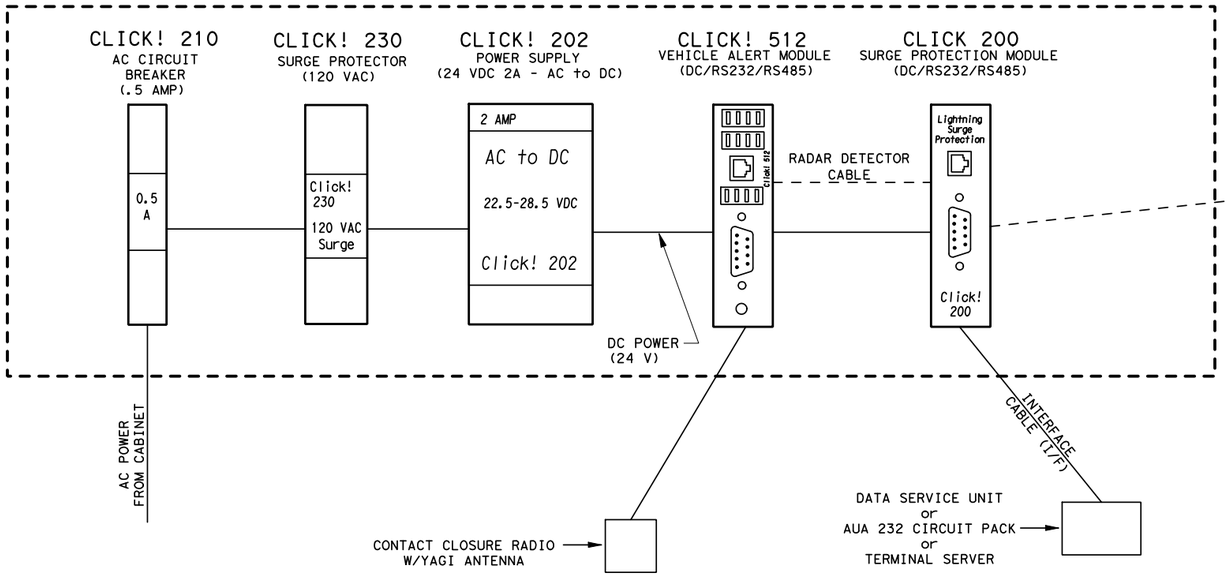
WIRELESS LINK

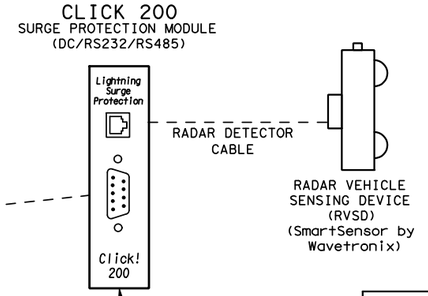
SOLAR POWER KIT TO POWER ALL
BLANK-OUT SIGNS & LED WW SIGNS
(MOUNT AS DIRECTED BY ENGINEER)



OSB STRUCTURE W/BLANK OUT AND LED WRONG WAY SIGNS

HD RVSD NEAR TRANSGUIDE CABINET





9 CONDUCTOR CABLE CUSTOM MADE
FOR WAVETRONIX AND AVAILABLE FROM
WAVETRONIX ONLY.

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: NOT INTENDED
FOR PERMIT, BIDDING OR CONSTRUCTION.
ENGINEER: JOHN P. GIANOTTI
P.E. SERIAL NO.: 79730
DATE: 7/6/12

CLICK! MODULES DETAIL

HD RVSD & BLANK-OUT SIGN SCHEMATIC

FED.RD. DIV.NO.	TRANSGUIDE MAINTENANCE CONTRACT		SHEET NO.
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TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.

11:07:59 AM
8/6/2012
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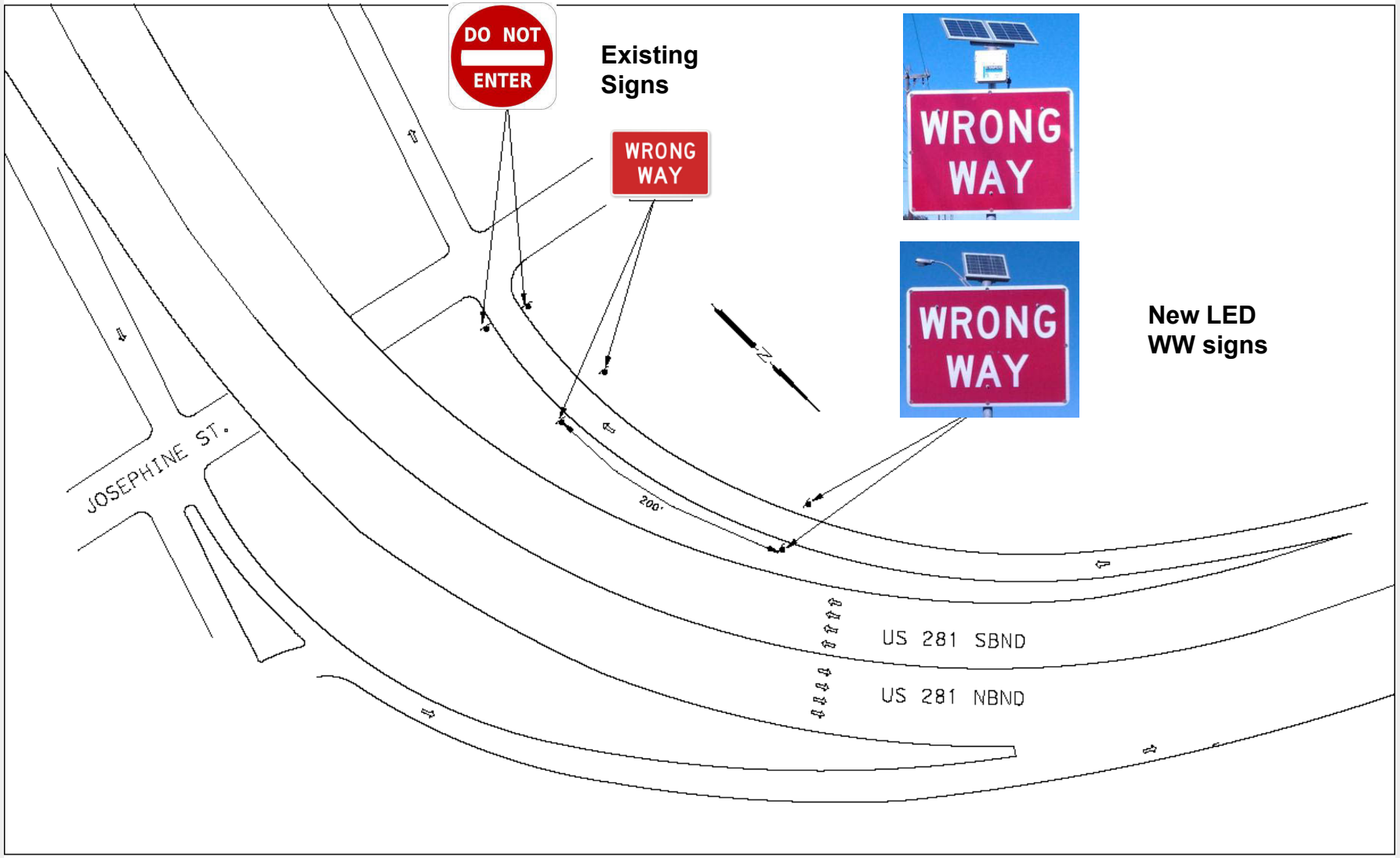
PLAN

Detection Technologies (Radar Sensors)

Exit Ramps – TAPCO Radar

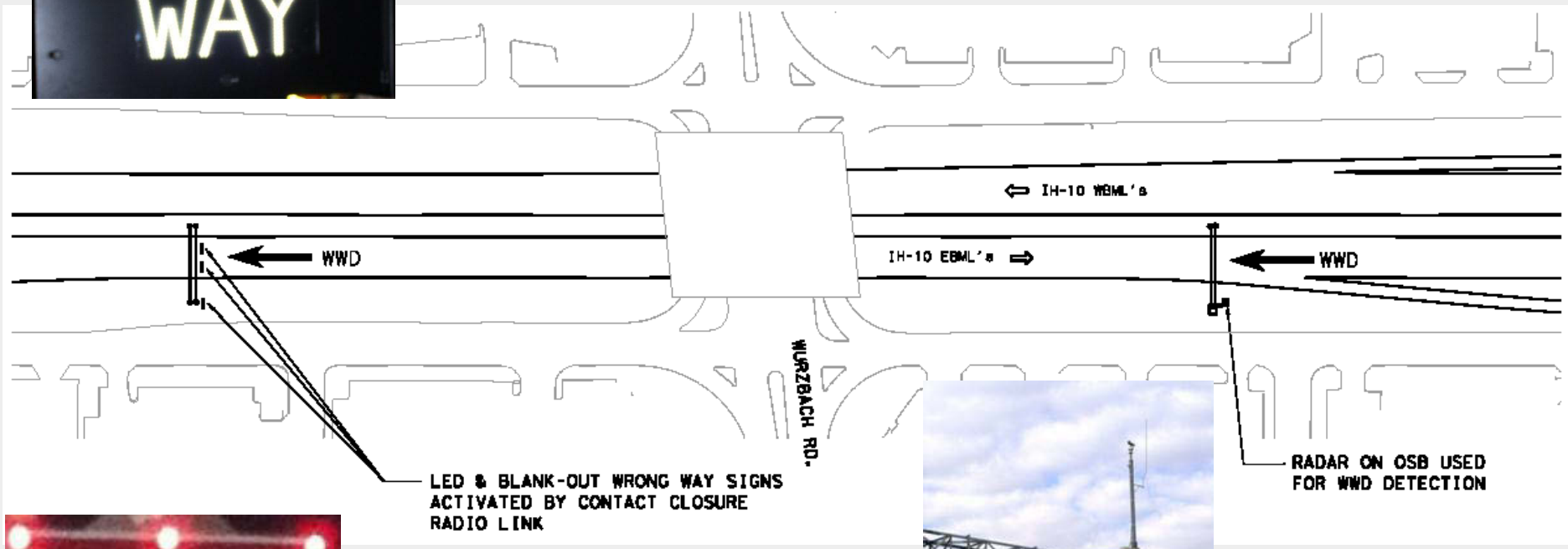
Mainlanes – Wavetronix HD Radar

Exit Ramp Counter measures



Exit Ramp Counter measures

Mainlane Counter measures



Mainlane Counter measures

Budget for WWD Active Counter measures

- **Exit Ramps**
  - LED WW sign w/solar panel = $1,988
  - LED WW sign w/Radar & solar panel = $5,340
  - Prices are for existing sign mounts.
  - Labor & misc. electronic parts - $6,500
  - **Typical ramp installation = $14,000**

- **Mainlane System**
  - 2 LED WW signs Sign = $3,996
  - 2 Blank Out Signs = $16,400
  - 1 Radar Detector = $6,400
  - 1 contact closure radio link = $3,800
  - Additional electronic components - $1,430
  - Labor - $9,600
  - **Typical mainlane system = $42,000**

SPECIAL SPECIFICATION

8922

Installation of Wrong Way Driver Sign(s) & Radar Equipment

1. **Description.** Transport, install and test Department furnished LED Wrong Way Signs, LED Blank Out Signs, Wrong Way Driver Radar Detectors, Contact Closure Radios, Serial Radios, Wireless Modems, and Solar Power Kits.

2. **Materials.** Provide all materials not supplied by the Department necessary for the installation of the LED Wrong Way Signs, LED Blank Out Signs, Wrong Way Driver Radar Detectors, Contact Closure Radios, Serial Radios, Wireless Modems, and Solar Power Kits. All materials provided by the Contractor must be new. Include a task in the project schedule for delivery of Department furnished materials and provide a minimum of 30 days notice to the Department for pick up of Department furnished materials. Unless otherwise shown on the plans, Wrong Way Drivers Signs and Radar Equipment will be stored by the Department for pick up at location(s) shown on the plans.

   Ensure that all materials and construction methods necessary to complete the installation conform to the requirements of this Item, the plans and the pertinent requirements of the following Items:
   - Item 618, “Conduit”
   - Item 620, “Electrical Conductors”
   - Item 644, “Small Roadside Sign Supports and Assemblies”
   - Item 656, "Foundations for Traffic Control Devices"
   - Item 6013, “Electronic Components”

3. **Construction**.

   A. Installation. Before installation of any equipment, perform a site survey of the proposed locations to determine the optimal positioning of the signs and radar units to achieve proper operation based on the manufacturer’s recommendations. Test wireless links to assure they provide optimal communication between transmitters and receivers. Adjust locations as approved by the Engineer if necessary.

   Install equipment in accordance with this Item and the lines, grades, details and dimensions as shown on the plans or as directed. Maintain safe construction practices. Ensure the mechanical execution of work complies with NEC, Article 110.12. Equipment must be installed in a neat and workmanlike manner.

   Provide all mounting hardware and cabling necessary to install and make operational all equipment. Provide only new and corrosion resistant materials. Consider all mounting hardware and cables as subsidiary to this item with no direct payment.

Adjustments and/or addition of sign attachment hardware, support brackets and appurtenances, such as conduit, etc., may be necessary for compatibility with specified positioning recommended by the manufacturer, as shown on the plans, or as directed. All adjustments and/or additional materials will not be paid for directly but will be subsidiary to this Item.

Prevent damage to all equipment provided by the department. Replace any portion of the equipment that is damaged or lost during transportation or installation. Do not use any materials furnished by the Department on any other work which is not part of the contract. Materials not used which were furnished by the Department must be returned undamaged to the location from which the materials were obtained upon completion of the work. Any unused or removed material deemed salvageable by the Engineer shall remain the property of the Department and shall be delivered to a designated site. Accept ownership of unsalvageable materials and dispose of in accordance with federal, state, and local regulations.

Stockpile all materials designated for reuse or to be retained by the Department within the project limits or at a designated location as directed.

B. Experience Requirements. The Contractor or subcontractor must meet the following experience requirements prior to installation of equipment:

1. Two years continuous existence by the Contractor of the subcontractor offering services in the installation of vehicle radar detectors and of wireless radios operating at 902–928 MHz, with frequency hopping and spread spectrum modulation. The devices must have been made operational with and able to be monitored by a central traffic management control center.

2. Two completed projects for each of the following items: A minimum of 2 vehicle radar detectors and 2 wireless radios (as described above) where the Contractor or subcontractor's personnel installed and tested this equipment and made it operational and monitored by a central traffic management control center. The detectors and radios must have been installed outdoors and permanently mounted. The completed system installations must have been in continuous satisfactory operation for a minimum of 1 year.

C. Testing. Testing of the installed equipment locations is for the purpose of relieving the Contractor of maintenance of the equipment. The Contractor will be relieved of the responsibility for maintenance of the equipment in accordance with Item 7, "Legal Relations and Responsibilities", after all testing is successfully completed.

After all equipment locations have been installed, the Department and the contractor will conduct approved continuity, stand alone, and system tests on the installed field equipment with central, remote, and laptop equipment. A final acceptance test will be conducted to demonstrate all control, monitor, and communication requirements for 60 days. The Engineer will furnish a Letter acknowledging the final acceptance testing commencement date stating the first day of the final acceptance test.

The completion of the final acceptance test occurs when system downtime due to mechanical, electrical, or other malfunctions to equipment furnished or installed does not exceed 72 hr. and any individual points of failure identified during the test period have operated free of defects. Assume responsibility only for test failures directly related to the work in accordance with this Item. Upon completion of successful final acceptance testing, document the acceptance date and project identification information and provide 2 copies to the Engineer.

4. Measurement. Install LED Wrong Way Sign will be measured as each LED Wrong Way Sign installed and made operational in accordance with this specification and as shown on the plans.

Install LED Wrong Way Sign with Solar Power Kit will be measured as each LED Wrong Way Sign with Solar Power Kit installed and made operational in accordance with this specification and as shown on the plans.

Install Wrong Way Driver Radar Detector will be measured as each Wrong Way Driver Radar Detector installed, positioned properly, configured, tested, and made operational with the TransGuide system in accordance with this specification and as shown on the plans.

Install Wireless Modem Transmitter Kit (for Wrong Way Driver Radar Detector) will be measured as each Wireless Modem Transmitter Kit (for Wrong Way Driver Radar Detector) installed, positioned properly, configured for optimal communication, tested, and made operational with the TransGuide system in accordance with this specification and as shown on the plans.

Install Wireless Modem Receiver Kit (for Wrong Way Driver Radar Detector) will be measured as each Wireless Modem Receiver Kit (for Wrong Way Driver Radar Detector) installed, positioned properly, configured for optimal communication, tested, and made operational with the TransGuide system in accordance with this specification and as shown on the plans.

Install LED Blank Out Sign will be measured as each LED Blank Out Sign installed and made operational in accordance with this specification and as shown on the plans.

Install LED Blank Out Sign with Solar Power Kit will be measured as each LED Blank Out Sign with Solar Power Kit installed and made operational in accordance with this specification and as shown on the plans.

Install HD Radar Vehicle Sensing Device (RVSD) Vehicle Alert Module will be measured as each HD Radar Vehicle Sensing Device (RVSD) Vehicle Alert Module installed, configured, tested, and made operational with the TransGuide system in accordance with this specification and as shown on the plans.

Install Solar Power Kit for HD Radar Vehicle Sensing Device (RVSD) will be measured as each Solar Power Kit for HD Radar Vehicle Sensing Device (RVSD) installed and made operational in accordance with this specification and as shown on the plans.

Install Contact Closure Radio Link will be measured as each Contact Closure Radio Link which consists of both radios, both antennas, all cables, mounting brackets and hardware; installed, positioned for optimal communication, configured, tested, and made operational with the main lane LED Blank Out signs and LED Wrong Way signs in accordance with this specification and as shown on the plans.

Install Serial Radio Link will be measured as each Serial Radio Link which consists of both radios, both antennas, all cables, mounting brackets and hardware; installed, positioned for optimal communication, configured, tested, and made operational with the TransGuide system in accordance with this specification and as shown on the plans.

5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Install LED Wrong Way Sign", "Install LED Wrong Way Sign with Solar Power Kit", "Install Wrong Way Driver Radar Detector", "Install Wireless Modem Transmitter Kit (for Wrong Way Driver Radar Detector)", "Install Wireless Modem Receiver Kit (for Wrong Way Driver Radar Detector)", "Install LED Blank Out Sign", "Install LED Blank Out Sign with Solar Power Kit", "Install HD Radar Vehicle Sensing Device (RVSD) Vehicle Alert Module", "Install Solar Power Kit for HD Radar Vehicle Sensing Device (RVSD)", "Install Contact Closure Radio Link", and "Install Serial Radio Link". This price is full compensation for transportation and installation of equipment; furnishing and installing any new mounting hardware or cables; storing the equipment when required; testing the equipment; replacement/repair of damaged components; disposal of unsalvageable material and for all manipulations, labor, tools, working drawings, equipment and incidentals.

FEDRD. DIV.NO.	FEDERAL AID PROJECT NO.		SHEET NO.
6	M0352(340)		1
STATE	STATE DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH10

STATE OF TEXAS
DEPARTMENT OF TRANSPORTATION

PLANS OF PROPOSED
STATE HIGHWAY IMPROVEMENT

FEDERAL-AID PROJECT

IH 10

BEXAR COUNTY

PROJECT NO: IM 0352(340)
HIGHWAY: IH 10
CCSJ: 0072-12-190
ROADWAY LENGTH: 15,269.76 FT = 2.892 MILE
NET LENGTH OF PROJECT: 15,269.76 FT = 2.892 MILE
LIMITS: S. OF HUEBNER RD TO IH 410

FOR WORK CONSISTING OF MILL, SC, OVERLAY AND RESTRIPE
FOR OPERATIONAL IMPROVEMENTS

INDEX OF SHEETS

SHEET NO.	DESCRIPTION
SEE SHEET 2 FOR INDEX OF SHEETS	

DESIGN SPEED = N/A
AREA OF DISTURBED SOIL = 0 ACRES
ADT: N/A

FINAL PLANS

LETTING DATE: _____

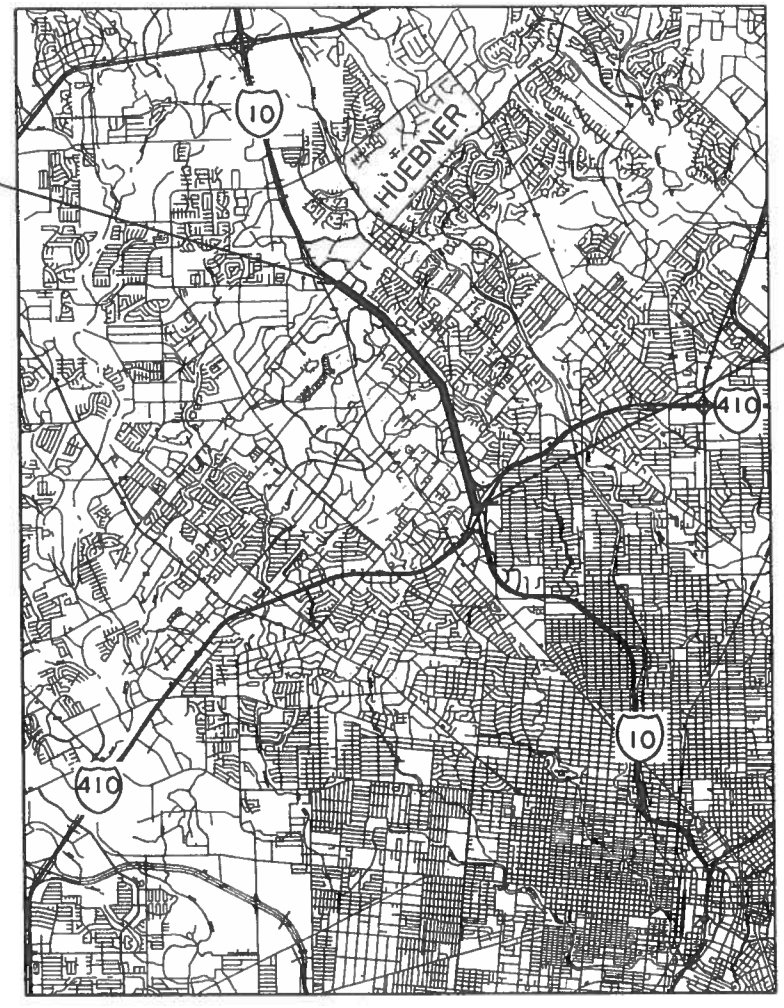
DATE CONTRACTOR BEGAN WORK: _____

DATE WORK WAS ACCEPTED: _____

FINAL CONTRACT COST: $ _____

CONTRACTOR: _____

NOT TO SCALE



BEGIN PROJECT
CSJ 0072-12-190
STA 925+00.00
MI MRKR: 15.656
REF MRKR: 560+0.638

END PROJECT
CSJ 0072-12-190
STA 1077+69.76
MI MRKR: 18.548
REF MRKR: 563+0.538

FINAL PLANS STATEMENT:

THE CONSTRUCTION WORK WAS PERFORMED IN ACCORDANCE WITH THE PLANS.

_____ P.E. _____
AREA ENGINEER DATE

TEXAS DEPARTMENT OF TRANSPORTATION

T:\Engdata\Standards\Misc\TITLESHT.DGN

FILE LOCATION AND NAME BEXAR IM0352(340)

LEVELS 6 1

COUNTY _____ PROJ. NO. _____
HWY. NO. _____ LETTING DATE _____
DATE ACCEPTED _____

SPECIFICATIONS ADOPTED BY THE TEXAS DEPARTMENT OF TRANSPORTATION, JUNE 1, 2004 AND SPECIFICATION ITEMS LISTED AND DATED AS FOLLOWS, SHALL GOVERN ON THIS PROJECT: REQUIRED CONTRACT PROVISIONS FOR ALL FEDERAL-AID CONSTRUCTION CONTRACTS (FORM FHWA 1273, MAY 2012).

EXCEPTIONS: NONE
EQUATIONS: NONE
RR X-INGS: NONE

SUBMITTED FOR LETTING 10/23/12
DISTRICT DESIGN ENGINEER

APPROVED FOR LETTING
DIRECTOR, TRAFFIC OPERATIONS DIVISION

RECOMMENDED FOR LETTING 10/24/12
DISTRICT ENGINEER

APPROVED FOR LETTING
DIRECTOR, DESIGN DIVISION

GENERAL

TRAFFIC CONTROL PLAN

TRAFFIC CONTROL PLAN STANDARDS

ROADWAY DETAILS

TRAFFIC DETAILS

TRAFFIC SIGNAL STANDARDS

PAVEMENT MARKINGS & DELINEATION STANDARDS

ENVIRONMENTAL ISSUES

103 - Storm water Pollution Prevention Plan (SW3P)

105- EC (1)-09

• STATE STANDARD
•• SAN ANTONIO DISTRICT STANDARD

STATE OF TEXAS
DIANA C. ROGERIO
100243
LICENSED
PROFESSIONAL ENGINEER

THE STANDARD SHEETS SPECIFICALLY IDENTIFIED ABOVE (•), HAVE BEEN SELECTED BY ME OR UNDER MY RESPONSIBLE SUPERVISION AS BEING APPLICABLE TO THIS PROJECT.

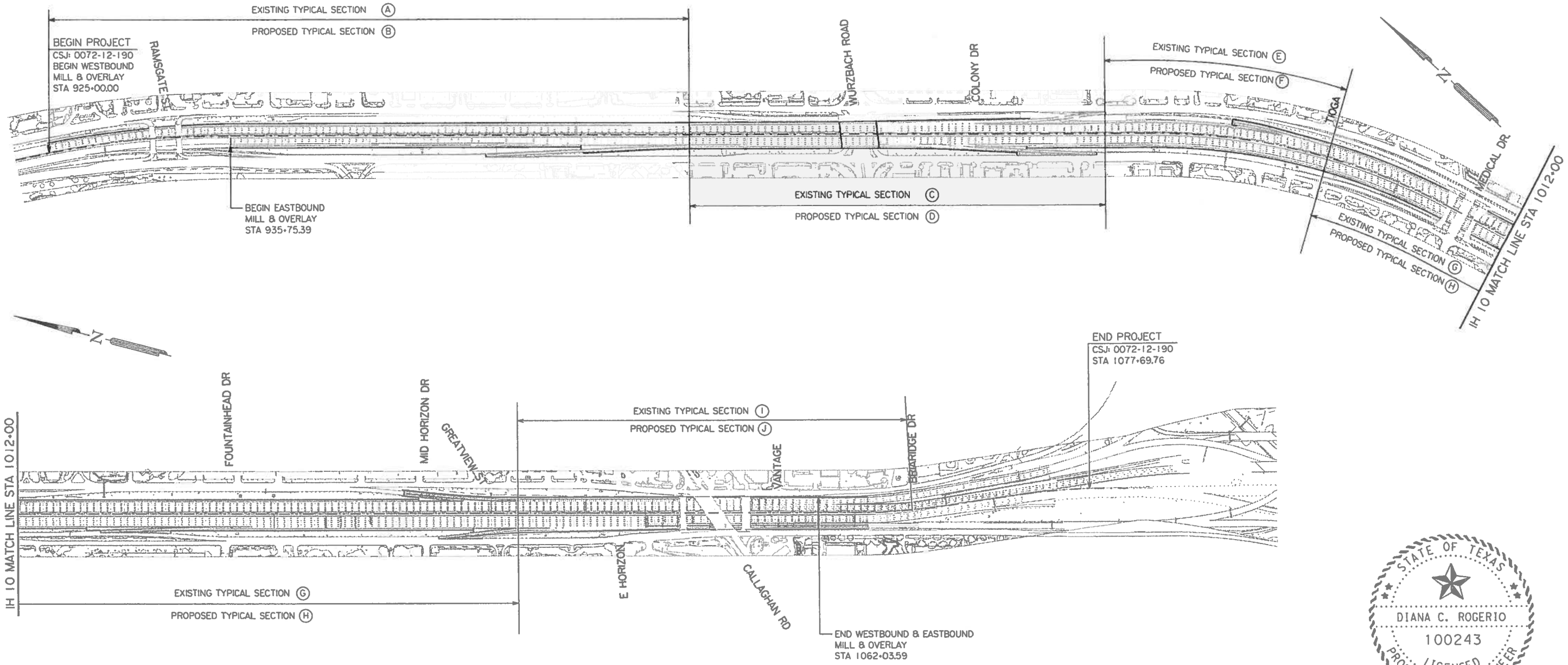
DRogio, PE 11/8/12
DATE

IH 10

INDEX OF SHEETS

SHEET 1 OF 1

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			2
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10



NOTES:

1. RE-STRIPING FOR OPERATIONAL IMPROVEMENTS ONLY PERTAINS TO THE IH 10 WESTBOUND DIRECTION. IH 10 EASTBOUND PROPOSED PAVEMENT MARKINGS WILL MATCH EXISTING CONFIGURATION.

STATE OF TEXAS
DIANA C. ROGERIO
100243
LICENSED PROFESSIONAL ENGINEER

DiRogerio P.E. 9-13-12
DIANA C. ROGERIO DATE

SCALE: N.T.S.

Texas Department of Transportation

IH 10

PROJECT LAYOUT

SHEET 1 OF 1

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			3
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

9/12/2012 4:06:51 PM

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ESTIMATE SUMMARY

EST.	FINAL	EST.	FINAL	EST.	FINAL	EST.	FINAL

PROJECT IM 0352(340)
CONTROL 0072-12-190
IH10
ALL ITEMS

EST.	FINAL	ALT	ITEM-CODE ITEM NO	ITEM-CODE DESC CODE	ITEM-CODE SP NO	DESCRIPTION	UNIT	TOTAL EST.	TOTAL FINAL
71404.000		1	316	2707	016	ASPH (TIER III)	GAL	71404.000	
2379.000		1	316	2719	016	AGGR (TIER III)	CY	2379.000	
20532.000			346	2014		STONE-MTRX-ASPH SMA-D SAC-A PG76-22	TON	20532.000	
5182.000			351	2004		FLEXIBLE PAVEMENT STRUCTURE REPAIR (8")	SY	5182.000	
238017.000			354	2041		PLANE ASPH CONC PAV (1.5")	SY	238017.000	
1.000			500	2001	011	MOBILIZATION	LS	1.000	
4.000			502	2001	033	BARRICADES, SIGNS AND TRAFFIC HANDLING	MO	4.000	
980.000			618	2034		CONDT (PVC) (SCHD 80) (2")	LF	980.000	
585.000			618	2052		CONDT (RM) (2")	LF	585.000	
410.000			620	2010	001	ELEC CONDR (NO. 6) INSULATED	LF	410.000	
2.000			624	2008	014	GROUND BOX TY A (122311) W/APRON	EA	2.000	
2.000			644	2001		IN SM RD SN SUP&AM TY10BWG(1)SA(P)	EA	2.000	
1.000			644	2063		INS SM RD SN SUP&AM (RAIL MOUNT)	EA	1.000	
8.000			644	2077		REMOVE SM RD SN SUP & AM (SIGN ONLY)	EA	8.000	
1.000			644	2085		RELOCATE SM RD SN SUP & AM (SIGN ONLY)	EA	1.000	
40361.000			662	2004		WK ZN PAV MRK NON-REMOV (W) 4" (SLD)	LF	40361.000	
39960.000			662	2005		WK ZN PAV MRK NON-REMOV (W) 6" (BRK)	LF	39960.000	
14071.000			662	2012		WK ZN PAV MRK NON-REMOV (W) 8" (SLD)	LF	14071.000	
1078.000			662	2013		WK ZN PAV MRK NON-REMOV (W) 12" (LNDP)	LF	1078.000	
4780.000			662	2014		WK ZN PAV MRK NON-REMOV (W) 12" (SLD)	LF	4780.000	
24.000			662	2017		WK ZN PAV MRK NON-REMOV (W) (ARROW)	EA	24.000	
8.000			662	2018		WK ZN PAV MRK NON-REMOV (W) (DBL ARROW)	EA	8.000	
60.000			662	2027		WK ZN PAV MRK NON-REMOV (W) (WORD)	EA	60.000	
43500.000			662	2032		WK ZN PAV MRK NON-REMOV (Y) 4" (SLD)	LF	43500.000	
10566.000			666	2036		REFL PAV MRK TY I (W) 8" (SLD) (100MIL)	LF	10566.000	
620.000			666	2039		REFL PAV MRK TY I (W) 12" (LNDP) (100MIL)	LF	620.000	
3529.000			666	2042		REFL PAV MRK TY I (W) 12" (SLD) (100MIL)	LF	3529.000	
20.000			666	2054		REFL PAV MRK TY I (W) (ARROW) (100MIL)	EA	20.000	
4.000			666	2069		REFL PAV MRK TY I(W) (DBL ARROW) (100MIL)	EA	4.000	
48.000			666	2095		REFL PAV MRK TY I (W) (WORD) (100MIL)	EA	48.000	
4.000			666	2269		REFL PAV MRK TY I (W) (LNDP ARW) (100MIL)	EA	4.000	
8.000			666	2270		PAVEMENT SEALER (LNDP ARROW)	EA	8.000	
3.000			668	2145		PREFAB PAV MRK TY C (W) (NUMBER)	EA	3.000	
154.000			672	2014	034	REFL PAV MRKR TY I-R	EA	154.000	
2137.000			672	2017	034	REFL PAV MRKR TY II-C-R	EA	2137.000	
25940.000			677	2001		ELIM EXT PAV MRK & MRKS (4")	LF	25940.000	
2476.000			677	2003		ELIM EXT PAV MRK & MRKS (8")	LF	2476.000	
1696.000			677	2005		ELIM EXT PAV MRK & MRKS (12")	LF	1696.000	
16.000			677	2008		ELIM EXT PAV MRK & MRKS (ARROW)	EA	16.000	
9.000			677	2018		ELIM EXT PAV MRK & MRKS (WORD)	EA	9.000	
56.000			6834	2001		PORTABLE CHANGEABLE MESSAGE SIGN	DAY	56.000	
960.000			6986	2007		PREFB PV MK W/WNTY TY B(W)9" (BRK) CNTST	LF	960.000	
440.000			7419	2001		PREPARATION OF EXISTING CONDUIT	LF	440.000	
15014.000			8020	2008		REF PROF PAV MRK TY I(Y)4" (SLD) (100MIL)	LF	15014.000	
26644.000			8251	2006	005	RE PM W/RET REQ TY I(W)4" (SLD) (100MIL)	LF	26644.000	
26060.000			8251	2009	005	RE PM W/RET REQ TY I(W)6" (BRK) (100MIL)	LF	26060.000	
13472.000			8251	2018	005	RE PM W/RET REQ TY I(Y)4" (SLD) (100MIL)	LF	13472.000	
6.000			8821	2001		RADAR VEHICLE SENSING DEVICE	EA	6.000	
12.000			8922	2001		INST LED WRONG WAY SIGN W/SOLAR POW KIT	EA	12.000	
5.000			8922	2002		INST WRONG WAY RADAR DETECTOR	EA	5.000	

ESTIMATE & QUANTITY SHEET

STATE DIST. NO.	COUNTY	PROJECT NO.	SHEET NO.
15	BEXAR	IM 0352(340)	10

ESTIMATE SUMMARY

EST.	FINAL	EST.	FINAL	EST.	FINAL	EST.	FINAL

PROJECT IM 0352(340)
CONTROL 0072-12-190
IH10
ALL ITEMS

EST.	FINAL	ALT.	ITEM-CODE ITEM NO	ITEM-CODE DESC CODE	ITEM-CODE SP NO	DESCRIPTION	UNIT	TOTAL EST.	TOTAL FINAL
5.000			8922	2003		INS WRLESS MOD TRANS KIT(WR WY RAD DET)	EA	5.000	
5.000			8922	2004		INS WRLESS MOD REC KIT (WR WY RAD DET)	EA	5.000	
2.000			8922	2005		INS LED WR WY BLNK OT SGN W/SOL POW KIT	EA	2.000	
1.000			8922	2006		INST HD RVSD VEH ALERT MODULE	EA	1.000	
1.000			8922	2007		INST SOLAR POWER KIT FOR HD RVSD	EA	1.000	
1.000			8922	2008		INST HD RVSD WIRELESS RADIO LINK	EA	1.000	
2.000			8922	2009		INSTALL LED BLANK OUT SIGN	EA	2.000	
2.000			8922	2010		INSTALL LED WW SIGN	EA	2.000	
2.000			8922	2011		INSTALL CONTACT CLOSURE RADIO LINK	EA	2.000	
						ALTERNATE NO. 1A			
33323.000			3233	2001		MEMBRANE UNDERSEAL	GAL	33323.000	
						CONTRACTOR FORCE ACCOUNT WORK (PART)			
						FURNISH POLICE OFFICER AND CRUISER	LS	1.000	

ESTIMATE & QUANTITY SHEET

STATE DIST. NO.	COUNTY	PROJECT NO.	SHEET NO.
15	BEXAR	IM 0352(340)	10A

* Except for PG 64, may pave at temperatures 10° F lower than the values shown in Table 1when utilizing a paving process or equipment that eliminates thermal segregation. In these cases, use either an infrared bar attached to the paver, or a hand held thermal camera, or a hand held infrared thermometer operated in accordance with Text Method 244-F to demonstrate that the uncompacted mat has no more than 10° F of thermal segregation.

--Item 354--
Retain planed material.
Take precaution to avoid damage to existing bridge decks and armor joints. Repair any damage to the bridge decks and/or armor joints as approved.

--Item 500--
"Materials on Hand" payments will not be considered in determining percentages for mobilization payments.

--Item 502--
Place standard markings no later than 14 days after surface treatment operations are completed.

When advanced warning flashing arrow panels and/or changeable message sign is specified, have one standby unit in good condition at the job site.

Treat the pavement drop-offs as shown in the TCP.

After written notification, the time frame to provide properly maintained signs and barricades before considered in non-compliance is 48 hours from receipt of the notification.

Moving an existing sign to a temporary location is subsidiary to this Item. Installations with permanent supports at permanent locations will be paid for under the applicable bid item (s).

Notify the Engineer 5 business days in advance of any temporary or permanent lane, ramp, connector, etc. closures/detours, restrictions to lane widths, alterations to vertical clearances, or modifications to radii. Any other modifications to the roadway that may adversely affect the mobility of oversized/overweight trucks also require 5 business days advance notice to the Engineer. Unless shown in the TCP, no lane, ramp, connector, etc. closures are allowed during special events. At least one lane has to remain open at all times. For all lane closures, provide written closure information by 1:00PM on the business day prior to the closure. For closures on a Monday or following a Holiday, furnish the information the workday prior to the closure. Lane closures will not be allowed if this reporting requirement is not met.

Avoid placing stockpiles within the roadway's horizontal clear zone. If a stockpile is placed within the clear zone, address in accordance with the TMUTCD.

Do not place barricades, signs, or any other traffic control devices where they interfere with sight distance at driveways or side streets.

In addition to providing a Contractor's Responsible Person and a phone number for emergency contact, have an employee available to respond on the project for emergencies and for taking corrective measures within 2 hours or within a reasonable time frame as specified by the Engineer.

--Item 585--
Use Surface Test Type B, pay adjustment schedule 2 to evaluate ride quality of travel lanes.

--Item 666 & 8251--
Use TY II material as the sealer for the TY I markings, place the TY II a minimum of 14 calendar days (to provide adequate curing) before placing the TY I markings.

--Item 672--
Place all adhesive material directly from the heated dispenser to the pavement. Do not use portable or non-heated containers. Use adhesive of sufficient thickness so that when the marker is pressed into the adhesive, 1/8" or more adhesive will remain under 100% of the marker. The adhesive should extend not less than 1/2" but not more than 1 1/2" beyond the perimeter of the marker.

--Item 677--
Obtain approval before using the mechanical method for the elimination of existing thermoplastic pavement markings.

TMS GENERAL NOTES

"TMS" is abbreviation for Traffic Management System.

All references to the TRANSGUIDE mainframe are references to the TRANSGUIDE computer network.

Provide a submittal compliance matrix with all TMS submittals.

Perform all TMS Prototype approval, Design approval, and Demonstration tests within the State of Texas.

Not previously used TMS equipment:

Test any TMS Equipment (including but not limited to Radar Vehicle Sensing Devices), which has not previously been proven to be fully operational and fully compatible with the existing TRANSGUIDE software and hardware in the following manner:

Conduct tests for each type of TMS equipment, as directed by the Engineer, to determine compatibility of the equipment with the existing TRANSGUIDE software and hardware. Prior to field installation, test one complete unit with all components to ensure that it is fully compatible with the existing TRANSGUIDE system. Mount the equipment to a trailer and connect in the field to an existing Fiber Hub. Make all hardware connections and configuration (in the operations center and in the field) and provide all incidentals (cable, connectors, etc.) to make the unit operational. Test all aspects of the system to show full functionality of the equipment and to show full compatibility with the TRANSGUIDE software and hardware. Failure to perform to the requirements of any test will be considered as a defect, and the equipment will be subject to rejection by the Engineer. Rejected equipment may be offered again for retest provided all noncompliance's have been corrected and retested by the Contractor and evidence thereof submitted to the Engineer. Testing is considered subsidiary to the particular bid item, with no direct payment made.

Partial Payments:
The contractor will receive partial payments for the following TMS items unless otherwise approved by the Engineer:

Radar Vehicle Sensing Device (RVSD)
Install Wrong Way Driver Radar Detector
Install Wireless Modem Transmitter Kit (for Wrong Way Driver Radar Detector)
Install Wireless Modem Receiver Kit (for Wrong Way Driver Radar Detector)
Install LED Blank Out Sign
Install LED Blank Out Sign with Solar Power Kit
Install HD Radar Vehicle Sensing Device (RVSD) Vehicle Alert Module
Install Contact Closure Radio Link
Install Serial Radio Link

Partial Payments Consist Of The Following:

Materials On Hand: the Contractor's paid amount is based on the invoices for the material received and stored in his/her yard.

Field Installation: When the Contractor has completed the installation of the Radar Vehicle Sensing Device (RVSD), the department will pay up to 80% of the bid item.

Stand-Alone Test: When the Radar Vehicle Sensing Device (RVSD) has passed the stand-alone test, the department will pay 15% of the bid item.

When the Radar Vehicle Sensing Device (RVSD) has passed the test portion of the Final Acceptance Test, the Department will pay the final 5% of the bid item.

Field Installation for "Install Wrong Way Driver Radar Detector":
When the contractor has completed installation of the Wrong Way Driver Radar Detector, the Department will pay 50% of the bid item.

Integration for "Install Wrong Way Driver Radar Detector":
When the Wrong Way Driver Radar Detector has been installed, configured, and made operational with the TransGuide system, the Department will pay the final 50% of the bid item.

Field Installation for "Install Wireless Modem Transmitter Kit (for Wrong Way Driver Radar Detector)":
When the contractor has completed installation of the Wireless Modem Transmitter Kit (for Wrong Way Driver Radar Detector), the Department will pay 50% of the bid item.

Integration for "Install Wireless Modem Transmitter Kit (for Wrong Way Driver Radar Detector)":
When the Wireless Modem Transmitter Kit has been installed, configured, and made operational with the TransGuide system, the Department will pay the final 50% of the bid item.

Field Installation for "Install Wireless Modem Receiver Kit (for Wrong Way Driver Radar Detector)":
When the contractor has completed installation of the Wireless Modem Receiver Kit (for Wrong Way Driver Radar Detector), the Department will pay 50% of the bid item.

Integration for "Install Wireless Modem Receiver Kit (for Wrong Way Radar Detector)":
When the Wireless Modem Receiver Kit has been installed, configured, and made operational with the TransGuide system, the Department will pay the final 50% of the bid item.

Field Installation for "Install LED Blank Out Sign":
When the contractor has completed installation of the LED Blank Out Sign, the Department will pay 50% of the bid item.

Integration for "Install LED Blank Out Sign":
When the LED Blank Out Sign has been installed, configured, and made operational with the TransGuide system, the Department will pay the final 50% of the bid item.

Field Installation for "Install LED Blank Out Sign with Solar Power Kit":
When the contractor has completed installation of the LED Blank Out Sign with Solar Power Kit, the Department will pay 50% of the bid item.

Integration for "Install LED Blank Out Sign with Solar Power Kit":

When the LED Blank Out Sign with Solar Power Kit has been installed, configured, and made operational with the TransGuide system, the Department will pay the final 50% of the bid item.

Field Installation for "Install HD Radar Detector Vehicle Alert Module":
When the contractor has completed installation of the HD Radar Detector Vehicle Alert Module, the Department will pay 50% of the bid item.

Integration for "Install HD Radar Detector Vehicle Alert Module":
When the HD Radar Detector Vehicle Alert Module has been installed, configured, and made operational with the TransGuide system, the Department will pay the final 50% of the bid item.

Field Installation for "Install Contact Closure Radio Link":
When the contractor has completed installation of the Contact Closure Radio Link, the Department will pay 50% of the bid item.

Integration for "Install Contact Closure Radio Link":
When the Contact Closure Radio Link has been installed, configured, and made operational with the TransGuide system, the Department will pay the final 50% of the bid item.

Field Installation for "Install Serial Radio Link":
When the contractor has completed installation of the Contact Closure Radio Link, the Department will pay 50% of the bid item.

Integration for "Install Serial Radio Link":
When the Contact Closure Radio Link has been installed, configured, and made operational with the TransGuide system, the Department will pay the final 50% of the bid item.
The above percentages do not include the deduction for standard Retainage.

TMS Submittals:
Include in all TMS submittals the respective bid item (specification number and descriptive code). Indicate compliance on a paragraph by paragraph basis. Ensure that the statements claiming compliance reference the appropriate documentation and the referenced documentation supporting this claim is included with the submittal. Provide referenced documentation that contains the same numbering system as referenced in the submittal. For example, submittal item XXXX-XXXX, Section 2.3, Paragraph 3, Meets Requirements (See Attachment "B"). The supporting documentation for Item XXXX-XXXX, Section 2.3, Paragraph 3, would be titled as Attachment "B". Provide submittals with the same numbering system as stated in the specification. Failure to submit accordingly will result in rejection by the Engineer.

A TMS submittal will be considered as incomplete and therefore rejected, if it contains items listed as "being furnished by others". It is the responsibility of the Contractor to make sure the submittal addresses all items of the specification.

Provide the following TMS submittals (to be received by TxDOT San Antonio Traffic Management office) within the designated time. The time frame is in calendar days.

Item Description	Submitted By Contractor W/I Days After Authorization To Begin Work	Returned By State W/I Days
Radar Vehicle Sensing Device (RVSD)	15	15

Submit those items designated with the (*), if any, together as a Package.

The Contractor may submit items sooner if needed for construction, but no later than the dates stated above.

Provide, to the Engineer, as-built plans in MicroStation format (.dgn files) of the TMS portion of this project when the project is complete. TxDOT will provide the .dgn files of the TMS plan sheets. Update these files with all TMS items as ACTUALLY CONSTRUCTED in the field. Cost to provide as-built plans as described above is subsidiary to the various bid items with no direct payment.

Customize all training specifically for the TRANSGUIDE system; generic training will not be accepted on this project. Training materials and labor are subsidiary to the various Bid Items with no direct payment.

TMS equipment and conduit locations are approximate; the precise location is to be determined in the field, therefore the Contractor should not scale equipment off of plan sheets. Plan sheets are to be used for visual location (vicinity). Equipment locations may have to be adjusted due to conflicts with utilities or other structures, as approved by the Engineer. Do not obstruct the natural flow of water with Traffic Management equipment. In low water areas, place Traffic Management equipment on high side of ditch.

Any existing Traffic Management Equipment, conduit, cables, etc. damaged by contractor during construction will be replaced by the contractor at no cost to TxDOT with equipment as approved by the Traffic Management Engineer. Replace all pavement, sidewalk, curb, rip-rap or any item damaged during construction, subsidiary to the various bid items with no direct payment.

Stencil structure numbers on all new TMS structures for permanent identification as directed by the Engineer.

Ensure that all TMS equipment furnished and installed is completely compatible with the existing hardware and software located within the TRANSGUIDE operations center (i.e.

TRANSGUIDE central software). TRANSGUIDE is unique and complicated. The Contractor should contact the Traffic Management Engineer for details on the system network architecture.

All new TMS equipment and any existing TMS equipment that is relocated will be incorporated into the existing Network Management System, subsidiary to the various bid items.

Security against theft and vandalism of all Traffic Management equipment is the full responsibility of the Contractor until the date of final acceptance of the project by the Engineer.

Maintenance of all Traffic Management equipment furnished and installed on this project is the full responsibility of the Contractor until date of final acceptance of this project by the Engineer. All required documentation must be turned in before TxDOT will accept project for maintenance.

Submit a layout of equipment and interconnect wiring schematic for the TRANSGUIDE Control Center and Fiber Hubs for approval by the Engineer prior to ordering materials. Consider all interconnect wiring within the TRANSGUIDE Control Center and all interconnect wiring for all equipment in the plans and described within the specifications as subsidiary to the various Bid Items with no direct payment.

Perform all TMS electrical work and provide all TMS electrical materials in accordance with the National Electrical Code.

The location of utilities (including TMS), either underground or overhead, if shown within the right of way are approximate and must be verified by the Contractor before beginning construction operations. TRANSGUIDE will provide the approximate location of TMS equipment, however, it is the responsibility of the Contractor to determine the depth of the Traffic Management conduit.

In accordance with the Underground Facility Damage Prevention Act (One Call Bill) the phone number for a utility locator is 1-800-545-6005. It is the Contractor's responsibility to make arrangements for utility locators as needed.

TxDOT (Traffic Management)	(210)731-5109
TxDOT (Sign Lighting)	(210)615-5995
TxDOT (Traffic Signal)	(210)615-5975

--Item 618--
Make all TMS underground conduit bends of 45 degrees or more in PVC systems, including bends into ground boxes, with rigid metal conduit, subsidiary to the various bid items with no direct payment. Ensure that grounding is in accordance with the ED sheets.

When installing TMS conduit in areas where riprap presently exists, use care and do not break out more riprap that is necessary for placement of conduit. Replace riprap with concrete to the exact slope, pattern and thickness of the existing riprap, subsidiary to the various bid items with no direct payment

--Item 620—
Wire nuts for TMS installations are not be permitted.

To ensure immediate identification, consistently color code and permanently identify all TMS power conductors, twisted wire pair cables, shielded cables, control cables, and fiber optic cables in all manholes, ground boxes, and at all termination points and splices. Submit a chart or list identifying all cables and conductors in a logical and sequential manner.

Install all TMS conductors and cables continuous and without splices from terminal point to terminal point unless otherwise shown on the plans.

The TMS plans show the conduits numbered and specified cables in specific conduits. The purpose of these notes is to instruct the contractor on how to group the cables in the conduits and not to specify the exact conduit to carry the cables. Except for the main trunklines (4- 3" PVC or 4" PVC Multiduct [2-way] or [4-way, etc], the numbering system is arbitrary and may be set by the contractor.

Test all TMS circuits to be clear of faults, grounds or open circuits.

--Item 1122—
It is not anticipated that erosion control devices will be needed. However; in the event devices are needed, the SW3P shall consist of the control measures approved. Depending on the type and amount of work, payment will be handled with the Force Account Procedure, or by individual pay items.

--Item 6011—TESTING, TRAINING, DOCUMENTATION, FINAL ACCEPTANCE AND WARRANTY

The 60 day test will begin only when all TMS equipment installation, cabling, wiring, testing, field work, TRANSGUIDE operations center work, etc. for the entire project is completed and acceptable to TxDOT. Partial testing is not allowed.

TRAFFIC MANAGEMENT SUMMARY
I.H. 10 (CSJ 0072-12-190)

2005 2001 2002 2003 2004

SHEET NO	STATION TO STATION OR DESCRIPTION		ITEM NO.►	618-2034 CONDT PVC (SCHD 80) (2")	618-2052 CONDT (RM) (2")	620-2010 ELEC CONDR (No.6) INSULATED	624-2008 GROUND BOX (TY - A) WITH APRON	644-2001 INS SM RD SN SUP&AM TY 10BWG(1) SA (P)	644-2063 INS SM RD SN SUP&AM (RAIL MOUNT)	644-2077 REMOVE SM RD SN SUP & AM (SIGN ONLY)	644-2085 RELOCATE SM RD SN SUP & AM (SIGN ONLY)	8821-2001 RADAR VEHICLE SENSING DEVICE (RVSD)	7419-2001 PREP. OF EXIST. CONDUIT	INSTALL LED BLANK OUT SIGN	INSTALL LED BLANK OUT SIGN W/ SOLAR PWR	INSTALL LED WW SIGN	INSTALL LED WW SIGN/W SOLAR PWR	INSTALL WW DRIVER RADAR DETECTOR	INSTALL WIRELESS MODEM TRANS KIT FOR WWDRD	INSTALL WIRELESS MODEM RECV KIT FOR WWDRD
				EST LF	EST LF	EST LF	EST EA	EST EA	EST EA	EST EA	EST EA	EST EA	EST LF	EST EA	EST EA	EST EA	EST EA	EST EA	EST EA	EST EA
	IH 10																			
	925+00 to	936+00	1 OF 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	936+00 to	948+00	2 OF 12	-	-	-	-	-	-	2	1	-	-	-	-	-	2	1	1	1
	948+00 to	960+00	3 OF 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	960+00 to	972+00	4 OF 12	-	210	410	-	1	-	2	-	1	180	2	-	2	2	1	1	1
	972+00 to	984+00	5 OF 12	-	50	-	-	-	1	-	-	-	-	-	-	-	2	1	1	-
	984+00 to	996+00	6 OF 12	630	40	-	1	-	-	-	-	2	-	-	-	-	-	-	-	1
	996+00 to	1008+00	7 OF 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1008+00 to	1020+00	8 OF 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1020+00 to	1032+00	9 OF 12	350	150	-	1	1	-	2	-	2	-	-	-	-	2	1	1	1
	1032+00 to	1044+00	10 OF 12	-	-	-	-	-	-	2	-	-	-	-	-	-	2	1	1	-
	1044+00 to	1056+00	11 OF 12	-	20	-	-	-	-	-	-	1	40	-	-	-	-	-	-	1
	1056+00 to	1062+00	12 OF 12	-	115	-	-	-	-	-	-	-	220	-	2	-	2	-	-	-
TOTAL				980	585	410	2	2	1	8	1	6	440	2	2	2	12	5	5	5

NOTIFY THE OFFICE OF TRAFFIC MANAGEMENT
AT TRANSGUIDE, 3500 N.W. LOOP 410, (210) 731-5247, PRIOR
TO BEGINNING ANY WORK ON THE ABOVE LISTED ITEMS

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8/9/2012
7:58 AM

TRAFFIC MANAGEMENT SUMMARY

SHEET 1 OF 3

FED.RD. DIV.NO.	FEDERAL AID PROJECT			SHEET NO.
6				13
STATE	DIST.	COUNTY		
TEXAS	15	BEXAR		
CONT.	SECT.	JOB	HIGHWAY	
0072	12	190	IH 10	

TRAFFIC MANAGEMENT SUMMARY
I.H. 10 (CSJ 0072-12-190)

2006 2007 2008

SHEET NO	STATION TO STATION OR DESCRIPTION		ITEM NO.►					**	**	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
				INSTALL HD RVSD VEHICLE ALERT MODULE	INSTALL SOLAR POWER KIT FOR RVSD	INSTALL CONTACT CLOSURE RADIO LINK	INSTALL SERIAL RADIO LINK	R.V.S.D. CABLE	INSTALL EQUIP. CABINET	DATA SERVICE UNIT (DSU)	EQUIP. CABINET	LED BLANK OUT SIGN	LED BLANK OUT SIGN W/ SOLAR PWR	LED W/W SIGN	LED W/W SIGN/W SOLAR PWR	WRONG WAY DRIVER RADAR DETECTOR	WIRELESS MODEM TRANS KIT FOR WWDRD	WIRELESS MODEM RECV KIT FOR WWDRD	HD RVSD VEHICLE ALERT MODULE	SOLAR POWER KIT FOR RVSD
				EST EA	EST EA	EST EA	EST EA	EST LF	EST LF	EST EA	EST EA	EST EA	EST EA	EST EA	EST EA	EST EA	EST EA	EST EA	EST EA	EST EA
	IH 10																			
	925+00 to	936+00	1 OF 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	936+00 to	948+00	2 OF 12	-	-	-	-	-	-	1	-	-	-	-	2	1	1	1	-	-
	948+00 to	960+00	3 OF 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	960+00 to	972+00	4 OF 12	-	-	-	-	160	1	-	1	2	-	2	2	1	1	1	-	-
	972+00 to	984+00	5 OF 12	1	1	1	-	50	1	-	1	-	-	-	2	1	1	-	1	1
	984+00 to	996+00	6 OF 12	-	-	-	1	1340	-	3	-	-	-	-	-	-	-	1	-	-
	996+00 to	1008+00	7 OF 12	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-
	1008+00 to	1020+00	8 OF 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1020+00 to	1032+00	9 OF 12	-	-	-	-	1000	-	2	-	-	-	-	2	1	1	1	-	-
	1032+00 to	1044+00	10 OF 12	-	-	-	-	-	-	-	-	-	-	-	2	1	1	-	-	-
	1044+00 to	1056+00	11 OF 12	-	-	-	-	60	-	3	-	-	-	-	-	-	-	1	-	-
	1056+00 to	1062+00	12 OF 12	1	-	1	-	220	1	1	1	-	2	-	2	-	-	-	1	-
	TOTAL			2	1	2	1	2830	3	14	3	2	2	2	12	5	5	5	2	1

◐ SUPPLIED BY TXDOT, TO BE INSTALLED BY CONTRACTOR

** NON-PAY ITEM. SUBSIDIARY TO VARIOUS BID ITEMS

NOTIFY THE OFFICE OF TRAFFIC MANAGEMENT,
AT TRANSGUIDE, 3500 N.W. LOOP 410, (210) 731-5247, PRIOR
TO BEGINNING ANY WORK ON THE ABOVE LISTED ITEMS

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8/9/2012
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TRAFFIC MANAGEMENT SUMMARY

SHEET 2 OF 3 SHEETS

FED.RD. DIV.NO.	FEDERAL AID PROJECT NO.		SHEET NO.
6			64
STATE	DIST.	COUNTY	
TEXAS	15	BEXAR	
CONT.	SECT.	JOB	HIGHWAY
0072	12	190	IH 10.

TRAFFIC MANAGEMENT SUMMARY
I.H. 10 (CSJ 0072-12-190)

SHEET NO	STATION TO STATION OR DESCRIPTION		ITEM NO. ▶	◐ CONTACT CLOSURE RADIO LINK	◐ SERIAL RADIO LINK															
	IH 10																			
	925+00 to	936+00	1 OF 12	-	-															
	936+00 to	948+00	2 OF 12	-	-															
	948+00 to	960+00	3 OF 12	-	-															
	960+00 to	972+00	4 OF 12	-	-															
	972+00 to	984+00	5 OF 12	1	-															
	984+00 to	996+00	6 OF 12	-	1															
	996+00 to	1008+00	7 OF 12	-	-															
	1008+00 to	1020+00	8 OF 12	-	-															
	1020+00 to	1032+00	9 OF 12	-	-															
	1032+00 to	1044+00	10 OF 12	-	-															
	1044+00 to	1056+00	11 OF 12	-	-															
	1056+00 to	1062+00	12 OF 12	1	-															
TOTAL				2	1															

◐ SUPPLIED BY TXDOT, TO BE INSTALLED BY CONTRACTOR

NOTIFY THE OFFICE OF TRAFFIC MANAGEMENT,
AT TRANSGUIDE, 3500 N.W. LOOP 410, (210) 731-5247, PRIOR
TO BEGINNING ANY WORK ON THE ABOVE LISTED ITEMS

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8/9/2012
8:00 AM

TRAFFIC MANAGEMENT SUMMARY

SHEET 3 OF 3 SHEETS

FED.RD. DIV.NO.	FEDERAL AID PROJECT NO.		SHEET NO.
6			15
STATE	DIST.	COUNTY	
TEXAS	15	BEXAR	
CONT.	SECT.	JOB	HIGHWAY
0072	12	190	IH 10

NOTE:
EXIST. TMS ITEMS AND QUANTITIES ARE NOT GUARANTEED TO BE 100% ACCURATE OR ALL INCLUSIVE.

STA. 982+62 EBND

LED WRONG WAY SIGN (SOLAR) WITH WWDRD & WIRELESS MODEM TRANS. KIT

LED WRONG WAY SIGN (SOLAR)

RF

EXIST. CCTV 10W 562.027

CCTV CABLES

TRF SIG. CONTROLLER MEDICAL

EXIST. 6 PR

EXISTING DMS3 CABINET STA. 990+00 EBND 0010E-561.689

EXIST. 6 PR

RVSD (SOLAR) STA. 978+10

RVSD CABLE

EXISTING DMS3 CABINET STA. 991+00 WBND 0010W-561.771

EXIST. 6 PR

EXIST. FH 77
STA. 998+70
0010W-562.021

EXIST. (1) ETH MPEG4 ENCODER
EXIST. (1) CIP-3
EXIST. (1) ETHERNET SWITCH
EXIST. (2) TERMINAL SERVER
EXIST. (3) DATA SERVICE UNIT
(4) DATA SERVICE UNIT

EXISTING LCS(5) CABINET STA. 1012+00 WBND 0010W-562.273

EXIST. 6 PR

EXIST. 25 PR

EXISTING COMM. CABINET (CC18) STA. 988+00 EBND 0010E-561.667

-USE DSU PREVIOUSLY USED BY LCU FOR ONE RVSD

(3) DATA SERVICE UNIT
(1) WIRELESS MODEM RECEIVER KIT
(1) SERIAL RADIO

SERIAL RADIO LINK

EQUIP. CABINET STA. 978+10 EBND (ON OSB)

-SOLAR POWER HARDWARE
(1) CONTACT CLOSURE RADIO W/ANTENNA
(1) SERIAL RADIO

CONTACT CLOSURE RADIO LINK

EQUIP. CABINET STA. 966+00 EBND (ON OSB)

(AC POWER SOURCE THRU FH 78)
(1) CONTACT CLOSURE RADIO W/ANTENNA

RVSD CABLE

RVSD CABLE

RVSD STA. 994+50

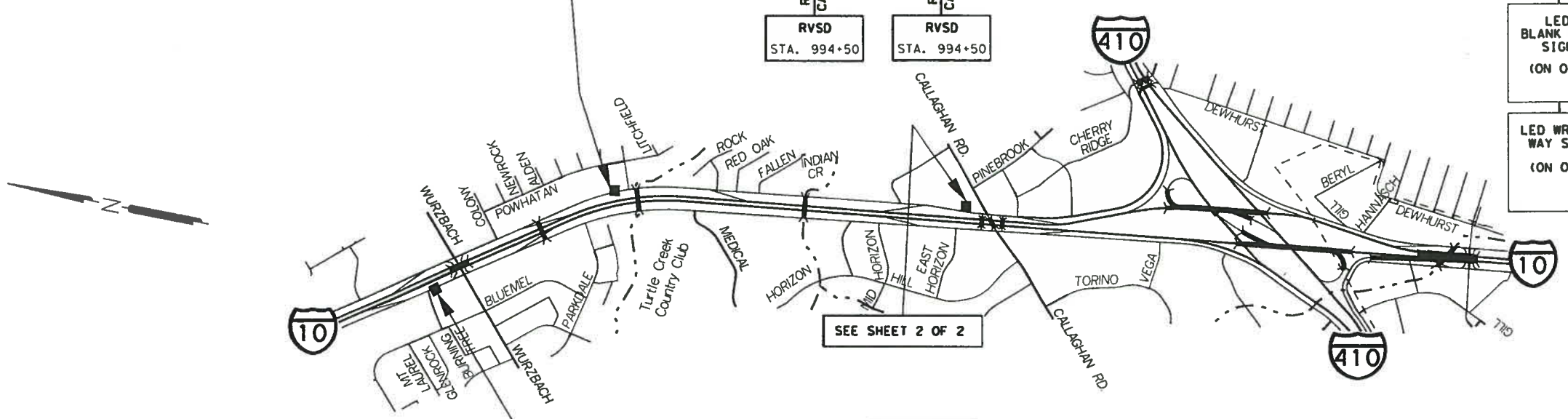
RVSD STA. 994+50

LED BLANK OUT SIGN (ON OSB)

LED BLANK OUT SIGN (ON OSB)

LED WRONG WAY SIGN (ON OSB)

LED WRONG WAY SIGN (ON OSB)



LED WRONG WAY SIGN (SOLAR) WITH WWDRD & WIRELESS MODEM TRANS. KIT

LED WRONG WAY SIGN (SOLAR)

RF

STA. 964+47 WBND

EXIST. FH 78
STA. 966+00
0010E-561.242

EXIST. (1) ETH MPEG4 ENCODER
EXIST. (1) CIP-3
EXIST. (1) ETHERNET SWITCH
EXIST. (2) TERMINAL SERVER
EXIST. (4) DATA SERVICE UNIT
(1) DATA SERVICE UNIT
(1) WIRELESS MODEM RECEIVER KIT

EXIST. CCTV 10E-561.242

CCTV CABLES

TRF SIG. CONTROLLER WURZBACH

EXIST. 6 PR

EXISTING DMS2 CABINET STA. 966+00 EBND 0010E-561.242

EXIST. 6 PR

EXISTING LCS(5) CABINET STA. 966+00 EBND 0010E-561.242

EXIST. 6 PR

RVSD CABLE

RVSD STA. 966+10

EXIST. 25 PR

EXISTING COMM. CABINET (CC19) STA. 959+70 EBND 0010E-561.130

(17) EXIST LOOPS

EXIST. 6 PR

EXISTING DMS3 CABINET STA. 946+70 EBND 0010E-560.846

(1) DATA SERVICE UNIT
(1) WIRELESS MODEM RECEIVER KIT

RF

LED WRONG WAY SIGN (SOLAR) WITH WWDRD & WIRELESS MODEM TRANS. KIT

LED WRONG WAY SIGN (SOLAR)

STA. 937+18 EBND

EXIST. 6 PR

EXISTING LCS(4) CABINET STA. 956+00 WBND 0010W-561.060

EXIST. 6 PR

EXISTING DMS2 CABINET STA. 956+00 WBND 0010W-561.060

LEGEND

RVSD = RADAR VEHICLE SENSING DEVICE
WWDRD = WRONG WAY DRIVER RADAR DETECTOR
FH = FIBER HUB
DMS = DYNAMIC MESSAGE SIGN
LCS = LANE CONTROL SIGNAL
CC = COMMUNICATION CABINET
DSU = DATA SERVICE UNIT
TRANS. = TRANSMITTER
RF = RADIO FREQUENCY (WIRELESS LINK)

STATE OF TEXAS
BRIAN G. FARIELLO
66186
LICENSED PROFESSIONAL ENGINEER

Brian G. Fariello, P.E. 8/9/12
DATE

Texas Department of Transportation

IH 10
TRAFFIC MANAGEMENT SYSTEM SCHEMATIC

SHEET 1 OF 2

FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
6			63
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

9:37:31 AM
8/9/2012
T:\TMS\10-0072-12-190 (S. of Huebner to IH 410)\TMS Layouts\SCHEMATIC(REV8-7-12).dgn

NOTE:
EXIST. TMS ITEMS AND QUANTITIES ARE NOT GUARANTEED TO BE 100% ACCURATE OR ALL INCLUSIVE.

RVSD
STA. 1055+60
(ON OSB)

RVSD CABLE

EXISTING
DMS2 CABINET
STA. 1057+75 WBND
0010W-563.099
(1) DSU (RVSD BLANK OUT SYS)
(1) CONTACT CLOSURE RADIO W/ANTENNA
(1) HD RVSD VEH. ALERT MOD

CONTACT CLOSURE RADIO LINK

EQUIP. CABINET
STA. 1066+60 WBND
(ON OSB)
-SOLAR POWER HARDWARE
-CONTACT CLOSURE RADIO W/ANTENNA

LED BLANK OUT SIGN (SOLAR) (ON OSB)
LED BLANK OUT SIGN (SOLAR) (ON OSB)
LED WRONG WAY SIGN (SOLAR) (ON OSB)
LED WRONG WAY SIGN (SOLAR) (ON OSB)

RVSD
STA. 1027+10
RVSD CABLE
RVSD CABLE
RVSD
STA. 1027+10

EXISTING
COMM. CABINET (CC17)
STA. 1023+50 EBND
0010E-562.490
-USE DSU PREVIOUSLY USED BY LCU FOR ONE RVSD
(2) DATA SERVICE UNIT (FOR RVSD & WWDRD)
(1) WIRELESS MODEM RECEIVER KIT

EXISTING
LCS(6) CABINET
STA. 1027+10 EBND
0010E-562.557
EXIST. 6 PR

EXISTING
DMS3 CABINET
STA. 1028+60 EBND
0010E-562.589
EXIST. 6 PR

EXIST. 25 PR

EXIST. 6 PR

EXISTING
LCS(6) CABINET
STA. 1058+00 WBND
0010W-563.099
EXIST. 6 PR

EXIST. RVSD
(ON OSB)
STA. 47+54
(EBOBC)
EXIST. RVSD CABLE

LED WRONG WAY SIGN (SOLAR)
LED WRONG WAY SIGN (SOLAR) WITH WWDRD & WIRELESS MODEM TRANS. KIT
RF
STA. 1022+28 EBND

EXIST. FH 76
STA. 1046+50 WBND
0010W-562.930
EXIST. (1) ETH MPEG4 ENCODER
EXIST. (1) CIP-3
EXIST. (1) ETHERNET SWITCH
EXIST. (4) TERMINAL SERVER
EXIST. (8) DATA SERVICE UNIT
(3) DATA SERVICE UNIT
(1) WIRELESS MODEM RECEIVER KIT

EXISTING
COMM. CABINET
STA. 1077+20 EBND
0010E-
EXIST. (2) LOOPS
EXIST. (2) DATA SERVICE UNITS
EXIST. 6 PR
EXISTING
DMS3 CABINET
STA. 1071+60 EBND
0010E-
EXIST. 6 PR
EXISTING
LCS(3) CABINET
STA. 1080+00 EBND
0010E-

EXISTING
LCS(6) CABINET
STA. 1046+50 EBND
0010E-562.989
EXIST. 6 PR

EXISTING
COMM. CABINET (CC15)
STA. 1046+50 EBND
0010E-562.930
(1) EXIST LOOP
EXIST. 25 PR

EXIST. 25 PR

EXIST. RVSD CABLE

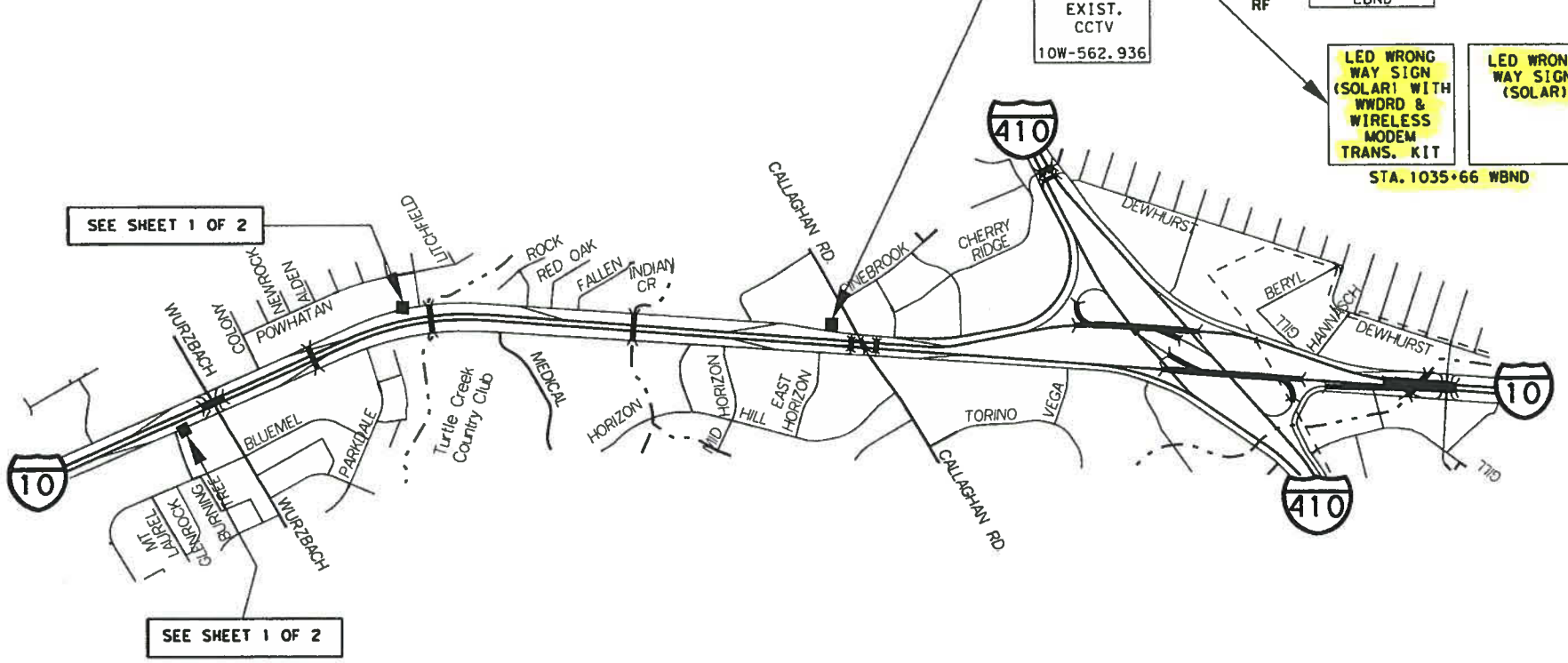
EXIST. RVSD
(ON POLE)
STA. 1076+40
EBND

EXIST. CCTV CABLES

EXIST. CCTV
10W-562.936

RF

LED WRONG WAY SIGN (SOLAR) WITH WWDRD & WIRELESS MODEM TRANS. KIT
LED WRONG WAY SIGN (SOLAR)
STA. 1035+66 WBND



LEGEND

RVSD = RADAR VEHICLE SENSING DEVICE
WWDRD = WRONG WAY DRIVER RADAR DETECTOR
FH = FIBER HUB
DMS = DYNAMIC MESSAGE SIGN
LCS = LANE CONTROL SIGNAL
CC = COMMUNICATION CABINET
DSU = DATA SERVICE UNIT
TRANS. = TRANSMITTER
RF = RADIO FREQUENCY (WIRELESS LINK)

STATE OF TEXAS
BRIAN G. FARIELLO
66186
LICENSED PROFESSIONAL ENGINEER

Brian G. Fariello, P.E. 8/9/12
DATE

Texas Department of Transportation

IH 10
TRAFFIC MANAGEMENT SYSTEM SCHEMATIC

SHEET 2 OF 2

FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
6			64
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

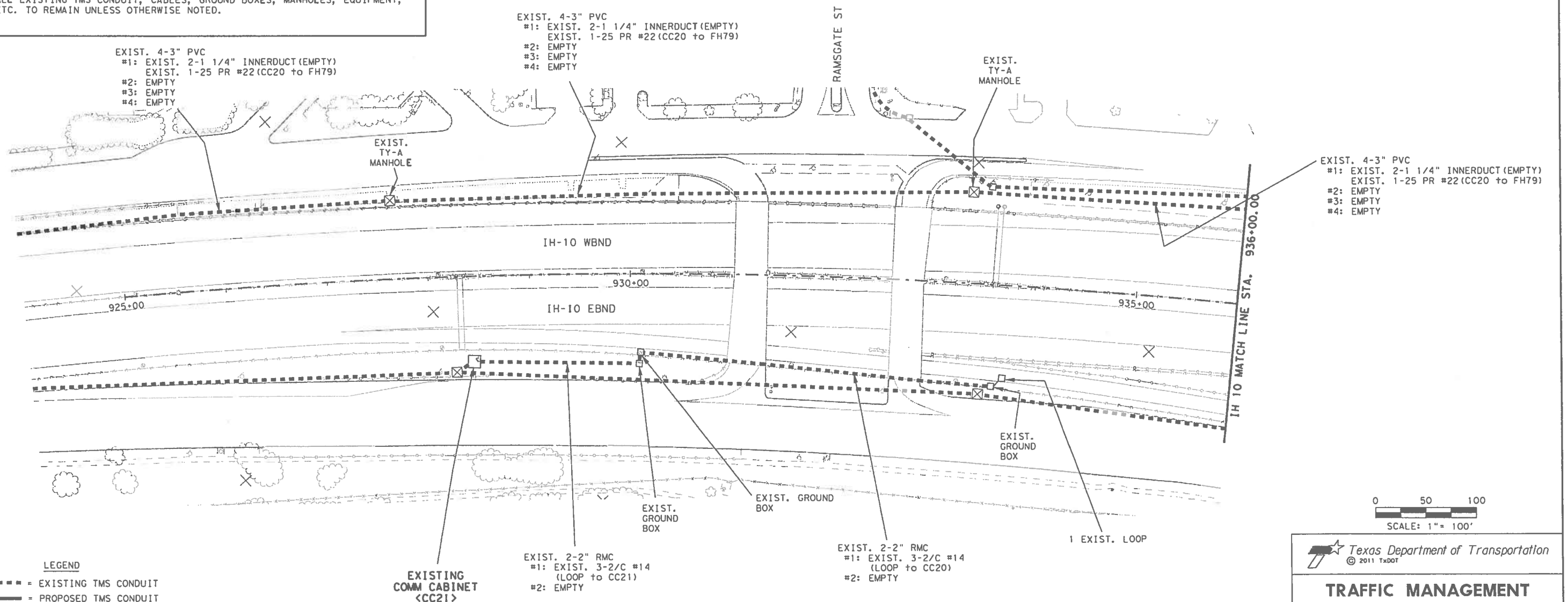
9:37:53 AM
8/9/2012
T:\TMS\10=0072-12-190 (S. of Huebner to IH 410)\TMS Layouts\SCHEMATIC(REV8-7-12).dgn

NOTES:

1. TEST EXISTING DATA CIRCUIT(S) AND COMPONENTS THAT ARE TO BE USED FOR NEW DEVICE CIRCUIT(S) BEFORE DOING ANY TMS WORK SHOWN. USE "BERT" - "BIT ERROR RATE" TESTING. REPORT FINDINGS OF TESTING IN WRITING TO TRANSGUIDE MAINTENANCE (731-5109) BEFORE CONTINUING ANY TMS WORK.
2. DISCONNECT EXISTING LOOP CABLES (2/C #14) FOR LOOPS BEING ABANDONED. (DISCONNECT FROM LOOP LEAD-INS AND FROM LOCAL CONTROL UNITS AND MARK DISCONNECTED CABLES IN ALL GROUND BOXES THEY PASS THRU AND AT EACH END AS "ABANDONED", SUBSIDIARY TO THE VARIOUS BID ITEMS.) CONTACT TRANSGUIDE MAINTENANCE PRIOR TO ANY DISCONNECTIONS.
3. IF PLANS SHOW NEW DATA SERVICE UNIT (DSU) INSTALLATION, CONTRACTOR IS RESPONSIBLE FOR INSTALLING, CONFIGURING, AND MAKING THEM FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM, AND FOR MAKING ALL CONNECTIONS NECESSARY IN THE FIELD AND AT TRANSGUIDE (INCLUDING PROVIDING AND INSTALLING ANY CABLES), SUBSIDIARY TO THE VARIOUS BID ITEMS.
4. EACH NEW DATA SERVICE UNIT (DSU) INSTALLED WILL REQUIRE TWO UNUSED PAIRS OF THE EXISTING COMMUNICATION CABLES FROM THE CABINET WITHIN WHICH THE DSU IS INSTALLED (DMS, LCS OR CC) BACK TO THE FIBER HUB. IF EXISTING GOOD UNUSED PAIRS CANNOT BE FOUND, CONTRACTOR WILL PROVIDE & INSTALL NEW COMMUNICATION CABLE AS APPROVED BY THE ENGINEER, SUBSIDIARY TO THE VARIOUS BID ITEMS.
5. EXISTING TMS EQUIPMENT AND CONDUIT LOCATIONS SHOWN ON LAYOUTS IS NOT GUARANTEED TO BE 100% ACCURATE OR ALL INCLUSIVE AND IS THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY.
6. ALL EXISTING TMS CONDUIT, CABLES, GROUND BOXES, MANHOLES, EQUIPMENT, ETC. TO REMAIN UNLESS OTHERWISE NOTED.

ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
	- NO TMS QUANTITIES THIS SHEET -		



LEGEND

- = EXISTING TMS CONDUIT
- = PROPOSED TMS CONDUIT
- R.V.S.D. = RADAR VEHICLE SENSING DEVICE
- DSU = DATA SERVICE UNIT
- FH = FIBER HUB
- CC = COMMUNICATION CABINET
- DMS = DYNAMIC MESSAGE SIGN
- LCS = LANE CONTROL SIGNAL
- F.O.C. = FIBER OPTIC CABLE
- ▲ = CONCRETE ENCASED
- (01) = CONDUIT RUN NUMBER (ARBITRARY NUMBER ASSIGNED TO CONDUIT RUN TO HELP CONTRACTOR IDENTIFY RUN DURING CONSTRUCTION)

0 50 100
SCALE: 1"= 100'

STATE OF TEXAS
BRIAN C. FARIELLO
66186
LICENSED PROFESSIONAL ENGINEER

Brian C. Fariello, P.E. 8/9/12
Brian C. Fariello DATE

Texas Department of Transportation

TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 1 OF 12

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			65
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

8/8/2012 3:21:02 PM

T:\TMS\10-0072-12-190 (S. of Huebner to IH 410)\TMS Layouts\IH10TMS*01.dgn

NOTES:

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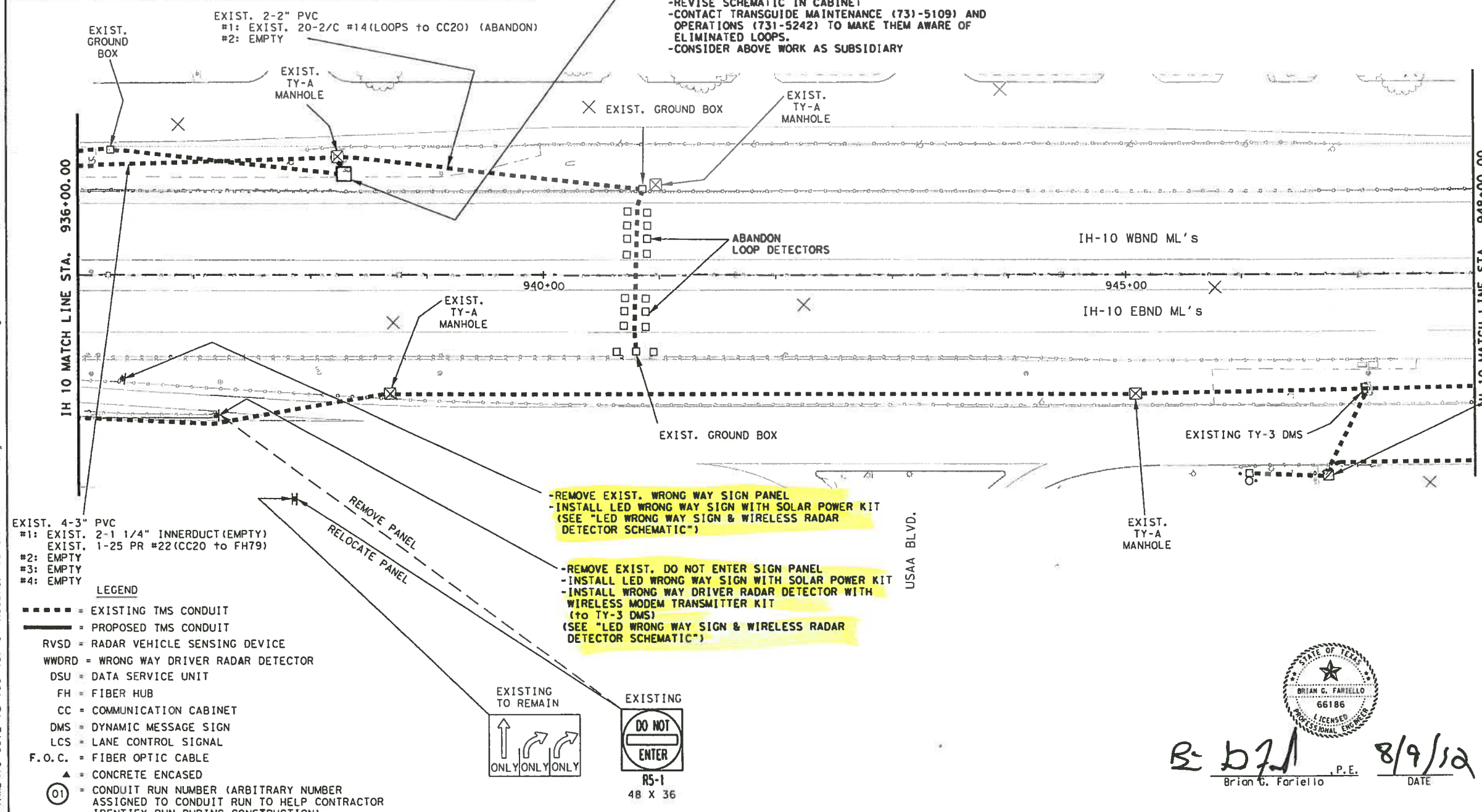
6. ALL EXISTING TMS CONDUIT, CABLES, GROUND BOXES, MANHOLES, EQUIPMENT, ETC. TO REMAIN UNLESS OTHERWISE NOTED.

ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
644-2077	REMOVE SM RD SN SUP&AM (SIGN ONLY)	EA	2
644-2085	RELOCATE SM RD SN SUP&AM (SIGN ONLY)	EA	1
	INSTALL LED WRONG WAY SIGN WITH SOLAR POWER KIT	EA	2
	INSTALL WRONG WAY DRIVER RADAR DETECTOR	EA	1
	INSTALL WIRELESS MODEM TRANSMITTER KIT	EA	1
	INSTALL WIRELESS MODEM RECEIVER KIT(IN DMS CAB.)	EA	1
◐	DATA SERVICE UNIT	EA	1
◐	LED WRONG WAY SIGN (SOLAR)	EA	2
◐	WRONG WAY DRIVER RADAR DETECTOR	EA	1
◐	WIRELESS MODEM TRANSMITTER KIT	EA	1
✳	DISCONNECT EXISTING LOOP CABLES	LS	1

✳ SUBSIDIARY TO THE VARIOUS BID ITEMS

◐ PROVIDED BY TRANSGUIDE UNDER PROJECT'S FORCE ACCOUNT. CONTRACTOR TO INSTALL, CONFIGURE AND MAKE FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM, SUBSIDIARY TO THE VARIOUS BID ITEMS.



LEGEND

- ▬▬▬ = EXISTING TMS CONDUIT
- ——— = PROPOSED TMS CONDUIT
- RVSD = RADAR VEHICLE SENSING DEVICE
- WWDRD = WRONG WAY DRIVER RADAR DETECTOR
- DSU = DATA SERVICE UNIT
- FH = FIBER HUB
- CC = COMMUNICATION CABINET
- DMS = DYNAMIC MESSAGE SIGN
- LCS = LANE CONTROL SIGNAL
- F.O.C. = FIBER OPTIC CABLE
- ▲ = CONCRETE ENCASED
- (01) = CONDUIT RUN NUMBER (ARBITRARY NUMBER ASSIGNED TO CONDUIT RUN TO HELP CONTRACTOR IDENTIFY RUN DURING CONSTRUCTION)

STATE OF TEXAS
BRIAN G. FARIELLO
66186
LICENSED PROFESSIONAL ENGINEER

Brian G. Fariello, P.E. — DATE 8/9/12

Texas Department of Transportation

TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 2 OF 12

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			66
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

8/8/2012 3:21:55 PM
T:\TMS\10-0072-12-190 (S. of Huebner to IH 410)\TMS Layouts\IH10TMS*02.dgn

NOTES:

1. TEST EXISTING DATA CIRCUIT(S) AND COMPONENTS THAT ARE TO BE USED FOR NEW DEVICE CIRCUIT(S) BEFORE DOING ANY TMS WORK SHOWN. USE "BERT" - "BIT ERROR RATE" TESTING. REPORT FINDINGS OF TESTING IN WRITING TO TRANSGUIDE MAINTENANCE (731-5109) BEFORE CONTINUING ANY TMS WORK.
2. DISCONNECT EXISTING LOOP CABLES (2/C #14) FOR LOOPS BEING ABANDONED. (DISCONNECT FROM LOOP LEAD-INS AND FROM LOCAL CONTROL UNITS AND MARK DISCONNECTED CABLES IN ALL GROUND BOXES THEY PASS THRU AND AT EACH END AS "ABANDONED", SUBSIDIARY TO THE VARIOUS BID ITEMS.) CONTACT TRANSGUIDE MAINTENANCE PRIOR TO ANY DISCONNECTIONS.
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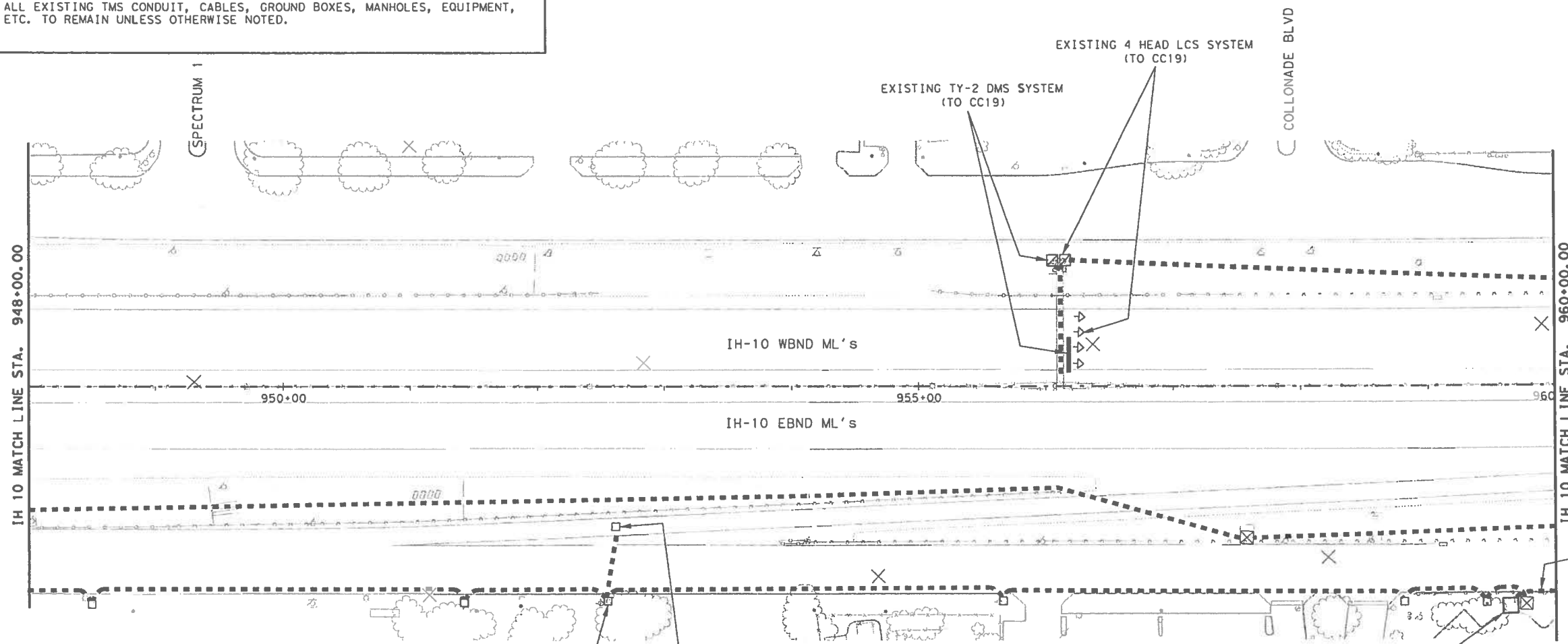
6. ALL EXISTING TMS CONDUIT, CABLES, GROUND BOXES, MANHOLES, EQUIPMENT, ETC. TO REMAIN UNLESS OTHERWISE NOTED.

ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
*	DISCONNECT EXISTING LOOP CABLES	LS	1

* SUBSIDIARY TO THE VARIOUS BID ITEMS



LEGEND

- EXISTING TMS CONDUIT
- PROPOSED TMS CONDUIT
- RVSD = RADAR VEHICLE SENSING DEVICE
- DSU = DATA SERVICE UNIT
- FH = FIBER HUB
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- LCS = LANE CONTROL SIGNAL
- F.O.C. = FIBER OPTIC CABLE
- ▲ = CONCRETE ENCASED
- (01) = CONDUIT RUN NUMBER (ARBITRARY NUMBER ASSIGNED TO CONDUIT RUN TO HELP CONTRACTOR IDENTIFY RUN DURING CONSTRUCTION)
- ⊠ = EXISTING MANHOLE

EXISTING 1-3" PVC
EXIST. 18-2/C #14(LOOPS TO CC19) (ABANDON)
AND
EXISTING 2-2" PVC
#1: EXIST. 1-25 PR #22 (CC19 TO FH78)
#2: EXIST. 2-6 PR #22 (LCS,DMS TO CC19)

0 50 100
SCALE: 1"= 100'

STATE OF TEXAS
BRIAN G. FARIELLO
66186
LICENSED
PROFESSIONAL ENGINEER

Brian G. Fariello, P.E. 8/9/12
DATE

Texas Department of Transportation

TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 3 OF 12

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			67
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

8/8/2012 3:22:48 PM

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NOTES:

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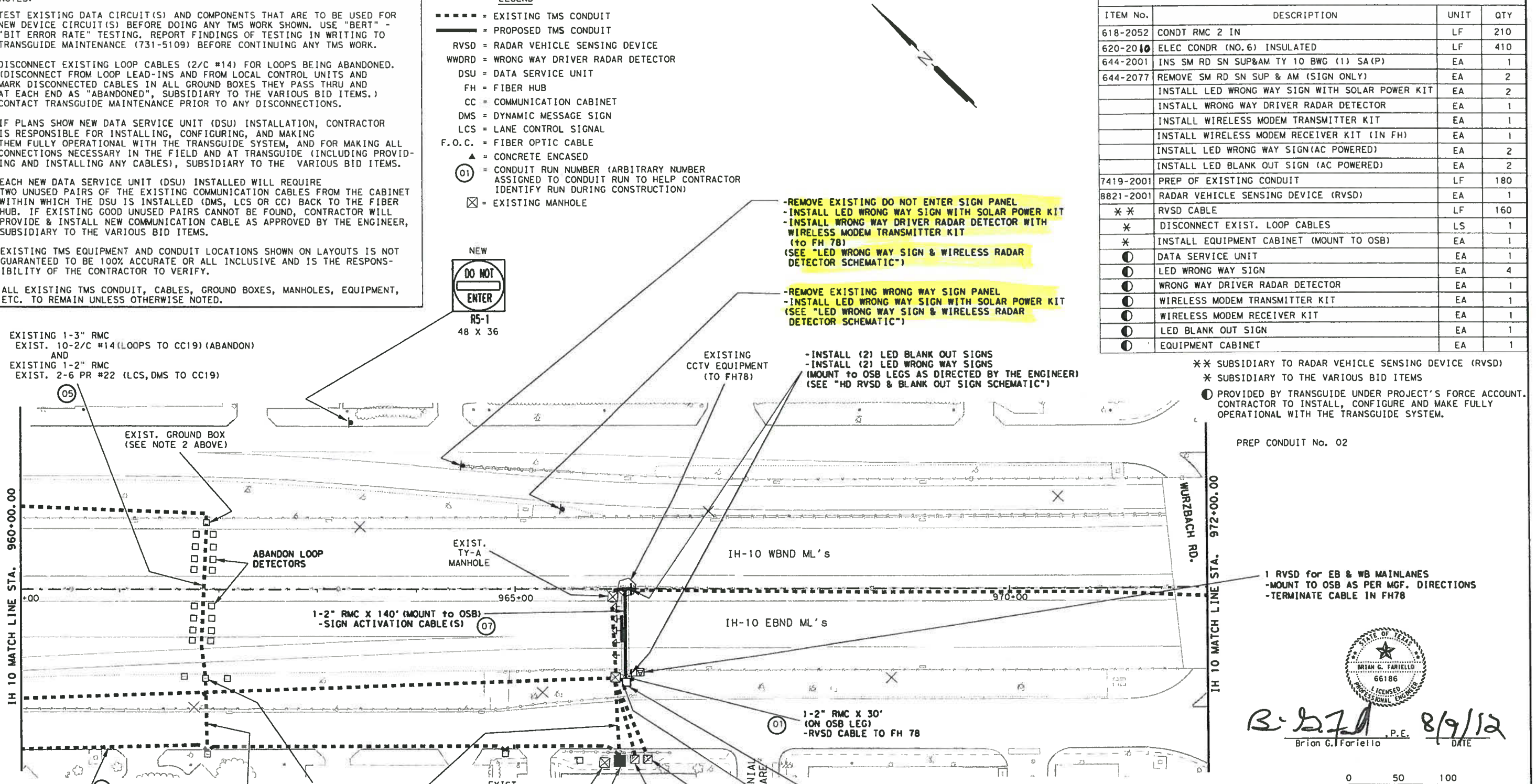
LEGEND

- ▪▪▪▪ = EXISTING TMS CONDUIT
- ——— = PROPOSED TMS CONDUIT
- RVSD = RADAR VEHICLE SENSING DEVICE
- WWDRD = WRONG WAY DRIVER RADAR DETECTOR
- DSU = DATA SERVICE UNIT
- FH = FIBER HUB
- CC = COMMUNICATION CABINET
- DMS = DYNAMIC MESSAGE SIGN
- LCS = LANE CONTROL SIGNAL
- F.O.C. = FIBER OPTIC CABLE
- ▲ = CONCRETE ENCASED
- (01) = CONDUIT RUN NUMBER (ARBITRARY NUMBER ASSIGNED TO CONDUIT RUN TO HELP CONTRACTOR IDENTIFY RUN DURING CONSTRUCTION)
- ⊠ = EXISTING MANHOLE

ESTIMATED QUANTITIES			
ITEM No.	DESCRIPTION	UNIT	QTY
618-2052	CONDT RMC 2 IN	LF	210
620-2010	ELEC CONDR (NO.6) INSULATED	LF	410
644-2001	INS SM RD SN SUP&AM TY 10 BWG (1) SA(P)	EA	1
644-2077	REMOVE SM RD SN SUP & AM (SIGN ONLY)	EA	2
	INSTALL LED WRONG WAY SIGN WITH SOLAR POWER KIT	EA	2
	INSTALL WRONG WAY DRIVER RADAR DETECTOR	EA	1
	INSTALL WIRELESS MODEM TRANSMITTER KIT	EA	1
	INSTALL WIRELESS MODEM RECEIVER KIT (IN FH)	EA	1
	INSTALL LED WRONG WAY SIGN(AC POWERED)	EA	2
	INSTALL LED BLANK OUT SIGN (AC POWERED)	EA	2
7419-2001	PREP OF EXISTING CONDUIT	LF	180
8821-2001	RADAR VEHICLE SENSING DEVICE (RVSD)	EA	1
✳✳	RVSD CABLE	LF	160
✳	DISCONNECT EXIST. LOOP CABLES	LS	1
✳	INSTALL EQUIPMENT CABINET (MOUNT TO OSB)	EA	1
◐	DATA SERVICE UNIT	EA	1
◐	LED WRONG WAY SIGN	EA	4
◐	WRONG WAY DRIVER RADAR DETECTOR	EA	1
◐	WIRELESS MODEM TRANSMITTER KIT	EA	1
◐	WIRELESS MODEM RECEIVER KIT	EA	1
◐	LED BLANK OUT SIGN	EA	1
◐	EQUIPMENT CABINET	EA	1

✳✳ SUBSIDIARY TO RADAR VEHICLE SENSING DEVICE (RVSD)
✳ SUBSIDIARY TO THE VARIOUS BID ITEMS
◐ PROVIDED BY TRANSGUIDE UNDER PROJECT'S FORCE ACCOUNT. CONTRACTOR TO INSTALL, CONFIGURE AND MAKE FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM.

PREP CONDUIT No. 02



★ EQUIPMENT CABINET PROVIDED BY TRANSGUIDE, TO BE INSTALLED BY CONTRACTOR. CONTRACTOR TO PROVIDE AND INSTALL ALL NEEDED MOUNTING BRACKETS & HARDWARE FOR CABINET. CONSIDER INSTALLATION OF CABINET AND PROVIDING AND INSTALLING MOUNTING BRACKETS & HARDWARE AS SUBSIDIARY TO THE VARIOUS BID ITEMS.

STATE OF TEXAS · BRIAN G. FARIELLO · 66186 · LICENSED PROFESSIONAL ENGINEER

B. G. Fariello, P.E. 8/9/12
Brian G. Fariello DATE

0 50 100
SCALE: 1"= 100'

Texas Department of Transportation

TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 4 OF 12

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			68
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

8/8/2012 3:23:38 PM
T:\TMS\10-0072-12-190 (S. of Huebner to IH 410)\TMS Layouts\IH10TMS04.dgn

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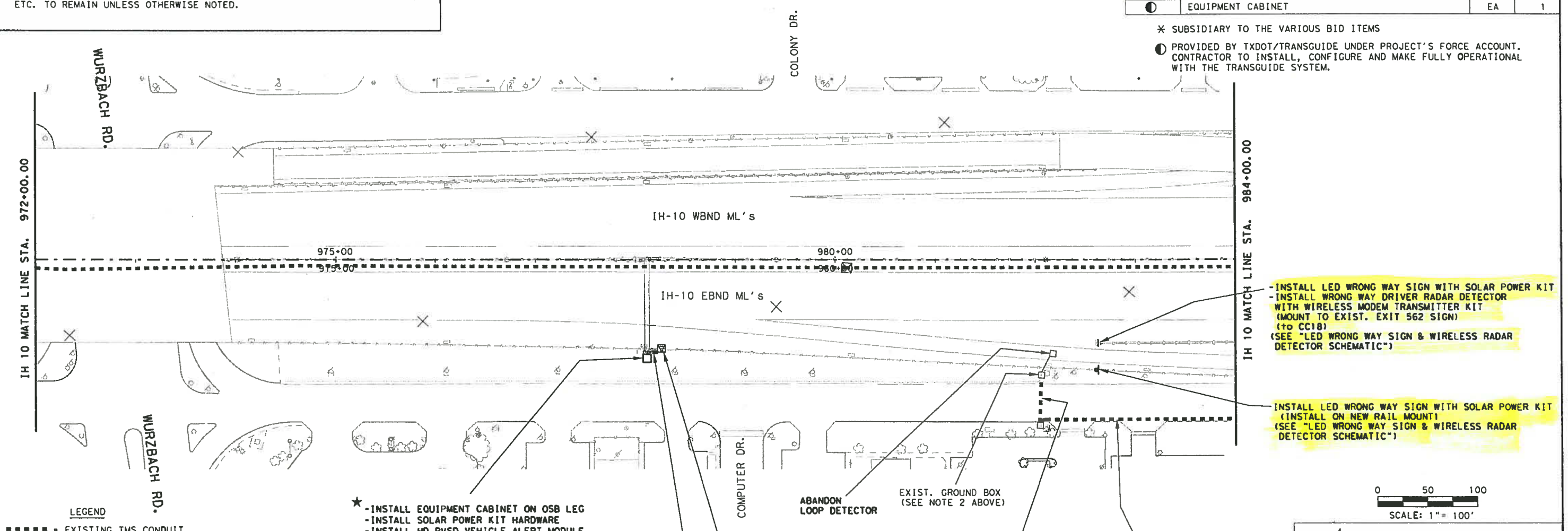
ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
618-2052	CONDT RMC 2 IN	LF	50
644-2063	INS SM RD SN SUP&AM(RAIL MOUNT)	EA	1
	INSTALL LED WRONG WAY SIGN WITH SOLAR POWER KIT	EA	2
	INSTALL WRONG WAY DRIVER RADAR DETECTOR	EA	1
	INSTALL WIRELESS MODEM TRANSMITTER KIT	EA	1
	INSTALL HD RVSD VEHICLE ALERT MODULE	EA	1
	INSTALL CONTACT CLOSURE RADIO LINK	EA	1
	INSTALL SOLAR POWER KIT FOR HD RVSD	EA	1
8821-2001	RADAR VEHICLE SENSING DEVICE (RVSD)	EA	1
✳	INSTALL EQUIPMENT CABINET	EA	1
✳	RVSD CABLES	LF	50
✳	DISCONNECT EXISTING LOOP CABLES	LS	1
◐	LED WRONG WAY SIGN (SOLAR)	EA	2
◐	WRONG WAY DRIVER RADAR DETECTOR	EA	1
◐	WIRELESS MODEM TRANSMITTER KIT	EA	1
◐	HD RVSD VEHICLE ALERT MODULE	EA	1
◐	CONTACT CLOSURE RADIO LINK	EA	1
◐	SOLAR POWER KIT FOR HD RVSD	EA	1
◐	EQUIPMENT CABINET	EA	1

✳ SUBSIDIARY TO THE VARIOUS BID ITEMS

◐ PROVIDED BY TXDOT/TRANSGUIDE UNDER PROJECT'S FORCE ACCOUNT. CONTRACTOR TO INSTALL, CONFIGURE AND MAKE FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM.



LEGEND

- ▬▬▬ = EXISTING TMS CONDUIT
- ▬▬▬ = PROPOSED TMS CONDUIT
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STATE OF TEXAS
BRIAN C. FARIELLO
66186
LICENSED PROFESSIONAL ENGINEER

Brian C. Fariello, P.E. — DATE 8/9/12

Texas Department of Transportation
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TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 5 OF 12

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			69
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

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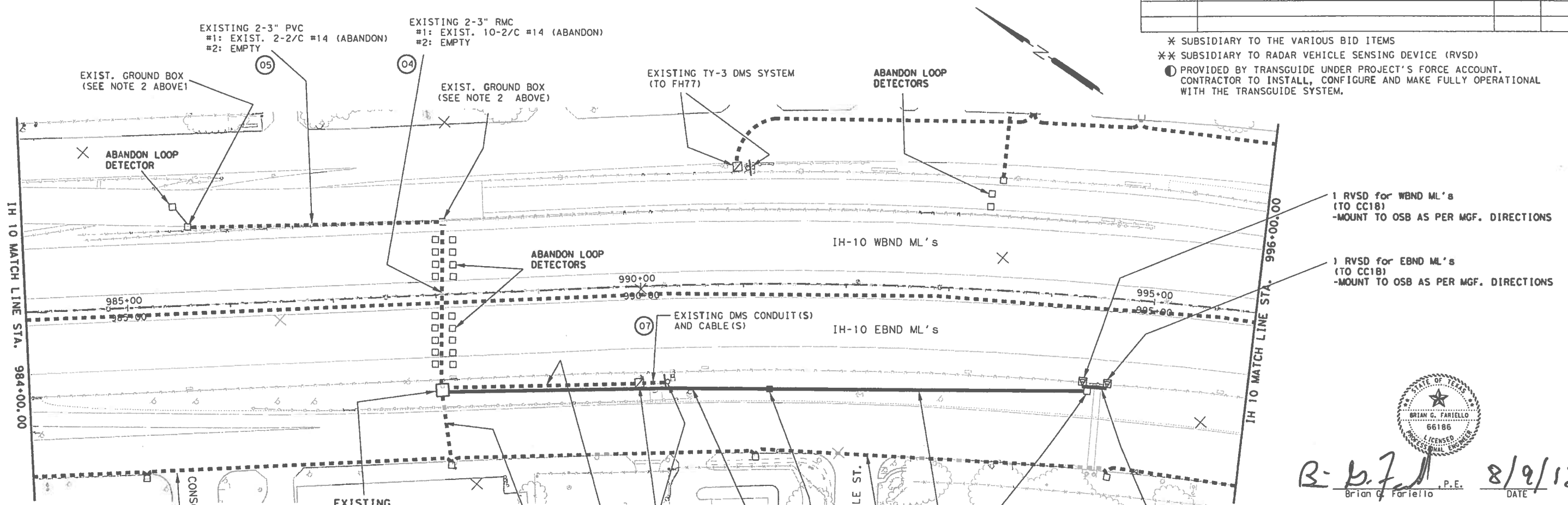
NOTES:

1. TEST EXISTING DATA CIRCUIT(S) AND COMPONENTS THAT ARE TO BE USED FOR NEW DEVICE CIRCUIT(S) BEFORE DOING ANY TMS WORK SHOWN. USE "BERT" - "BIT ERROR RATE" TESTING. REPORT FINDINGS OF TESTING IN WRITING TO TRANSGUIDE MAINTENANCE (731-5109) BEFORE CONTINUING ANY TMS WORK.
2. DISCONNECT EXISTING LOOP CABLES (2/C #14) FOR LOOPS BEING ABANDONED. (DISCONNECT FROM LOOP LEAD-INS AND FROM LOCAL CONTROL UNITS AND MARK DISCONNECTED CABLES IN ALL GROUND BOXES THEY PASS THRU AND AT EACH END AS "ABANDONED", SUBSIDIARY TO THE VARIOUS BID ITEMS.) CONTACT TRANSGUIDE MAINTENANCE PRIOR TO ANY DISCONNECTIONS.
3. IF PLANS SHOW NEW DATA SERVICE UNIT (DSU) INSTALLATION, CONTRACTOR IS RESPONSIBLE FOR INSTALLING, CONFIGURING, AND MAKING THEM FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM, AND FOR MAKING ALL CONNECTIONS NECESSARY IN THE FIELD AND AT TRANSGUIDE (INCLUDING PROVIDING AND INSTALLING ANY CABLES), SUBSIDIARY TO THE VARIOUS BID ITEMS.
4. EACH NEW DATA SERVICE UNIT (DSU) INSTALLED WILL REQUIRE TWO UNUSED PAIRS OF THE EXISTING COMMUNICATION CABLES FROM THE CABINET WITHIN WHICH THE DSU IS INSTALLED (DMS, LCS OR CC) BACK TO THE FIBER HUB. IF EXISTING GOOD UNUSED PAIRS CANNOT BE FOUND, CONTRACTOR WILL PROVIDE & INSTALL NEW COMMUNICATION CABLE AS APPROVED BY THE ENGINEER, SUBSIDIARY TO THE VARIOUS BID ITEMS.
5. EXISTING TMS EQUIPMENT AND CONDUIT LOCATIONS SHOWN ON LAYOUTS IS NOT GUARANTEED TO BE 100% ACCURATE OR ALL INCLUSIVE AND IS THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY.
6. ALL EXISTING TMS CONDUIT, CABLES, GROUND BOXES, MANHOLES, EQUIPMENT, ETC. TO REMAIN UNLESS OTHERWISE NOTED.

ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
618-2034	CONDT PVC 2 IN	LF	630
618-2052	CONDT RMC 2 IN	LF	40
624-2008	GROUND BOX (TY-A) WITH APRON	EA	1
8821-2001	RADAR VEHICLE SENSING DEVICE (RVSD)	EA	2
	INSTALL WIRELESS MODEM RECEIVER KIT (IN CC18)	EA	1
	INSTALL SERIAL RADIO LINK	EA	1
◐	WIRELESS MODEM RECEIVER KIT	EA	1
◐	SERIAL RADIO LINK	EA	1
◐	DATA SERVICE UNIT	EA	3
✻✻	RVSD CABLE	LF	1340
✻	DISCONNECT EXISTING LOOP CABLES	LS	1

✻ SUBSIDIARY TO THE VARIOUS BID ITEMS
✻✻ SUBSIDIARY TO RADAR VEHICLE SENSING DEVICE (RVSD)
◐ PROVIDED BY TRANSGUIDE UNDER PROJECT'S FORCE ACCOUNT. CONTRACTOR TO INSTALL, CONFIGURE AND MAKE FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM.



LEGEND

- ▬▬▬ = EXISTING TMS CONDUIT
- ▬▬▬ = PROPOSED TMS CONDUIT
- RVSD = RADAR VEHICLE SENSING DEVICE
- DSU = DATA SERVICE UNIT
- WWDRD = WRONG WAY DRIVER RADAR DETECTOR
- FH = FIBER HUB
- CC = COMMUNICATION CABINET
- DMS = DYNAMIC MESSAGE SIGN
- LCS = LANE CONTROL SIGNAL
- F.O.C. = FIBER OPTIC CABLE
- ▲ = CONCRETE ENCASED
- (01) = CONDUIT RUN NUMBER (ARBITRARY NUMBER ASSIGNED TO CONDUIT RUN TO HELP CONTRACTOR IDENTIFY RUN DURING CONSTRUCTION)

STATE OF TEXAS — BRIAN G. FARIELLO — 66186 — LICENSED PROFESSIONAL ENGINEER

B. G. Fariello, P.E. 8/9/12
Brian G. Fariello DATE

Texas Department of Transportation

TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 6 OF 12

FED. RD. DIV. NO.	FEDERAL AID PROJECT		SHEET NO.
6			70
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

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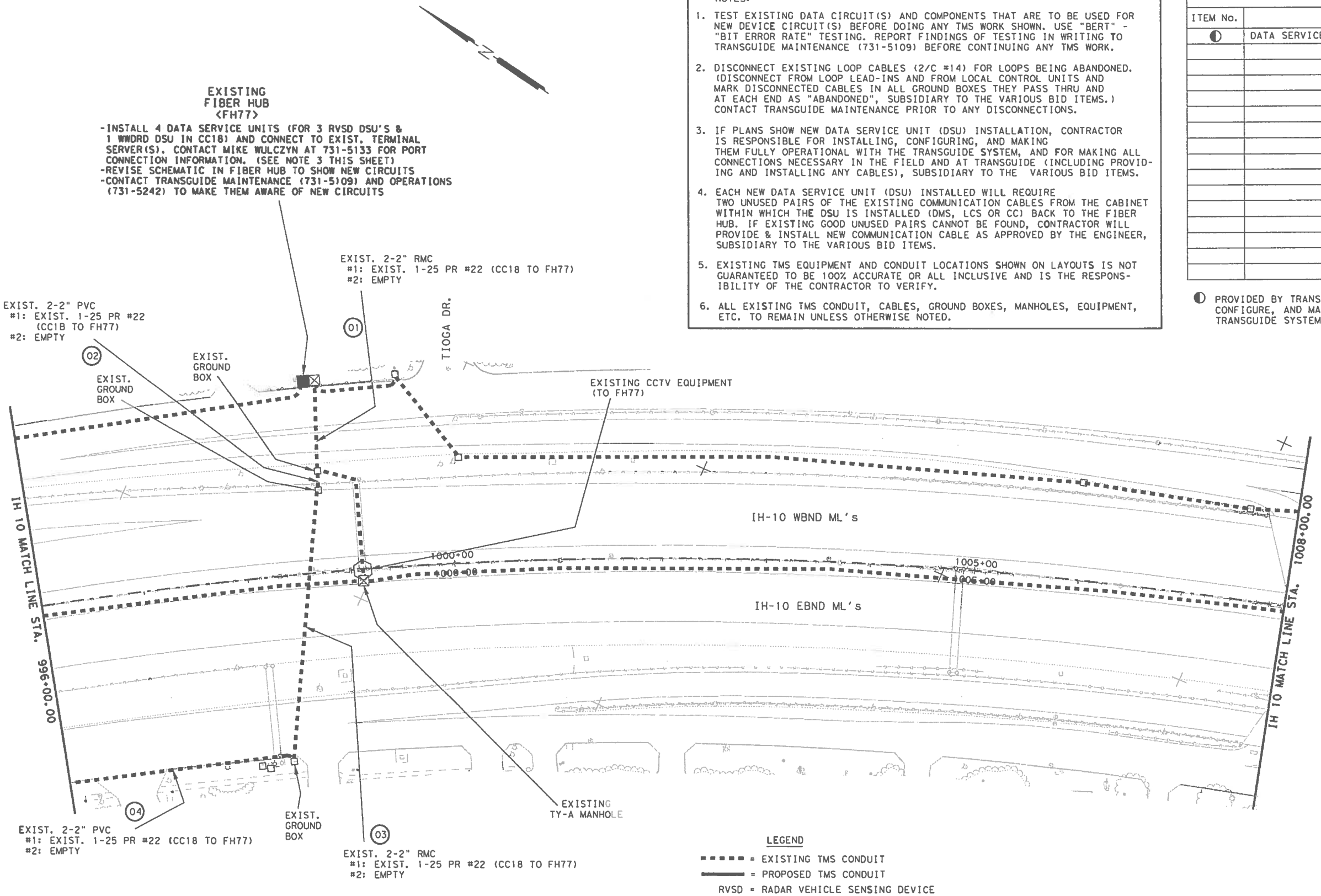

NOTES:

1. TEST EXISTING DATA CIRCUIT(S) AND COMPONENTS THAT ARE TO BE USED FOR NEW DEVICE CIRCUIT(S) BEFORE DOING ANY TMS WORK SHOWN. USE "BERT" - "BIT ERROR RATE" TESTING. REPORT FINDINGS OF TESTING IN WRITING TO TRANSGUIDE MAINTENANCE (731-5109) BEFORE CONTINUING ANY TMS WORK.
2. DISCONNECT EXISTING LOOP CABLES (2/C #14) FOR LOOPS BEING ABANDONED. (DISCONNECT FROM LOOP LEAD-INS AND FROM LOCAL CONTROL UNITS AND MARK DISCONNECTED CABLES IN ALL GROUND BOXES THEY PASS THRU AND AT EACH END AS "ABANDONED", SUBSIDIARY TO THE VARIOUS BID ITEMS.) CONTACT TRANSGUIDE MAINTENANCE PRIOR TO ANY DISCONNECTIONS.
3. IF PLANS SHOW NEW DATA SERVICE UNIT (DSU) INSTALLATION, CONTRACTOR IS RESPONSIBLE FOR INSTALLING, CONFIGURING, AND MAKING THEM FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM, AND FOR MAKING ALL CONNECTIONS NECESSARY IN THE FIELD AND AT TRANSGUIDE (INCLUDING PROVIDING AND INSTALLING ANY CABLES), SUBSIDIARY TO THE VARIOUS BID ITEMS.
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5. EXISTING TMS EQUIPMENT AND CONDUIT LOCATIONS SHOWN ON LAYOUTS IS NOT GUARANTEED TO BE 100% ACCURATE OR ALL INCLUSIVE AND IS THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY.
6. ALL EXISTING TMS CONDUIT, CABLES, GROUND BOXES, MANHOLES, EQUIPMENT, ETC. TO REMAIN UNLESS OTHERWISE NOTED.

ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
◐	DATA SERVICE UNIT	EA	4

◐ PROVIDED BY TRANSGUIDE. CONTRACTOR TO INSTALL, CONFIGURE, AND MAKE FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM, SUBSIDIARY TO THE VARIOUS BID ITEMS.

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- ⊠ = EXISTING MANHOLE

STATE OF TEXAS
BRIAN G. FARIELLO
66186
LICENSED PROFESSIONAL ENGINEER

Brian G. Fariello, P.E. 8/9/12
Brian G. Fariello DATE

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SCALE: 1"= 100'

Texas Department of Transportation
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TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 7 OF 12

FED. RD. DIV. NO.	FEDERAL AID PROJECT		SHEET NO.
6			71
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

8/8/2012 3:25:53 PM

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NOTES:

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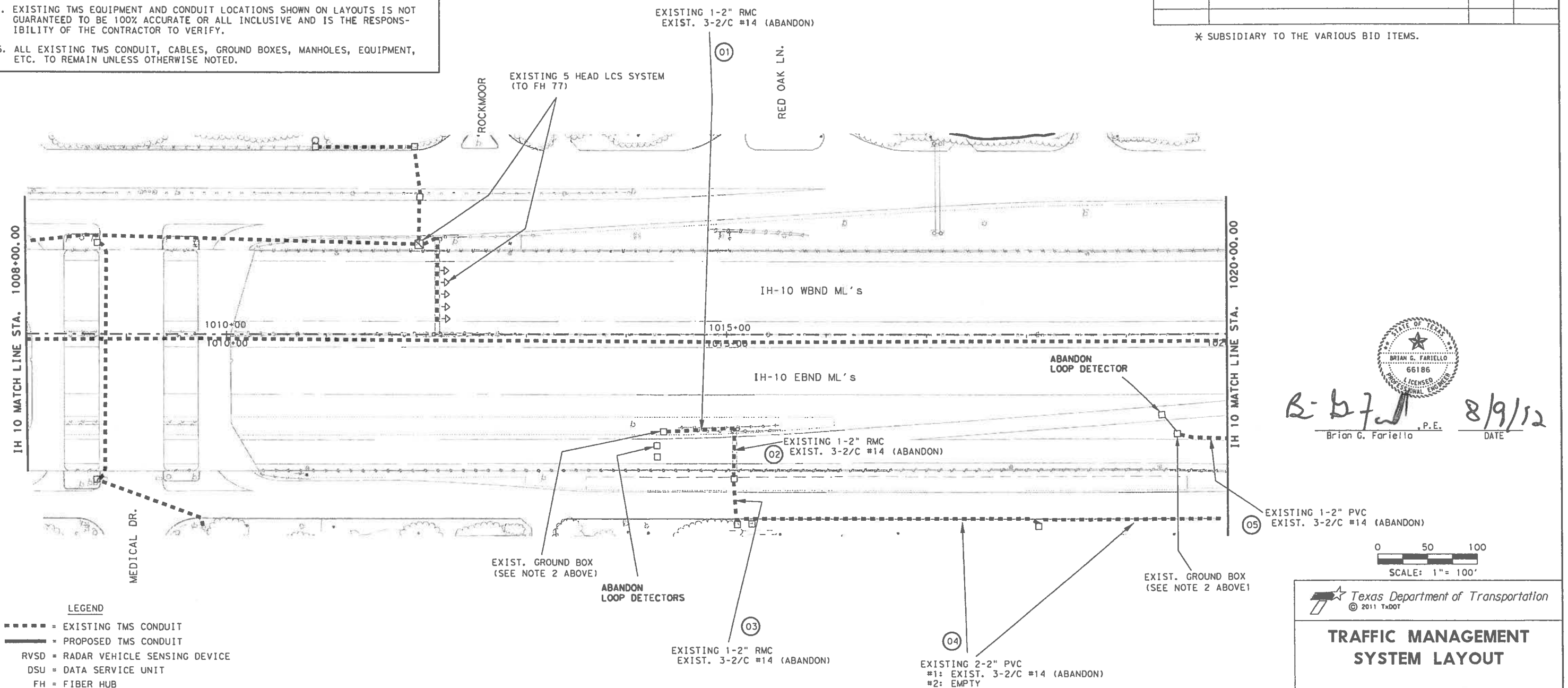
ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
*	DISCONNECT EXISTING LOOP CABLES	LS	1

* SUBSIDIARY TO THE VARIOUS BID ITEMS.



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STATE OF TEXAS
BRIAN G. FARIELLO
66186
LICENSED
PROFESSIONAL ENGINEER

B-B7 , P.E. 8/9/12
Brian G. Fariello DATE

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SCALE: 1"= 100'

Texas Department of Transportation

TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 8 OF 12

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			72
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

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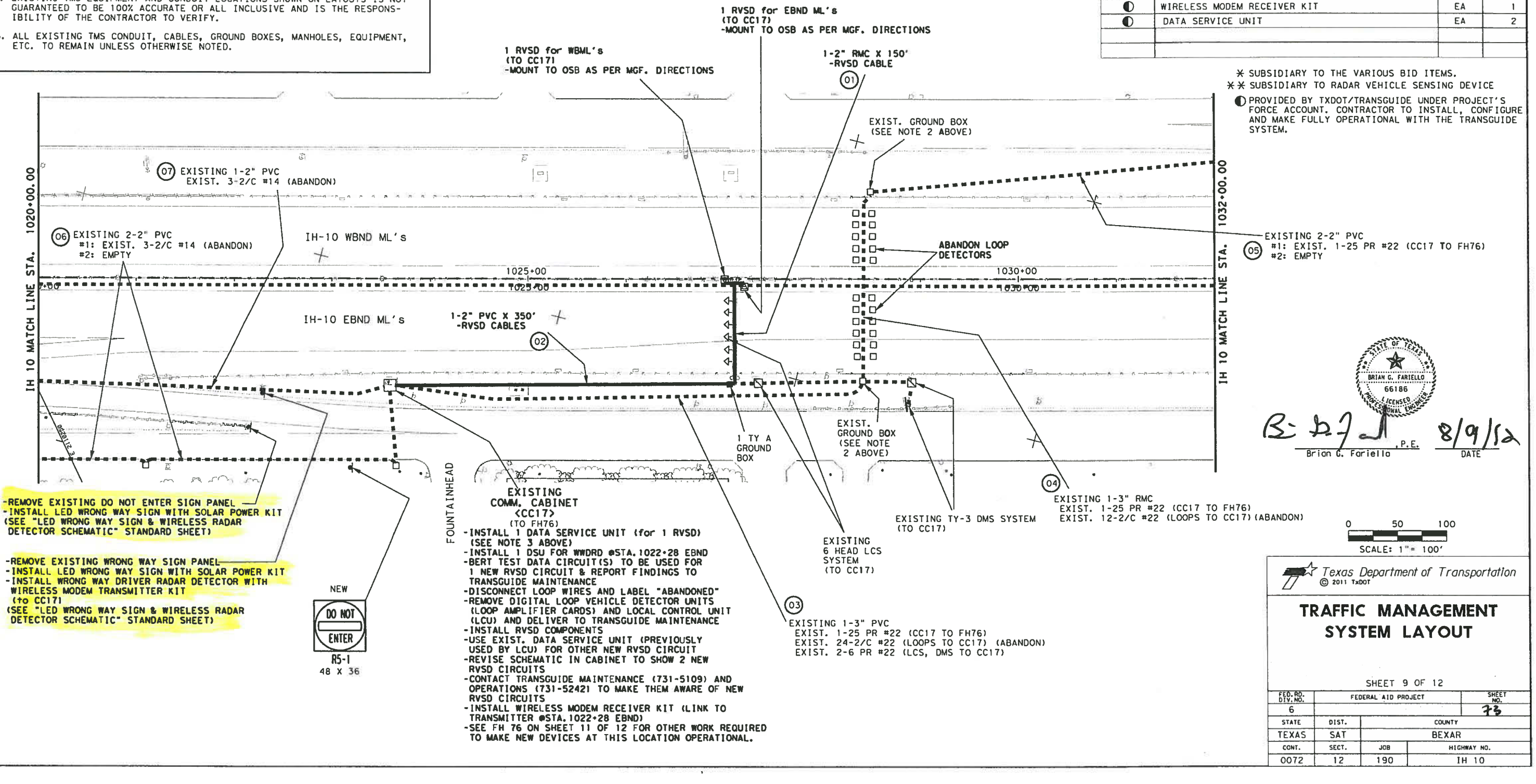
- F.O.C. = FIBER OPTIC CABLE
- ▲ = CONCRETE ENCASED
- (01) = CONDUIT RUN NUMBER (ARBITRARY NUMBER ASSIGNED TO CONDUIT RUN TO HELP CONTRACTOR IDENTIFY RUN DURING CONSTRUCTION)

ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
618-2034	CONDT PVC 2 IN	LF	350
618-2052	CONDT RMC 2 IN	LF	150
624-2008	GROUND BOX (TY-A) WITH APRON	EA	1
644-2001	INS SM RD SN SUP&AM TY 10 BWG (1) SA(P)	EA	1
644-2077	REMOVE SM RD SN SUP & AM (SIGN ONLY)	EA	2
8821-2001	RADAR VEHICLE SENSING DEVICE (RVSD)	EA	2
	INSTALL LED WRONG WAY SIGN WITH SOLAR POWER KIT	EA	2
	INSTALL WRONG WAY DRIVER RADAR DETECTOR	EA	1
	INSTALL WIRELESS MODEM TRANSMITTER KIT	EA	1
	INSTALL WIRELESS MODEM RECEIVER KIT (IN CC17)	EA	1
✱✱	RVSD CABLE	LF	1000
✱	DISCONNECT EXISTING LOOP CABLES	LS	1
◐	LED WRONG WAY SIGN (SOLAR)	EA	2
◐	WRONG WAY DRIVER RADAR DETECTOR	EA	1
◐	WIRELESS MODEM TRANSMITTER KIT	EA	1
◐	WIRELESS MODEM RECEIVER KIT	EA	1
◐	DATA SERVICE UNIT	EA	2

✱ SUBSIDIARY TO THE VARIOUS BID ITEMS.
✱✱ SUBSIDIARY TO RADAR VEHICLE SENSING DEVICE
◐ PROVIDED BY TXDOT/TRANSGUIDE UNDER PROJECT'S FORCE ACCOUNT. CONTRACTOR TO INSTALL, CONFIGURE AND MAKE FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM.



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SCALE: 1"= 100'

STATE OF TEXAS
BRIAN G. FARIELLO
66186
LICENSED PROFESSIONAL ENGINEER

Brian G. Fariello, P.E. 8/9/12
DATE

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TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 9 OF 12

FED. RD. DIV. NO.	FEDERAL AID PROJECT		SHEET NO.
6			73
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

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NOTES:

1. TEST EXISTING DATA CIRCUIT(S) AND COMPONENTS THAT ARE TO BE USED FOR NEW DEVICE CIRCUIT(S) BEFORE DOING ANY TMS WORK SHOWN. USE "BERT" - "BIT ERROR RATE" TESTING. REPORT FINDINGS OF TESTING IN WRITING TO TRANSGUIDE MAINTENANCE (731-5109) BEFORE CONTINUING ANY TMS WORK.
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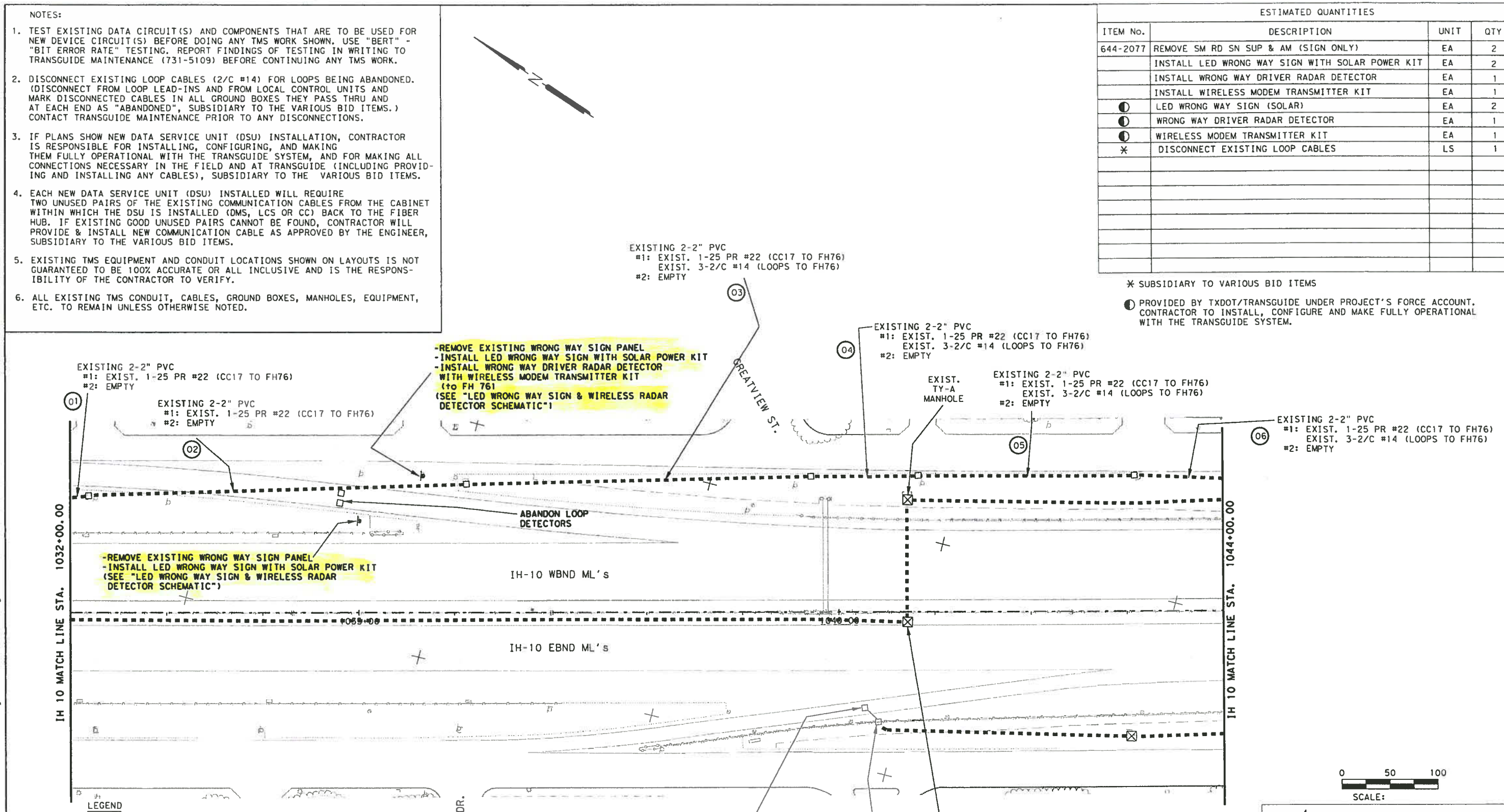
ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
644-2077	REMOVE SM RD SN SUP & AM (SIGN ONLY)	EA	2
	INSTALL LED WRONG WAY SIGN WITH SOLAR POWER KIT	EA	2
	INSTALL WRONG WAY DRIVER RADAR DETECTOR	EA	1
	INSTALL WIRELESS MODEM TRANSMITTER KIT	EA	1
◐	LED WRONG WAY SIGN (SOLAR)	EA	2
◐	WRONG WAY DRIVER RADAR DETECTOR	EA	1
◐	WIRELESS MODEM TRANSMITTER KIT	EA	1
*	DISCONNECT EXISTING LOOP CABLES	LS	1

* SUBSIDIARY TO VARIOUS BID ITEMS

◐ PROVIDED BY TXDOT/TRANSGUIDE UNDER PROJECT'S FORCE ACCOUNT. CONTRACTOR TO INSTALL, CONFIGURE AND MAKE FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM.



LEGEND

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- DSU = DATA SERVICE UNIT
- WWDRD = WRONG WAY DRIVER RADAR DETECTOR
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- DMS = DYNAMIC MESSAGE SIGN
- LCS = LANE CONTROL SIGNAL
- F.O.C. = FIBER OPTIC CABLE
- ▲ = CONCRETE ENCASED
- (01) = CONDUIT RUN NUMBER (ARBITRARY NUMBER ASSIGNED TO CONDUIT RUN TO HELP CONTRACTOR IDENTIFY RUN DURING CONSTRUCTION)
- ⊠ = EXISTING MANHOLE

0 50 100
SCALE: 1" = 100'

Texas Department of Transportation

TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 10 OF 12

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			74
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

STATE OF TEXAS — BRIAN G. FARIELLO — 66186 — LICENSED PROFESSIONAL ENGINEER

Brian G. Fariello, P.E. — DATE 8/9/12

8/8/2012 3:28:21 PM

T:\TMS\10-0072-12-190 (S. of Huebner to IH 410)\TMS Layouts\IH10TMS#10.dgn

NOTES:

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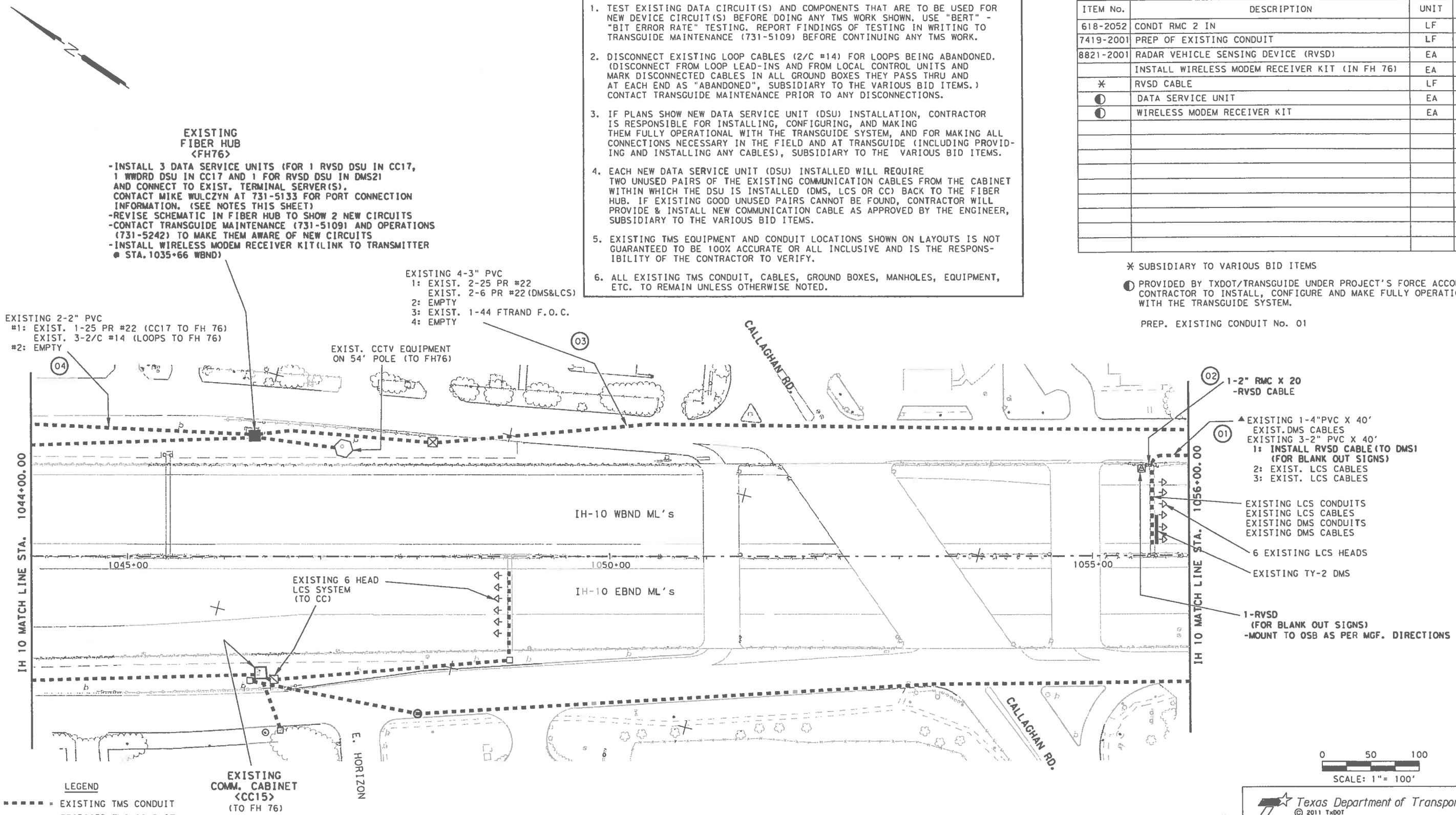
ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
618-2052	CONDT RMC 2 IN	LF	20
7419-2001	PREP OF EXISTING CONDUIT	LF	40
8821-2001	RADAR VEHICLE SENSING DEVICE (RVSD)	EA	1
	INSTALL WIRELESS MODEM RECEIVER KIT (IN FH 76)	EA	1
*	RVSD CABLE	LF	60
◐	DATA SERVICE UNIT	EA	3
◐	WIRELESS MODEM RECEIVER KIT	EA	1

* SUBSIDIARY TO VARIOUS BID ITEMS

◐ PROVIDED BY TXDOT/TRANSGUIDE UNDER PROJECT'S FORCE ACCOUNT. CONTRACTOR TO INSTALL, CONFIGURE AND MAKE FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM.

PREP. EXISTING CONDUIT No. 01



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- DMS = DYNAMIC MESSAGE SIGN
- LCS = LANE CONTROL SIGNAL
- F.O.C. = FIBER OPTIC CABLE
- ▲ = CONCRETE ENCASED
- (01) = CONDUIT RUN NUMBER (ARBITRARY NUMBER ASSIGNED TO CONDUIT RUN TO HELP CONTRACTOR IDENTIFY RUN DURING CONSTRUCTION)
- ⊠ = EXISTING MANHOLE

0 50 100
SCALE: 1"= 100'

Texas Department of Transportation

TRAFFIC MANAGEMENT SYSTEM LAYOUT

SHEET 11 OF 12

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			75
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

STATE OF TEXAS
BRIAN G. FARIELLO
66186
LICENSED PROFESSIONAL ENGINEER

Brian G. Fariello, P.E. — DATE 8/9/12

8/8/2012 3:29:15 PM

T:\TMS\10=0072-12-190 (S. of Huebner to IH 410)\TMS Layouts\IH10TMS11.dgn

NOTES:

1. TEST EXISTING DATA CIRCUIT(S) AND COMPONENTS THAT ARE TO BE USED FOR NEW DEVICE CIRCUIT(S) BEFORE DOING ANY TMS WORK SHOWN. USE "BERT" - "BIT ERROR RATE" TESTING. REPORT FINDINGS OF TESTING IN WRITING TO TRANSGUIDE MAINTENANCE (731-5109) BEFORE CONTINUING ANY TMS WORK.

2. DISCONNECT EXISTING LOOP CABLES (2/C #14) FOR LOOPS BEING ABANDONED. (DISCONNECT FROM LOOP LEAD-INS AND FROM LOCAL CONTROL UNITS AND MARK DISCONNECTED CABLES IN ALL GROUND BOXES THEY PASS THRU AND AT EACH END AS "ABANDONED", SUBSIDIARY TO THE VARIOUS BID ITEMS.) CONTACT TRANSGUIDE MAINTENANCE PRIOR TO ANY DISCONNECTIONS.

3. IF PLANS SHOW NEW DATA SERVICE UNIT (DSU) INSTALLATION, CONTRACTOR IS RESPONSIBLE FOR INSTALLING, CONFIGURING, AND MAKING THEM FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM, AND FOR MAKING ALL CONNECTIONS NECESSARY IN THE FIELD AND AT TRANSGUIDE (INCLUDING PROVIDING AND INSTALLING ANY CABLES), SUBSIDIARY TO THE VARIOUS BID ITEMS.

4. EACH NEW DATA SERVICE UNIT (DSU) INSTALLED WILL REQUIRE TWO UNUSED PAIRS OF THE EXISTING COMMUNICATION CABLES FROM THE CABINET WITHIN WHICH THE DSU IS INSTALLED (DMS, LCS OR CC) BACK TO THE FIBER HUB. IF EXISTING GOOD UNUSED PAIRS CANNOT BE FOUND, CONTRACTOR WILL PROVIDE & INSTALL NEW COMMUNICATION CABLE AS APPROVED BY THE ENGINEER, SUBSIDIARY TO THE VARIOUS BID ITEMS.

5. EXISTING TMS EQUIPMENT AND CONDUIT LOCATIONS SHOWN ON LAYOUTS IS NOT GUARANTEED TO BE 100% ACCURATE OR ALL INCLUSIVE AND IS THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY.

6. ALL EXISTING TMS CONDUIT, CABLES, GROUND BOXES, MANHOLES, EQUIPMENT, ETC. TO REMAIN UNLESS OTHERWISE NOTED.

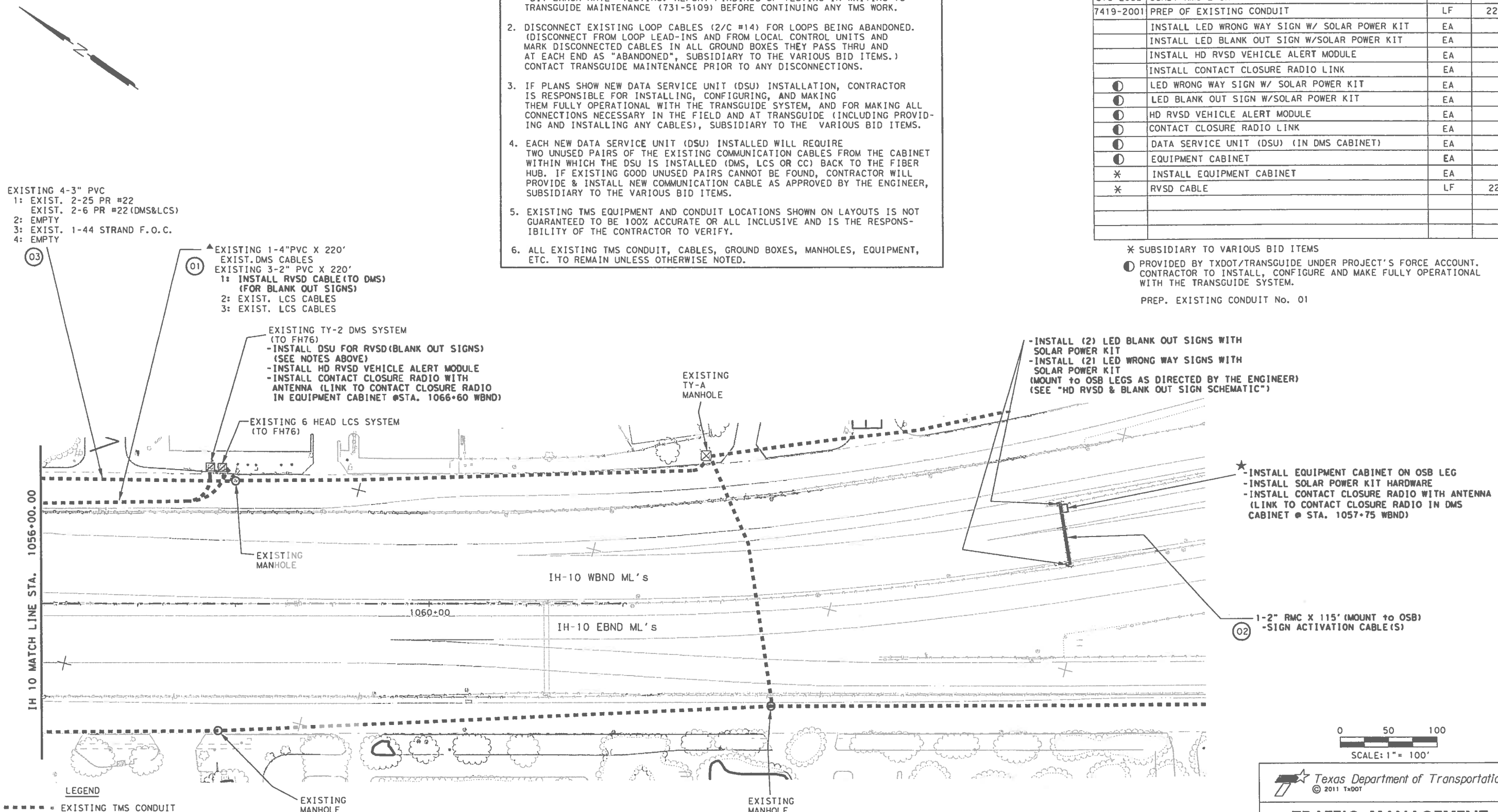
ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	QTY
618-2052	CONDT RMC 2 IN	LF	115
7419-2001	PREP OF EXISTING CONDUIT	LF	220
	INSTALL LED WRONG WAY SIGN W/ SOLAR POWER KIT	EA	2
	INSTALL LED BLANK OUT SIGN W/SOLAR POWER KIT	EA	2
	INSTALL HD RVSD VEHICLE ALERT MODULE	EA	1
	INSTALL CONTACT CLOSURE RADIO LINK	EA	1
◐	LED WRONG WAY SIGN W/ SOLAR POWER KIT	EA	2
◐	LED BLANK OUT SIGN W/SOLAR POWER KIT	EA	2
◐	HD RVSD VEHICLE ALERT MODULE	EA	1
◐	CONTACT CLOSURE RADIO LINK	EA	1
◐	DATA SERVICE UNIT (DSU) (IN DMS CABINET)	EA	1
◐	EQUIPMENT CABINET	EA	1
✳	INSTALL EQUIPMENT CABINET	EA	1
✳	RVSD CABLE	LF	220

✳ SUBSIDIARY TO VARIOUS BID ITEMS

◐ PROVIDED BY TXDOT/TRANSGUIDE UNDER PROJECT'S FORCE ACCOUNT. CONTRACTOR TO INSTALL, CONFIGURE AND MAKE FULLY OPERATIONAL WITH THE TRANSGUIDE SYSTEM.

PREP. EXISTING CONDUIT No. 01



LEGEND

- = EXISTING TMS CONDUIT
- = PROPOSED TMS CONDUIT
- RVSD = RADAR VEHICLE SENSING DEVICE
- DSU = DATA SERVICE UNIT
- FH = FIBER HUB
- CC = COMMUNICATION CABINET
- DMS = DYNAMIC MESSAGE SIGN
- LCS = LANE CONTROL SIGNAL
- F.O.C. = FIBER OPTIC CABLE
- ▲ = CONCRETE ENCASED
- (01) = CONDUIT RUN NUMBER (ARBITRARY NUMBER ASSIGNED TO CONDUIT RUN TO HELP CONTRACTOR IDENTIFY RUN DURING CONSTRUCTION)

★ EQUIPMENT CABINET PROVIDED BY TRANSGUIDE, TO BE INSTALLED BY CONTRACTOR. CONTRACTOR TO PROVIDE AND INSTALL ALL NEEDED MOUNTING BRACKETS & HARDWARE FOR CABINET. CONSIDER INSTALLATION OF CABINET AND PROVIDING AND INSTALLING MOUNTING BRACKETS & HARDWARE AS SUBSIDIARY TO THE VARIOUS BID ITEMS.

STATE OF TEXAS · BRIAN C. FARIELLO · 66186 · LICENSED PROFESSIONAL ENGINEER

Brian C. Fariello, P.E. — DATE 8/9/12

0 50 100
SCALE: 1"= 100'

Texas Department of Transportation

TRAFFIC MANAGEMENT SYSTEM LAYOUT

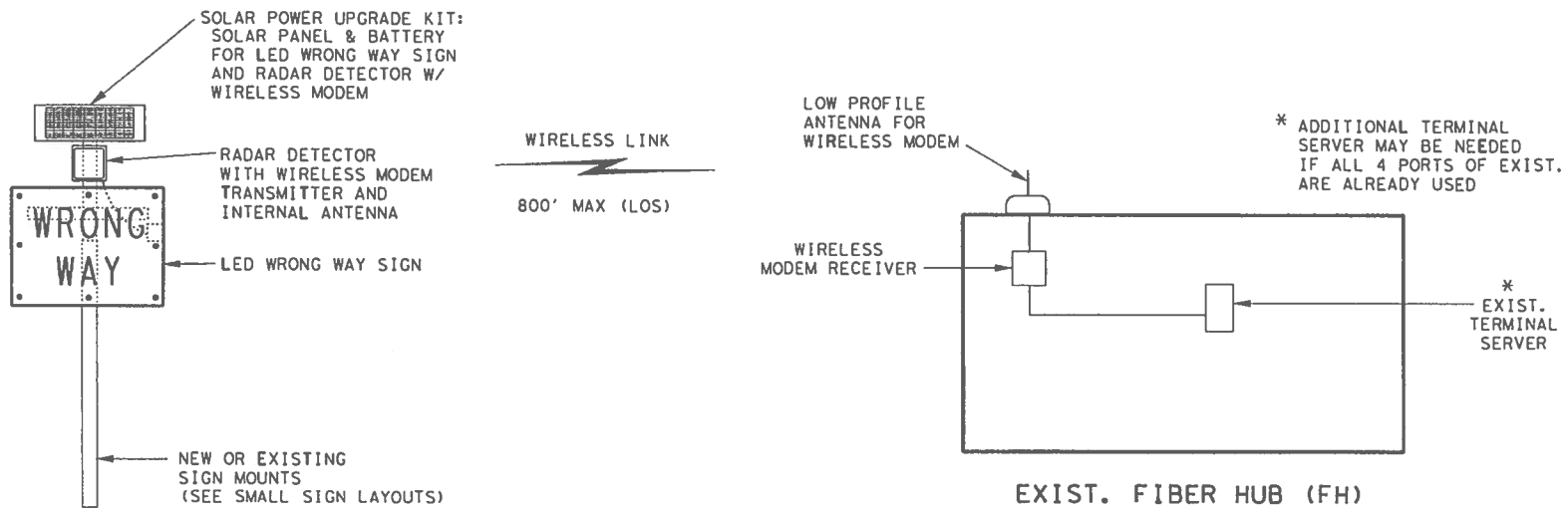
SHEET 12 OF 12

FED.RD. DIV.NO.	FEDERAL AID PROJECT		SHEET NO.
6			76
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

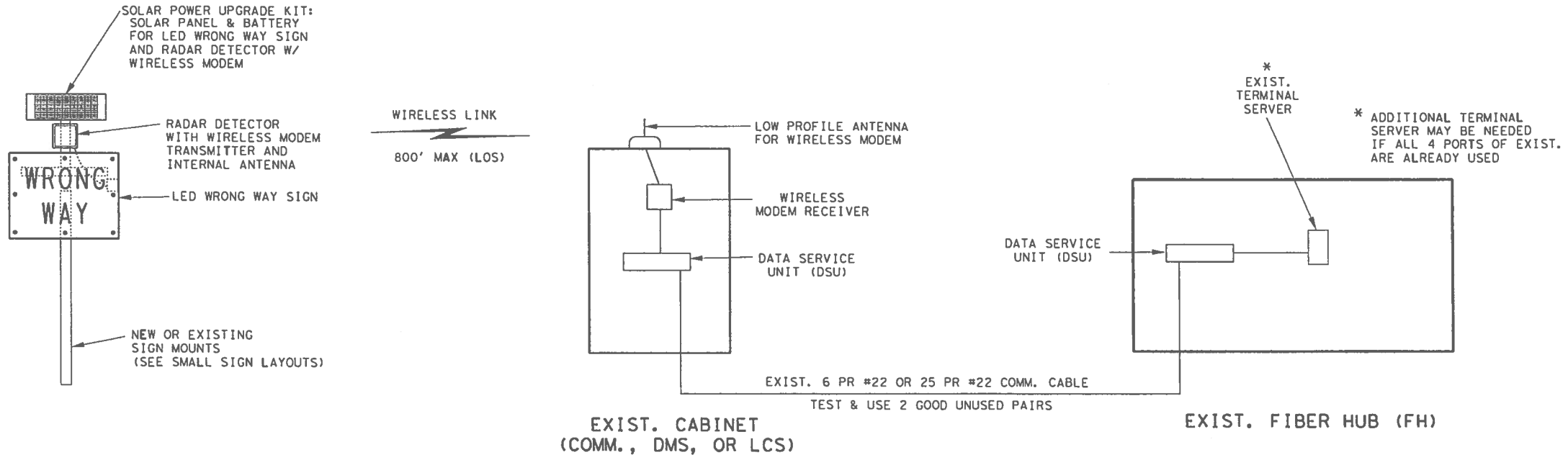
8/8/2012 3:29:57 PM

T:\TMS\10=0072-12-190 (S. of Huebner to IH 410)\TMS Layouts\IH10TMS*12.dgn

NOTES:
1. PROVIDE AND INSTALL ALL MATERIALS THAT ARE NOT SUPPLIED BY TXDOT IN ORDER TO MAKE ALL WRONG WAY RADAR DETECTORS OPERATIONAL.
2. REVISE EXISTING SCHEMATICS AT FIBER HUB OR CABINET LOCATIONS TO SHOW NEW WRONG WAY RADAR DETECTOR HARDWARE AND CIRCUIT(S).
3. NEW SIGN MOUNTS FOR WRONG WAY SIGNS WILL BE PROVIDED BY CONTRACTOR (AS SHOWN ON SMALL SIGN LAYOUTS)



WRONG WAY RADAR DETECTOR CONNECTION TO EXIST. FIBER HUB



WRONG WAY RADAR DETECTOR CONNECTION TO EXIST. COMM, DMS, OR LCS CABINET

STATE OF TEXAS
BRIAN G. FARIELLO
66186
LICENSED
PROFESSIONAL ENGINEER

Brian G. Fariello, P.E. — DATE 8/9/12

LED WRONG WAY SIGN & WIRELESS RADAR DETECTOR SCHEMATIC

SHEET 1 OF 1

FED.RD. DIV.NO.	FEDERAL AID PROJECT NO.		SHEET NO.
6			77
STATE	DIST.	COUNTY	
TEXAS	SAT	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.
0072	12	190	IH 10

9:41:00 AM
8/9/2012
T:\TMS\10-0072-12-190 (S. of Huebner to IH 410)\Standards\WWS*WRD*SCHEMATIC.dgn

PLAN

US 281 Pilot Project - 36 Month Results

	July 2012 to July 2015
Reduction in Avg. Rate of WWD Events (TransGuide Logs)	29.22%
Reduction in Avg. Rate of WWD Events (SAPD 911 Logs)	31.19% (thru May 2014)
Project Cost	$377,605
Annual Cost Savings – Avg. of SAPD & TxDOT data	$257,283
Benefit - Cost ratio	13.6 : 1
Cost Recovery Time (yrs)	1.5

Scalable Wrong Way Warning System

Wrong Way Alert™

WrongWayAlert™ *Basic System*

The WWA *Basic System* is designed to provide a simple, affordable, no maintenance enhancement solution to existing Wrong Way warning situations. The beauty of the WWA *Basic System* is that it can be easily expanded and upgraded with additional devices and capabilities for situations where greater traffic flow or other factors require more layers of warning.

A Wrong Way warning system that is affordable, scalable, solar powered and designed for quick installation.

Components of WWA *Basic*:

1 High Intensity LED Flasher Bars (2 per existing Wrong Way sign)

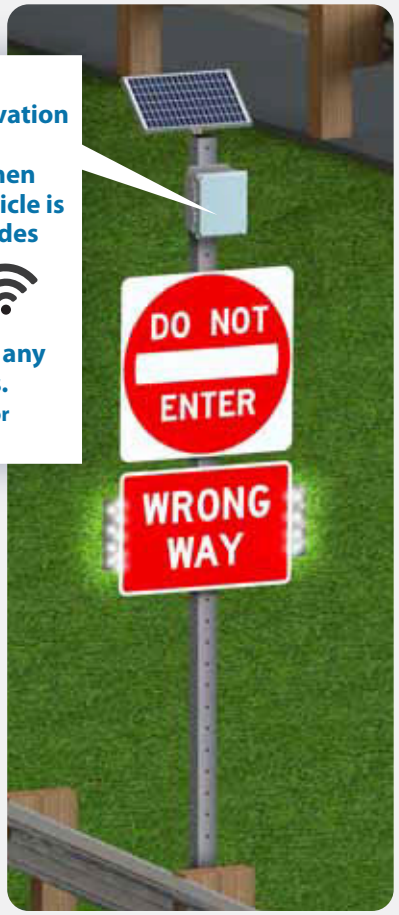
- Quickly mount on existing Wrong Way signage with permanent bonding tape and optional mechanical fasteners
- Sealed, potted unit

WWA Flasher Bars mount securely on existing Wrong Way signs

2 Detection/Activation Unit

- Detection of wrong way driver using doppler radar
- Unit can be located with Flasher Bars or remotely
- Net-radio - Allows immediate communication with remote devices tied into the system
- Battery – 20 days standby power and power for activation
- Optional cellular modem (see reverse side for upgrades)
- Solar charge controller
- 20 Watt solar panel
- Data Logging
  - Date & time stamp of every activation
  - "Right way" vehicle counting
  - Speed capture of both "wrong way" and "right way" drivers
  - System status & battery health

Radar-based Detection/Activation Unit activates Flasher Bars when wrong way vehicle is detected. Includes net-radio which can communicate wirelessly with any remote devices. (see reverse side for upgrades)



TRAFFICALM™ SYSTEMS
Division of MOR Manufacturing
E. 5676 Seltice Way Post Falls, Idaho 83854
sales@trafficalm.com • 1-855-738-2722
www.trafficalm.com

Scalable Wrong Way Warning System

System Expansion & Upgrades

The WWA *Basic System* is a foundation upon which a more advanced Wrong Way warning system can be built. Because often wrong way drivers are intoxicated or otherwise impaired, it is important to provide warnings to "right way" drivers as well. Also, cell technology allows for automatically alerting law enforcement or traffic safety personnel via SMS or email, that a wrong way incident is occurring.

Truly Scalable System

Highway on and off ramps come in all shapes and sizes. Because of the extreme danger caused by inadvertent wrong way drivers in these situations, an alert system has been needed which can easily be adapted to the particular roadway design. Our Remote Alert Links (RALs) and Flasher Bar Controllers have been designed to activate simultaneously and communicate with one another wirelessly.

Each RAL has a range of up to 2000' in ideal conditions. Range can be extended by strategic placement of RALs since the units pass along network communications until they reach the intended units. This capability can allow the network to "see" around obstacles and terrain in complicated on or off ramp situations. The *mesh-net* architecture allows for many configurations.

*Bright flashing LEDs on the **Remote Alert Links** warn exiting drivers of approaching wrong way vehicles.*

1 Remote Alarm Link (RAL)

- Series of 24 high intensity LED's strategically aligned in a circular pattern, with high output built-in alarm.
- Net-radio - Allows immediate communication with other units or devices tied into system
- Lithium Battery – 20 days standby power and power for activation
- Solar charge controller
- 10 Watt solar panel

2 Flasher Bar Controller

- Use when Detection/Activation Unit is located remotely.
- Net-radio - Allows immediate communication with remote devices tied into the system
- Battery – 30 days standby power and power for activation
- Solar charge controller
- 10 Watt solar panel
- Optional external alarm output

3 "Wrong Way Driver When Flashing" Sign

- Yellow warning sign which can be mounted with each RAL and/or Flasher Bar Controller to communicate more effectively with "right way" drivers.

4 Cellular Modem

- Immediate SMS communications to key first responders. Can be used to automatically send SMS or emails to select recipients and provides communication to existing infrastructure.

Cell Modem provides communication capability of the system to provide automatic SMS and emails to select recipients

TRAFFICALM™ Division of MOR Manufacturing SYSTEMS
E. 5676 Seltice Way Post Falls, Idaho 83854
sales@trafficalm.com • 1-855-738-2722 • **www.trafficalm.com**

TxDOT Project 0-6867 Connected Vehicle Wrong-Way Driving Detection and Mitigation Demonstration

The Texas A&M Transportation Institute (TTI) and Southwest Research Institute (SwRI) are currently working with the Texas Department of Transportation (TxDOT) to develop a concept of operations, functional requirements, and high-level system design for a connected vehicle test bed for wrong-way driving applications. While the primary focus of this project is on connected vehicle applications that will detect and notify TxDOT and emergency response personnel (primarily law enforcement) about wrong-way driving events, other wrong-way driving connected vehicle applications will be explored. These additional areas of interest may include, but are not limited to, alerting the wrong-way driver and other travelers in the vicinity of the wrong-way driver.

By the end of July 2015, the research team will have completed the following tasks:

- Review of wrong-way crash data on freeways in Texas (2011-2014).
- Review of potential test bed sites in Texas.
- Assessment of potential connected vehicle applications and technologies for use with a wrong-way driving system.
- Identification of user needs associated with detecting, warning, and intervening in a wrong-way driving event.
- Development of a concept of operations for wrong-way driving connected vehicle applications.

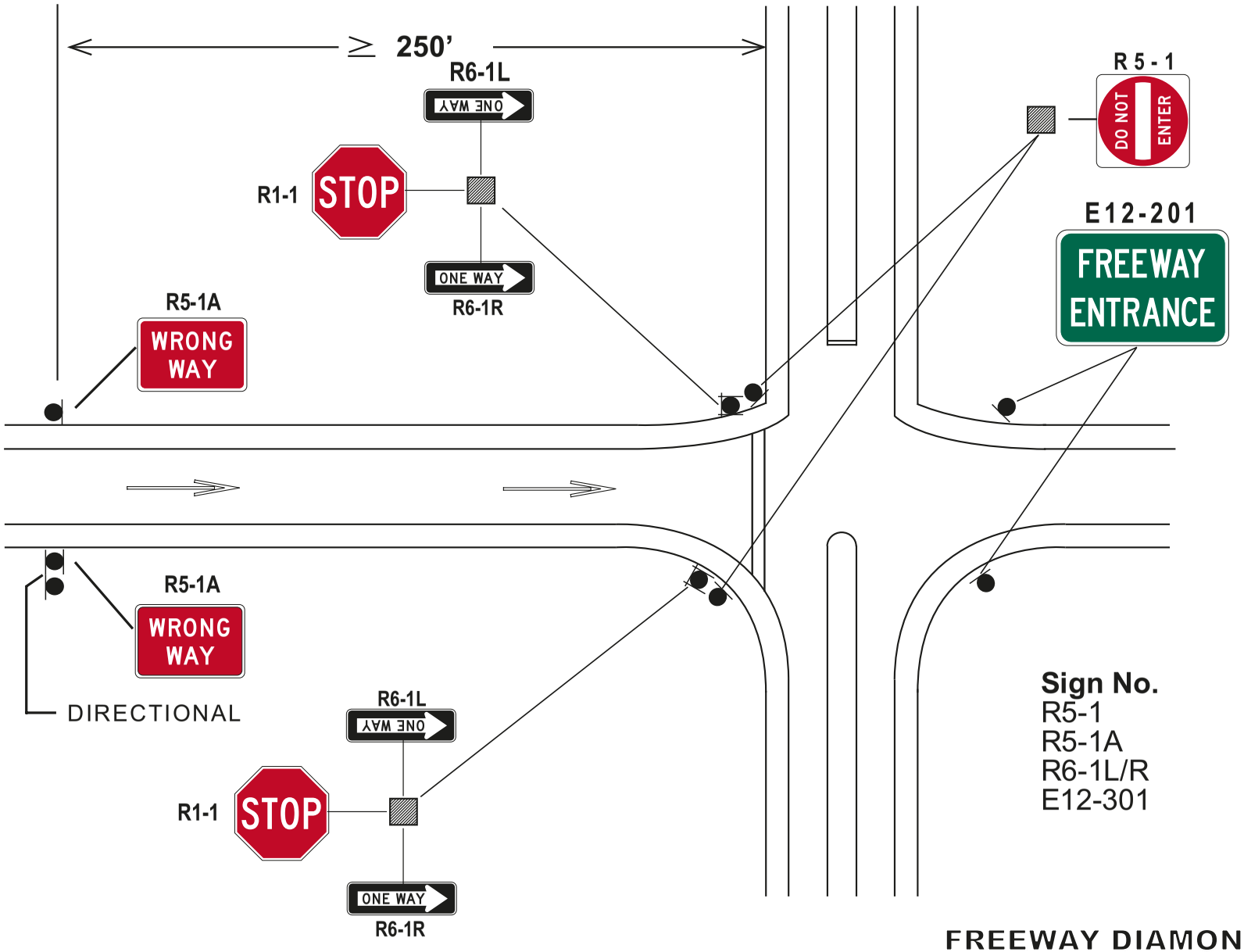
Ongoing tasks include:

- Development of functional requirements and hi-level architecture for wrong-way driving test bed deployment and operation.
- Evaluation of wrong-way driver warning messages.

The research team will complete phase 1 in December 2015. Additional project phases are planned and expected to include a demonstration and evaluation of a wrong-way driving connected vehicle test bed in a closed environment, followed by the implementation and evaluation of a wrong-way driving connected vehicle test bed in at least one TxDOT district.

Contact Information:

Melisa D. Finley, P.E.
TxDOT Project 0-6867 Principal Investigator
Texas A&M Transportation Institute
m-finley@tti.tamu.edu
979-845-7596



Sign No.	Size
R5-1	48”x48”
R5-1A	42”X30”
R6-1L/R	54”x18”
E12-301	48”X30”

FREEWAY DIAMOND I/C APPLICATIONS

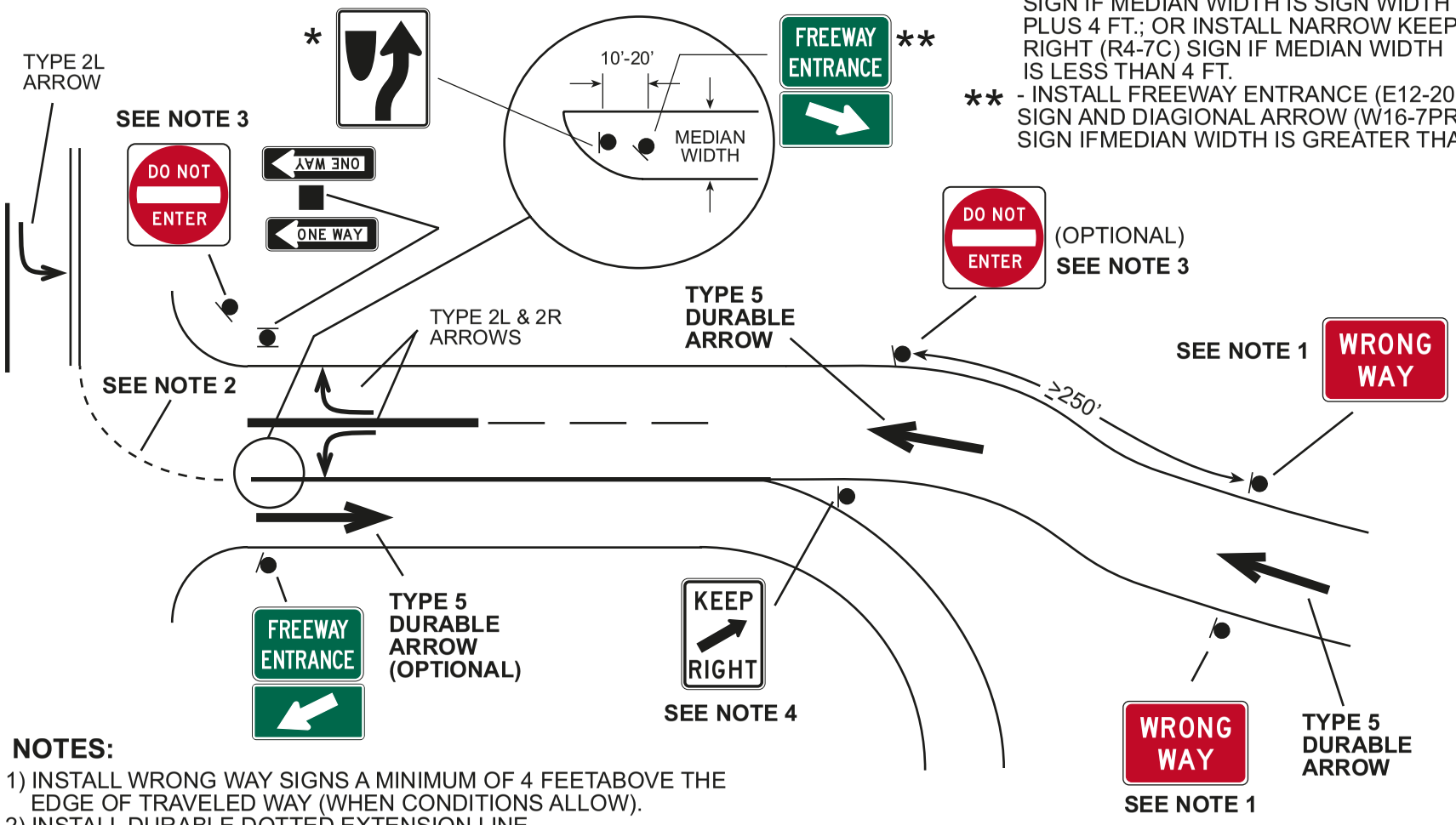
Wrong Way Traffic Control for Partial Cloverleafs Barrier or Curb Separation Between Ramps

06/21/2012

(NOT TO SCALE)

* - INSTALL KEEP RIGHT SYMBOL (R4-7) SIGN IF MEDIAN WIDTH IS SIGN WIDTH PLUS 4 FT.; OR INSTALL NARROW KEEP RIGHT (R4-7C) SIGN IF MEDIAN WIDTH IS LESS THAN 4 FT.

** - INSTALL FREEWAY ENTRANCE (E12-201) SIGN AND DIAGIONAL ARROW (W16-7PR MOD.) SIGN IFMEDIAN WIDTH IS GREATER THAN 7 FT.



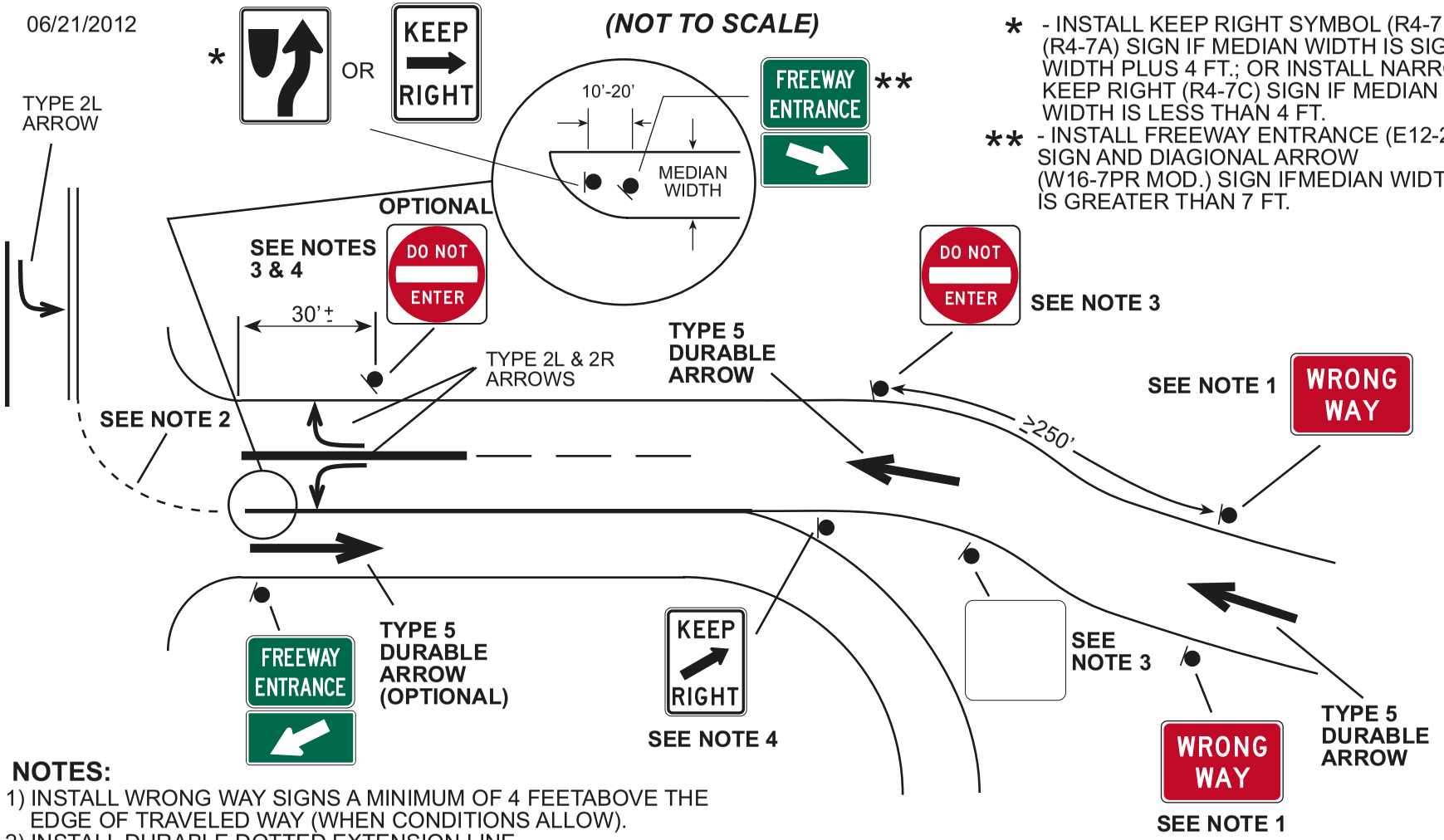
NOTES:

1) INSTALL WRONG WAY SIGNS A MINIMUM OF 4 FEETABOVE THE EDGE OF TRAVELED WAY (WHEN CONDITIONS ALLOW).
2) INSTALL DURABLE DOTTED EXTENSION LINE
3) DO NOT ENTER SIGNS MAY BE INSTALLED AT 4 FEET ABOVE THE EDGE OF TRAVELED WAY, IF THE LOWER HEIGHT DOES NOT CREATE A SIGHT TRIANGLE ISSUE FOR RAMP TRAFFIC, AND/OR DOES NOT INTERFERE WITH PEDESTRIAN MOVEMENTS.
4) INSTALL KEEP RIGHT (R4-7B), IF MEDIAN FOR TWO-WAY RAMPS IS STRIPED ONLY.

SIGN TYPE	SIZE
DO NOT ENTER (R5-1)	48"X48"
WRONG WAY (R5-1A)	42"X30"
ONE WAY (R6-1L/R)	54"X18"

Wrong Way Traffic Control for Partial Cloverleafs
Pavement Markings Only Separation Between Ramps

06/21/2012



* - INSTALL KEEP RIGHT SYMBOL (R4-7) OR (R4-7A) SIGN IF MEDIAN WIDTH IS SIGN WIDTH PLUS 4 FT.; OR INSTALL NARROW KEEP RIGHT (R4-7C) SIGN IF MEDIAN WIDTH IS LESS THAN 4 FT.

** - INSTALL FREEWAY ENTRANCE (E12-201) SIGN AND DIAGIONAL ARROW (W16-7PR MOD.) SIGN IFMEDIAN WIDTH IS GREATER THAN 7 FT.

NOTES:

1) INSTALL WRONG WAY SIGNS A MINIMUM OF 4 FEETABOVE THE EDGE OF TRAVELED WAY (WHEN CONDITIONS ALLOW).
2) INSTALL DURABLE DOTTED EXTENSION LINE
3) DO NOT ENTER SIGNS MAY BE INSTALLED AT 4 FEET ABOVE THE EDGE OF TRAVELED WAY, IF THE LOWER HEIGHT DOES NOT CREATE A SIGHT TRIANGLE ISSUE FOR RAMP TRAFFIC, AND/OR DOES NOT INTERFERE WITH PEDESTRIAN MOVEMENTS.
4) IF THE EXIT AND ON RAMPS PARRALEL 150' OR LESS INSTALL A DO NOT ENTER SIGN; IF THE EXIT AND ON RAMPS PARRALEL MORE THAN 150' THE DO NOT ENTER SIGN IS OPTIONAL.

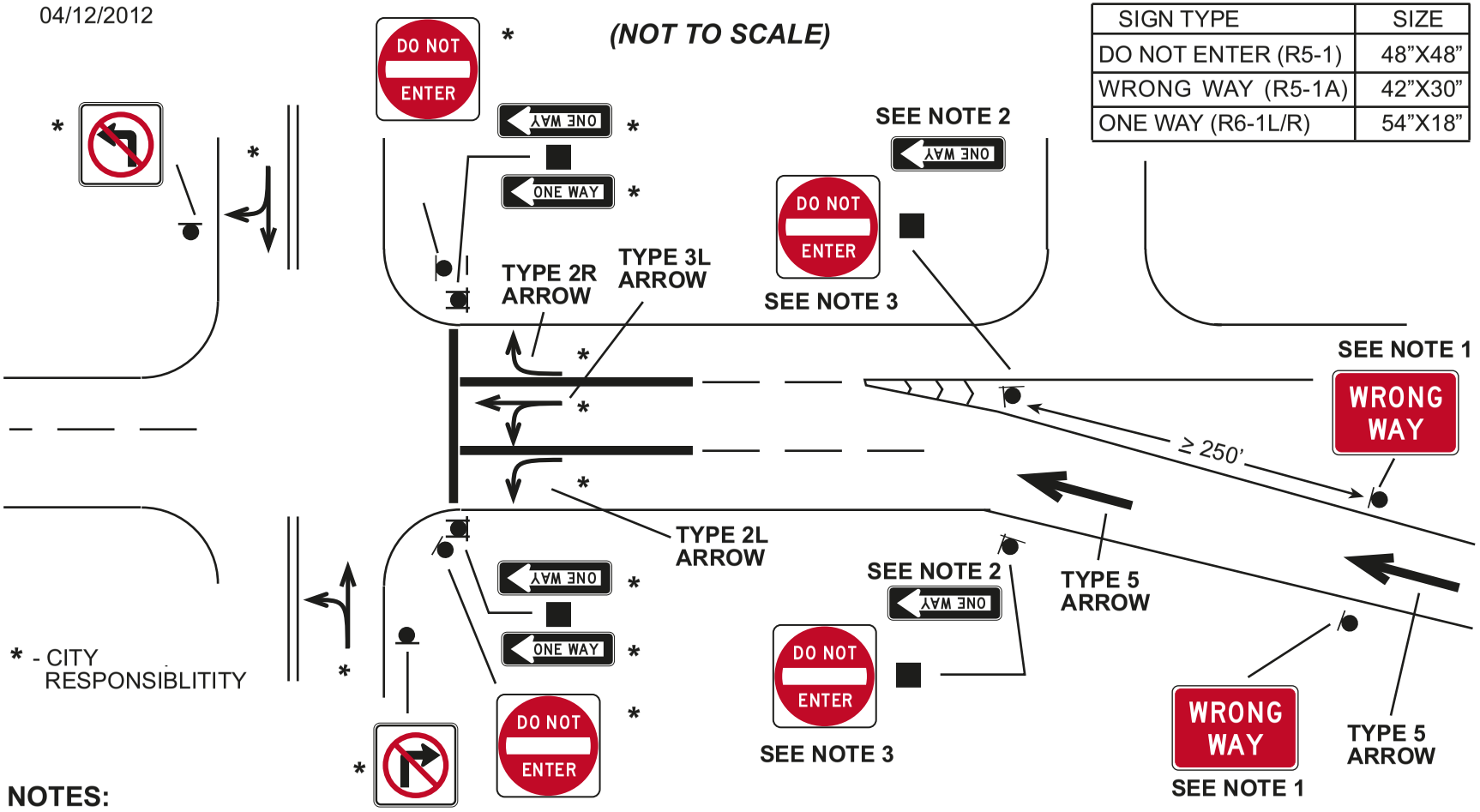
SIGN TYPE	SIZE
DO NOT ENTER (R5-1)	48"X48"
WRONG WAY (R5-1A)	42"X30"
ONE WAY (R6-1L/R)	54"X18"

Wrong Way Traffic Control for Slip Exit Ramp

04/12/2012

(NOT TO SCALE)

SIGN TYPE	SIZE
DO NOT ENTER (R5-1)	48”X48”
WRONG WAY (R5-1A)	42”X30”
ONE WAY (R6-1L/R)	54”X18”



NOTES:

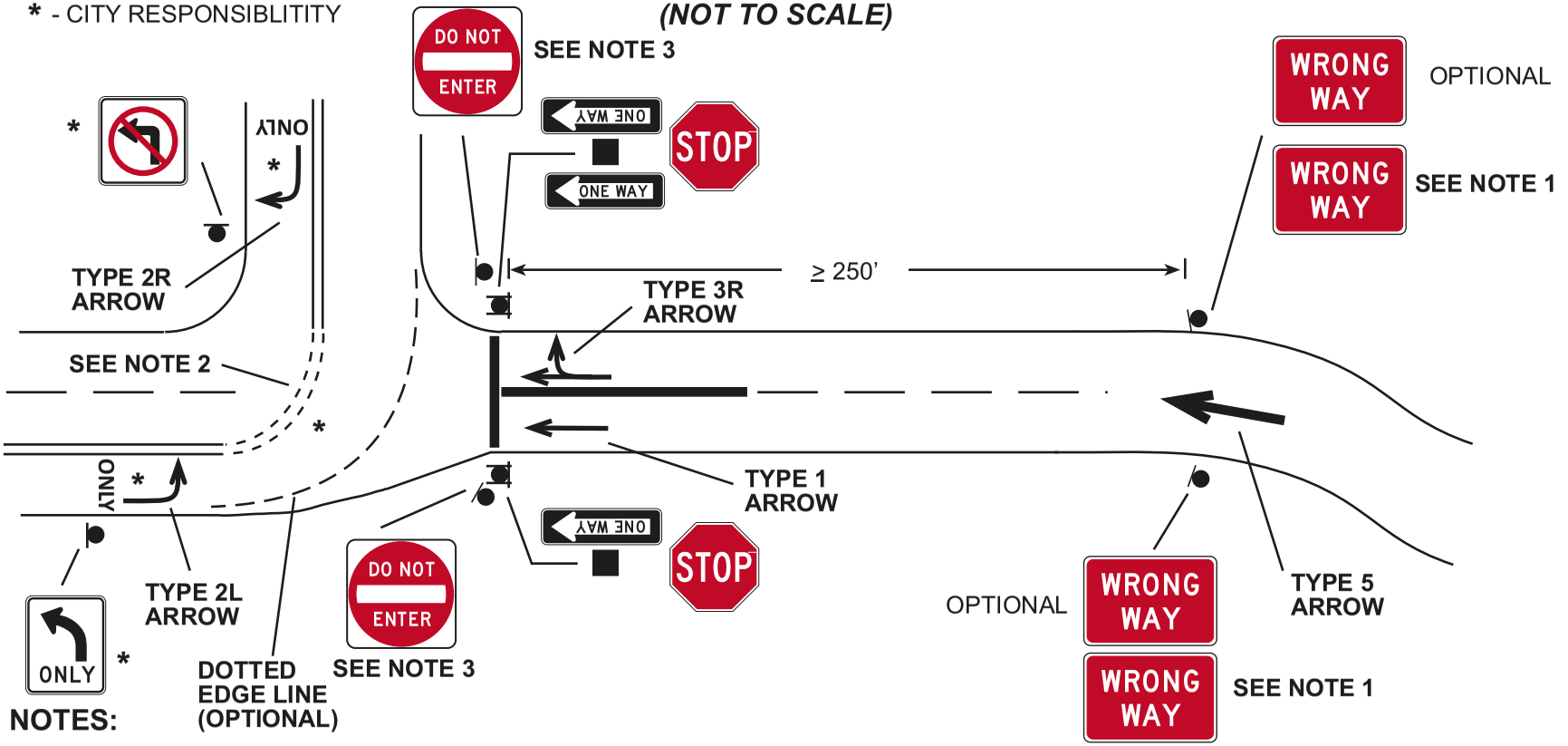
1) INSTALL WRONG WAY SIGNS A MINIMUM OF 4 FEET.ABOVE THE EDGE OF TRAVELED WAY (WHEN CONDITIONS ALLOW).
2) INSTALL ONE WAY SIGNS AS SHOWN IF THERE IS AN EXISTING CROSS STREET OR DRIVEWAY NEAR THE EXIT GORE AREA.
3) DO NOT ENTER SIGNS MAY BE INSTALLED AT 4 FEET ABOVE THE EDGE OF TRAVELED WAY, IF THE LOWER HEIGHT DOES A CREATE SIGHT TRIANGLE ISSUE FOR RAMP TRAFFIC, AND/OR DOES NOT INTERFERE WITH PEDESTRIAN MOVEMENTS.

Wrong Way Traffic Control for Two-Way Street to Exit Ramp

04/12/2012

* - CITY RESPONSIBLITITY

(NOT TO SCALE)



NOTES:

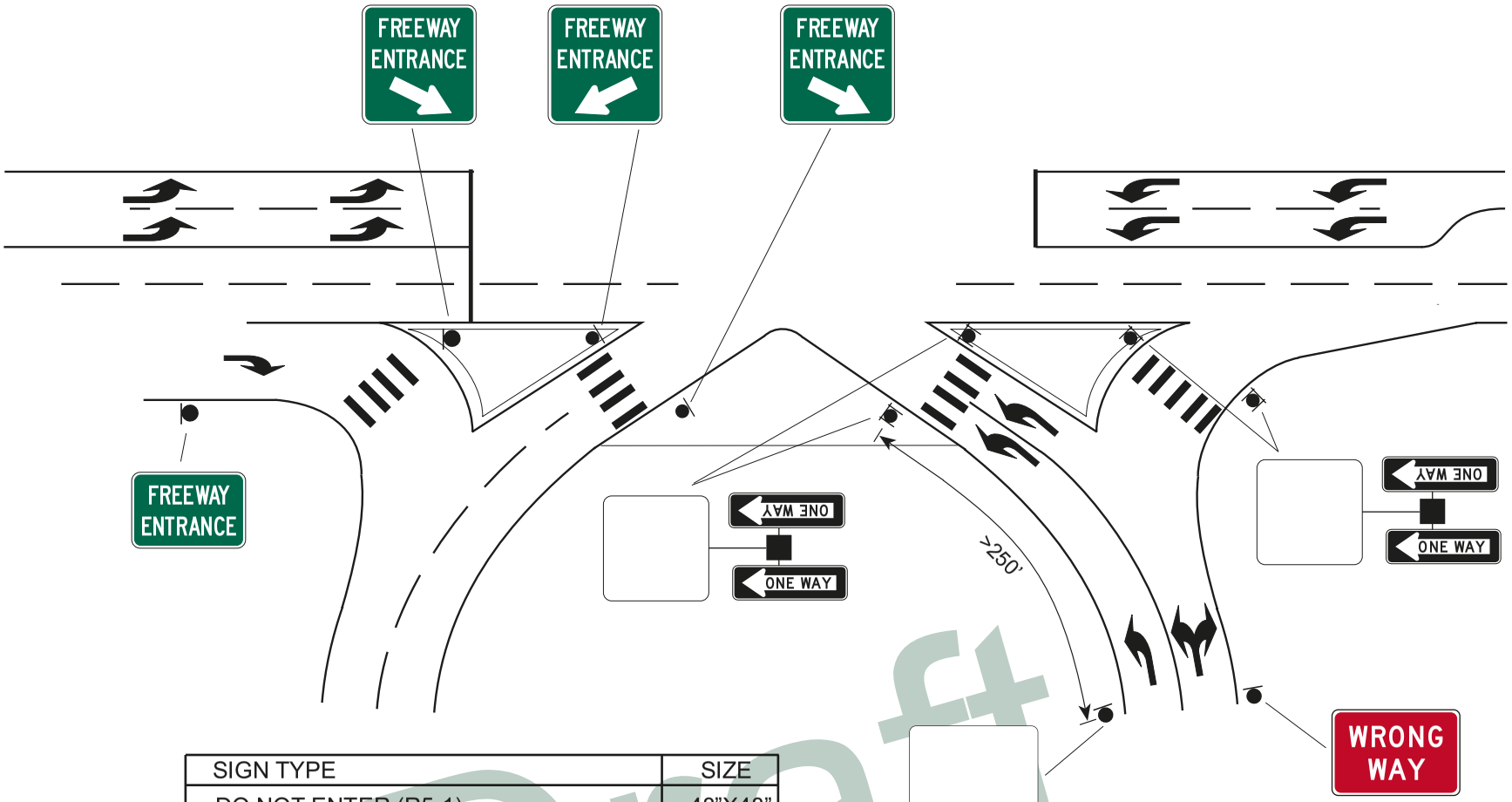
1) INSTALL WRONG WAY SIGNS A MINIMUM OF 4 FEET ABOVE THE EDGE OF TRAVELED WAY (WHEN CONDITIONS ALLOW); THE SECOND WRONG WAY SIGN IS OPTIONAL AND TO BE MOUNTED AT 7 FEET ABOVE THE EDGE OF TRAVELED WAY..
2) INSTALL DURABLE DOTTED LANE LINES
3) DO NOT ENTER SIGNS MAY BE INSTALLED AT 4 FEET ABOVE THE EDGE OF TRAVELED WAY, IF THE LOWER HEIGHT DOES A CREATE SIGHT TRIANGLE ISSUE FOR RAMP TRAFFIC, AND/OR DOES NOT INTERFERE WITH PEDESTRIAN MOVEMENTS.

SIGN TYPE	SIZE
DO NOT ENTER (R5-1)	48"X48"
WRONG WAY (R5-1A)	42"X30"
ONE WAY (R6-1L/R)	54"X18"

Wrong Way Traffic Control for Single Point Interchanges with No Curbing on the LX

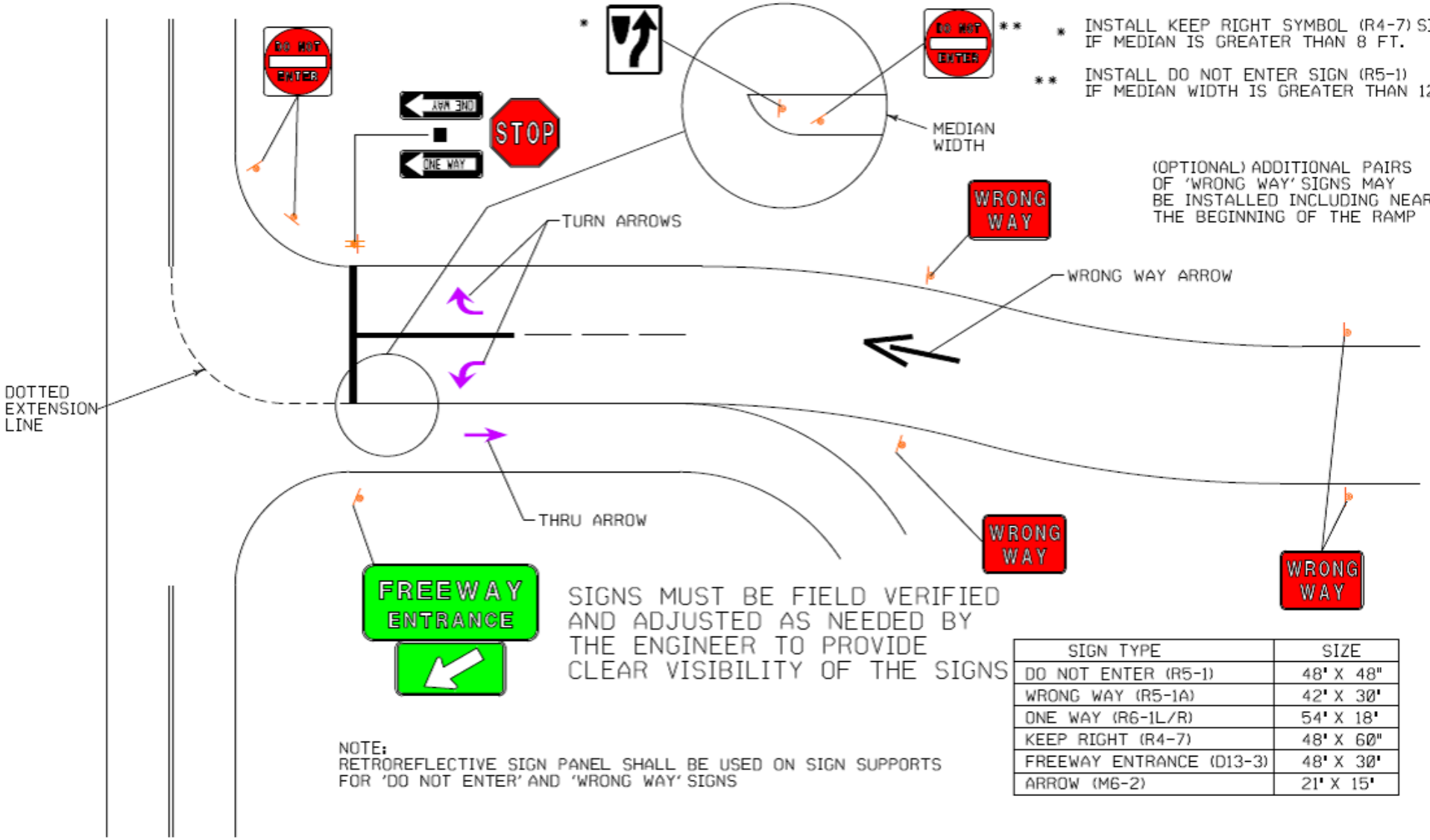
(NOT TO SCALE)

01/17/2014



SIGN TYPE	SIZE
DO NOT ENTER (R5-1)	48”X48”
WRONG WAY (R5-1A)	42”X30”
ONE WAY (R6-1L/R)	54”X18”
FREEWAY ENTRANCE (E12-201)	48”X30”
FREEWAY ENTRANCE W/ARR. (D13-3A)	48”X42”

Wrong Way Traffic Control for Partial Cloverleafs Without Island



* INSTALL KEEP RIGHT SYMBOL (R4-7) SIGN IF MEDIAN IS GREATER THAN 8 FT.

** INSTALL DO NOT ENTER SIGN (R5-1) IF MEDIAN WIDTH IS GREATER THAN 12 FT.

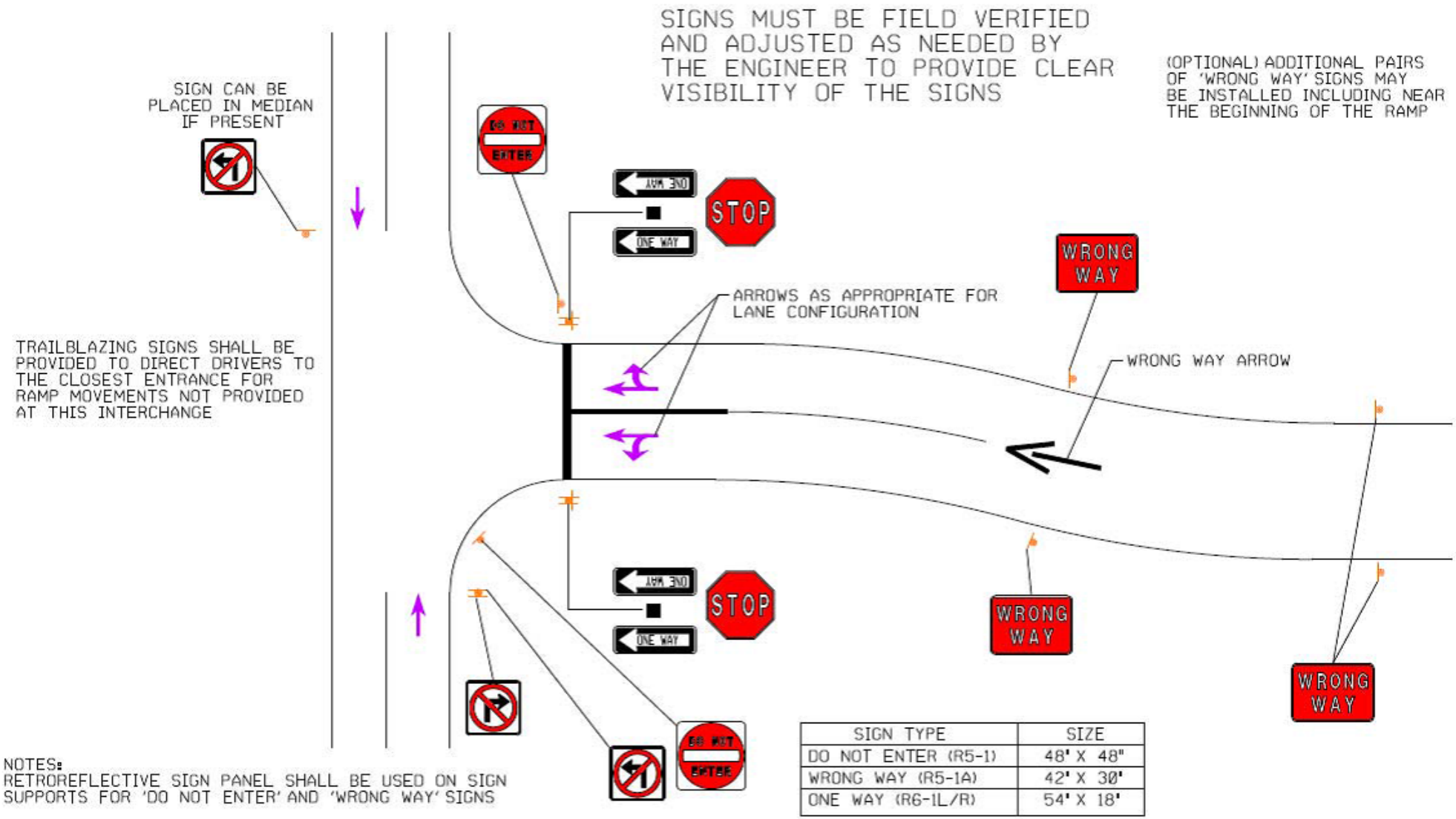
(OPTIONAL) ADDITIONAL PAIRS OF 'WRONG WAY' SIGNS MAY BE INSTALLED INCLUDING NEAR THE BEGINNING OF THE RAMP

SIGNS MUST BE FIELD VERIFIED AND ADJUSTED AS NEEDED BY THE ENGINEER TO PROVIDE CLEAR VISIBILITY OF THE SIGNS

SIGN TYPE	SIZE
DO NOT ENTER (R5-1)	48" X 48"
WRONG WAY (R5-1A)	42" X 30"
ONE WAY (R6-1L/R)	54" X 18"
KEEP RIGHT (R4-7)	48" X 60"
FREEWAY ENTRANCE (D13-3)	48" X 30"
ARROW (M6-2)	21" X 15"

NOTE:
RETROREFLECTIVE SIGN PANEL SHALL BE USED ON SIGN SUPPORTS FOR 'DO NOT ENTER' AND 'WRONG WAY' SIGNS

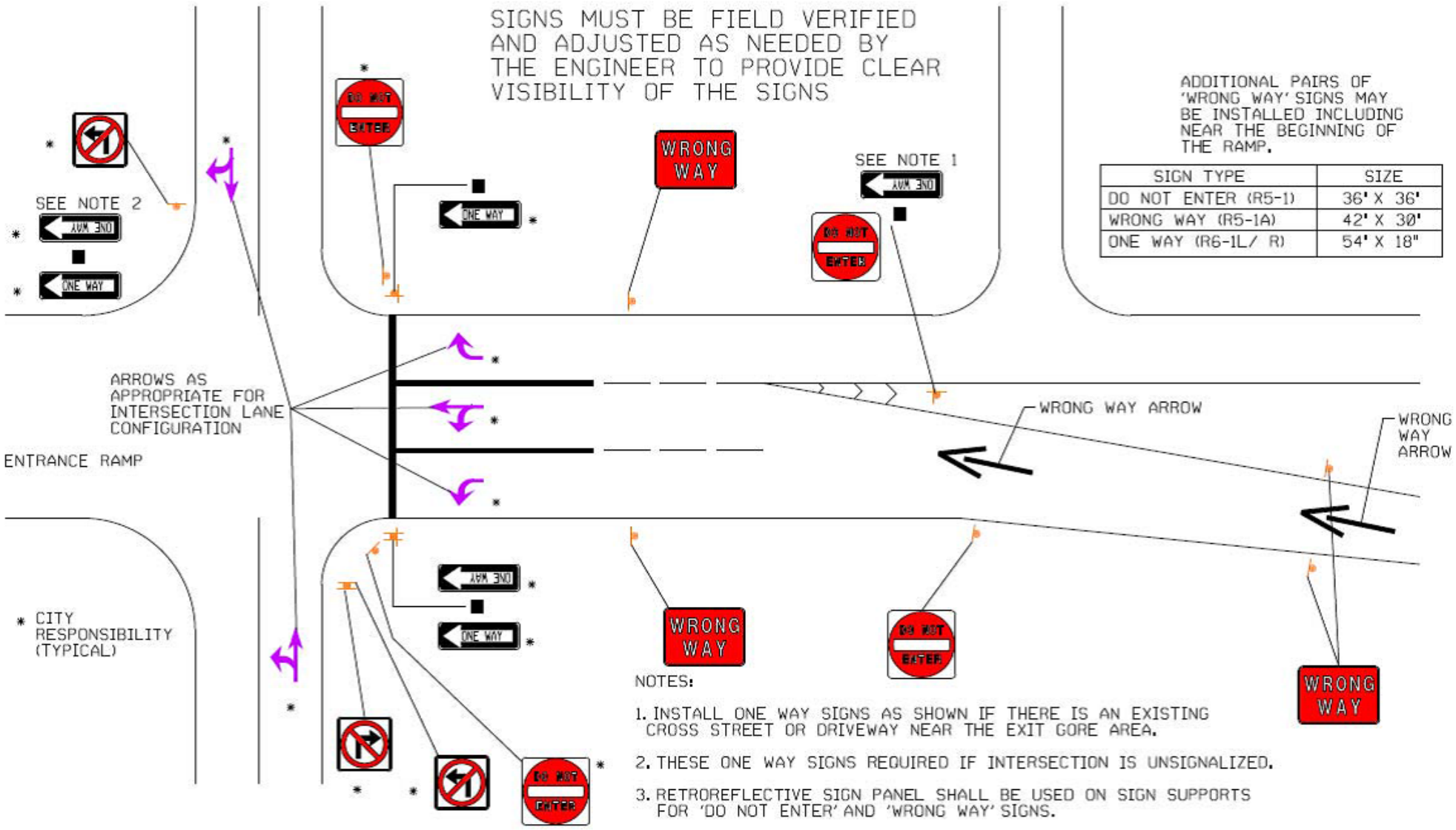
Wrong Way Traffic Control for Half Diamond Interchange Exit Ramp



SIGN TYPE	SIZE
DO NOT ENTER (R5-1)	48" X 48"
WRONG WAY (R5-1A)	42" X 30"
ONE WAY (R6-1L/R)	54" X 18"

NOTES:
RETROREFLECTIVE SIGN PANEL SHALL BE USED ON SIGN SUPPORTS FOR 'DO NOT ENTER' AND 'WRONG WAY' SIGNS

Wrong Way Traffic Control for Compressed Diamond Interchange

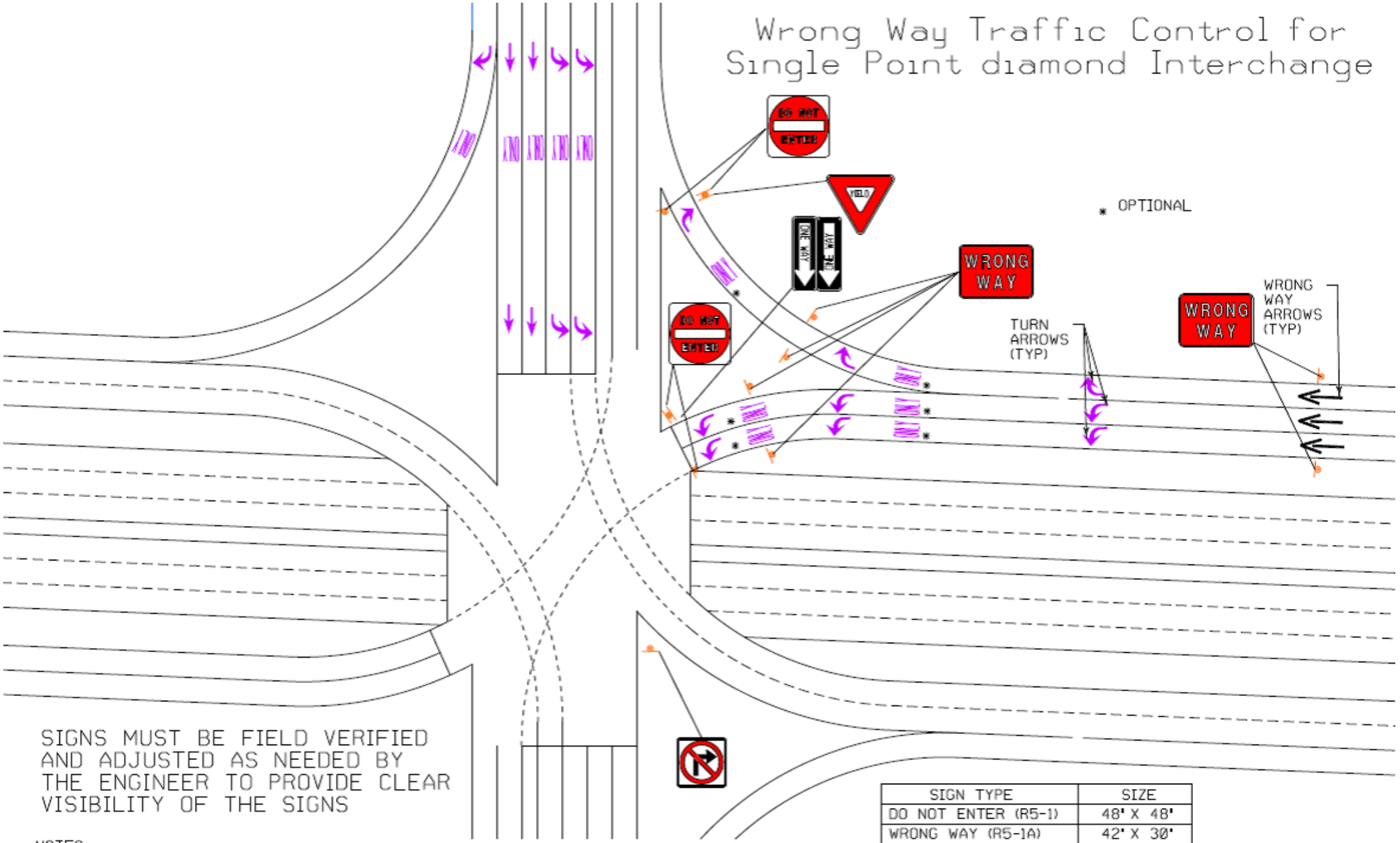


SIGN TYPE	SIZE
DO NOT ENTER (R5-1)	36" X 36"
WRONG WAY (R5-1A)	42" X 30"
ONE WAY (R6-1L/ R)	54" X 18"

NOTES:

1. INSTALL ONE WAY SIGNS AS SHOWN IF THERE IS AN EXISTING CROSS STREET OR DRIVEWAY NEAR THE EXIT GORE AREA.
2. THESE ONE WAY SIGNS REQUIRED IF INTERSECTION IS UNSIGNALIZED.
3. RETROREFLECTIVE SIGN PANEL SHALL BE USED ON SIGN SUPPORTS FOR 'DO NOT ENTER' AND 'WRONG WAY' SIGNS.

Wrong Way Traffic Control for Single Point diamond Interchange

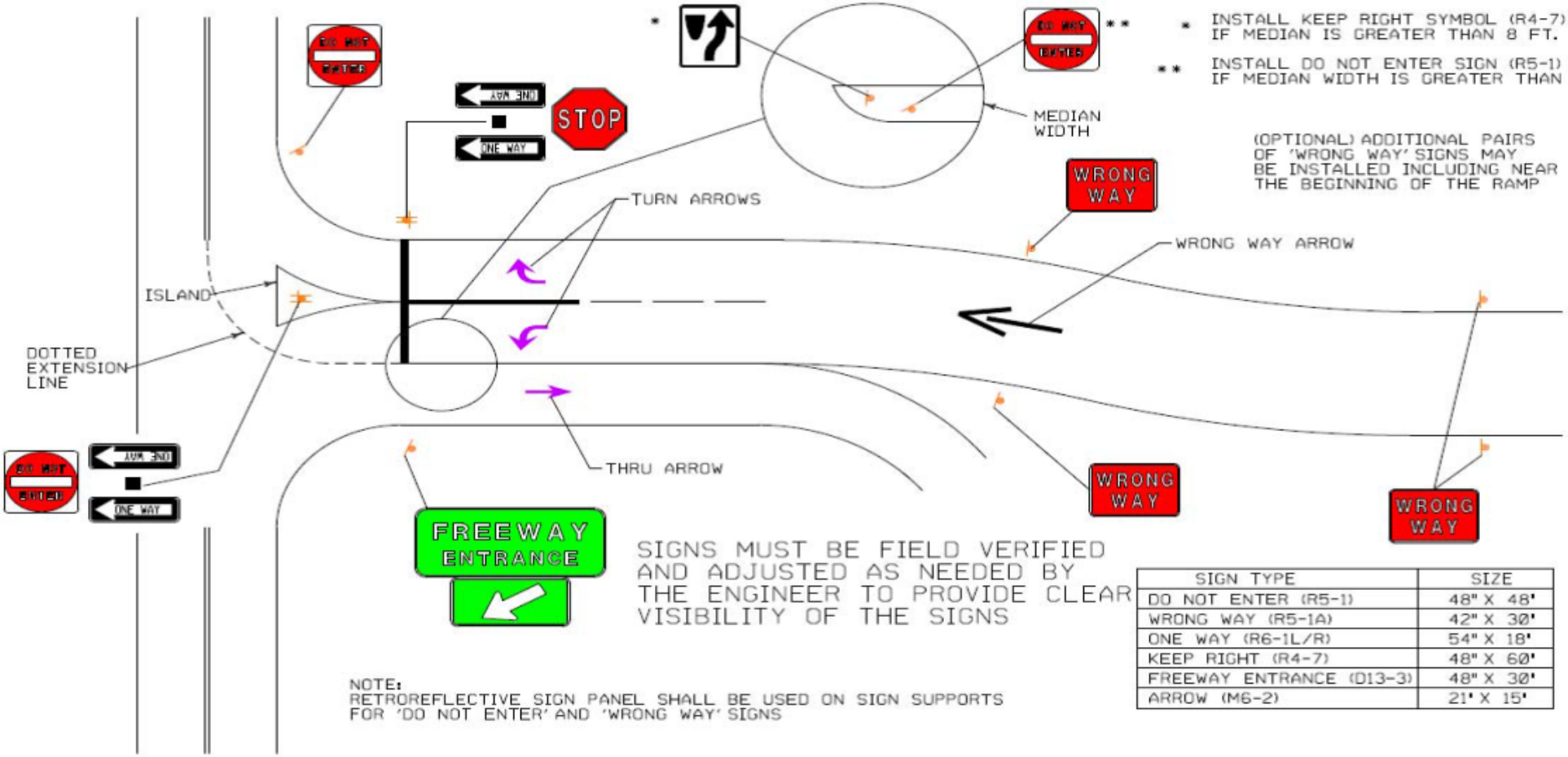


SIGNS MUST BE FIELD VERIFIED AND ADJUSTED AS NEEDED BY THE ENGINEER TO PROVIDE CLEAR VISIBILITY OF THE SIGNS

SIGN TYPE	SIZE
DO NOT ENTER (R5-1)	48" X 48"
WRONG WAY (R5-1A)	42" X 30"
ONE WAY (R6-1L/R)	54" X 18"

NOTES:
RETROREFLECTIVE SIGN PANEL SHALL BE USED ON SIGN SUPPORTS FOR 'DO NOT ENTER' AND 'WRONG WAY' SIGNS

Wrong Way Traffic Control for Partial Cloverleafs With Island



* INSTALL KEEP RIGHT SYMBOL (R4-7) SIGN IF MEDIAN IS GREATER THAN 8 FT.

** INSTALL DO NOT ENTER SIGN (R5-1) IF MEDIAN WIDTH IS GREATER THAN 12 FT.

(OPTIONAL) ADDITIONAL PAIRS OF 'WRONG WAY' SIGNS MAY BE INSTALLED INCLUDING NEAR THE BEGINNING OF THE RAMP

SIGNS MUST BE FIELD VERIFIED AND ADJUSTED AS NEEDED BY THE ENGINEER TO PROVIDE CLEAR VISIBILITY OF THE SIGNS

SIGN TYPE	SIZE
DO NOT ENTER (R5-1)	48" X 48"
WRONG WAY (R5-1A)	42" X 30"
ONE WAY (R6-1L/R)	54" X 18"
KEEP RIGHT (R4-7)	48" X 60"
FREEWAY ENTRANCE (D13-3)	48" X 30"
ARROW (M6-2)	21" X 15"

NOTE:
RETROREFLECTIVE SIGN PANEL SHALL BE USED ON SIGN SUPPORTS FOR 'DO NOT ENTER' AND 'WRONG WAY' SIGNS

Prevention of Wrong-Way Accidents On Freeways

A Research Report

By the Division of Traffic Operations

California Department of Transportation
Business, Transportation and Housing Agency

Disclaimer

The contents of this report reflect the views of the investigators and authors who are responsible for the facts and accuracy of the data presented herein. The contents of this report do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This report does not constitute a standard specification, design standard, or regulation.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/CA-TE-89-2		

4. Title and Subtitle	5. Report Date
Prevention of Wrong-Way Accidents On Freeways	June, 1989
	6. Performing Organization Code: 51 358
7. Author: Joyce E. Copelan	8. Performing Organization NO.: EA 623219
9. Performing Organization Name and Address: Division of Traffic Operations, California Department of Transportation, 1120 "N" Street, Sacramento CA 95814	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address: California Department of Transportation, 1120 "N" Street, Sacramento CA 95814	13. Type of Report and Period Covered: Final
	14. Sponsoring Agency Code: F88TE10

15. Supplementary Notes

16. Abstract

Senate bill 233 (Davis 1987) required a current study on the wrong-way problem on freeways. This report discusses solutions developed over the years to prevent wrong-way driving by Caltrans, results of recent camera surveillance studies and the current annual wrong-way monitoring program. To determine if other states had developed any new solutions to the problem, traffic engineers from all the states were surveyed.

The recommendations to prevent wrong-way accidents are in the areas of sign maintenance, annual accident monitoring using a check-list process, ramp and intersection design, and reducing drunk drivers. It also recommends the purchase of new still camera, video, or movie camera and detector equipment, and continuing the pavement light experiment in San Diego.

17. Key Words	18. Distribution Statement
Wrong-Way, Wrong Direction, Sign, Pavement Arrow, Traffic Safety, Accident Prevention, Freeway, Interchange, Off-Ramp, On-Ramp, Design, Pavement Light, Spikes, Drunk Drivers, Accident Monitoring.	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	95	

Prevention of Wrong-Way Accidents on Freeways

was prepared by the

Division of Traffic Operations
California Department of Transportation
Business, Transportation and Housing Agency
State of California

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Conclusions

Methods of preventing wrong-way driving on freeways were thoroughly reviewed in the preparation of this report. It is important to realize that half of the wrong-way driving on freeways is from deliberate, illegal U-turns. Measures taken to improve ramp operation would not affect this half of the wrong-way problem. For the other half, none of the physical barriers tested to date appear appropriate. Methods other than physical barriers have proven helpful in decreasing the incidence of wrong-way driving.

Effective treatments include repainting or adding wrong-way pavement arrows; reorienting, moving, or adding wrong-way sign packages; modifying the trailblazing freeway entrance packages; placing edge lines and pavement markers; upgrading signs with high intensity reflective sheeting; and modifying lighting. Occasionally more extensive measures could be used to solve the problem at unique locations, such as airport-type pavement lights, modifying the design features of ramp terminals and adding ramps to incomplete interchanges.

It is important to note that three-quarters of the fatal wrong-way accidents are caused by drivers involved with alcohol or drugs. This presents a difficult challenge in terms of developing appropriate solutions.

Additional wrong-way pavement arrows may be beneficial. The use of larger DO NOT ENTER signs may be considered if an off-ramp still has a recurring problem. Larger, highly reflective signs may be helpful for confused or elderly drivers. Use of red pavement lights which are activated by wrong-way drivers may be considered at locations where traditional treatment is not effective. The condition of wrong-way signing packages at off-ramps and directional signs is important.

Fatal wrong-way accidents as a percentage of all fatal accidents on freeways have decreased substantially in the last 20 years. This reduction is believed to be related to the many actions taken by Caltrans over the years. Despite this reduction, additional improvement should be possible, as outlined on the next page.

Recommendations

The actions Caltrans can take which should further reduce wrong-way accidents were identified during this in-depth review.

1. Continue the annual monitoring of wrong-way accidents. An annual review is made in the field of off-ramps, which have been identified as entry points or are near concentrations of wrong-way accidents. This practice should be continued. The "Check List for Wrong-Way Entry Review" (Appendix A), developed as part of this project, should be helpful.

2. Conduct periodic reviews of every ramp. The systematic periodic review of the ramps for missing or worn signs or pavement arrows, and for a variety of changed conditions is very important. The review begun late last year should be expeditiously completed. Future reviews should be scheduled on about a three to five year cycle.

3. Purchase new still camera, video, or movie camera and detector equipment. The further systematic photographing of wrong-way vehicle entries at each ramp is not needed. However, each district should have access to reliable equipment for those few cases where photographs or videotapes would be helpful. This equipment should be purchased by Headquarters Traffic Operations.

4. Continue the pavement light experiment in San Diego. Definitive data on the effectiveness of the pavement lights to prevent vehicles from entering the freeway in the wrong direction is still needed. New movie or video cameras are needed for this experiment. The cameras should be operated as long as necessary to obtain statistically significant data.

5. Conduct a training effort for designers. Ramp and intersection design can have a significant effect on wrong-way entries. Training classes or instructional material should be developed for designers, especially the new ones.

6. Consider edge lines or heavy bars across off-ramps. The only technique identified which has not been previously tried or considered in California is to carry edge lines or wide painted bars across the off-ramps. This technique should be further investigated.

7. Consider the option of using a second set of Wrong-Way and Do Not Enter signs and wrong-way arrows further along the off-ramp. The option of using additional signs and markings on selected ramps may give a drivers a second chance to realize that they are headed the wrong-way before they enter the freeway.

8. Contact the California Highway Patrol (CHP) regarding the wrong-way problem. The CHP has been very helpful in the past. They should be contacted again to stress our continued interest in identifying problem ramps.

9. Review the Traffic and Design Manuals. Although not specifically discussed in this report, both the Traffic and Design Manuals should be reviewed to see that they reflect the latest thinking.

Introduction

This report is a current review on preventing the incidence of wrong-way driving on freeways. It also discusses solutions to decrease entering or leaving freeways via on-ramps and off-ramps in the wrong direction. This report discusses in more detail the report required by Senate Bill No. 233 (Davis, 1987) which was submitted to the California legislature in December 1988.[27]* This bill afforded Caltrans an opportunity to critically review the steps being taken to reduce wrong-way accidents, and to determine if any other states had developed any new solutions to this problem.

Because wrong-way accidents are tragic, they have been under intensive study by the California Department of Transportation (Caltrans) for nearly 30 years. Wrong-way fatal accidents account for about three percent of the fatal accidents on California freeways and about five percent of the fatalities.[26] The actual number of wrong-way fatal accidents is the same today--about 35 per year--as in 1963 despite the fact that freeway travel has increased five-fold. Various actions taken by Caltrans over the years have been successful in preventing these accidents from increasing in proportion to the travel.

To review current practices in preventative methods, traffic engineers from the states were surveyed. The annual wrong-way monitoring program conducted by engineers in California's districts is discussed. Camera surveillance studies were conducted at seven off-ramps in southern California especially for this report. The renovated pavement lights projects in San Diego were reviewed. In addition, the California Highway Patrol's (CHP) programs against drunk drivers are summarized.

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*See references starting on page 36.

History of Wrong-Way Research

The problem of wrong-way driving on freeways has been studied intensively by Caltrans, formerly the California Division of Highways, since 1961. During this year, the California Highway Patrol, at the request of the Division of Highways, reported on 743 incidents of wrong-way driving.[1,2] Immediate solutions were needed to the developing problem of wrong-way accidents as significant portions of new freeways were being opened to traffic.

By 1964, wrong-way signs and 24-foot white wrong-way pavement arrows had been developed by Caltrans and were being installed on California's freeways.[4] The original signs included a black on white "DO NOT ENTER" sign mounted on the same post with a white on red "WRONG WAY" sign. White on green "FREEWAY ENTRANCE" signs at either side of on-ramp entrances were also posted to aid motorists in finding the correct way onto the freeway. Further studies on wrong-way sign colors indicated white on red was seen earlier than black on white.[5] The "DO NOT ENTER" sign was later revised to white on red. These signs and pavement arrows were adopted as a national standard in 1967.

In the mid-1970s, the "Do Not Enter" packages were upgraded and other improvements were made in signing, delineation, lighting, and ramp design at the on- and off-ramps. Automatic cameras were used to record wrong-way entries. The cameras were in place for a minimum of 30 days at each of 4,000 off-ramps across the state.[20] The "Do Not Enter" sign packages were relocated and lowered for better visibility to the headlights of vehicles entering the wrong-way. These various actions reduced the frequency of wrong-way moves from as high as 50 to 60 to 2 to 6 per month at problem ramps and completely eliminated them at the majority of ramps. The camera surveillance indicated that wrong-way entries were reduced to low levels of less than 2 per month at 90% of the ramps with previous entry problems.

In 1978, follow-up camera surveillance revealed that the most effective corrections for wrong-way movements were: the installation of "FREEWAY ENTRANCE" signs at on-ramps, and "DO NOT ENTER" and "WRONG WAY" signs at off-ramps; posting supplementary trailblazing signs and extra lighting at on-ramps; reducing the off-ramp throat opening and eliminating the free right turn from the off-ramp.[20] These improvements have been incorporated into present standard procedures.

Locations where the sight distance was less than 1200 feet (366 m) on the mainline freeway lanes were the site of over one-half of the fatal and injury accidents.[9] Design standards were changed to increase sight distances on new freeways. For over 25 years, data has been accumulated for wrong-way accidents and their corresponding off-ramp classifications. A few types of ramps and interchanges, such as the cul-de-sac, button hook, trumpet, and two quadrant cloverleaf were determined to have a greater number of wrong-way accidents than other types.[4,7,9,13] Modifications to these interchanges are discussed later in this report. Also studies found that left-hand off-ramps appeared to be on-ramps to the wrong-way driver, and should be avoided.

During the late 1960s Caltrans installed red-backed reflective pavement markers on the lane lines on freeways.[14] The Department of Motor Vehicles educated the public to the concept that a driver who sees red reflectors is going the wrong-way. The reflectors proved to be of limited value, especially with drunk drivers. Therefore, the red-backed markers are now installed only in the vicinity of off-ramps as a secondary treatment.

In 1965 parking lot spike barriers were tested to determine if they could be used at off-ramps to stop vehicles from entering the wrong way.[3,8] Unfortunately, these devices were not found suitable. The spikes, even when modified with a fish-hook shape, would not cause tires to deflate quickly enough to prevent a vehicle from entering the freeway. Under high-volume traffic the spikes broke, leaving stubs that would damage the tires of right-way vehicles. It was believed that some right-way drivers, upon seeing the spike barriers, would hit their brakes and create a hazardous situation. Also, camera surveillance of off-ramps indicated that most drivers quickly realized they were starting a wrong-way entry and took corrective action. The spike barriers could prevent this corrective action from being taken.

California has designed moveable gates to bar traffic from high occupancy vehicle lanes. The gates are designed to stop even the heaviest vehicle. However, the gates take approximately 20 seconds to lower or raise, which is far too slow for a wrong-way vehicle entering a ramp. With the present state of the art, gates would not be appropriate for retaining a wrong-way vehicle.

The state of Georgia tested a pop-up device that presented a physical curb-like barrier to the wrong-way driver, but it was unsuitable for reasons similar to those of the spike barriers.[22] A recent poll of the 50 states revealed that none has found a suitable physical barrier. No state is presently testing or considering to use barriers.

California tried adding horns and flashing red lights over the "WRONG WAY" signs in the 1970s, but these were found to be ineffective and drew complaints from neighbors.[6]

One device that was tried did show promise. Red, airport-type pavement lights, embedded in the pavement across an off-ramp, activated by wrong-way vehicles, were shown by camera monitoring to reduce further wrong-way entries. From camera monitoring, about half of the wrong-way drivers at these ramps braked before reaching the wrong-way signs. Nearly half continued past the signs but braked before the pavement lights. However, some continued past the pavement lights and went out of view of the camera.

Reports on wrong-way driving have concluded that drinking drivers were responsible for three out of every four wrong-way accidents on California freeways.[4,9,12,15] The typical wrong-way driver had received more traffic violations and more felony convictions and had been involved in considerably more accidents of all types than the average motorist.[9] The majority of the wrong-way drivers were male.[9] Another complicating characteristic of wrong-way drivers is that many make intentional U-turns on freeways; they do not enter via an off-ramp. Nearly half of the wrong-way accidents are caused by U-turns and half from wrong-way entries via off-ramps.[1,4]

Since 1985, Caltrans has had a program to monitor wrong-way accidents. Ramps in the vicinity of wrong-way accident sites are investigated. Field reviews are conducted to make sure that signs and markings are in good repair, and that there are no conditions which could mislead drivers. A wide variety of improvements are made as are found appropriate.

In terms of technology development, rather than research, new materials have been developed for the wrong-way signs and markings in recent years. High intensity reflective sheeting for signs has recently been adopted for the wrong-way and freeway entrance sign replacements and upgrades. The use of larger signs also provides more visibility, especially for elderly drivers. Thermoplastic pavement wrong-way arrows are now being installed. The thermoplastic has a high reflectivity and greater durability.

With the results of present technology, new materials are being tested for wrong-way signs and markings. Synthetic materials are being developed for anti-theft signs in "high vandalism" urban areas (motivated by the aluminum resale value). An anti-graffiti coating is being developed. Innovations in reflective coatings are being made. The electronic system for the pavement lights is now more reliable under varying moisture conditions. Research is continuing on the effectiveness of these lights.

The research conducted to date has clearly led to a reduction in wrong-way accidents. This is illustrated in the next section. Other than continuing research into the accident reducing potential and reliability of the airport-type pavement lights, no research needs were identified.

Wrong-Way Accidents in California

The following charts and graphs highlight the wrong-way accident picture on California freeways. The number of fatal wrong-way accidents has averaged 35 per year over the last 20 years (Figure 1). The number of accidents has remained constant even as the miles of freeway and travel have increased substantially. Fatal wrong-way accident rates have decreased from about 1.5 per billion vehicle-miles of travel to under 0.4 (Figure 2). This is over a percent decrease.

Wrong-way accidents accounted for approximately 2.9% of the fatal, 0.3% of the injury and 0.1% of the property damage accidents on California freeways in 1987 (Figure 3). Wrong-way accidents tend to be more severe, and have a greater proportion resulting in death or injury than other types of accidents. In 1963, wrong-way accidents comprised of six percent of the freeway fatal accidents. By 1987, this figure had decreased to just under three percent. This is a reduction of over 50 percent.

Wrong-way accidents show distinct patterns by time of day (Figure 4). Caltrans is organized into 12 geographical districts. The freeways in districts 1,2,3,5,6,8,9,10 are predominantly in rural regions. The freeways in districts 4,7,11,12 are mostly in urban areas Wrong-way accidents peak around 2 to 3 a.m. in every district, although this is more noticeable in the urban areas. The bars are required by law to close at 2 a.m. in California. The higher traffic volumes during the day in urban areas probably depress the wrong-way accidents during these hours. Urban areas have a much greater number of wrong-way accidents than rural areas.

The sobriety of drivers in wrong-way accidents on California freeways is shown next (Figure 5). During 1983 to 1987, the majority of the drivers either had been drinking or were driving under the influence of alcohol or drugs. Impaired drivers accounted for a staggering three-quarters of the wrong-way accidents. Drivers with drugs or alcohol in their systems are the number one cause of wrong-way accidents on California freeways.

Fatal wrong-way accidents as a percentage of all fatal accidents on freeways have decreased in the last 20 years. This reduction is believed to be substantially related to the many actions taken by Caltrans over the years.

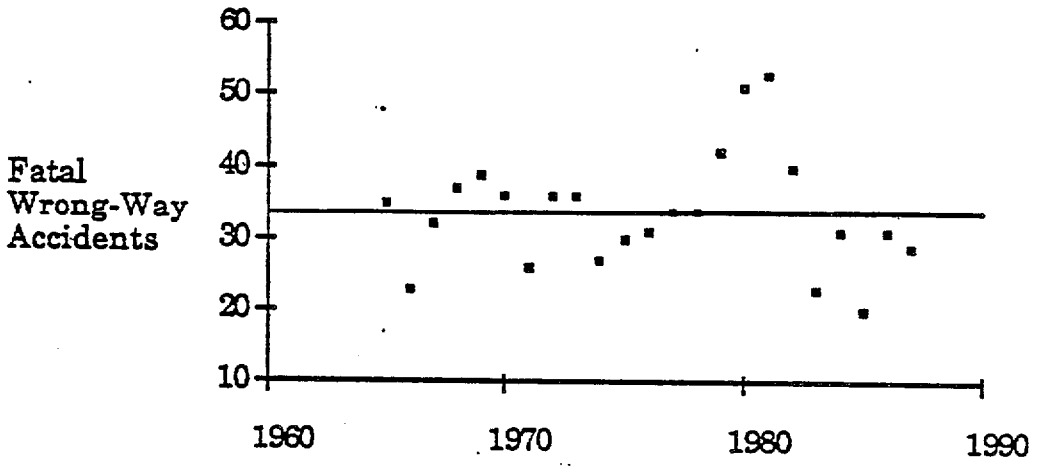


Figure 1

Number of Fatal Wrong-Way Accidents
on California Freeways Over the Years

The number of wrong-way fatal accidents is the same today as in 1963, approximately 35.

Source: Caltrans Traffic Accident Surveillance And Analysis System (TASAS)

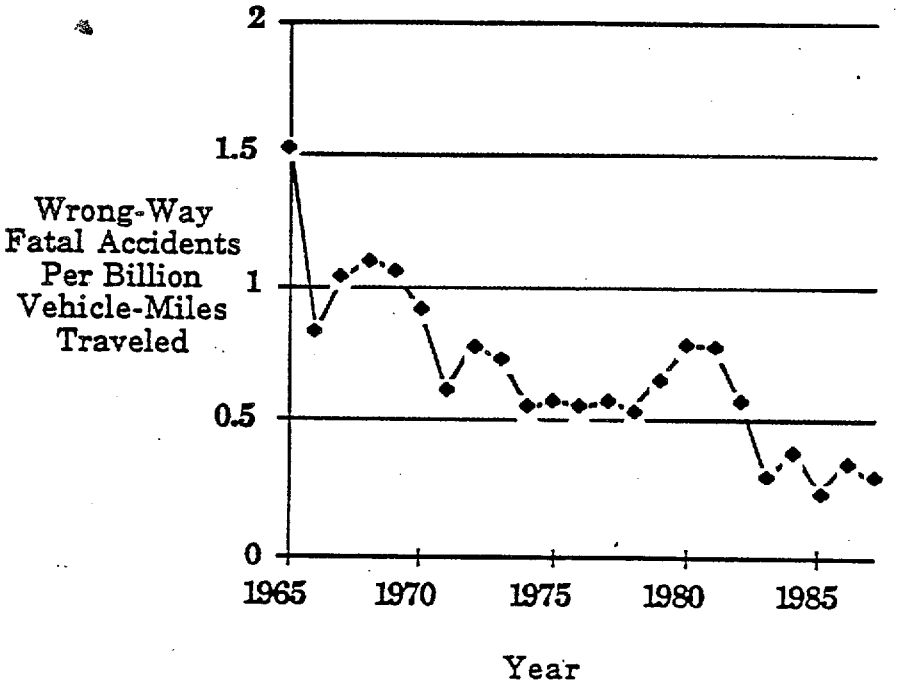


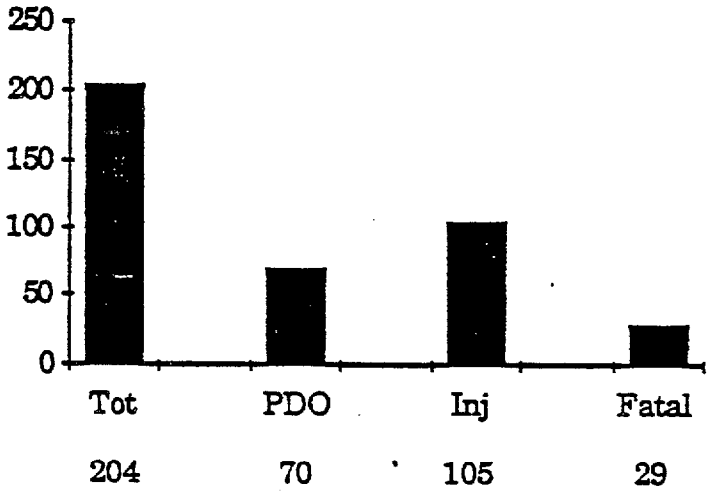
Figure 2

Fatal Wrong-Way Accident Rates
on California Freeways

Research into solving the problem of wrong-way drivers started in the early 1960s. As new solutions have been found, the number of fatal wrong-way accidents per billion vehicle-miles traveled has decreased.

Source: Caltrans Traffic Accident Surveillance And Analysis System (TASAS)

Wrong-Way Freeway Accidents



All Types of Freeway Accidents

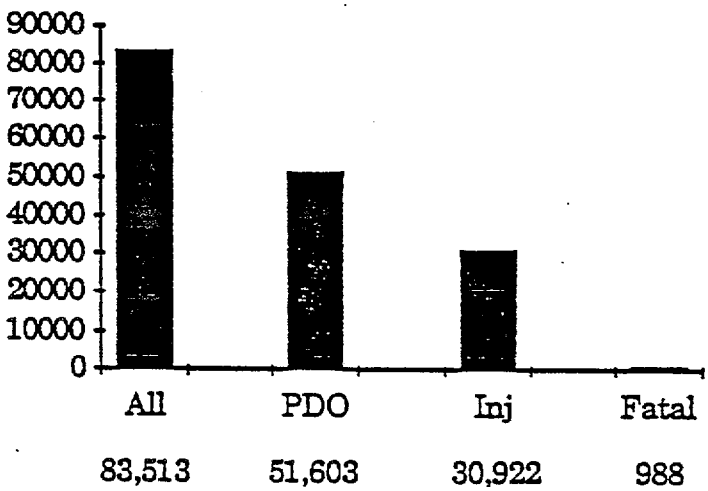
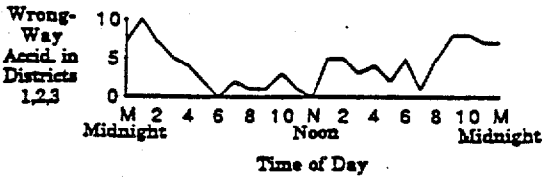


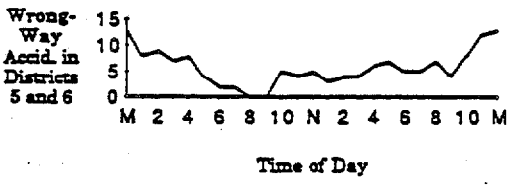
Figure 3

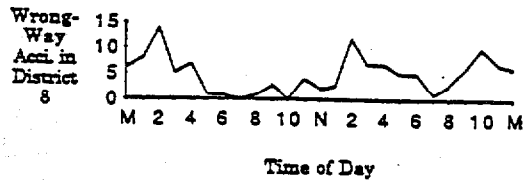
Wrong-Way Accidents Compared to All Accidents on California Freeways in 1987

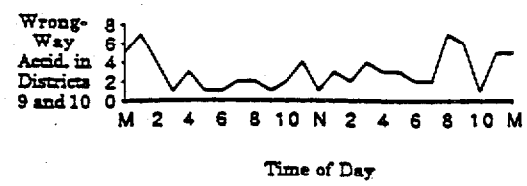
These charts show wrong-way accidents as compared to the total number of recorded accidents on California freeways during 1987. About 0.24 percent (approximately one out of 400) of the accidents were wrong-way. About 2.9 percent of all the fatal accidents were wrong-way. Although wrong-way accidents account for 0.24 percent of all accidents on California freeways, they are more severe and more likely to result in injury or death than other types of accidents.

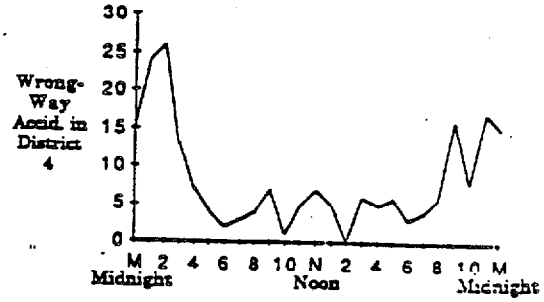
The source of data is from the Caltrans Traffic Accident Surveillance And Analysis System (TASAS) and 1987 Accident Data on California State Highways (Road Miles, Travel, Accidents, Accident Rates)
PDO, Property Damage Only Accident; Inj, Injury Accident; Fatal, Fatal Accident

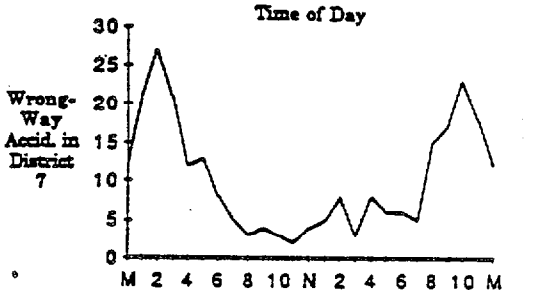


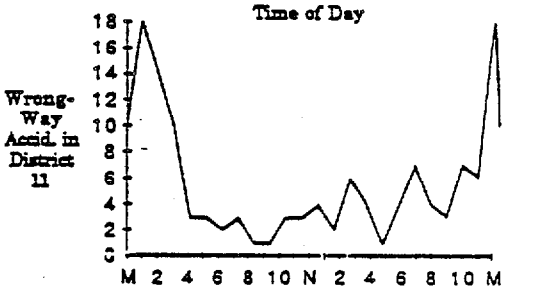


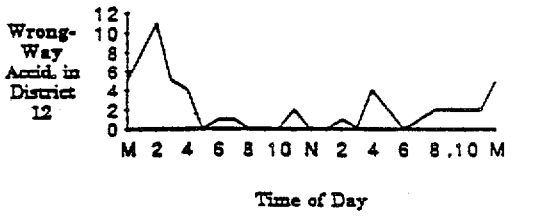












Rural Areas

Urban Areas

Figure 4

Wrong-Way Accidents, Time of Day and District 1983 - 1987, Inclusive

Urban areas have more wrong-way accidents than rural areas. The numbers of wrong-way accidents are higher in the evening than the daytime hours. Congestion in urban areas may prevent wrong-way drivers from entering or driving on the freeway during the daytime. The peaking of fatal wrong-way accidents occurs around 2 a.m. in all areas, although this is more evident in the urban areas, and is probably related to the closing time for bars in California.

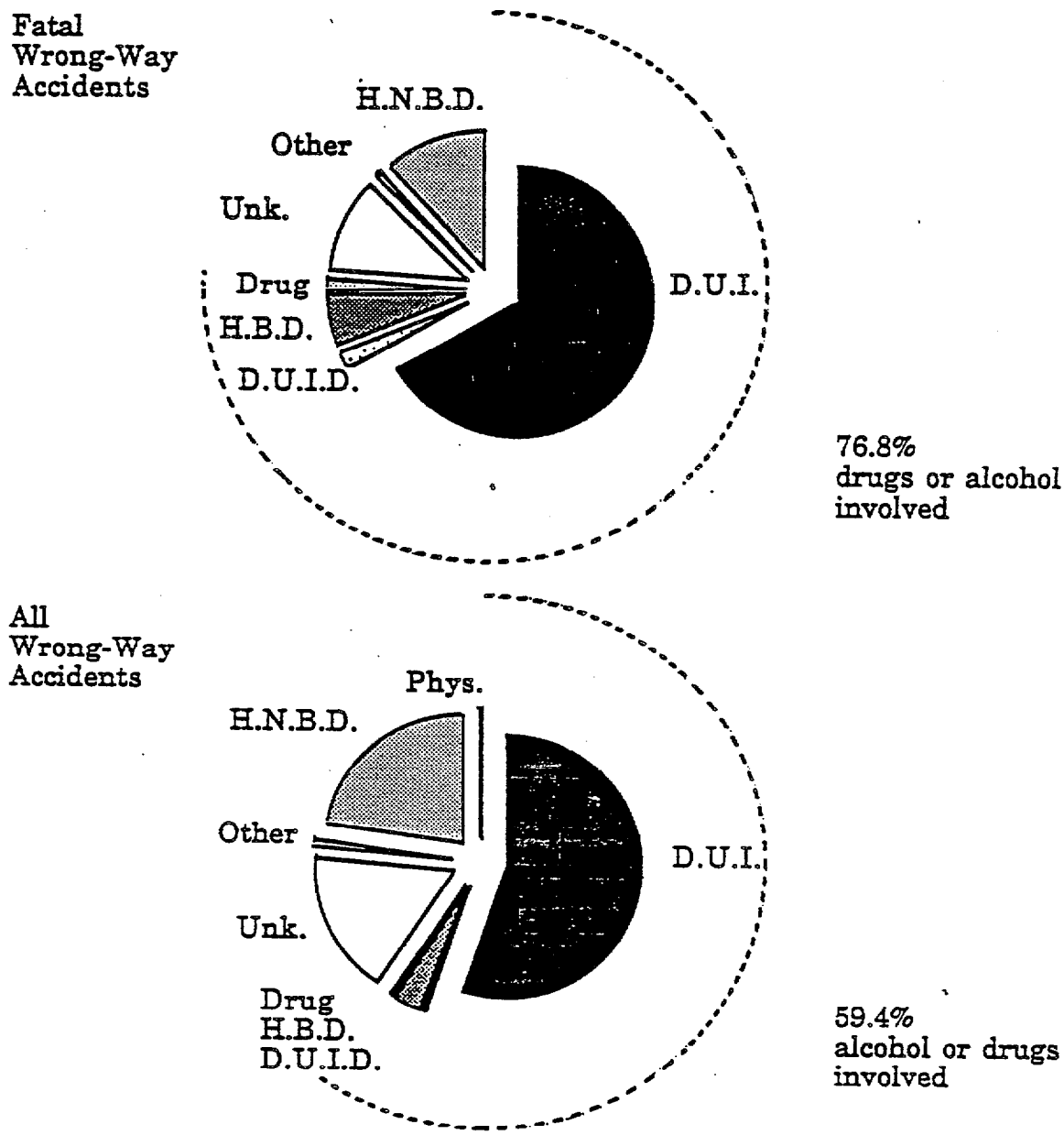


Figure 5

Sobriety of Drivers in Wrong-Way Accidents
on California Freeways During 1983 to 1987

The primary cause of wrong-way accidents, especially those which are fatal, is drivers who are under the influence of drugs or alcohol.

The source of data is from the Caltrans Traffic Accident Surveillance And Analysis System (TASAS).
D.U.I., Driving Under the Influence; D.U.I.D., Driving Under the Influence of Drugs; H.B.D., Had Been Drinking, Impairment Unknown; Unk., Sobriety Unknown; H.N.B.D., Had Not Been Drinking; Phys., Physical Impairment.

Annual Monitoring of Wrong-Way Accidents

The purpose of the annual wrong-way accident monitoring system is to make sure everything possible is being done to prevent wrong-way accidents. This program was started in 1985. Listings of wrong-way accidents along with accident concentrations are provided annually to the traffic engineers in the twelve districts. Information on accident location, accident severity, time of day, direction of travel, and sobriety of the driver are noted. (Wrong-way accidents involving bicycles are eliminated from the listings. Most of these accidents happen when the drivers leaving the off-ramps and making right turns hit bicyclists going the wrong-way on the cross streets.) A running 5-year accident listing is maintained.

Field investigations are made upstream of wrong-way accident concentrations and at ramps of known or suspected wrong-way entries. Aerial photographs and accident reports are also reviewed. Most entry points are unknown because the wrong-way driver usually can not provide information due to his intoxicated condition, or because of his death in the accident. A new check list procedure has been developed as part of this current report which summarizes the experience and input of district field engineers. The check list, may be used as a training tool for new field investigators. (See Appendix A).

Reports are produced by the districts which cover the wrong-way concentrations, descriptions of deficiencies found, and changes or modifications made because of these investigations. These changes may include repainting or adding wrong-way pavement arrows; reorienting, moving, or adding wrong-way sign packages; modifying the trailblazing freeway entrance packages; placing edge lines and pavement markers; upgrading signs with high intensity reflective sheeting; and modifying lighting. Occasionally more extensive measures would be required to solve the problem at unique locations, such as installing pavement lights; adding ramps to incomplete interchanges; regrading ramps to improve sight distance; and other ramp redesigns. With the exception of pavement lights (now under testing) and minor redesigns at ramp terminals, modifications to interchanges and ramps are usually prohibitively expensive and have seldom been proposed.

This monitoring program appears to be effective in pin-pointing deficiencies in the field. It should lead to reduced accidents (although this has not been quantified yet), and the program should be continued as an annual effort. The check-list should be of significant use in the field reviews.

Special Review of Off-Ramps in Los Angeles and Ventura Counties

As a part of the effort requested by Senate Bill 233, (1987) Caltrans conducted a special review of seven ramps in Los Angeles and Ventura Counties. These ramps, based on previous studies, were thought to be the most susceptible to wrong-way moves. Automatic cameras were installed at each ramp for a minimum of 30 days. The seven ramps were:

Los Angeles County

I-10, WB Off-Ramp to Hoover Street
I-10, EB Off-Ramp to Ramona Road
I-405, NB Off-Ramp to Palo Verde
I-605, SB Off-Ramp to Rose Hills Road
CA-101, NB Off-Ramp to Ventura Boulevard

Ventura County

CA-1, NB Off-Ramp to Pleasant Valley Boulevard
CA-1, SB Off-Ramp to Pleasant Valley Boulevard

No wrong-way moves were detected at 5 of the ramps. One wrong-way vehicle was photographed at Hoover Street. It is assumed that the driver realized his situation and turned around, since no accident was reported in the area. A field review showed that the wrong-way sign packages were in place and in good condition. The ramp configuration with the off- and on-ramps side by side may have contributed to this driver's error. No changes were recommended.

Five wrong-way moves were recorded at Rose Hills Road. It is assumed that the drivers realized their mistakes and made corrections, since no information with respect to wrong-way drivers on the freeway during the study period was received. The study concluded that city-owned directional signs to a local recreation area may have been the cause of driver confusion and wrong turns onto the freeway off-ramp.

The recommendations for improvement at Rose Hills Road were two-fold. First, the city was informed of the sign problem and requested that it be corrected. The city did remedy the problem with their signs. Second, Caltrans placed a second set of wrong-way signs closer to the ramp terminus, installed a no-turn sign facing westbound traffic on the city street, and installed a one-way sign on the easterly side of the off-ramp.

Based on previous experience, it was expected that these ramps would have 2 or more wrong-way moves per month each. The fact that they did not (with the exception of Rose Hills Road) was gratifying. The routine camera surveillance program had been continued for several years.[20] As every ramp came to be photographed, as the equipment wore out, and as the belief grew that little was being achieved for a large expenditure of employee time, the camera effort mostly ceased by the mid-1980s. However, some cameras have remained in operation. The decision to stop the program in general appears warranted. In the course of preparing this report, it was disclosed that the remaining detectors and camera equipment are now in very poor condition.

It is therefore recommended that new equipment be purchased for those few cases where wrong-way entry problems continue and where cameras surveillance could help in deriving a solution.

The case of Rose Hills illustrates the importance of periodic reviews of every ramp. The systematic reviews of the ramps for missing signs, worn signs and pavement arrows, and changed conditions have been done several times in the past.[12] Pavement arrows should now conform to the policy developed in 1985.[23] The most recent review began in late 1988. It is recommended that this review be expeditiously completed and that future reviews be scheduled on about a 3 to 5 year cycle.

Pavement Lights Project in San Diego

In 1976, the freeway off-ramps in District 11 were studied to determine where wrong-way problems might occur. From the results of this study, seven off-ramps were selected for modification. Selection was based on an indication of operational problems, which meant a history of wrong-way entrances and/or misleading layouts of ramps. The modifications consisted of installing airport-type red pavement lights, induction loops in the pavement to detect the wrong-way vehicles and controllers, and adding extra wrong-way sign packages. These seven off-ramps were located as follows:

I-5, NB Off-Ramp to Sorrento Valley Road
I-5, SB Off-Ramp to Sea World Drive
I-8, WB Off-Ramp to Fletcher Parkway
I-8, EB Off-Ramp to Severin/Fuerte Drive
I-94, EB Off-Ramp to Broadway/College Avenue
I-163, NB Off-Ramp to Mesa College Drive
I-805, NB Off-Ramp to Mesa College Drive
(I-94, EB Off-Ramp to Home Avenue was installed at a different time.)

The pavement lights appeared to be effective in further reducing wrong-way entries. However, the equipment experienced severe and continuing maintenance problems. In the 1970s, the loops were replaced at the Off-Ramp to Fletcher Parkway. In 1985, an improved design was developed and the installations were rebuilt at five off-ramps:

I-5, SB Off-Ramp to Sea World Drive
I-94, EB Off-Ramp to Home Avenue
I-94, EB Off-Ramp to Broadway/College Avenue
I-163, NB Off-Ramp to Mesa College Drive
I-805, NB Off-Ramp to Mesa College Drive

The project was completed in 1986. The Sorrento Valley Road and Fletcher Parkway Off-Ramps did not require retrofits since they were working satisfactorily. Now, the system at Fletcher Parkway Off-Ramp is due for a minor retrofit. No retrofit was made at Severin/Fuerte Drive Off-Ramp since the bridge and ramps were soon to be removed and relocated during the construction of the Routes 8/125 interchange. The Off-Ramp to Home Avenue was reconstructed too.

In 1987, a study was initiated to determine whether there were still any operational problems at the remaining six locations.

I-5, NB Off-Ramp to Sorrento Valley Road
I-5, SB Off-Ramp to Sea World Drive
I-8, WB Off-Ramp to Fletcher Parkway
I-94, EB Off-Ramp to Broadway/College Avenue
I-163, NB Off-Ramp to Mesa College Drive
I-805, NB Off-Ramp to Mesa College Drive

Still cameras were installed at these six locations, which were monitored to determine if the improvements had the desired effects. Problems arose at several of these locations regarding false wrong-way readings. These false recordings were attributed mainly to "rollbacks", which occur when a vehicle on an uphill ramp rolls back across the detectors. At two locations, motorcycles traveling in the correct direction produced most of the false readings. Equipment was adjusted and detector placements were changed. The problems were alleviated, but not completely eliminated.

In the wrong-way accidents documented in 1986 and 1987, none were attributed to the six locations. At one location, however, several wrong-way entries were experienced, although no accidents were recorded there. A few motorists mistook the off-ramp for a city street. Modifications were made to the wrong-way signs and to the pavement markings. These changes resulted in only one detected wrong-way entry since the modifications.

Now that the design of the equipment appears to have been improved to withstand problems such as short circuiting caused by ground water, the pavement lights may be a feasible solution at locations where other treatments have not been sufficiently effective.

The pavement light installations are relatively expensive (over $10,000 each) and require constant maintenance. It is still not known for certain how effective the lights really are in preventing entry onto the freeway lanes. The lights were theorized to be effective since intoxicated persons experience poor divided attention (for roadside signs) but relatively good concentrated attention (for the roadway straight ahead).[18] Prior research indicated that the lights were effective in stopping most but probably not every driver.[20] It was never possible to get good data due to equipment problems. Now that a reliable design has apparently been developed, it may be possible to obtain good data. To do this, new movie or video cameras are needed. It is necessary to determine how many vehicles pass the lights in the wrong direction and enter the freeway. Therefore, it is recommended that still camera, video or movie camera equipment be purchased and installed at these pavement light ramps. The cameras should be operated as long as it takes to obtain statistically significant entry data.

Ramp and Intersection Design

Over twenty years ago, many of the wrong-way movements and accidents were caused by drivers who were honestly confused. Since then, guide and wrong-way signs and pavement markings provide better visual cues for the motorists. Many of the ramps which were determined to be confusing were modified with signs, pavement markings and sometimes minor reconstruction of ramp terminals. The number of wrong-way entries caused by confusion is now believed to be minor. Drivers under the influence of alcohol are the major cause of wrong-way accidents. However, improvements in interchanges and ramps to discourage wrong-way entries may still be desirable at some locations.

The following figures illustrate some of the factors which should be considered in new designs or in reconstruction to reduce wrong-way entries. Incomplete and partial interchanges, such as the half diamond, pose a particular problem. Sometimes motorists will risk using an off-ramp to enter a freeway if the on-ramp is miles away. A similar situation exists for motorists exiting the freeway using on-ramps. During construction or maintenance activities, closure of some ramps encourages wrong-way movements. When an off-ramp is closed (for example for maintenance), advance notice and detour guide signs should be considered on both the freeway and the surface streets; otherwise some drivers may exit the freeway and make an illegal U-turn across the median to the off-ramp on the other side of the freeway.

Interchanges with short sight distances at the decision points have a disproportionate number of wrong-way movements. These locations lack some of the visual cues, such as headlights of on-coming vehicles, which may alert the wrong-way driver. If possible, the sight distances at decision points should be as long as possible.

It is especially important that the wrong-way signs on both sides of the off-ramp and pavement arrows be visible from the decision points in the intersection. Guide signs should lead motorists to the correct on-ramp. When a local road is located opposite an off-ramp, special attention is required. The stop bar of the local road may be rotated toward the direction of travel to assist the driver in facing toward the on-ramp. The stop bar on the frontage road should not be perpendicular to the facing off-ramp, but rather slanted to direct drivers away from the facing off-ramp. Also helpful are pavement markings, such as directional turning arrows and lead lines with buttons or reflective markers, double yellow center lines and even curbed medians on the cross street.

Consistency and predictability are helpful in avoiding wrong-way movements. For example, if every interchange in a series of interchanges are of the cloverleaf type, the driver will consistently maneuver to the right lane to reach the freeway entrance ramp from a local street. Advance trail-blazing guide signs are particularly helpful for on-ramps requiring left lane entry from the city street.

Drivers can make only one decision at a time. Since motorists are used to a maximum of four legs at an intersection, five-legged intersections near off-ramps should be avoided. A tee intersection with the off-ramp perpendicular to the frontage road demands fewer decisions. Ramps should be located far enough apart for guide signs to provide precise on-ramp entrance information.

Many accidents occur when drivers collide with bicyclists at the ends of off-ramps. The drivers are looking to their left and the bicyclists are coming from the drivers' right, riding on the wrong side of the road. Markings for two direction bicycle flow on one side of a city street invites an unfavorable situation near off-ramps. Bicycling against traffic on the wrong side of the street is illegal in California.

Wrong-way entries due to confusion have largely been eliminated after years of research on the design of ramps, interchanges and their signing. Changes have been made to the Design and Traffic Manuals to reduce wrong-way accidents. The problem of how to deal with intoxicated drivers continues to present a difficult problem.

Changes in design policies have also been made as a result of wrong-way research. This information has been transmitted to designers in the past. However, new engineers are now entering the organization. The following figures could form the core of a training program or instructional bulletin for these new engineers. New interchanges are being built, and others are being modified as a result of property development.

It is important that the wrong-way problem be fully considered in these new designs. Therefore, it is recommended that training efforts be scheduled, especially for the new engineers.

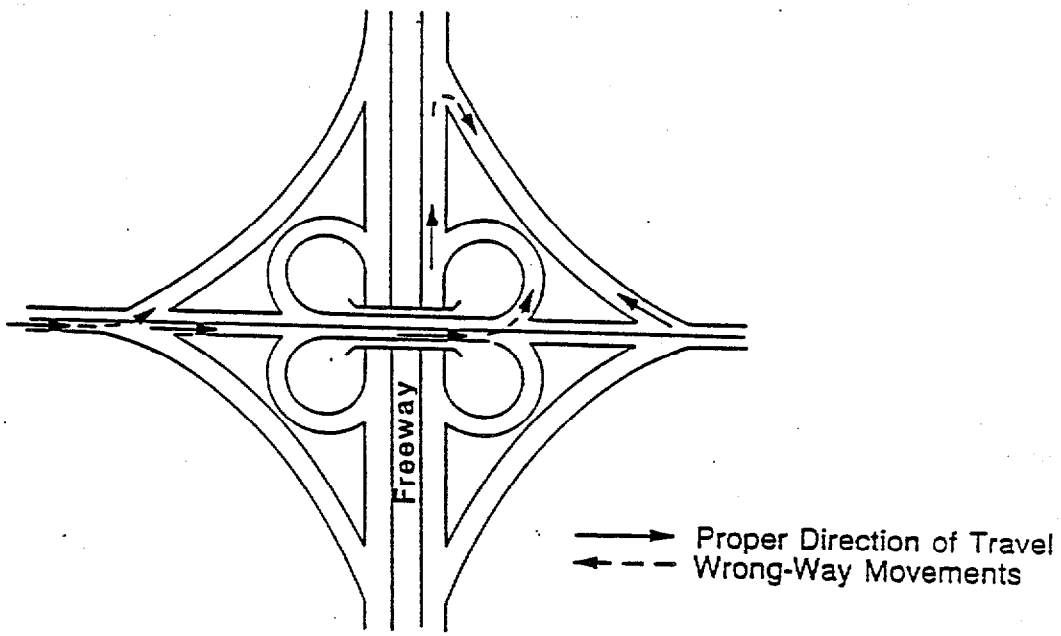


Figure 6

Cloverleaf Interchange

Cloverleaf interchanges are the most desirable type of interchange to avoid wrong-way movements. Freeway access is provided in both directions with only right turns. Wrong-way movements are seldom a problem with this interchange, but the provision of a double yellow barrier stripe on the overcrossing bridge with reflective markers may help motorists stay on the proper side of the road. During the planning phase, developers sometimes try to apply pressure for a two quadrant cloverleaf (which is less desirable than the full cloverleaf interchange in terms of wrong-way entries) to create developed properties on the two opposite corners.

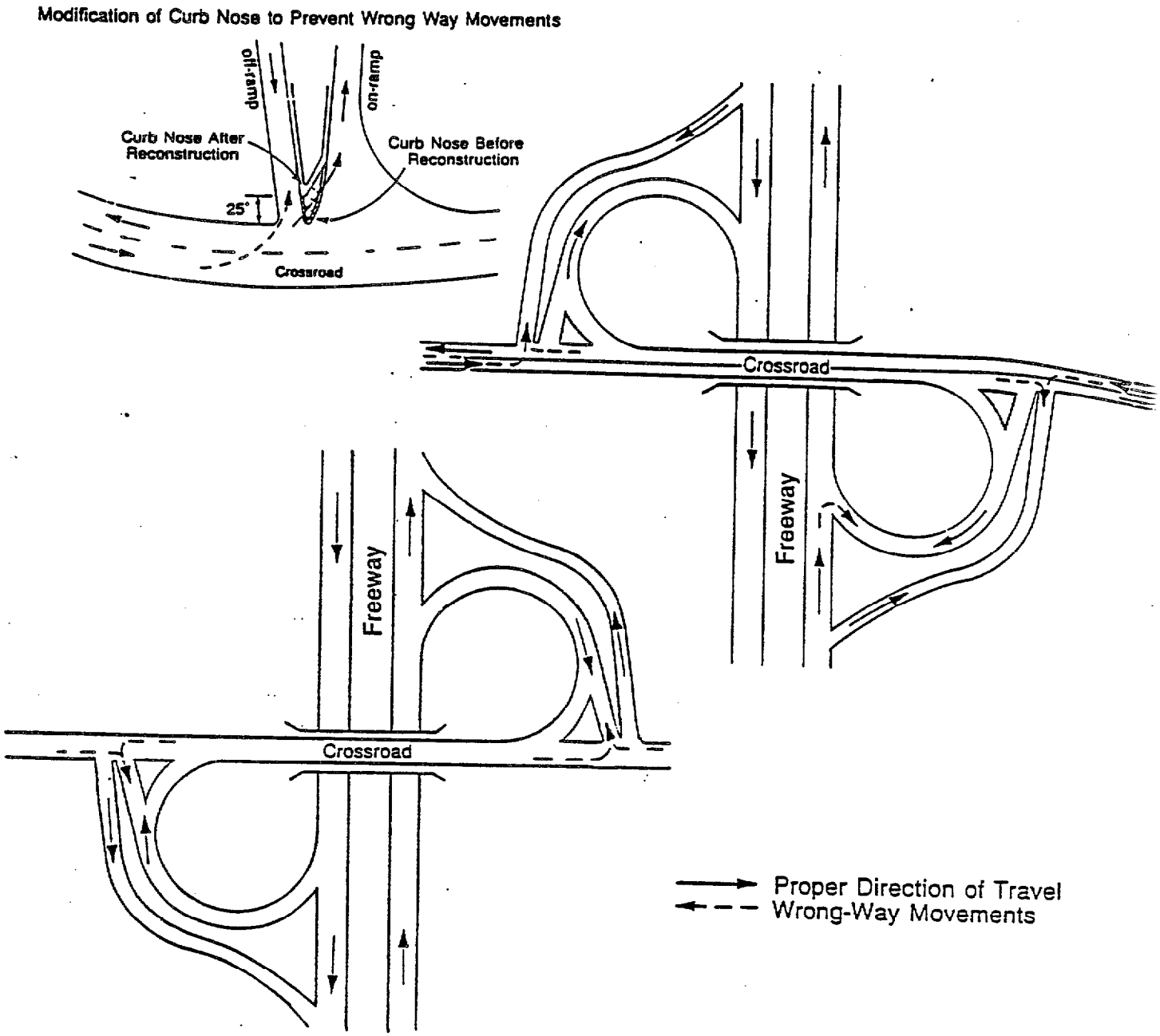


Figure 7

Two Quadrant Cloverleaf Interchange

Wrong-way movements may be prevented in two-quadrant cloverleaf interchanges by:

1. separating the on-and off-ramps;
2. designing the orientation of the on-ramp for easy access;
3. constructing a larger, better lit opening for the on-ramp than the off-ramp;
4. reconstructing the curb nose between adjacent ramps;
5. grading the on-ramp entrance for better visibly than the off-ramp as viewed from the cross-road.

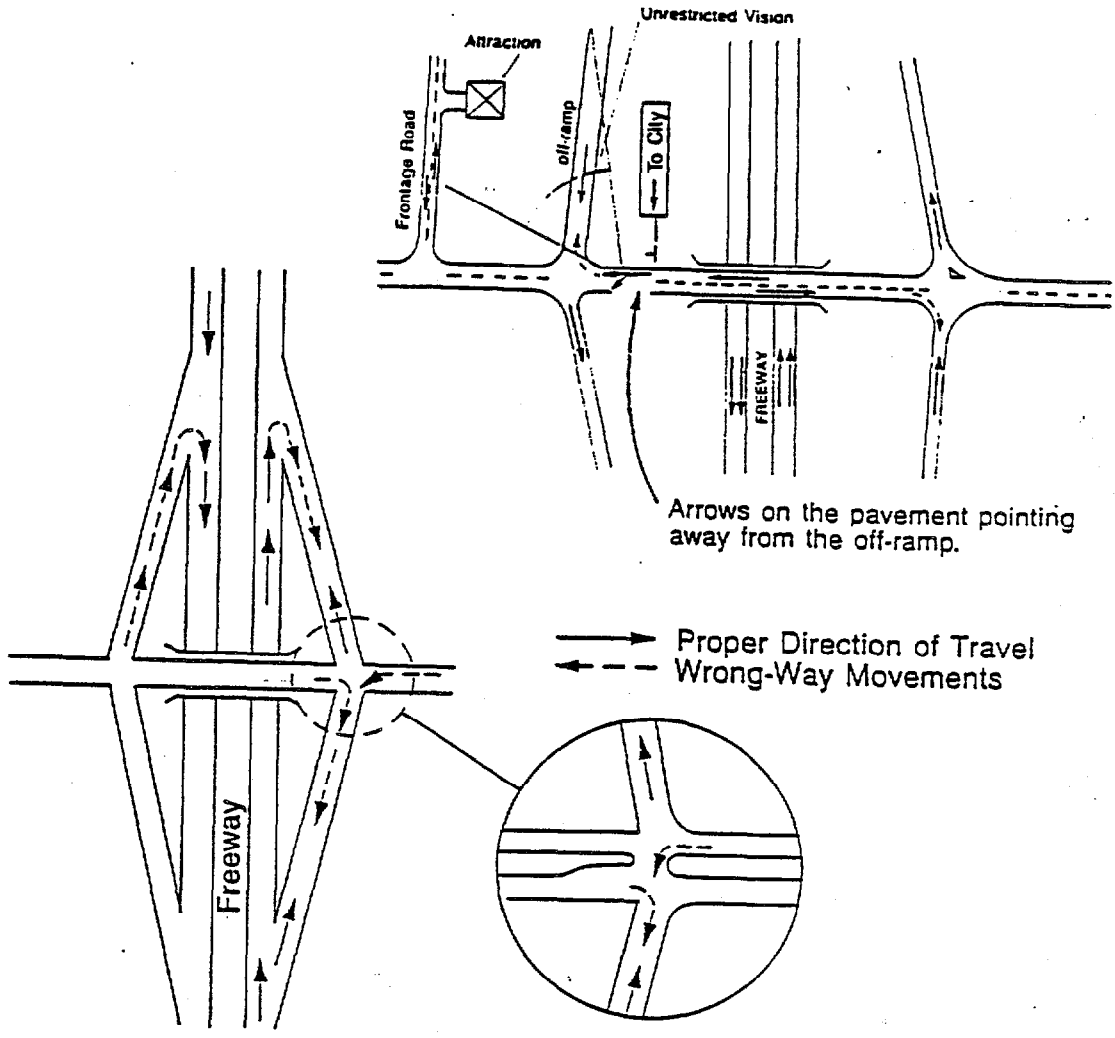


Figure 8

Full Diamond Interchange

Occasionally, motorists will mistake an off-ramp of a diamond interchange for a frontage road located parallel to the ramp. If an attraction exists on the frontage road, signing is important in order that the motorists will not confuse the off-ramp with the frontage road. Signing to the attraction should be placed away from the off-ramp. The wrong-way signs and markings should be visible from the decision points in the intersection.

To prevent left turns on to an off-ramp, an island may be constructed to partially overlap the off-ramp. Thus, a motorist would have to make an unnatural turn to enter the off-ramp.

Proper guide signing and direction pavement arrows are important to direct motorists to the correct lane for the left turns onto the freeway. Lead pavement markers may also be installed to direct to the entrance of the on-ramp. If space permits, a left-turning lane may be provided.

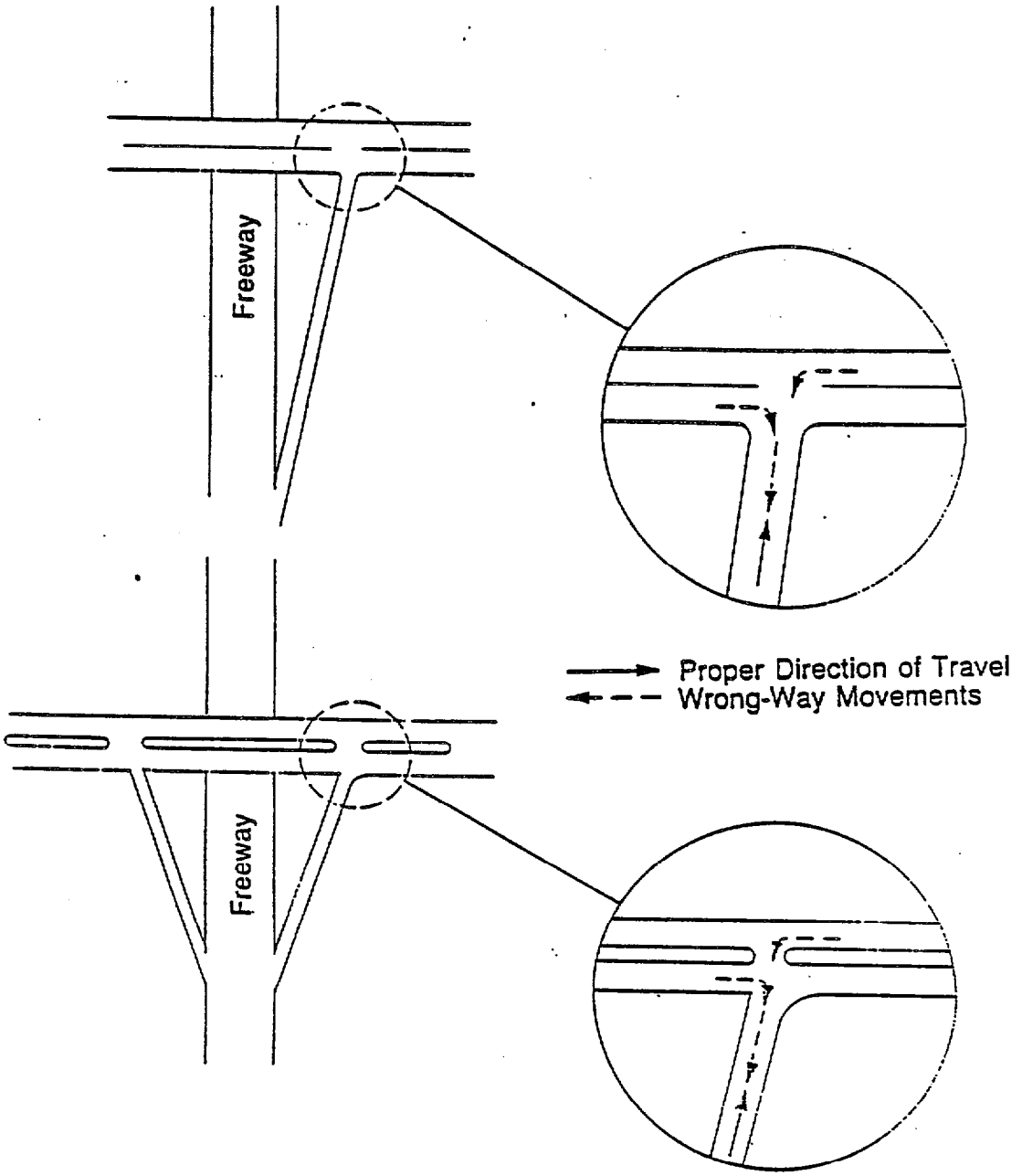


Figure 9

Half Diamond Interchange

Access to the freeway from all directions is not provided for in half diamond interchanges. Therefore, good signing is extremely important. If the guide signing does not clearly indicate a safe route for the drivers to enter and exit the freeway, wrong-way movements may result. Also, as in partial interchanges, some may use U-turns to reach the freeway exit.

A full diamond interchange may function as a half-diamond at the time when ramps are closed for maintenance activities. Temporary signs are needed to give information on times of ramp closures and alternate routes available.

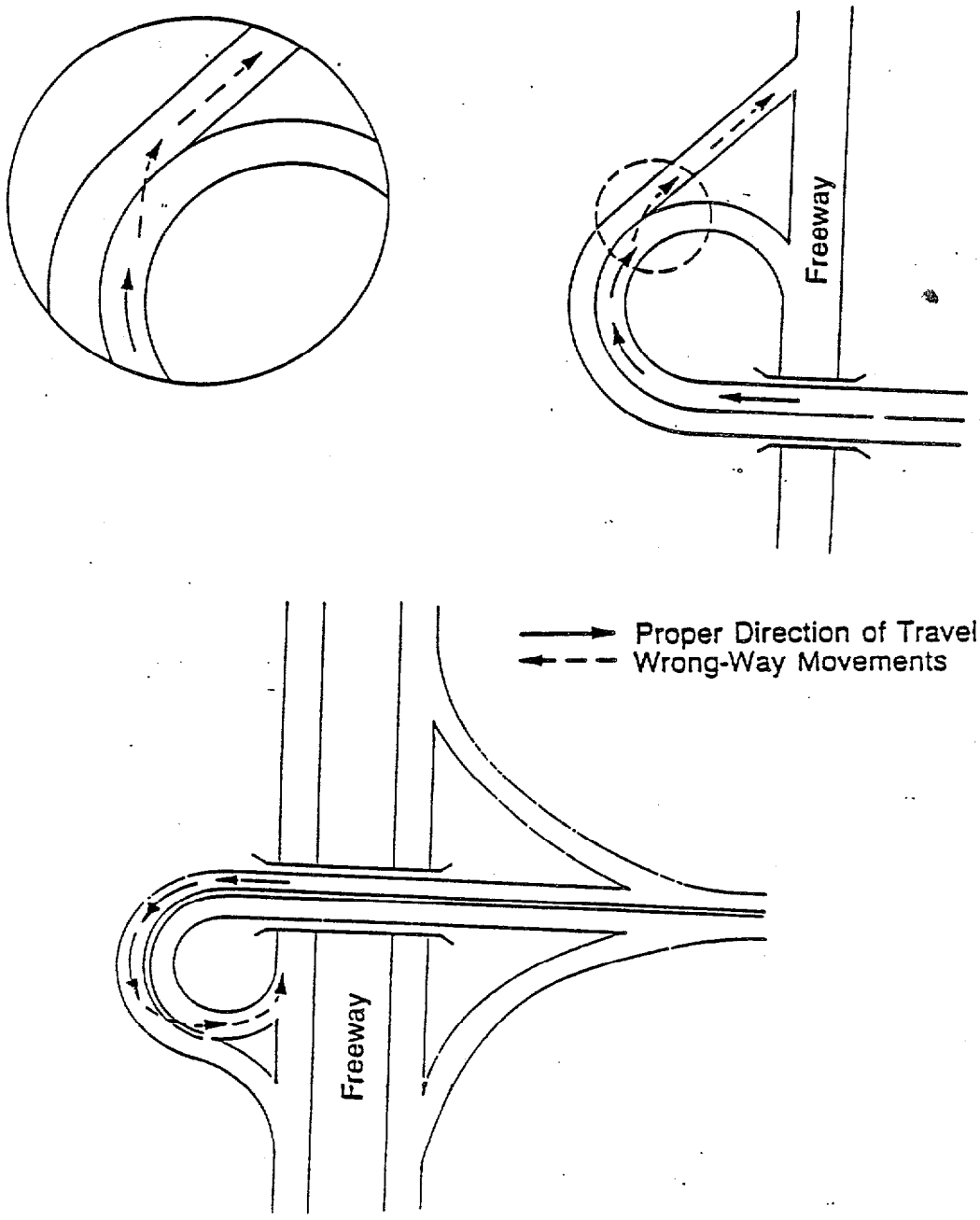


Figure 10

Trumpet Interchange

Wrong-way movements can be avoided in trumpet interchanges by installing curbed medians on the ramps or by using barrier stripes of double yellow lines and reflectors. As a last resort, a trumpet interchange may be modified by using a concrete median barrier.

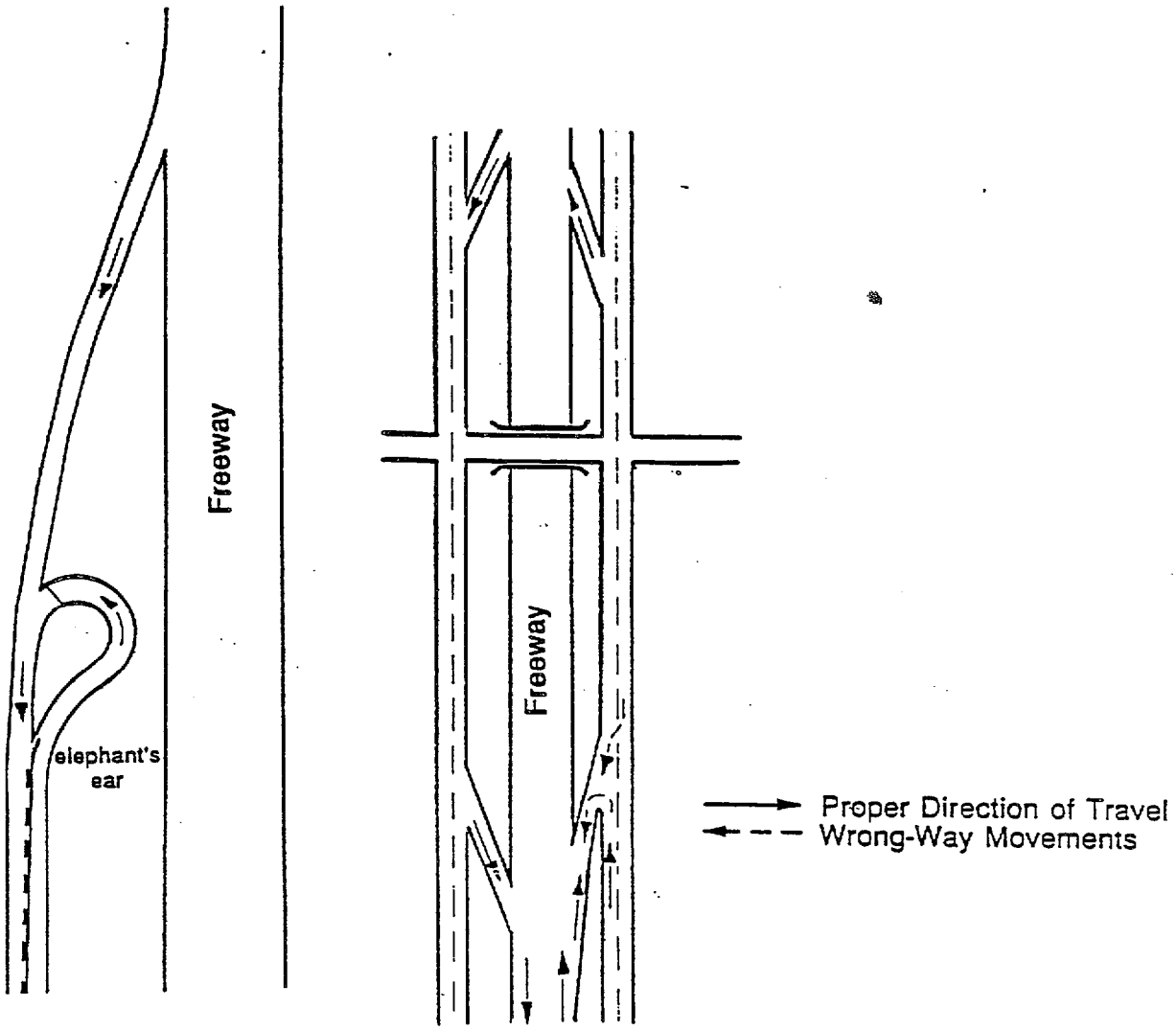


Figure 11

Slip Ramp

Relatively few problems exist with slip ramps, except in locations where a two-way frontage road terminates at a slip ramp. An elephant's ear with a stop sign may be installed at the end of the road to assist the motorist in turning around. Slip ramps entering frontage roads at flat angles are more desirable than those oriented perpendicular to the frontage road, since they discourage turns onto the one-way ramp. (See buttonhook ramps on the following page.)

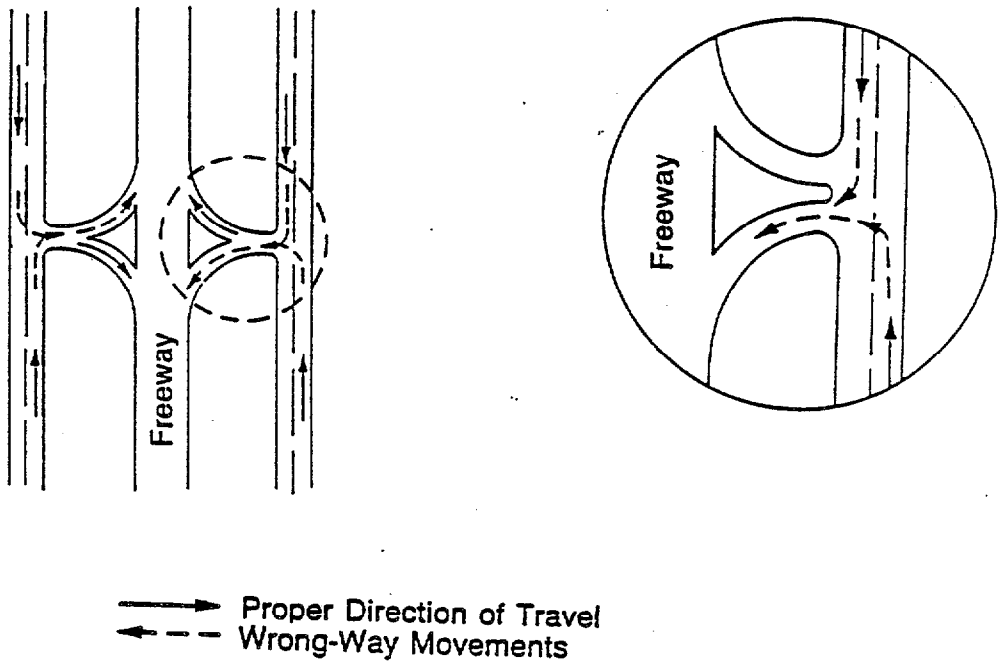


Figure 12

Buttonhook Ramp

Buttonhook ramps can be very susceptible to wrong-way moves. With clear separation of the on- and off-ramps and signing, the wrong-way movements can be decreased. The nose may be reconstructed, and the on-ramp made wider and better lit than the off-ramp.

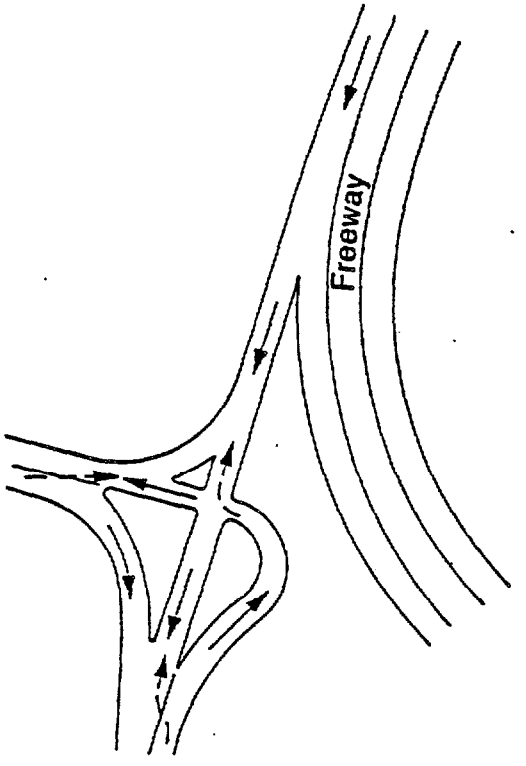


Figure 13

Cul-De-Sac Intersection Near Off-Ramp

This type of off-ramp should be obsolete in new designs, although many still exist. Directional arrows and wrong-way pavement arrows, lead lines, reflective markers, and special attention to wrong-way signs are required so that the motorist avoids entering the freeway in the wrong direction from the cul-de-sac off-ramp.

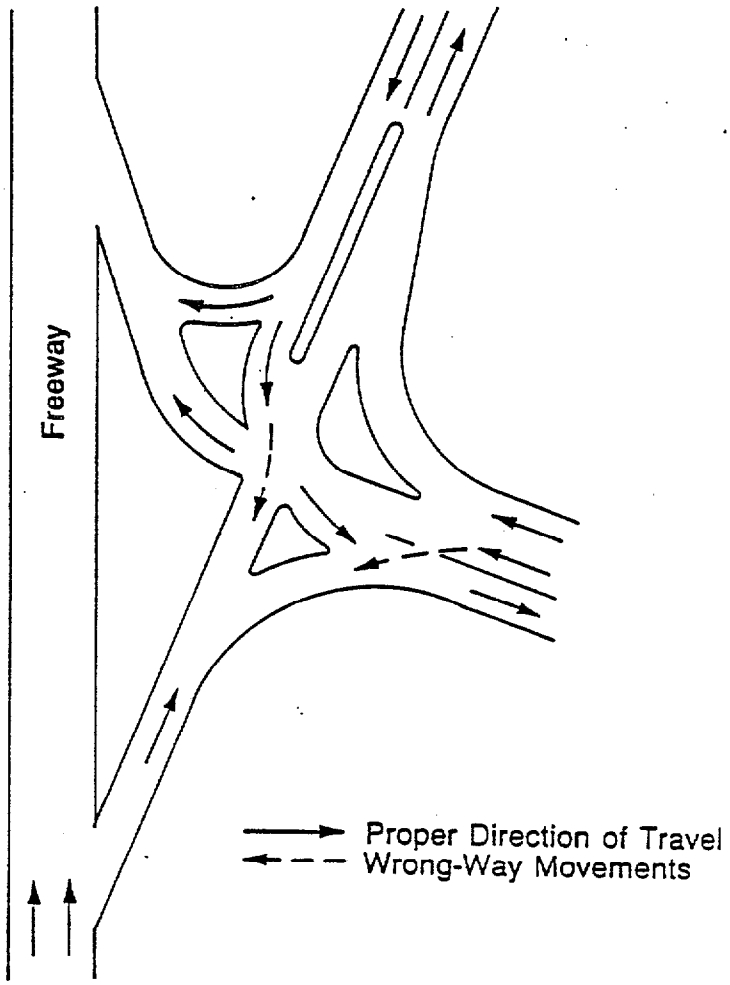


Figure 14

Scissors Off-Ramp

This type of off-ramp is also obsolete and can be confusing for some drivers who head straight ahead onto the off-ramp instead of turning left. Directional and wrong-way pavement arrows, lead lines and reflective markers and special attention to wrong-way signs are also needed.

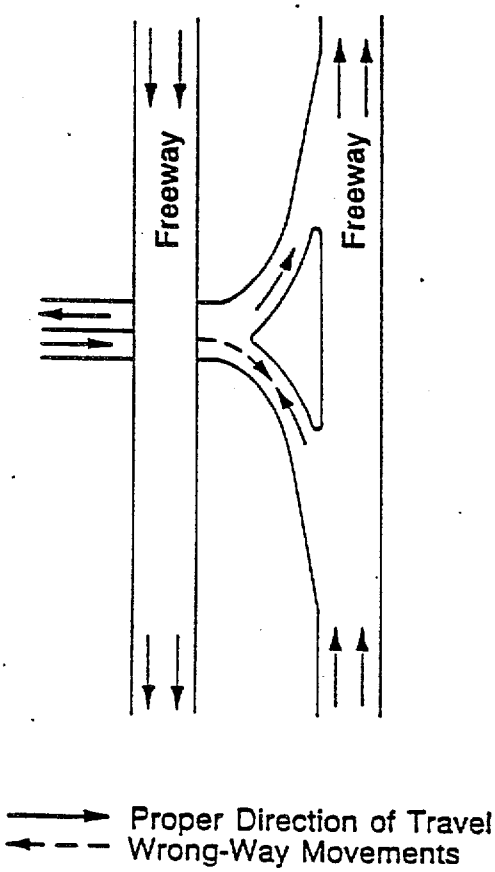


Figure 15

Left-Hand Off-Ramp

Left-hand off-ramps are obsolete and must be avoided in new construction. A driver naturally expects to enter the freeway using a right turn and may mistakenly make this turn and travel the wrong-way.

Work Done by Other States

A questionnaire was sent to the traffic engineers in the 50 states. Replies have been received from 40. (See appendix B for the questionnaire and state responses and appendix C for diagrams submitted by the other states.) The survey was designed to identify the actions taken by other states to reduce wrong-way accidents. Caltrans was particularly interested in knowing if anyone had developed special devices which would physically stop wrong-way drivers.

Most states have concluded that the most common cause of wrong-way accidents is alcohol. The Manual on Uniform Traffic Control Devices (MUTCD) is followed and considered adequate by most states for wrong-way signs and markings.

The traffic engineer's input into the planning and design process, the use of wrong-way pavement arrows, edge lines and painted channelization were mentioned as important in the effort to reduce wrong-way accidents.

One very important finding was that no state has developed special devices to physically prevent wrong-way entries. No traffic engineer responding to the survey endorsed the use of parking-lot spikes, barriers, raising curbs, etc. As mentioned previously, Caltrans has tested spikes and Georgia has tested raising curbs. Both states found the devices impractical.

In terms of the MUTCD, it is interesting that several states use more signs, better positioned than required by the MUTCD. Caltrans requires as a minimum more than twice as many signs (two wrong-way sign packages versus one in the MUTCD plus the freeway entrance totem pole which is optional in the MUTCD), better positioned (lower to be in the headlights or direct line of vision), and larger (36 inches versus 30 inches).

All of the techniques except one, mentioned by the states have been tried or considered in California. The one exception is the idea to carry edgelines on the crossing streets directly across the off-ramps to discourage right turns into the off-ramps.[18] Another possible solution would be to place heavier stop bars at the off-ramp. It is recommended that these ideas be further investigated for possible implementation and incorporation into the Traffic Manual.

California Highway Patrol Contributions

The California Highway Patrol (CHP) makes a valuable contribution in combatting wrong-way driving. The California Vehicle Code contains provisions in wrong-way accident-related areas such as sobriety, turning movements, and sign theft which are enforced by the CHP. Accident reports reveal that the typical wrong-way accident is caused by a driver who was either driving under the influence of alcohol or drugs, or had been drinking. The CHP has programs to remove these drivers from the road.

The CHP conducts two important programs: the Sobriety Checkpoint Program and the Sober Graduation Program. The aim of the Sobriety Checkpoint Program is to detect and remove drinking drivers from the road to reduce alcohol-caused accidents. Sites are chosen on the basis of high alcohol and drug related accident and arrest activity. For example, from May 1 to October 31, 1985, checkpoint teams screened over 16,000 vehicles, administered over 500 field sobriety tests and made over 200 arrests and citations in the Bakersfield and Sacramento Areas. Accidents caused by driving under the influence dropped 6% statewide, and 12% in the North Sacramento area. The cost, including salaries and equipment, was $51,887 for the 23 checkpoints.

The California Supreme Court ruled on October 29, 1987 that operation of the sobriety checkpoints was constitutional. The CHP resumed state wide checkpoints on November 27, 1987 in time for the holiday season. From the end of November 1987 to the end of September 1988, over 900 arrests were made after screening over 83,000 vehicles at 114 Sobriety Checkpoints.

The goal of the Sober Graduation Program, started in 1985, is to curb drinking and driving among young people. It is conducted during May and June, the two months of proms, grad nights, and end-of-school celebrations. The community-based effort involves 15 to 19-year-old drivers in accepting the 'don't drink and drive' message themselves and then delivering it to their peers.

The Sober Graduation Program is a catalyst that is unique to each area of the state. The CHP distributes basic materials like television and radio public service announcements, posters, bumper stickers, decals, key chains, and book covers. The CHP works with student groups, and local individuals and organizations. The Sober Graduation Program has a different creative emphasis in each community. Local involvement is the key to its success. The results of this program have been rewarding. In the 1985 May to June period alone, fatal accidents in this age group dropped 25%, and injury accidents decreased 19%.

Two examples of Sober Graduation Program radio announcements are:

1."On grad night will you let your friends down? Of course not. That's why no one you know is gonna drive if they've been drinking. You won't let them, because you <u>care</u> about them. K_____ and the CHP care too. Have a Sober Graduation Class of '88 and make it to your future!"

2. "What's the best thing about graduation? Friends, family, fun, the future? K_____ and the CHP suggest that the <u>best</u> thing about graduation is being around tomorrow to start the rest of your life. Sober Graduation. Make it to your future!"

The Sobriety Checkpoint and Sober Graduation Programs appear to be very effective. Another way, however, in which the CHP can be of assistance is to make a special effort to report missing, damaged or worn wrong-way signs to Caltrans. Also the CHP can note on accident reports identified or suspected entry points in wrong-way accidents or in observed wrong-way travel. It is recommended that the CHP be contacted again, stressing our continued interest in wrong-way accidents. Renewing our request for information, such as outlined above, will help solve this problem.

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Appendix A

Check List for Wrong-Way Entry Review

Check List for Wrong-Way Entry Review

1. Review pertinent accident reports. Using the aerial photographs, review ramps, cross roads, and median openings 3 miles upstream (less in urban, more in rural areas), from the accident location. Field investigation of ramps located within these 3 miles of the wrong-way accident site may reveal needed improvements in signing and striping. Bring figures 4-15 to 4-24, 6-16, 6-24, and 6-38 from the Traffic Manual with you.

2. Inspect off-ramps during both daylight and dark conditions, especially if the accident occurred at night. It is desirable to check the general visibility close to the same time of day and weather condition as when the accident occurred (sunrise, sunset, dark, fog, rain, etc.) Choose a safe observation location near entry points to the off-ramp where a wrong-way driver may have driven. Get out of your vehicle and view the scene from the wrong-way driver's perspective.

3. Check if Do Not Enter sign packages (R11 over R11A) are:

- ☐ present in the minimum quantities (See Traffic Manual figures),
- ☐ visible from the entry decision point; not too far back,
- ☐ mounted at the recommended height (about 2' above the edge of the traveled way pavement but visible to headlights),
- ☐ unfaded (3M company will replace faded signs 2 for 1),
- ☐ not hidden by other objects or bushes ,
- ☐ oriented at the best possible viewing angle,
- ☐ in good repair (riveted or bolted connections, etc.),
- ☐ and free from graffiti,
- ☐ specify replacement and added signs made of high intensity sheeting.

4. Check if the 24' wrong-way pavement arrows (figure 6-23) are:

- ☐ in the proper locations starting at about 20' from the limit line,
- ☐ present in the minimum quantity (at least 2 per lane),
- ☐ visible, with a reflective freshly painted look,
- ☐ unfaded, not covered with grease, not chipped away,
- ☐ not embedded between directional arrows in left/right only lanes.
- ☐ Highly reflective thermoplastic material may be specified for replacement and added wrong-way arrows.

5. Check if other pavement directional arrows (figure 6-23) are:

- ☐ visible,
- ☐ unfaded, not covered with grease, not chipped away.

6. Check for the presence of other signs which discourage wrong-way movements:

- ☐ One Way (R10, R10A) about 1 1/2 ' above the edge of traveled way pavement, but visible to headlights;
- ☐ No Right/Left Turn (R16B, R17B);
- ☐ No U-Turn (R34, R34A);
- ☐ Keep Right (R7, R7A);
- ☐ Divided Highway (R98, R98A, W25, W25A, W26, W26A);
- ☐ Two Way Traffic (W44).

7. Off-ramp openings should discourage wrong-way entry from the cross street. The openings should:

- ☐ be narrow, and
- ☐ have an island or painted median dividing parallel, adjacent on and off-ramps,
- ☐ have small radius corners on either side of the throat and be aligned towards local street travel.
- ☐ Also, red-clear markers may be used on the freeway mainline approaching exit ramps (fig. 6-2, det. 14; fig. 6-9, det. 36-37; fig. 6-17).

8. Freeway entrances must be obvious and accessible.

- ☐ Check that pathfinder-trailblazing signs are adequate for motorists to find the freeway entrances,
- ☐ entrance packages are in place and in good condition,
- ☐ one 18' entrance arrow per lane exists, in good repair (fig. 6-23),
- ☐ freeway entrances are better lit than exits (fig. 9-15, 9-16),
- ☐ interchanges are complete so motorists never have to enter a freeway using an off-ramp.

9. Where left turning movements may be confusing in an intersection adjacent to an off-ramp, recommend:

- ☐ turning guide lines, either solid or broken,
- ☐ pavement markers to aid the turning movement,
- ☐ pavement markers on guide lines (good wear for high ADT),
- ☐ directional pavement arrows.

10. Consider eliminating factors which contribute to wrong way moves on adjacent right of way by:

- ☐ recommending removal of guide signs or privately owned directional signs located close to the off-ramp which may encourage wrong way entry,
- ☐ locating guide signs for frontage roads paralleling off-ramps far from the off-ramp opening,
- ☐ removing bushes and structures which decrease visibility.

- ☐ During the planning process, discourage the location of business driveways next to off-ramps in original right-of-way agreements,
- ☐ deny permission for bar permits near freeway ramps.

11. Any recommendations which result from the field investigation should be approved by a supervisor with Traffic Engineering experience before filling out the HT-65 form. Recommendations shown on the HT-65 form must be accomplished in a timely manner to prevent tort liability. Do not editorialize. Never write suggestions on the HT-65 form which will not be accomplished. Recommendation for the installation of wrong way preventive treatments such as wrong-way packages and pavement arrows do not require a safety index > 200, but do require engineering judgment; Minor B funding is at the discretion of the District.

12. In locations where sign theft is a problem, try:

- ☐ replacing any missing signs with those made of synthetic material,
- ☐ coating the backs of existing signs with a thick layer of grease.

13. For recurring problems, try:

- ☐ reviewing through another pair of eyes,
- ☐ installing more Do Not Enter sign packages, larger Do Not Enter sign packages, illuminating the signs, or increasing the number of pavement arrows,
- ☐ monitoring with camera or video to isolate the sources and patterns of the problem,
- ☐ observing traffic flow during different times of day,
- ☐ increasing traffic flow on low ADT off-ramps (reroute),
- ☐ closing the ramp or a road to the intersection,
- ☐ regrading or realigning ramps with limited sight distances,
- ☐ regrading or realigning portions of freeways where sight distances are < 1200 feet,
- ☐ constructing wrong-way, vehicle activated red pavement lights,
- ☐ contact Headquarters Traffic Operations or other districts for new ideas.

Figure 4-15

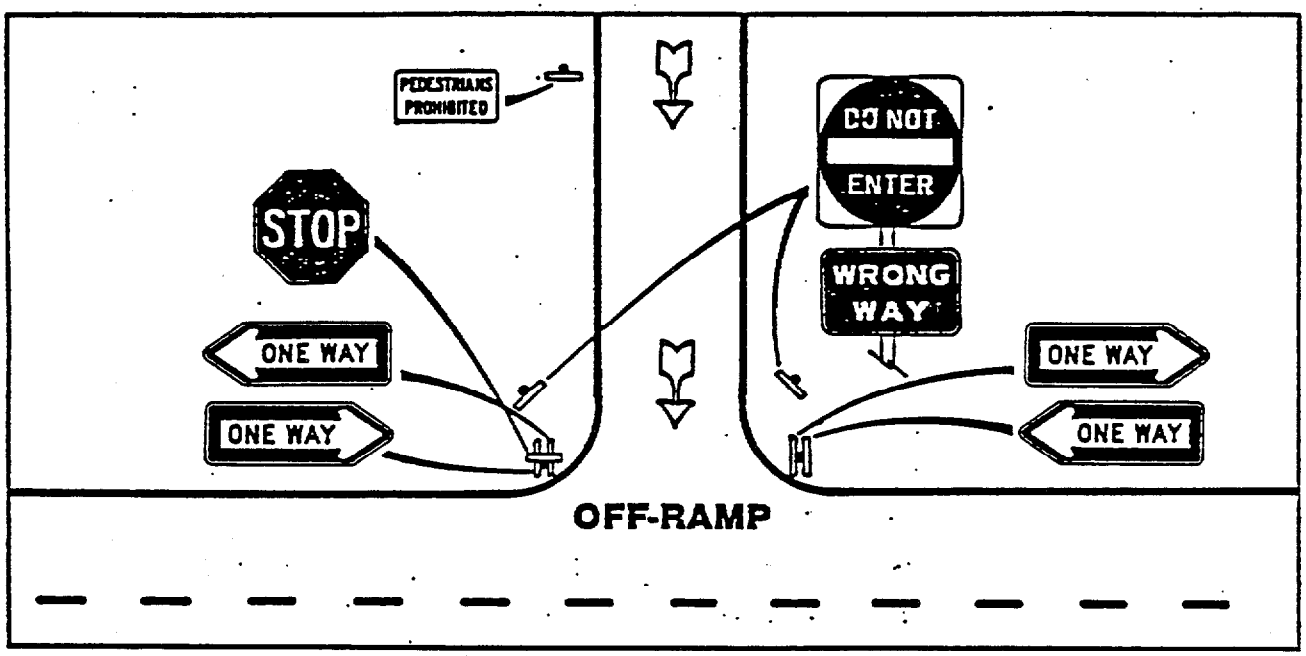


Figure 4-16

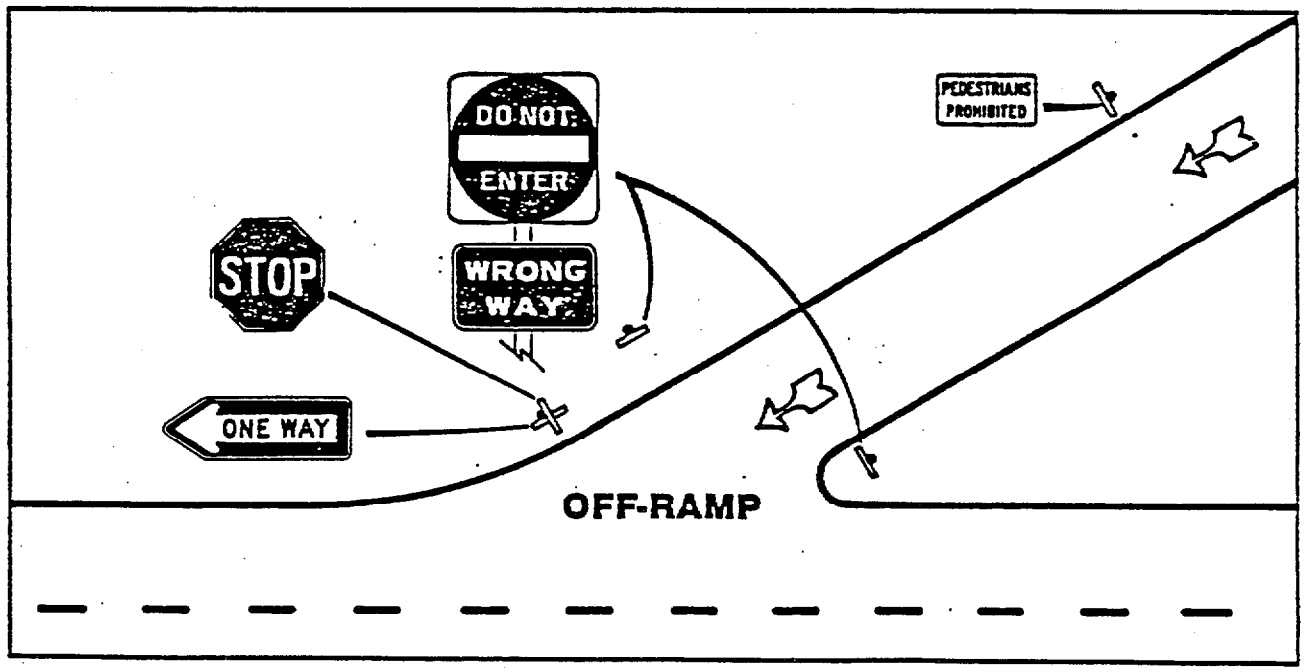


Figure 4-17

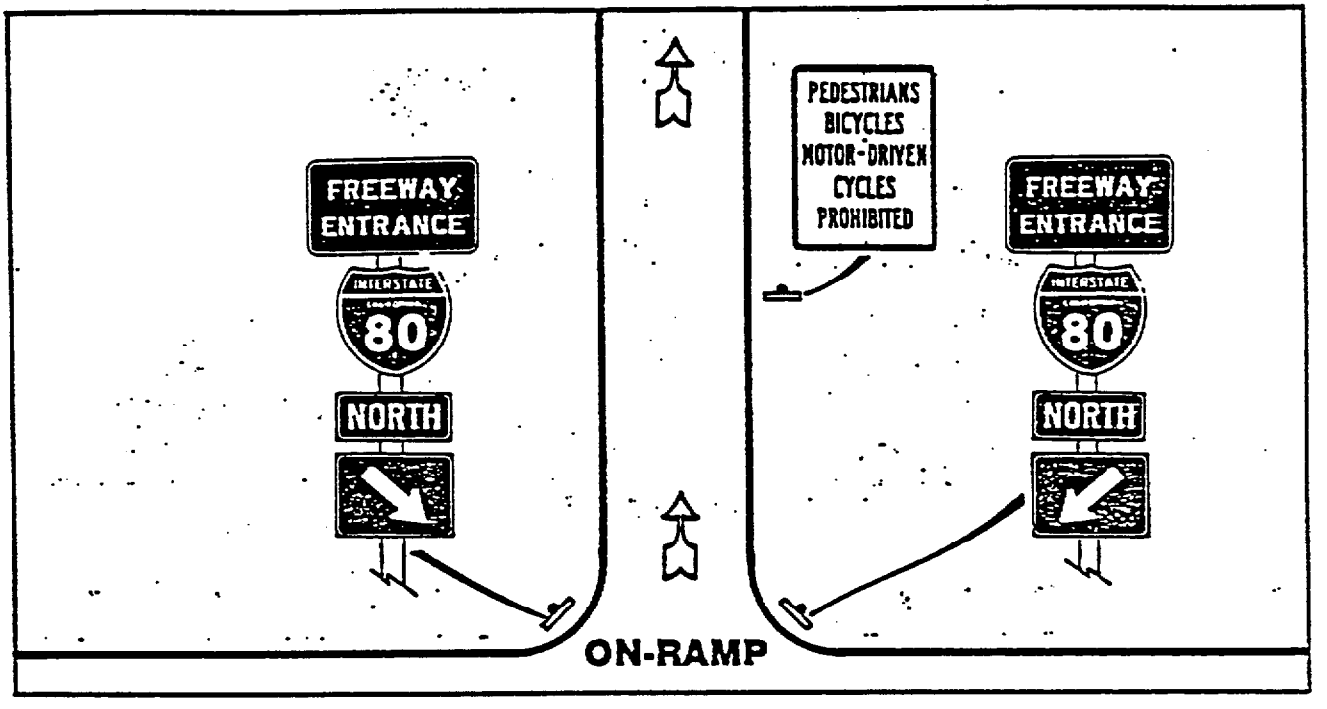


Figure 4-18

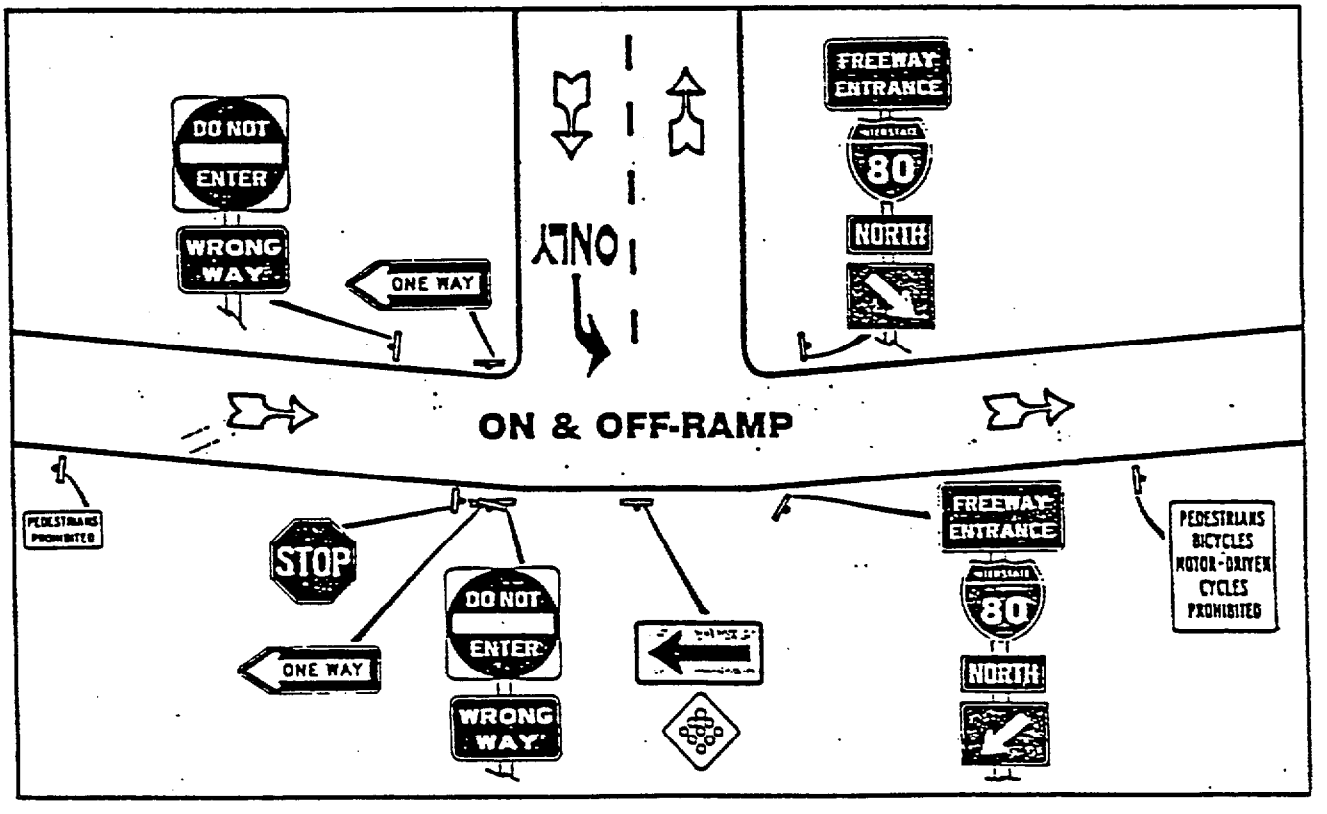


Figure 4-19

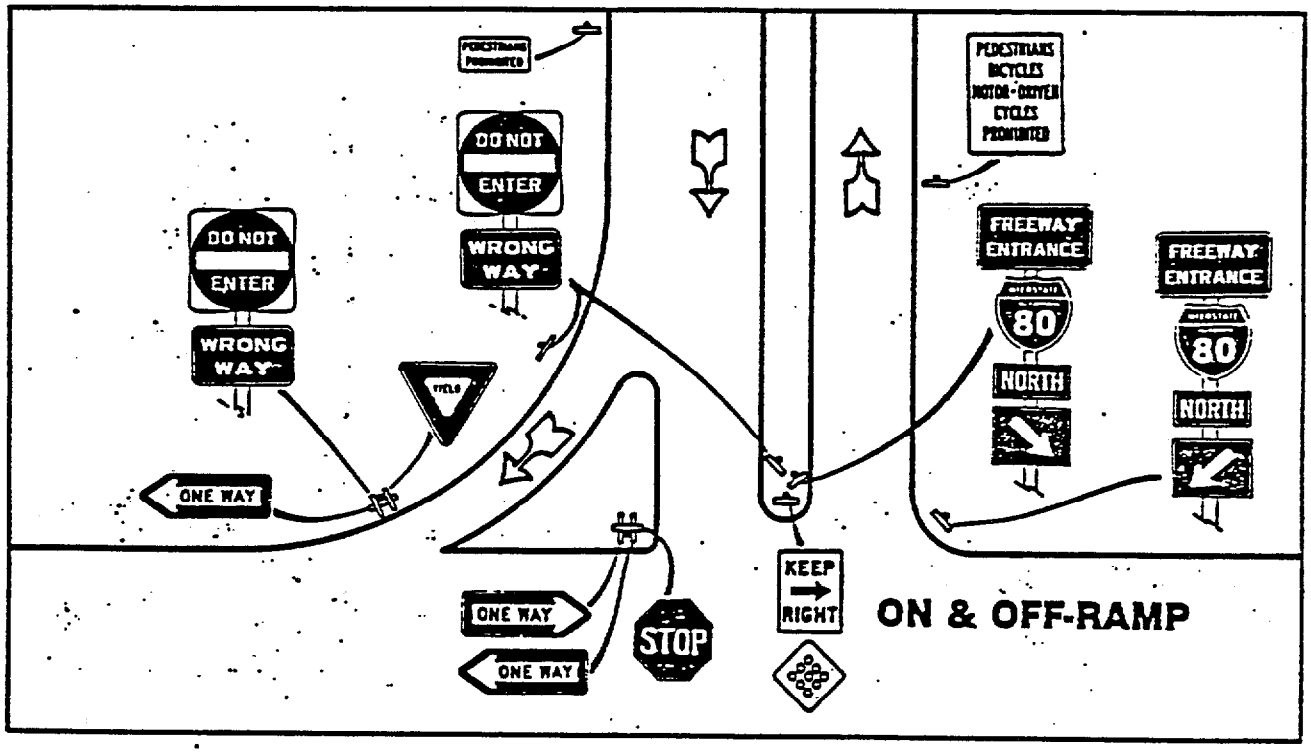


Figure 4-20

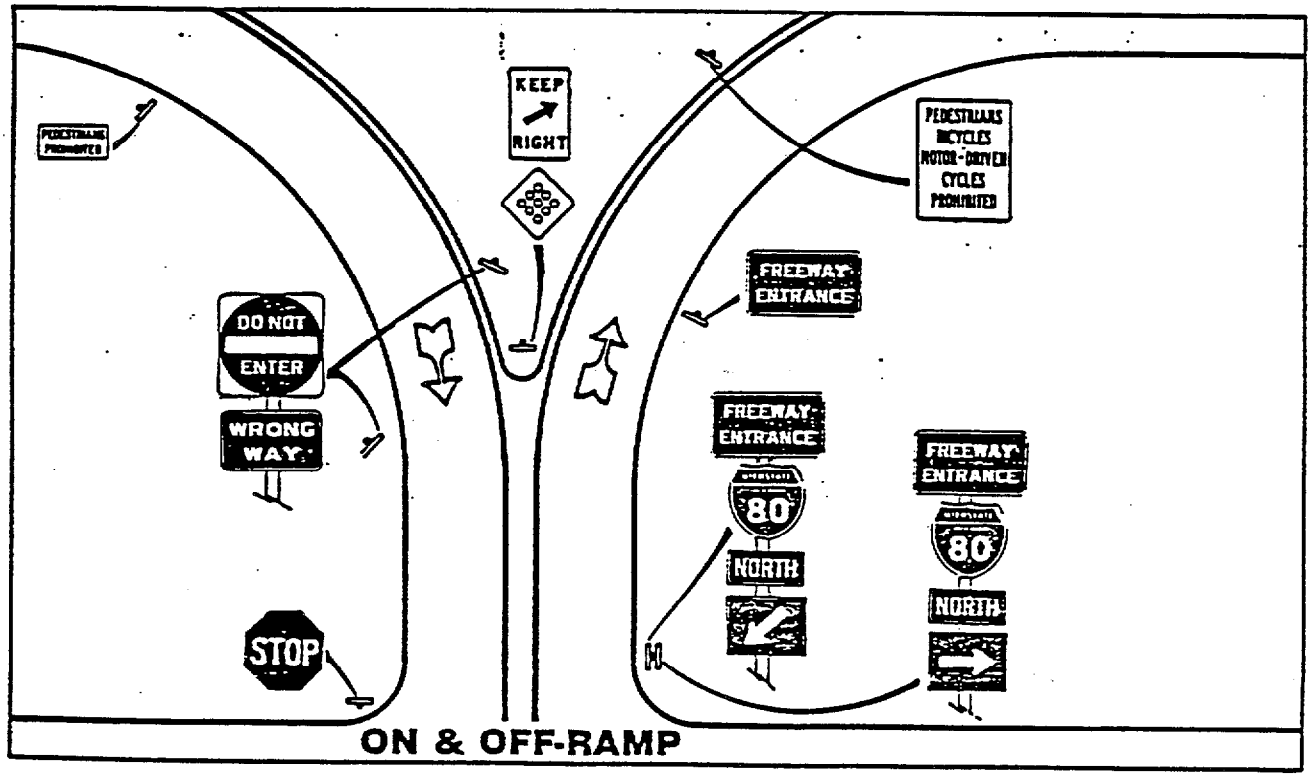


Figure 4-21

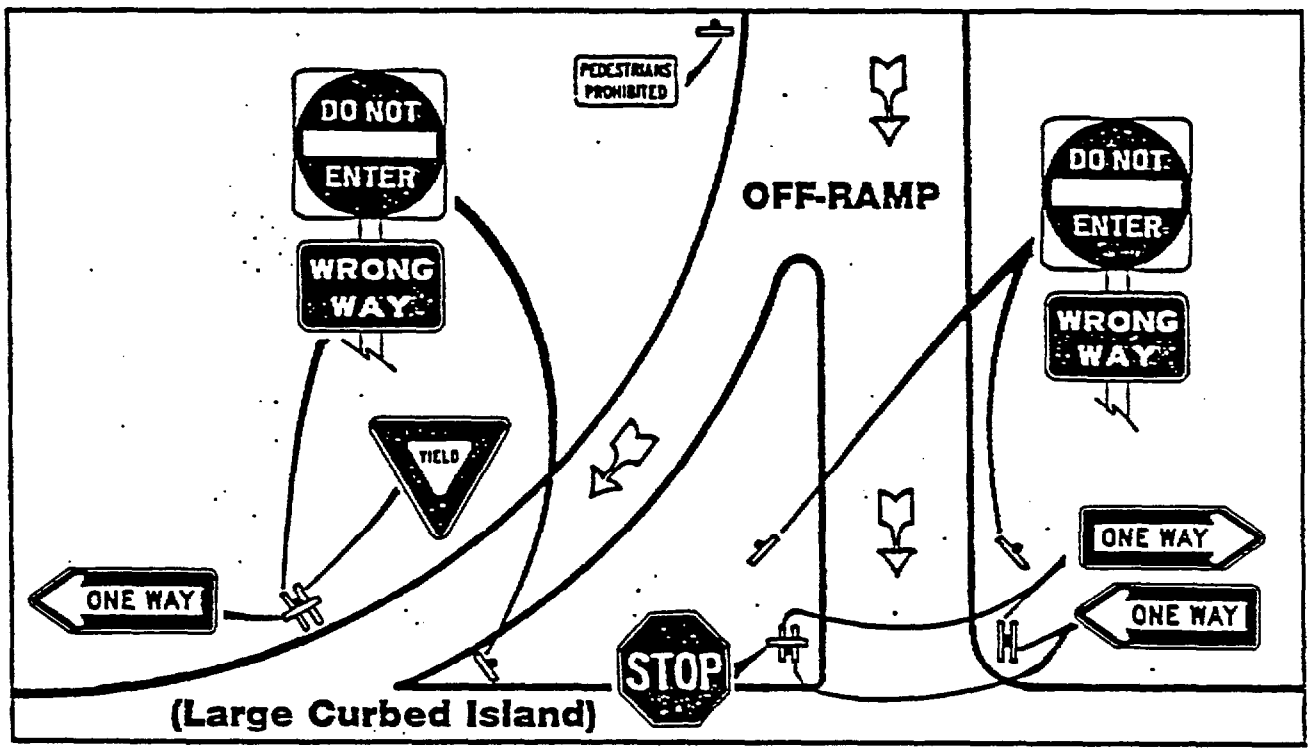


Figure 4-22

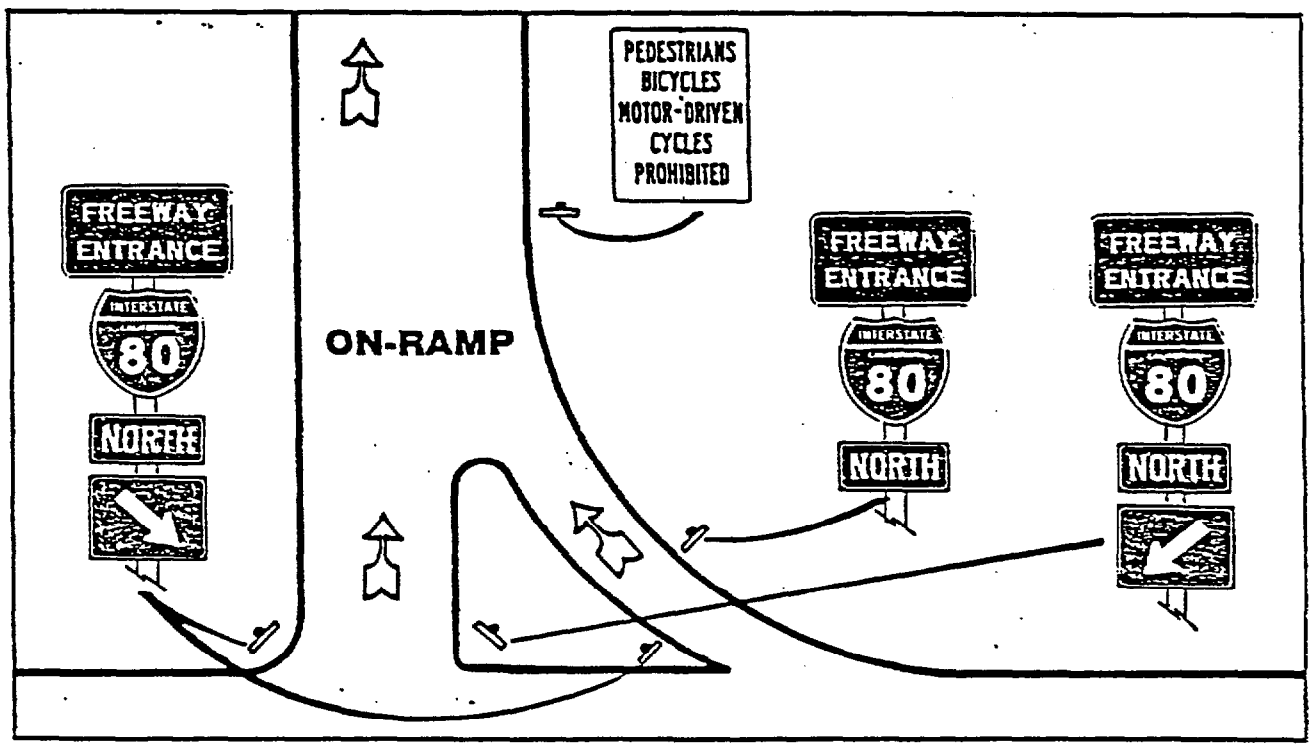


Figure 4-23

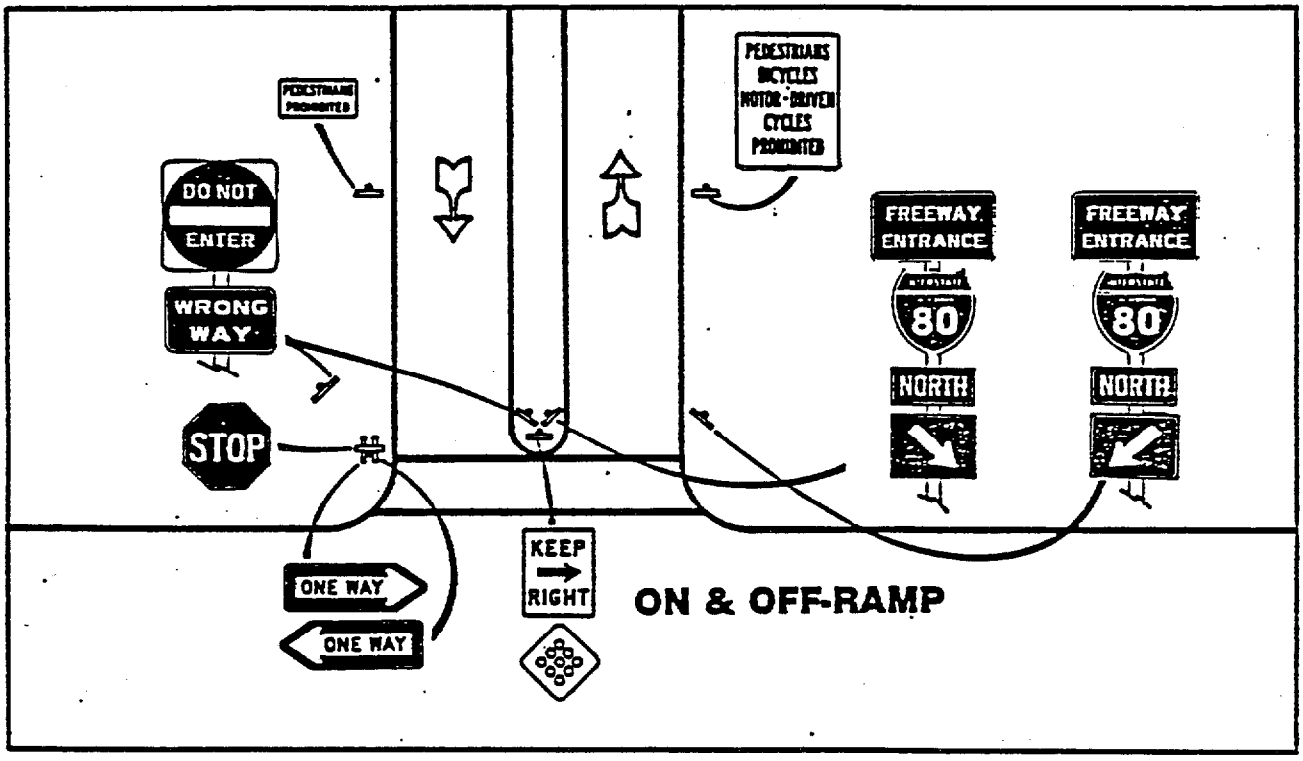
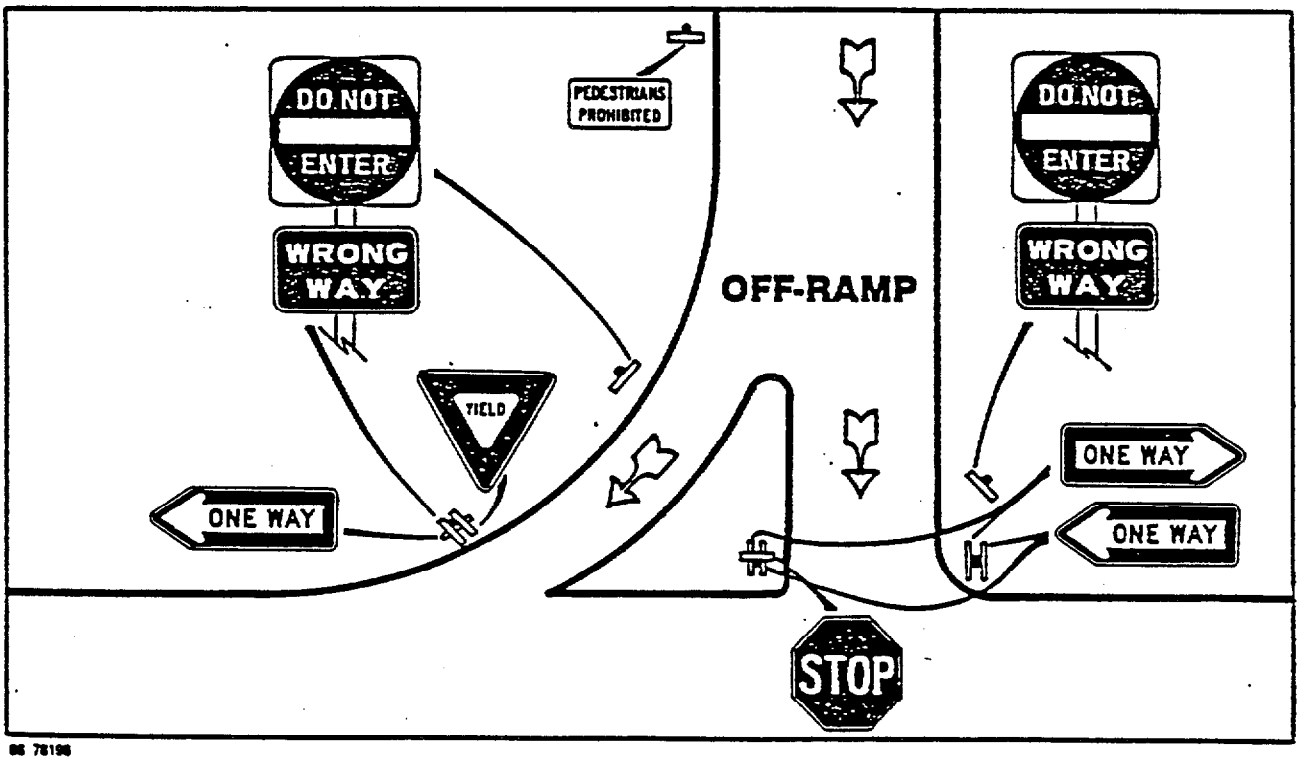


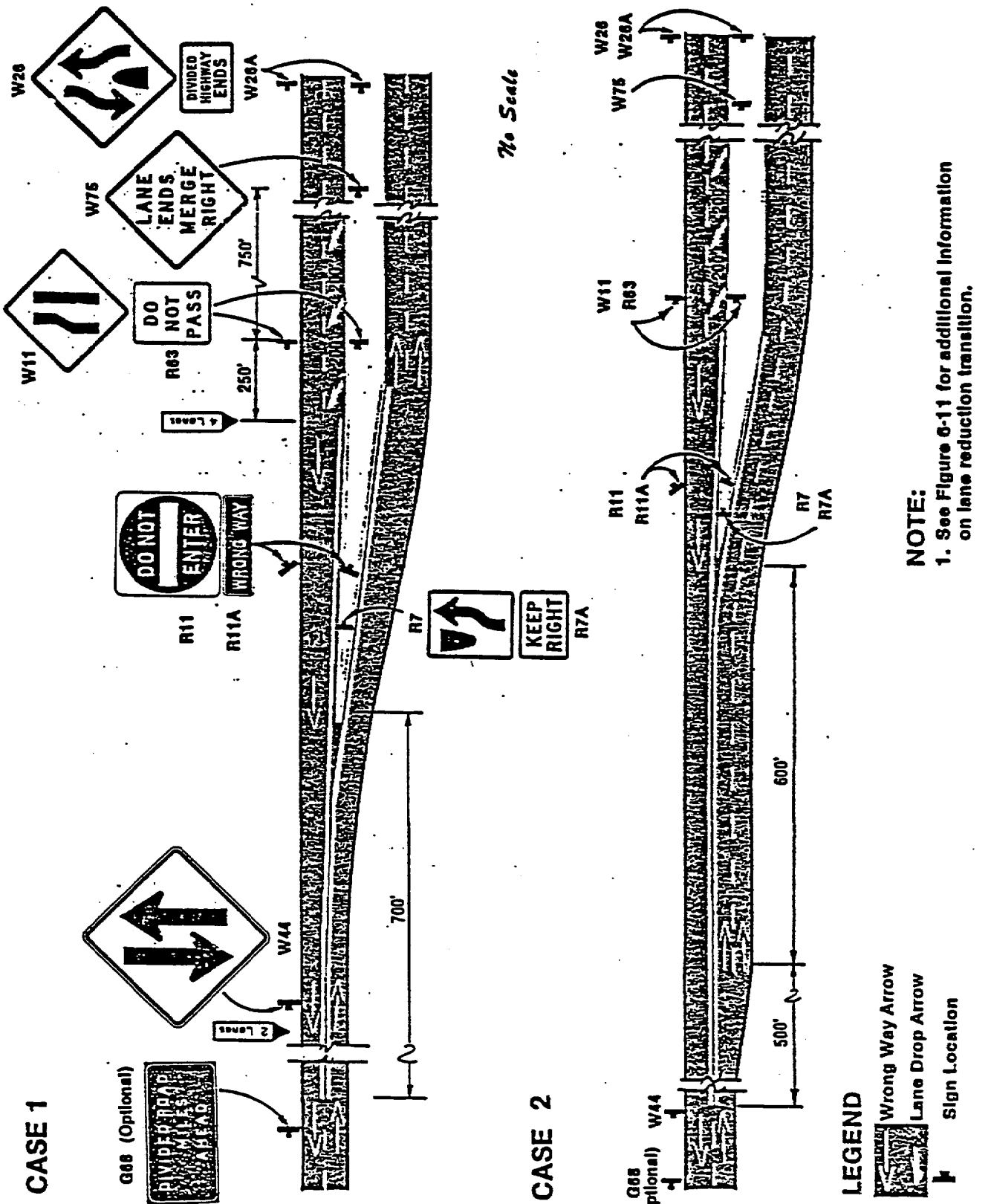
Figure 4-24

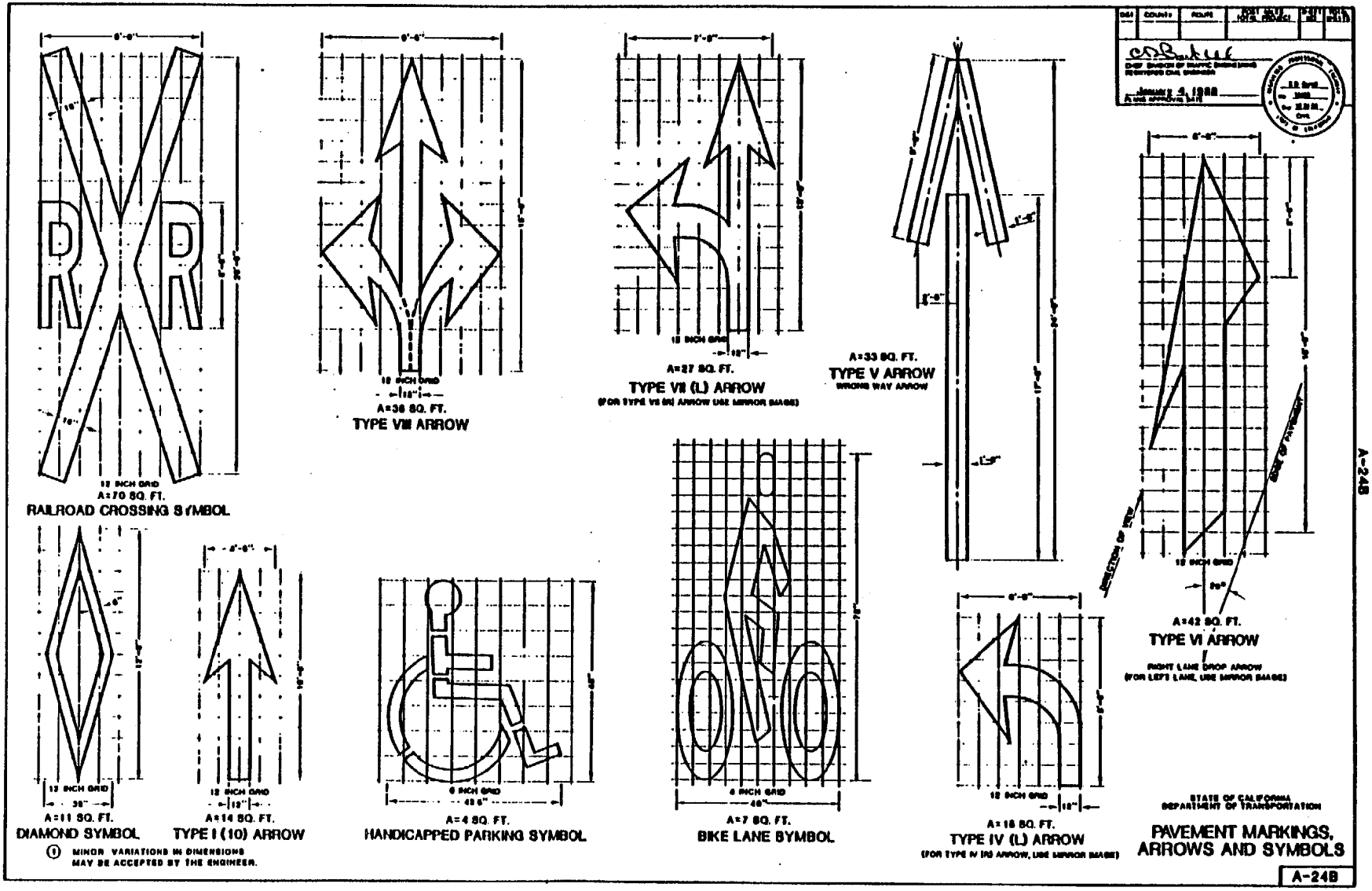


86 78198

Figure 6-16

TRANSITION FROM TWO-LANE TO FOUR-LANE DIVIDED



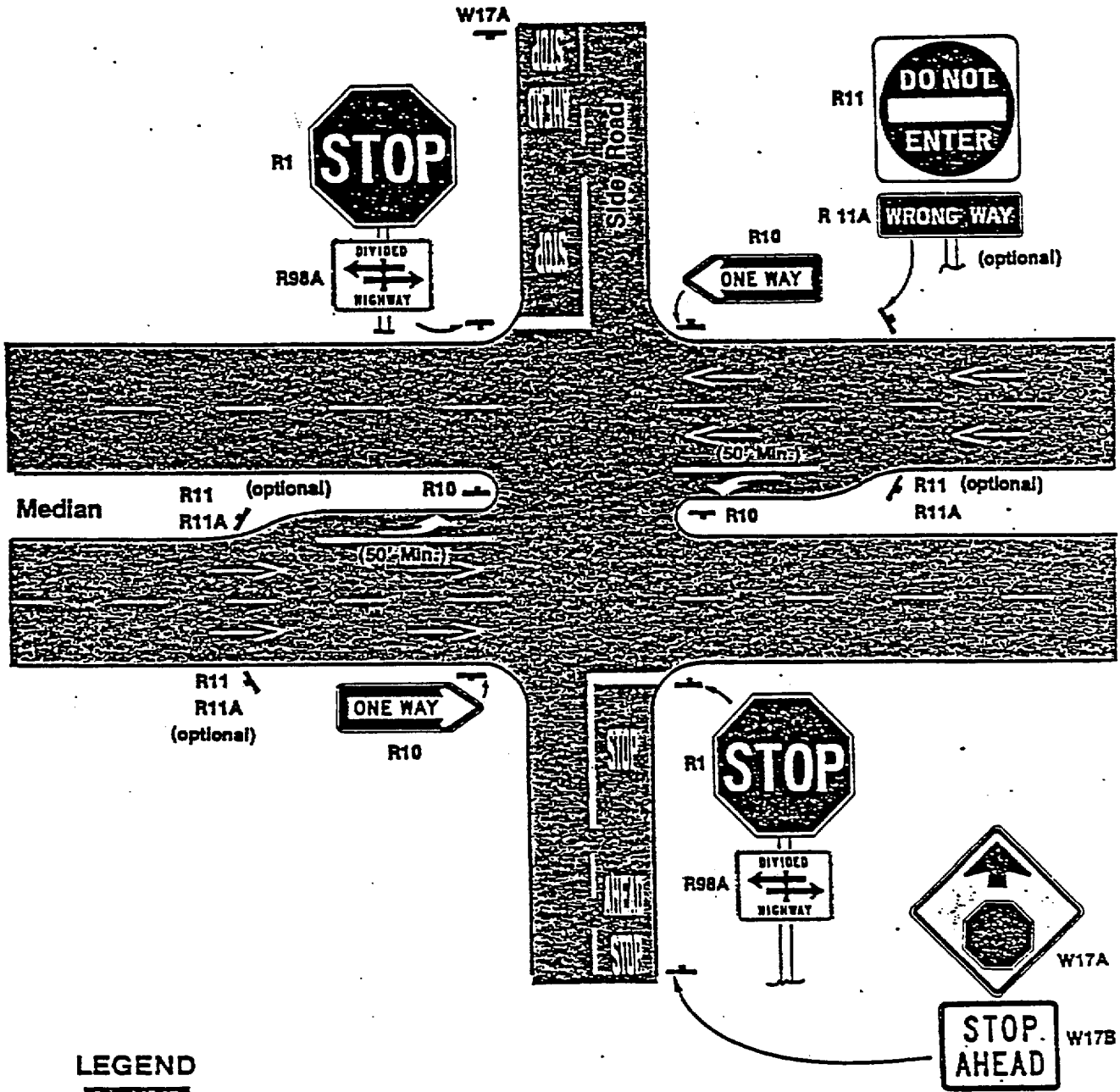


① MINOR VARIATIONS IN DIMENSIONS MAY BE ACCEPTED BY THE ENGINEER.

A-24B

Figure 6-24

TYPICAL RURAL EXPRESSWAY INTERSECTION SIGNS AND MARKINGS



LEGEND

Wrong Way Arrow

Left Turn Arrow

Sign Location

NOTES:

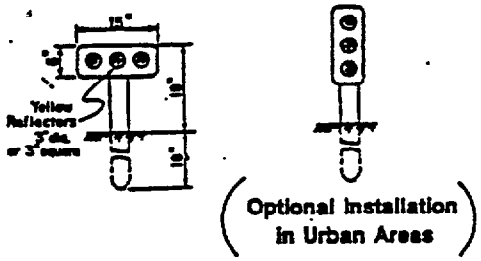
1. Distance between wrong way arrows is 100' ±.
2. See Figure 6-20 for location of intersection markings.
3. Use 8" white solid line for left turn lane.
4. The R98A sign may be placed as a separate installation in advance of stop sign.

Figure 6-38

TYPICAL OBJECT MARKERS

(See Section 6-05)

TYPE K

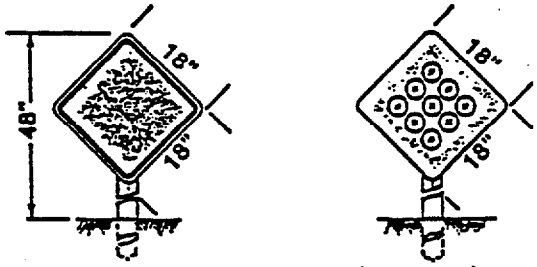


POLICY

Type K marker is used:

- In the far nose of median island openings
- Facing approaching traffic at the noses of islands forming right-turn lanes.
- In the nose of an island where traffic may proceed to either side.
- In the nose of exit ramps where there are curbs in the neutral area.

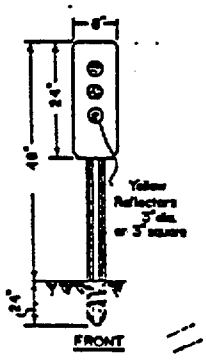
TYPE N



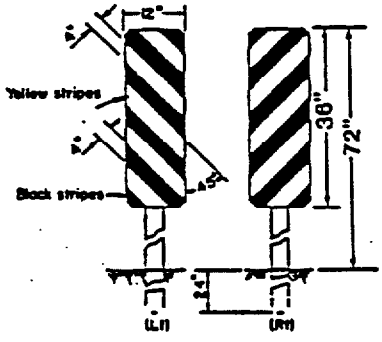
1. Yellow Reflective Background
2. Red Reflective Background
3. Orange Reflective Background
4. Yellow Background with 9-3" Yellow Reflectors
5. Red Background with 9-3" Red Reflectors

- Yellow Type N marker may be used below and on the same post with the W56 or W57 arrow signs to warn of an abrupt turn. Orange Type N marker is used in construction zones.
- Red Type N marker is normally mounted below and on the same post with the W31 END sign to mark the end of a street or highway.

TYPE L

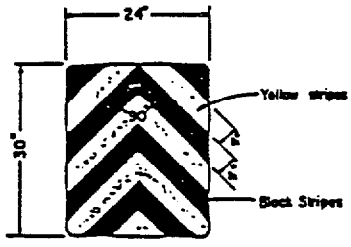


TYPE P



- Type L marker is used to mark obstructions adjacent to the roadbed (outside of paved shoulder).
- Type P marker is used to mark an obstruction within the roadbed (between edges of paved shoulders). Type P marker with orange and white stripes is used in construction zones.

TYPE R



- Type R marker is used to mark an obstruction within the roadbed where traffic may proceed on either side. It is mounted on the front of a crash cushion or guardrail protecting a fixed object. Except for crash cushions where traffic may pass to only one side of a fixed object, a Type P marker should be used instead of Type R. The bottom of the marker is normally mounted one foot above pavement.

82575—500 6/31 6.200 OEP

Appendix B

Questionnaire Sent and Responses From Other States

Questionnaire Sent to the State Traffic Engineers

STATE OF CALIFORNIA—BUSINESS, TRANSPORTATION AND HOUSING AGENCY GEORGE DEUKMEJIAN, *Governor*

DEPARTMENT OF TRANSPORTATION
1120 N STREET
SACRAMENTO, CA 95814
TDD (916) 323-7665

(916) 445-4124
(TDD: 445-5945)

August 1, 1988

Wrong-way traffic movements and their consequences are a major concern to all of us. The California Department of Transportation (Caltrans) is devoted to developing more effective signs, pavement markings, and devices to prevent the wrong-way entry of vehicles onto our freeways, and wrong-way U-turns on our freeways.

In addition, Caltrans is interested in standards and ideas developed by other states for preventing wrong-way movements. We are particularly interested in any positive barriers, such as spikes, raising curbs, etc., or other unique treatments you may have tried. Could you provide us information and diagrams of your standards for signs and markings other than the standard MUTCD (Manual of Uniform Traffic Control Devices) treatment, lights, devices, etc., used in your state to prevent wrong-way traffic movements? Please send your response to:

Mr. Charles D. Bartell
Chief, Division of Traffic Engineering
California Department of Transportation
1120 N Street, Room 4212
Sacramento, CA 95814

A summary of responses will be compiled by the end of this year. We would appreciate receiving this information by August 31, 1988. Please let us know in your response if you wish to obtain a copy of the final report on prevention of wrong-way traffic movements.

Sincerely,

C. D. BARTELL, Chief
Division of Traffic Engineering

States Responding to August 1988 Survey

Alaska	Gordon G. Hayes, P.E., Traffic Safety Standards Engineer
Arizona	Roger L. Hatton, P.E., State Traffic Engineer
Arkansas	J. D. Barnett, Engineer of Traffic Division
Colorado	Johan J. Bemelen, Staff Traffic Engineer
Connecticut	Frank M. D'Addabbo Sr., P.E., Director-Traffic Engineering
Dist. of Columbia	George W. Schoene, Bureau Chief
Florida	Gregory Xanders, P.E., Asst. State Traffic Engineer
Hawaii	Roy Komoto, Traffic Engineer
Idaho	Max N. Jensen, P.E., Traffic Supervisor
Illinois	R. W. Jones, Engineer of Traffic
Indiana	Clinton A. Venable, Chief, Division of Traffic
Iowa	Dwight L. Stevens, State Traffic Engineer
Kansas	Arlen F. Tappan, P.E., Highway Marking Engineer
Kentucky	John R. Luttrell, P.E., Director, Division of Traffic
Maine	Douglas F. McCobb, Engineer of Traffic
Maryland	Thomas Hicks, Deputy Chief Engineer, Office of Traffic
Michigan	Calvin Roberts, Engineer of Traffic and Safety
Minnesota	D. H. Differt, Deputy Commissioner
Mississippi	Richard Young, Assist. Traffic Control and Safety Engineer
Missouri	Roy I. Coplen, P.E., Division Engineer, Maint. and Traffic
Nebraska	Ken Gottula, Traffic Engineer
Nevada	P. D. Kiser, Chief Traffic Engineer
New Hampshire	Frank B. Lindh, P.E., Admin., Bur. of Traffic & Traffic Engr.
New Jersey	P. Norman Deitch, Chief, Bur. of Traffic Engr. & Safety Prog.
New York	R. M. Gardeski, Director, Traffic and Safety Division
North Dakota	Allan Covlin, Engineering Services Div., ND State Hwy. Dept.
Ohio	Robert D. Yankovich, Acting Engineer, Brueau of Traffic
Oklahoma	H. R. Hofener, P.E., Chief Traffic Engineer
Oregon	Dwayne Hofstetter, Traffic Engineer
Pennsylvania	J. R. Doughty, P.E., Chief, Traffic Engr. and Operations Div.
South Carolina	Luther F. Fant, Assist. Director of Traffic Engineering
South Dakota	George Sherrill, Traffic Operations Engr., Div. of Operations
Tennessee	Richard Fitzgerald, Engr. Manager, Traffic Engr. Office
Utah	David K. Miles, P.E., Engineer for Traffic and Safety
Vermont	Leon R. Magnant, Traffic Engineer
Virginia	A. L. Thomas, Jr., State Traffic Engineer
Washington	Wayne T. Gruen, State Traffic Engineer
West Virginia	Ken F. Kobetsky, Director, Traffic Engineering Division
Wisconsin	Harry O. Price, P.E., State Traffic Engineer

Summary of Responses to Questionnaire

Response on Causes

Driving Under the Influence, Elderly Drivers, Night-Time Conditions

The most common stated cause of wrong-way accidents was drivers who were under the influence of alcohol. These accidents tend to occur late at night. "Needless to say many drivers were impaired in one way or another."* "In discussing this matter with law enforcement officials, we find that the majority of wrong-way movements and wrong-way U-turns on the freeway system involve drivers under the influence of alcohol." Elderly drivers also accounted for a fraction of wrong-way drivers. "We had a recent rash of these wrong-way accidents in a one week period, all of which were either alcoholized or in one case an elderly person, and all happened late at night."

Response on Solutions

Solutions in preventing wrong-way accidents include using the signing and markings in the MUTCD (Manual on Traffic Control Devices), and obtaining the traffic engineers' input in the planning phase of ramp and interchange design. Particular attention is made to the sign location, mounting height and maintenance. Markings include wrong-way pavement arrows, pavement markers, and edge lines.

Traffic Engineer's Input in the Planning Phase

Since the sight distance and layout and types of off-ramps and interchanges have been shown to correlate with the frequency of wrong-way accidents, the traffic engineer's input in the planning phase of intersection, ramp, and interchange design is vital to public safety. "At the design phase for new construction, we include the traffic engineer's input in reference to ramp location and entrance control to discourage wrong-way maneuvers."

Complete, consistent interchanges lead to vehicles being channelized onto ramps in the correct direction. "We depend on geometric design, supplemented by standard signs and markings to discourage wrong-way movements." "To minimize the possibility of wrong-way traffic movements, we have utilized relatively few partial interchanges."

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*Quotations from various respondents which give the flavor of the replies. Identification of individuals quoted would serve little purpose.

MUTCD

The majority of states adhere to the MUTCD standard which states:

> "the 'DO NOT ENTER' sign should be conspicuously placed in the most appropriate position at the end of a one-way roadway or ramp. The sign should normally be mounted on the right-hand side of the roadway, facing traffic entering the roadway in the wrong direction...The 'WRONG WAY' sign may be used as a supplement to the 'DO NOT ENTER' sign...placed at a location along the exit ramp or the divided highway farther from the crossroad than the 'DO NOT ENTER' sign." The "DO NOT ENTER" sign is placed conspicuously on ramps, facing traffic entering the road in the wrong direction.

After research studies on visibility, California uses a Do Not Enter package, which is a "DO NOT ENTER" (R-11) sign with a "WRONG WAY" (R-11A) sign directly beneath it on a single post on both sides of the ramp. Other states responded that they also double up their signs. "Many times we have doubled up signs, especially 'Wrong Way' or 'Do Not Enter.'"

Legal Authority

Signs and markings are enforced by vehicle code sections regarding direction of travel, U-turns, and driving while intoxicated. One state provided an outline of their "legal authority to prohibit U-turns at median crossovers."

Sign Location

Many responding states provided diagrams of sign and pavement marking locations from of their standards These diagrams are included in the appendix of this report. Some of the states used more signs, above the standard shown in the MUTCD, either as their own standard, or as determined by engineering judgment.

Sign Mounting Height

States which had looked into sign height lowered their signs. "We do mount our 'Wrong-Way' ramp signs at a 4-foot height to the bottom of the sign. We believe that the sign at the lower elevation is more noticeable to a wrong-way driver than if it were mounted at the standard 7-foot height. Speeds are low at the ramp terminals so the low height should not present a hazardous situation."

One of the states increased the mounting height of the "ONE WAY" signs from 1-1/2 feet to 3 feet for better visibility. "There has been some concern about the 1 1/2 feet mounting height of the 'ONE WAY' signs...this mounting height should be adjusted, especially at locations where the 'ONE WAY' sign is mounted behind guard rail. Also there was concern about the signs being obscured by vegetation. Therefore in order to alleviate these concerns, it has been decided to increase the mounting height of the 'ONE WAY' sign to 3 feet."

From research studies in both responsiveness to headlights and avoidance of sight restrictions, California mounts the Freeway Entrance and Do Not Enter sign packages with the bottom of lower sign 2 feet higher than the edge of traveled way pavement, rather than the 7-foot height called for in the Manual. The Do Not Enter sign package consists of a "DO NOT ENTER" sign with a "WRONG WAY" sign directly beneath it on a single post The Freeway Entrance package consists of a "FREEWAY ENTRANCE" sign, a route shield, cardinal direction, and arrow signs mounted on a single post. This places the signs directly in the view and in the headlights of vehicles turning into off-ramps.

Sign Material

Visibility is important. "We require that 'WRONG WAY' and 'DO NOT ENTER' signs be fabricated with high brightness encapsulated type reflective sheeting."

Sign Size

The MUTCD Manual sizes of the "DO NOT ENTER" and "WRONG WAY" signs were 30" x 30" and 36" x 24" respectively. California has sizes of 36" x 36", 48" x 48", and 72" x 72" for the "DO NOT ENTER" sign and 36" x 21" and 72" x 21" for the "DO NOT ENTER" sign.

Sign Maintenance

A sign maintenance and verification system ensures that the signs are in an acceptable condition and not missing. "We have also tried to keep the devices and markings in a good state of repair." "We recently made a special drive to insure that all our exit ramps were signed in accordance with the MUTCD."

In California, reviews are made by district traffic engineers of the wrong-way signing and delineation packages to remedy any deficiencies in missing signs, lost reflectivity of the signs, and worn wrong-way pavement arrows. As they are retrofitted and newly installed, the Do Not Enter sign packages in California have high intensity sheeting.

Wrong-Way Pavement Arrow

The wrong-way pavement arrow was designed to look like an arrow (not a "glob") when viewed from the pointed end of the arrow. Some states experimented with visibility of the arrow with raised pavement markers. "We also use the pavement arrow strategically thru interchange areas to guide motorists and to supplement the effectiveness of the arrow. We plan to experiment with outlining the arrow with raised pavement markers at locations where there is a high incident frequency." Also, reflective thermoplastic material is now being used as an alternative to reflective paint for wrong-way pavement arrows.

Pavement Markers and Edge Lines

Edge lines and pavement markers help to guide traffic, especially at intersections adjacent to ramps with left-turns. "We are strong advocates of using the turning path dots for guiding left turning traffic in the par-clo's and folded diamond interchange types. But, once again, that is a standard marking consideration." "Where there are two ramps in the same quadrant, such as at a partial cloverleaf, we have dashed the left edge line from the crossroad to the ramp terminal to provide left-turning drivers with a defined path to follow the proper ramp."

Red/yellow and red/colorless reflective markings, which require extensive driver education programs are used by some states. "We use red/colorless, and red/yellow reflective pavement markers on ramps." "Two-way white/red reflectors have been used in raised pavement markers on lane lines at intersections and interchanges to provide the red indication for wrong-way movements."

Raised Medians

Raised curbs and medians are used to channelize traffic at ramps and to separate the entrance and exit ramps which lie parallel to each other. "We do use raised medians to channelize some intersections and ramp terminals. However, these are treatments which can be found in the AASHTO Manual on Geometric Design for Streets and Highways." Another state summarized the practice of using a "raised curb at one location where the entrance and exit ramps were somewhat parallel to each other. The purpose was to better define the entrance ramp from the exit ramp, and to control access." "Also, we make extensive use of curbed channelization in our interchange designs, with lateral separation between on and off ramps. Therefore, at most locations, overt action on the part of the motorist would be necessary to initiate a wrong-way movement."

Delineators

Delineators are being tried by two states on an experimental basis. In the first case, the delineators provide visible trail-blazing at on-ramp entrances. "At a few unlit entrance ramp locations, we have installed an experimental delineation treatment. Five reboundable delineator posts are placed on each side of the freeway entrance ramp. Standard signs and pavement markings accompany this." In the second case, "red reflectors will be placed on the backside (wrong-way side) of flexible delineator posts used on divided highways near intersections and on some freeway ramps and mainline."

Response on Treatments Not Used

Spikes

Every state in the nation was surveyed. Not one Traffic Engineer endorsed the use of spikes or barriers. In addition, past research has shown that a wrong-way vehicle may continue traveling onto the freeway after the tires are punctured. "We have considered the use of spikes to prevent wrong-way movements but we are concerned about legal liability associated with such a drastic device in case some motorist inadvertently backs up or enters the wrong-way and becomes disabled in a traffic lane." Spikes do not stop a vehicle from entering a freeway. A drunk driver may not notice that the tires have been punctured. The majority of the wrong-way drivers may not get into accidents since they do notice the signs, pavement arrows, or traffic flow, and get out of the way of traffic while still on the ramp, turn around, and head in the correct direction. "Barriers to wrong-way vehicles such as one-way spikes, sensor actuated lights etc. have been suggested but are not under consideration at this time." "Please be advised that ...DOT does not use any spikes, raising curbs, etc. to prevent wrong-way traffic movements."

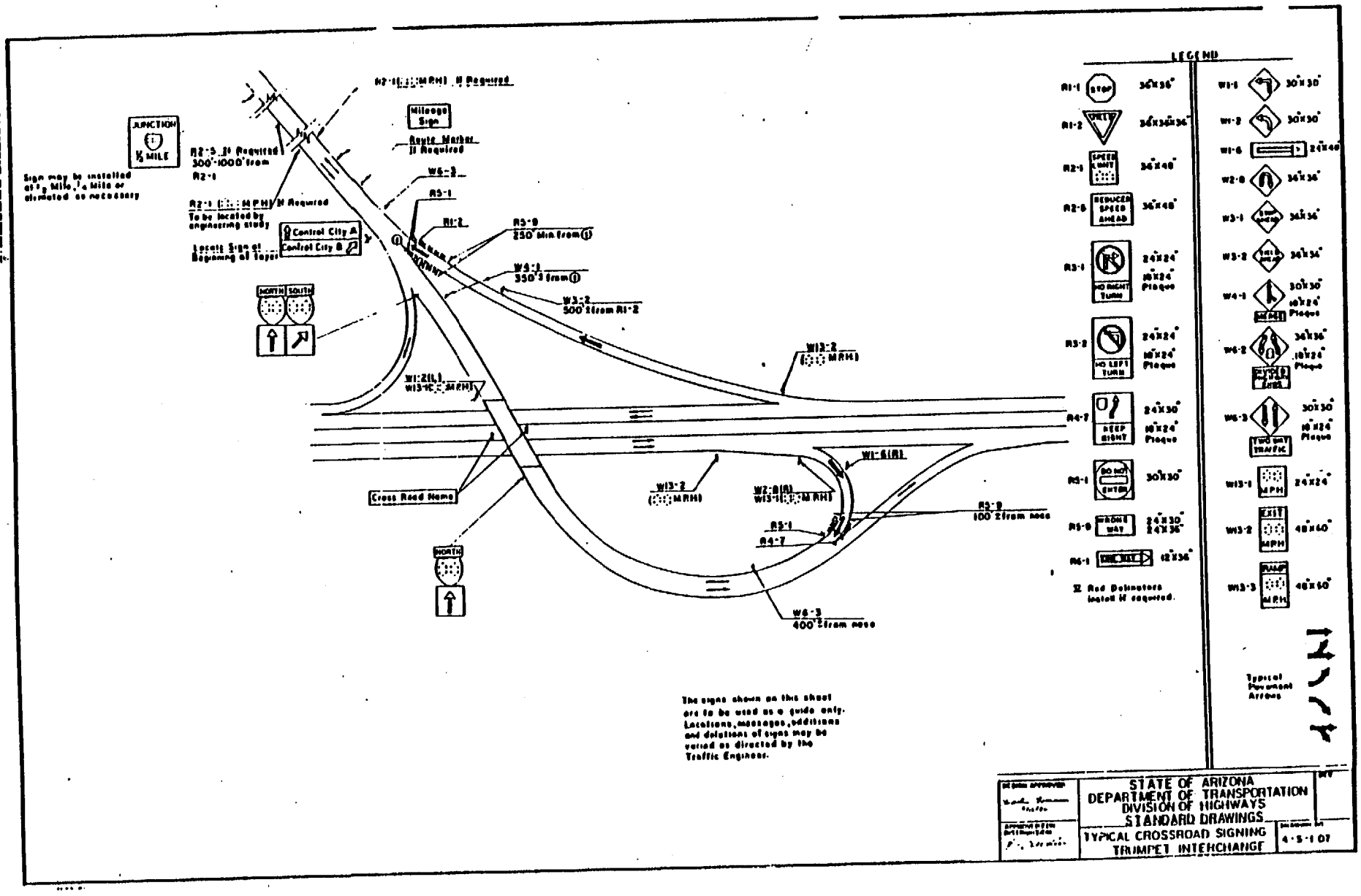
Positive Barriers

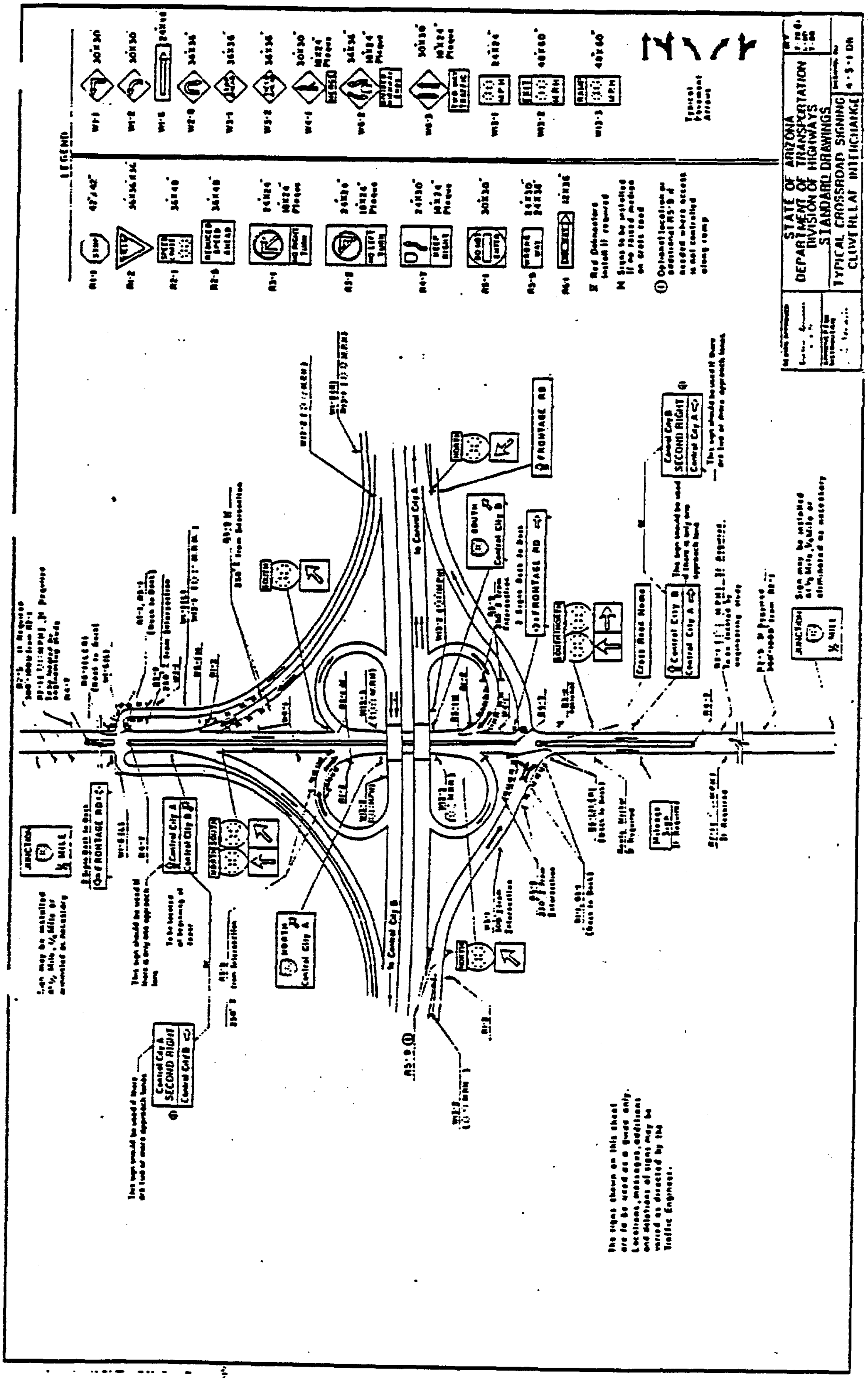
There was also a consensus of the responding states in not using positive barriers. The problem of false signaling in pavement sensors because of motorcycles and backed-up traffic could result in harm to innocent victims. "We have not taken a positive approach to the problem and therefore have no experience with any such devices." "We have never installed any type of positive barriers, nor do we have any plans to do so in the future."

California has experimented with moving gates to change the direction of rush hour traffic flow and optimize high occupancy vehicle lanes. These positive barrier gates take 20 seconds to open or close. A gate designed to take the high impact loads of a wrong-way vehicle can not respond in time (up to 20 seconds) to stop a wrong-direction vehicle.

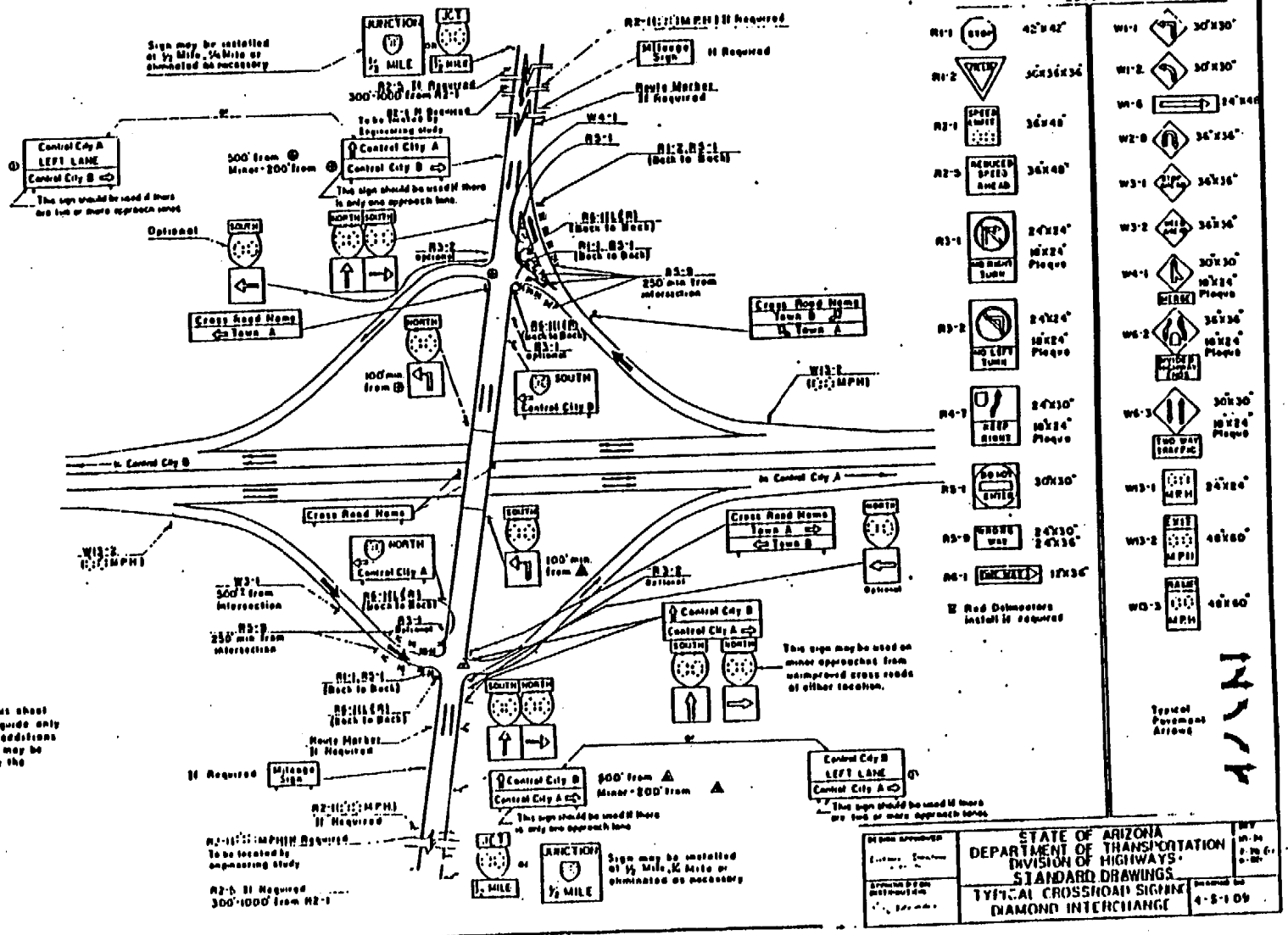
Appendix C

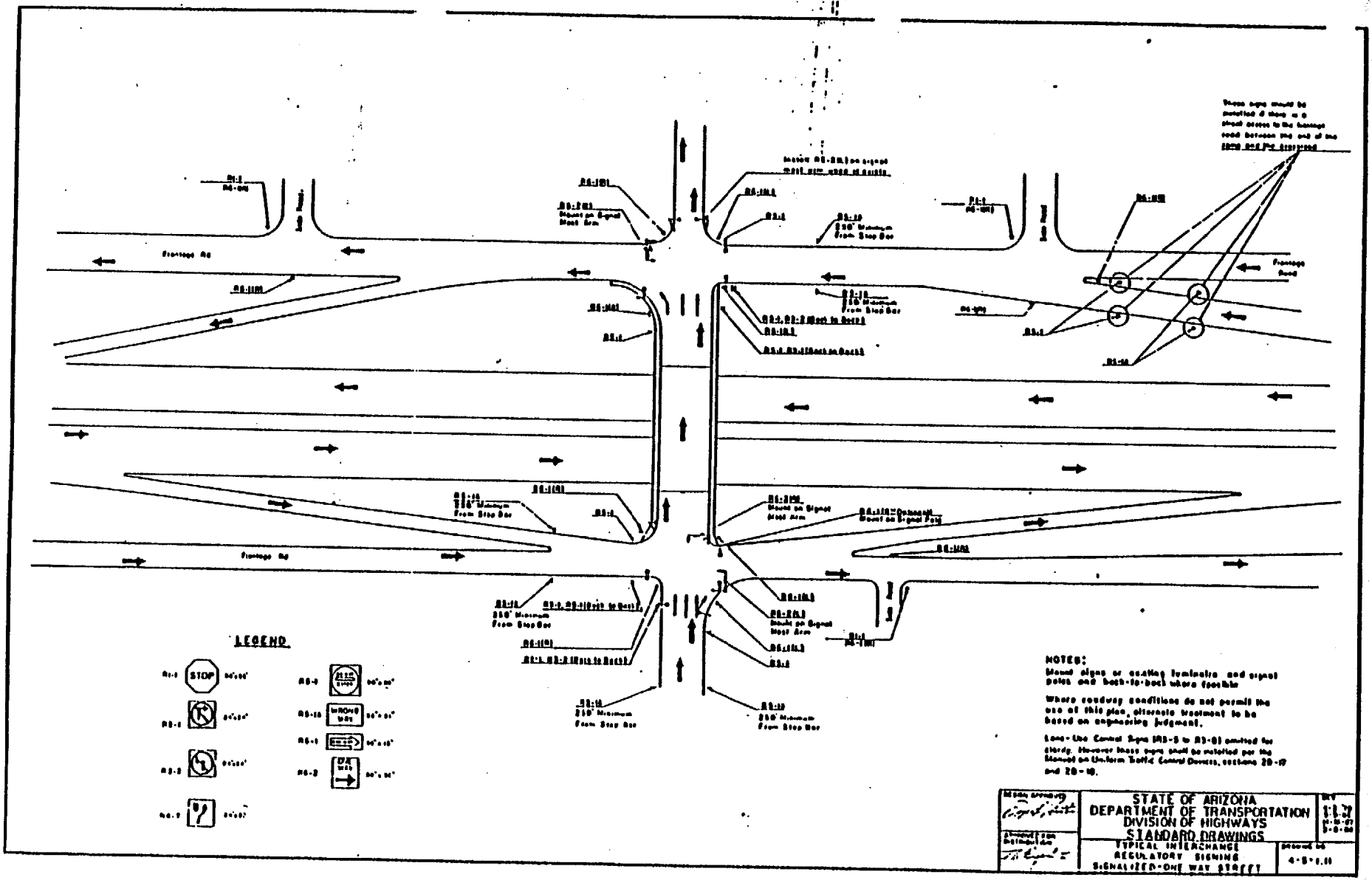
Diagrams Submitted by Other States

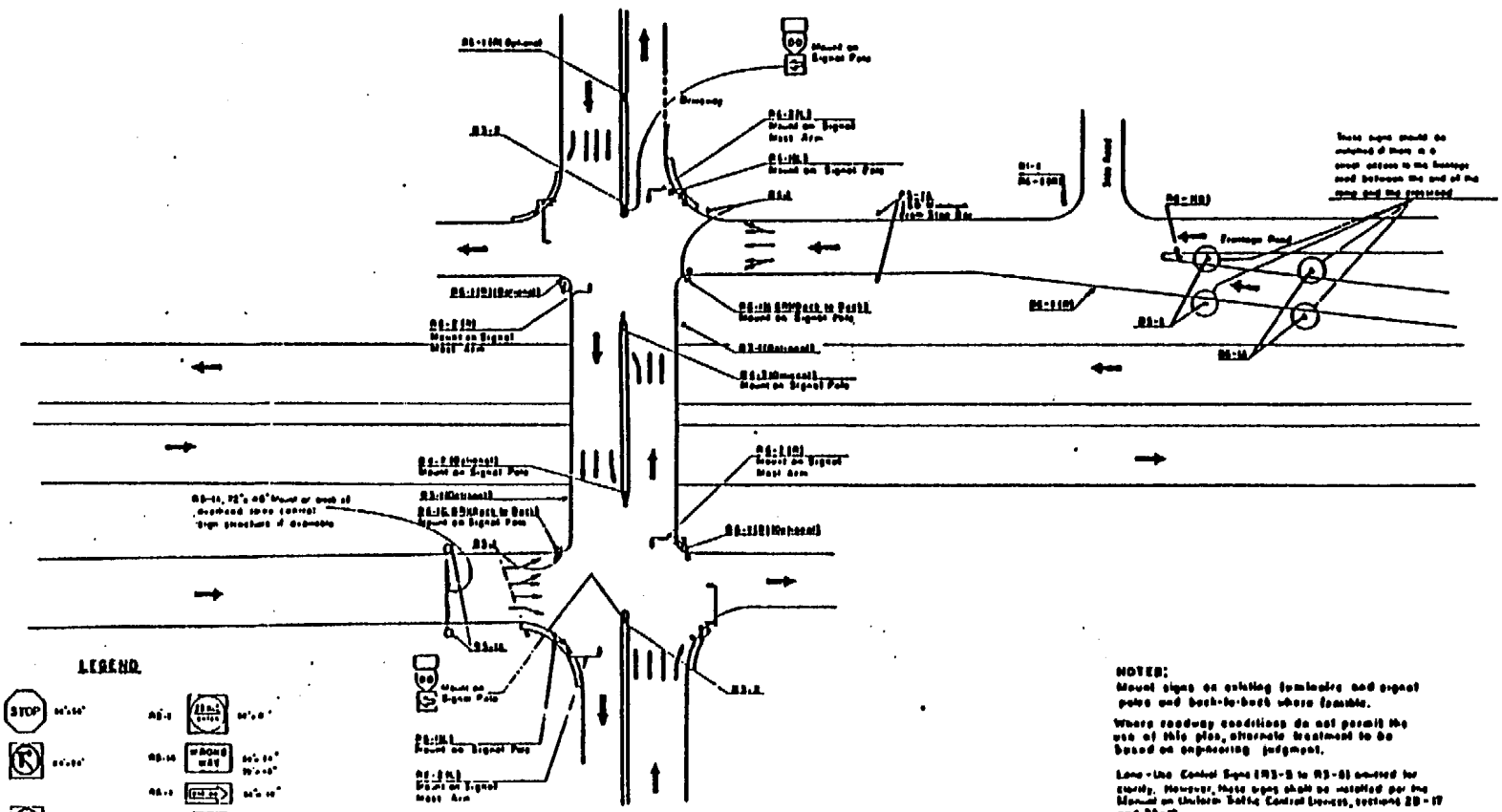

JUNCTION
½ MILE
Sign may be installed at ¼ Mile, ¼ Mile or eliminated as necessary
R2-5 If Required 300'-1000' from R2-1
R2-1 (MPH) If Required
To be located by engineering study
Locate Sign at Beginning of Taper
Control City A
Control City B
Mileage Sign
Route Marker If Required
W6-3
R5-1
R1-2
R5-9 250' Min from ①
W9-1 350' ± from ①
W3-2 500' ± from R1-2
NORTH
SOUTH
W13-2 (MPH)
W1-2(L)
W13-1(L) (MPH)
Cross Road Name
W13-2 (MPH)
W2-8(R)
W13-1(R) (MPH)
W1-6(R)
R5-9 100' ± from nose
R5-1
R4-7
NORTH
W6-3 400' ± from nose
LEGEND
R1-1 STOP 36"X36"
R1-2 YIELD 36"X36"X36"
R2-1 SPEED LIMIT (MPH) 36"X48"
R2-5 REDUCED SPEED AHEAD 36"X48"
R3-1 NO RIGHT TURN 24"X24" 18"X24" Plaque
R3-2 NO LEFT TURN 24"X24" 18"X24" Plaque
R4-7 KEEP RIGHT 24"X30" 18"X24" Plaque
R5-1 DO NOT ENTER 30"X30"
R5-9 WRONG WAY 24"X30" 24"X36"
R6-1 ONE WAY 12"X36"
W1-1 30"X30"
W1-2 30"X30"
W1-6 24"X48"
W2-8 36"X36"
W3-1 36"X36"
W3-2 36"X36"
W4-1 30"X30" 18"X24" Plaque
W6-2 36"X36" 18"X24" Plaque
W6-3 30"X30" 18"X24" Plaque
W13-1 (MPH) 24"X24"
W13-2 (MPH) 48"X60"
W13-3 (MPH) 48"X60"
Typical Pavement Arrows
Red Delineators Install If required.
The signs shown on this sheet are to be used as a guide only. Locations, messages, additions and deletions of signs may be varied as directed by the Traffic Engineer.
STATE OF ARIZONA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STANDARD DRAWINGS
TYPICAL CROSSROAD SIGNING
TRUMPET INTERCHANGE
4-5-1 07



LEGEND
STATE OF ARIZONA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STANDARD DRAWINGS
TYPICAL CROSSROAD SIGNING
CLOVERLEAF INTERCHANGE
FRONTAGE RD
Cross Road Name
JUNCTION
½ MILE
To Control City A
To Control City B
SECOND RIGHT


LEGEND
STATE OF ARIZONA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STANDARD DRAWINGS
TYPICAL CROSSROAD SIGNING
DIAMOND INTERCHANGE
4-8-109
The signs shown on this sheet are to be used as a guide only. Locations, messages, additions and deletions of signs may be varied as directed by the Traffic Engineer
Sign may be installed at ½ Mile, ¼ Mile or eliminated as necessary
Control City A
Control City B
Cross Road Name
Town A
Town B
NORTH
SOUTH
JUNCTION
½ MILE
¼ MILE
Mileage Sign
Route Marker
This sign should be used if there is only one approach lane.
This sign should be used if there are two or more approach lanes.
This sign may be used on minor approaches from unimproved cross roads at either location.
Typical Pavement Arrows


LEGEND
STOP
ONE WAY
NOTES:
Mount signs or existing luminaire and signal poles and back-to-back where feasible
Where roadway conditions do not permit the use of this plan, alternate treatment to be based on engineering judgment.
STATE OF ARIZONA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STANDARD DRAWINGS
TYPICAL INTERCHANGE
REGULATORY SIGNING
SIGNALIZED-ONE WAY STREET



LEGEND

NOTES:
Mount signs on existing luminaire and signal poles and back-to-back where feasible.

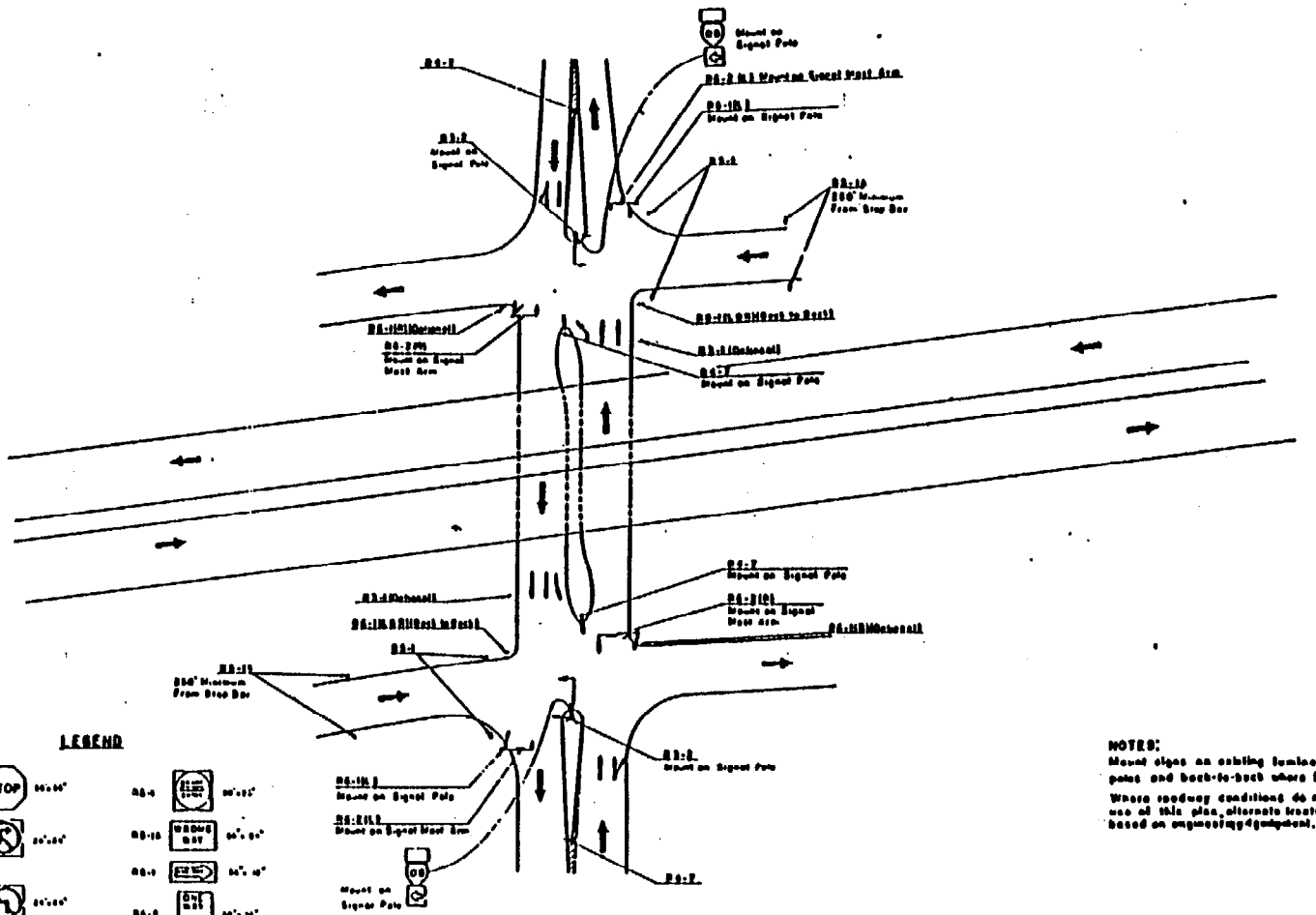
Where roadway conditions do not permit the use of this plan, alternate treatment to be based on engineering judgment.

Lane-Use Control Signs R3-5 to R3-8 covered for clarity. However, these signs shall be installed per the Manual on Uniform Traffic Control Devices, sections 2B-17 and 2B-18

STATE OF ARIZONA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STANDARD DRAWINGS

TYPICAL INTERCHANGE
REGULATORY SIGNING
SIGNALIZED - NARROW MEDIAN

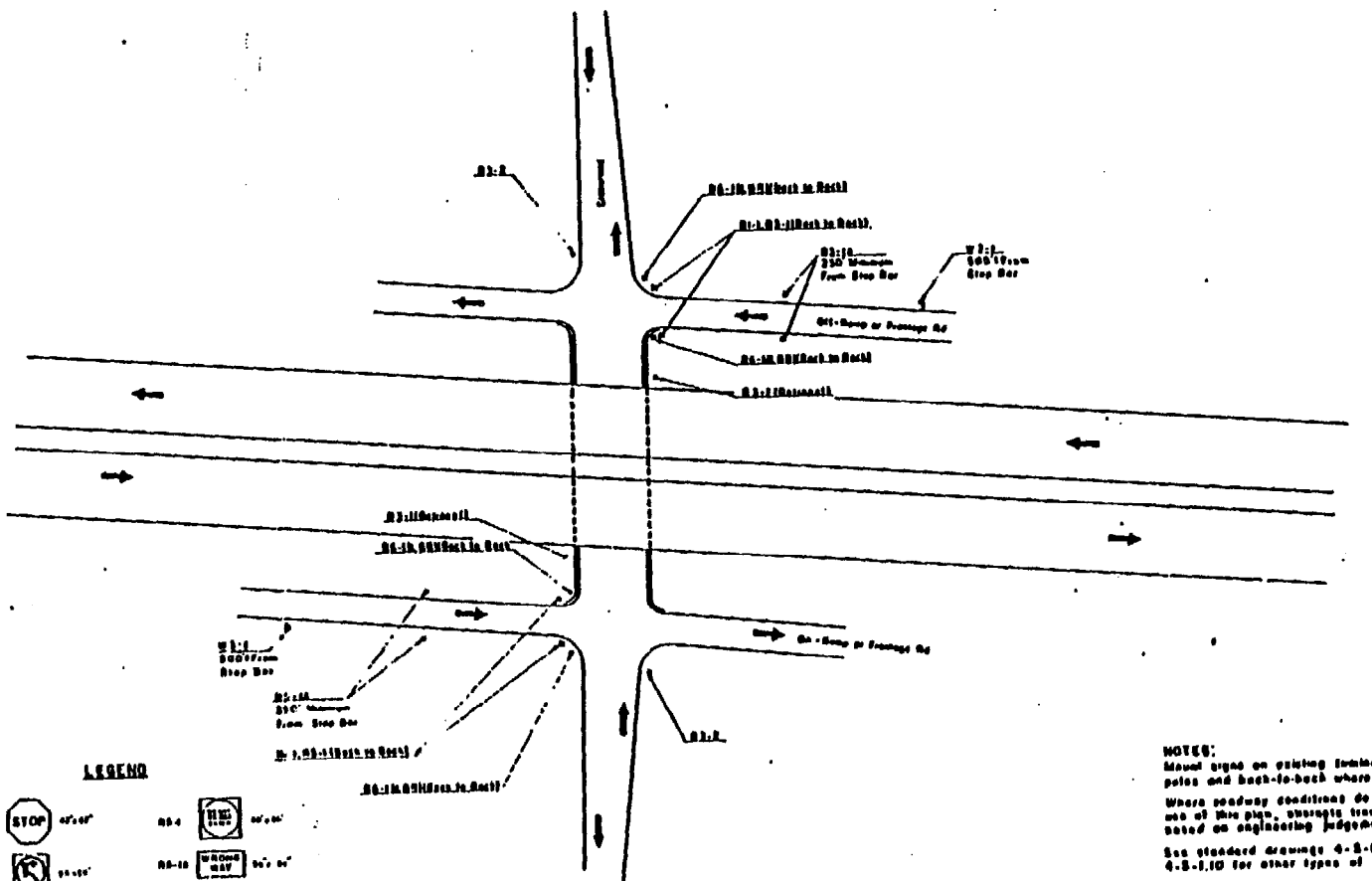
4-8-8.18



STATE OF ARIZONA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STANDARD DRAWINGS

TYPICAL INTERCHANGE
REGULATORY SIGNING
SIGNALIZED - WIDE MEDIAN

4-8-1 (3)



LEGEND

NOTES:
Mount signs on existing luminaire and signal poles and back-to-back where feasible.

Where roadway conditions do not permit the use of this plan, alternate treatment to be based on engineering judgement.

See standard drawings 4-5-1.07 through 4-5-1.10 for other types of interchanges.

STATE OF ARIZONA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STANDARD DRAWINGS

TYPICAL INTERCHANGE
REGULATORY SIGNING
STOP SIGN CONTROL

4-5-1.14

OFF - RAMP SIGNING

1. "Wrong Way" signing, see Traffic Guidelines.

2. "No Pedestrians" signing, normally one (1) sign per ramp.
   Use R5-10c for off-ramps and 31-05P0 for on-ramps.

3. "Exit Speed" (off-ramp), ramp speed (turning roadway).
   First sign normally on parallel section.

4. Warning signs: Curve - Turn - U-Curve

   Depending on geometry and safe speed, normally use "Curve" or "Turn" signing on loop ramps. These signs may be supplimented with "Arrow" signs.

   "U-Curve" sign may be used only with existing geometry where there is an accident problem.

   "Chevron" signs are used in accordance with our policies only when there is an accident problem.

   "Stop Ahead", "Signal Ahead" and "Yield Ahead" are used only when there is a substandard sight line to the control.

5. Guide Signs:

   Destination Signs (D1-1) should be placed on off-ramps. The legends should be the same as the main line signing.

   Advance turn route marker assemblies should be placed on off-ramps. These signs may be combined with destination signs when there is not more than three (3) destinations and one (1) route number.

6. Service Signs:

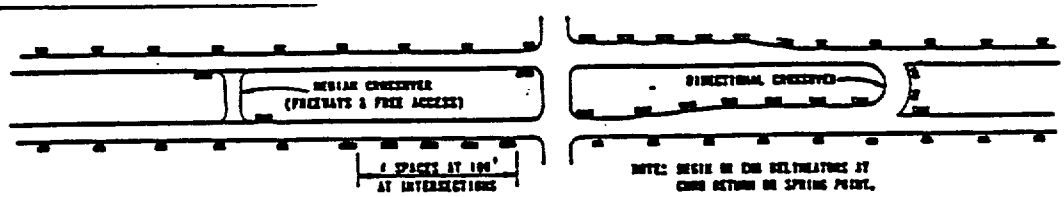
   Service signs should normally be placed on the far side of the intersecting road. The signs may be placed on the off-ramp if space permits. The "Hospital" symbol sign with arrow should be installed on the off-ramp.

7. Commuter Parking Signs:

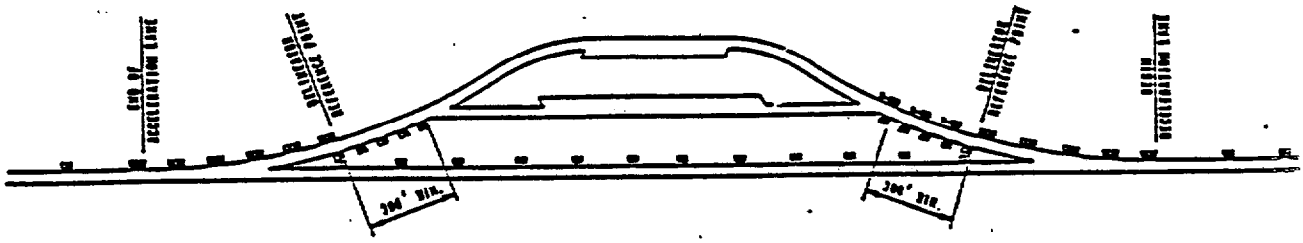
   Install these signs only when you cannot see the commuter lot from the highway or ramp. Normally install these signs on the far side of the intersecting road. The signs may be placed on the off-ramp if space permi

8. Special Destinations:

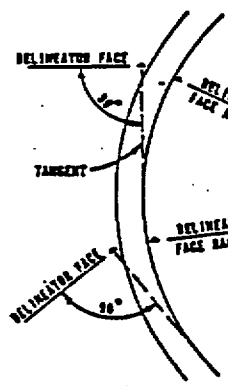
   Auto Emission Test Centers, Historic locations not signed on the main line and other special signs are normally placed on the far side of the intersection.



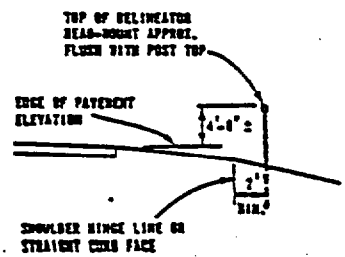
DIVIDED HIGHWAY & MEDIAN CROSSOVER



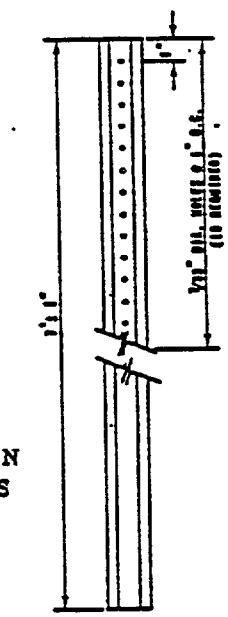
REST AREA & WEIGH STATION



DELINEATOR ORIENTATION ON HORIZONTAL CURVES

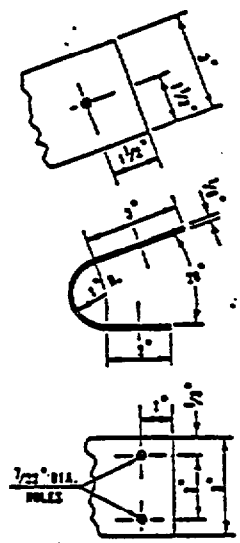


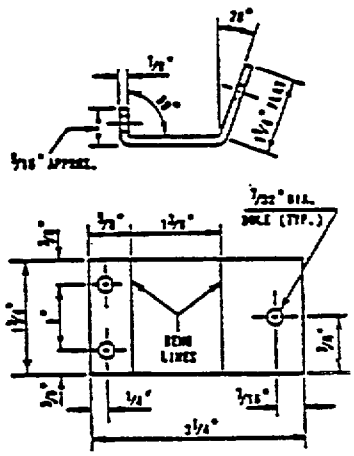
INSTALLATION OF DELINEATORS

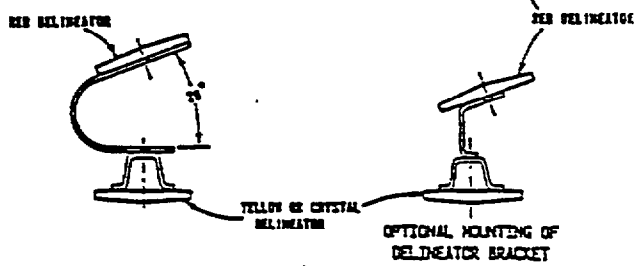


MIN. WEIGHT = 1.33 LBS. PER FT.
MIN. THICKNESS = 3/32"
MIN. MOMENT OF INERTIA ABOUT X-X AXIS = 0.040 IN.⁴

DELINEATOR POST DETAIL







BRACKET MATERIAL: 5" x 2" x 1/8" OR 2 3/4" x 1 3/4" x 1/8" FLAT-BILL FINISH SHEET ALUMINUM 6061-T6 OR EQUIVALENT

RED DELINEATOR MOUNTING BRACKETS

PREPARED BY DESIGN DIVISION

ENGINEER OF CONSTRUCTION

ENGINEER OF MAINTENANCE

ENGINEER OF TESTING AND RESEARCH

ENGINEER OF TRAFFIC AND SAFETY

ENGINEER - ROAD DESIGN

ENGINEER OF DESIGN

DEPARTMENT DIRECTOR
JAMES P. PITZ

DEPUTY DIRECTOR - HIGHWAYS

DRAWN BY: B.F.H.

CHECKED BY: T.E.

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS STANDARD PLAN FOR

DELINEATOR INSTALLATIONS

11-15-69	7-12-66	VI-127D	SHEET 4 OF 6
F.H.W.A. APPROVAL	PLAN DATE		

TRAFFIC AND SAFETY DIVISION NOTE

SUBJECT:	Pavement Marking Guide for Freeways and Ramps
ACTIVITY:	Selection of appropriate pavement markings for use on freeway exit and entrance ramps, weave lanes, service road connections, and lane drops.
PURPOSE:	To achieve statewide uniformity in freeway markings that are in compliance with national standards.
ORIGINATING UNIT:	Reflective Systems

INFORMATION: Drawings (pages 3.1.2a, 3.1.2b, and 3.1.2c) are intended to provide guidelines for installing pavement markings on freeway exit and entrance ramps, weave lanes, service road connections, and lane drops.

ACTION REQUIRED: Those engaged in contract plan and work authorization preparation should follow the guidelines shown by the drawings.

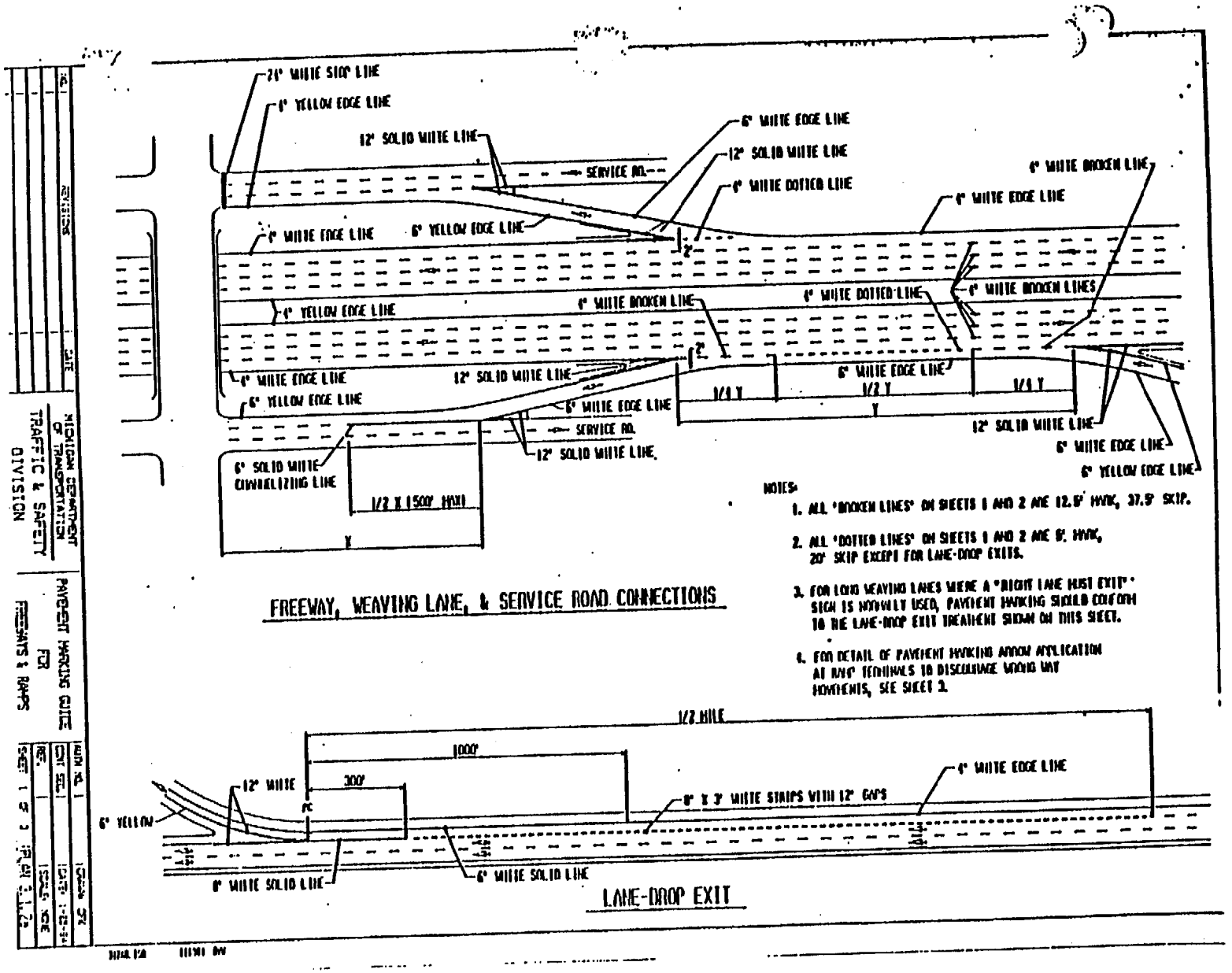
This note updates and replaces the existing Traffic and Safety Division Note 3.1.2.

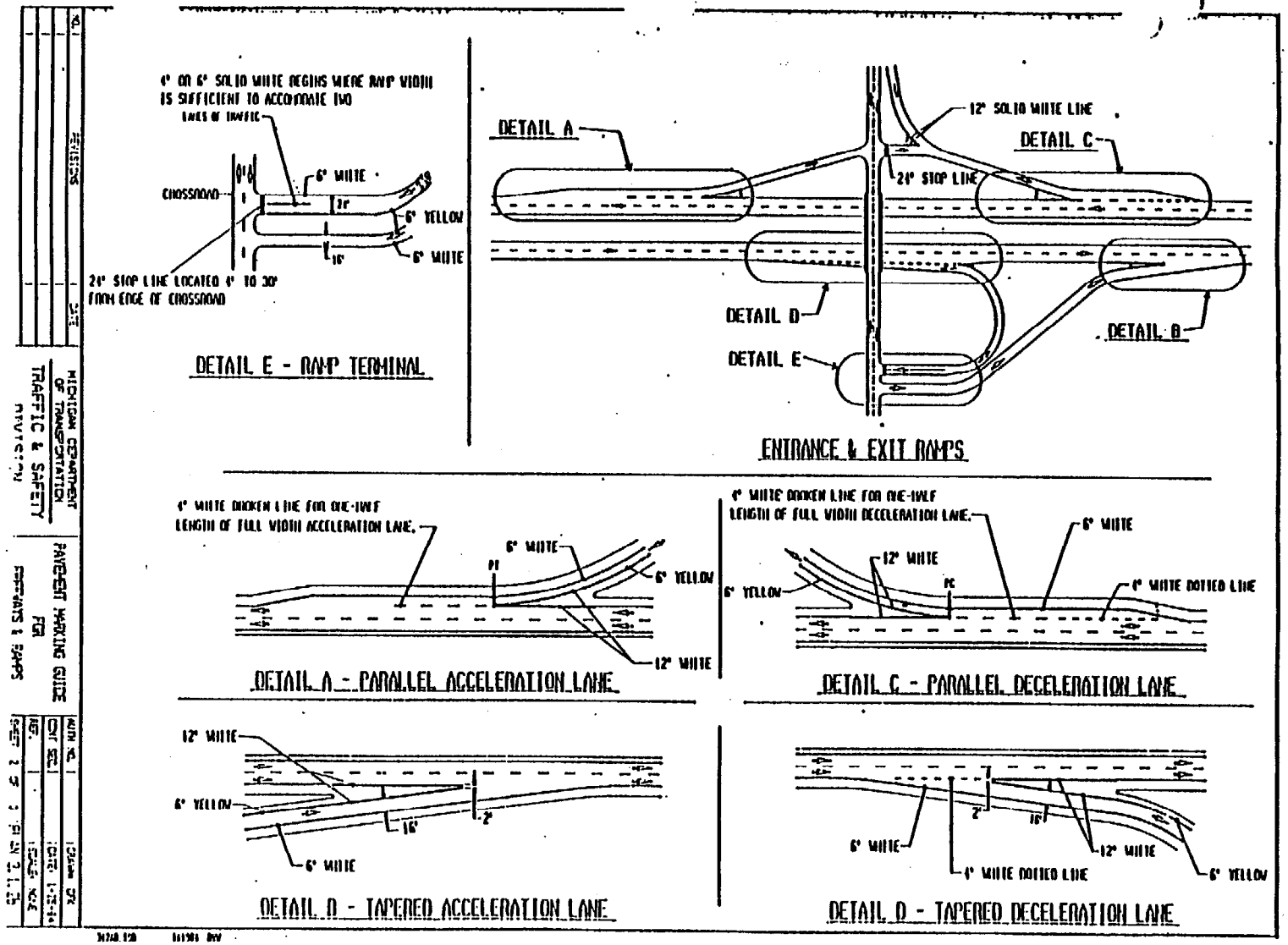
INFORMATION/COMPLETION: This note shall become effective upon date of signing.

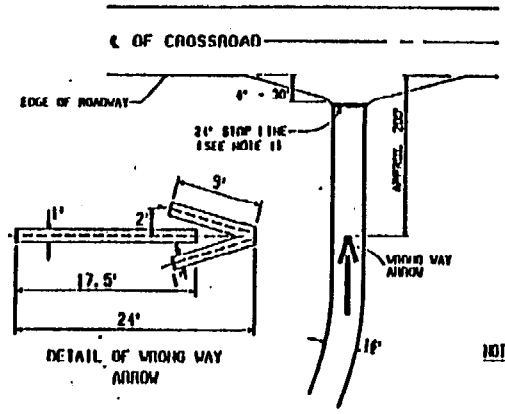
#3 From:
Michigan Department of
Transportation
Traffic & Safety Notes

11/28/84
Date

By: M E Wittenauer
Engineer of Traffic and Safety


24" WHITE STOP LINE
6" YELLOW EDGE LINE
12" SOLID WHITE LINE
SERVICE RD.
6" WHITE EDGE LINE
12" SOLID WHITE LINE
6" WHITE DOTTED LINE
6" WHITE BROKEN LINE
6" WHITE EDGE LINE
6" WHITE EDGE LINE
6" YELLOW EDGE LINE
6" WHITE BROKEN LINE
6" WHITE DOTTED LINE
6" WHITE BROKEN LINES
6" WHITE EDGE LINE
12" SOLID WHITE LINE
6" YELLOW EDGE LINE
6" WHITE EDGE LINE
SERVICE RD.
12" SOLID WHITE LINE
6" SOLID WHITE CHANNELIZING LINE
1/2 X 1500' MAX.
X
1/4 Y
1/2 Y
Y
1/4 Y
12" SOLID WHITE LINE
6" WHITE EDGE LINE
6" YELLOW EDGE LINE
NOTES:
1. ALL "BROKEN LINES" ON SHEETS 1 AND 2 ARE 12.5' MIN., 37.5' SKIP.
2. ALL "DOTTED LINES" ON SHEETS 1 AND 2 ARE 8' MIN., 20' SKIP EXCEPT FOR LANE-DROP EXITS.
3. FOR LONG WEAVING LANES WHERE A "RIGHT LANE MUST EXIT" SIGN IS NORMALLY USED, PAVEMENT MARKING SHOULD CONFORM TO THE LANE-DROP EXIT TREATMENT SHOWN ON THIS SHEET.
4. FOR DETAIL OF PAVEMENT MARKING ARROW APPLICATION AT RAMP TERMINALS TO DISCOURAGE WRONG WAY MOVEMENTS, SEE SHEET 2.
FREEWAY, WEAVING LANE, & SERVICE ROAD CONNECTIONS
1/2 MILE
1000'
300'
12" WHITE
PC
6" YELLOW
8" X 3' WHITE STRIPS WITH 12' GAPS
4" WHITE EDGE LINE
8" WHITE SOLID LINE
6" WHITE SOLID LINE
LANE-DROP EXIT
MICHIGAN DEPARTMENT OF TRANSPORTATION
TRAFFIC & SAFETY DIVISION
PAVEMENT MARKING GUIDE FOR FREEWAYS & RAMPS
REVISIONS
DATE
NO.

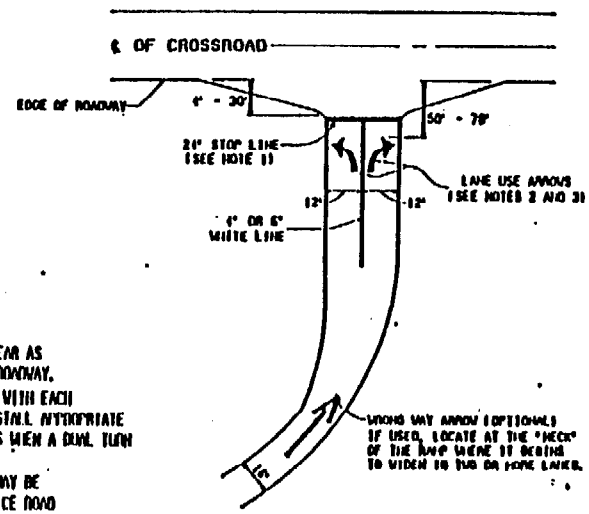

4" OR 6" SOLID WHITE BEGINS WHERE RAMP WIDTH IS SUFFICIENT TO ACCOMMODATE TWO LANES OF TRAFFIC
6" WHITE
CROSSROAD
2'
6" YELLOW
16'
6" WHITE
24" STOP LINE LOCATED 4' TO 30' FROM EDGE OF CROSSROAD
DETAIL E - RAMP TERMINAL
DETAIL A
12" SOLID WHITE LINE
DETAIL C
24" STOP LINE
DETAIL D
DETAIL B
DETAIL E
ENTRANCE & EXIT RAMPS
4" WHITE BROKEN LINE FOR ONE-HALF LENGTH OF FULL WIDTH ACCELERATION LANE.
6" WHITE
PT
6" YELLOW
12" WHITE
DETAIL A - PARALLEL ACCELERATION LANE
4" WHITE BROKEN LINE FOR ONE-HALF LENGTH OF FULL WIDTH DECELERATION LANE.
6" WHITE
12" WHITE
6" YELLOW
PC
4" WHITE DOTTED LINE
DETAIL C - PARALLEL DECELERATION LANE
12" WHITE
6" YELLOW
16'
2'
6" WHITE
DETAIL B - TAPERED ACCELERATION LANE
6" WHITE
2'
16'
12" WHITE
4" WHITE DOTTED LINE
6" YELLOW
DETAIL D - TAPERED DECELERATION LANE
MICHIGAN DEPARTMENT OF TRANSPORTATION
TRAFFIC & SAFETY DIVISION
PAVEMENT MARKING GUIDE FOR FREEWAYS & RAMPS
REVISIONS
DATE



DETAIL OF WRONG WAY ARROW

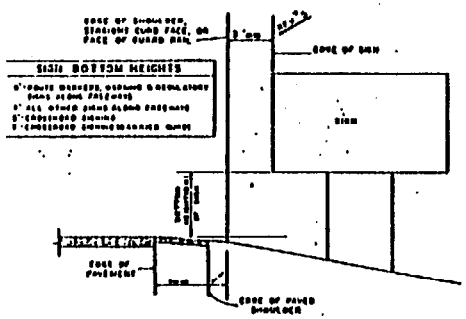
SINGLE LANE
EXIT RAMP TERMINAL

NOTES:
1. LOCATE STOP LINE AS NEAR AS PRACTICAL TO EDGE OF ROADWAY.
2. ADD THE LEGEND "ONLY" WITH EACH LANE USE ARROW AND INSTALL APPROPRIATE LANE-USE CONTROL SIGNS WHEN A DUAL TURN IS REQUIRED.
3. DOUBLE-HEADED ARROWS MAY BE REQUIRED WHERE A SERVICE ROAD OR CITY STREET IS LOCATED OPPOSITE A RAMP TERMINAL.



MULTILANE
EXIT RAMP TERMINAL

SIGN LOCATION

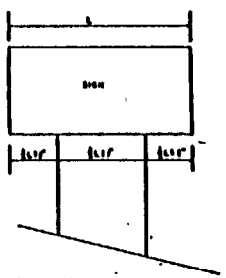


SIGN PLACEMENT - LEFT OR RIGHT SIDE
RAMPS, CROSSROAD OR THROUGH ROADWAY INSTALLATIONS

NOTES

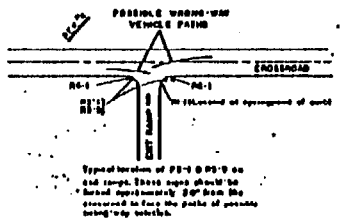
1. LATERAL CLEARANCE OF ALL SIGNS SHALL BE AS INDICATED UNLESS OTHERWISE SHOWN ON SIGNING PLANS.
2. THE TERM "SIGN" AS USED ON THIS PLAN MEANS ONE OR A GROUP OF PANELS COMBINED TO FORM ONE INSTALLATION.
3. OVERHEAD SIGNS SHALL BE INSTALLED AT LOCATIONS AS SHOWN ON THE SIGNING PLANS.
4. BOTTOM SIGNS SHALL BE AS INDICATED UNLESS OTHERWISE SHOWN ON SIGNING PLANS. BOTTOM SIGNS SHALL BE THE HEIGHT FROM THE HEAD EDGE OF THE PAVEMENT TO THE BOTTOM OF THE SIGN.
5. SUPPORT LOCATIONS SHALL BE ... OTHERWISE SPECIFIED ON SIGN DETAIL DRAWINGS.

SUPPORT LOCATION

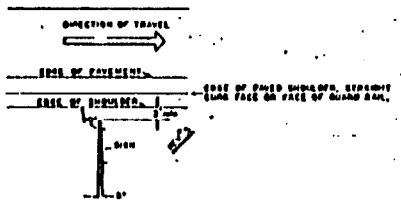


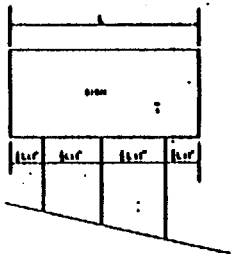
2 SUPPORT ASSEMBLY

POSITIONING OF SIGNS AT EXIT RAMP TERMINALS



LOCATION SKETCH





3 SUPPORT ASSEMBLY

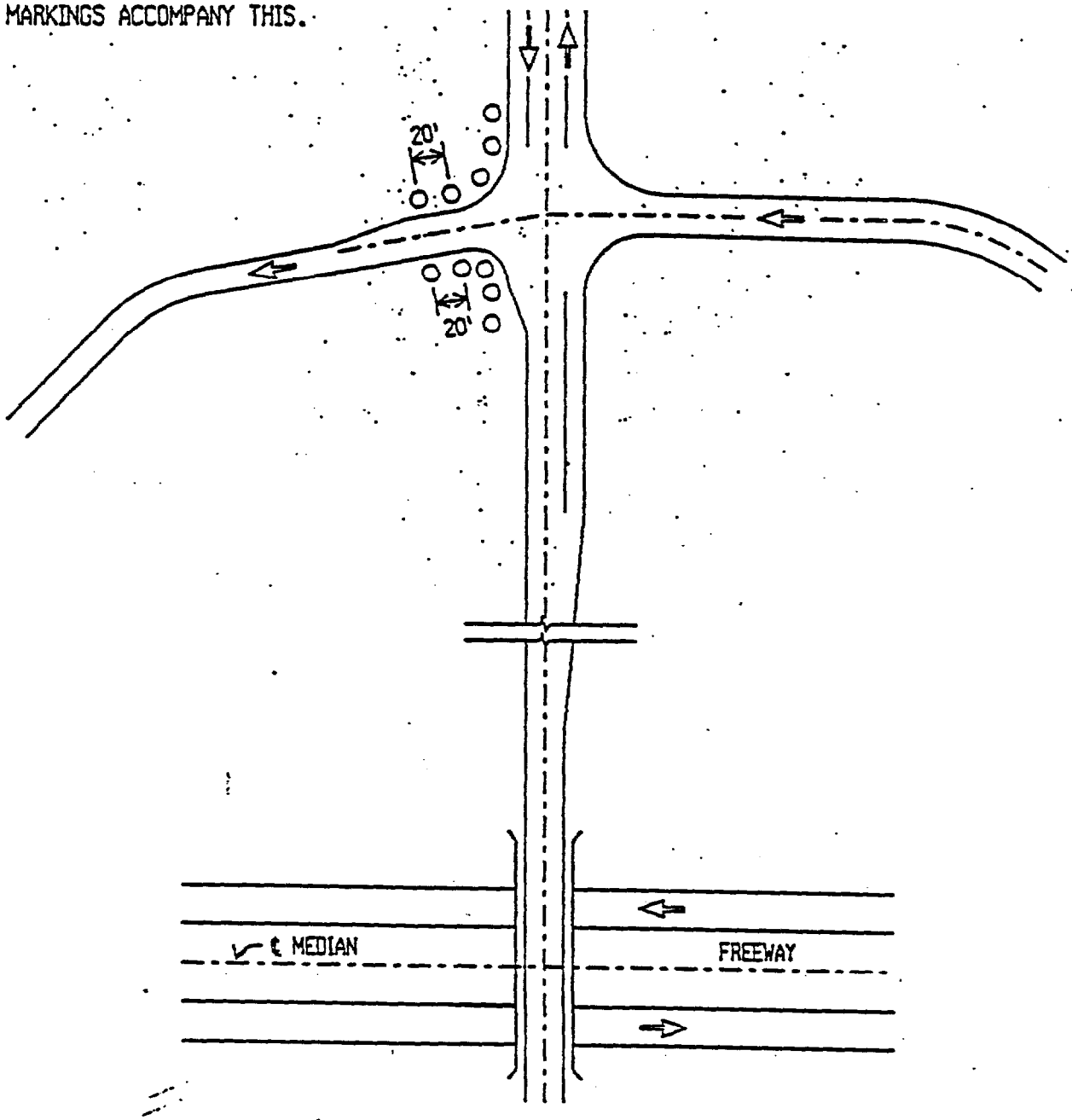
MICHIGAN DEPARTMENT OF TRANSPORT

TYPICAL LOCATIONS
ROADSIDE SIGNS & SUPPORTS

S2.

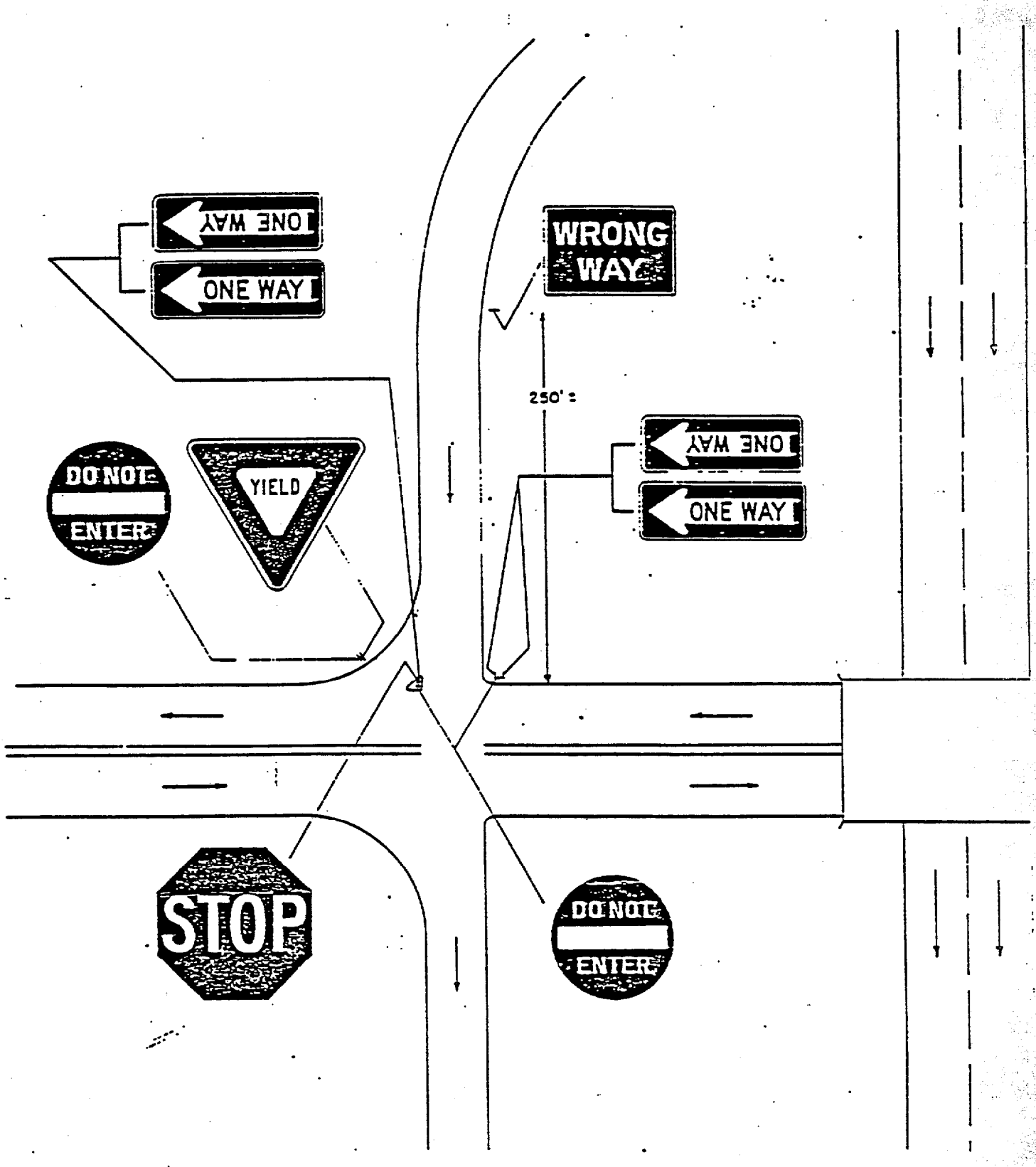
- 5 REBOUNDABLE DELINEATOR POSTS ARE PLACED ON EACH SIDE OF THE FREEWAY ENTRANCE RAMP.

- STANDARD SIGNS AND PAVEMENT MARKINGS ACCOMPANY THIS.



EXPERIMENTAL DELINEATION
USED @ UNLIT RURAL FREEWAY ENTRANCE RAMP

MICHIGAN DEPARTMENT OF TRANSPORTATION
8-11-88



DO NOT ENTER Signs – 30" X 30"
WRONG WAY Signs – 48" X 30"

missouri

WRONG WAY TRAFFIC CONTROL

The first sign shall be located 100 feet in advance of the point where the shoulder markings begin. Successive signs shall be spaced at intervals of 750 to 1,000 feet throughout the marked section.

These signs shall be placed on the right hand side of the road, facing traffic. The mounting height and lateral position shall comply with the specifications contained herein.

R-52

Type	Code No.	Size
Standard Maj. Std. Expressway & Freeway	R-52-24	24"x30"

2J-6 Keep Off Median Sign (R-74)

On divided roadways having no physical barrier between the separated roadways, drivers often attempt to cross the median, particularly where such crossings offer an opportunity to correct an error in choice of direction at an intersection of interchange. A median also may be an inviting place to park. These practices can be dangerous and are prohibited by Section 4511.35 RC.

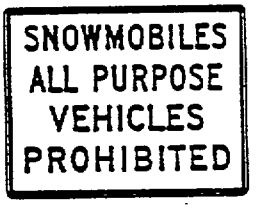
The Keep Off Median sign may be erected on the left of the roadway within the median wherever there is a tendency for drivers to enter or cross.

R-74

Type	Code No.	Size
Expressway	R-74-36	36"x48"
Freeway	R-74-48	48"x60"

2J-7 Snowmobiles All Purpose Vehicles Sign (R-20)

This sign may be erected anywhere within the right-of-way, as needed, to inform operators of snowmobiles or all purpose vehicles that these vehicles shall not be operated on any limited access highway, freeway, interstate highway, or the right-of-way thereof in violation of Sec. 4519.40 RC.



R-20

Type	Code No.	Size
Std. & Maj. Std.	R-20-30	30"x24"
Expressway & Freeway	R-20-36	36"x30"

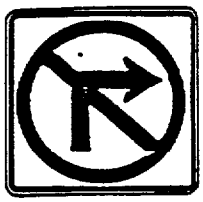
2J-9 Other Exclusion Signs

In addition to the foregoing specific exclusion signs other legends may be required. Signs which clearly state the exclusion shall be designed in accordance with the principles stated in this manual.

Because of the variety of possible messages for these signs, it is not practicable to fix standard sizes for them as a class. In all cases the lettering should be large enough to give adequate legibility. They should be conspicuously placed at all entrances to the restricted roadway.

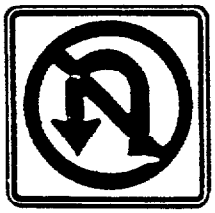
2J-10 Turn Prohibition Signs (R-22, 120, 121, 123)

These signs, except R-123, shall be used at intersections to indicate regulations prohibiting, turning movements.



R-120

R-121



R-123

R-22

Type	Code No.	Size
Std. Maj. Std.	R-22-24	24"x24"
Expressway	R-22-36	36"x36"
Std. & Maj. Std.	R-120-24	24"x24"
	R-121-24	24"x24"
	R-123-24	24"x24"
Expressways and Freeways	R-120-36	36"x36"
	R-121-36	36"x36"
	R-123-36	36"x36"

Turn Prohibition signs should be placed where they will be most easily seen by drivers intending to turn. The No Right Turn sign shall be placed at the near right-hand corner of the intersection. Where No Left Turn or No Turns signs are required, two should be used, one at the near right-hand corner and one at the far left-hand corner, facing traffic approaching the intersection.

These are minimum requirements, and additional signs should be placed as necessary at or in advance of the intersection. Overhead signs are sometimes desirable, particularly in congested areas. Signs may be mounted just above, below, or alongside traffic signal faces governing the traffic to which they apply. If advance signs are used, care should be taken that no alley or public driveway exists between them and the intersection where the turning movement is prohibited.

At an intersection with a one-way street, whether signalized or not, the One Way sign shall be used, and may be supplemented by the Turn Prohibition sign. (See Figure RS-7 and Section 2J-36) A Turn Prohibition sign is not needed at a ramp entrance to an expressway or freeway where the design is such as to indicate clearly the one-way traffic movement on the ramp.

A Turn Prohibition sign mounted in conjunction with a traffic signal installed directly over any roadway shall have a clearance of at least 15 feet above the roadway.

When the movement restriction applies during certain periods only, the use of Turn Prohibition signs calls for special treatment. The following alternatives are listed in order of preference:

(a) Internally illuminated signs or variable message signs that are lighted and made legible only during the restricted hours (particularly desirable at signalized intersections).

(b) Permanently mounted signs incorporating a supplementary legend showing the hours during which the prohibition is applicable.

(c) Moveable signs at each corner of the intersection where required, put in place under police supervision only when applicable and removed at other hours.

The "NO U TURN" sign may be used at or between intersections to indicate regulations prohibiting U turns at or on the specific intersections or roadways so posted. This sign may be used also on expressways and freeways where a cross-over between roadways has been provided for emergency and authorized use only.

(Rev. 12)

LANE USE SIGNS

2J-15 Lane-Use Control Signs (R-24, R-25A thru R-30A, R-31, R-32)

Lane-Use Control signs are intended for use to control vehicle movements in specific lanes. These signs should be used where turning movements are required or where unconventional turning movements are permitted from specific lanes at an intersection. Overhead mandatory movement, signs (R-26A, R-27A, R-30A) shall show a single arrow and the regulatory word message "ONLY". The overhead optional movement signs (R-28A, R-29A) shall show a straight and a curved arrow with the lower ends of their shafts superimposed, to indicate that either of the movements symbolized is permissible.

Lane-use controls permitting left or right turns from two or more lanes are normally warranted whenever the turning volume exceeds the capacity of one turning lane and when all movements can be accommodated in the lanes available to them. When multiple lane turns are to be permitted at signalized intersections, signal phasing should be used to allow the turning movements without interference from opposing or cross traffic, including pedestrians.

Side-mounted lane-use signs consist of combinations of arrows in the R-31 series of signs or the word messages of the R-24, R-25A, and the R-32 signs. The signs LEFT TURN ONLY (R-24) or RIGHT TURN ONLY (R-25A) should be used where all traffic must turn.

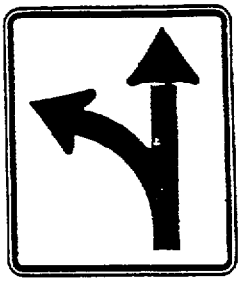
The optional movement signs R-28A and R-29A shall not be used alone to effect a turn prohibition.

Pavement markings may be used to supplement lane-use control signs and should be used with mandatory turn signs. See Section 3B-41 and Figures P-27, 28, 29.

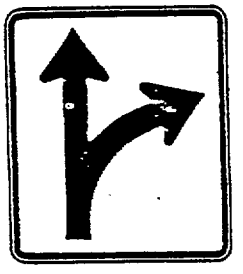
(R-26A through R-30A)

R-26A

R-27A



R-28A



R-29A

R-30A

Type	Code No.	Size
Standard	R-26A-30 R-27A-30 R-28A-30 R-29A-30 R-30A-30	30"x36"
Major Standard & Expressway	R-26A-36 R-27A-36 R-28A-36 R-29A-36 R-30A-36	36"x42"

Ohio

2J-32 Keep Right (Arrow) Sign (R-37 R & L)

The Keep Right (Arrow) sign should be used at median openings to guide traffic entering from the cross street into the proper roadway. This sign may also be used as an alternate to the R-38. See RS-6.

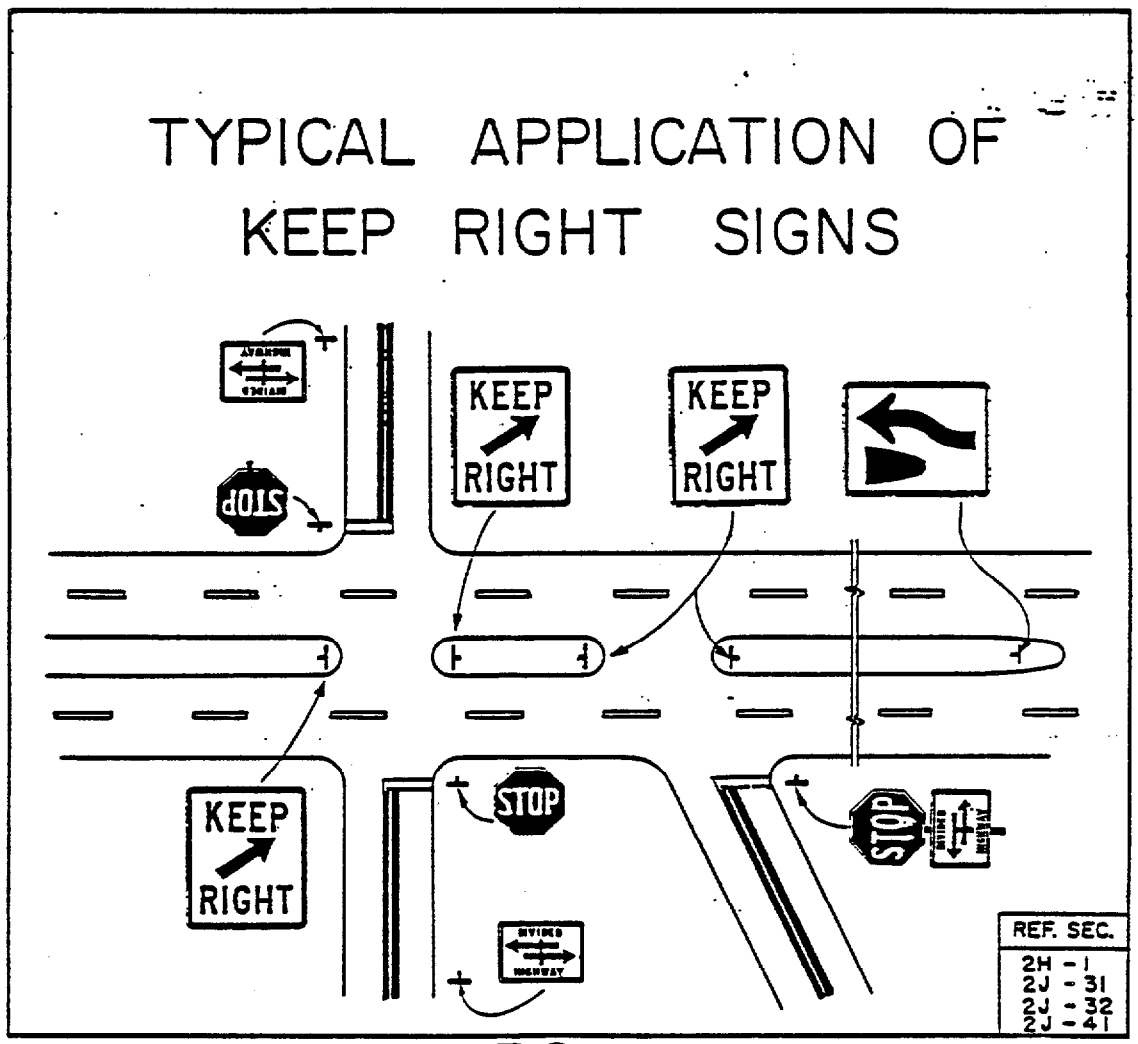
A Keep Left sign may be substituted where appropriate.

R-37R

Type	Code No.	Size
Std. & Maj. Std.	R-37R-24	24"x30"
Expressway	R-37R-36	36"x48"
Freeway	R-37R-48	48"x60"

2J-33 Keep Right (Left) Sign (OC-39R, L)

Information regarding the application of this Keep Right (Left) Sign in construction and maintenance work areas is presented in Part 7 of this manual. See Section 7E-13.



RS-6

(Rev. 12)

Ohio

2J-36 One Way Signs (R-43) (R-44)

The ONE WAY sign shall be used when required to indicate streets or roadways upon which vehicular traffic is allowed to travel in one direction only. The sign shall be either (a) a white arrow on a black horizontal rectangle with the words ONE WAY centered in the ARROW (R-43); or (b) a vertical rectangle with black lettering and arrow on a white background (R-44). The vertical design has advantages where lateral space is limited. Both designs may be made in rights and lefts. A special size (72" x 24") of the R-43 sign is provided for use on freeways and expressways under special or unusual conditions which require a larger size to deter wrong-way movements.

One Way signs shall be placed on the near righthand and the far lefthand corners of the intersection so as to face traffic entering or crossing the one-way street. Where the intersection is signalized, the signs shall be placed near the appropriate signal faces. One Way signs shall also be placed parallel to the one-way street directly opposite the exits from alleys and other public ways. A One Way sign may be supplemented by a Turn Prohibition sign (Figure RS-7).

R-43R

R-43L

R-44L

R-44R

Type	Code No.	Size
Standard & Maj. Standard	R-43R-36 R-43L-36	36"x12" 36"x12"
Expressway & Freeway	R-43R-48 R-43L-48	48"x18" 48"x18"
Special	R-43R-72 R-43L-72	72"x24" 72"x24"
Standard	R-44R-18 R-44L-18	18"x24" 18"x24"
Maj. Standard	R-44R-24 R-44L-24	24"x30" 24"x30"
Expressway & Freeway	R-44R-36 R-44L-36	36"x48" 36"x48"

(Rev. 12)

2J-37 Do Not Enter Sign (R-41B)

To prohibit traffic from entering a restricted road section the DO NOT ENTER sign should be conspicuously placed in the most appropriate position at the end of a one-way roadway or ramp.

The sign should normally be mounted on the right-hand side of the roadway, facing traffic entering the roadway or ramp in the wrong direction. However, a second sign on the left-hand side of the roadway may be justified, particularly where traffic may be approaching in a turn. Larger sizes are prescribed for use on major standard roadways or on expressways and freeways with one-way ramp or roadway connections.

When Do Not Enter and Stop signs are mounted back-to-back in an installation, the R-41B-30 shall not be used with a Stop sign smaller than the R-1-36, and only the R-1-48 shall be used with the R-41B-36.

R-41B

Type	Code No.	Size
Standard	R-41B-30	30"x30"
Maj. Standard Expressway Freeway	R-41B-36	36"x36"

(Rev. 12)

2J-38 Wrong Way Sign (R-41A)

The WRONG WAY sign may be used as a supplement to the DO NOT ENTER sign where an exit ramp intersects a crossroad or a crossroad intersects a divided highway, or at the end of a section of one-way roadway.

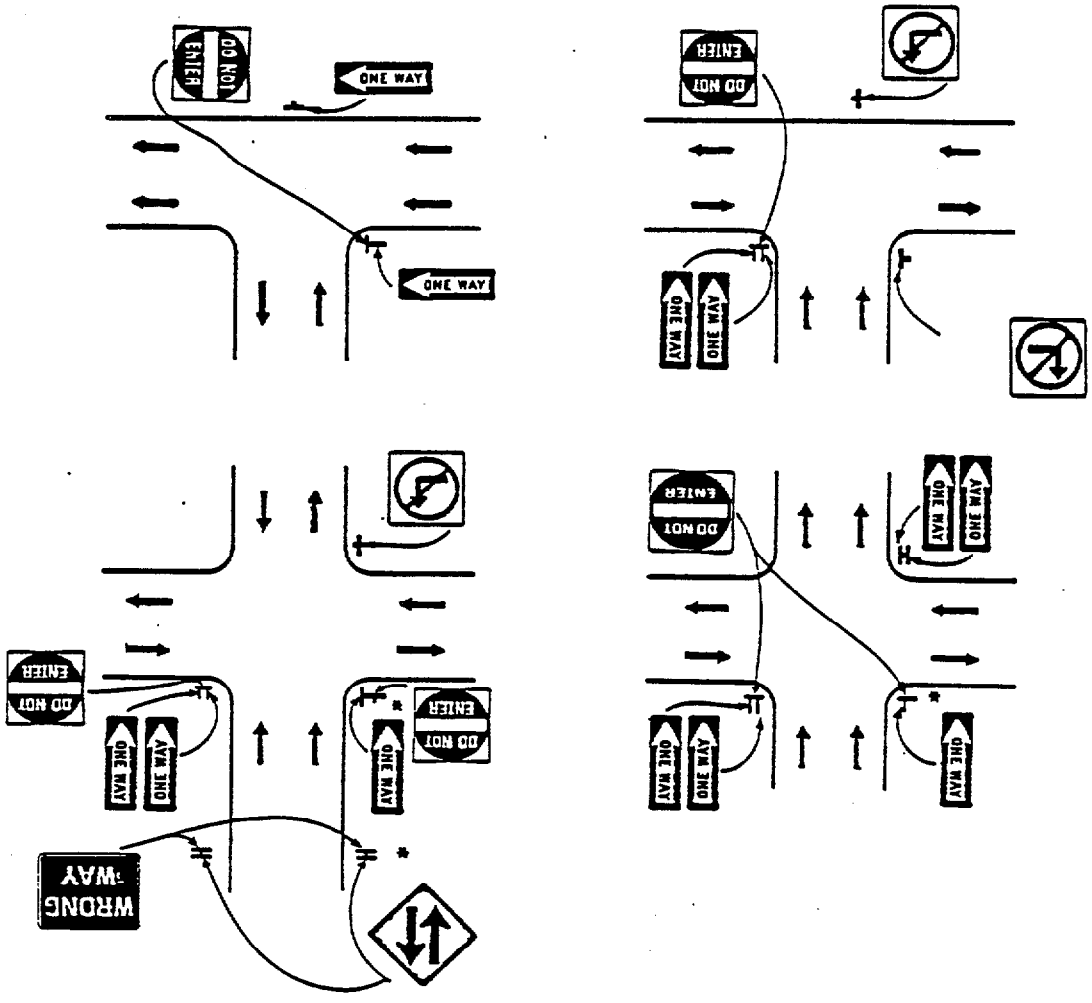
The sign should be placed at a location along the exit ramp, the divided roadway, or the one-way roadway, farther from the crossroad than the DO NOT ENTER sign.

R-41A

Code No.	Size
R-41A-36	36"x24"

Ohio

TYPICAL LOCATION OF SIGNS FOR MARKING ONE WAY STREETS



* OPTIONAL DUAL INSTALLATION OF "DO NOT ENTER" AND "WRONG WAY" SIGNS.

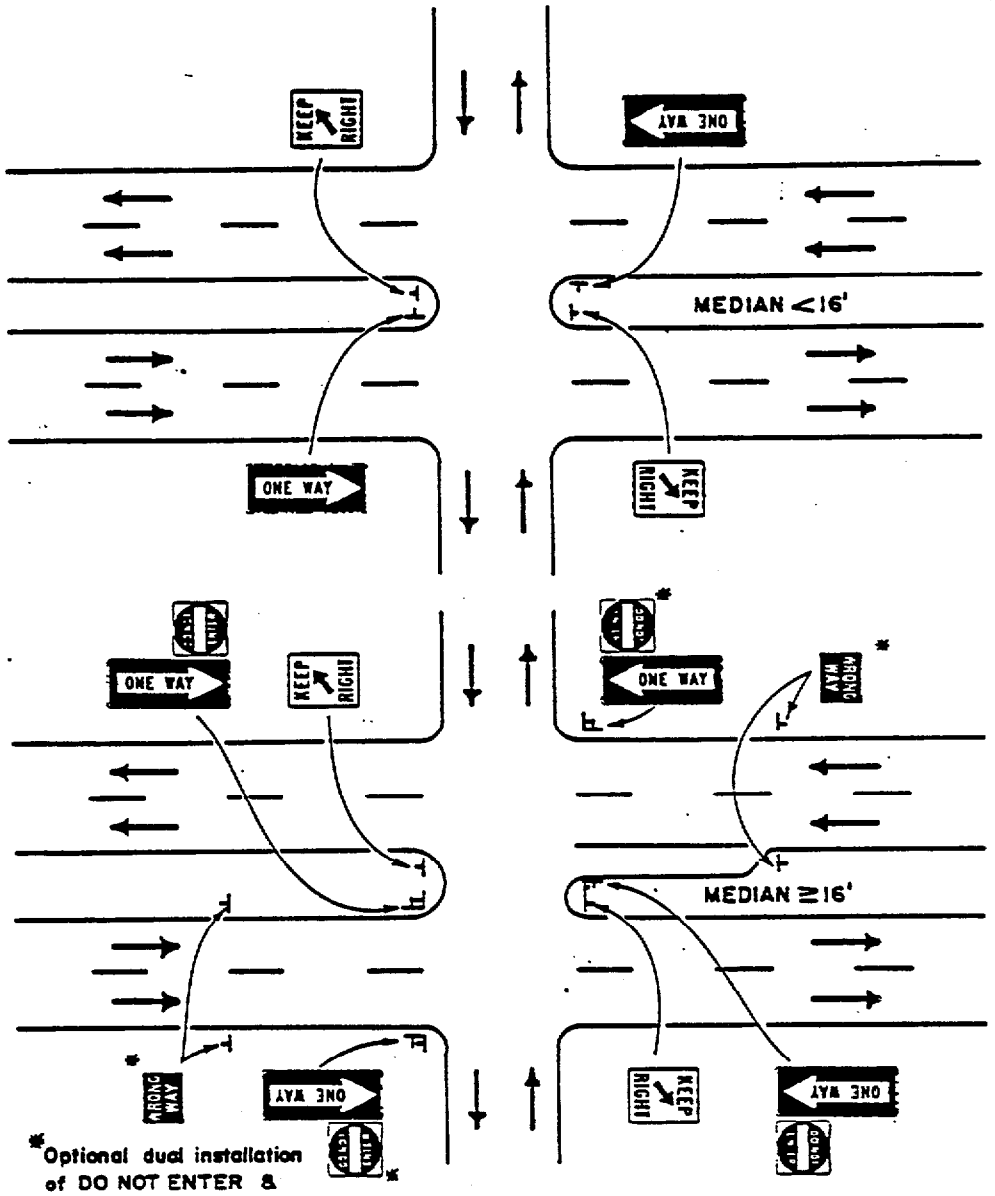
REF. SEC.
2J-36

RS-7

(REV. 11)

Ohio

TYPICAL LOCATION OF ONE WAY AND WRONG WAY MOVEMENT SIGNS FOR EXPRESSWAY INTERSECTIONS



*Optional dual installation of DO NOT ENTER & WRONG WAY signs where median exceeds 30'.

NOTES:

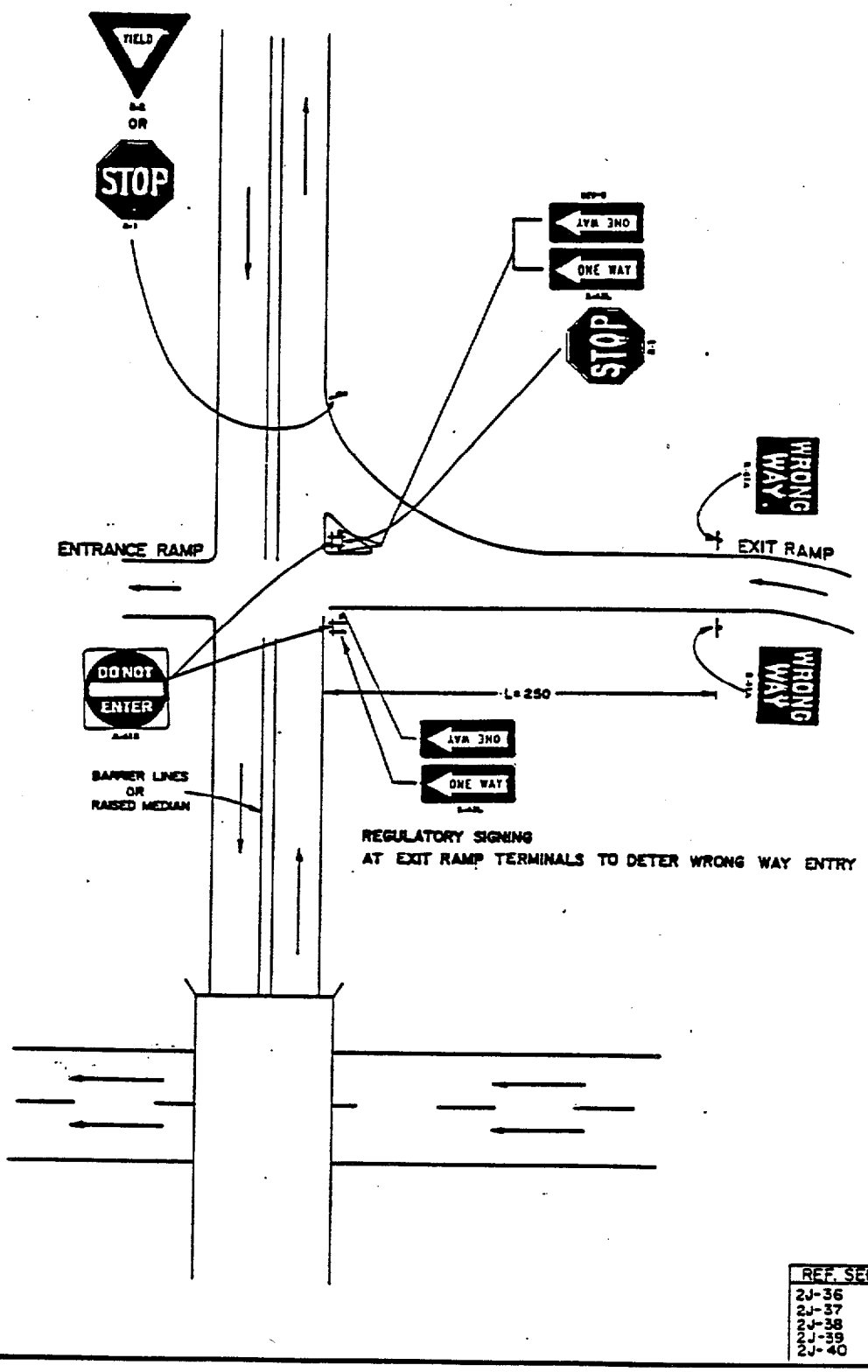
1. ONE WAY sign should be used to indicate single allowable direction of travel when median width exceeds 8'.
2. DO NOT ENTER sign should be used to prevent wrong-way movement on a one-way roadway when median width exceeds 16'.
3. WRONG WAY sign may be used to supplement DO NOT ENTER sign.

REF. SEC. 2J-36

RS-8

Ohio

TYPICAL LOCATION OF ONE WAY AND WRONG WAY MOVEMENT SIGNS FOR FREEWAY RAMP INTERSECTION



RS-9

Ohio

2J-39 Wrong Way Traffic Control for Divided Highway Intersections

Efforts should be made to identify and make practical corrections at grade intersections on divided highways where wrong-way usage is being experienced or where a wide median, a rural unlighted environment or other contributing factors indicate the likelihood of wrong-way movements.

Where the roadways are separated by a median more than 8 feet wide, ONE-WAY (R-43) signs should be erected for each crossroad approach. For lesser median widths their use is optional. DO NOT ENTER (R-41-B) signs should be used to prevent wrong-way movement on a one-way roadway when the median width exceeds 16 feet. See Figure RS-8.

Where the median width exceeds 30 feet, both DO NOT ENTER (R-41B) and WRONG WAY (R-41A) signs should be placed on a divided highway at a location to be directly in view of a driver making a wrong-way entry from the crossroad. Additional signs may be placed where the median width is 30 feet or more.

Standard directional arrow pavement markings may be placed in each approach lane of each roadway in advance of a grade intersection and at other selected locations to indicate the direction of traffic flow.

At locations which are determined to have a special need, other standard warning or prohibitive methods and devices may be used as a deterrent to the wrong-way pavement.

2J-40 Wrong Way Traffic Control For Ramp Intersections

To help prevent wrong-way usage, efforts shall be made to identify and correct wrong-way movements at highway ramp terminals.

For interchange exit ramps, ONE-WAY signs shall be placed where the exit ramp intersects the crossroad. Turn prohibition signs may be placed, especially on two lane rural crossroads, appropriately in advance of the ramp intersection to supplement the ONE-WAY sign. DO NOT ENTER signs shall be conspicuously placed near the end of the exit ramp in positions appropriate for full view of a driver starting to enter wrongly. At least one WRONG-WAY sign shall be placed on the exit ramp. Additional WRONG-WAY signs may be used where the ramp geometrics justify their installations.

On two-lane paved crossroads at interchanges double solid yellow lines should be used as a centerline for an adequate distance on both sides approaching the ramp intersections. Symbol arrow pavement markings may be placed on the crossroad at appropriate locations near the ramp junction to indicate that permissive direction of flow. See Figure RS-9.

At locations which are determined to have a special need, other standard warning or prohibitive methods and devices may be used as a deterrent to the wrong-way movement.

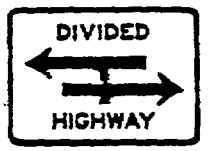
2J-41 Divided Highway Crossing Sign (R-107A, B)

The Divided Highway Crossing sign may be used as a supplemental sign on the approaching legs of a roadway that intersects with a divided highway.

The sign may be placed beneath a Stop sign or mounted separately. See Figure RS-6.

When the Divided Highway Crossing sign is used at a four-legged intersection, sign R-107A shall be used. When used at a "T" intersection, sign R-107B shall be used.

R-107A



R-107B

Type	Code No.	Size
Std. and Mod. Std.	R-107A-24 R-107B-24	24" × 18"

2K PARKING CONTROL SERIES

2K-1 General

Information regarding the classification; legal authority, and application of parking control signs is presented in PART 5 of this manual under the subject of Parking Control Zones.

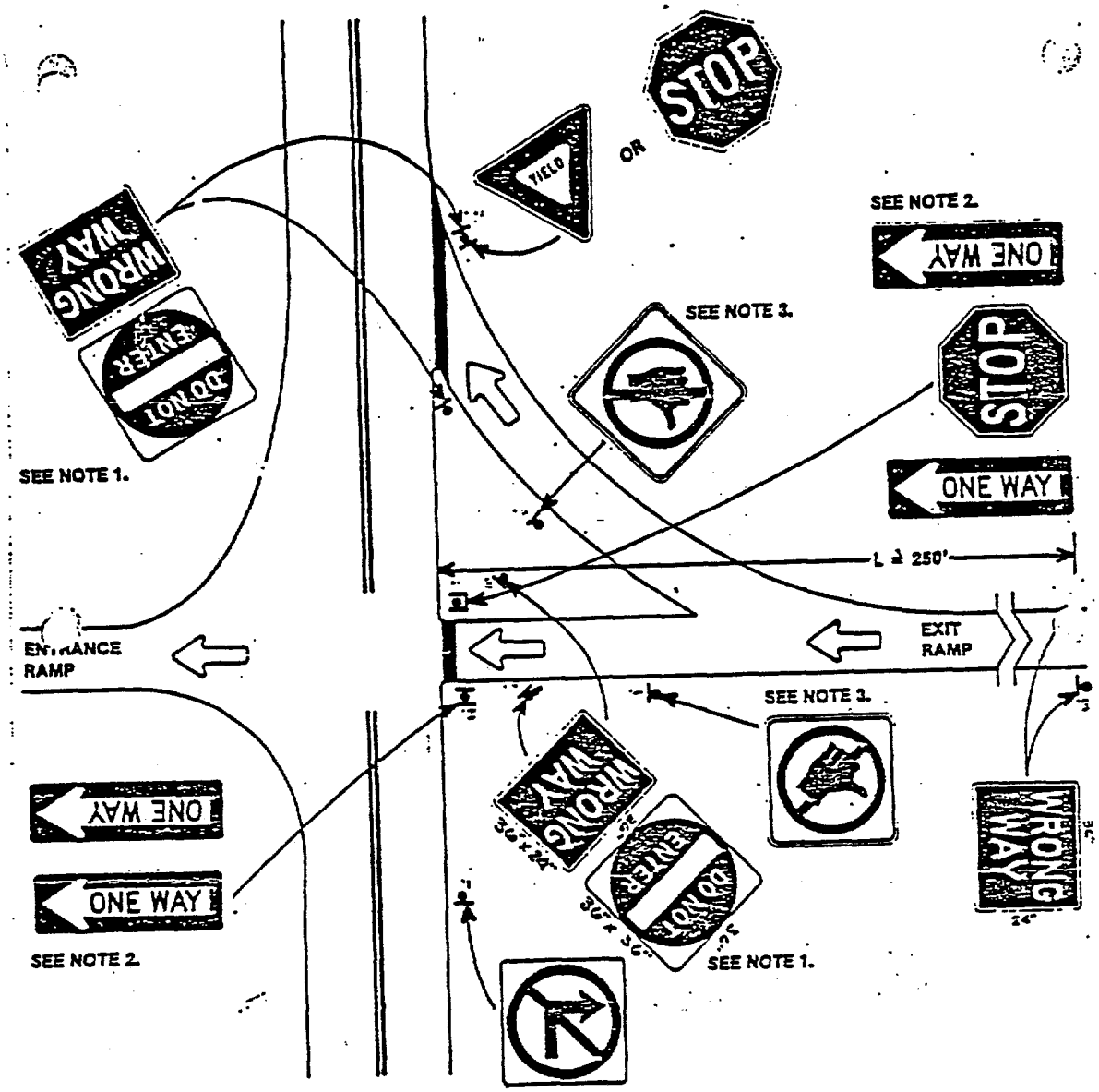
2L MISCELLANEOUS SERIES PEDESTRIAN SIGNS

2L-1 Walk on Left Sign (R-71)

The pedestrian sign WALK ON LEFT FACING

Ohio

TYPICAL REGULATORY SIGNING FOR EXIT RAMP TERMINALS



NOTES:

1. DO NOT ENTER and WRONG WAY assembly shall be mounted with the bottom of the lower sign 2' above edge of pavement.
2. ONE WAY arrows shall be mounted 3' above edge of pavement.
3. Located 50' - 100' from stop bar.

DR MD TA-1400 dated OCTOBER 12, 1981

Virginia

VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION

TRAFFIC AND SAFETY DIVISION

MEMORANDUM

GENERAL SUBJECT: Traffic Signs		NUMBER: T&S No. 166
SPECIFIC SUBJECT: Typical Regulatory Signing for Exit Ramp Terminals		DATE: December 21, 1981
		SUPERSEDES: T&S No. 165
DIRECTED TO: District Engineers	SIGNATURE: B. L. Thomas	

There has been some concern about the 1 1/2 feet mounting height of the ONE WAY signs as specified in T&S memorandum No. 165 dated October 20, 1981, by District personnel and the Federal Highway Administration. They feel that this mounting height should be adjusted, especially at locations where the ONE WAY sign is mounted behind guard-rail. Also, there was concern about the signs being obscured by vegetation.

Therefore, in order to alleviate these concerns, it has been decided to increase the mounting height of the ONE WAY sign to 3 feet. Drawing No. TA-1500 has been revised this date to reflect this change, as shown on the back of this memorandum.

MTA:bbf

cc: Mr. Leo E. Busser, III
Mr. J. T. Warren
Mr. J. M. Wray, Jr.
Mr. O. K. Mabry
Mr. W. L. Brittle, Jr.
Mr. H. W. Worrall
Division Heads
Resident Engineers
District Traffic Engineers

Appendix D

Wrong-Way Related California Vehicle Codes

Wrong-Way Related California Vehicle Codes

California Highway Patrol officers can cite an individual for violating the California Vehicle Code if they witness the infraction. In the Los Angeles area, the wrong-way signs.were vandalized with territorial gang symbols and stolen for their scrap metal value. Efforts were made in curbing vandalism and theft of traffic signs in the 26 citations for violation of the "Interference With Traffic Devices" Vehicle Code Section 21464. In addition, officers were instructed to "report any actual or potential highway condition that may affect the safe and efficient flow of traffic to the responsible highway authority." The majority of wrong-way accidents were caused by those driving under the influence. DUI arrests during the first three quarters of the 1988 year amounted to 725, in the sobriety checkpoint locations alone. The State of California Vehicle Code Sections which relate to wrong-way and U-turn related violations follow.

Designated Traffic Direction

21657. The traffic authorities in charge of any highway may designate any highway, roadway, part of a roadway, or specific lanes upon which vehicular traffic shall proceed in one direction at all times as shall be indicated by official traffic control devices. When a roadway has been so designated, a vehicle shall be driven only in the direction designated at all times or such times as shall be indicated by traffic control devices.

Interference With Traffic Devices

21464. (a) No person shall without lawful authority deface, injure, attach any material or substance to, knock down, or remove, nor shall any person shoot at, any official traffic control device, traffic guidepost, traffic signpost, or historical marker placed or erected as authorized or required by law, nor shall any person without such authority deface, injure, attach any material or substance to, or remove, nor shall any person shoot at, any inscription, shield, or insignia on any such device, guide, or marker.
(c) Any willful violation of subdivision (a) or (b) which results in injury to, or death of, a person shall be punished by imprisonment in the state prison, or imprisonment in a county jail for a period of not more than six months.

Willful or Negligent Damage

17300. (a)Any person who willfully or negligently damages any street or highway, or its appurtenances, including, but not limited to, guardrails, signs, traffic signals, and similar facilities, is liable for the reasonable cost of the repair or replacement thereof.
(d) The Department of Transportation and local authorities, with respect to highways under their respective jurisdictions, may present claims for liability under this section, bring actions for recovery thereon, and settle and compromise in their discretion claims arising under this section.
(e) If the Department of Transportation or a local authority provides services on a highway outside its jurisdiction, at the request of the department or the local authority which has jurisdiction over that highway, the department or the local authority may present a claim for liability for rendering this service under this section, bring actions for recovery thereon, and, in its discretion, settle and compromise the claim.

Damage by Illegal Operation of Vehicle

17301. (a) Any person driving any vehicle, object, or contrivance over a highway or bridge is liable for all damages which the highway or bridge may sustain as a result of any illegal operation, driving or moving of the vehicle, object, or contrivance, or a a result of operating, driving, or moving any vehicle, object, or contrivance weighing in excess of the maximum weight specified in this code which is operated under a special permit issued by the Department of Transportation.
(b) Whenever the driver is not the owner of the vehicle, object, or contrivance but is operating, driving, or moving the same with the express or implied permission of the owner, the owner and driver are jointly and severally liable for the damage.

Recovery of Damages

17303. Damages under Sections 17301 and 17302 may be recovered in a civil action brought by the authorities in control of the highway or bridge.

Blood Alcohol Information

1666 The department shall do all of the following:
(a) Include at least one question in each test of an applicant's knowledge and understanding of the provisions of this code, as administered pursuant to Section 12804 or 12814, to verify that the applicant has read and understands the table of blood alcohol concentration published in the Driver's Handbook made available pursuant to subdivision (b) of Section 1656. In order to minimize costs, the questions shall be initially included the earliest opportunity when the test is otherwise revised or reprinted.
(b) Include with each driver's license or certificate of renewal and each vehicle registration renewal mailed by the department, information which shows with reasonable certainty the amount of alcohol consumption necessary for a person to reach a 0.10 percent blood alcohol concentration by weight.

Arrest Without Warrant

40300.5 Notwithstanding any other provision of law, a peace officer may, without a warrant, arrest a person who is (1) involved in a traffic accident or (2) observed by the peace officer in or about a vehicle which is obstructing a roadway, when the officer has reasonable cause to believe that the person had been driving vehicle under the influence of an alcoholic beverage and any drug.

Place of Arrest: Driving Under the Influence

40300.6 Section 40300.5 shall be liberally interpreted to further safe roads and the control of driving while under the influence of an alcoholic beverage or any drug in order to permit arrests to be made pursuant to that section within a reasonable time and distance away from the scene of a traffic accident.
The enactment of this section during the 1985-1986 Regular Session of the Legislature does not constitute a change in, but is declaratory of, the existing law.

Alcohol or Drugs: Driver

23152 (a) It is unlawful for any person who is under the influence of an alcoholic beverage or any drug, or under the combined influence of an alcoholic beverage and drug, to drive a vehicle.
(b) It is unlawful for any person who has 0.10 percent or more, by weight, of alcohol in his blood to drive a vehicle. For purposes of this subdivision, percent, by weight, of alcohol shall be based on grams of alcohol per 100 millimeters of blood. In any prosecution under this subdivision, it is a rebuttable presumption that the person had 0.10 percent or more, by weight, of alcohol in his or her blood at the time of driving the vehicle if the person had 0.10 percent or more, by weight, of alcohol in his or her blood at the time of the performance of a chemical test within three hours after the driving.
(c) It is unlawful for any person who is addicted to the use of any drug to drive a vehicle. This subdivision shall not apply to a person who is participating in a methadone maintenance treatment program approved pursuant to Article 3 (commencing with Section 4350) of Chapter 1 of Part 1 of Division 4 of the Welfare and Institutions Code.

Alcohol or Drugs Causing Injury: Driver

21353. (a) It is unlawful for any person, while under the influence of an alcoholic beverage or any drug, or under the combined influence of an alcoholic beverage and any drug, to drive a vehicle and, when so driving, do any act forbidden by law or neglect any duty imposed by law in the driving of the vehicle, which act or neglect proximately causes bodily injury to any person other than the driver.
(b) It is unlawful for any person, while having 0.10 percent or more, by weight, of alcohol in his blood to drive a vehicle and, when so driving, do any act forbidden by law or neglect any duty imposed by law in the driving of the vehicle, such act or neglect proximately causes bodily injury to any person other than the driver.
For purposes of this subdivision, percent, by weight, of alcohol shall be based upon grams of alcohol per 100 milliliters of blood.
In any prosecution under this subdivision, it is a rebuttable presumption that the person had 0.10 percent or more, by weight, of alcohol in his or her blood at the time of driving the vehicle if the person had 0.10 percent or more, by weight, of alcohol in his or her blood at the time of the performance of a chemical test within three hours after the driving.
(c) In proving the person neglected any duty imposed by law in the driving of the vehicle, it is not necessary to prove that any specific section of this code was violated.

State Authority

21350. The Department of Transportation shall place and maintain, or cause to be placed and maintained, with respect to highways under its jurisdiction, appropriate signs, signals and other traffic control devices as required hereunder, and may place and maintain, or cause to be placed and maintained, such appropriate signs, signals or other traffic control devices as may be authorized hereunder, or as may be necessary properly to indicate and to carry out the provisions of this code, or to warn or guide traffic upon the highways. The Department of Transportation may, with the consent of the local authorities, also place and maintain, or cause to be placed and maintained, in or along city streets and county roads, appropriate signs, signals and other traffic control devices, or may perform, or cause to be performed, such other work on city streets and county roads, as may be necessary or desirable to control, or direct traffic, or to facilitate traffic flow to or from or on state highways.

Traffic and Pedestrian Regulation on State Highways

21352. The Department of Transportation may erect stop signs at any entrance to any state highway and whenever the department determines that it is necessary for the public safety and the orderly and efficient use of the highways by the public, the department may erect and maintain, or cause to be erected and maintained, on any state highway any traffic control signal or any official traffic control device regulating or prohibiting the turning of vehicles upon the highway, allocating or restricting the use of specified lanes or portions of the highway by moving vehicular traffic, establishing crosswalks at or between intersections, or restricting use of the right-of-way by the public for other than highway purposes.

Divided Highways

21651. (a) Whenever a highway has been divided into two or more roadways by means of intermittent barriers or by means of a dividing section of not less than two feet in width, either unpaved or delineated by curbs, double-parallel lines, or other markings on the roadway, it is unlawful to do either of the following:
(1) To drive any vehicle over, upon or across the dividing section.
(2) To make any left, semicircular, or U-turn with the vehicle on the divided highway, except through an opening in the barrier designated and intended by public authorities for the use of vehicles or through a plainly marked opening in the dividing section.
(b) It is unlawful to drive any vehicle upon a highway, except to the right of an intermittent barrier or a dividing section which separates two or more opposing lanes of traffic.
(c) A violation of subdivision (b) on a freeway is a misdemeanor.

On Ramp Exit

21664. It is unlawful for the driver of any vehicle to make an exit from or to leave any freeway which has full control of access and no crossings at grade upon any on-ramp providing entrance to such freeway.

U-Turn in Business District

22102 No person in a business district shall make a U-turn, except at an intersection, or on a divided highway where an opening has been provided in accordance with Section 21651. This turning movement shall be made as close as practicable to the extreme left-hand edge of the lanes moving in the driver's direction of travel immediately prior to the initiation of the turning movement, when more than one lane in the direction of travel is present.

Turning Near Fire Stations

22104. No person shall make a U-turn in front of the driveway entrance or approaches to a fire station. No person shall use the driveway entrance or approaches to a fire station for the purpose of turning a vehicle so as to proceed in the opposite direction.

Unobstructed View Necessary for U-turn

22105. No person shall make a U-turn upon any highway where the driver of such vehicle does not have an unobstructed view for 200 feet in both directions along the highway and of any traffic thereon.

U-Turn in Residence District

22103. No person in a residence district shall make a U-turn when any other vehicle is approaching from either direction within 200 feet, except at an intersection when the approaching vehicle is controlled by an official traffic control device.

Driving When Privilege Suspended or Revoked

14601. (a) No person shall drive a motor vehicle at any time when that person's driving privilege is suspended or revoked for reckless driving in violation of Section 23103 or 23104, and reason listed in ( ) subdivision (a) license, negligent or incompetent operation of a motor vehicle as prescribed in subdivision (e) of Section 12809, or negligent operation as prescribed in Section 12810, and when the person so driving has knowledge of the suspension or revocation. Knowledge shall be presumed if notice has been given by the department to the person. The presumption established by this subdivision is a presumption affecting the burden of proof.

Driving When Privilege Suspended or Revoked for Other Reasons

14601.1 (a) No person shall drive a motor vehicle when his or her driving privilege is suspended or revoked for any reason other than those listed in Section 14601 or 14601.2 and when the person so driving has knowledge of the suspension or revocation. Knowledge shall be presumed if notice has been given by the department to the person. The presumption established by this subdivision is a presumption affecting the burden of proof.

Driving When Privilege Suspended or Revoked for Driving Under the Influence, With Excessive Blood Alcohol, or When Addicted

14601.2 (a) No person shall drive a motor vehicle at any time when that person's driving privilege is suspended or revoked for a conviction of a violation of Section 23152 or 23153, and when the person so driving has knowledge of the suspension or revocation.

Habitual Traffic Offender

14601.3 (a) It is unlawful for a person whose driving privilege has been suspended or revoked to accumulate a driving record history which results from driving during the period of suspension or revocation. A person who violates this subdivision is designated a habitual traffic offender. For purposes of this section, a driving record history means any of the following, if the driving occurred during any period of suspension or revocation which resulted from a conviction of an offense or offenses of driving under the influence of alcohol or drugs, or both, or from negligent driving:

(1) Two or more convictions within a 12-month period of an offense given a violation point count of two pursuant to Section 12810.

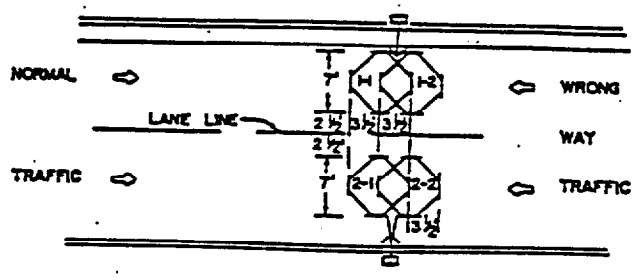
(2) Three or more convictions within a 12-month period of an offense given a violation point count of one pursuant to Section 12810.

(3) Three or more accidents within a 12-month period that are subject to the reporting requirements of Section 16000.

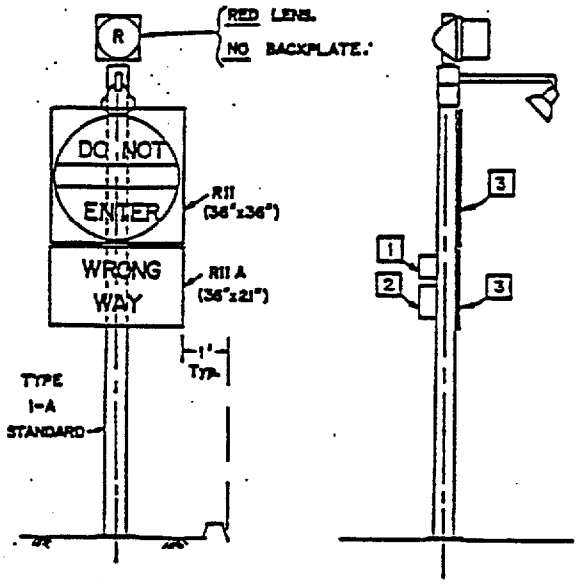
(4) Any combination of convictions or accidents, as specified in paragraphs (1) to (3), inclusive, which results during any 12-month period in a violation point count of three or more pursuant to Section 12810.

Appendix E

Pavement Lights Retrofit Diagrams



TYPICAL LOOP DETECTOR PLACEMENT
AND LOOP NUMBERING DETAIL
(NO SCALE)



FLASHING BEACON INSTALLATION

NOTES (THIS SHEET)

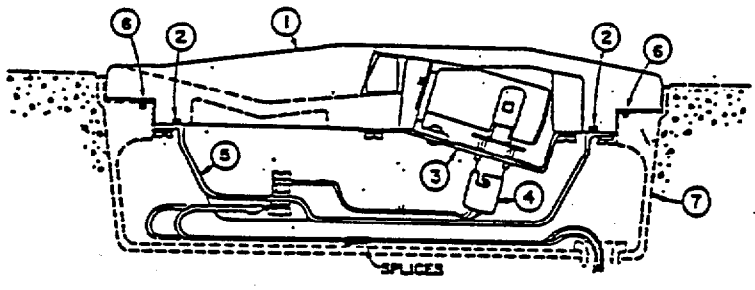
1 - FLASHING BEACON CONTROL ASSEMBLY, WHEN REQUIRED. WIRING DIAGRAM-STANDARD PLAN ES-4C.

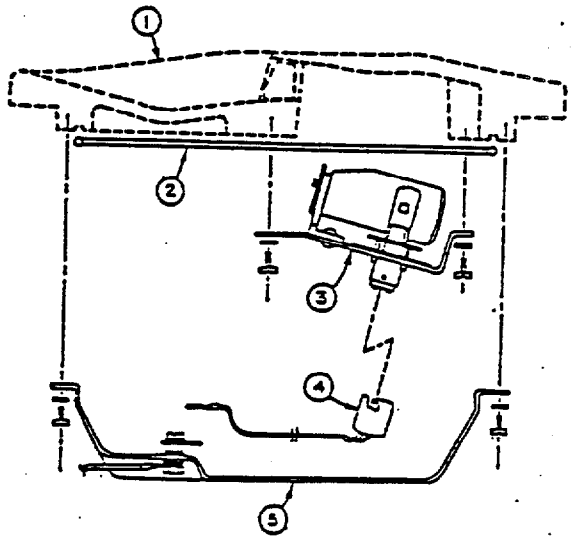
2 - NEMA 3R ENCLOSURE FOR TRANSFORMER, WHEN SHOWN ON THE PLANS. (APPROX. DIMENSIONS: 12"H. x 8"W. x 8"D.)

3 - INSTALL STATE-FURNISHED SIGN. INSTALLATION DETAILS-STANDARD PLAN S44-7.

4 - LOCATE SUCH THAT WIREWAYS DO NOT INTERFERE WITH CONTROL EQUIPMENT IN "G" CABINET.

(1) - EXISTING UPPER CASTING, WITH LENS.
(2) - "O"-RING GASKET-SEPCO PART NO. 20400-2.
(3) - LAMP AND REFLECTOR ASSEMBLY-SEPCO PART NO. 20149-1.
(4) - SOCKET AND LEAD ASSEMBLY-SEPCO PART NO. 19095-1.
(5) - INNER COVER-SEPCO PART NO. 20016-4.
(6) - "O"-RING GASKET-SQUARE-SEPCO PART NO. 18874-1.
(7) - EXISTING 3-INCH L850 BASE RECEPTACLE.





COMPLETE PAVEMENT LIGHT ASSEMBLY
INSTALLED IN AN
EXISTING BASE RECEPTACLE