RIVERSIDE COUNTY TRANSPORTATION COMMISSION

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December 21, 2018

California Traffic Control Devices Committee (CTCDC)
Traffic Operations Headquarters
1120 N Street, MS 36, Room 4500
Sacramento, CA 95814

Subject: REQUEST TO EXPERIMENT:
(1) NON-STANDARD STRIPING DETAIL - 6" WHITE SKIP STRIPE NEXT TO 6" WHITE SOLID STRIPE
(2) NEW STRIPING DETAIL – 6" DOUBLE WHITE SOLID STRIPE

Dear CTCDC,

The Riverside County Transportation Commission (RCTC) requested permission from the Federal Highway Administration (FHWA) on January 3, 2017 and received approval from Manual on Uniform Traffic Control Devices (MUTCD) team to conduct an experiment using modified striping as a non-standard/new traffic control device to determine its effectiveness in improving operations and safety in the ingress and egress areas of an express lane system.

BACKGROUND

The 91 Express Lanes originally consisted of a 10-mile long priced managed lane facility located in the median of State Route 91 in Orange County, California. The lanes began at the junction of State Routes 91 and 55 and terminated at the Orange/Riverside county line. This facility had been in operation since 1995. RCTC extended the lanes another 8 miles to the junction of State Route 91 and Interstate 15. This extension was opened to traffic in the spring of 2017. As part of the extension project, an intermediate egress from and an intermediate ingress to the Express Lanes were constructed at the county line. RCTC was granted permission to conduct an experiment to install a: (1) non-standard striping detail and; (2) a new striping detail at the intermediate egress supplemented by appropriate signage and pavement markings at the transition zone (ingress/egress) location to enhance the effectiveness in improving operations and safety for motorist entering/exiting the area where the Express Lanes and the general purpose lanes converge. The experimental striping was only installed at the intermediate access locations.

PROBLEM STATEMENT

RCTC originally designed the intermediate access as a continuous weave lane to address the high volume of traffic expected to enter and exit the express lanes at this location. However, feedback from recent experience on LA Metro's I-110 express lanes has led to RCTC's redesign of the intermediate access with a separate egress and ingress. According to Metro's Executive Director of Congestion Management Kathy McCune, "general purpose lane traffic [uses the weave lane] as a means to pass other vehicles in the #1 general purpose lane [and this] creates a potential conflict for vehicles entering and exiting [and] impacts the flow of traffic of vehicles in the express lanes."

The SR-91 intermediate ingress and egress zone is 1.5 miles long in the eastbound direction and 1.25 miles long in the westbound direction. (The following describes the eastbound direction, however, similar conditions and proposed solutions apply to the westbound direction.) It contains three segments. The first segment is the 0.5 mile egress segment. Following the egress segment is a 0.5 mile chevron striped buffer segment. This is followed by the ingress segment.

RCTC is concerned that non-Express Lane traffic from the general purpose lanes would attempt to enter the egress lane during heavy congestion periods and continue downstream to re-enter the general purpose lanes, thereby queue jumping, which would impact toll traffic entering/exiting the Express Lanes. Furthermore, there is a potential for Express Lane bound traffic in the general purpose lanes to enter the Express Lanes early at the egress location raising additional operational and safety concerns.

Additional safety concerns with vehicles entering the egress segment occur if a motorist expects this segment to be the entrance to the Express Lanes. A vehicle entering the egress lane would merge from the general purpose lane into the egress lane then have to merge over once again into the Express Lane. Merging into higher speed Express Lane traffic within the egress section creates added safety concerns.

Per the Statewide Integrated Traffic Records System (SWITRS) data, total collisions for preconstruction years 2012, 2013, 2014 for July through December at Green River Road are shown below:

Westbound direction
- 62 collisions – 7/01/2014 - 12/31/2014
- 25 collisions – 7/01/2013 - 12/31/2013
- 39 collisions – 7/01/2012 - 12/31/2012

Eastbound direction
- 64 collisions – 7/01/2014 - 12/31/2014
- 49 collisions – 7/01/2013 - 12/31/2013
- 40 collisions – 7/01/2012 - 12/31/2012

The SWITRS data collected indicates the majority of the collisions on SR-91 at Green River Road were cited for unsafe speed with the resulting collision type classified as Rear End. The combination of unsafe speed, unnecessary weaving, queue jumping, as well as confusion to motorist, especially non-local residents or

frequent commuters, may increase rear end collisions in the area. Although the time periods of the accident data provided above are not consistent with the evaluation period, Southern California does not experience seasonal differences as does the rest of the Country. Temperatures are mild in the winter and rainfall is moderate.

PROPOSED SOLUTION

The ingress/egress transition area contains three segments (see Figure 1). The first segment is the 3,920 feet egress section with the installation of the non-standard striping detail – 6-inch white skip stripe next to 6-inch white solid stripe. The egress section is bounded on the left by the new striping detail - 6-inch double white solid stripe. Following the egress segment is a 0.5 mile buffer segment comprised of 8-inch double white solid striping and chevron markings. This is followed by a 0.5 mile ingress opening section that transitions to a 1,600 feet ingress lane drop.

The non-standard striping detail, 6-inch white skip stripe next to 6-inch white solid stripe, further enhances the egress only condition by signifying that an allowable movement across this stripe can only be in the egress direction. A similar striping detail exists in a few limited locations identified in the United States and one instance overseas as follows (see attached photos):

- I-495 Long Island Expressway, NY
- US-36 Colorado, CO
- I-405 Orange County, CA (yellow stripe application)
- Taipei, Taiwan

The new striping detail, 6-inch double white stripe (FHWA approval not required; California exception only), along the left side further enhances this egress movement into the general purpose lanes making it illegal to cross over from the express lane side (late exit) or from the general purpose lane side (wrong entry).

It should be noted RCTC's initial request to CTCDC and FHWA for experimental striping requested a non-standard striping detail of 4-inch white skip stripe next to 4-inch white solid stripe and a new striping detail with 4-inch double white solid stripe. Upon further review from Caltrans, OCTA and internal RCTC peer reviews, 4-inch white skip stripe next to 4-inch white solid stripe was revised to use 6-inch white striping. The 4-inch double white solid was also revised to 6-inch white striping. This was done to enhance visibility of the stripe due to pavement type chances, joints, and horizontal curves.

RCTC requested comments and held discussions with Captain Kevin Porter of the California Highway Patrol (CHP) Inland Division regarding proposed signing and striping. Captain Porter reviewed the proposed signing and striping with his staff and CHP believes that the experimental striping is enforceable. Furthermore, CHP has requested a black on white "ILLEGAL TO CROSS DOUBLE WHITE LINES" sign to further emphasize this movement is illegal.

OBJECTIVE

The objective of this experiment was to determine the effectiveness of the experimental striping supplemented by appropriate signage and pavement markings within the egress segment for improving operations and safety for motorist exiting and entering the Express Lanes. The original signing and striping concept plan is included as Figure 1.

WORK PLAN

The intermediate access zone stripings were installed as an integral part of the SR-91 CIP Express Lanes project. Intermediate access zone striping at proposed access locations were installed with these treatments designed specifically for the locations under consideration.

Effectiveness and acceptance were measured in accordance with the time period and evaluation procedures shown below.

EXPERIMENT SCHEDULE

- Pre-Installation Evaluation - N/A
- Installation - March 2017
- Experimental Period - March 2017 – July 2018
- Evaluation of Results - July 2017, August 2018

EVALUATION PROCEDURES

The following procedures were followed:

1) Installation Documentation – Project signing and striping plans and specifications were used for the original installation of signing and experimental striping for SR-91 Express Lanes and general purpose lanes. Opening day of SR-91 Express Lanes occurred on March 20, 2017. Any revisions to the striping, signage or additional signing were addressed by revising the "Released for Construction" (RFC) original project plans to provide "Notice of Design Change" (NDC) plans. Approved NDC plans were sent to the contractor for implementation.

   Additional changes or revisions to signing and striping after striping and signs were installed were documented through a directive letter prepared by RCTC staff. Directive letter, DL-161 Rev2 was issued on September 13, 2017 to revise a portion of Express Lane signing and striping.

   DL-161 Rev2 revised the 4-inch experimental striping to 6-inch, revised 4-inch double white buffer striping to 6-inch, added lane drop arrow pavement markings and also modified two overhead sign panels with enhanced

messaging. Delineators were also added to the buffer segment between SR-91 Express Lanes egress and ingress segments. Signing and striping revisions were completed and installed by the end of September 2017.

2) Maintenance Recording – RCTC maintains operations along SR-91 Express Lanes throughout the project limits with COFIROUTE USA providing tolling operations and management for the electronic tolling facilities. Maintenance along SR-91 Express Lanes is performed by Caltrans. Caltrans maintenance crews perform such activities as refresh striping, replace missing pavement markers, replace missing or damaged channelizers, repair pot holes, weed abatement and sweeping. Maintenance occurs approximately every three weeks on Sunday mornings. Crews provide a detailed account of the completed work. Scheduled work that is not completed is noted and rescheduled for completion during the next maintenance period.

3) Observations were conducted to determine the effectiveness of the operation. Video and digitized photographs were used to help document the operation. Measures of effectiveness and acceptance include the following actions:

- Compare the total number of accidents and the average accident rates;
- Compare statewide accident rates at similar express lane locations;
- Evaluate vehicular conflicts in the weave zone;
- Evaluate driver behaviors in the weave area;
- Compare the number vehicles complying or in violation of the express lane buffer striping and signing.

RCTC worked with California Department of Transportation (Caltrans) and CHP to help assess acceptance and effectiveness. RCTC only conducted the after studies at the ingress/egress locations and compared statewide accident rates at similar express lane locations.

EXPERIMENT RECAP

ACCIDENT DATA ANALYSIS

SR-91 accident data for the project area was analyzed and compared to similar statewide express lane facilities. Six operational express lane facilities were reviewed. Only two facilities have weave lane access locations and used for the comparison below. The four remaining express lane facilities have a weave zone or separated ingress-egress merge lane or continuous access designs. The two facilities with weave access locations are I-110 Express Lanes in Los Angeles County and I-15 Express Lanes in San Diego County. Accident data was obtained from Caltrans for both facilities at weave access locations. SR-91 accident data was obtained from Caltrans, California Highway Patrol (CHP) and Statewide Integrated Traffic Records System (SWITRS).

I-110 Express Lane weave lane access locations occur at post mile 14.2–15.9 and post mile 16.5–17.2. However, weave access at post mile 14.2-15.9 is only in the southbound direction.

I-15 Express Lane weave lane access locations occur at post mile post mile 12.0–13.8, post mile 14.0-15.5, post mile 19.4-22.4 and post mile 24.5-25.6. However, weave access at post mile 14.0-15.5 is only in the northbound direction.

Evaluation of the summary of accident data rates located within the Express Lane area for the SR-91, I-110, and I-15 freeway segments, presented in Table 1, reveals that the actual accident rate along SR-91 during the 9 month experimental period in 2017 (March 20, 2017 to December 31, 2017) is higher compared to I-110 and I-15 freeway segments with similar Express Lane facilities. Compared to the SR-91 segment before the opening of the Express Lane facility (January 1, 2012 to December 31, 2014), the actual accident rate along SR-91 during the 9 month experimental period in 2017 (March 20, 2017 to December 31, 2017) is higher as well.

Table 1: Summary of Accident Data

Location	TOTAL COLLISIONS	Actual Accident Rate (per MVM)
I-110 (December 31, 2013 to June 30, 2015)		
Northbound and Southbound - 76th St to Florence Ave (PM 16.5- 17.2)	67	0.55
Southbound - W Manchester Ave On-ramp to I-105 EB Off-ramp (PM 14.2 -15.90)	71	0.25
I-15 (January 1, 2012 to December 31, 2014)		
Northbound and Southbound - Weave Lane at Ammo Rd (PM 12.0-13.8)	189	0.34
Northbound - Weave Lane North of Pomerado Rd/Miramar Rd (PM 14.0-15.5)	204	0.45
Northbound and Southbound - Weave Lane North of Ted William Pkwy (PM 19.4- 22.4)	224	0.31
Northbound and Southbound - Weave Lane South of Pomerado Rd/ Bernardo Dr (PM 24.5-25.6)	60	0.25
SR-91 (January 1, 2012 to December 31, 2014) – 36 Months		
Eastbound - 2,500 feet West of Coal Canyon Rd to 1,800 feet East of Coal Canyon Rd (PM R17.5-R18.313)	73	0.32
Westbound - 2,500 feet West of Coal Canyon Rd to 2,000 feet East of Coal Canyon Rd (PM R17.5-R18.336)	74	0.32
SR-91 (March 20, 2017 to December 31, 2017) – 9 Months (All Lanes)		
Eastbound – Coal Canyon Rd to County Line (PM ORA R17.95-R18.899)	82	1.15
Eastbound – County Line to Green River Rd (PM R18.899-RIV R1.03)	58	0.75
Westbound – Coal Canyon Rd to County Line (PM ORA R17.95-R18.899)	30	0.44
Westbound – County Line to Green River Rd (PM R18.899-RIV R1.03)	67	0.90
SR-91 (March 20, 2017 to December 31, 2017) – 9 Months (Express Lanes Only)		

Table 1: Summary of Accident Data

Location	TOTAL COLLISIONS	Actual Accident Rate (per MVM)
Eastbound – Coal Canyon Rd to County Line (PM ORA R17.95-R18.899) Total (Express Lane)	6	0.19
Eastbound – County Line to Green River Rd (PM R18.899-RIV R1.03) Total (Express Lane)	5	0.15
Westbound – Coal Canyon Rd to County Line (PM ORA R17.95-R18.899) Total (Express Lane)	3	0.10
Westbound – County Line to Green River Rd (PM R18.899-RIV R1.03) Total (Express Lane)	5	0.15
SR-91 (January 1, 2018 to April 30, 2018) – 4 Months (All Lanes)		
Eastbound – Coal Canyon Rd to County Line (PM ORA R17.95-R18.899)	30	0.95
Eastbound – County Line to Green River Rd (PM R18.899-RIV R1.03)	22	0.64
Westbound – Coal Canyon Rd to County Line (PM ORA R17.95-R18.899)	12	0.39
Westbound – County Line to Green River Rd (PM R18.899-RIV R1.03)	23	0.69
SR-91 (January 1, 2018 to April 30, 2018) – 4 Months (Express Lanes Only)		
Eastbound – Coal Canyon Rd to County Line (PM ORA R17.95-R18.899)	2	0.06
Eastbound – County Line to Green River Rd (PM R18.899-RIV R1.03)	0	0.0
Westbound – Coal Canyon Rd to County Line (PM ORA R17.95-R18.899)	0	0.0
Westbound – County Line to Green River Rd (PM R18.899-RIV R1.03)	2	0.06

SR-91 accident data obtained from CHP and SWITRS indicates an increase in total collisions for year 2017 compared to Caltrans 2012 – 2014 Traffic Accident Surveillance and Analysis System (TASAS) accident data. The freeway segments that appear to have an increase in collisions are eastbound SR-91 from Coal Canyon Road to County Line (ORA R17.95 – ORA R18.899) and westbound SR-91 from Green River Road to County Line (ORA R18.899 – RIV R1.03), as presented in Table 1. Both of these segments are prone to traffic congestion due to the close proximity to Green River Road interchange and the geometric features of the roadway. Roadway geometry through this area contains both vertical curves and horizontal curves bounded by the Santa Ana Mountains on the south side of SR-91 and Santa Ana River on the north side. Previous accident data indicates the majority of collisions in this area are cited for unsafe speed.

Newly constructed egress sections of SR-91 Express Lanes and the newly improved westbound Green River Road on-ramp fall within these segments that have an increase in traffic collisions.
These changes to geometry, and the addition of traffic merging into a section of freeway that motorists are not accustomed to can cause confusion and indecision to motorists. This could be a factor leading to an increase in traffic collisions.

Once motorists become accustomed to changes in geometry, motorist confusion, indecision and or hesitation is expected to decline.

The majority of traffic on SR-91 is commuter traffic traveling between Orange and Los Angeles Counties and the Inland Empire. Therefore motorists traveling on SR-91 would become accustomed to the new geometry and the Express Lane egress and ingress sections.

Additional accident data was collected in 2018 (January 1, 2018 to April 30, 2018). Table 1 indicates the total collisions on SR-91 and collisions within the Express Lanes is decreasing. Table 1 also indicates the accident rates for the first four months of 2018 has decreased over accident rates for 2017.

Evaluation of the summary of accident data located within the Express Lane area for the SR-91, I-110, and I-15 freeway segments presented in Table 2a and 2b, reveals that the most common type of accident reported for the analyzed segments were sideswipes, followed by rear-ends.

Compared to the I-110 segments, the percentage of sideswipes (38.5% from I-110 and 36.8% from SR-91) and rear-ends (38.5% from I-110 and 42.1% from SR-91) accident occurring on the Express Lane along the SR-91 segments (during the 9 month experimental period in 2017 from March 20 to December 31) are similar. Compared to the I-15 segments, the percentage of sideswipes (50.0% from I-15 and 36.8% from SR-91) and rear-end (10.0% from I-15 and 42.1% from SR-91) accidents occurring on the Express Lane along the SR-91 segments (during the 9 month experimental period in 2017 from March 20 to December 31) are slightly different. The similarities to I-110 and differences to I-15 may be related to the respective similarities and differences in congestion levels.

Overall, the implementation of the SR-91 experimental striping did not cause a change in the primary collision factor within the area. As noted in the above discussion on the SR-91 segments, the primary collision factor was due to unsafe speed and improper turn/unsafe lane change. Compared to other similar Express Lane facilities on the I-110 and I-15, unsafe speed and improper turn/unsafe lane change are also the primary collision factors. In addition, the total number of collisions within SR-91 Express Lanes continued to decrease after the implementation of the experimental striping.

According to CHP Inland Division Commander, Captain Kevin Porter "I don't see any big glaring issue with the configuration right now." – August 1, 2017

Table 2a: Summary of Type of Accident (I-110 and I-15)

Accident Type →	**Head-on**	**Sideswipe**	**Rear End**	**Broadside**	**Hit Object**	**Overturn**	**TOTAL**
Northbound I-110 (December 31, 2013 to June 30, 2015)							
W 76th St/S Grand Ave Off-ramp to W Florence Ave/S Grand Ave On-ramp (PM 16.5- 17.2)							
Total (Express Lane)	0	4	4	0	2	0	10
Southbound I-110 (December 31, 2013 to June 30, 2015)							
W Manchester Ave On-ramp to I-105 EB Off-ramp (PM 14.2 -15.90)							

Table 2a: Summary of Type of Accident (I-110 and I-15)

Accident Type →	**Head-on**	**Sideswipe**	**Rear End**	**Broadside**	**Hit Object**	**Overturn**	**TOTAL**
Total (Express Lane)	0	0	1	0	0	0	1
Florence Ave/ S Flower St Off-ramp to W 76th St/S Flower St On-ramp (PM 16.5 -17.2)							
Total (Express Lane)	0	1	0	1	0	0	2
Total	0	5	5	1	2	0	13
Percentage	*0.0%*	***38.5%***	***38.5%***	*7.7%*	*15.4%*	*0.0%*	100.0%
Northbound I-15 (January 1, 2012 to December 31, 2014)							
I-15 NB Express Lane Weave Lane at Ammo Rd (PM 12.0-13.8)							
Total (Express Lane)	0	0	0	0	0	0	0
I-15 NB Express Lane Weave Lane North of Pomerado Rd/Miramar Rd (PM 14.0-15.5)							
Total (Express Lane)	0	1	0	0	0	0	1
I-15 NB Express Lane Weave Lane North of Ted William Pkwy (PM 19.4- 22.4)							
Total (Express Lane)	0	3	1	0	1	0	5
I-15 NB Express Lane Weave Lane South of Pomerado Rd/ Bernardo Dr (PM 24.5- 25.6)							
Total (Express Lane)	0	1	0	0	1	0	2
I-15 Southbound (January 1, 2012 to December 31, 2014)							
I-15 SB Express Lane Weave Lane at Ammo Rd (PM 12.0-13.8)							
Total (Express Lane)	0	0	0	0	1	0	1
I-15 SB Express Lane Weave Lane North of Ted William Pkwy (PM 19.4- 22.4)							
Total (Express Lane)	0	0	0	0	0	0	0
I-15 SB Express Lane Weave Lane South of Pomerado Rd/ Bernardo Dr (PM 24.5- 25.6)							
Total (Express Lane)	0	0	0	1	0	0	1
Total	0	5	1	1	3	0	10
Percentage	*0.0%*	***50.0%***	*10.0%*	*10.0%*	***30.0%***	*0.0%*	100.0%

Bold indicates most occurring accident
Blue Bold indicates second most occurring accident

Table 2b: Summary of Type of Accident (SR-91)

Accident Type →	Head-on	Sideswipe	Rear End	Broadside	Hit Object	Overturn	TOTAL
SR-91 (March 20, 2017 to December 31, 2017) – 9 Months							
Eastbound - Coal Canyon Rd to County Line (ORA R17.95 - R18.899)							
Total (Express Lane)	0	2	1	2	1	0	6
Eastbound – County Line to Green River Rd (ORA R18.899 - RIV R1.03)							
Total (Express Lane)	0	2	2	1	0	0	5
Westbound - Coal Canyon Rd to County Line (ORA R17.95 - R18.899)							
Total (Express Lane)	0	1	2	0	0	0	3
Westbound – County Line to Green River Rd (ORA R18.899 - RIV R1.03)							
Total (Express Lane)	0	2	3	0	0	0	5
Total	0	7	8	3	1	0	19
Percentage	*0.0%*	***36.8%***	***42.1%***	*15.8%*	*5.3%*	*0.0%*	100.00%
SR-91 (January 1, 2018 to April 30, 2018) – 4 Months							
Eastbound - Coal Canyon Rd to County Line (ORA R17.95 - R18.899)							
Total (Express Lane)	0	1	0	0	0	0	1
Eastbound – County Line to Green River Rd (ORA R18.899 - RIV R1.03)							
Total (Express Lane)	0	1	0	0	0	0	1
Westbound - Coal Canyon Rd to County Line (ORA R17.95 - R18.899)							
Total (Express Lane)	0	0	0	0	0	0	0

Accident Type →	Head-on	Sideswipe	Rear End	Broadside	Hit Object	Overturn	TOTAL
Westbound – County Line to Green River Rd (ORA R18.899 - RIV R1.03)							
Total (Express Lane)	0	1	1	0	0	0	2
Total	0	3	1	0	0	0	4
Percentage	*0.0%*	***75.0%***	***25.0%***	*0.0%*	*0.0%*	*0.0%*	*100.0%*
SR-91 Eastbound (January 1, 2012 to December 31, 2014) – 36 Months							
2,500 feet West of Coal Canyon Rd to 1,800 feet East of Coal Canyon Rd (R17.5- R18.313)							
Total (Express Lane)	0	2	2	1	4	0	9
SR-91 Westbound (January 1, 2012 to December 31, 2014) – 36 Months							
2,500 feet West of Coal Canyon Rd to 2,000 feet East of Coal Canyon Rd (R17.5- R18.336)							
Total (Express Lane)	0	7	3	0	5	0	15
Total	0	9	5	1	9	0	24
Percentage	*0.0%*	***37.5%***	***20.8%***	*4.2%*	***37.5%***	*0.0%*	*100.0%*

Bold indicates most occurring accident
Blue Bold indicates second most occurring accident

EVALUATE VEHICULAR CONFLICTS IN THE WEAVE ZONE

Four video cameras were installed along SR-91 within the 1.5 mile long egress segment, buffer zone and ingress segment on eastbound SR-91. Camera 33 covers the egress segment of eastbound SR-91. Video footage of Camera 33 was reviewed to capture the driver behaviors in the weave zone. Results of the vehicular conflicts in the weave zone on northbound I-110 and eastbound SR-91 are shown on Tables 3 and 4 respectively. General observations from Camera 33 are listed below:

- Much more traffic exiting than NB I-110
- Late exiting of egress lane much more than NB I-110
- CMS Special "Merged Right" Sign did not appear to change driver behavior
- More vehicles exiting across double white solid stripe on weekends
- No pattern established for vehicles entering at egress area

Table 3a: EB SR-91 Weave Lane

Express Lanes Customer Actions	Friday 3/24/17 2 - 3pm		Saturday 3/25/17 4:30-5:30pm		Thursday 4/20/17 4 - 5pm		Saturday 4/22/17 4:30-5:30pm		Thursday 5/18/17 4 - 5pm		Saturday 5/20/17 4:30-5:30pm		Wednesday 6/21/2017 4 - 5pm		Saturday 6/24/17 5 - 6pm	
Waiting until end of Exit Zone	754	90.4%	447	91.0%	914	92.3%	409	85.92%	848	94.9%	500	84.2%	797	95.2%	448	89.4%
Exiting across skip/solid stripe	59	7.1%	30	6.1%	66	6.7%	54	11.35%	40	4.5%	70	11.8%	35	4.2%	43	8.6%
Crossing double white stripe to exit *	21	2.5%	14	2.9%	10	1.0%	13	2.73%	5	0.6%	24	4.0%	5	0.6%	10	2.0%
Total	834	100%	491	100%	990	100%	476	100%	893	100%	594	100%	837	100%	501	100%
General Purpose Lanes																
Entering at Exit Zone from GP lane *	21	+	13	+	12	+	12	+	18	+	6	+	+	+	+	+
Entering at Exit Zone from transition lane *	19	+	9	+	18	+	7	+	15	+	5	+	+	+	+	+
Total	40	+	22	+	30	+	19	+	33	+	11	+	+	+	+	+

* Violation
+ Volume for GP lanes unavailable

Table 3b: EB SR-91 Weave Lane

Express Lanes Customer Actions	Thursday 5/17/18 3 - 4pm		Saturday 5/19/18 4:30-5:30pm		Thursday 6/28/18 4 - 5pm		Saturday 6/30/18 5 - 6pm	
Waiting until end of Exit Zone	645	98.18%	393	90.98%	809	97.94%	407	95.77%
Exiting across skip/solid stripe	3	0.45%	13	3.00%	8	0.97%	12	2.82%
Crossing double white stripe to exit *	9	1.37%	26	6.02%	9	1.09%	6	1.41%
Total	657	100%	432	100%	826	100%	425	100%
General Purpose Lanes								
Entering at Exit Zone from GP lane *	2	+	1	+	3	+	1	+
Entering at Exit Zone from transition lane *	3	+	4	+	2	+	3	+
Total	5	+	5	+	5	+	4	+
* Violation + Volume for GP lanes unavailable								

Table 4: NB I-110 Weave Lane

Entering	Saturday 7/8/17 2:30-3:30pm		Wednesday 7/12/17 4-5pm	
Entering correctly	179	82.87%	162	85.71%
Entering over solid white line	37	17.13%	27	14.29%
Total	216	100%	189	100%
Queue-jumping/swerving				
Entering transition lane from GP, then exiting	18	+	10	+
Swerving in and out of transition lane from GP	8	+	5	+
Entering transition lane from EL, but not exiting	18	+	12	+
Swerving in and out of transition lane from EL	0	+	3	+
Total	44	+	30	+
Exiting				
Waiting to exit	18	15.60%	27	24.80%
Exiting ASAP	80	69.60%	75	68.80%
Crossing white stripe to exit	17	14.80%	7	6.40%
Total	115	100%	109	100%
+ Volume for GP lanes unavailable				

Violations of crossing the buffer zone (8-inch solid double white stripe) results are shown on Table 5 and violations for exiting at ingress segment (opening and lane drop area) results are shown on Table 6. General observations from Ingress and Buffer segment cameras are listed below:

- Violations have decreased over time
- Relatively low number/percentage of violations

Table 5: EB SR-91 Crossing Double White Stripe (buffer zone)

Express Lane Customer Actions	Friday 3/24/17 2 - 3pm	Saturday 3/25/17 4:30-5:30pm	Tuesday 4/18/17 4 - 5pm	Tuesday 5/16/17 4 -5pm
Crossing double white stripe from GP	5	2	0	0
Crossing double white stripe from EL	4	1	4	1

Table 6: EB SR-91 Exiting at Entrance

Express Lane Customer Actions	Thursday 4/20/17 4 -5pm		Saturday 4/22/17 4:30-5:30pm		Thursday 5/18/17 4 -5pm		Saturday 5/20/17 4:30-5:30pm	
Continuing in EL	1941	98.13%	1659	99.22%	1379	99.35%	1494	99.53%
Exiting at Entrance (violation)	37	1.87%	13	0.78%	9	0.65%	7	0.47%
Total	1978	100%	1672	100%	1388	100%	1501	100%

IMPLEMENTATION

SIGNING AND STRIPING CHANGES

On opening day of the Express Lanes, 4-inch white experimental striping was installed along with the signing shown on Figure 1. RCTC and Caltrans monitored operations at the ingress and egress segments. Upon further review of the Express Lanes, Caltrans, as well as FHWA provided comments to the signing and striping. Based upon these comments, signing and striping changes were implemented and are shown on Figure 2. The 4-inch white experimental striping was updated to 6-inch white striping. The skip stripe was reduced in length from 12 feet to a 3 foot skip stripe. The solid double white striping separating the ingress and egress segments were also revised from 4-inch solid double white to 6-inch solid double white. Delineators were installed in the buffer area to further enhance separation between the GP lanes and Express Lanes. Additional lane drop arrows and "EXPRS LANE EXIT ONLY" pavement legends were added to the Egress segment to help encourage Express Lane traffic to merge over into general purpose lanes. Furthermore, an existing overhead guide sign panel (located at beginning of egress area) with down arrow was replaced with diagonal arrow, another existing overhead

warning sign panel (located at the beginning of the skip stripe) with "LANE ENDS ¼ MILE with down arrow" was replaced with "LANE ENDS MERGE RIGHT".

Additional changes were made on the overhead sign panels located at the beginning of the skip stripe as shown on Figure 3. The guide sign panel with diagonal arrow was replaced with the existing "LANE ENDS MERGE RIGHT" warning sign panel shifted to the left, and a new "ILLEGAL TO CROSS DOUBLE WHITE LINES" regulatory sign was installed on existing overhead sign structure. Signing and striping revisions were completed in September 2017.

An additional feature was implemented one week after opening day. On March 27, 2017, toll information changeable message sign (CMS) located approximately 1300 feet downstream from the beginning of the eastbound egress lane displayed a message to help inform motorists when exiting the Express Lanes. The message displayed "EXIT LANE MERGE RIGHT". The CMS sign also included an image of an arrow crossing over the experimental skip/striping line merging into the general purpose lane. This image of the arrow crossing over indicated the preferred egress movement to the motorist. A photo of the CMS special sign is shown in Photo 5. The message and arrow image were displayed until May 15, 2017.

In order to determine the effect of the CMS special sign and the experimental skip/solid stripe, Express Lanes customer actions were observed. Evaluation of Express Lanes customer actions for eastbound SR-91 were monitored periodically in 2017 and 2018 and are shown in tables 3a and 3b. As shown in Table 3a, a vast majority of vehicles exiting the eastbound Express Lanes waited until the end of the exit zone before merging into the general purpose lanes. A very small portion of the vehicles crossed over the experimental skip/solid stripe. The two time periods, 4/20/2017 and 4/22/2017 (CMS special sign was displayed) provide almost identical percentages as the various other time periods shown in Tables 3a and 3b. It appears the CMS special sign message did not alter driver behavior. Drivers continued to the end of the exit zone and did not cross over into the general purpose lanes as displayed on the CMS special sign. Therefore, providing a special sign for exiting Express Lanes does not appear beneficial.

The summary of the signing and striping changes is listed below:

- No wholesale changes to the configuration or experimental striping
- Increase lane drop arrows (see Figure 2)
- Add "MERGE RIGHT" sign (see Figure 2)
- Add delineators to "buffer zone" (see Figure 2)
- Change 4" experimental skip/solid stripe to 6" (see Figure 2)
- Change double 4" solid white stripes to double 6" (see Figure 2)
- Replace overhead sign panels at Egress area (see Figure 2 and 3)
- Add shadow stripes to striping on white pavement
- Wet Night Thermoplastic striping for Experimental striping
- Wet Night Thermoplastic striping for egress Express Lane lane drop arrows

RECOMMENDATIONS

(a) Non-Standard Detail – results of experiment appear inconclusive, more driver education is needed, RCTC plans to replace this stripe with the standard Detail 37 in 2019.
(b) New Striping Detail – this stripe as modified during the experiment to a double 6" white wet-night thermoplastic without raised pavement markers appears to be effective in this narrow lane application. Caltrans concurs with leaving this stripe detail in place at this site application.

Thank you for your consideration of this request. RCTC is looking forward to working with the CTCDC and MUTCD Team to improve the 91 Project to the extent possible. Please feel free to contact me at (951) 393-6894 if you have any further questions or comments.

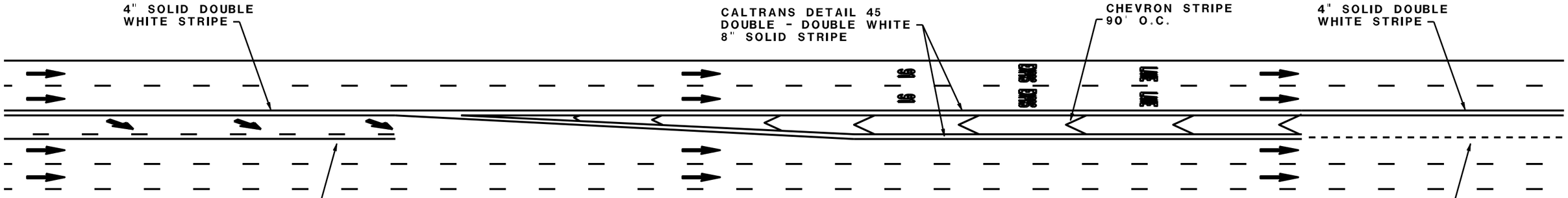
Sincerely,

David K. Thomas

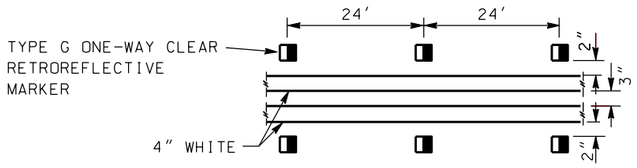
David K. Thomas
Toll Project Manager
Riverside County Transportation Commission

Attachments:
Figure 1 – Signing and Buffer Detail
Figure 2 – Signing and Striping Exhibit
Figure 3 – Revised Signing
Photos

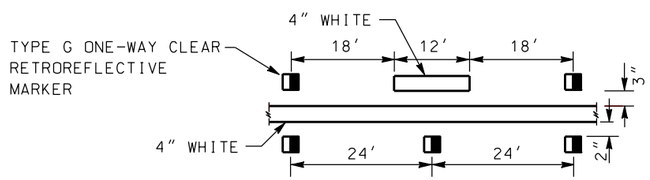
Cc: RCTC File



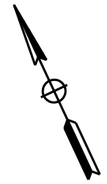
STRIPING BUFFER DETAIL

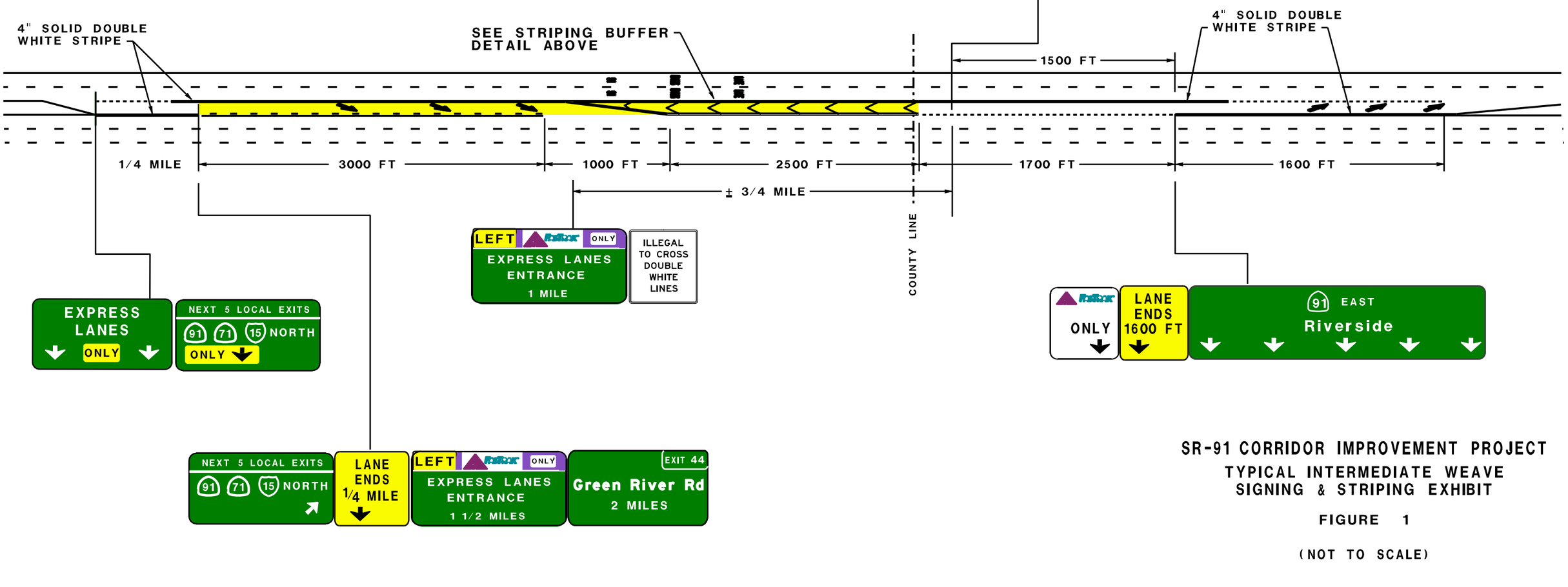


4" SOLID DOUBLE WHITE STRIPE DETAIL



4" WHITE SKIP AND 4" WHITE SOLID STRIPE DETAIL





SR-91 CORRIDOR IMPROVEMENT PROJECT

TYPICAL INTERMEDIATE WEAVE SIGNING & STRIPING EXHIBIT

FIGURE 1

(NOT TO SCALE)

6" 4" SOLID DOUBLE WHITE STRIPE

CALTRANS DETAIL 45
DOUBLE - DOUBLE WHITE
8" SOLID STRIPE

CHEVRON STRIPE
90' O.C.

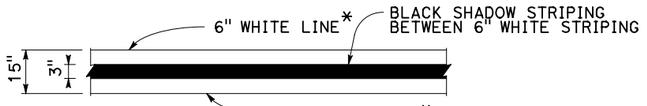
INSTALL DELINEATORS
AT 20' ON CENTER

6" 4" SOLID DOUBLE WHITE STRIPE

6" WHITE SKIP AND 6" WHITE SOLID
EGRESS STRIPING - EXPERIMENTAL STRIPING

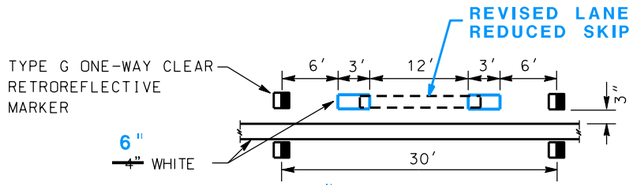
CALTRANS DETAIL 37B
8" WHITE SKIP STRIPE

STRIPING BUFFER DETAIL

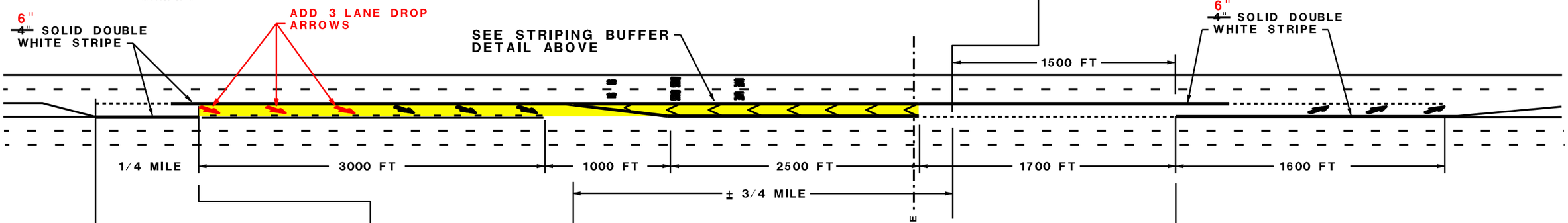


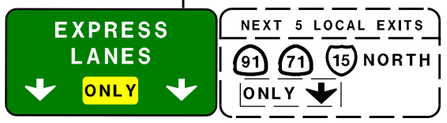
6" 4" SOLID DOUBLE WHITE STRIPE DETAIL

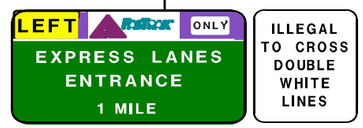
* WET/NIGHT THERMOPLASTIC STRIPING

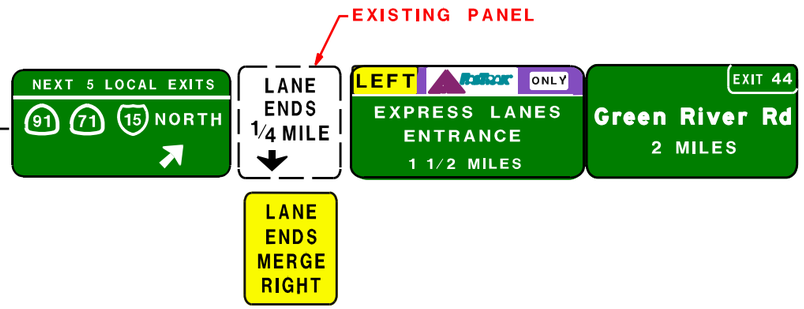


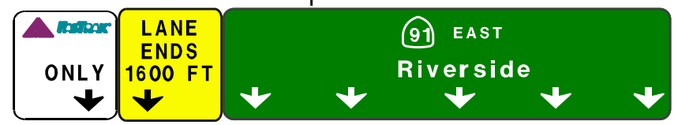
6" 4" WHITE SKIP AND WHITE SOLID STRIPE DETAIL









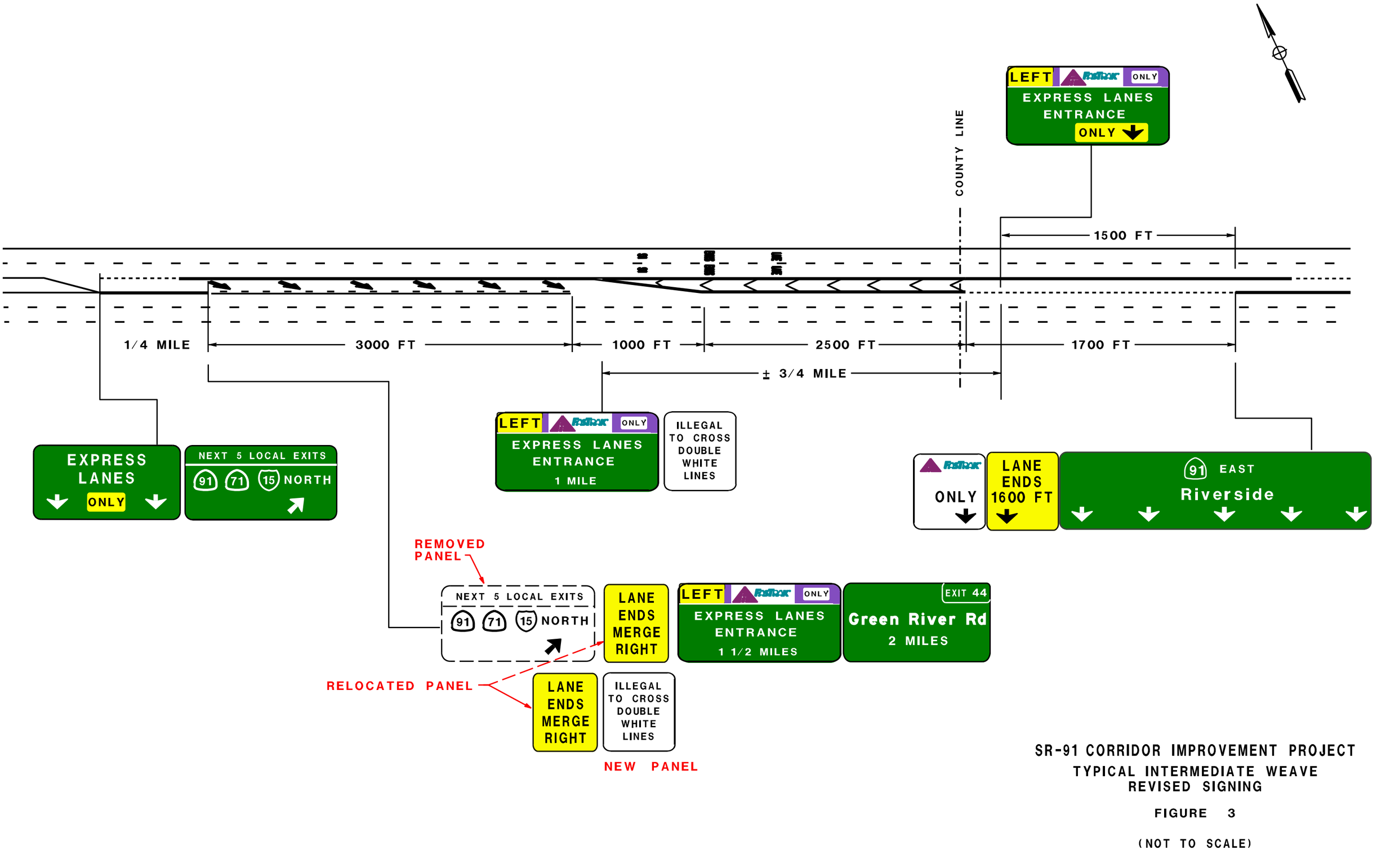


SR-91 CORRIDOR IMPROVEMENT PROJECT

TYPICAL INTERMEDIATE WEAVE
SIGNING & STRIPING EXHIBIT

FIGURE 2

(NOT TO SCALE)



SR-91 CORRIDOR IMPROVEMENT PROJECT

TYPICAL INTERMEDIATE WEAVE
REVISED SIGNING

FIGURE 3

(NOT TO SCALE)

I-495 Long Island Expressway, NY

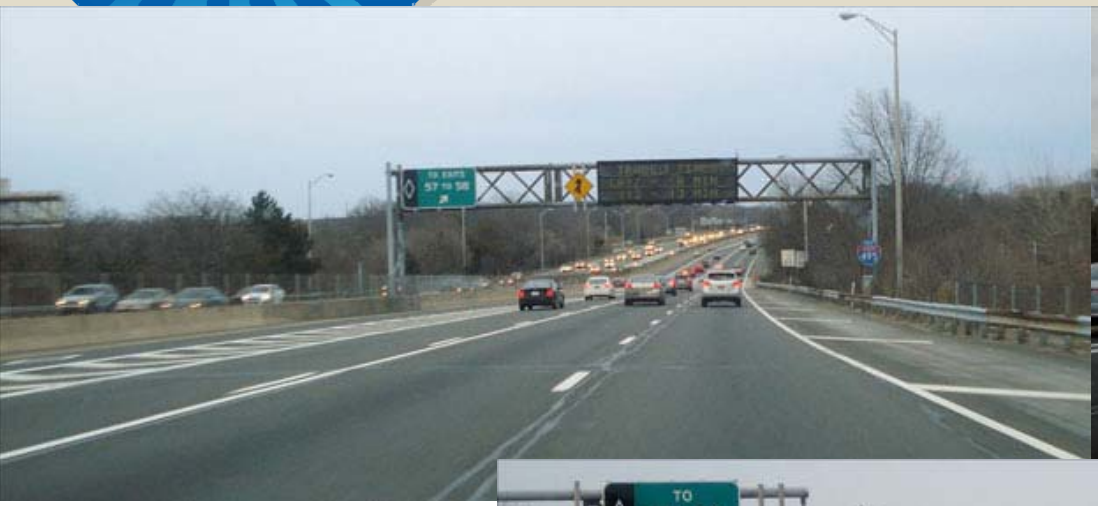


Photo 1

US-36 Colorado

Photo 2

I-405 Orange County, CA (yellow)

Photo 3

Taipei, Taiwan

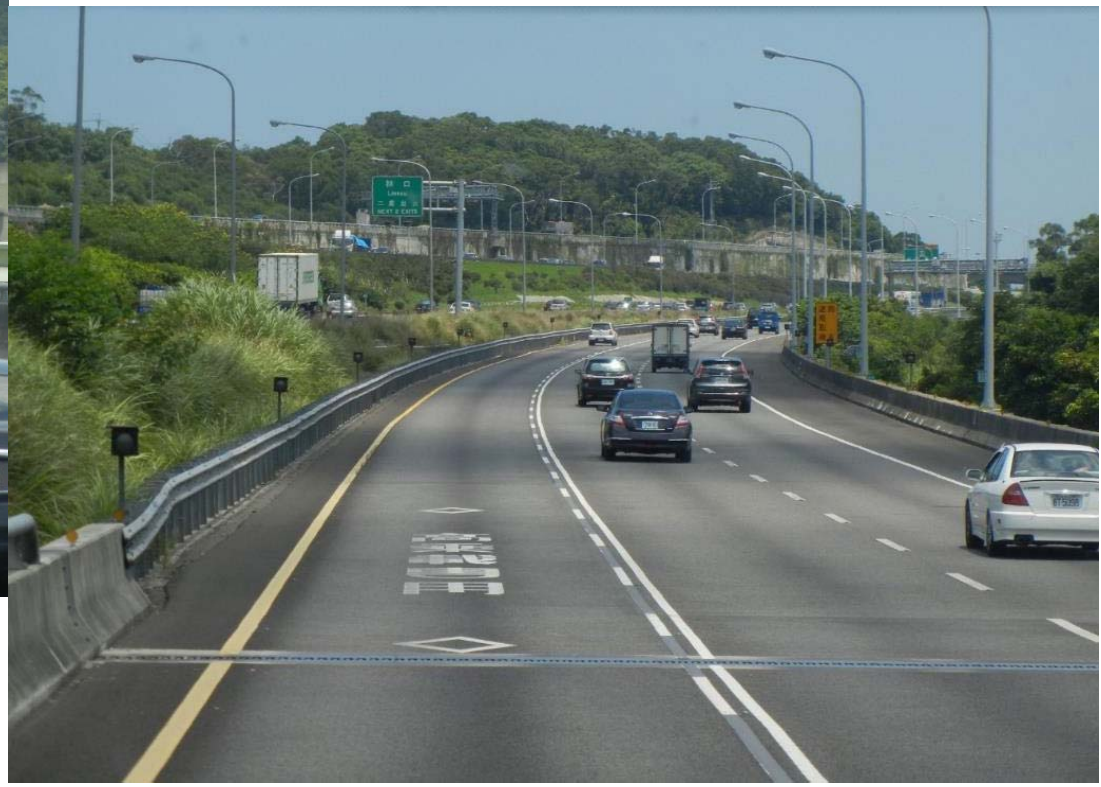


Photo 4

91 PROJECT
FAST FORWARD

3/27/17 – 5/15/17

Photo 5