Innovative Traffic Management Following the 1994 Northridge Earthquake

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Prepared for
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Introduction

It is often necessary to study the methodology of what was done to keep a society moving when disaster strikes. Others may look back on those methods to help them in their times of need. The traffic management following the 1994 Northridge Earthquake in southern California was a prime example of using innovative methods to deploy new and old technology, new procurement and coordination methods to keep the traffic flowing. There are many materials and reports that exist concerning various areas of those operations. This report is designed to combine and link this information into one concise document, one reference, if you will, that others may refer back on to see what was done in the southern California area after the earthquake to keep the traffic situation from becoming a disaster in itself. Documents prepared by the California Department of Transportation (Caltrans), mostly Albert Yee and Stephen Leung, a paper written primarily by Jim Kerr, and a paper by Frank Cechini were vital in this collaboration.

Background

On January 17, 1994, Southern California was hit with an earthquake measuring 6.8 on the Richter scale.. Its epicenter was determined to be in western Los Angeles County, specifically Northridge, which is in the western part of the San Fernando Valley. This earthquake resulted in considerable damage to the surrounding area roadways, in addition to building damage. This greatly disrupted the traffic flow in the region.

The damage to surrounding buildings was quite extensive. In Los Angeles County alone there was an estimated 4,322 homes declared unsafe and 10,254 damaged with an approximate price tag of $1.5 billion. The repairs on other structures that were damaged in the area were estimated to be at least $70 million.

Many of the freeways in the region suffered extensive damage. The major interchange between the Golden State Freeway (Interstate 5) and the Antelope Valley Freeway (State Route 14) sustained extensive damage to two of the four connectors while the other two collapsed completely, rendering it useless for sometime. Interstate 5 (I-5) experienced damage at several locations north of the 5/14 interchange as well, specifically the Gavin Canyon bridges. The Santa Monica Freeway (Interstate 10) had two overcrossings collapse, closing four miles of the world's busiest freeway State Route 118 (SR- 118) encountered a total collapse of the roadway at two separate locations in the Granada Hills area. Additional damage on SR- 118 between Interstate 405 (I-405) and Interstate 2 10 (I-2 10) resulted in complete closure of that section of roadway. The Pacific Coast Highway (SR- 1) experienced minor damage with short-term closures.

The reconstruction costs of these and the other damaged roadways is estimated to be around $308 million. Approximately $19.6 million went to the 5/14 interchange and $14.8 million to the Gavin Canyon bridges. Federal emergency funding and emergency contract procedures were used for the repairs. The contracts were given with an incentive/disincentive clause of various amounts. These and the other major construction projects were completed with considerable rapidity and are wonderful examples of how to get the roadways back on line as soon as possible. A report done by the joint FHWA/CALTRANS/ Industry Task Force chronicles what was done in much greater detail'.

The Traffic Management Plan

Following the quake, a strategy was needed to bring the traffic operations under one net and to point it in the right direction. This came about in the form of the Traffic Management Plan (TMP) that was developed by a team of traffic engineers from Caltrans. This team was headed by a Task Force Chairman whose duties included the coordination and the implementation of the Traffic Management Plan. It governed all of the strategies and deployments implemented after the initial responses in the first week after the quake.

Coordination

The TMP set in motion many different measures. First and foremost it was a plan to organize and identify the detours that were to be set in place. Since there were several vital roadways that were closed, it was imperative that the detours be deployed quickly and coordinated so that the traffic flow could be kept at a maximum. It also planned for transit adjustments to handle the. new influx of ridership.

Another measure taken was the deployment of Intelligent Transportation System (ITS) technologies. These technologies were controlled by an operations center that was built specifically for the management of the post-quake operations. This Earthquake Planning and Implementation Center (EPI-center), located near the Traffic Management Center (TMC) in downtown Los Angeles, worked as a nucleus to coordinate all new systems put in place around the detours and other affected areas. It was largely built as a supplement to the existing and overloaded TMC in the Los Angeles area.

The TMP also included other provisions necessary for the management efforts. A large public awareness campaign was developed to provide information about detours, alternate transportation modes, and the freeway recovery plan and schedule. New communication equipment was provided by the TMP along with equipment to monitor and analyze the new traffic movements. Helicopter surveillance, enhanced tow service, and additional California Highway Patrol coverage worked as a part of the incident management effort under the TMP. Much of this additional incident management was organized through a pre-quake agreement between the California Highway Patrol (CHP) and Caltrans called the Construction Zone Enhanced Enforcement Program (COZEEP). The estimated costs of these provisions along with the EPI-center and detours was $2 1.5 million of the federal emergency relief funding[2].

Much of the initial responses to the traffic needs immediately following the quake were coordinated through the existing Emergency Operations Centers. These centers were established in 1992 after the Los Angeles riots to help the city cope with future disasters, whether they be natural or man-made. They focused on mobilizing personnel and equipment, interagency coordination, incident management, and establishing reliable communications between emergency personnel.

Deployments

Initial Reactions

Immediately following the quake, there were concerns about roadways that were critical to the region's mobility. All of the region's highway structures had to go through an inspection in order to assess any immediately unrecognizable hazards to the roads and implement the appropriate closures. Traffic operations Traffic Management Teams (TMT's) provided assistance in arranging detours around the closures. Landslides and bridge collapses had to be dealt with as well.

Within hours after the earthquake, the Emergency Operations Centers took control of the situation by coordinating incident management and setting up detours.. They also helped facilitate communications between all aspects of emergency services'. These actions were later enhanced and expanded upon with the implementation of the TMP.

Alternate Transportation

Since many of the major freeways and roadways were either partially or completely closed, there were massive amounts of vehicles that had to be diverted to adjacent streets. It is plainly obvious that although these detours were set up promptly and organized well, there was a definite limitation on their capacities. These streets just could not handle that much additional traffic. As a result, other modes of transportation were promoted to reduce the demand placed on the closed roadways.

There were many alternatives presented to commuters. Reduction of unnecessary trips was encouraged. If the trips were necessary residents were encouraged to utilize ridesharing methods or use public transit. Employers were encouraged to promote employee car pools as well. The employers were also asked to utilize telecommunication and staggered work hours to help reduce the traffic congestion.

Of these options, the most emphasis was placed on the use of public transit. Metrolink rail line and Metrobus were already in use throughout the region. They provided service from the outskirts to the downtown areas. Under the TMP, these services were enhanced to both make them more appealing to the customers, and to handle the immediate increase in ridership. Enhancement procedures included the establishment of buses and taxis that created a shuttle service to the Metrolink stations. Three new park & ride lots were created near the I-5/SR- 14 interchange to promote the use of the Metrolink and to coerce people into ridesharing. These lots created 900 new spaces for commuters to use to take the Metrolink rail'.

'Along with the additional park & ride lots, the routes and scheduling for the buses and rail lines were enhanced. Transit providers were asked to permit commuters to bring bikes on the transit vehicles, add bike racks on buses. Metrolink allowed bikes in rail cars as well.

Six of the bus systems in Los Angeles county added new routes. These systems also extended the schedule times and modified their existing routes, specifically those routes around I- 10. The Metrolink rail provided extra service to those affected by the closures on I-5 and SR- 14. In this area extra trains and line extensions provided the extra capacity needed. Seven new trains were added to the lines as well as four new stations in Lancaster, Palmdale, Sylmar and Vincent Grade-Acton[4].

Commuter response was almost automatic For example, pre-quake daily ridership on the Metrolink at the Santa Clarita station (which is near the I-5/SR- 14 interchange) was about 1,000 per day. When the Palmdale and Lancaster stations were opened on Friday, January 2 1 st, the following Tuesday saw ridership grow to 22,000 boardings per day. However, ridership decreased at a fairly regular rate during reconstruction until it leveled off at around 4,500 riders per day upon completion of the repairs. Even though the Metrolink did not sustain the heavy ridership, it did prove to play a vital part in the plan to reduce the demand on the freeways'.

Incident Management

As the demand on the detour routes increased and pushed the capacity of the roadways to the limits, it was evident that there would have to be an enhancement or modification to the incident management programs. Emergency vehicles had to be ready to assist and restore traffic flow much faster so as to minimize the back-ups and accidents in the earthquake detour roadways. This was especially true because of the lack of a shoulder area in much of these new routes. An incident here would amplify the already strained traffic situation in these areas. There were several deployments and operations that were put in motion to ensure there existed the type of rapid response needed.

The first of these was the Los Angeles County Freeway Service Patrol (FSP) and is run jointly by the CHP and Caltrans. This service was introduced in July of 1991 and proved to be very useful during reconstruction. The patrol has functioned in assisting in early detection and removal of minor roadway incidences, mainly in the peak hours of the day. Pre-quake the FSP had 144 tow trucks patrolling 44 sections (beats) covering 381.3 centerline miles and it made an average of 220,000 assists per year since its inception[6].

As a result of the post-earthquake traffic patterns, the FSP was enhanced to provide more comprehensive coverage in the quake-affected areas. Thirteen additional FSP tow trucks were deployed to the quake-affected area roadways. Included in this was enhancing the existing beats and adding new beats that did not exist before the earthquake. Peak hour service was also extended and enhanced by adding hours of service. Along with these new trucks came an addition of a heavy tow truck that could handle vehicles with three or more axles (semis). Since 5% of the disabled vehicles were of this larger type, it was necessary to give the FSP a tool to handle these situations. This heavy-duty tow truck assisted in 64 1 incidents during its three and a half month deployment[2] Under the aforementioned Construction Zone Enhanced Enforcement Program (COZEEP), the CHP provided additional safety coverage on the detour routes and the construction repair zones as well[2].

Another contribution made in relation to emergency response was the use of helicopter surveillance. The helicopters assisted in coordinating traffic management teams, damage assessment, and evaluations of the detour routes'. The helicopters were provided through an interagency agreement between Caltrans and the City of Los Angeles. LAPD helicopters were also used in peak period surveillance to provide more accurate and more real-time traffic data.

The incident management programs were key in aiding the traffic management efforts. The Traffic Management Center made contributions in addition to the other deployments, mainly in coordination efforts. Other advanced deployments in incident management will be discussed later.

Traffic Management - Detour Deployments

As a result of the damage to the roadways, many of them were obviously closed. In many closure areas, it was imperative that traffic still flow. For example, I-5 is the only primary regional route connecting areas north of the San Gabriel Mountains with the Los Angeles Basin and the San Fernando Valley. This vital artery had to be kept moving during its reconstruction. Detours were set up to bypass the damaged areas and to keep the area to some level of accessibility. Major detours were also set up at the I-5/SR- 14 interchange, around I- 10, and on a section of SR-118. High Occupancy Vehicle (HOV) lanes were used in some areas to reduce demand and to encourage car pooling. These detour routes were coordinated and maintained by the COZEEP, helicopter surveillance, the LA TMC, and the new EPI-center.

Following the earthquake, Caltrans and the City of Los Angeles Department of Transportation (LADOT) in conjunction with other local agencies promptly attempted to reestablish the traffic capacity along the I-10 corridor. Detours were established within a week, revised a week later and consisted of both east and westbound directions. At the same time, HOV-2 lanes in each direction were also created which had shorter routes and proved to have shorter time delays. Westbound HOV traffic exited the freeway at Washington Boulevard, followed Apple Street to Ballona Creek a&reentered the freeway using the unused eastbound ramps. This route required only 0.5 miles of city streets*.

The mixed flow westbound exited at La Brea Avenue and followed that to Venice Boulevard. Venice would take them to Cadillac Avenue, then cross La Cienega Boulevard to reenter the freeway at the westbound ramp. This route consisted of 3 miles of city streets*.

Eastbound routes were a little more complicated. The HOV lane exited the freeway at La Cienega and took that street to Washington Boulevard which it followed to the eastbound on-ramps; using 0.8 miles of city streets, Eastbound mixed flow exited at Robertson Boulevard, crossing Venice BL. to National Boulevard, on to Jefferson Boulevard to the reentry point at La Brea Avenue. This mixed flow detour used about 3 miles of city streets as well[8].

North of the I-5/SR- 14 interchange, I-5 had several bridge collapses that forced a large part of the freeway to close. In a reaction to this, the Old Road detour was constructed to get around the Gavin Canyon bridges. The Old Road detour consisted of two mixed flow lanes in each direction and went from Calgrove Boulevard to the I-5 truck stop just north of the I-5/SR-14 interchange?

Another major detour installation was deployed at the interchange between I-5 and SR- 14. Southbound I-5 traffic was routed off of the freeway at Lyons Avenue, to San Fernando Road, on to Sierra Highway, back to San Fernando Road, to Sepulveda Boulevard, and reentered at the Roxford Avenue on-ramp. Northbound I-5 used Foothill Boulevard as the main detour route. HOV lanes were also established in this area. A lane was set up on southbound SR- 14 and on northbound SR-14 using the right shoulder of the truck lanes connecting I-5 and SR-14[9].

There was some damage at the I-405 and SR-118 interchange that required a closing. I-405 north and southbound to westbound 118 had a detour that had the traffic get off at Nordoff Street or Devonshire Street and over to Tampa Avenue, which takes you to westbound 118. Traffic diversion for the 405 SB and 118 WB led you to exit at Rinaldi Street, a left on Reseda Boulevard, and on to the WB 118 on-ramp. Finally, to make the connection on westbound 118 to bypass damage, traffic was routed onto Sepulveda which leads to Devonshire Street. Motorists then had a choice on whether to take Reseda Boulevard or Tampa avenue over to rejoin west bound SR- 118.

Besides detours, other rerouting methods were used to handle the need for access to these areas. On SR- 118, the eastbound direction was closed from Ruffner Avenue to Woodley Avenue. To accommodate the eastbound traffic, the flow was diverted to the westbound side which had been restriped and divided for oncoming traffic.

Traffic Management Centers

Deployment of advanced technology in the LA area had been underway for several years. LADOT already had an existing traffic management center (TMC) known as the Automated Traffic Surveillance and Control (ATSAC) This system consisted of a computerized traffic signal system for the arterial streets in Los Angeles. It uses loop detectors and closed circuit television (CCTV) to monitor intersections and relays information to changeable message signs (CMS) placed throughout the city.

In the aftermath of the earthquake however, it became evident that this TMC 'could not handle all of the unprecedented congestion generated by an earthquake, as it was already operating at capacity before the earthquake. Not only this, but the center did not have information acquisition equipment in many of the affected areas. The TMP designers realized this and decided to enhance this technology with the addition of an emergency center for accessing all of the information required to set up detours, and to implement traffic strategies. (This system came to be known as the Earthquake Planning and Implementation Center (EPI-Center).

The 2,000 square foot EPI-center acted as a hub for many advanced technologies that facilitated the traffic management in the disaster areas. It consisted of a central system that used UNIX-based workstations and severs to provide the field control, user screens and data storage. The software is built around a centralized real-time database which automatically distributes field data to all workstations and arbitrates control requests from the users to the field elements. User interface is fully graphical with multimedia extensions[10].

This central system controls various elements of ITS technologies. Communication with the motorist is a main function of the EPI-center. Eight changeable message signs were placed in the detour zones so that the center could relay information about traffic conditions, detours, and road closures to the traveler on the road. Slow-scan cameras were used in conjunction with the CMS to verify the given message. Nine Highway Advisory Radios (HAR) were deployed that also supplied the traveler with real-time traffic information and warnings. In addition to the HAR themselves, 34 dynamic advance warning signs were located on the approaches in advance of the signal ranges of each HAR would post frequency infonnation[10].

, Another function of the EPI-center is the acquisition of traffic information in the area of the road closures. In order to obtain this information, 9 real-time CCTV's with pan/tilt/zoom capabilities were linked to the central system and controlled by one of the workstations there. Inductance loops (called VDS for Vehicle Detecetion Stations) imbedded in the pavement provide real-time volume, occupancy, and estimated speed data throughout the area. Tbis information is sent to the central system and presented in numerical and graphical formats. Along with these field systems, 2 Video Image Processing Systems (VIPS) are also used to collect up-to-the-minute traffic data in and around viaduct structures where use of inductance loops was not possible".

The EPI-center was vital in coordinating the traffic management deployments and giving the traffic engineers adequate, accurate and immediate traffic information. This allowed them to make better decisions and to collect information about the changes in the traffic behavior during a disaster. This information from the inductor, VIPS, and CCTV databases will allow for even better planning and implementation in the future of the EPI-center.

Communication

It is imperative that the motorist in a disaster area be supplied with accurate, real-time traffic information to increase safety and, reduce secondary accidents, and allow the motorist to make informed decisions on choosing their route during their trip. In order to accomplish this, wmmunications links had to be established between the field equipment and the central system. These links must be versatile enough to change quickly, especially when CMS's are moved to different locations in the detour areas. Also, these systems could not interfere with the effort to reestablish wmmunications links in the affected areas of the earthquake.

Considering this, it was decided to use a wireless service. Requirements for the system (bandwidth of the video cameras) pointed toward the use of very small aperture terminal (VSAT) satellite links. VSAT was used for transmitting information to and from the CCTV's, VIPS, and CMS deployments. This allowed for continuous access and information transfer. Functioning the same way but using different technology was the slow-scan cameras which used cellular telephone links. This allows the random, infrequent access that is required for this system".

The HAR systems were handled differently. It required a dual-tone multi-frequency (DTMF) control and voice transmission. Since there were many beacons, a less expensive way to communicate than the VSAT link was needed. So, the radio signal itself was used to activate the beacons. A standard AM radio with a DTMF decoder was at each beacon to decode a unique series of tones to turn each beacon on individually and an all-encompassing set of tones to turn all of them off. This allows the message only to be heard by the motorists that are affected by the relevant message[1O].

The helicopter surveillance was also a vital wmmunication tool. It would give traffic information to the TMT's and keep them updated on the traffic 'situations. The helicopter(s) would also relay real-time traffic condition information to the TMC in the area. The TMC would then use the data for analysis and/or relay information to the various motorist advisory systems.

The Freeway Service Patrol integrated their wmmunications in a variety of ways. FSP tow trucks were equipped with radios and Mobile Data Terminals allowed the tow truck drivers to communicate information and to talk with the Los Angeles Communication Center, Caltrans and the Computer Aided Dispatching System (CAD). Also, the trucks are equipped with some ITS technology in the form of the Automatic Vehicle Locator (AVL) which sends their location and status to the CAD. The flow of information to these centers allowed the dispatchers to make more informed decisions on where to send FSP trucks[6].

Integration and Cooperation

In adding all of the new equipment, operations, and patrols, it was necessary to ensure that these new and different deployments supported and enhanced the existing operations, not hinder their missions.

The TMC

The EPI-center was designed with the intentions of being a supplement to the existing traffic management center. The TMC, along with ATSAC, was overloaded after the earthquake disaster and needed assistance. Many of the affected areas were not under the TMC's control, as they were farther out of the city. The EPI-center helped alleviate the new influx of information to the TMC and expanded its area of effectiveness.

An open system approach was taken in the construction of the EPI-center. This would allow the system to be upgraded and integrated with other systems consistent with the long-term ITS deployment plans. Distributed open system application reaps the benefits of cost saving (50: 1) when compared to older centralized mainframes on upgrades or when new information sources are added. Integration with other traffic systems is maximized through this approach[10].

The EPI-center is not in operation when the traffic situation is under normal circumstances, since the TMC can manage traffic on its own. Although it is a permanent addition to the traffic management in the area, the EPI-center was set up as an emergency nucleus to handle the additional logistics of coordinating traffic management, handling detours, and motorist advisory systems during a disaster. When it does "shut down", the center is monitored from a remote terminal in the existing TMC. The staff at the TMC deploy traffic management operations as required[10].

Just as the TMC can monitor the activities of the EPI-center, the EPI-center can monitor data that flows through the TMC. This is also done through a remote TMC' terminal located in the EPI-center Communication between the IWO centers is vital for confirmation of events and the condition of those events in the freeway system. The TMC also maintains direct wmmunication with CHP and Caltrans field personnel. This allows information to flow from the field to both centers and facilitates coordination between each. This integration allows for a more efficient system to gather and analyze data and tben inform the motorist about traffic conditions as quickly as possible[10].

Other Cooperative Efforts

Along with the cooperation and integration that was carried out through the traffic management side, other areas of the TMP encountered situations were it was necessary to cooperate with existing deployments and/or agencies to keep the society moving and to prevent a transportation disaster.

The post-quake transit operations was an example of integrating new equipment and integrating with the existing operations. New trains and stations were added and were combined into the established routes and schedules of the Metrolink system. The Metrobus system was also an example of integrating new routes with the old to accommodate the transportation difficulties following the quake.

The COZEEP program was also an instrumental player in the operations. It was very helpful in working with the CHP and the FSP to help manage the freeways along detour routes and in peak hours of congestion on the freeways surrounding the closures. The COZEEP and the FSP programs themselves are examples of agencies, Caltrans and CHP, integrating their assets to achieve a common goa1[5]. The helicopter surveillance was another joint effort that was between LAPD and Caltrans. Cooperation and integration of this type was absolutely necessary to allow the traffic recovery operations to be implemented as quick;y as they were.

Applications and innovations

Design/Build Concept, Procurement Strategies

In times of disaster such as this one, it is imperative to get traffic management strategies implemented as quickly as possible. The more rapid the deployment, the less chances of the resulting traffic congestion snowballing out of control. Therefore, the TMP set a target date for the completion of construction of the EPI-center to be May 7th. The center on that date was to run preliminary operations and then be fully integrated and operational on July 15,1994.

One of the major factors allowing this project to move quickly was the emergency declarations made by the Governor of California that exempted Caltrans Tom the State Contracting Act Limitations. This exemption paved the way for a design/build contract. National Engineering Technology (NET), a local engineering firm, was given this unprecedented contract. Design/build permitted NET to be responsible for and coordinate the entire design, performance, scheduling, management, equipment procurement, construction and commissioning requirements of the project, which resulted in faster development of the EPI-center. The contract also included design, procurement, and construction of many traffic system elements; placement of the EPI-center next to the TMC; and deployment of communication links between field sites and the EPI-center proper".

On January 30th, 1994, the go-ahead was given for NET to begin. NET worked side-by-side with FHWA and Caltrans to get a design on the drawing board and revise it until the center fit the constraints of the designed function. Many of the project components were "fast-tracked' designed which allowed construction and procurement to commence ahead of the design completion[10]. The project was completed to the level of operability originally required on May 7th.

Procurement procedures were sped up as well. Caltrans facilitated procurement by assigning CMS's that were to go to other projects and putting them on the EPI-center project. They also expedited licensing of the HAR equipment. A computer management tool kept track of procurement of the central and field systems. The equipment was categorized into aboveground and belowground activities. Acquiring many off-the-shelf items also helped in faster delivery. and installation".

New procedures for the design, procurement, and construction of the EPI-center and its field systems contributed greatly to the rapid deployment of the finished system. It was a joint effort put forth by NET, FHWA, and Caltrans. Without this cooperation, there would have not been the level of success of meeting the deadlines.

Everyday Applications of Deployed Technologies

Much of the equipment that was deployed to help the city engineers manage the earthquake related traffic situations is considered new and not used very widely. 'In fact, these technologies are deployed all over the country and the world. This new equipment is not just for disasters, but for everyday traffic and incident management; and for traveler information.

The EPI-center worked along with the LADOT TMC. This traffic management center has many uses in today's fast moving society. It functioned well in an emergency with the aid of the EPI-center, but it is designed for day-to-day applications. There are several management centers operating across the country. The TMC in Montgomery County, Maryland for example, operates the entire county's traffic signal system, similar to the ATSAC in LA. The computers at the center adjust the green-time at each light based on traffic counts it receives from loop detectors in order to alleviate congestion. Traveler advisory equipment similar to the EPI-center is also operating, like CCTV's, HAR and airborne surveillance ameras. An Automatic Vehicle Location (AVL) system for their public transit buses is in development'which would eventually allow the TMC fo notify travelers of the precise location of the bus on its route. Detroit also has a traffic surveillance system consisting of CCTV's, CMS, loop detectors, and ramp meters.

The CMS's are used in different places. In Northern Virginia, CMS's are used to notify motorists of traffic delays and other incidents on the freeways. Motorists can use this information to change the route to their destination which helps to relieve driver frustration, reduces secondary incidents, and prevents congestion from getting worse. Seattle also has a traveler information system that includes CMS's and HAR

The HOV lanes that were established on the detour routes to'encourage carpooling exist elsewhere. Houston, Northern Virginia, and Pittsburgh all have an HOV system set up that encourages all types of carpooling and ridesharing. The HOV lanes require at least two or more people per vehicle, and are available to be used by public transit as well. This reduces the . demand on the freeways by putting more people in fewer vehicles, thus reducing congestion, driver frustration, fuel consumption, and pollution.

Conclusions

The innovations affecting how traffic management is operated made following the earthquake in Northridge, California can be applied in the future. Disasters can and will strike areas which do not have an infrastructure to handle the types of transportation interruptions that the Los Angeles area experienced. To be able to cope with an interruption in the mobility of an area or region, several components must exist to nurse the system while repairs are underway.
These include:

1) Some type of traffic management center using advanced technology that has communications links with emergency or incident management elements, traveler advisory capability, and some type of roadway surveillance capability in and around the affected areas.

2) The granted authority to facilitate the procurement and/or licensing any equipment in order to speed up deployment times.

3) Cooperative agreements and extensive communication between the transportation, emergency response, and contracting agencies to enable them to work together more efficiently and smoothly towards a common goal.

4) Alternate modes oftransportation must exist to reduce the demand on the roadways, thus decreasing congestion. Also, alternate modes must be flexible to reroute and/or reschedule to compensate for closures and damaged roadways.

5) Emergency operation teams or centers that can immediately react to any type of road or building damage, disrupted communications, and coordinate emergency responses. This includes an incident management patrol to deal with traffic congesting incidents on the roadways and detour routes.

Having these components can greatly enhance a region’s ability to handle a major disruption in its transportation system.

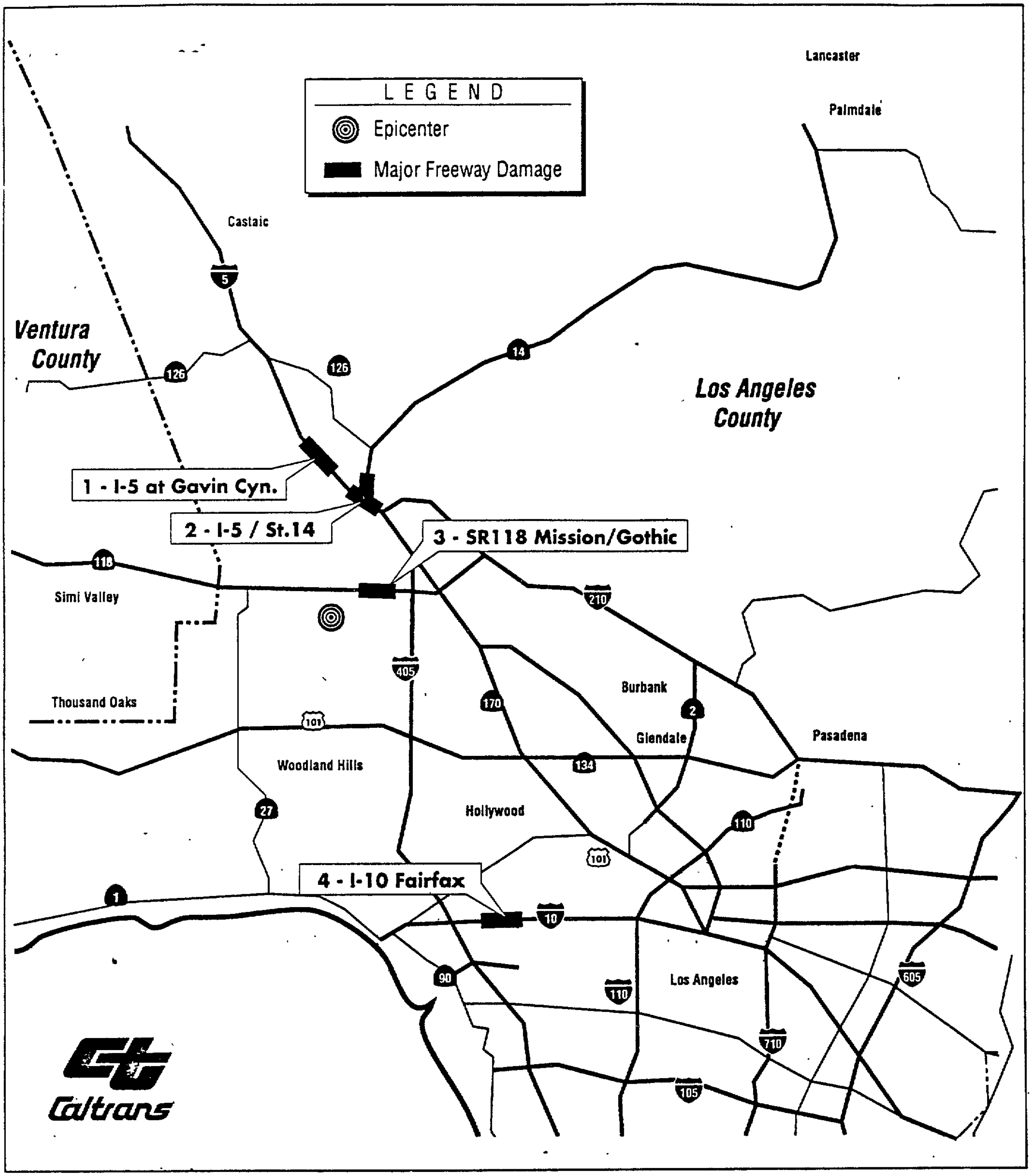

Figure 1. The Northridge Earthquake Affected Freeways and Roadways[6]

Damage: Bridge Collapse at Fairfax and Washington,

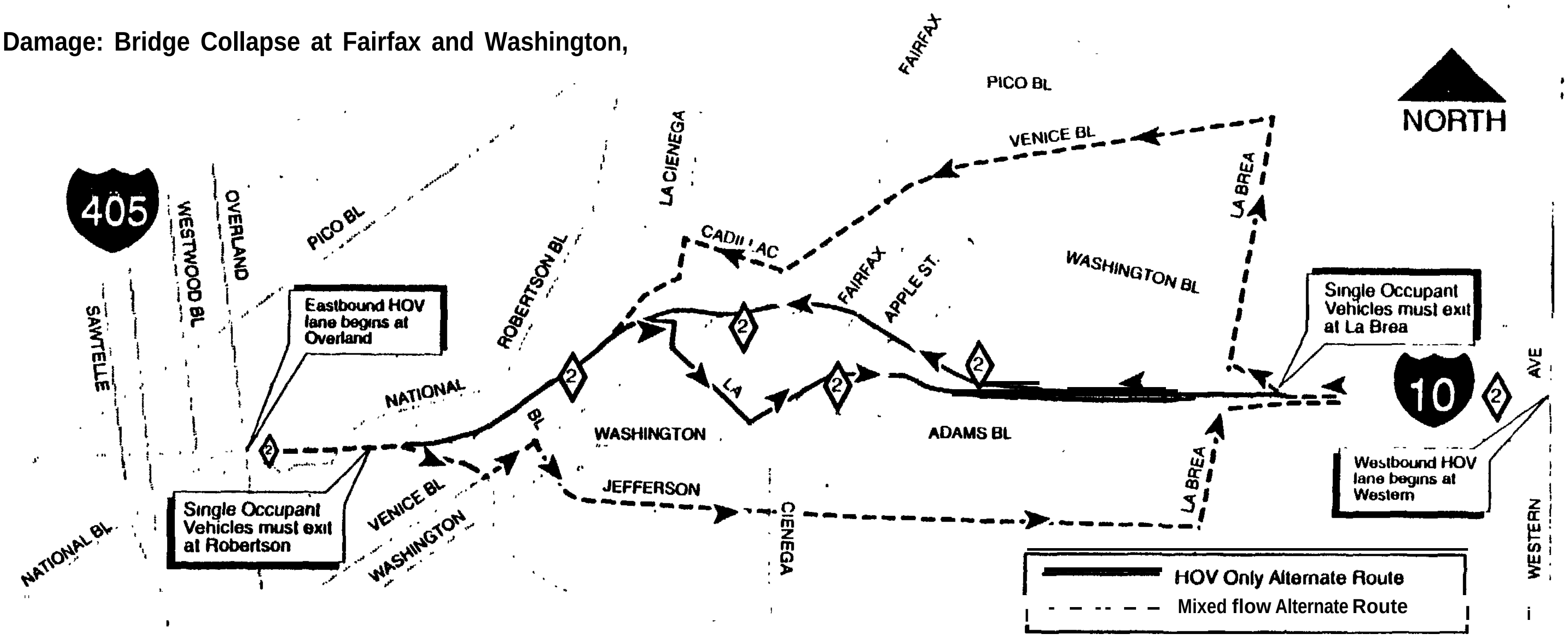

Figure 2. The I-10 Corridor Detours

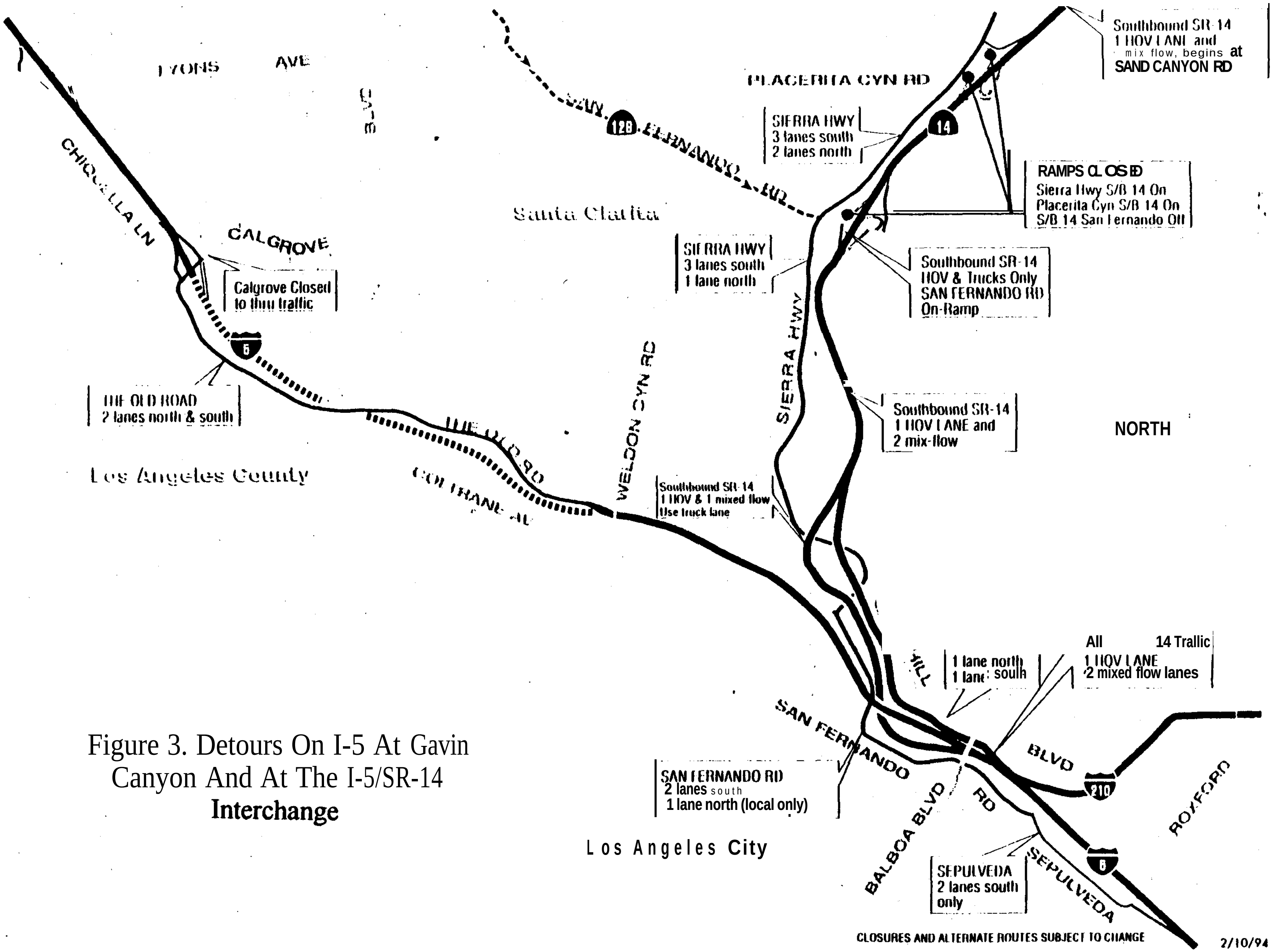

Figure 3. Detours On I-5 At Gavin Canyon And At The I-5/SR-14 **Interchange**

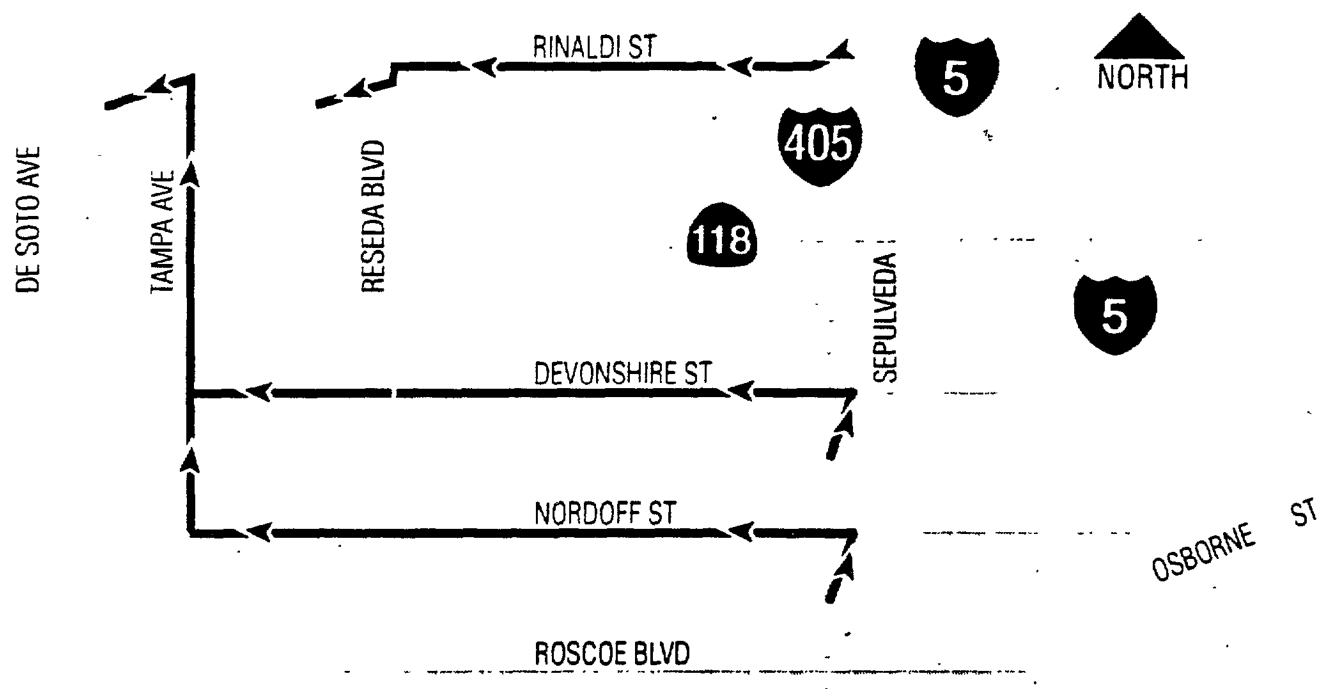

Figure 4. Detours At The I-405/SR-118 Interchange: North and South Bound I-405 to West Bound I-118

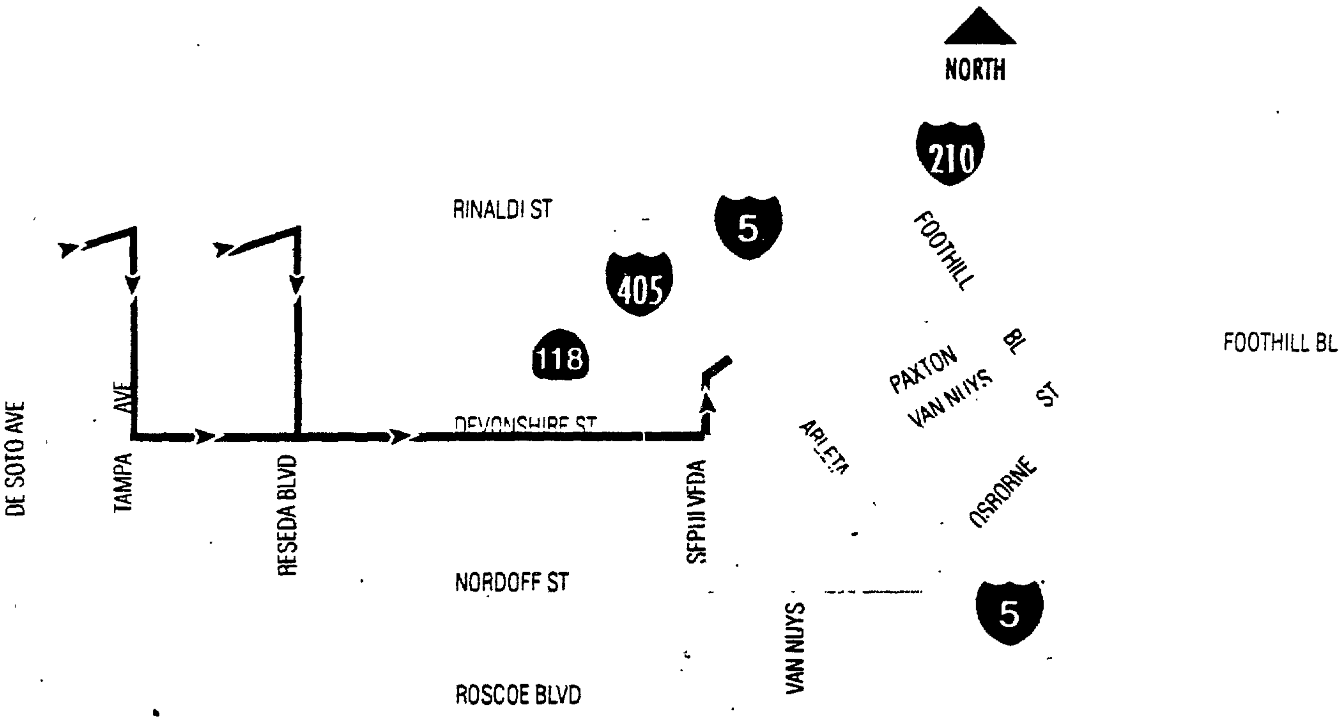

Figure 5. Detours At The I-405/SR-118 Interchange: West Bound SR-118

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