

Designing for Work Zone Incident Management

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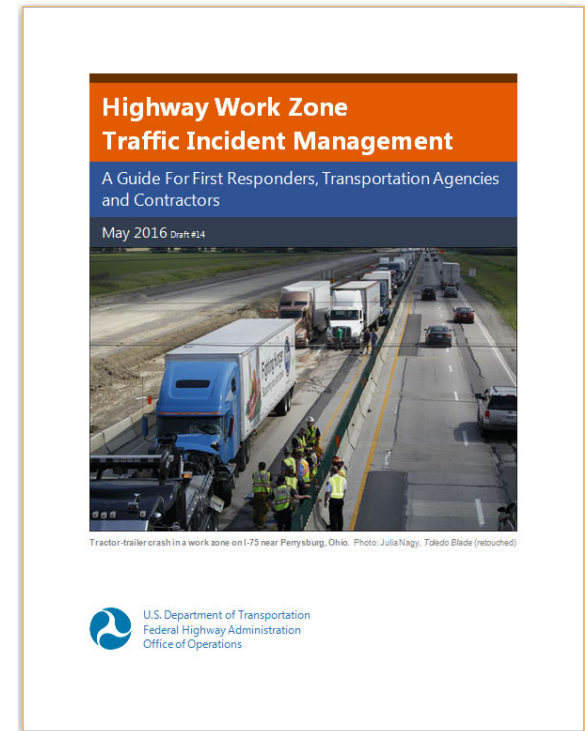
Learning Objectives

- Recognize the main differences between Work Zone Traffic Incident Management (WZ-TIM) and TIM in ordinary situations.
- Compare and contrast the WZ-TIM roles and responsibilities of first responders, transportation agency staff, and the contractor.
- Describe several strategies for improving work zone incident prevention and response.
- Become familiar with the advantages and disadvantages of contractor involvement in work zone incident management.



Resources

- Designing for Work Zone Incident Management Guidebook
- *Highway Work Zone Traffic Incident Management: A Guide for First Responders, Transportation Agencies and Contractors.*
- *Toward Zero Deaths* national strategy on highway safety.
- OECD *Safe System* approach to highway safety management.



U.S. Department of Transportation
Federal Highway Administration
Office of Operations

 **Toward Zero Deaths™**
National Strategy on Highway Safety

Types of Work Zone Incidents

- Traffic crashes and similar incidents
 - Within work zone
 - In approach to work zone
- Worker medical problems
 - Injury
 - Illness
- Work site mishaps
 - Damage to roadway or other infrastructure
 - Trench collapse
 - Embankment collapse
 - Equipment tip-over
 - Fire, explosion, etc.
- Work Area Intrusions



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Incident Response Involves Many Disciplines

Dealing with a crash or other traffic incident occurring in a work zone requires the combined skills of many people/disciplines.



WZ-TIM Goals

- Reduce Time
- Expedite Arrival
- Minimize Roadway Capacity Loss
- Facilitate Management
- Reduce Incident Clearance Time
- Rapidly Notify Upstream Travelers

How does work zone design affect work zone incident management?



Unique WZ Challenges

Work Zone Traffic Incident Management (WZ-TIM) differs from TIM on ordinary roadways in several ways:

- **Difficult access** to work zone incidents
- **Limited space:** lane restrictions
- **Traffic congestion:** back-ups / queues
- **Many organizations** to coordinate:
 - First responders (police, fire, EMS, towing)
 - Agency traffic operations center
 - Contractor personnel
 - Agency construction management personnel



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The Designer's Influence

- Allocation of Space
 - When an incident occurs, where can first responders do their jobs?
 - Where can incident management vehicles be staged?
 - Work space → seldom available for first responders
 - Road space → conflicting demands for incident response space and traffic space
- Accessibility
 - Primary and secondary access to traffic lanes and shoulders
 - Primary and secondary access to work areas



- Contractual Relationships
 - Role of contractor in incident management
 - Coordination of first responder agencies and jurisdictional issues
 - Coordination with highway agency Traffic Management Center

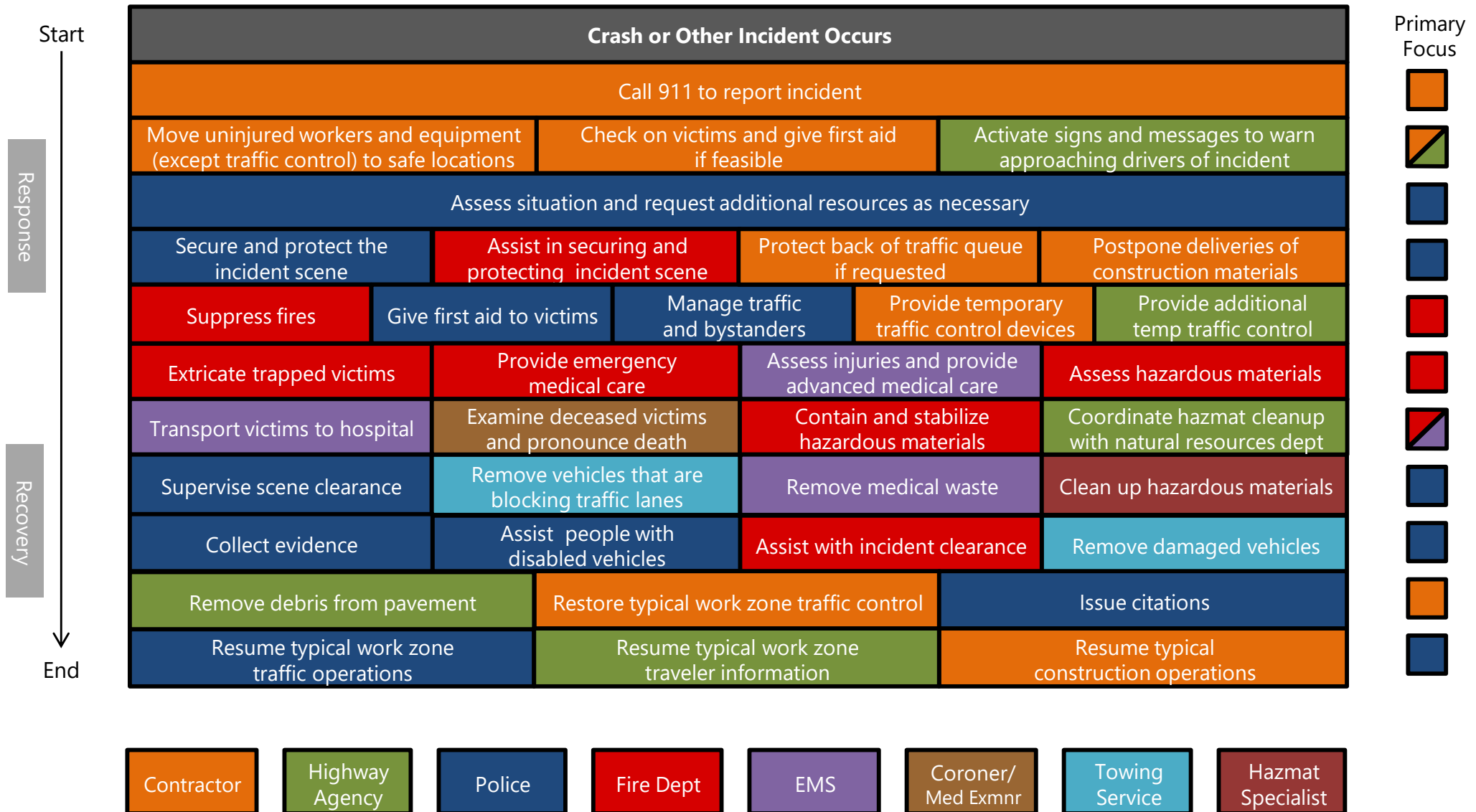
Safe System Strategies

- Make the WZ environment as “forgiving” as possible to errors or misjudgments made by workers, first responders, drivers, or others
- If a crash does occur, emergency response personnel—and people already on scene—need to respond quickly and correctly
- Assure victims receive appropriate treatment as promptly as possible



What Happens When An Incident Occurs?

Working Together: Coordinated Response to a Generic Work Zone Incident



Note: Roles and responsibilities shown in this chart are generalized, and could vary based on State and local laws, agreements, and contracts.

Phases of the Incident Management Process

Response

- Notify first responders of incident
- Emergency vehicles travel to scene
 - Access to incident site
 - Emergency vehicle staging
- Secure the scene
 - Get workers and equipment out of harm's way
 - Manage traffic
 - Suppress fire and prevent explosion
 - Protect hazardous materials
- Extricate victims
- Triage victims, medical transport, and on-site treatment
- Pronounce death, if required

Recovery

- Collect physical evidence
- Collect involved party and witness statements
- Issue citations
- Clear disabled vehicles
- Clean up spills and debris
- Make lanes driveable
- Restore traffic control
- Resume traffic operations
- Repair damaged infrastructure

Incident Response: Roles for First Responders

- **Secure** and protect the scene
- **Aid** crash victims
- **Coordinate** the response
- **Protect** the back-of-queue to prevent secondary collisions
- **Manage** traffic and re-route if necessary
- **Ask** for contractor equipment and manpower if it will help expedite response and recovery
- **Investigate** the incident, gather evidence, and issue citations as appropriate



Incident Response: Potential Roles for Contractors

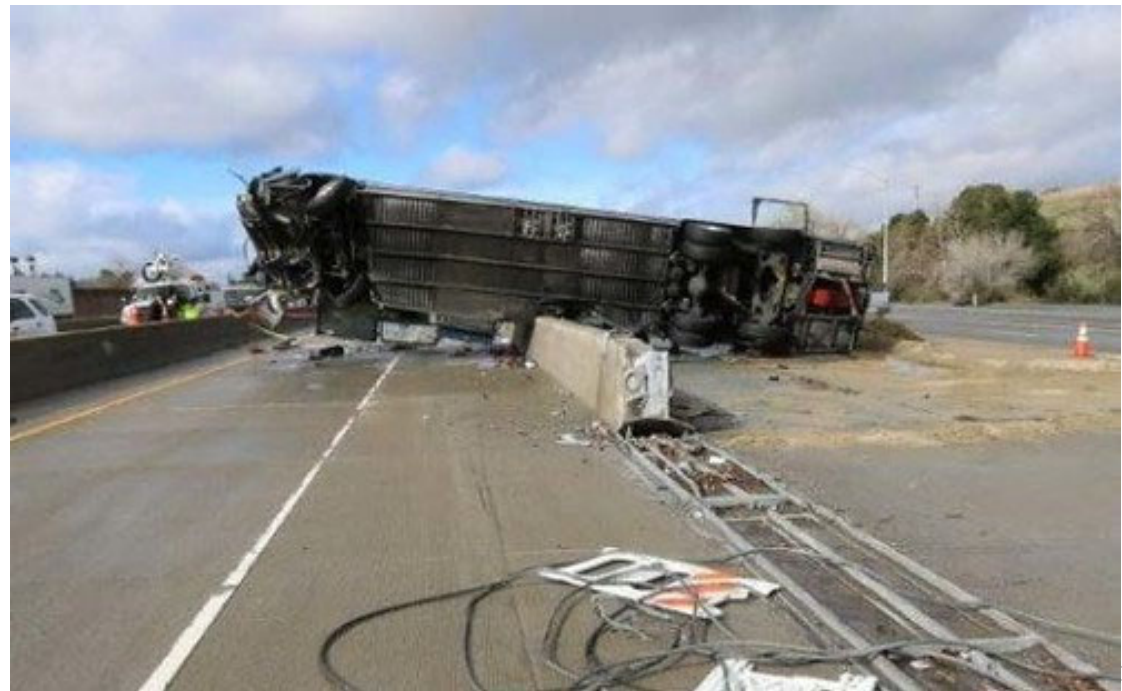
- **Report** the incident by calling 911
- **Move** construction personnel and equipment out of the way
- **Give first aid** to crash victims until help arrives (if qualified)
- **Assist** with the response if requested:
 - Traffic control equipment
 - Back-of-queue protection
 - Lifting equipment
 - Spill containment



Incident Complexity Levels

Traffic incident and response levels can be organized into three categories, based on expected duration and complexity:

- **Minor** – Expected duration *less than 30 minutes*
- **Intermediate** – Expected duration *30 minutes to two hours*
- **Major** – Expected duration *more than two hours*



Incident Command System Principles

Modular Organization

- Top-down hierarchy
- First to arrive establishes initial command and control.
- Command is handed over to the agency most deeply involved in response and recovery.
- As response progresses, the leader will change.

Unity of Command

- Everyone on site has one and only one supervisor.
- Every supervisor has 3 to 7 subordinates.

Span of Control

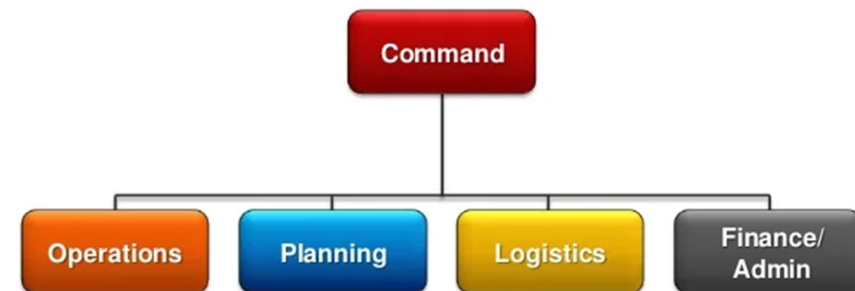
- Supervisors coordinate with one another, but not directly involved in front-line operations
- Supervisors allocate work based on individual skills and abilities.

Management by Objective

- Objectives → Strategy → Tactics → Implementation



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Case Study: Truck Rollover

West Des Moines, Iowa – September 2014



Facts & Circumstances

- Rural freeway with 25,800 vehicles per day
- Northbound semi struck, penetrated concrete barrier
- Two southbound passenger cars struck the semi
- All lanes blocked
- Diesel spill



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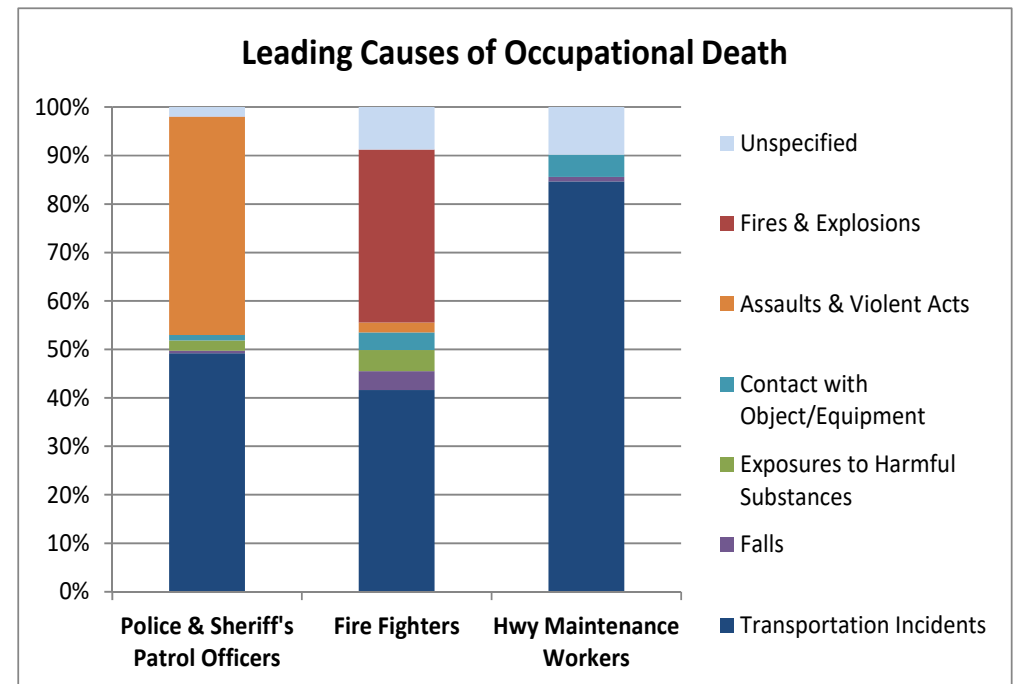
- Traffic re-routed to arterials
- Extended closure due to delayed arrival of HazMat contractor

First Responder Safety

- More on-duty police officers killed in traffic crashes than by bullets.
- More firefighters killed by motor vehicles than by fires and explosions.
- Tow truck operators and EMS personnel also at high risk of being struck by traffic.



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Source: Bureau of Labor Statistics

Incident Prevention: What Can Designers Do?

Pre-Construction

- **Prepare** for handling work zone incidents
 - Physical Accommodations
 - Inter-Agency Coordination
 - Contractual Provisions
- **Engage** first responders in Transportation Management Plan (TMP) development and incident management planning.

During Construction

- **Keep responders informed** about lane/ramp closures and “back door” ways to access the work zone.
- **Say something** if you observe a problem.
 - Situations that encourage illegal/risky road user behavior.
 - Missing traffic control devices.
 - Improper work practices.
- **Set a positive example** by complying with work zone traffic laws, on- and off-duty.

Back-Of-Queue Protection

Secondary Crashes

- “Secondary crash” is a second (or subsequent) crash that occurs at the incident scene or in a traffic queue resulting from the original incident.
- About **19%** of freeway fatalities are the result of front-to-rear crashes.
- Most common scenario: traffic is backed up and a fast-moving vehicle strikes a slowed or stopped vehicle at the back of the queue.
- Less likely to occur if warning is provided about $\frac{1}{4}$ mile in advance of the slowed traffic.



Back-of-Queue Protection Methods

Roll-Up Fabric Signs

- Pro: Easy to set up and remove
- Con: Small, may need to reposition as queue changes

Hinged Fixed Signs

- Pro: Bigger and more conspicuous than portable signs
- Con: Cannot move with queue.

Electronic Signs

- Pro: Large, conspicuous, can change the message
- Con: Cannot move with queue. Expensive. Not crash-tested.

Law Enforcement Vehicle

- Pro: Can move as queue grows/shrinks
- Con: Officer not available for other duties



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Queue Warning Vehicles



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Contractor- or Agency-Supplied Vehicle

- Pro: Can move as queue grows/shrinks
- Con: Requires special contractual provisions, response time possibly slower than law enforcement

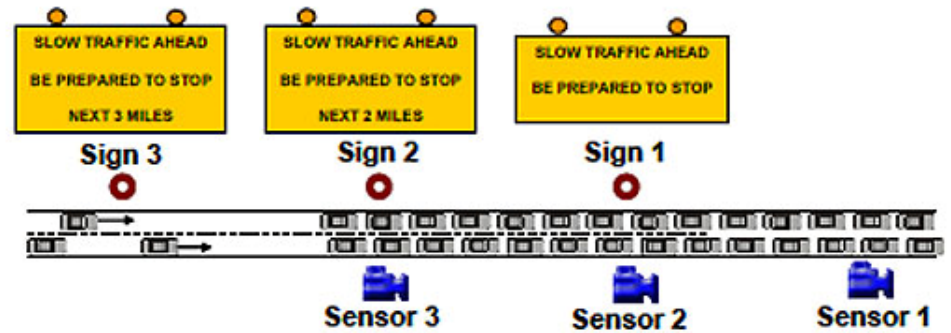
Automated Queue Warning Systems



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- Series of speed sensors and electronically-actuated signs
- If speeds near sensor fall below pre-determined threshold, the corresponding upstream sign is activated.
- In freeway applications, the distance between the sensor and its upstream sign is typically $\frac{1}{2}$ to 1 mile.

Discussion

- What types of back-of-queue protection have you used?
- Were they sufficient?

Site Access

Primary & Secondary Access/Egress

Fire codes for buildings: every occupied space must have a secondary means of egress.

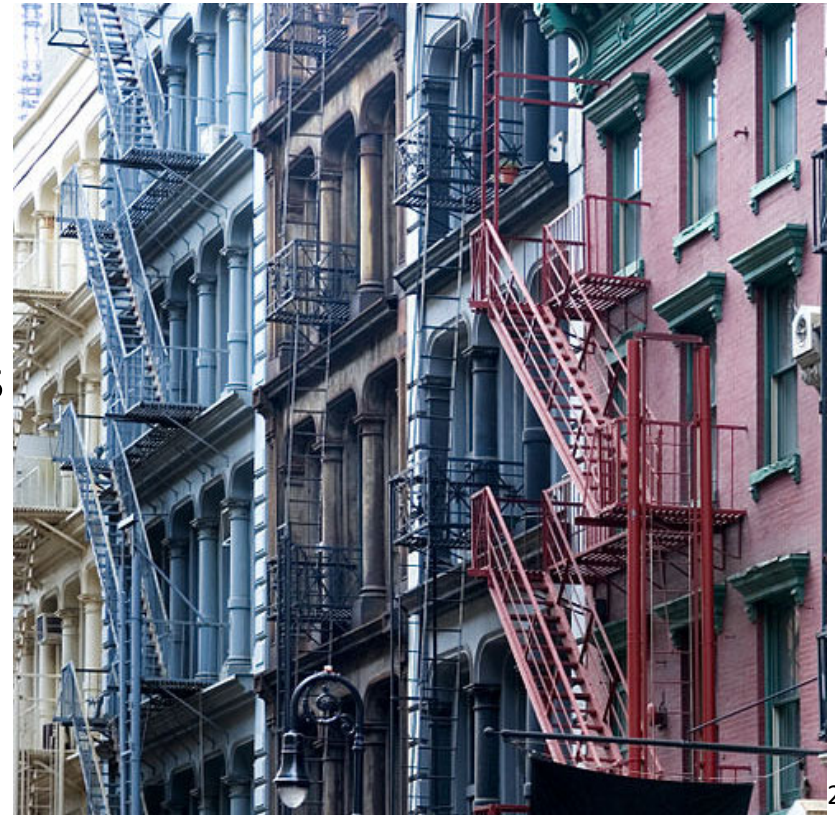
- Primary egress: doors, hallways, stairs
- Secondary egress: windows, fire escapes

Work Zones

- Not codified, but...
- Same concepts apply

Some Sites are Challenging

- Barrier-separated lanes without shoulders
- Multi-level interchanges



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Congestion caused by incidents often hampers response and recovery

Improving Access to Incident Sites



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- Gates in temporary barriers
- Temporary access from overpasses or side roads



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All-Terrain Emergency Response Vehicles

- All-terrain vehicles can resolve some access issues
- Some fire agencies own all-terrain vehicles
- May need to redeploy from other locations



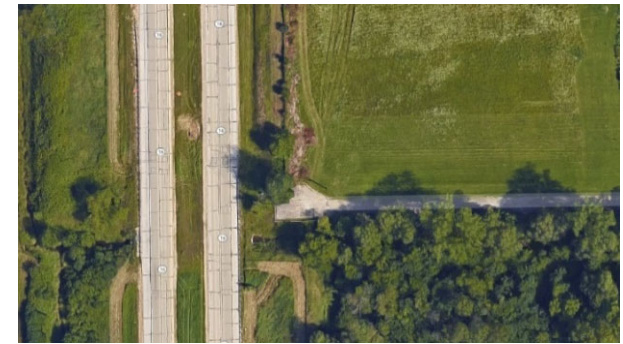
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Gated Secondary Access

- Alternate pathway to access work zone
- Helps avoid driving through traffic back-ups to reach incident site
- Access usually from local road
- Usually locked to deter unauthorized use
- Traversable surface (sometimes unpaved)
- Can be given a name/number and mapped for 911 dispatch systems



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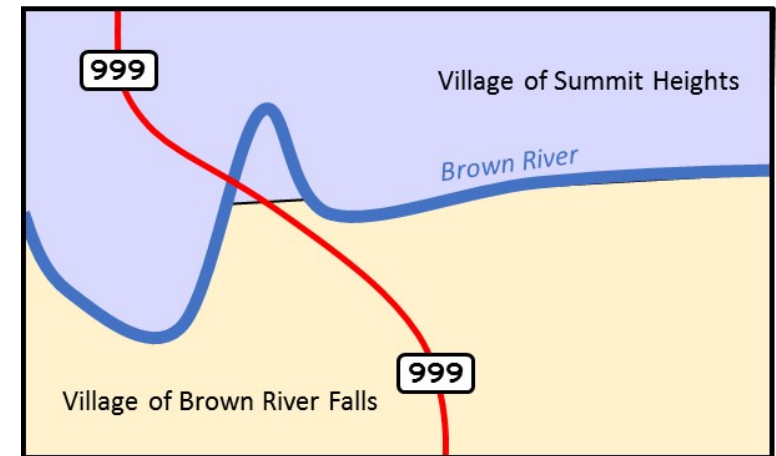
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Temporary Loss of Access for Emergency Response Stations

- Some projects temporarily cut off access to police, fire, or ambulance stations.
- Sometimes can be resolved administratively (mutual aid)
- Semi-permanent solutions should be proportionate to the project impact
- Response time is the usual measure of effectiveness



Difficult Sites Require Extra Effort

Examples

- Long/high bridges
- Tunnels
- One-side-only access
 - Coastal highways
 - Highways paralleling rivers
 - Highways paralleling rail lines
- Remote sites
- Complex urban sites
 - Mass transit in median
 - Multi-level roadways
- Sites near high-security facilities
 - Airports
 - National defense



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Discussion

- What are the challenges of reaching an incident if one occurs in this work zone?
- What design strategies could be used to mitigate them?



Physical Accommodations

Ramp Closure Gates & Signs



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Gates reduce police manpower required to:

- Reduce traffic volume approaching incident site
- Prevent vehicles from entering a high-delay situation

Type III barricades can be used temporarily
Flip-up signs reduce unintentional entry to closed ramps



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Drops down.
Inconspicuous
color when not
deployed.



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Traffic Control Device Caches



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- Near-site supply of incident management cones, drums, signs, etc.
- Possibly upstream of work zone
- Some agencies pre-load equipment on a trailer
- Urban areas: possibly include portable fences and other crowd control devices



Orange:
Construction



Fluorescent Pink:
Incident Management



W3-4



W4-2



W9-3



E5-2a



M4-8a



M4-9



M4-10

Allocating Road Space

- Construction activities and traffic compete for road space (especially width) in many work zones.
- Temporary barriers also require space (typically 4 ft)
- Converting shoulders to driving lanes is popular, but without shoulders:
 - Disabled vehicles will block a travel lane.
 - Difficult for first responders to reach the incident scene.
 - No place to stage equipment that will be used during later stages of response and recovery.

Hierarchy of Options

(From the Incident Management Perspective)

Full Shoulder
(8 to 10 ft or more)

Intermittent Shoulder
+ Emergency Pull-Outs

Intermittent Shoulder

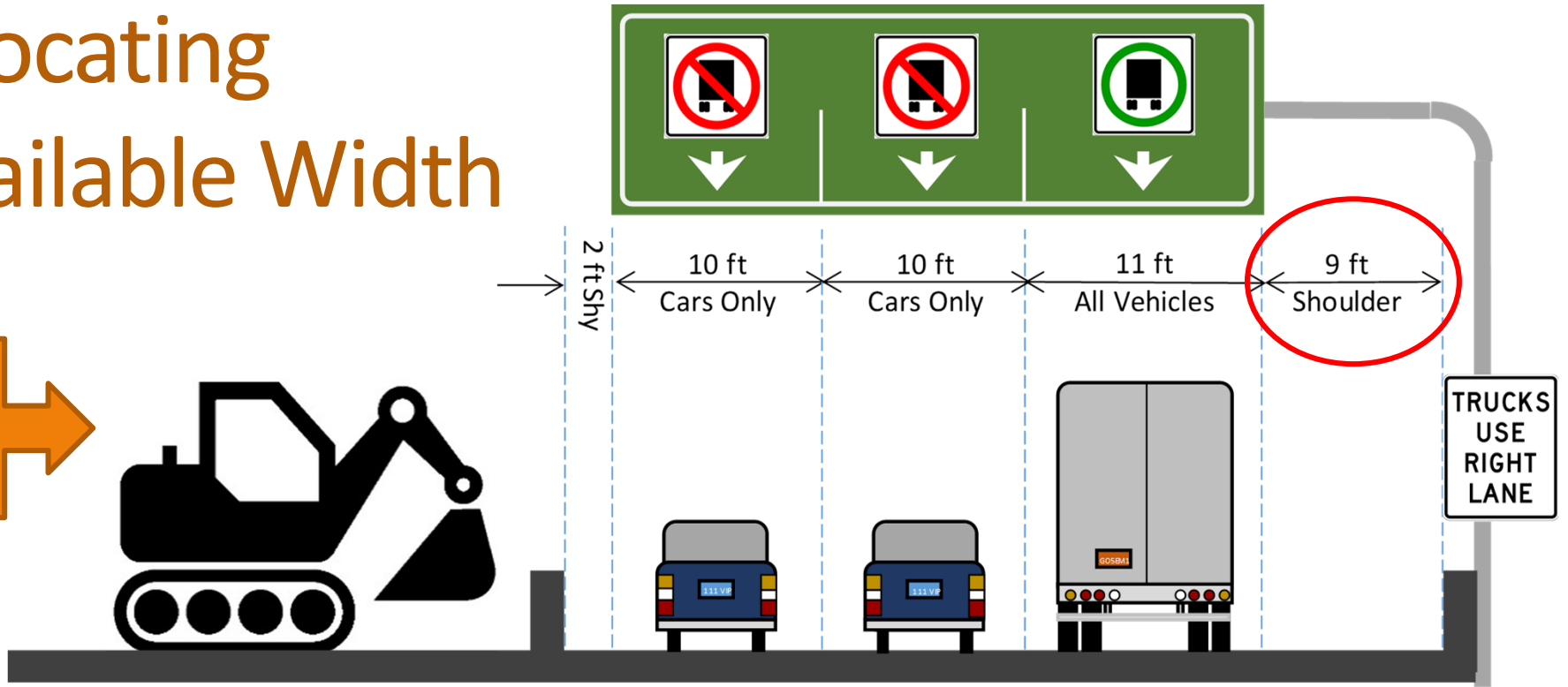
Narrow Shoulder (6 to 8 ft)

Very Narrow Shoulder
(3 to 6 ft)

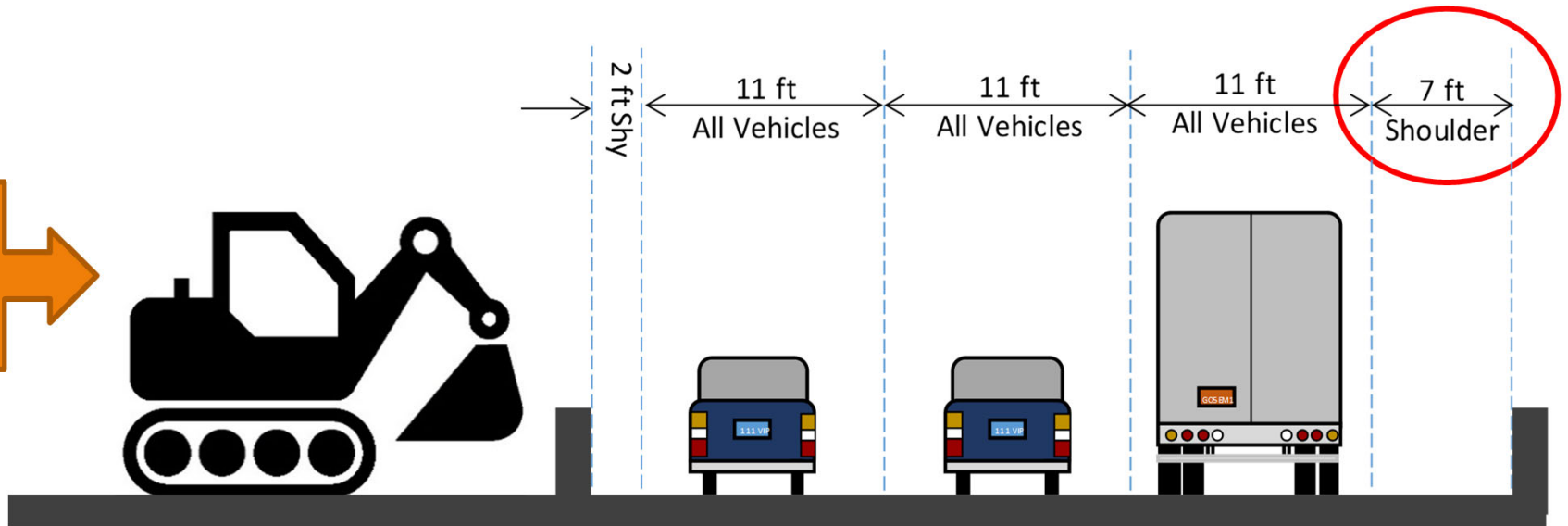
Traversable Foreslope

Allocating Available Width

Unequal Lane Width



Equal Lane Width

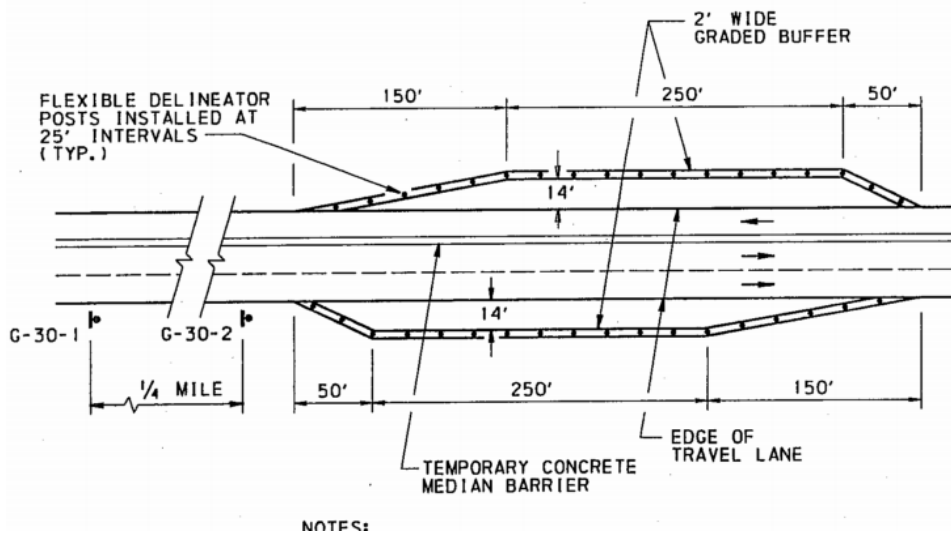


Emergency Parking (Pull-offs)



- Safe space for disabled vehicles when work zone has little/no shoulder
- Useful for staging emergency vehicles
- Sometimes used for law enforcement
- Typically placed where terrain is favorable (roughly $\frac{1}{2}$ to 2 mile intervals)

Short vs Long Emergency Parking Areas

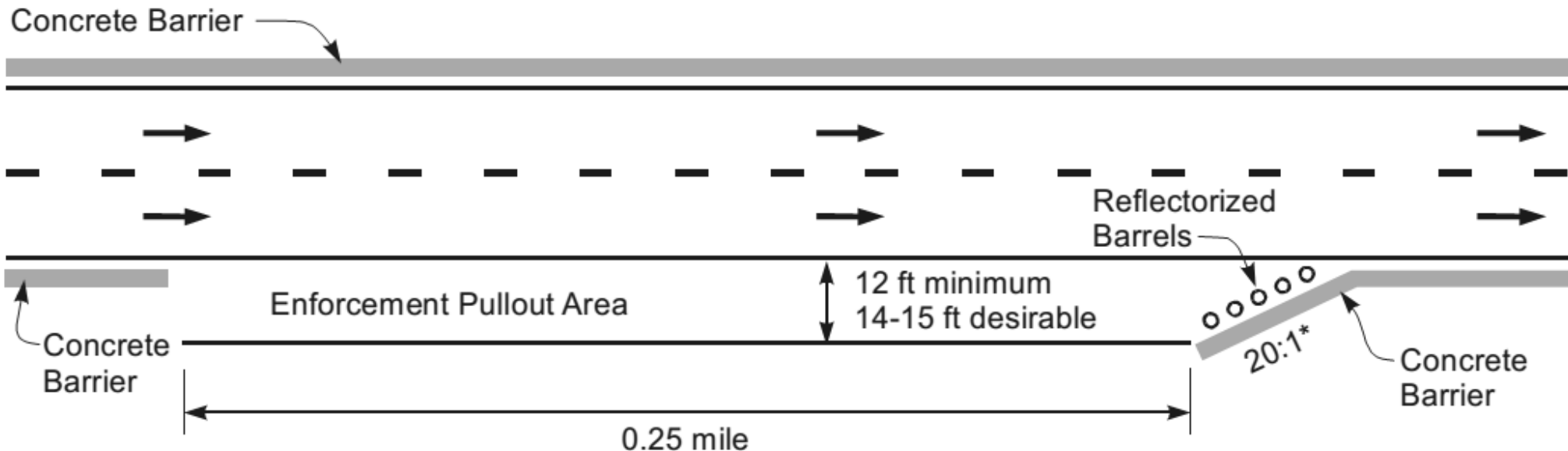


Short:

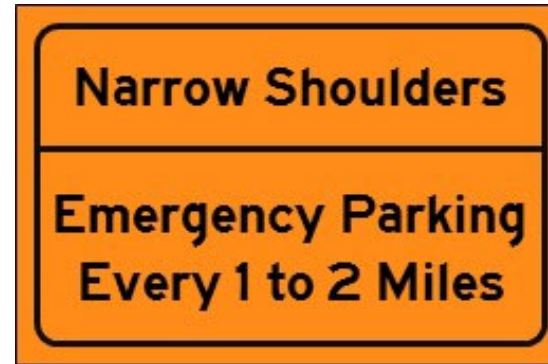
- 100-250 ft plus 75-200 ft of tapers
- Coast in / tow out

Long:

- 750 to 1320 ft plus 300 ft exit taper
- Enter/exit at freeway speeds
- Useful for law enforcement



Emergency Parking Signage



Upstream End of Work Zone



Approaching Parking Area

Signage in Emergency Parking Area



Pre-Designated First Responder Staging Areas

Functions

- Rally-point where responders assemble.
- Waiting area for responders and equipment not immediately needed at incident scene.
- Location where responders can take breaks and meals in case of a long-duration incident.
- Safe work area for media reporting on the incident.



Air Ambulance Landing Zones (LZs)



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Typical Applications:

- Remote/rugged sites
- High-risk construction operations (*e.g.* blasting)

LZ Design:

- Usually 100 x 100 ft
- Level ground
- Corners marked by cones and (at night) strobe lights
- Distant from overhead wires, trees, buildings, pedestrians, livestock, etc.
- Paved, sealed, or wetted to reduce flying debris
- GPS coordinates posted at the site
- Floodlighting, if used, directed away from aircraft

Triage Areas



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Purpose:

- Sort mass casualty victims based on injury severity
- Allocate ambulances and medical resources sensibly
- Highest treatment priority: severe but survivable injuries

Typical Applications:

- Remote/rugged sites
- High-risk construction operations (e.g. blasting)

CONTAMINATED TRIAGE TAG

Personal Property Receipt
Evidence Tag
Destination
Via

TRIAGE TAG

1 2 3 4 5
AUTO INJECTION

HT	Coat Size
HT	Shoe Size
HT	Weight
HT	Sex
HT	Color
HT	Eye
HT	Hair
HT	Age
HT	Gender
HT	Other

VITAL SIGNS

HT	BP	Pulse	Respiration
HT			
HT			
HT			

MORGUE
Prolonged Breathing

IMMEDIATE
Life-Threatening Injury

DELAYED
Serious, Non-Life-Threatening

MINOR
Walking Wounded

Alternate Routes

Alternate Routes



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- Review existing alternate route plans if available
- Detour routes for nighttime full closures sometimes double as daytime emergency/overflow routes
- Consider offering different alt routes for cars and heavy trucks:
 - Minimize travel distance for easily-maneuverable vehicles
 - Split up traffic volume

Alternate Route Selection Factors

- Proximity to main roadway.
- Length (Compared to staying on the main route).
- Ease of access to/from alternate route.
- Complexity (Is it confusing for unfamiliar drivers?).
- Land use.
- Existing safety record.
- Height, width, weight, and turning restrictions.
- Pavement and bridge condition.
- Existing traffic volume on the alternate route and capacity to handle additional traffic (especially at intersections).
- Traffic control features (*e.g.* signals and railroad grade crossing warning systems).
- Existing ITS infrastructure (traffic cameras, traffic flow sensors, and changeable message signs).
 - Gather information about travel conditions on the alternate route.
 - Provide feedback to road users.
- Effect on pedestrians, bicycles, and transit.
- Roadway ownership/jurisdiction.

Contractual Provisions

Tactical Pre-Planning

- Pre-planning incident response tactics help avoid secondary incidents.
 - For example, a plan can be established to close upstream ramps to limit incoming traffic volume.
- Up-front consideration should be given for how tactics will change depending on traffic conditions

Coordination Meetings

Everyone involved with the project discuss:

- Roles and Responsibilities
- Construction Details
- Procedures & Schedules
- Decisions that must be made
- Questions that have not been answered



Using Contractor's Traffic Control Devices

- Sometimes, drums and other devices already on site are repositioned to expedite incident traffic management.
- Coordinate with responders to assure that traffic is not directed into impassable areas.
- When incident is cleared, discuss whether traffic control should be put back in its previous location.





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Discussion: Should contractors be involved in incident management?

Pro

- Typically, the contractor is already on scene
- Some contractor personnel have experience as fire/EMS volunteers
- Contractor assets such as traffic control drums and lifting equipment might be useful for incident response

Con

- Contractor could get in the way of first responders
- Contractor personnel might lack relevant training
- Contractors might not understand Integrated Command
- Not a contractual bid item

Measuring Success




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Three generally accepted performance measures for gauging TIM effectiveness:

- **Roadway Clearance Time** – Interval between first awareness of an incident by a responding agency (detection, notification, or verification) and first confirmation that all lanes are available for traffic flow
- **Incident Clearance Time** – Interval between first awareness of an incident and time the last responder leaves the scene
- **Secondary Incidents** – Number of additional unplanned incidents that occur at the scene (or in the traffic queue approaching the scene) after the original incident is reported

After Action Reviews

- Post-incident information sharing contributes to long-term improvement in roadway safety.
- Each incident is an opportunity to:
 - **Review** how effectively response was handled.
 - **Inform** roadway agency and contractor about work zone conditions that potentially contributed to the incident.
 - **Consider** what can be done to achieve higher levels of safety and efficiency in the future.
- Works best when the discussion is open and candid.



What went well?

What can we improve?

Case Examples



ROAD CLOSED
TO
THRU TRAFFIC

SPEED
LIMIT
45

ENTERING
NEWMAN
ADDRESSING
SYSTEM



TRUCK
ROUTE



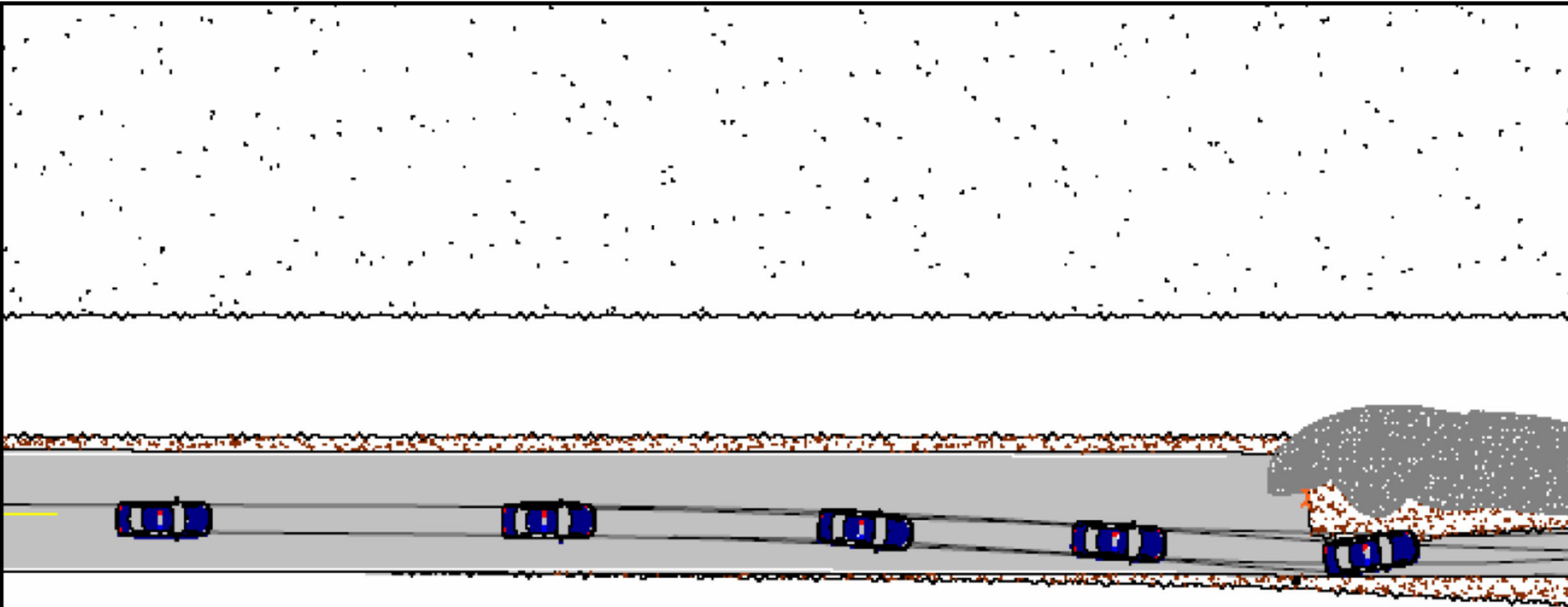
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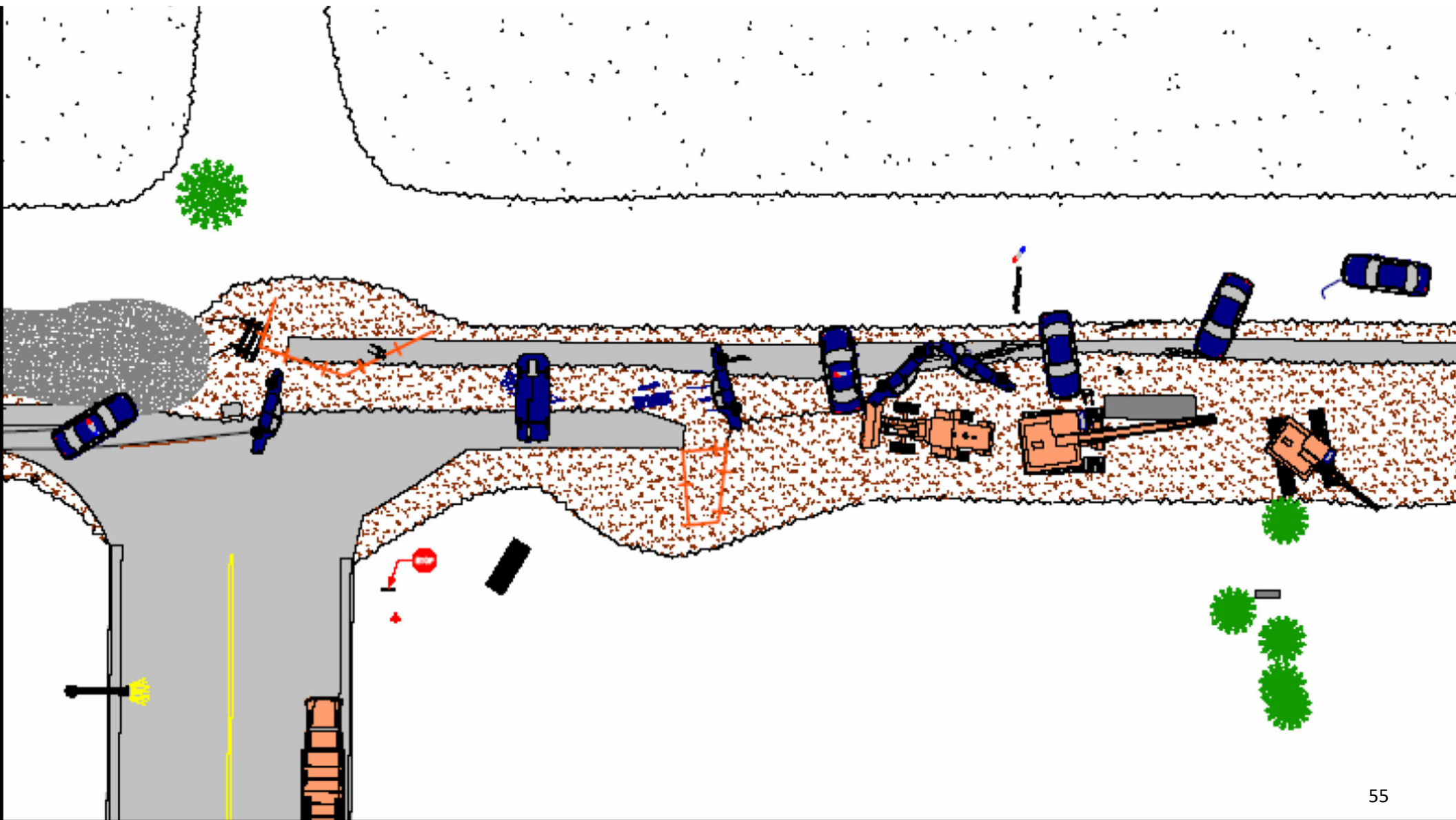




Collision Sequence



Case Study



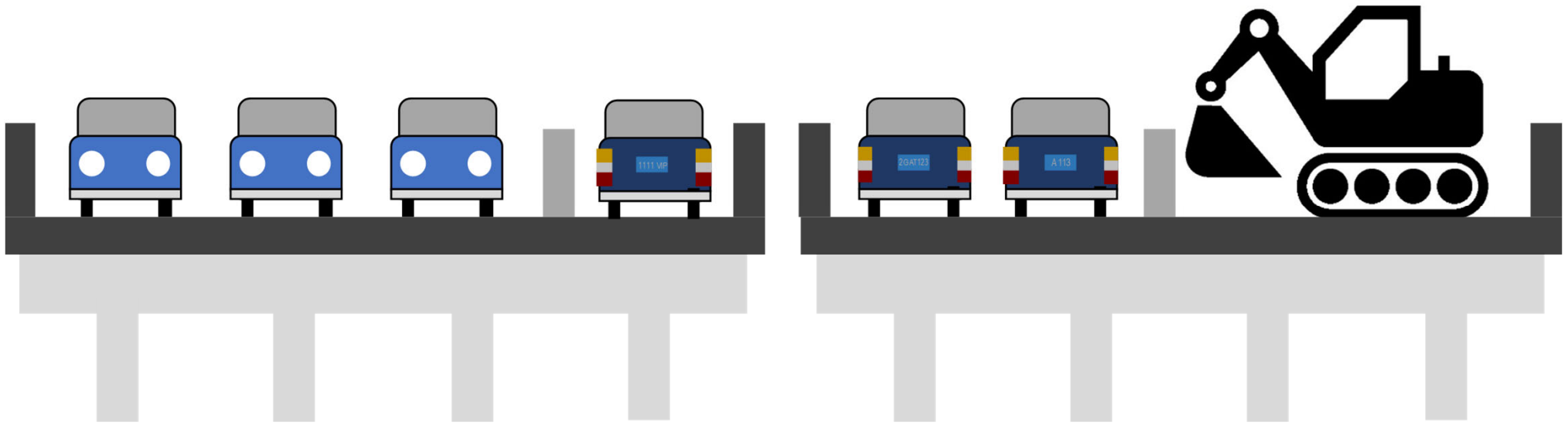
Lessons Learned

- Lack of coordination between the municipality and the signing contractor
- Signing and lighting of the work zone were not in conformity with the MUTCD requirements
- Signs were not properly secured and were moved by high winds which limited their effectiveness
- Signs at the gravel pile were defective and of inferior quality
- Little coordination with law enforcement regarding work zone dynamics and changing conditions

Case Study: Yahara River Bridge Re-Decking Madison, Wisconsin June 2013



Case Study: Yahara River Bridge Re-Decking Madison, Wisconsin – June 2013



- Urban freeway with 123,000 vehicles per day
- Causeway over river and wetlands
- Unusual split configuration

Case Study: Complex Urban Work Zone







Video





Lane 1 is Closed by Service Patrol and Local LE



Towing and Recovery



All Lanes Open



Lesson Learned

- All partners participated in pre-construction meetings
- Law enforcement and towing were assigned primary responsibility for the work zone
- Changing work zone conditions were discussed with partners
- Response was coordinated between law enforcement, towing and freeway service patrol, contractors and the traffic operations center
- Back of queue warning and protection strategies were implemented
- After action reviews were conducted to discuss lessons learned

Additional Resources

1. <https://search.creativecommons.org/photos/3bc466d1-e547-4a91-a771-b465fdf4e055>
2. <https://search.creativecommons.org/photos/6b86eb6e-0ee7-40e6-a3c9-a612a358f719>
3. <https://search.creativecommons.org/photos/a7a7d5e0-abc4-4304-bce3-601c5365125a>
4. <https://search.creativecommons.org/photos/d9c82c1b-b29f-443a-a32e-e0885d8fd3a8>
5. <https://search.creativecommons.org/photos/9d87d373-7da1-44d6-a1e0-f4edcf64ead4>
6. <https://search.creativecommons.org/photos/84c84781-d3b8-41c3-8a9d-393ccab49f87>
7. <https://search.creativecommons.org/photos/7fb7ff48-a3ed-4f26-8d9f-c4aa590ec595>
8. <https://search.creativecommons.org/photos/3256c9ed-6878-45d0-a19e-c08fb2084fcb>
9. <https://search.creativecommons.org/photos/0ee03304-64f5-4712-856f-3f15739ead35>
10. <https://search.creativecommons.org/photos/b8b5d539-ae89-4df2-9b13-2277b32bc72f>
11. <https://search.creativecommons.org/photos/03819f8c-598e-410a-a2dd-435f7cac0959>
12. <http://www.desmoinesregister.com/story/news/local/2014/09/30/semi-rollover-i-35/16473729/>
13. <https://search.creativecommons.org/photos/48b43bd8-89b2-4794-9578-02ef02b072ed>
14. [https://commons.wikimedia.org/wiki/File:Work_zone_barriers_for_bicycle_and_pedestrian_road_users_\(27114322245\).jpg](https://commons.wikimedia.org/wiki/File:Work_zone_barriers_for_bicycle_and_pedestrian_road_users_(27114322245).jpg)
15. https://commons.wikimedia.org/wiki/File:Boston_traffic_re-routed_Ted_Williams_tunnel,_2006.jpg
16. https://commons.wikimedia.org/wiki/File:FEMA_-_19021_-_Photograph_by_Leif_Skoogfors_taken_on_11-10-2005_in_Indiana.jpg
17. <http://www.newsobserver.com/news/local/news-columns-blogs/article22833990.html>
18. <http://www.dicolor.cn/solution/58.html>
19. https://commons.wikimedia.org/wiki/File:Police_car_with_emergency_lights_on.jpg
20. <https://www.rtinsights.com/why-edge-computing-is-here-to-stay-five-use-cases/>
21. https://www.fhwa.dot.gov/ipd/revenue/road_pricing/resources/webinars/webinar_091715.aspx
22. <http://www.its-ukreview.org/using-portable-its-applications-for-critical-road-works-and-road-weather-management/>
23. <https://www.streetsmartrental.com/products/queue-warning-system.html/>
24. Source: FHWA ITS ePrimer
25. https://commons.wikimedia.org/wiki/File:NYC_-_Fire_escapes_-_0151.jpg
26. <http://www.barriersystemsinc.com/armorguard-gate>
27. <http://www.equipmentworld.com/better-bridges-8/>
28. <http://www.4x4firetruck.com/>
29. <http://eeresq.com/id15.html>
30. Google Earth
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32. Google Earth
33. Google Earth
34. <https://search.creativecommons.org/photos/4b29e08b-74f8-4f1f-8e62-e93c0448a5c3>
35. Google Earth
36. <https://commons.wikimedia.org/wiki/File:LionsGateBridgeDeckReplacementProgressApril2001.jpg>
37. https://upload.wikimedia.org/wikipedia/commons/7/76/Tuscarora_Mountain_Tunnel.jpg
38. <https://search.creativecommons.org/photos/a8d2aa1f-8b6b-41fc-b760-35d64c155017>
39. [https://commons.wikimedia.org/w/index.php?title=Special:Search&limit=500&offset=0&profile=images&search=Kim+Scarborough&searchToken=2jwi308rdgcsif6n3aencwy7#/media/File:Traffic_\(43152228\).jpg](https://commons.wikimedia.org/w/index.php?title=Special:Search&limit=500&offset=0&profile=images&search=Kim+Scarborough&searchToken=2jwi308rdgcsif6n3aencwy7#/media/File:Traffic_(43152228).jpg)
40. <https://williamsburgsrealestate.com/2009/10/13/what-are-those-gates-on-i64/>
41. Google Earth
42. Google Earth
43. Steve Fareham/Geograph
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