



## Innovative Initiatives that Promote a Culture of Highway Safety

Module 7: Road Safety 365: A Process for Reducing Crashes  
(Reference: Module 5, Road Safety 365, FHWA)

Eng. Benjamín Colucci-Ríos, PhD, PE, PTOE, FITE, API, JD  
benjamin.colucci1@upr.edu

April 11 & 12, 2016  
CIAPR - Mayagüez Chapter





# Module 5: Making Safer Roads

## A Process for Reducing Crashes



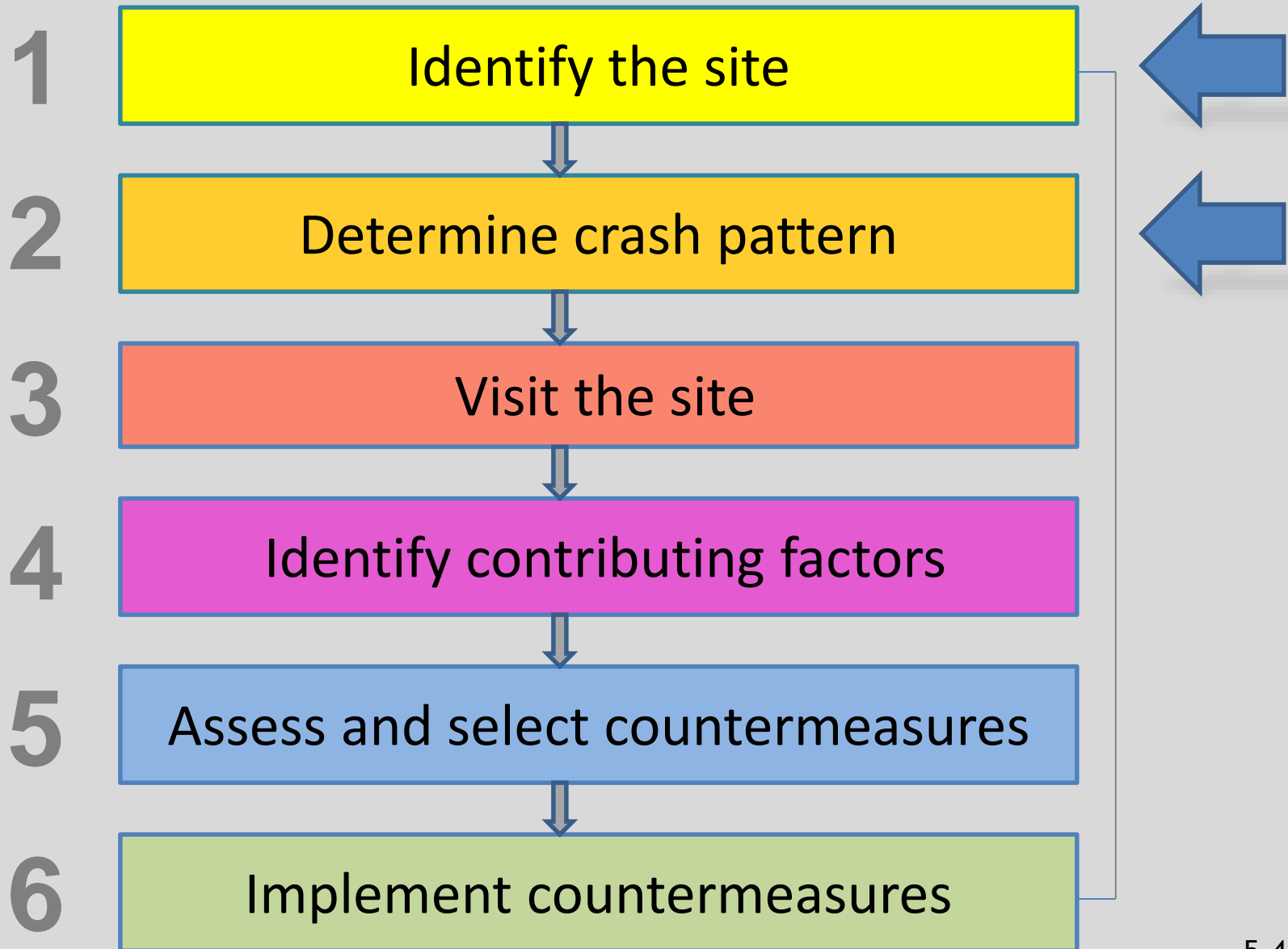
# Learning Outcomes

---

- Describe the crash reduction process.
- Identify the data/information needed to assess the safety of a roadway location.
- Identify practical and low-cost countermeasures.
- Describe best practices for making roads safer.

# Steps in Crash Reduction Process

---



# Crash Data Sources

---

- Crashes Reports: Police, DTOP
  - Place, time, drivers, vehicles, existing conditions, contributing factors
- Fatality Analysis Reporting System (FARS): NHTSA, CST
  - Fatal crashes database
- Motor Carrier Management Information System: FMCSA
  - CSP
  - Safety performance of individual suppliers

# Obtain Crash Data

**STATE OF MICHIGAN TRAFFIC CRASH REPORT**

Official Use Only - Do Not Write on This Side of the Line

Department Name: \_\_\_\_\_

Crash Date: MM/DD/YYYY | Crash Time: H:MM | No. of Lanes: \_\_\_\_\_

Crash Type:  Single Vehicle Accident,  Head-On,  Head-On-Left Turn,  Rollover,  Rear-End,  Rear-End-Right Turn,  Side-Swipe-Cut-Off,  Side-Swipe-Overlap,  Object Interference

Special Circumstances:  None,  Wet Road,  Ice and Frost,  Deer,  Falling Object,  Other

Special Study:  None,  Local,  State,  Federal

Weather:  Clear,  Partly Cloudy,  Cloudy,  Fog,  Rain,  Snow,  Ice,  Other

Light:  Daylight,  Dawn or Dusk,  Night,  Other

Road Condition:  Dry,  Wet,  Icy,  Slushy,  Other

Special Checks:  Fatal (Report All),  Connected Colls,  Repeat (Crash Report),  Death (Crash Report),  Non-Traffic Area,  Other/Snowmobile

Area: \_\_\_\_\_ | Total Lanes: \_\_\_\_\_ | Speed Limit: \_\_\_\_\_ | Posted: \_\_\_\_\_

Road Name: \_\_\_\_\_ | Road Type: \_\_\_\_\_ | Surface: \_\_\_\_\_

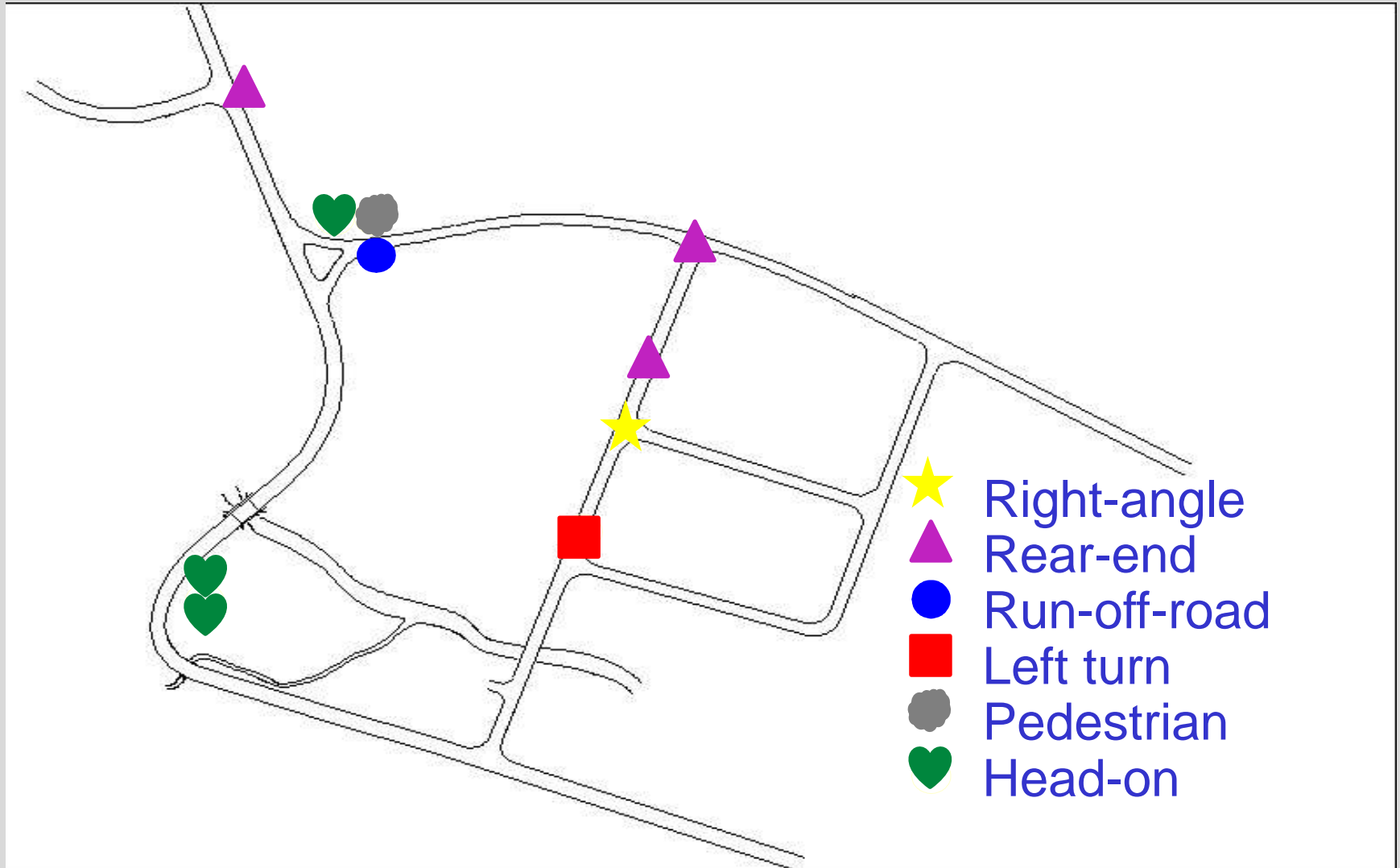
Distance: \_\_\_\_\_ | Intersecting Road: \_\_\_\_\_

Crash Report Data includes:

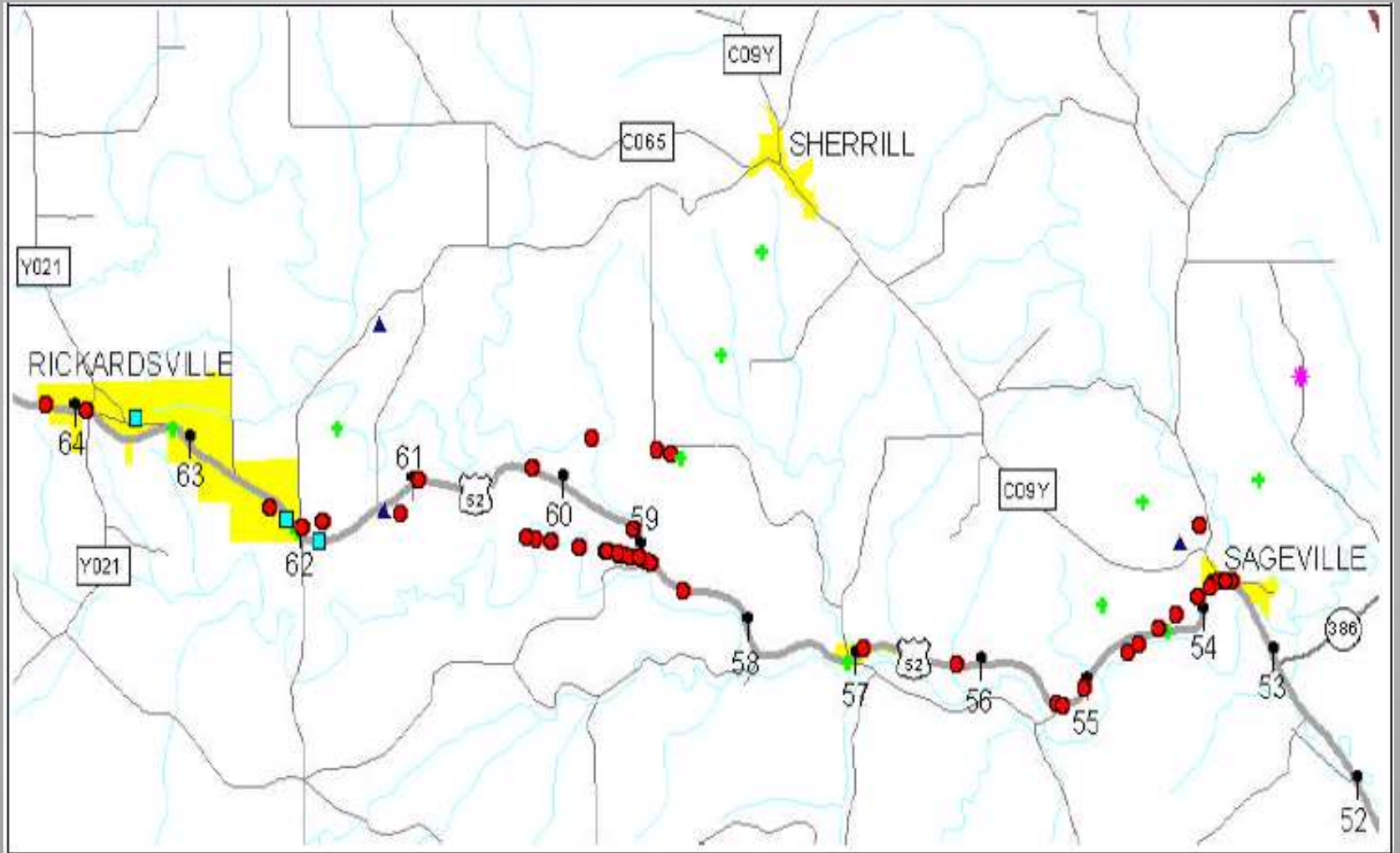
- Time/date of crash
- Pavement or surface conditions
- Weather conditions
- Other contributing factors



# Pin Map - Crash Locations and Crash Types



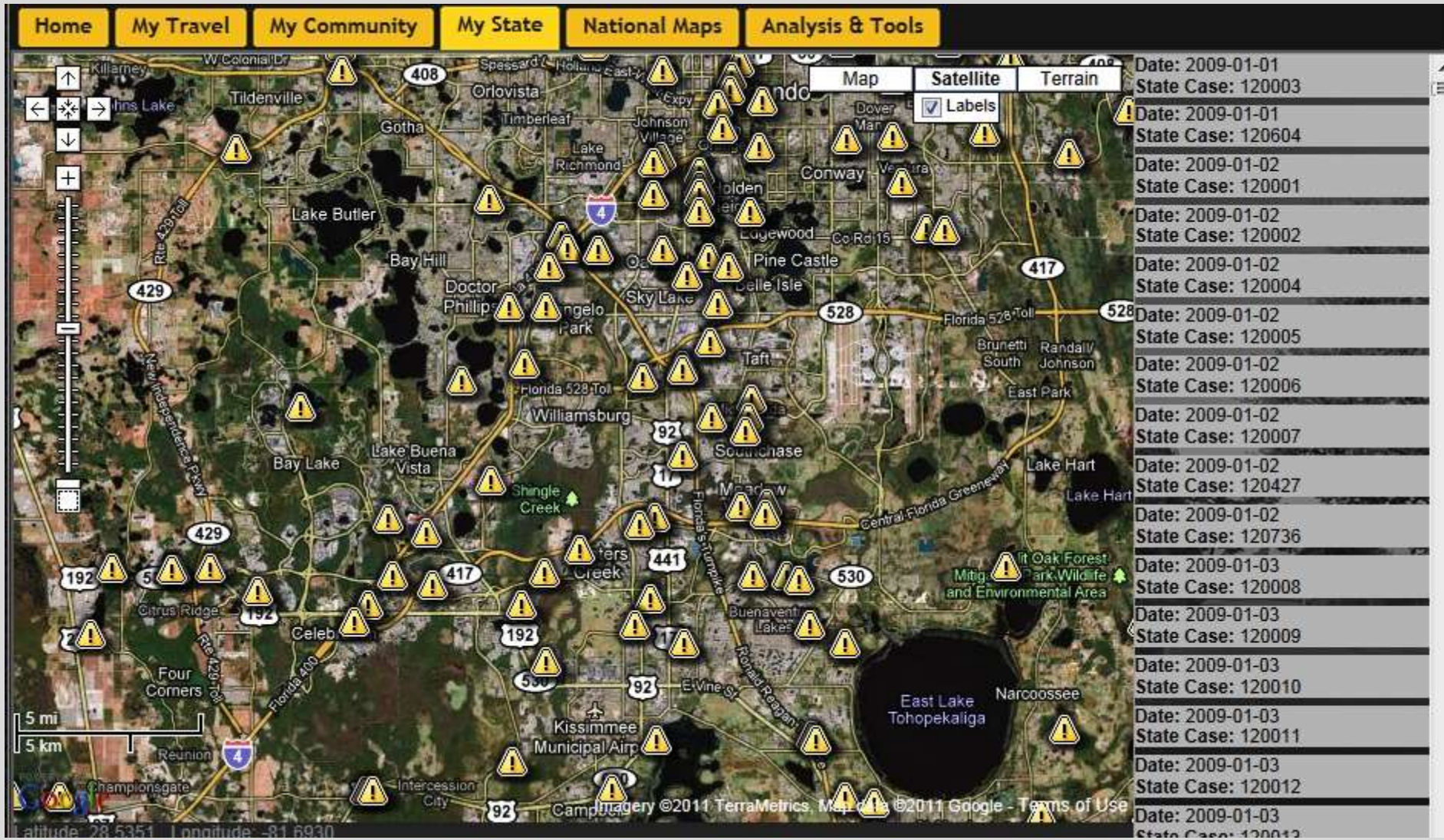
# Corridor Crashes Map



# Road Fatalities GIS Database

## Safe Road Maps

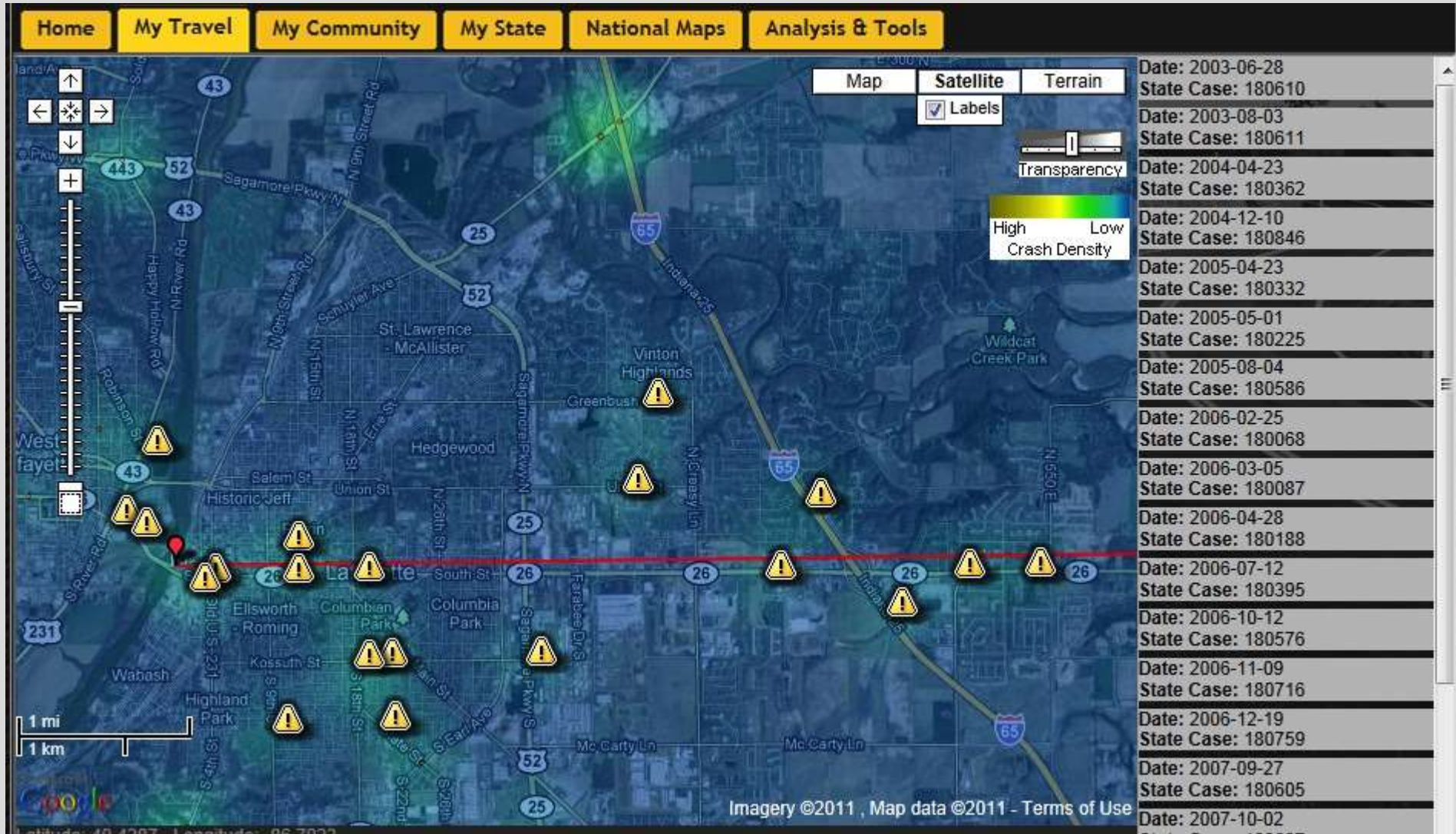
<http://www.saferoadmaps.org/home/>



# Road Fatalities GIS Database

## Safe Road Maps

<http://www.saferoadmaps.org/home/>



# Road Fatalities GIS Database

## Safe Road Maps

<http://www.saferoadmaps.org/home/>

Fatalities	Month	Day	Hour	Minute	Year
1	12	31	15	7	2002

SRM ID	Road Type	Speeding	Drinking	Restraint Type	Person Type	Age	Sex	Deceased
2002_180665	Rural Major Collector	No (Speeding Not Involved)	No (Alcohol Not Involved)	Unknown	Passenger of a Motor Vehicle in Transport	99	Unknown	No
2002_180665	Rural Major Collector	No (Speeding Not Involved)	Yes (Alcohol Involved)	Lap and Shoulder Belt	Driver	51	Male	No
2002_180665	Rural Major Collector	No (Speeding Not Involved)	No (Alcohol Not Involved)	Lap and Shoulder Belt	Passenger of a Motor Vehicle in Transport	8	Female	Yes
2002_180665	Rural Major Collector	No (Speeding Not Involved)	No (Alcohol Not Involved)	Lap and Shoulder Belt	Passenger of a Motor Vehicle in Transport	7	Male	No
2002_180665	Rural Major Collector	No (Speeding Not Involved)	No (Alcohol Not Involved)	None Used	Driver	32	Male	No



1. Crash frequency
2. Crash ratios
3. Prediction of crashes
4. Statistics comparison
  - a) Average
  - b) Distributions
5. Crash critical rate
6. Potential Safety Improvement (PSI)
7. Before/After Studies
8. Crash Reduction Factors (CRF)

## 1. Crash Frequency

- Total crashes in analysis period
- High volume places

$$\% \text{ change} = \frac{C_1 - C_0}{C_0} * 100\%$$

$C_0$  = crashes *before*

$C_1$  = crashes *after*

## 2. Crash Rates

### Intersections

$$CF_{int} = \frac{c * 1,000,000}{ADT * 365}$$

### Segment

$$CF_{seg} = \frac{c * 1,000,000}{ADT * 365 * L}$$

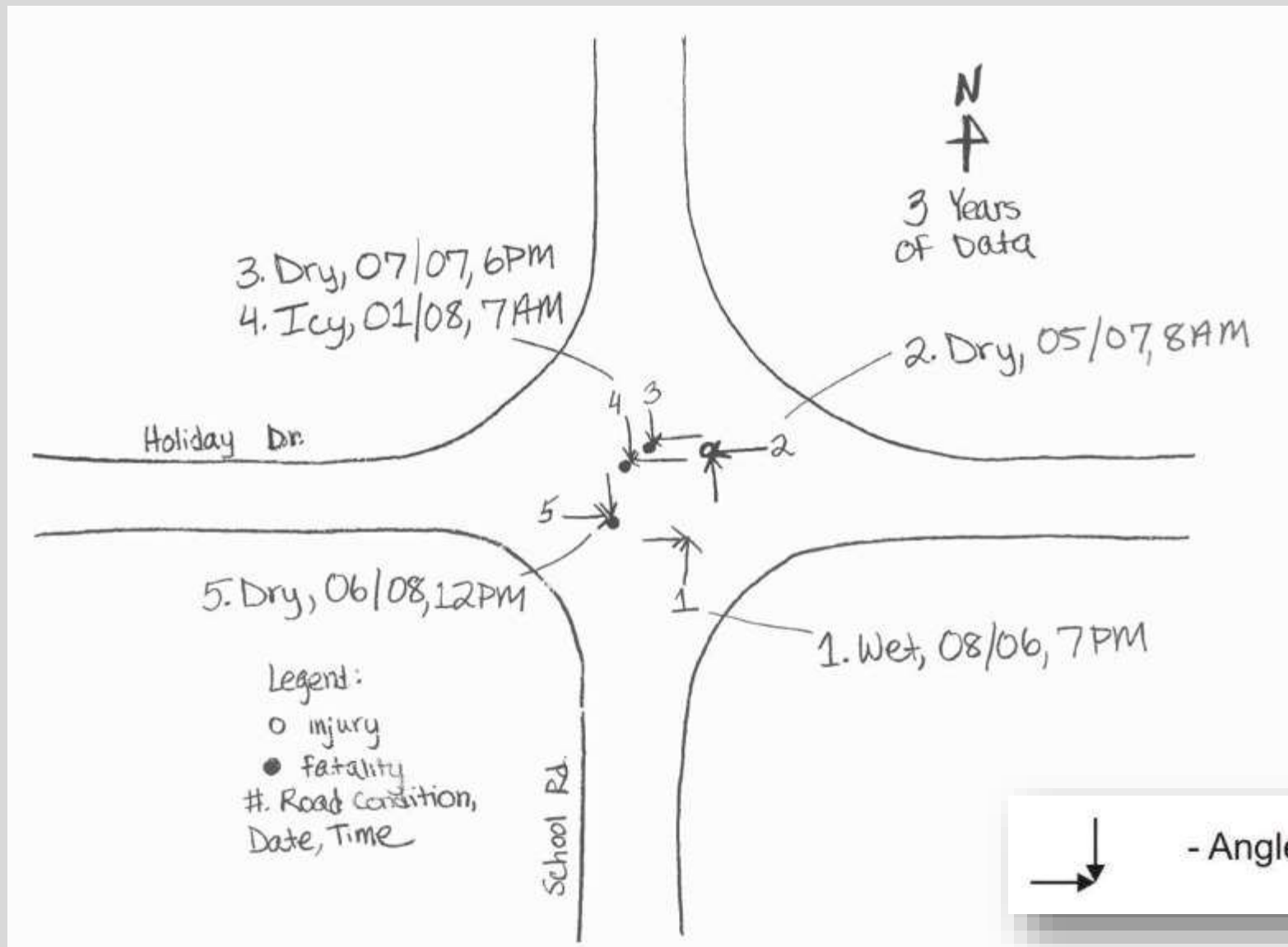
- C = crash total
- ADT = average daily traffic
- L = segment length: *miles*

---

## Crash Rates Exercise












1. In 2008 total of crashes registered in an intersection was 23. Average daily traffic in the intersection is 6,500 vehicles per day. *Calculate crash rate for every 1M vehicles.*
  
2. In a 17.5 miles segment occurred 40 crashes in 2008. The average daily traffic is 5,000 vehicles per day. *Calculate crash rate for every 100M vehicle-miles.*

# Create Collision Diagram



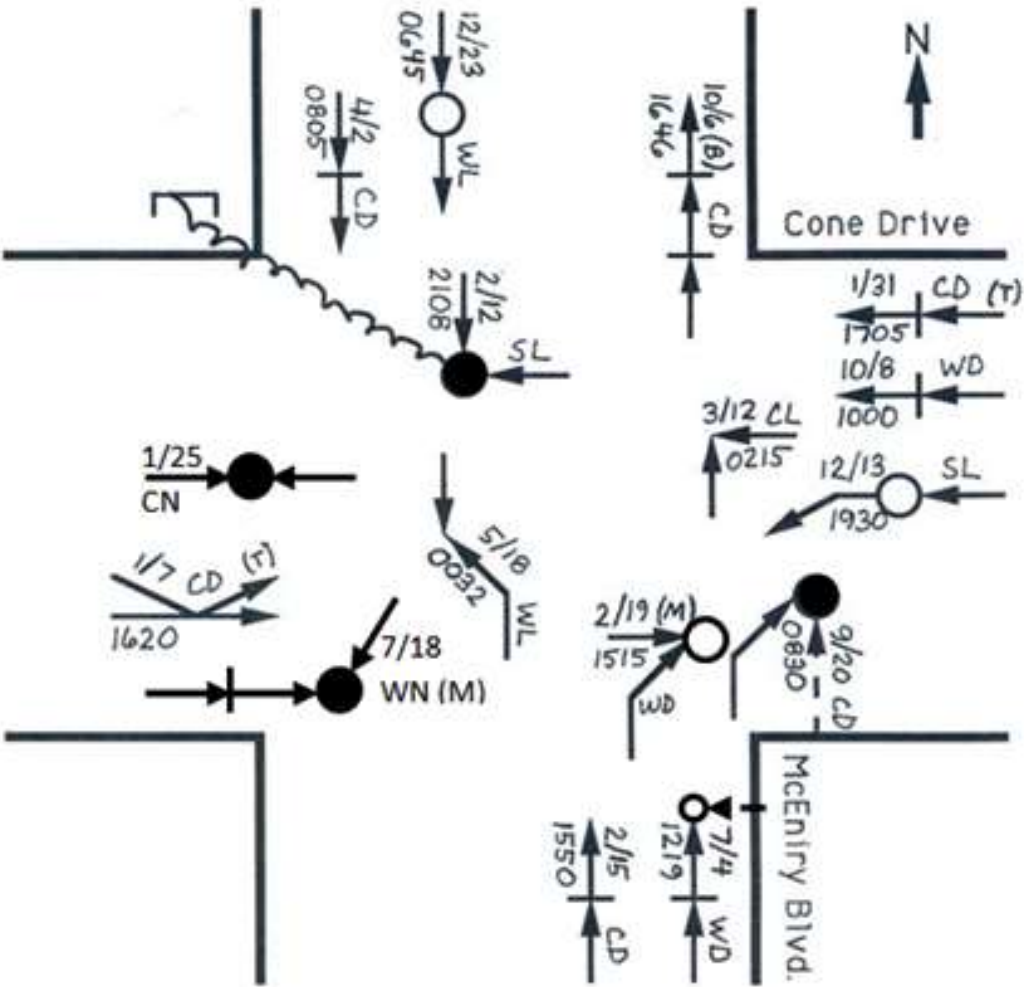
Collision Diagram

# Collision Diagram Symbols

	- Rear-end
	- Head-on
	- Left/Right Rear-end
	- Sideswipe Same Direction
	- Sideswipe Opposite Direction
	- Angle
	- Left-turn Head-on
	- Left/Right Turn
	- Left/Right Crossing
	- Single Vehicle
	- Fixed Object

# Crash Collision Diagrams

1/1/09 – 12/31/09



Key to Collision Diagram Symbols	
<u>Vehicle Type</u>	
→	Automobile
(T) →	Truck
(B) →	Bus
(M) →	Motorcycle
(O) →	Other
- - - →	Pedestrian
- - - - -	Uninvolved
<u>Vehicle Movement</u>	
↙	Left
↘	Right
→	Straight
←←←	Backing
<u>Severity</u>	
→+→	PDO
→○→	Injury
→●→	Fatal
<u>Accident Type</u>	
→+→	Rear-End
→+←	Head-On
↙↘	Angle
↘↘	Sideswipe, Same Direction
↘↙	Sideswipe, Opposite Direction
~~~~~	Out of Control
→+	Collision with Fixed Object
<u>Road Surface</u>	
C	Dry, Clear
W	Wet
S	Snowy, Icy
O	Other
<u>Lighting</u>	
D	Daylight
N	Dark, No Lights
L	Dark with Street Lights

ADT Cone Drive = 8,900 vehículos / día  
 ADT McEntry Blv = 12,750 vehículos día

# Crash Collision Diagrams

---

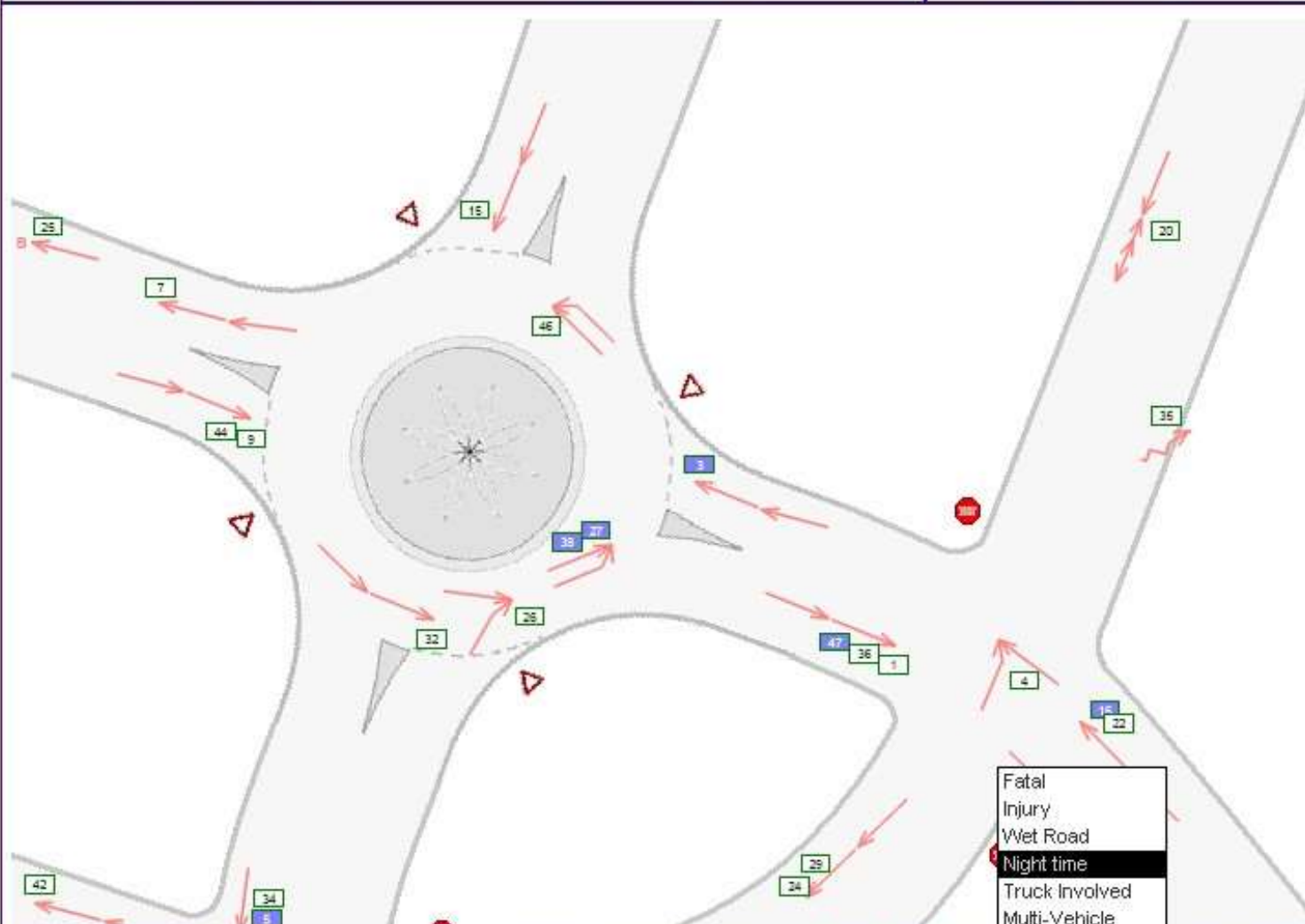
- A. Indicate the total of motor vehicles involved in crashes for the intersection in 2009.
  
- B. Indicate how many collisions occurred during the night for the intersection in 2009.
  
- C. Calculate crash rates for every 1M vehicles for fatal crashes for the intersection in 2009.

# COLLISION DIAGRAM

Key Number = 4

MUNICIPALITY: LAKEVILLE COUNTY: CLEARFIELD  
INTERSECTION: ROUTE 100  
PERIOD: 3 YEARS 0 MONTHS FROM 1/1/1995 TO 12/31/1997

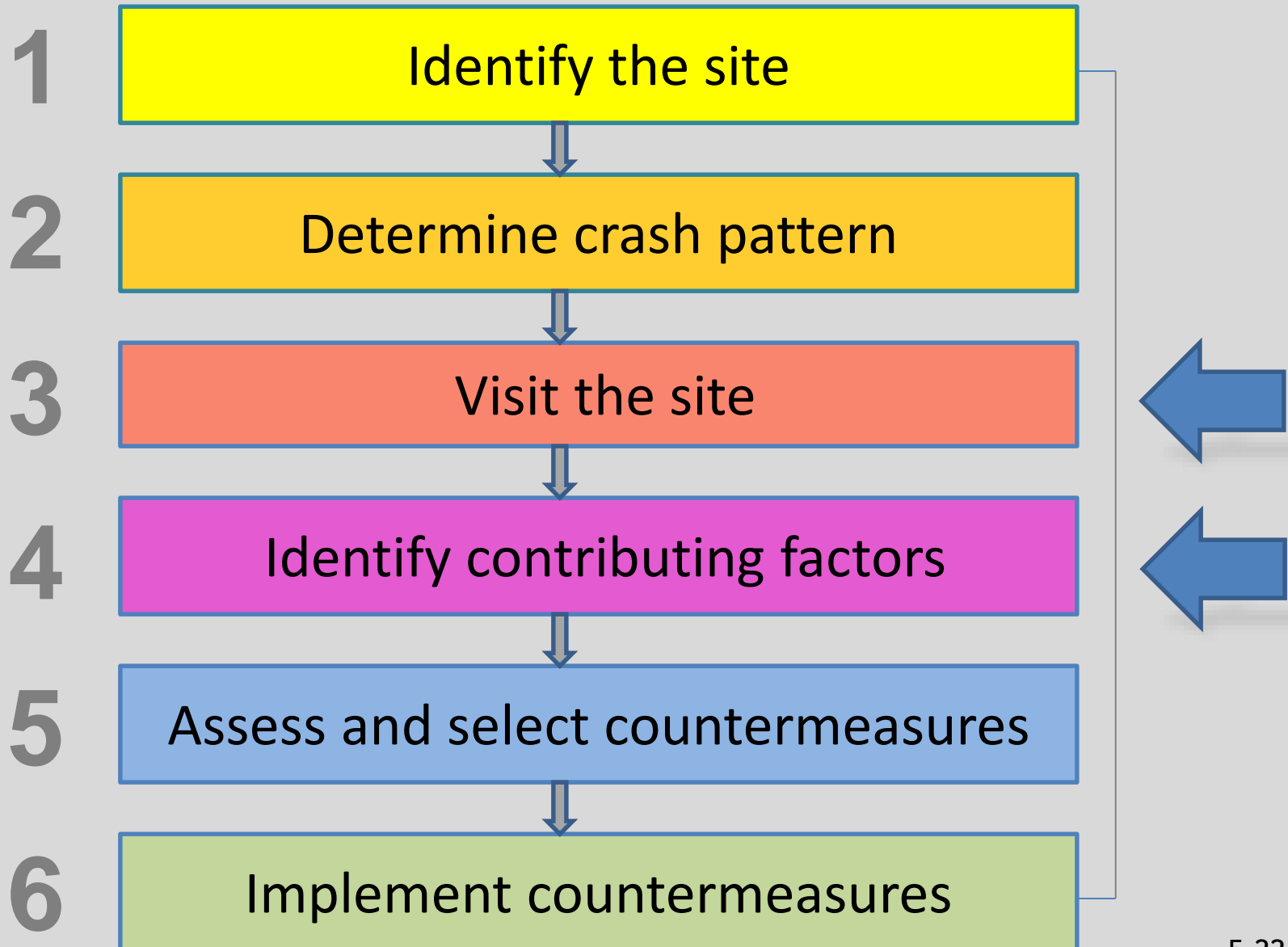
FILE: 101Test  
CASE #: 11-1111111  
BY: DBS DATE: 9/4/2005



Done Copy Total [Navigation icons] [Zoom icons] Night time [Traffic light icon] [Stop sign icon] [Yield sign icon]

# Steps in Crash Reduction Process

---



# Visit the site

---

- Observe traffic under conditions of interest
- Gather basic traffic data (volumes and speeds)



# Road Safety Audit/Assessment (RSA)

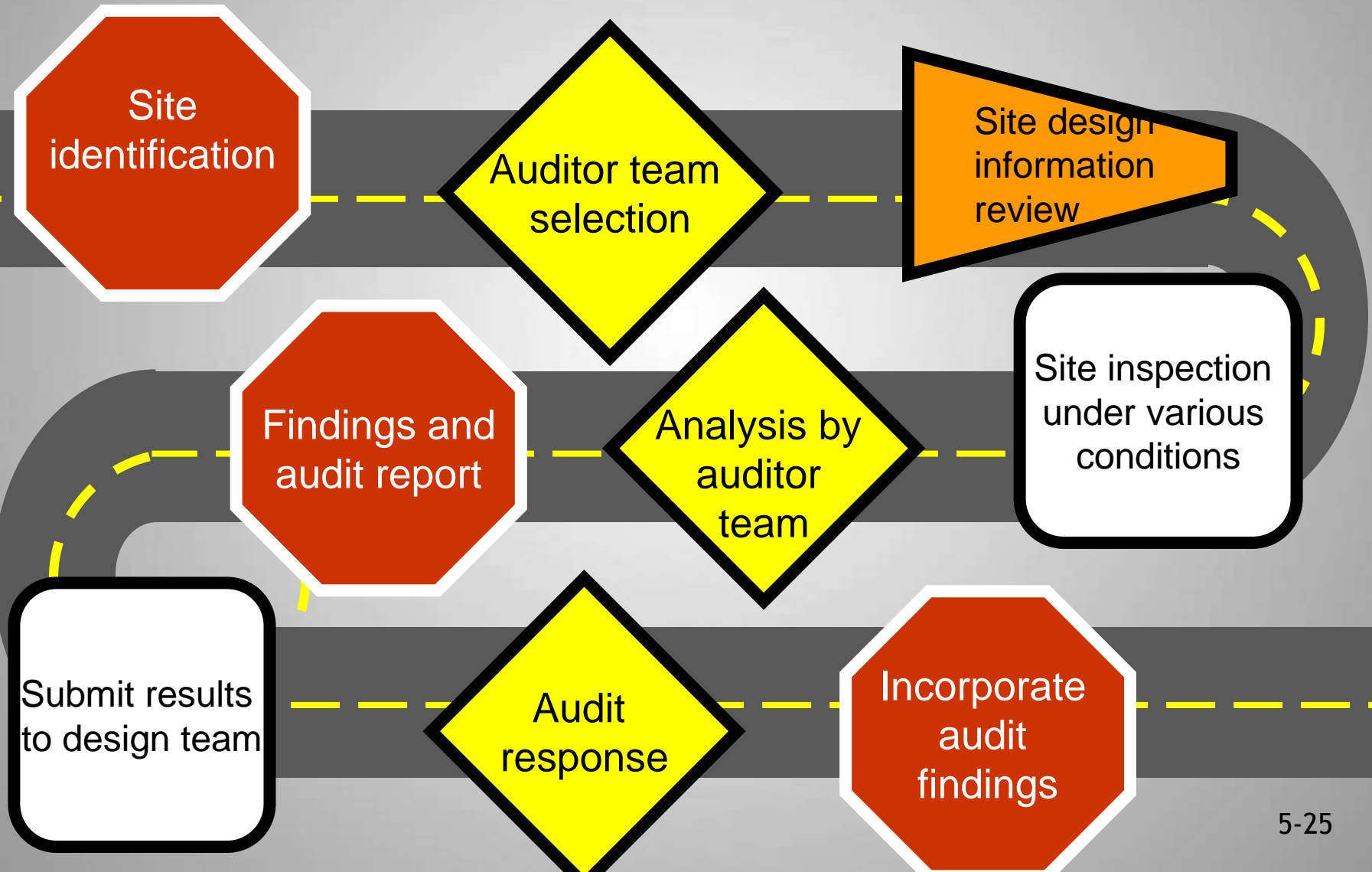
RSA = formal safety performance examination of an existing or future road by an independent audit team.



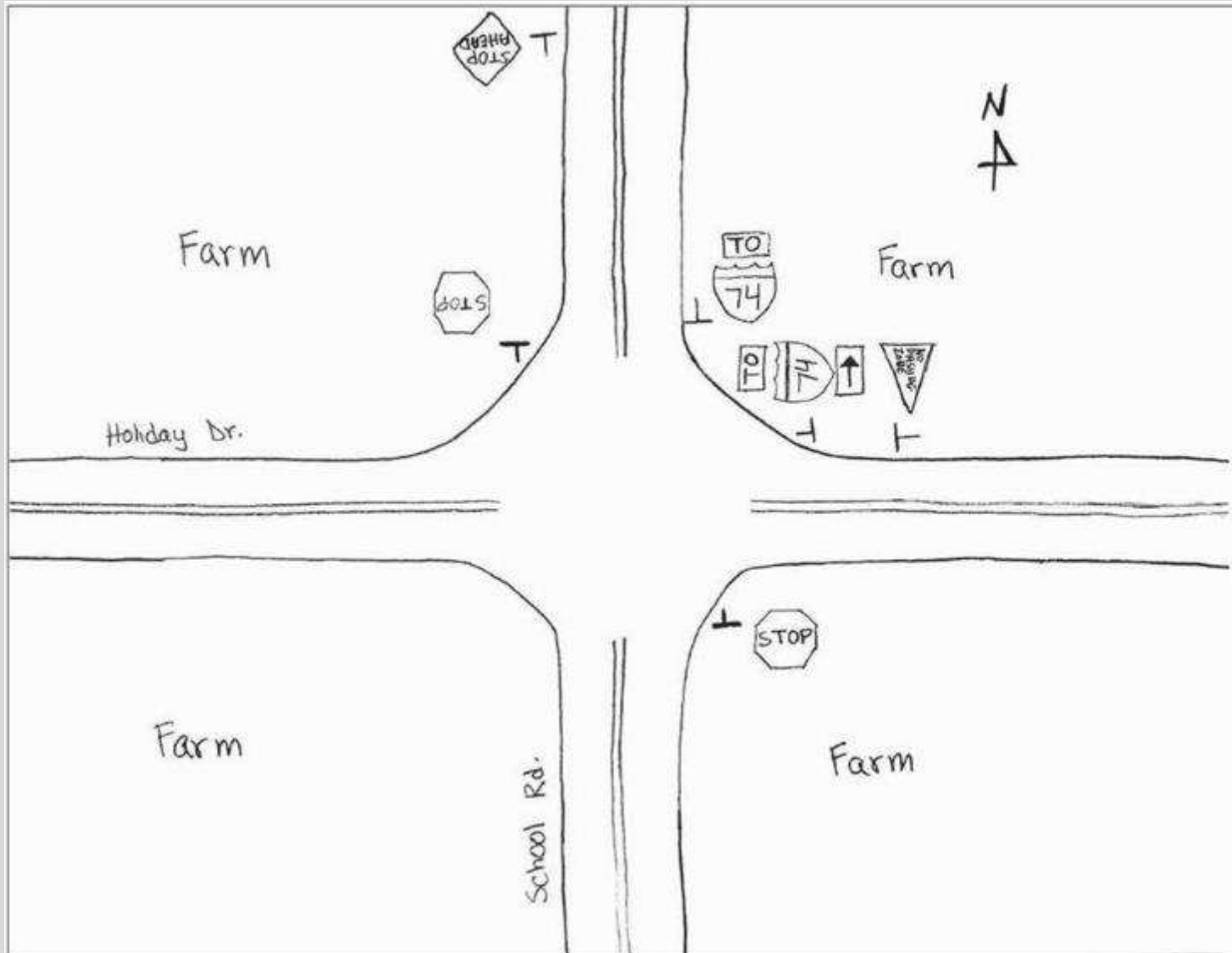
“RSAs are a proven way to review just how safe our local roads are and can be a valuable tool for local government road professionals in making their roads safer.”

Tony Giancola  
Executive Director, NACE

# General Process for Road Audits

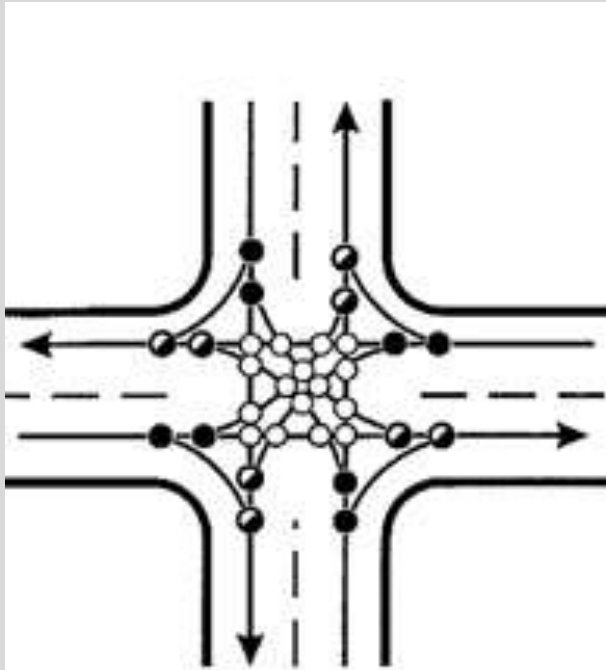


# Prepare a Condition Diagram

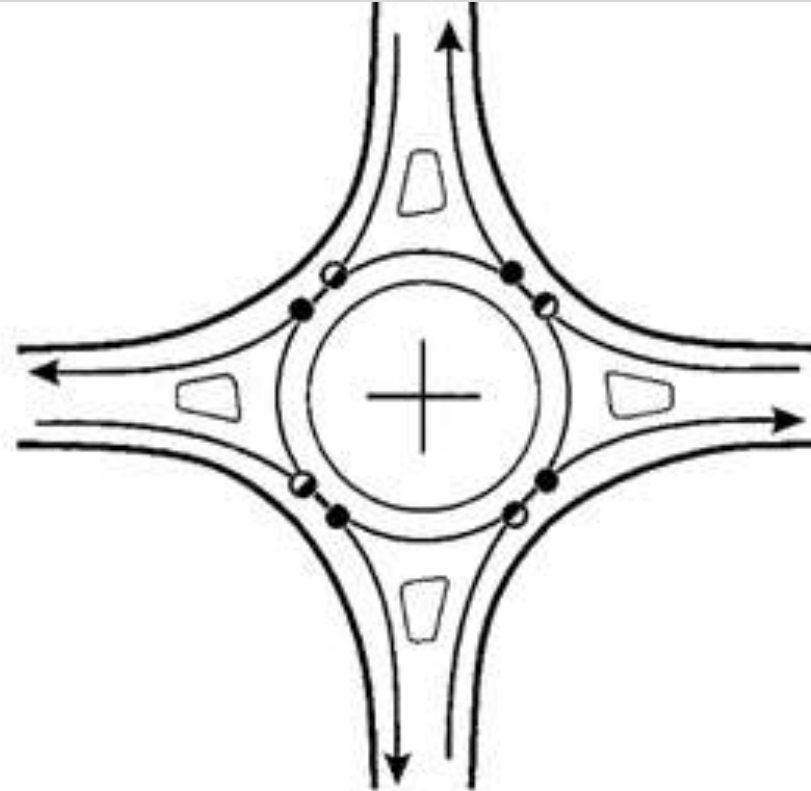


Condition Diagram

# Intersection Conflicts



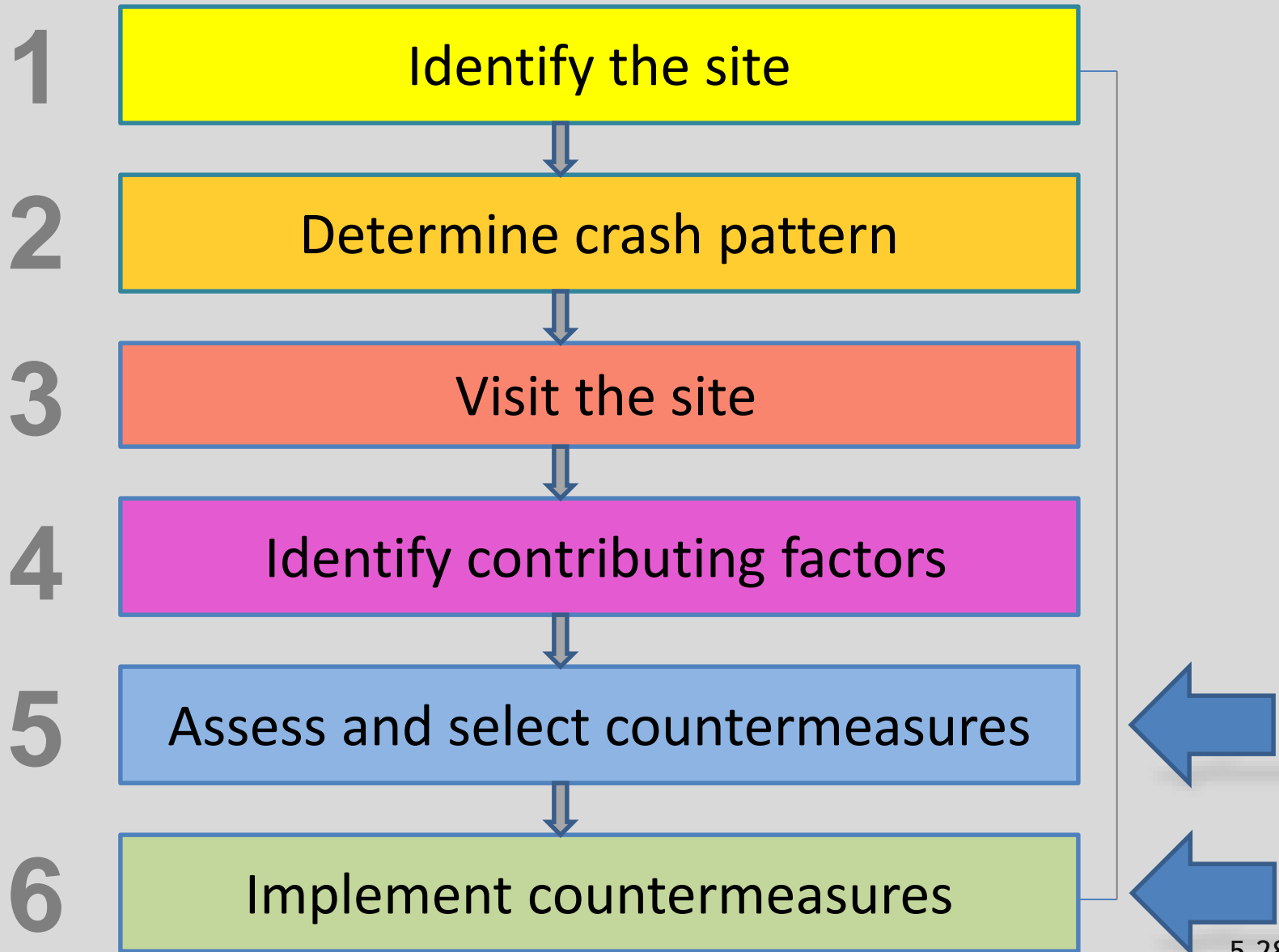
●	Diverging	8
◐	Merging	8
○	Crossing	16
		<hr/>
		32



●	Diverging	4
◐	Merging	4
○	Crossing	0
		<hr/>
		8

# Steps in Crash Reduction Process

---



# FHWA Proven Safety Countermeasures

---



Roundabouts



Corridor Access Management



Backplates with Retroreflective Borders



Longitudinal Rumble Strips and Stripes on Two-Lane Roads



Enhanced Delineation and Friction for Horizontal Curves



Safety Edges<sub>SM</sub>



Medians and Pedestrian Crossing Islands in Urban and Suburban Areas



Pedestrian Hybrid Beacon



Road Diet

<http://safety.fhwa.dot.gov/provencountermeasures/>

# Countermeasures to Consider

---

- Edgelines and delineation
- Rumble strips



<http://safety.fhwa.dot.gov/policy/memo071008/>

# Countermeasures to Consider

---

- Barrier/guardrail



# Countermeasures to Consider

---

- Safety Edges



Source: FHWA

<http://safety.fhwa.dot.gov/policy/memo071008/>

# Countermeasures to Consider

---

- Left-turn lanes



# Countermeasures to Consider

---

- Sidewalks
- Walkways



# Countermeasures to Consider

---

## Pedestrian Refuges



# Countermeasures to Consider

---

## Maintenance Strategies

- Patching Potholes
- Cleaning Drainage Structures
- Blading Ditches
- Trimming Vegetation



# Selection of Countermeasures

A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. The Crash Modification Factors Clearinghouse houses a Web-based database of CMFs along with supporting documentation to help transportation engineers identify the most appropriate countermeasure for their safety needs. Using this site, you can [search](#) to find CMFs or [submit](#) your own CMFs to be included in the clearinghouse.

[Improve pavement friction \(increase skid resistance\)](#)

CMF: 0.866

CRF: 13.4

Crash type: Rear end

Crash severity: All

[Install shoulder rumble strips](#)

CMF: 0.74

CRF: 26.1

Crash type: Run off road

Crash severity: All

[Install median on the minor approach of an unsignalized 3-leg intersection](#)

CMF: 0.82

CRF: 18

Crash type: All

Crash severity: All

# Example of CMF for Intersection Control

- Countermeasure: Conversion of stop-controlled intersection into single-lane roundabout

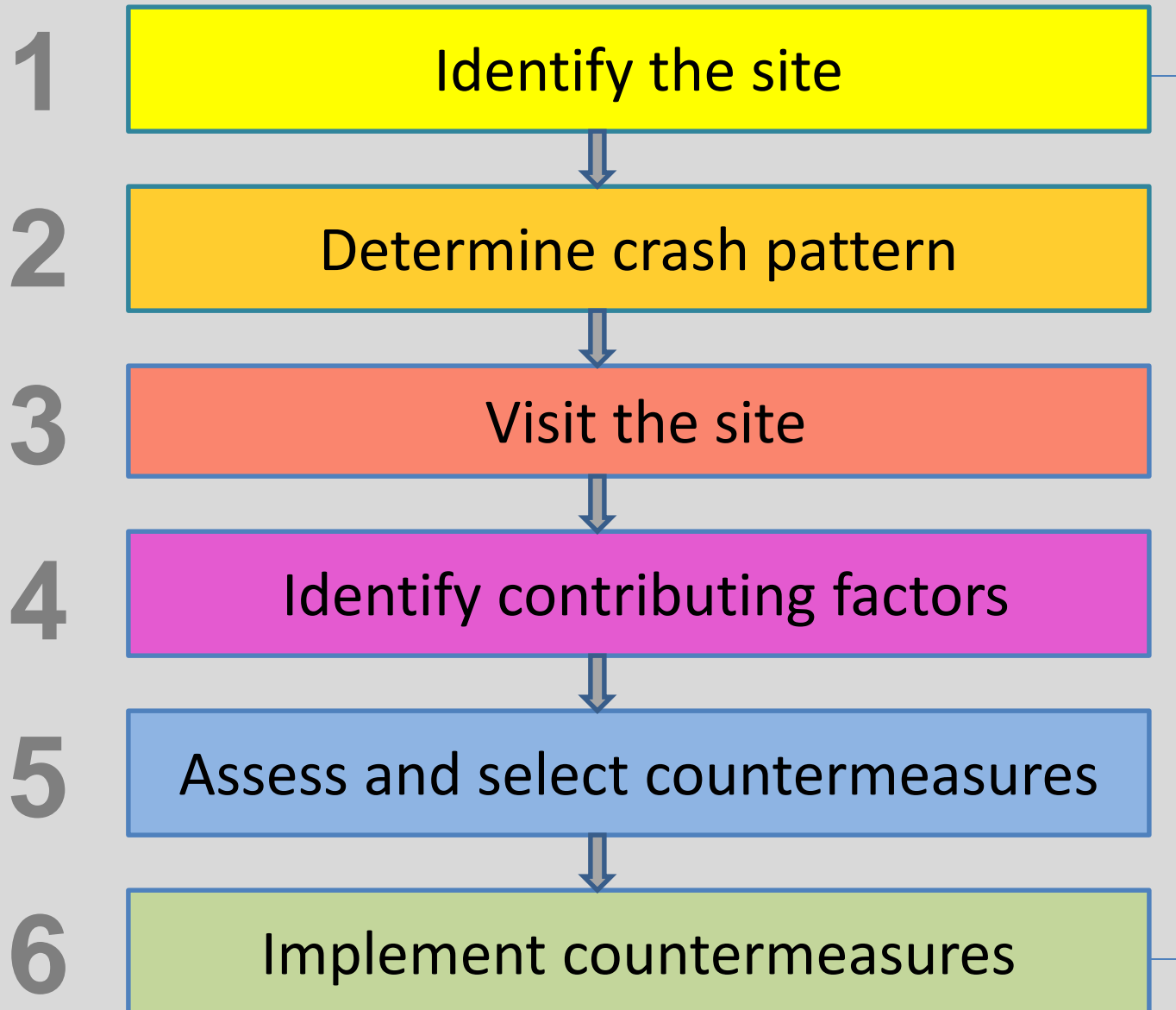
CMF	CRF(%)	Quality	Crash Type	Crash Severity	Roadway Type	Area Type	Reference
0.28	72	★★★★☆	All	All	Not specified	Urban	Persaud et al., 2001
0.42	58	★★★★☆	All	All	Not specified	Rural	Persaud et al., 2001
0.12	88	★★★★☆	All	Serious injury, Minor injury	Not specified	Urban	Persaud et al., 2001
0.18	82	★★★★☆	All	Serious injury, Minor injury	Not specified	Rural	Persaud et al., 2001



<http://www.highwaysafetymanual.org/Pages/default.aspx>

# Steps in Crash Reduction Process

---





# Steps in Crash Reduction Process

3

Visit the site



4

Identify contributing factors



Gather data



Create condition diagram

# Steps in Crash Reduction Process

5

Assess and select countermeasures



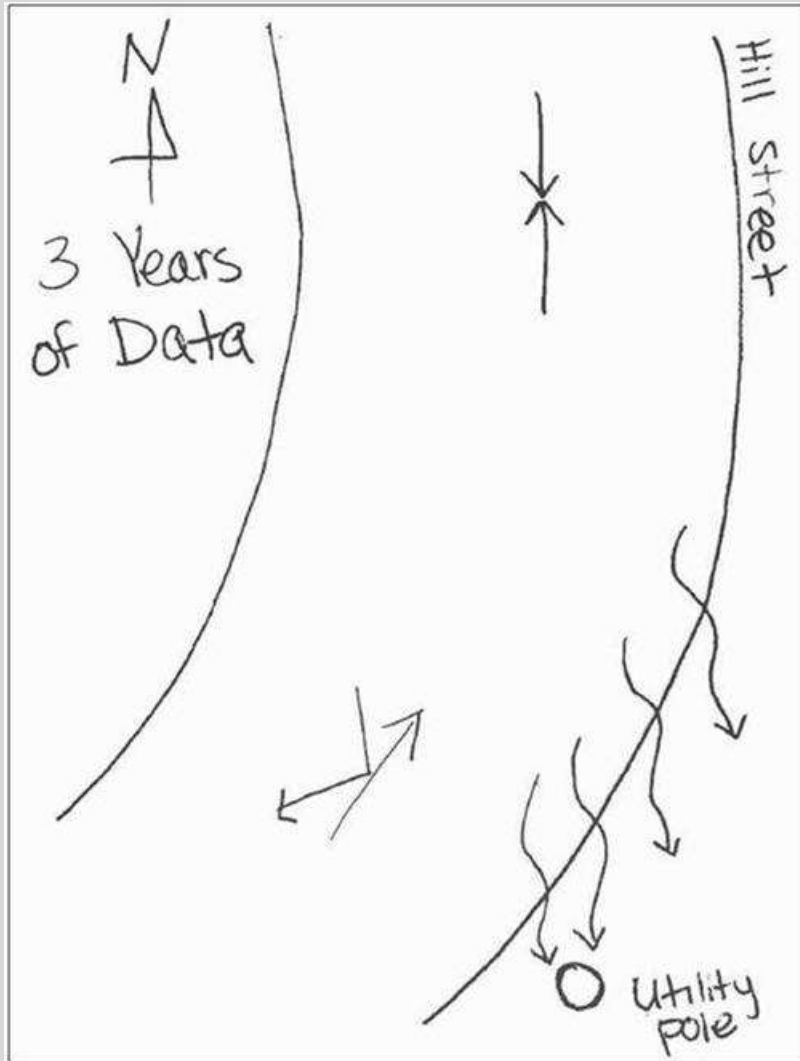
6

Implement countermeasures



Consider and implement countermeasures

# Example 1 - Identify Site & Obtain Crash Data



## 3 Years Crash Data

- 4 Run-off-road
  - 1 overturned
  - 1 went into creek
  - 2 struck utility pole
- 1 Sideswipe Opposite
- 1 Head-on

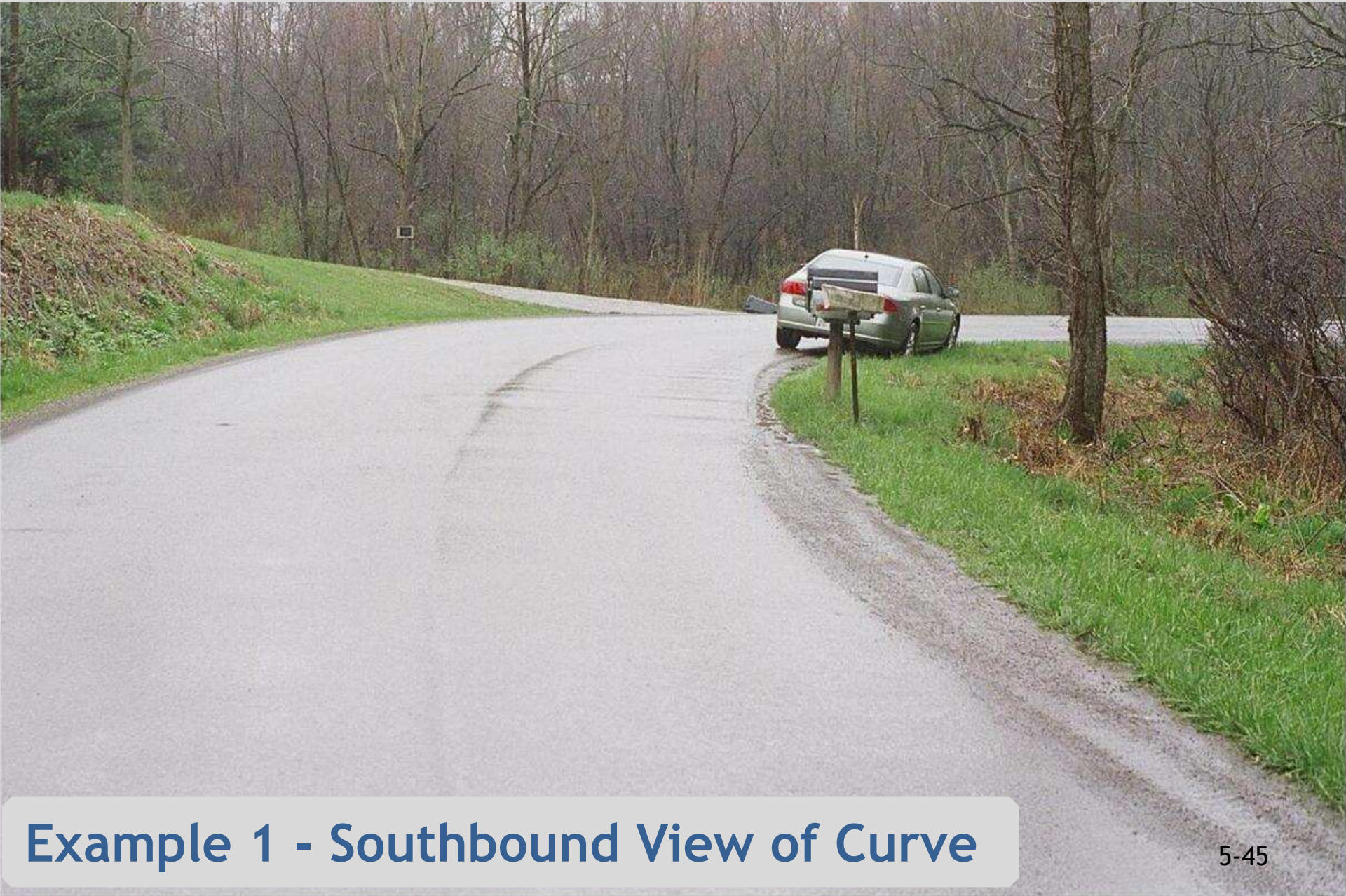
Collision Diagram

# Visit the Site & Identify Contributing Factors



**Example 1-Southbound View from Upstream of Curve**

# Visit the Site & Identify Contributing Factors



**Example 1 - Southbound View of Curve**

# Visit the Site & Identify Contributing Factors



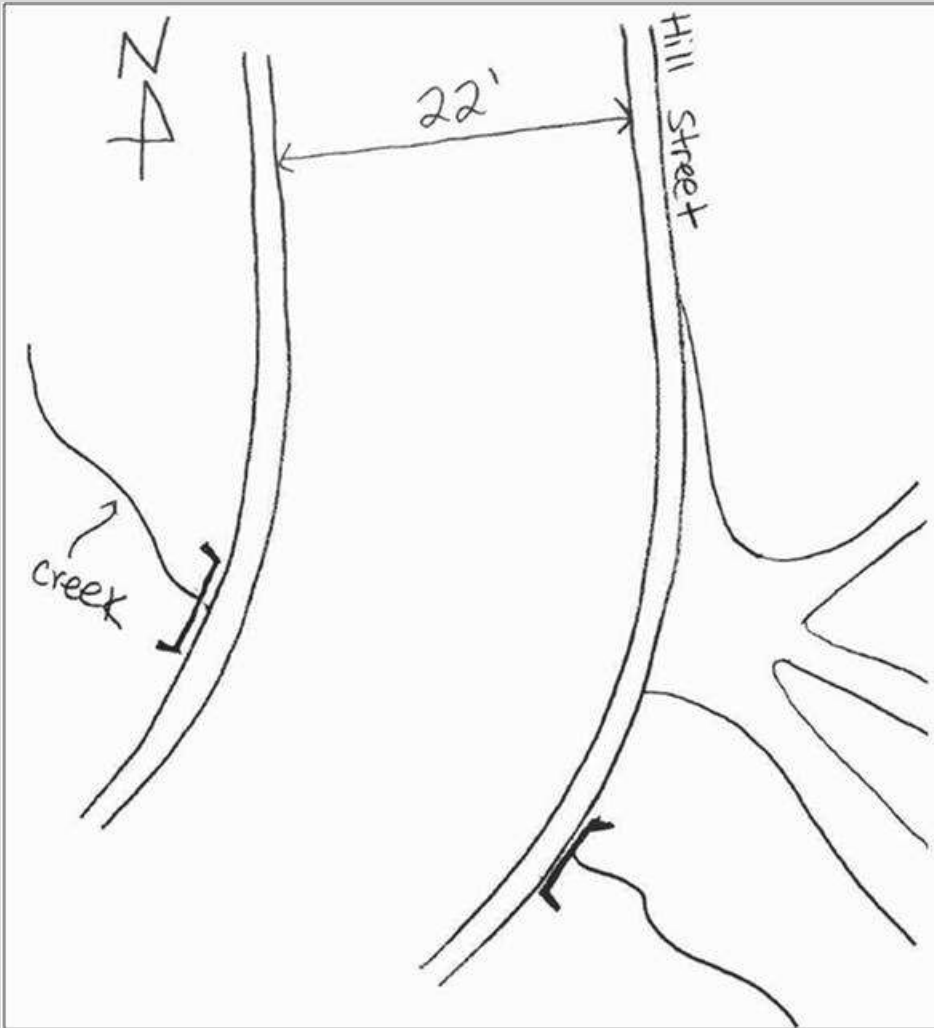
**Example 1 - Northbound View of Curve**

# Visit the Site & Identify Contributing Factors



**Example 1 - Evidence of Vehicle Running Off Road on Outside of Curve**

# Example 1 - Create Condition Diagram



- Posted Speed Limit = 35 mph
- Turf Shoulders of Variable Width
- 6 % Superelevation
- Radius = 110'

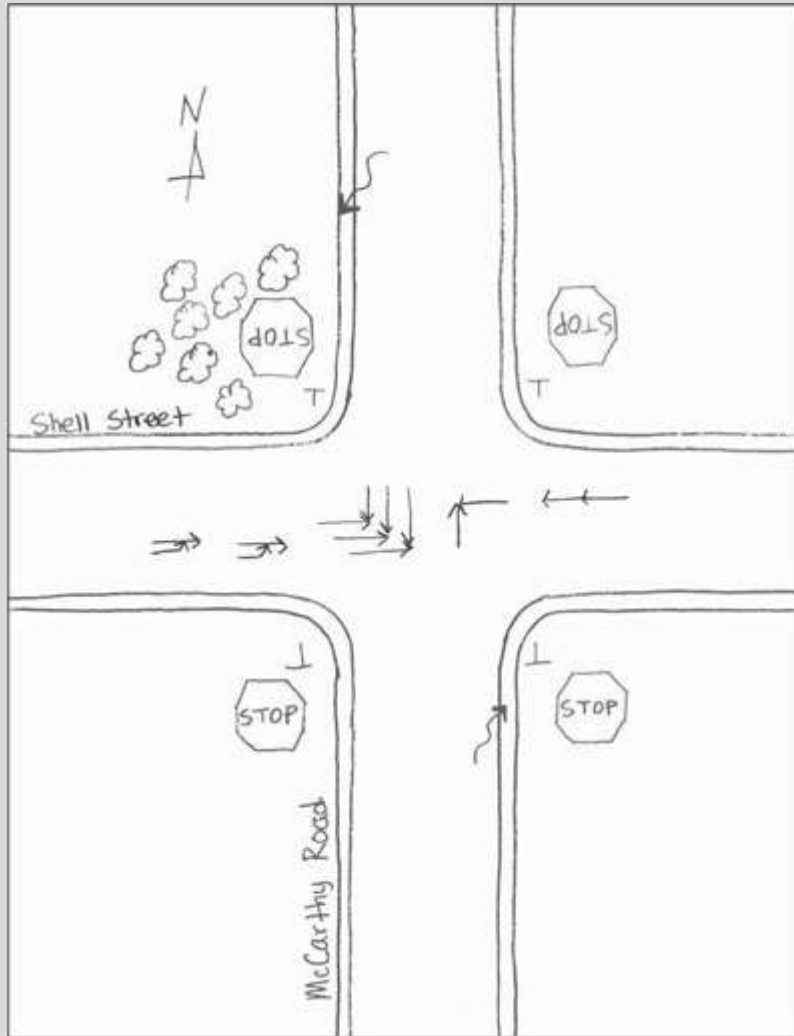
Condition Diagram

# Example 1 - Discussion

---

- What type of crash patterns do you see?
- What are the contributing factors
- What would be appropriate countermeasures?

# Example 2 - Identify Site & Obtain Crash Data



Collision Diagram

## 3 Years of Crash Data

- 4 Angle
- 2 overtaking left
- 2 run-off-road
- 1 Rear-end

# Visit the Site & Identify Contributing Factors



Example 2 - Northbound View

# Visit the Site & Identify Contributing Factors



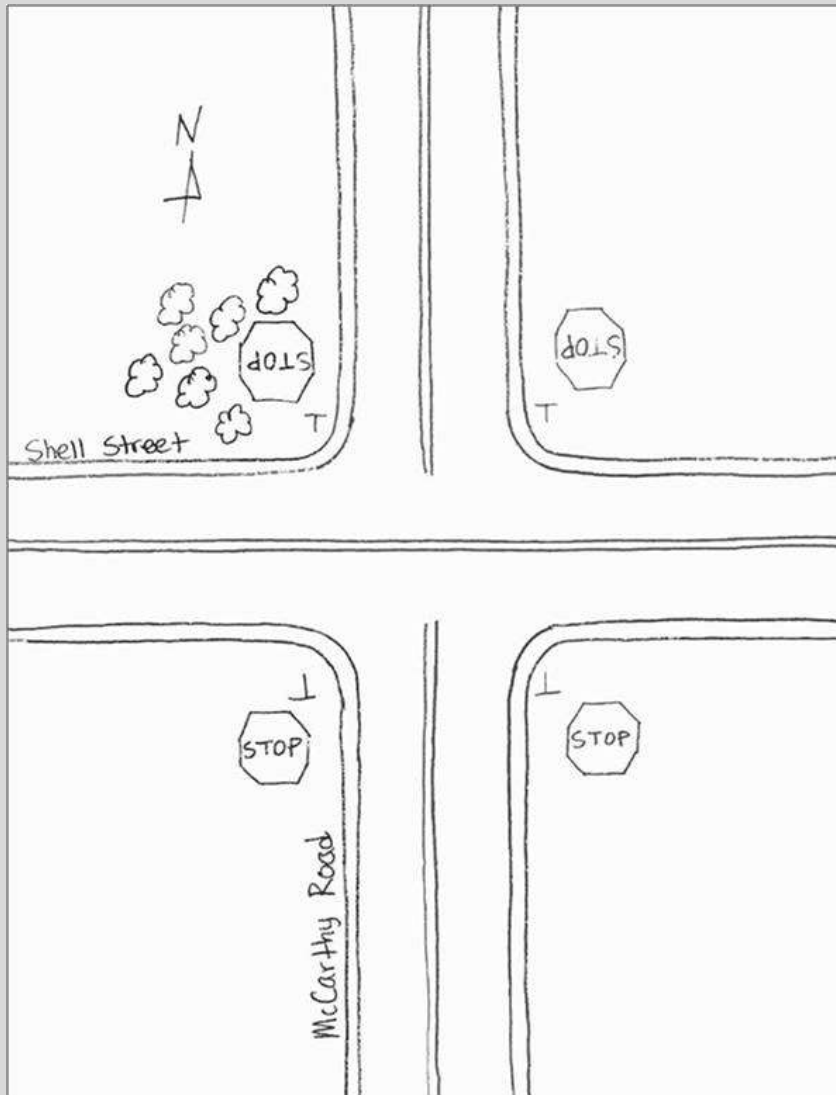
**Example 2 - Northbound View**

# Visit the Site & Identify Contributing Factors



**Example 2 - Eastbound Approach**

# Example 2 - Create Condition Diagram



- Two-way STOP control
- Posted Speed Limit = 55 mph on both roads
- Gravel Shoulders of Variable Width

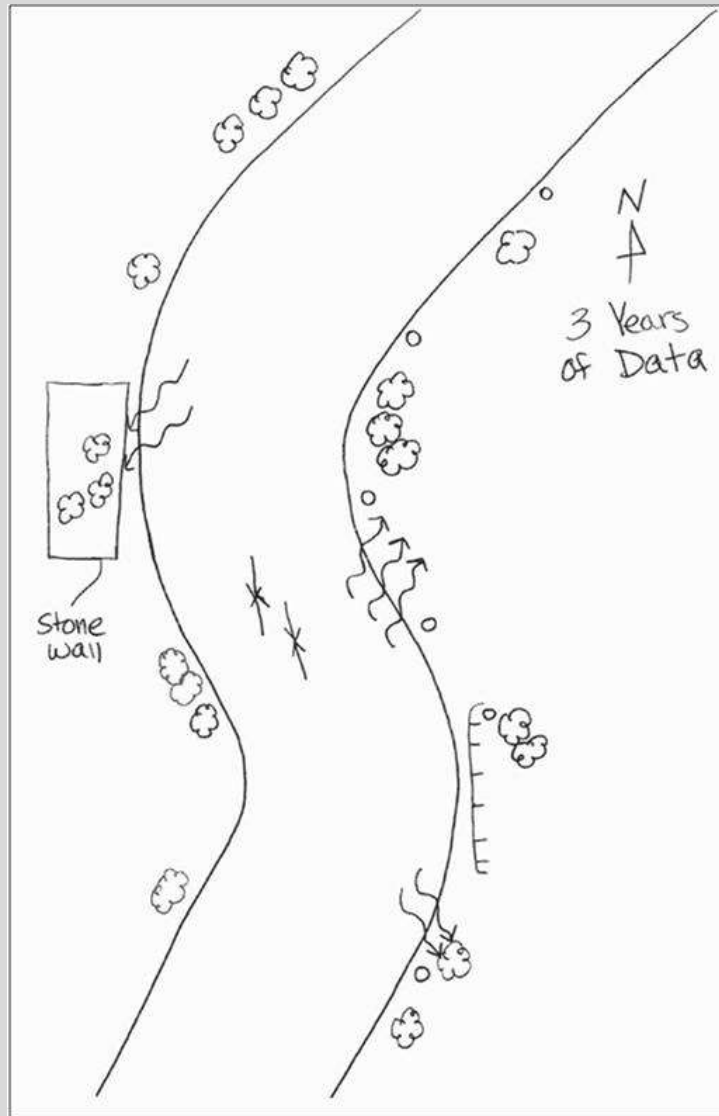
Condition Diagram

## Example 2 - Discussion

---

- What type of crash patterns do you see?
- What are the contributing factors
- What would be appropriate countermeasures?

# Example 3 - Identify Site & Obtain Crash Data



Collision Diagram

## 3 Years of Crash Data

- 7 Run-off-road
  - 3 overturned
  - 2 struck stone wall
  - 2 struck a tree
- 2 Head-on

# Visit the Site & Identify Contributing Factors



**Example 3 - Two-Lane Segment**

# Visit the Site & Identify Contributing Factors

---

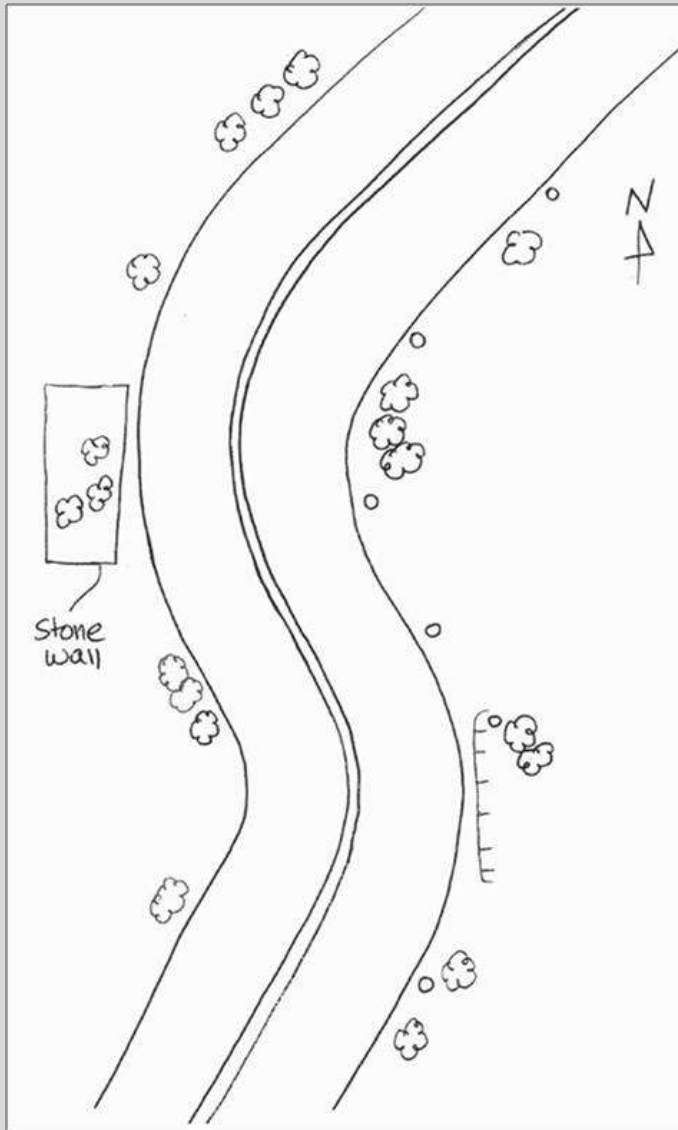


## Example 3 - Roadside Safety Issues

# Example 3 - Maintenance



# Example 3 - Create Condition Diagram



- Posted Speed Limit = 45 mph
- Gravel Shoulders of Variable Width
- Steep Sideslopes
- Many Horizontal curves

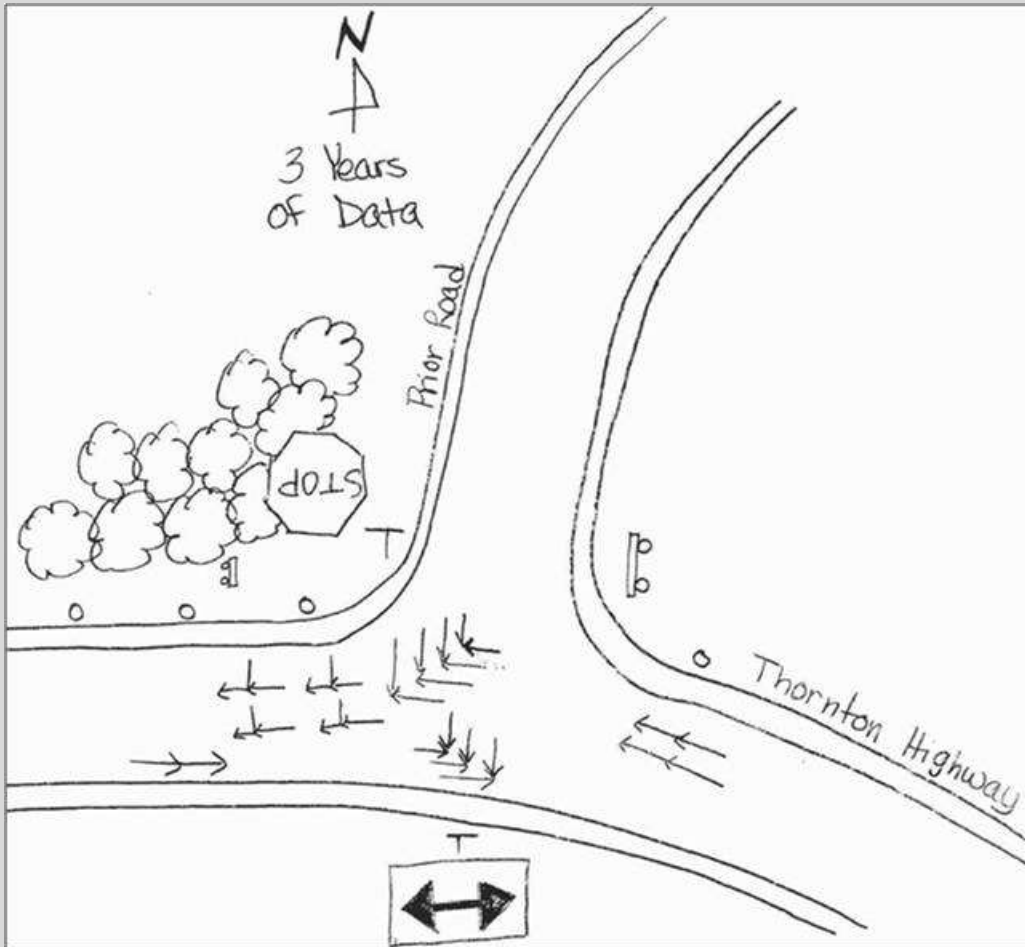
Condition Diagram

## Example 3 - Discussion

---

- What type of crash patterns do you see?
- What are the contributing factors
- What would be appropriate countermeasures?

# Example 4 - Identify Site & Obtain Data



Collision Diagram

## 3 Years of Crash Data

- 7 Angle
- 4 Right-turn Crossing
- 3 Rear-end

# Visit the Site & Identify Contributing Factors



**Example 4 - Southbound Approach**

# Visit the Site & Identify Contributing Factors



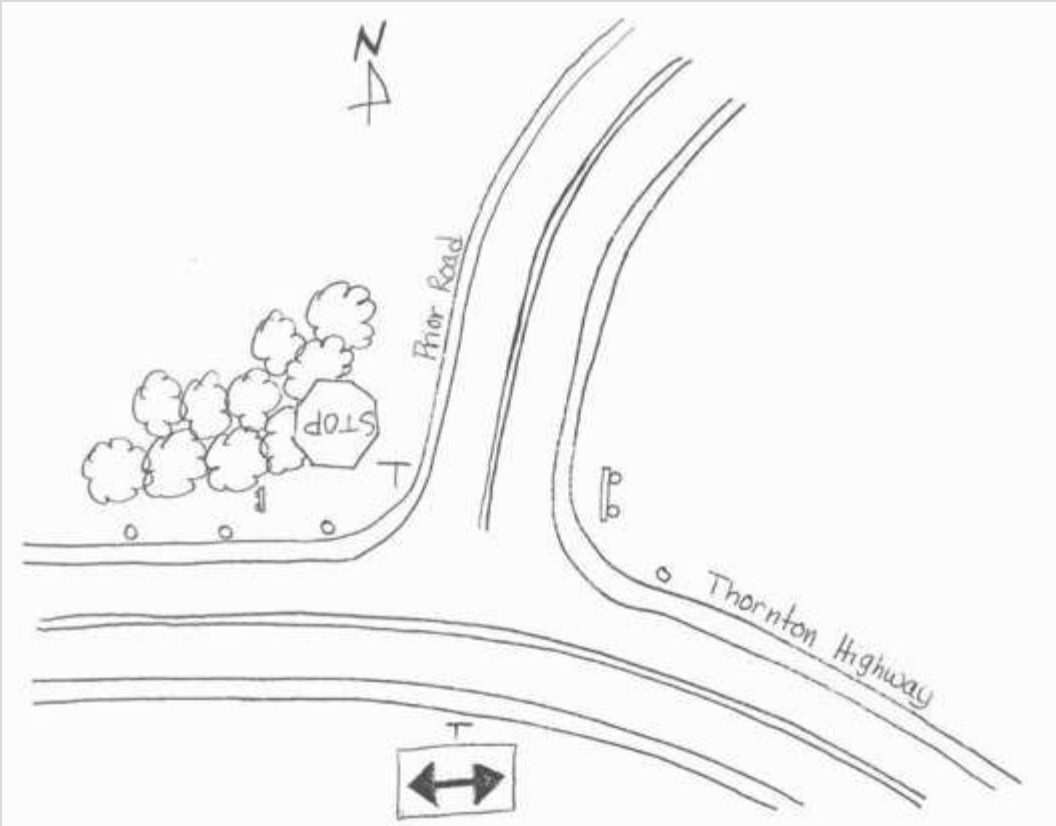
**Example 4 - Looking Westbound**

# Visit the Site & Identify Contributing Factors



Example 4 - Looking Eastbound

# Example 4 - Create a Condition Diagram



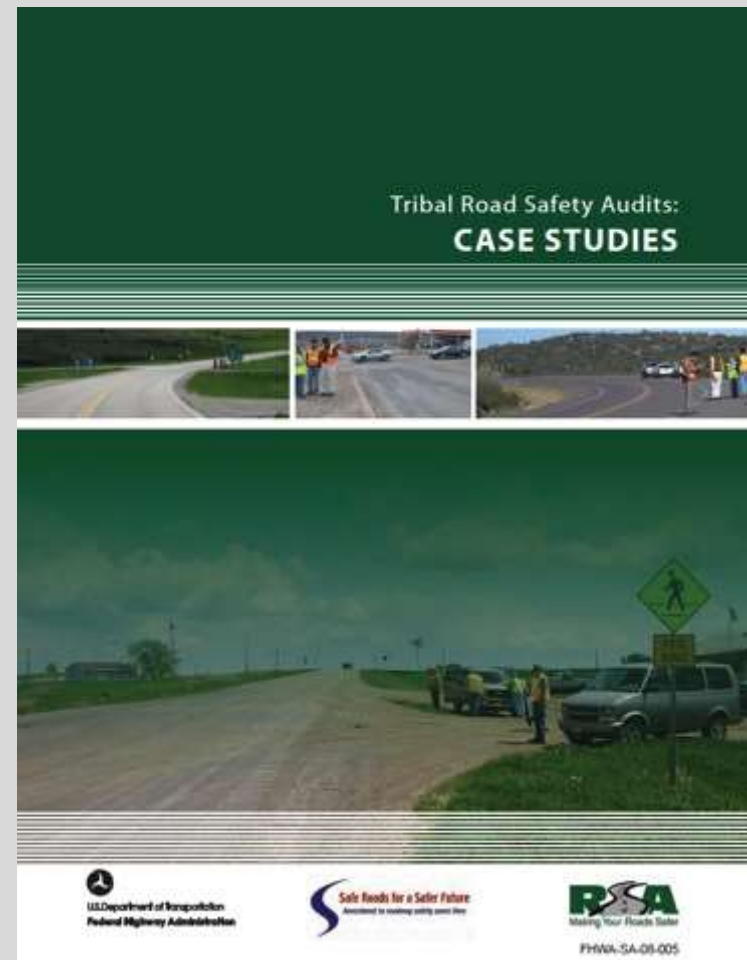
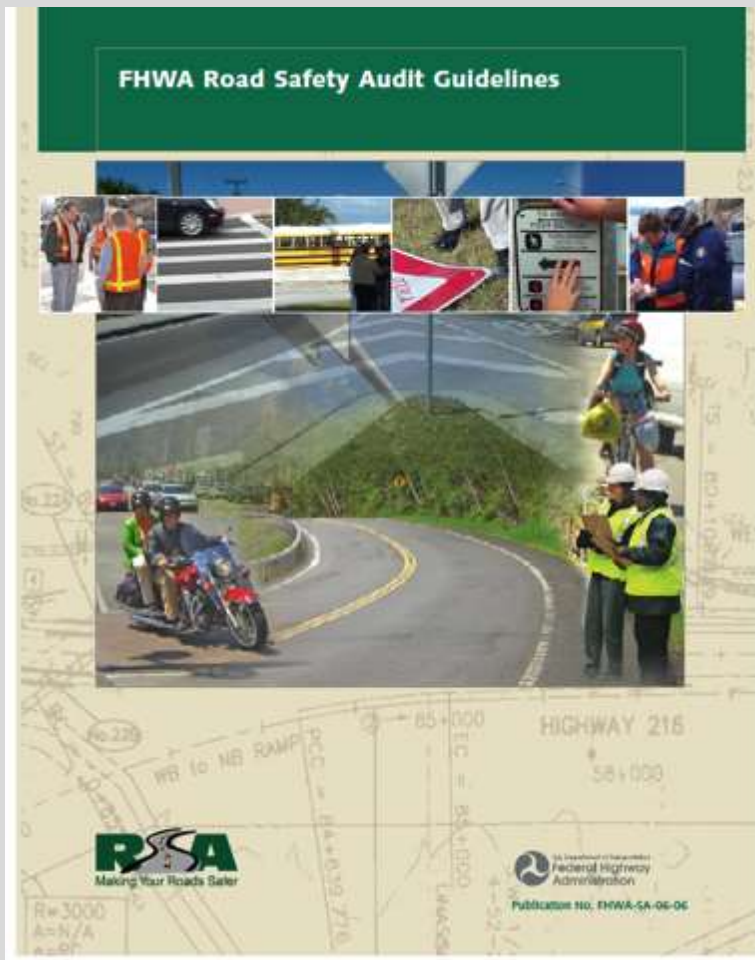
Condition Diagram

- T-intersection
- Posted Speed Limit = 55 mph on both roads
- 4' Paved shoulders on Thornton Hwy
- Gravel Shoulders of Variable Width on Prior Rd.

## Example 4 - Discussion

---

- What type of crash patterns do you see?
- What are the contributing factors
- What would be appropriate countermeasures?



[http://safety.fhwa.dot.gov/rsa/guidelines/documents/FHWA\\_SA\\_06\\_06.pdf](http://safety.fhwa.dot.gov/rsa/guidelines/documents/FHWA_SA_06_06.pdf)

[http://safety.fhwa.dot.gov/rsa/tribal\\_rsa\\_studies/tribal\\_rsa\\_studies.pdf](http://safety.fhwa.dot.gov/rsa/tribal_rsa_studies/tribal_rsa_studies.pdf)

U.S. Department of Transportation  
Federal Highway Administration

FHWA Home | Feedback

Home | About | Staff Directory | Events | Newsletters | Contact

Search FHWA Safety

**Highway Safety Improvement Program (HSIP)**  
**Intersection Safety**  
**Local & Rural Road Safety**  
**Pedestrian & Bicycle Safety**  
**Roadway Departure Safety**  
**Speed Management Safety**  
**Additional Safety Programs & Initiatives**  
**9 Proven Crash Countermeasures**  
**Crash Tested Hardware**  
**Facts & Statistics**  
**Geometric Design**  
**Highway Safety Manual**  
**Manual on Uniform Traffic Control Devices (MUTCD)**  
**Motorcycles**  
**Newsletters**  
**Older Road Users**  
**Peer-to-Peer Program**  
**Policy & Guidelines**  
**Railway/Highway Grade Crossings**  
**Road Safety Audits (RSA)**  
**Safe Routes to School**  
**SAFETEA-LU**  
**Safety Research**  
**Section 402 Highway Safety Funds**  
**Training & Education**

**Road Safety Audits (RSA)**

Home | Benefits | Legal Issues | Steps to Conduct | Training | Resources | Contacts

### Executive Summary

A Road Safety Audit (RSA) is the formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary team. It qualitatively estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users. The FHWA works with State and local jurisdictions and Tribal Governments to integrate RSAs into the project development process for new roads and intersections, and also encourages RSAs on existing roads and intersections.

The aim of an RSA is to answer the following questions:

- What elements of the road may present a safety concern: to what extent, to which road users, and under what circumstances?
- What opportunities exist to eliminate or mitigate identified safety concerns?

Public agencies with a desire to improve the overall safety performance of roadways under their jurisdiction should be excited about the concept of RSAs. Road safety audits can be used in any phase of project development from planning and preliminary engineering, design and construction. RSAs can also be used on any sized project from minor intersection and roadway retrofits to mega-projects.

### Subscribe or Post to the RSA Newsletter!

The Road Safety Audit (RSA) Newsletter is an outreach resource to provide you with the most current information on RSAs. Our regular features include an overview of State RSA programs, current resources to assist you in performing RSAs, and a compilation of RSA-related news stories.

**How to Subscribe:**

- Send an email to Heather Rigdon [ctr@dot.gov](mailto:ctr@dot.gov)
- In the subject line, type **subscribe RSA Newsletter**
- In the body, type **confirm RSA Newsletter**
- Do not include a signature

**How to Post Information:**

If you want to spread the word about an upcoming RSA or share your experiences with RSAs in any State, local areas, or Tribal areas, please send your information for consideration via an email to [rebecca.crowe@dot.gov](mailto:rebecca.crowe@dot.gov).

**Program Contact**

**Becky Crowe**  
Program Manager  
[rebecca.crowe@dot.gov](mailto:rebecca.crowe@dot.gov)  
804-775-3381

**Training**  
**Heather Rigdon**  
RSA Program Support  
[Heather.Rigdon\\_ctr@dot.gov](mailto:Heather.Rigdon_ctr@dot.gov)  
703-676-6828

**Technical Assistance**  
**K. Craig Allred**  
Transportation Specialist  
[craig.allred@dot.gov](mailto:craig.allred@dot.gov)  
720-963-3238

**What's New**

RSA Toolkit CD

Newsletter: Spring 2010, Volume 2, Number 3

2009 RSA Video

Tribal RSA: Case Studies

**Highlights**

RSA Software

Sample RSA Database

Sample RSA Printout

[safety.fhwa.dot.gov/rsa/](http://safety.fhwa.dot.gov/rsa/)

# Review - Crash Reduction Process

1

Identify the site

2

Determine crash pattern

3

Visit the site

4

Identify contributing factors

5

Assess and select countermeasures

6

Implement countermeasures

7. Evaluate effectiveness of projects

Two tools used in identifying contributing factors in crashes are:

1. Condition Diagram
2. Collision Diagram

Information that can be obtained from a site visit includes:

- Observing traffic under conditions of interest
- Gathering basic traffic data (volumes and speeds)

List 3-4 low-cost countermeasures that FHWA promotes:

1. Rumble strips
2. Safety Edge
3. Barrier/Guardrail
4. Left Turn Lanes
5. Right Turn Lanes
6. Bypass Lanes
7. Walkways
8. Pedestrian Refugees
9. Road Safety Audits

# Summary of Learning Outcomes

---

- Describe the crash reduction process.
- Identify the data/information needed to assess the safety of a roadway location.
- Identify practical and low-cost countermeasures.
- Describe best practices for making roads safer.

---

# Questions?

