Submitted
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Prepared for:

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PLANNERS
SURVEYORS

The City of Milford

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February 2009
TEC PN – 08095-002

Intersection Safety Study
US 50 & SR 131/Milford Parkway
Milford, Ohio

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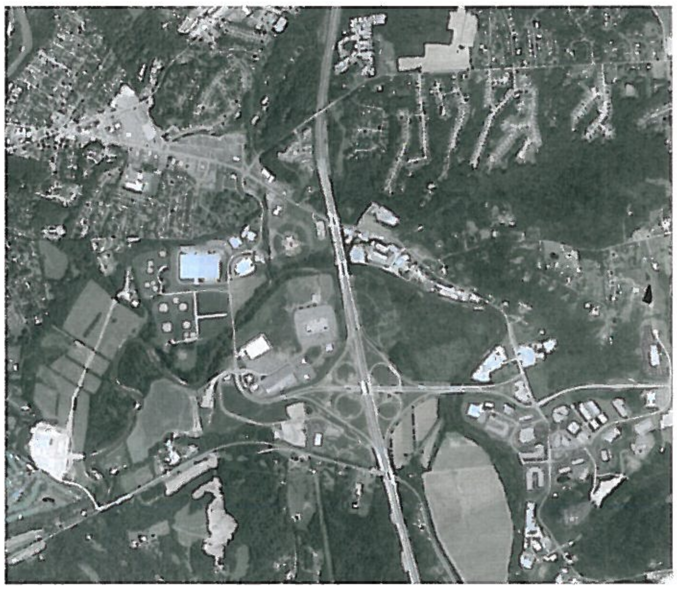
INTERSECTION SAFETY STUDY

US 50 and SR 131
Clermont County, Ohio

Prepared For:
The City of Milford
745 Center Street, Suite 200
Milford, OH 45150



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I. EXECUTIVE SUMMARY

A. Purpose

The intersection of State Route 50 and State Route 131 in Clermont County, Ohio has the 9th highest accident total in the City of Milford and is currently not part of a future improvement plan. As a result, TEC Engineering, Inc. was retained to conduct a safety study of this intersection. The purpose of this study is to analyze the crashes and propose feasible countermeasures that will effectively reduce these crashes. This intersection was studied as part of a traffic impact study, completed by TEC Engineering, Inc. in 2008. The improvements recommended in that traffic impact study will be evaluated in this study.

B. Background

US 50 is a major route running through Clermont County and is a major east-west connection to Cincinnati. Milford Parkway is the main connection from I-275 to the City of Milford. US 50 is not only the main road into Milford, it is also a main route to eastern Clermont County from the west. SR 131 connects Milford and I-275 to several towns including Newtonsville. ***Figure 1*** shows a vicinity map and aerial photograph of the intersection.

Figure 1: Vicinity Map and Aerial Photograph

C. Crash Data and Analysis

This intersection was the location of 46 crashes during the most recent three year period (2005-2007). Only 1 of these accidents resulted in injury. There were no fatal accidents. The crash information provided was analyzed, and together with data gathered from traffic counts and field observations, used to determine potential safety issues at US 50 and SR 131. These safety issues are listed below:

- Congestion leading to rear end accidents
- Insufficient merge length north of the intersection
- Speed limit issues at the intersection
- Inadequate lane use signage

D. Recommended Countermeasures and Costs

Countermeasures were proposed to alleviate some of the safety issues listed above. These countermeasures are listed below:

- Review signal timing (Short Term)
- Add and improve lane usage signs (Short Term)
- Improve pavement markings (Short Term)
- Widen bridge north of the intersection (Long Term)

E. Rate of Return

The rate of return is a value used to quantify the benefits expected due to the implementation of improvements. The rate of returns for the proposed countermeasures are shown in the table below:

Improvement	Estimated Cost	Rate of Return
Short Term Improvement	$15,500	385%
Long Term Improvement	$1,421,650	-29%

II. EXISTING CONDITIONS

The intersection of US 50 and SR 131 is located in the City of Milford in Clermont County Ohio. The speed limit on US 50 is 25 MPH east of the intersection and 45 mph west of the intersection. The speed limit on SR 131 is 40 mph north of the intersection and 25 mph south of the intersection. Both roadways are categorized as Urban Minor Arterials. The average daily traffic (ADT) of the intersection is 27,279 veh/day.

All approaches have both left and right turn lanes, with dual left turn lanes on eastbound US 50. The pavement markings and signage near the intersection are in good condition. ***Figure 2*** shows the existing lane configuration. Intersection pictures are provided in ***Appendix A***.

The intersection is signalized. The eastbound left turn and westbound left turns are protected only. Vehicles can only turn when there is an arrow. There is a southbound right turn overlap which runs with the eastbound left turn arrow. The northbound and southbound left turns are protected/permissive. Vehicles can turn on the green arrow, or can yield to thru vehicles on the green light.

A speed study was conducted on US 50 in the vicinity of the study area. This study found that the 85th percentile speed for eastbound traffic was 32.5 mph. This is higher than the 25 mph speed limit. For westbound US 50 the 85th percentile speed was 41.5 mph which is below the existing speed limit

The traffic pattern varies greatly from the AM Peak to the PM peak. During the AM Peak a higher number of vehicles are traveling from the north and east to the west. During the PM peak a higher number of vehicles are traveling from the west to the north and from the south to the west and north. ***Figure 2*** shows the peak hour turning movement volumes at the intersection. Full traffic count data is provided in ***Appendix B***.

Figure 2: Existing Conditions

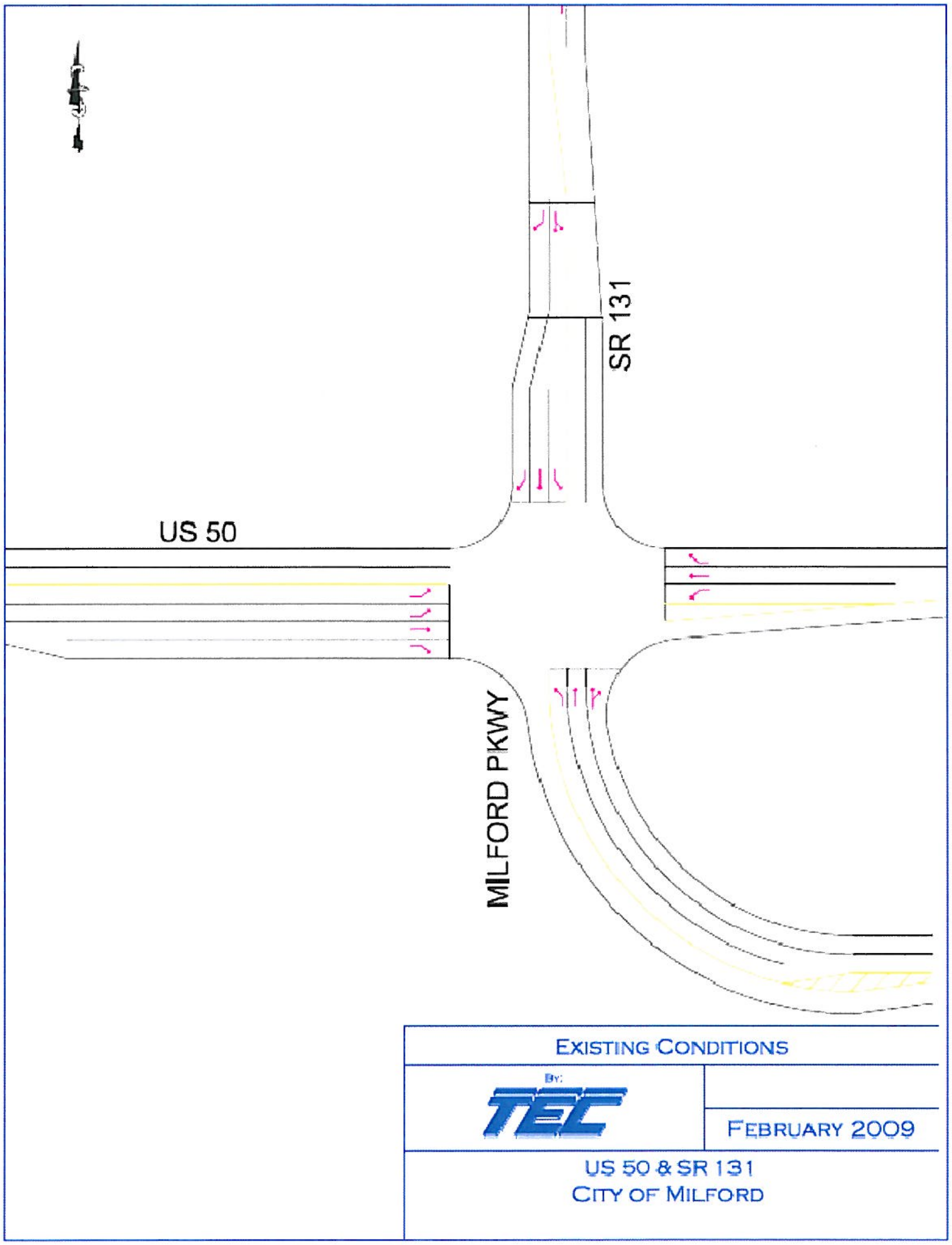
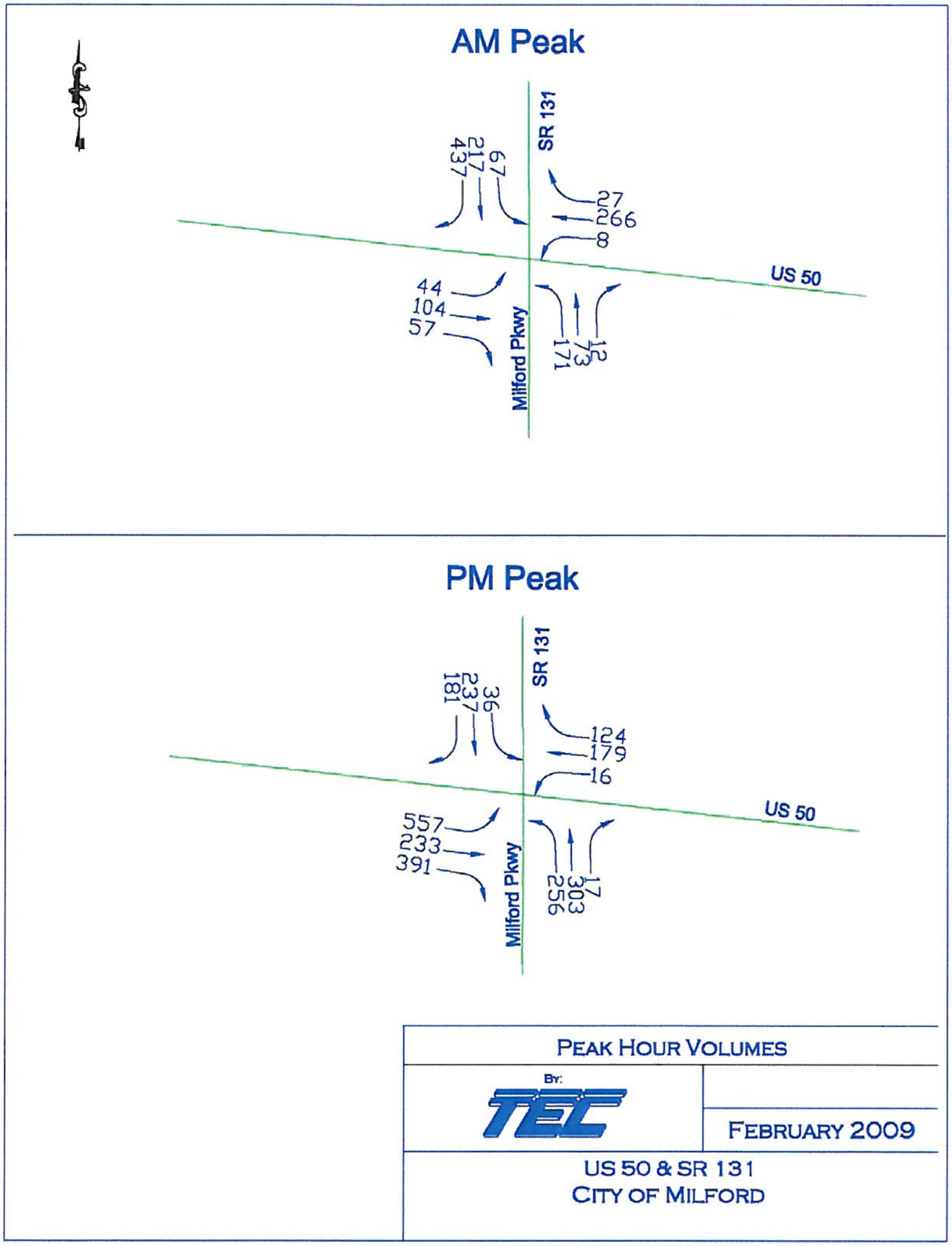


Figure 3: Peak Hour Volumes



III. CRASH DATA

A. Crash Report Summary

Crash data are the most important element of a safety study. The data can reveal crash patterns, which in turn can indicate safety problems. Without complete and accurate crash data, all analyses and recommendations are limited in value. Crash reports were obtained from the City of Milford.

The crash reports were grouped using several different criteria, including crash type, severity and environmental conditions among others. Collision diagrams were created to provide a visual depiction of the accidents. The crash summaries are provided in ***Figure 4*** and the collision diagrams are shown in ***Figure 5***. More comprehensive crash data is presented in ***Appendix C.***

B. Crash Data

ODOT has established a Highway Safety Program (HSP) that emphasizes safety in all phases of highway development. The HSP establishes procedures for project evaluation and statewide prioritization. The criteria used for scoring projects and determining prioritization are based on a point system corresponding to assigned value ranges. These statistics are generated from data collected over the most recent consecutive three year period. Data for intersection is listed in ***Table 1*** below.

Table 1: Crash Statistics for Intersection from 2005-2007

Intersection	Crash Frequency	Crash Rate	RSI	EPDO Rate	Truck Percentage
US 50 and SR 131	46	1.54	24670	1.7	2%

The *crash frequency* is simply the total number of crashes for a given intersection or roadway segment during the three year study period.

The *crash rate* takes into consideration traffic counts to recognize the exposure of each location. For an intersection, the crash rate is the number of crashes at that intersection per one million entering vehicles. The crash rate for a roadway segment is the number of crashes along that segment per one million vehicle miles traveled.

The *Relative Severity Index (RSI)* represents the relative cost to society of a specific crash type. The RSI is the sum of the relative costs per crash divided by the total number of crashes. The costs associated with specific crash types were determined by ODOT and can be seen in the rate of return worksheets (***Figure 6***).

The *Equivalent Property Damage Only (EPDO) Rate* weights crashes by property damage only, injury and fatality. The crashes are weighted as follows:

> *EPDO Rate = (# of PDO crashes * 1) + (# of injury crashes * 5.50) + (# of fatal crashes * 90.14)*

The EPDO Rate is then calculated by taking the EPDO value per one million entering vehicles for intersections or the EPDO value per one million vehicle miles for roadway segments.

Figure 4: Crash Summaries

CRASH SUMMARY

Crash Data					
Three Year Total	46	PDO	45	Truck %	2%
Annual Average	15.33	Injury	1	Fatal	
ADT (vpd)	27279	RSI	24670	EPDO Rate	1.69
Crash Rate (acc/MEV)	1.54	Seg Length (mi)		ΔChange	0.30

	Freeway
√	Non-Freeway
√	Urban
	Rural
√	Spot Location
	Roadway Segment

Crash Type												
Description				1			2			Total		
	Total	Injury	Fatal	Total	Injury	Fatal	Total	Injury	Fatal	Total	%	Injury	Fatal
Not Stated													
Head On							1			1	2%		
Rear End	8			10			7			25	54%		
Backing													
Sideswipe Meeting / Left-Turn													
Sideswipe Passing	2			2			2			6	13%		
Angle	3	1		6			1			10	22%	1	
Parked Vehicle													
Pedestrian													
Animal	1									1	2%		
Train													
Pedacycles													
Other Non Vehicle													
Fixed Object	1			1			1			3	7%		
Other Object													
NA													
Overturning													
Other Non Collision													
Grand Total	15	1		19			12			46	100%	1	

Red Text-Crash Types Not Shown in table "Crash Analysis" spreadsheet

Light Conditions													
Description				1			2			Total			
	Total	Injury	Fatal	Total	Injury	Fatal	Total	Injury	Fatal	Total	%	Injury	Fatal
1 Daylight	11	1		11			11			33	72%	1	
2 Dawn													
3 Dusk				2						2	4%		
4-6 Dark	4			6			1			11	24%		
7 Glare													
8 Other													
9 Unknown													
Grand Total	15	1		19			12			46	100%	1	

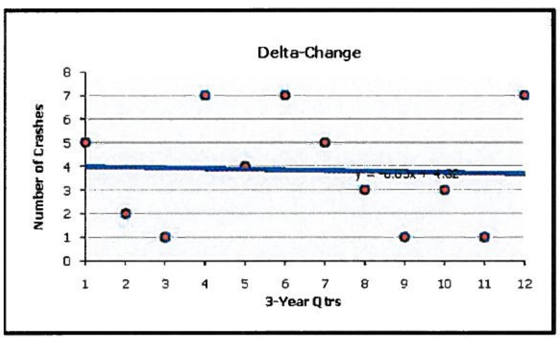
Road Conditions													
Description				1			2			Total			
	Total	Injury	Fatal	Total	Injury	Fatal	Total	Injury	Fatal	Total	%	Injury	Fatal
01 Dry	7	1		10			5			22	48%	1	
02 Wet	5			9			6			20	43%		
03 Snow	3									3	7%		
04 Ice							1			1	2%		
05 Sand, Mud, Etc.													
06 Water													
07 Slush													
08 Debris													
09 Rut, Holes, Etc.													
10 Other													
11 Unknown													
Grand Total	15	1		19			12			46	100%	1	

Weather													
Description				1			2			Total			
	Total	Injury	Fatal	Total	Injury	Fatal	Total	Injury	Fatal	Total	%	Injury	Fatal
01 Clear	7	1		6			6			19	41%	1	
02 Cloudy	3			5						8	17%		
03 Fog, Smog, Smoke													
04 Rain	1			8			5			14	30%		
05 Sleet, Hail	1									1	2%		
06 Snow	3						1			4	9%		
07 Severe Crosswinds													
08 Blowing Soil, Sand, Dirt													
09 Other													
10 Unknown													
Grand Total	15	1		19			12			46	100%	1	

CRASH SUMMARY

Direction (At Fault)													
Description				1			2			Total			
	From	To	I/F (From)	From	To	I/F (From)	From	To	I/F (From)	From	To	% From	I/F (From)
1 North	4	1		6	3		1	1		11	5	17%	
2 South	2	5	1	4	5		3	3		9	13	24%	1
3 East	2	6		4	4		1	1		7	11	20%	
4 West	7	3		5	7		7	7		19	17	39%	
5 Northeast													
6 Northwest													
7 Southeast													
8 Southwest													
9 Unknown													
Grand Total	15	15	1	19	19		12	12		46	46	100%	1

Direction (Not At Fault)													
Description				1			2			Total			
	From	To	I/F (From)	From	To	I/F (From)	From	To	I/F (From)	From	To	% From	I/F (From)
1 North	5	2	1	7	3		1	4		13	9	24%	1
2 South	2	5		2	7		3	1		7	13	22%	
3 East	1	5		6	3		1	6		8	14	24%	
4 West	5	1		3	5		6			14	6	22%	
5 Northeast													
6 Northwest													
7 Southeast													
8 Southwest													
9 Unknown													
Grand Total	13	13	1	18	18		11	11		42	42	100%	1



Delta Change			
	1	2	Quarter
5	4	1	1
2	7	3	2
1	5	1	3
7	3	7	4
0.500	-0.500	1.600	ΔYear
	0.300		ΔChange

CRASH SUMMARY

Contributing Factor (At-Fault)								
Description			1		2		Total	
	#	%	#	%	#	%	#	%
01 None (Motorist)	1	7%					1	2%
02 Failure to Yield	2	13%	6	32%	2	17%	10	22%
03 Ran Red Light, or Stop Sign			2	11%			2	4%
04 Exceeded Speed Limit								
05 Unsafe Speed	1	7%			1	8%	2	4%
06 Improper Turn								
07 Left of Center					1	8%	1	2%
08 Followed Too Closely	8	53%	8	42%	5	42%	21	46%
09 Improper Lane Change/Passing/Off Road	1	7%	2	11%	1	8%	4	9%
10 Improper Backing								
11 Improper Start from Parked Position								
12 Stopped or Parked Illegally								
13 Erratic/Negligent Driving								
14 Swerving to Avoid	1	7%					1	2%
15 Failure to Control					1	8%	1	2%
16 Vision Obstruction								
17 Driver Inattentiveness			1	5%			1	2%
18 Fatigue/Asleep								
19 Operating Defective Equipment								
20 Load Shifting/Falling/Spilling								
21 Other Improper Action								
22 Unknown (M)	1	7%			1	8%	2	4%
23 None (N-M)								
24 Improper Crossing (N-M)								
25 Darting (N-M)								
26 Lying and/or Illegally in Roadway (N-M)								
27 Failure to Yield Right of Way (N-M)								
28 Not Visible (N-M)								
29 Inattentive (N-M)								
30 Failure to Obey Signs, Signals, Etc. (N-M)								
31 Wrong Side of the Road (N-M)								
32 Other (N-M)								
33 Unknown (N-M)								
Totals	15	33%	19	41%	12	26%	46	

Pre-Crash Actions (At-Fault)								
Description			1		2		Total	
	#	%	#	%	#	%	#	%
01 Straight Ahead	11	73%	14	74%	7	58%	32	70%
02 Backing								
03 Changing Lanes	2	13%	1	5%	2	17%	5	11%
04 Passing								
05 Turning Right	1	7%	3	16%	1	8%	5	11%
06 Turning Left	1	7%	1	5%	1	8%	3	7%
07 Making U-Turn								
08 Entering Lane								
09 Leaving Lane								
10 Parked								
11 Slowing/Stopped								
12 Driverless								
13 Other								
14 Unknown					1	8%	1	2%
15 Enter/Cross (N-M)								
16 Walking, Running (N-M)								
17 Working (N-M)								
18 Pushing Vehicle (N-M)								
19 App/Leave Veh (N-M)								
20 Play/Work On Veh (N-M)								
21 Standing (N-M)								
22 Other (N-M)								
23 Unknown (N-M)								
Totals	15	33%	19	41%	12	26%	46	

CRASH SUMMARY

Vehicle Types								
Description			1		2		Total	
	#	%	#	%	#	%	#	%
Trucks					1	4%	1	1%
Other	28	100%	38	100%	22	96%	88	99%
Totals	28	31%	38	43%	23	26%	89	

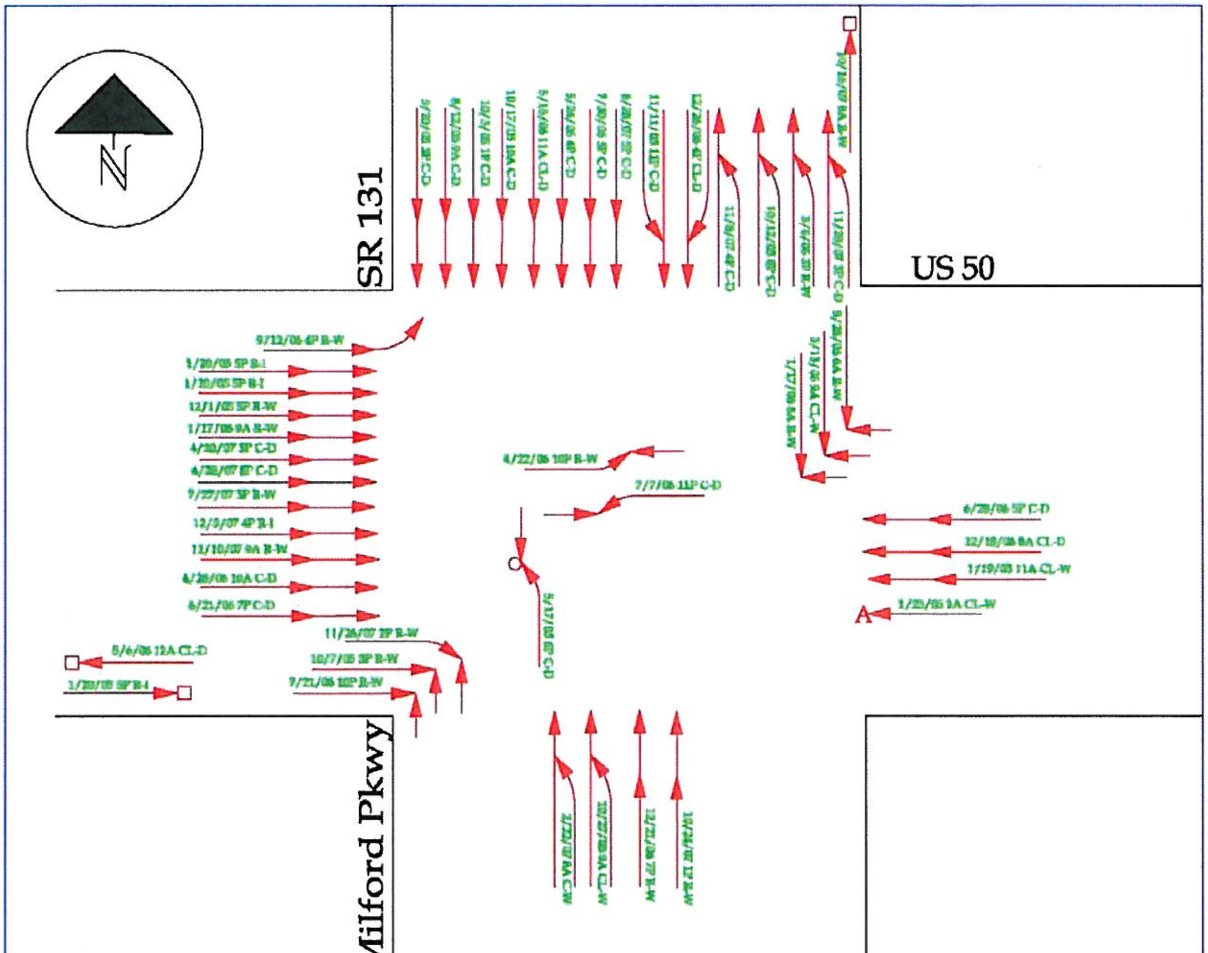
Alcohol/Drug Suspected								
Description			1		2		Total	
	#	%	#	%	#	%	#	%
1 None	14	25%	19	25%	12	27%	45	25%
2-5 Yes								
6 Unknown	1	2%					1	1%
Totals	15	33%	19	41%	12	26%	46	

Driver Age								
Description			1		2		Total	
	#	%	#	%	#	%	#	%
<20	1	4%	2	5%	4	17%	7	8%
20-24	3	11%	3	8%	4	17%	10	11%
25-65	17	61%	32	86%	13	57%	62	70%
>65	6	21%			1	4%	7	8%
NA	1	4%			1	4%	2	2%
Totals	28	32%	37	42%	23	26%	88	

Relative Severity Index (RSI)			
Description	Total	RSI-Urban	Sum of Products
Not Stated		14798	
Head On	1	41327	41327
Rear End	25	22568	564200
Backing		31039	
Sideswipe Meeting / Left-Turn		27145	
Sideswipe Passing	6	29480	176880
Angle	10	25684	256840
Parked Vehicle		24586	
Pedestrian		67346	
Animal	1	16606	16606
Train		76658	
Pedacycles		40457	
Other Non Vehicle		45378	
Fixed Object	3	26320	78960
Other Object		26016	
NA			
Overturning		40709	
Other Non Collision		24882	
Grand Total	46	**24670**	1134813

Freeway	Non-Freeway
	√
Urban	Rural
√	
Spot Location	Roadway Segment
√	

Figure 5: Collision Diagram



ACCIDENT SUMMARY	
Property Damage Accidents	45
Vehicular Injury Accidents	1
Pedestrian Injury Accidents	0
Vehicular Fatal Accidents	0
Pedestrian Fatal Accidents	0
TOTAL ACCIDENTS	46

LEGEND

C=CLEAR CL=CLOUDY R=RAIN F/S=FOG, SMOG, SMOKE
D=DRY W=WET I=ICE U=UNKNOWN

SYMBOLS	TYPES OF COLLISIONS
MOVING VEHICLE	REAR END
BACKING VEHICLE	HEAD ON
PEDESTRIAN	SIDESWIPE
PARKED VEHICLE	OUT OF CONTROL
□ FIXED OBJECT	ANGLE
A ANIMAL CRASH	LEFT TURN
● FATAL ACCIDENT	
○ INJURY ACCIDENT	

NOTES

* - Not to scale

COLLISION DIAGRAM

By: TEC

FEBRUARY 2009

US 50 & SR 131
CITY OF MILFORD
JANUARY 2005 - DECEMBER 2007

IV. CRASH ANALYSIS

A. Overview

The raw crash data for the years 2005 through 2007 were analyzed to identify patterns and possible safety deficiencies at the intersection. During this period a total of 46 crashes occurred at this intersection with 1 of these crashes resulting in an injury.

The predominant crash type along this section during the study years was rear end. Fifty-four percent (54%) of the accidents were rear end accidents. The other accident types included Angle (22%), Sideswipe/passing (13%), Fixed Object (7%), Head-on (2%) and Animal (2%).

Most frequently the contributing circumstance resulting in crashes at the intersection was following too closely, but failure to yield was also a contributing circumstance that resulted in a number of the crashes.

B. Possible Causes

Based on field observations and measurements, stopping sight distance does not seem to be a problem for motorists. A majority of the crashes at this intersection are rear end crashes. The motorists have difficulty stopping, resulting in rear end crashes. Rear end crashes are often caused by congestion. Congestion can be the cause of crashes as drivers sit in stop and go traffic. Angle accidents and turning accidents can also be related to congestion as drivers try to rush through the clearance interval so they do not have to sit through another signal cycle.

Several of the rear end accidents occurred after a lane change. This was especially true for southbound vehicles and is most likely due to inadequate lane signage and the jog in the lane.

Another common type of accident near this intersection is the sideswipe/passing accident. Several of these accidents occur on SR 131 north of the intersection. There are eastbound dual left turn lanes, which merge into one northbound lane a short distance from the intersection. This was the location of several accidents where drivers did not leave enough room to merge, or did not see the vehicle in the other lane.

C. Capacity Analysis

The software program *Synchro* was used to analyze capacity at the intersection. *Synchro* uses the methods prescribed in the *Highway Capacity Manual (HCM)* to determine the level of service (LOS). LOS is defined in terms of delay and is a measure of driver discomfort and intersection performance with respect to vehicular capacity and quality of service provided to road users. Delay refers to total average stopped delay experienced by motorists at the referenced intersection. For signalized intersections the level of service has six classifications ranging from A to F. These classifications are shown in ***Table 2.***

Table 2: LOS at Signalized Intersections

Level of Service	Description	Delay (seconds per vehicle)
A	Very low delay	<10
B	Good progression	10-20
C	Limit of acceptable delay	20-35
D	Start of traffic breakdown	35-55
E	High delay	55-80
F	Congested conditions, unacceptable delay	>80

A capacity analysis was performed for both the AM and PM peak hours to compare the LOS for existing conditions against the LOS with proposed countermeasures along the corridor. Volumes were obtained from peak hour turning movement counts conducted by TEC Engineering. The proposed countermeasures are discussed in detail in *Section V, Recommended Countermeasures and Costs*. A ~~summary~~ of the results of the capacity analysis is shown in ***Table 3*** below. This intersection was in the study area for a traffic impact study completed in 2008. This study included the outlot development on Chamber Drive at Milford Parkway. Table 3 includes the LOS for the existing conditions if the outlot are developed. The generated traffic volumes were acquired from Traffic Impact Study. The complete *Synchro* output is presented in ***Appendix D***.

Table 3: Peak Hour LOS and Delay

Intersection	Scenario	Peak Hour	Approach LOS/Delay				Intersection LOS/Delay
			NB	SB	EB	WB	
US 50 & SR 131/Milford Pkwy	Existing	AM	C/23.0 s	D/37.0	B/19.7 s	C/23.5 s	C/21.8 s
		PM	C/24.1 s	C/33.5 s	C/29.7 s	C/31.1 s	C/28.6 s
	With Outlots Developed	AM	C/21.4 s	D/37.0 s	C/20.6 s	C/27.7 s	C/29.9 S
		PM	C/27.7 s	D/32.3 s	C/27.7 s	D/36.1 s	C/31.0 s

There are existing turn lanes on all approaches at this intersection, therefore Turn Lane Warrants were not completed. Several of the existing turn lanes do not meet the design standards set forth in the Ohio Department of Transportation Location and Design Manual, Volume 1. These standards are based on the volume of turning vehicles, the speed and the cycle length at the intersection. ***Table 4*** shows the existing storage lengths and the recommended storage lengths. However, these lengths are not practical in all locations. The existing conditions of the roadway may limit the storage on some approaches. This includes existing driveways and bridges. The existing bridge just north of the intersection limits the width of the roadway. In the eastbound direction, there is a driveway 350 feet to the west of the intersection. Since there does not appear to be an accident problem for the Northbound and westbound directions. Lengthening these storage lanes is not recommended.

Table 4: Storage Lane Analysis

Approach	Lane	Existing**	Required (existing traffic)	Recommended in previous study	Meets Standard
Northbound	Right Turn Lane	-	-	-	-
	Left Turn Lane	250	440	544	NO
Southbound	Right Turn Lane	400	560*	-	NO*
	Left Turn Lane	100	211*	-	NO*
Eastbound	Right Turn Lane	300	550*	591	NO*
	Left Turn Lane	800	675	-	yes
Westbound	Right Turn Lane	250	300	-	NO
	Left Turn Lane	190	175	190	yes

* The required storage length cannot be attained due to geometric restrictions
**The existing lengths are the storage lengths measured at the time of this study

V. RECOMMENDED COUNTERMEASURES AND COSTS

Short Term Recommendations

The first short term recommendation is to review the signal timing and clearance intervals at the intersection. This will ensure that the clearance intervals are adequate for the 85th percentile speed. This will reduce the number of rear end and left turn accidents. The clearance intervals allow the drivers to react and stop in a timely manner before the opposing traffic enters the intersection. The yellow time is the amount of time it should take for a driver to notice the yellow light and slow down to a stop. This is based on the speed, the drivers reaction time and a deceleration time. The all red time is the time it takes for a person to cross the intersection if they drive across the stop bar after the light turns red. This is based on the speed and the distance from the stop bar to the opposite side of the intersection. Currently the clearance intervals are the same for all 4 approaches. The yellow time and 4.0 seconds and the All Red time is 2.0 seconds. This is based on a speed of 40 mph. The speed limit for northbound Milford Parkway and EB US 50 is only 25 mph. The 85th percentile speed for eastbound US 50 is 32.5 mph. Decreasing the yellow time to correlate with the speed will reduce the number of rear end accidents as well as red light runners. The cost for this improvement is $500. *Table 5* shows the recommended clearance intervals.

Table 5: Clearance Intervals

Recommended Clearance Intervals				
	Existing		Recommended	
	Yellow	All Red	Yellow	All Red
NB	4.0	2.0	3.2	2.8
SB	4.0	2.0	3.9	2.1
EB	4.0	2.0	3.6	2.4
WB	4.0	2.0	3.9	2.1

The second short term recommendation is to improve the signage. The eastbound approach should have overhead signage. There are currently two through lanes prior to the intersection. One of these through lanes becomes a left turn lane at the intersection. It is important that drivers are aware of this well before the intersection so they can maneuver into the correct lane. The overhead signage should be installed approximately 450 feet to the west of the intersection. The cost for this improvement is approximately $11,500.

The third short term recommendations is to modify the pavement markings at the intersection. The following pavement marking modifications should be made for SB SR 131:

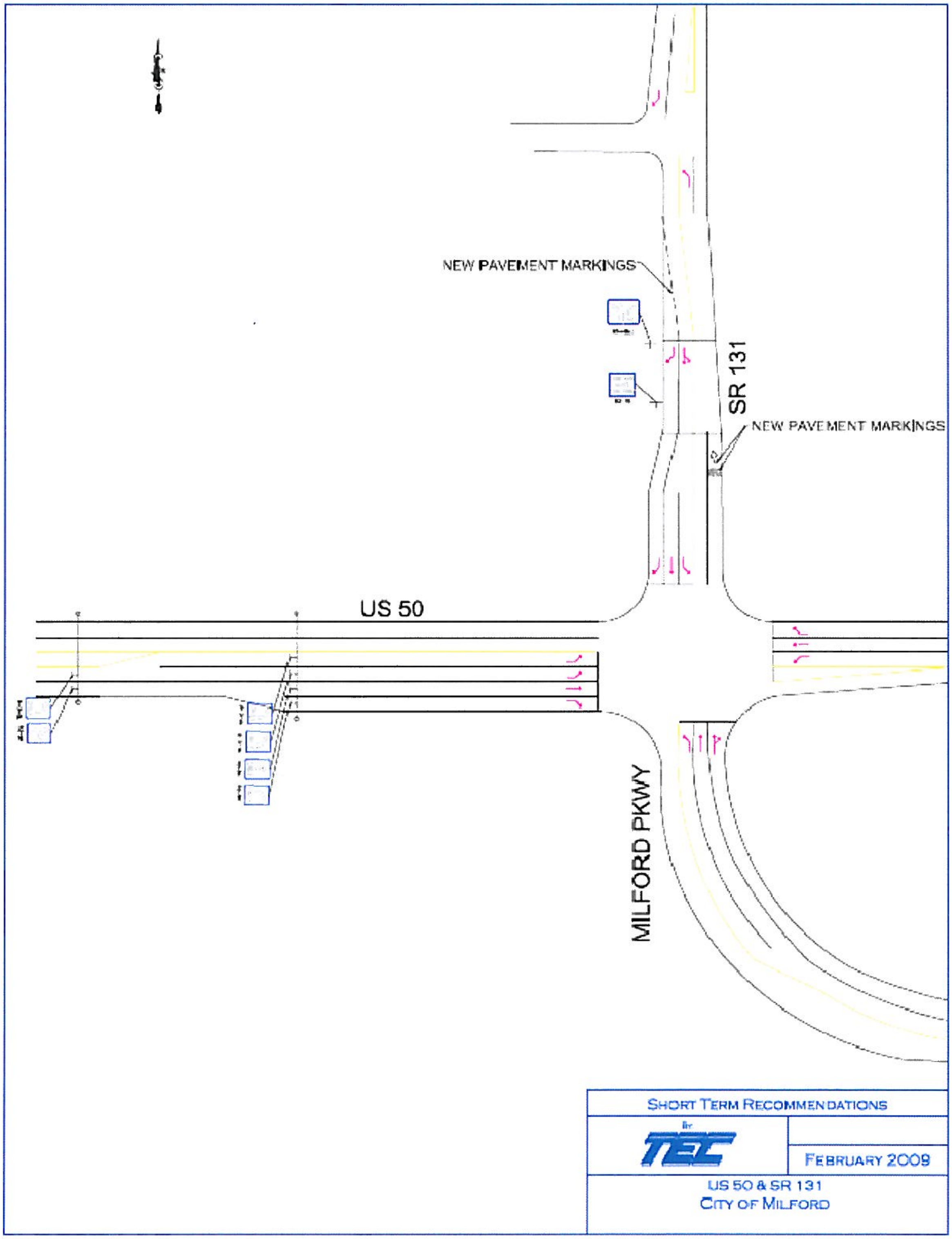
Extend the channelize lane line
Add a dotted line delineating the right turn lane to ensure drivers stay in the thru lane
Add a “MERGE” warning and arrow to the pavement on the north side of the intersection

Figure 6 is a schematic of the short term recommendations. The cost for this improvement is approximately $1,000. The total cost for the short term solutions, including a 20% contingency, is $15,500 as shown in *Table 6*. The rate of return for the short term recommendations is 385%. See *Section 5* for additional rate of return discussion.

Table 6: Short Term Recommendation Cost

Cost Estimate-Short Term Improvements					
Item No.	Description	Quant.	Unit	Unit Cost	Total Cost
630	Sign, Flat Sheet	30	SQ FT	$10.00	$300.00
630	Span Wire Sign Support Foundation	2	EA	$2,000.00	$4,000.00
630	Span Wire Sign Support	1	EA	$7,000.00	$7,000.00
630	Sign Post	20	FT	$10.00	$200.00
632	Signalization Misc. Review Clearance Intervals	1	LS	$500.00	$500.00
642	Dotted Line	100	FT	$5.00	$500.00
642	Channelizing Line	50	FT	$2.00	$200.00
642	Word on Pavement -"MERGE"	1	EA	$120.00	$120.00
642	Arrow on Pavement	1	EA	$100.00	$100.00
SPEC	Contingency (20%):	1	LS	$2,584.00	$2,584.00
Total					**$15,504.00**

Figure 6: Short Term Recommendations



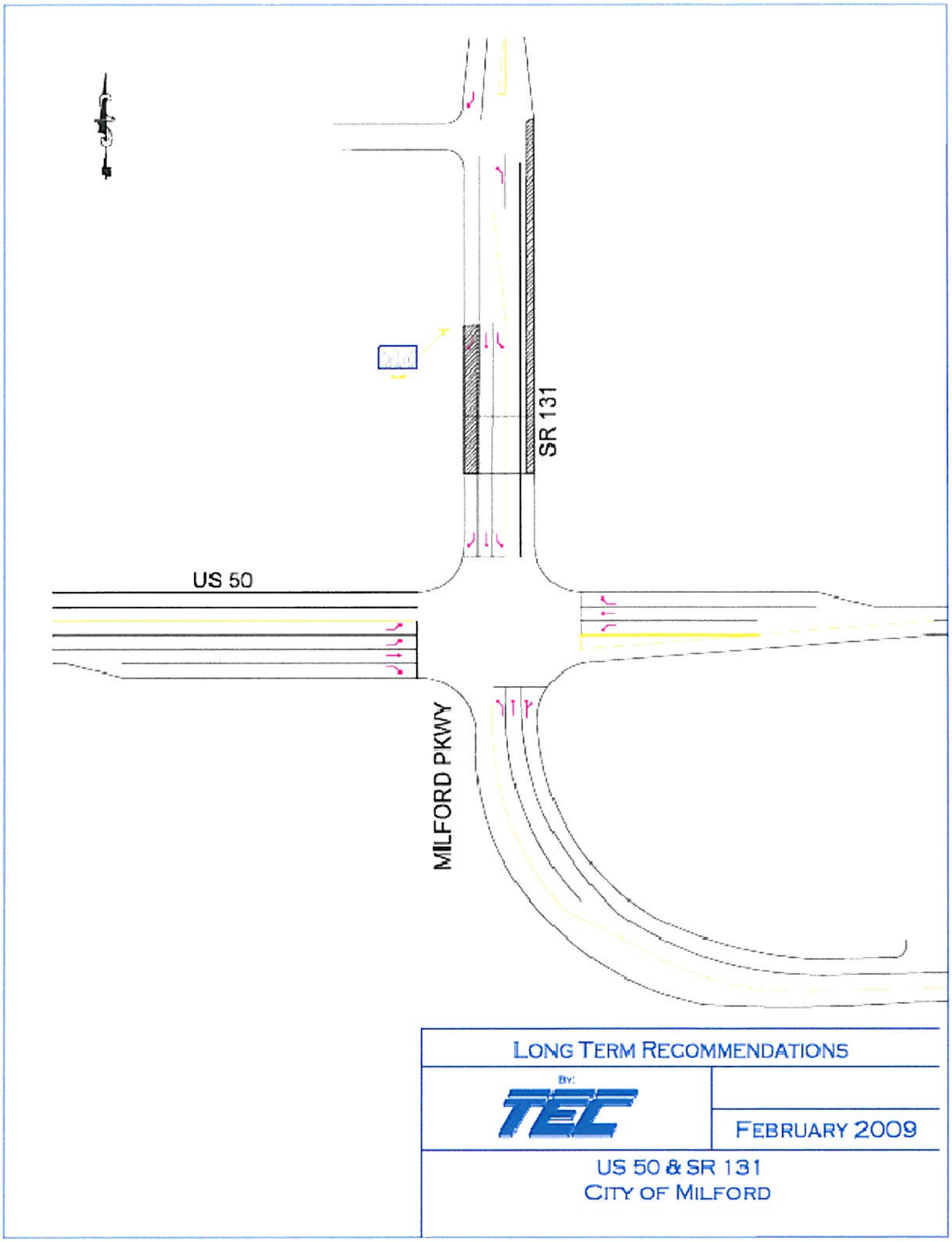
Long Term Recommendations

Widen the small bridge north of the intersection to better align the lanes. The road should also be widened north of the bridge to lengthen the merge or the two northbound lanes turning vehicles. This improvement will reduce the number of southbound rear end accidents, which can be caused by the abrupt lane changes as well as sideswipes from lane changes. This will also improve the conditions for the northbound traffic as it will increase the distance before the two inbound lanes merge to one lane which caused several sideswipe accidents during the study period. *Figure 7* is a schematic of the long term recommendations. The cost for this improvement is approximately $1,422,000. *Table 7* shows the cost estimate for this improvement. The rate of return for the short term recommendations is -29%. See *Section 5* for additional rate of return discussion.

Table 7: Long Term Recommendation Cost

Cost Estimate-Long Term Improvement					
Item No	Item	Quantity	Unit	Unit Cost	Cost
203	Subgrade Compaction	660	SY	$1.50	$990.00
203	Excavation	1	LS	$20,000.00	$20,000.00
203	Embankment	1	LS	$10,000.00	$10,000.00
207	Erosion Control	1	LS	$5,000.00	$5,000.00
254	Pavement Planning, Asphalt Concrete	2950	SY	$3.25	$9,587.50
301	Asphalt Concrete Base, PG 64-22	155	CY	$145.00	$22,475.00
304	Aggregate Base	210	CY	$40.00	$8,400.00
407	Tack Coat for Intermediate Course	40	GAL	$2.00	$80.00
448	Asphalt Concrete Surface Course, Type 1, PG 64-22	40	CY	$150.00	$6,000.00
448	Asphalt Concrete Intermediate Course, Type 1, PG 64-22	44.9653	CY	$160.00	$7,194.44
614	Maintaining Traffic	1	LS	$15,000.00	$15,000.00
644	Pavement Marking and Signage	1	LS	$5,000.00	$5,000.00
659	Seeding and Mulching	1	LS	$10,000.00	$10,000.00
SPEC	Bridge Removal	1	LS	$50,000.00	$50,000.00
SPEC	Bridge Widening & Replacement	5200	SF	$175.00	$910,000.00
ROW	Right of way	1	LS	$18,000	$18,000
SPEC	Contingency (30%):	1	LS	$323,918.08	$323,919.00
Total					**$1,421,650.00**

Figure 7: Long Term Recommendations



VI. RATE OF RETURN

The rate of return is a value used to quantify the benefits expected due to the implementation of improvements. Essentially, this value measures the expected yield or effective return of safety countermeasures. The effective return is an estimated interest rate that will make the net present value of the countermeasure minus the net present value of the countermeasure cost equal to zero. In this case, the net present value of the countermeasure is the expected dollar value of safety benefits in terms of crashes prevented. ODOT calculates the cost of crashes based on severity and location, and these costs were used in the rate of return calculation. The "Countermeasure Reduction Factors" used in the worksheets were provided by ODOT and are shown in ***Appendix F***.

The rate of return values for the countermeasures proposed were calculated for individual for the Short Term and Long Term recommendations. The rate of return values that were calculated are shown in ***Table 8*** below and the rate of return worksheets can be seen in ***Figure 8***.

Table 8: Rate of Return Values

Improvement	Estimated Cost	Rate of Return
Short Term Improvement	$15,500	385%
Long Term Improvement	$1,421,650	-29%

Figure 8: Rate of Return Worksheets

RATE OF RETURN - ECONOMIC ANALYSIS WORKSHEET

LPA: City of Milford
Crash Location: US 50 & SR 131
Prepared By: TEC Engineering, Inc.

Years: 2005 2005 2007
ADT: 27279 vpd
Segment Length (mi): 0

Project #: 08095.001
Date: 7/21/2008

Year	TIME OF DAY						ROADWAY CONDITION						CRASH TYPE																		TOTAL	
	Day		Dawn/Dusk		Dark		Dry		Wet		Snow/Ice		Rear End		SSM/LT		Angle		Head On		SS Pass		Fixed Object		Ran Off Road		Pedestrian		Other			
	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F
2005	10	1	0	0	4	0	6	1	5	0	3	0	8	0	0	0	2	1	0	0	2	0	1	0	0	0	0	0	1	0	14	1
2006	11	0	2	0	6	0	10	0	9	0	0	0	10	0	0	0	6	0	0	0	2	0	1	0	0	0	0	0	0	0	19	0
2007	11	0	0	0	1	0	5	0	6	0	1	0	7	0	0	0	1	0	1	0	2	0	1	0	0	0	0	0	0	0	12	0
Total	32	1	2	0	11	0	21	1	20	0	4	0	25	0	0	0	9	1	1	0	6	0	3	0	0	0	0	0	1	0	45	1
Avg.	10.67	0.333	0.667	0	3.667	0	7	0.333	6.667	0	1.333	0	8.333	0	0	0	3	0.333	0.333	0	2	0	1	0	0	0	0	0	0.333	0	15	0.333

RECOMMENDED IMPROVEMENTS

1. 7 Lane use signs - overhead
2. 6 Upgrade signs - general
3. 25 Revise signal timing
4. 1 Upgrade pavement markings - general

CRASH TYPES	PDO CRASHES							INJ. - FAT. CRASHES						
	R1	R2	R3	R4	RT	AVG PDO	EST. RED.	R1	R2	R3	R4	RT	AVG INJ-FAT	EST. RED.
All		0.05	0.10	0.10	0.23	15.00	3.46		0.05	0.10	0.10	0.23	0.33	0.08
Rear End-EB only	0.10				0.10	12.00	1.20	0.20				0.20	0.00	0.00
SSM/LT						0.00	0.00						0.00	0.00
Angle						3.00	0.00						0.33	0.00
Head On						0.33	0.00						0.00	0.00
SSP	0.20				0.20	0.00	0.00						0.00	0.00
Fixed Object						1.00	0.00						0.00	0.00
Ran Off Road						0.00	0.00						0.00	0.00
Pedestrian						0.00	0.00						0.00	0.00
Dark						3.67	0.00						0.00	0.00
Wet						6.67	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
	ESTIMATED PDO CRASH REDUCTION						4.66	ESTIMATED INJ. - FAT. CRASH REDUCTION						0.08

ADT Factor

Project Service Life: 20 years
Present ADT (PADT): 27279
Future ADT (FADT): 35462.7 — Future ADT determined using straight-line method & 1.5% annual growth rate

Average ADT = (PADT + FADT)/2 = (27279 + 35462.7)/2 = 31370.85
ADT Factor = Average ADT/PADT = 31370.85 / 27279 = 1.15

Average Annual Benefits

Annual PDO Benefits = Estimated PDO Crash Reduction * Avg PDO Cost	= 4.66	*	$9,960	=	$46,389
Annual INJ.-FAT. Benefits = Estimated INJ.-FAT. Crash Reduction * Avg INJ.-FAT. Cost	= 0.08	*	$82,224	=	$6,318
Total Benefits				=	$52,706
Average Annual Benefits = ADT Factor * Total Benefits	= 1.15	*	$52,706	=	$60,612

Rate of Return

Project Cost: $15,500
Maintenance and Energy Costs: $1,000
Salvage Value: $0

Rate of Return: 385%

Cost of Crashes for Determining ROR (2006)

System	PDO	I/F
Rural State Highway	$9,960	$82,224
Counties and Unincorporated Villages	$7,430	$59,234
Cities and Incorporated Villages	$10,846	$70,073

WHEN USING MULTIPLE COUNTERMEASURES, THE TOTAL REDUCTION FACTOR IS:
R1 + (1-R1)R2 + (1-R1)(1-R2)R3 + (1-R1)(1-R2)(1-R3)R4 + ... = RT

RATE OF RETURN - ECONOMIC ANALYSIS WORKSHEET

LPA: City of Milford
Crash Location: US 50 & SR 131
Prepared By: TEC Engineering, Inc.

Years: 2005 2005 2007
ADT: 27279 vpd
Segment Length (mi): 0

Project #: 08095-001
Date: 7/21/2008

Year	TIME OF DAY						ROADWAY CONDITION						CRASH TYPE																		TOTAL	
	Day		Dawn/Dusk		Dark		Dry		Wet		Snow/Ice		Rear End		SSM/LT		Angle		Head On		SS Pass		Fixed Object		Ran Off Road		Pedestrian		Other			
	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F
2005	10	1	0	0	4	0	6	1	5	0	3	0	8	0	0	0	2	1	0	0	2	0	1	0	0	0	0	0	1	0	14	1
2006	11	0	2	0	6	0	10	0	9	0	0	0	10	0	0	0	6	0	0	0	2	0	1	0	0	0	0	0	0	0	19	0
2007	11	0	0	0	1	0	5	0	6	0	1	0	7	0	0	0	1	0	1	0	2	0	1	0	0	0	0	0	0	0	12	0
Total	32	1	2	0	11	0	21	1	20	0	4	0	25	0	0	0	9	1	1	0	6	0	3	0	0	0	0	0	1	0	45	1
Avg.	10.67	0.333	0.667	0	3.667	0	7	0.333	6.667	0	1.333	0	8.333	0	0	0	3	0.333	0.333	0	2	0	1	0	0	0	0	0	0.333	0	15	0.333

RECOMMENDED IMPROVEMENTS

1. 39 Widen for left turn lane, including resurfacing
2.
3.
4.

CRASH TYPES	PDO CRASHES							INJ. - FAT. CRASHES						
	R1	R2	R3	R4	RT	AVG PDO	EST. RED.	R1	R2	R3	R4	RT	AVG INJ-FAT	EST. RED.
All						15.00	0.00						0.33	0.00
Rear End	0.20				0.20	2.66	0.53	0.20				0.20	0.00	0.00
SSM/LT	0.20				0.20	0.00	0.00	0.20				0.20	0.00	0.00
Angle						3.00	0.00						0.33	0.00
Head On						0.33	0.00						0.00	0.00
SS Pass	0.20				0.20	2.00	0.40	0.20				0.20	0.00	0.00
Fixed Object						1.00	0.00						0.00	0.00
Ran Off Road						0.00	0.00						0.00	0.00
Pedestrian						0.00	0.00						0.00	0.00
Dark						3.67	0.00						0.00	0.00
Wet						6.67	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
	ESTIMATED PDO CRASH REDUCTION						0.93	ESTIMATED INJ. - FAT. CRASH REDUCTION						0.00

ADT Factor

Project Service Life: 20 years
Present ADT (PADT): 27279
Future ADT (FADT): 35462.7 — Future ADT determined using straight-line method & 1.5% annual growth rate

Average ADT = (PADT + FADT)/2 = (27279 + 35462.7)/2 = 31370.85
ADT Factor = Average ADT/PADT = 31370.85 / 27279 = 1.15

Average Annual Benefits

Annual PDO Benefits = Estimated PDO Crash Reduction * Avg PDO Cost = 0.93 * $9,960 = $9,283
Annual INJ.-FAT. Benefits = Estimated INJ.-FAT. Crash Reduction * Avg INJ.-FAT. Cost = 0.00 * $82,224 = $0
Total Benefits = $9,283
Average Annual Benefits = ADT Factor * Total Benefits = 1.15 * $9,283 = $10,675

Rate of Return

Project Cost: $1,421,650
Maintenance and Energy Costs: $10,000
Salvage Value: $0

Rate of Return: -29%

Cost of Crashes for Determining ROR (2006)		
System	PDO	I/F
Rural State Highway	$9,960	$82,224
Counties and Unincorporated Villages	$7,430	$59,234
Cities and Incorporated Villages	$10,846	$70,073

WHEN USING MULTIPLE COUNTERMEASURES, THE TOTAL REDUCTION FACTOR IS
R1 + (1-R1)R2 + (1-R1)(1-R2)R3 + (1-R1)(1-R2)(1-R3)R4 + ... = RT