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MaineDOT

Transportation Research Division

Technical Report 06-2

A Before-and-After Study of Traffic Conflicts at the U. S. Route One Entrance to Camden Hills State Park- An Evaluation of a Portion of a Context Sensitive Design Project

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TRAFFIC CONFLICT STUDIES AT CAMDEN HILLS STATE PARK ENTRANCES

Study for Maine Department of Transportation

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ABSTRACT

Route 1 has been reconstructed as a Context Sensitive Design Project in the Camden, Maine area. The purpose of this study is to evaluate the safety effect of the reconstruction of the highway at the entrances to the Camden Hills State Park. The two T-intersections were replaced with a standard cross intersection with stop control on the park driveways and two refuge islands on Route 1, protecting left-turning vehicles and narrowing down the travel lanes. Speeds were reduced only marginally by about 3 mph, far from the 10-mph reduction in speed limit that was posted in connection with the reconstruction. Still, in the before situation, almost 20% of southbound drivers exceeded a speed of 50 mph. In the after situation, almost no drivers exceeded that speed. Traffic conflict studies, as well as analysis of crashes before the reconstruction, lead the author to conclude that the crash frequency has been cut to roughly *one-third* of the one existing prior to the reconstruction. The best estimate of the future crash rate would be around 0.25 reported crashes per year. Overall, it can be concluded that the reconstruction has been very successful in improving the safety situation at the Camden Hills State Park entrances.

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EXECUTIVE SUMMARY

Background

Route 1 has been reconstructed as a Context Sensitive Design Project in the Camden, Maine area. The purpose of this project is to evaluate the safety effect of the reconstruction of the highway at the entrance to the Camden Hills State Park, about two miles north of the center of Camden.

Research Methodology

Crash data analysis complemented with traffic conflict studies form the basis of this study. The conflict studies covered 720 minutes spread out over two days before reconstruction and 720 minutes after reconstruction. These studies were used as an alternative way to estimate the crash rates before and after the reconstruction of the area.

Layout Before

Figure 1 shows the general area with the layout before the reconstruction. The two T-intersections were separated by approximately 250 feet (80 meters).

Figure 1 Detail of layout before reconstruction (from Maine Office of GIS)

Layout After

The two T-intersections were replaced with a standard cross intersection with stop control on the park driveways. The new intersection is located where the southern T-intersection used to be. Two refuge islands were placed in Route 1, protecting left-turning vehicles and narrowing down the travel lanes. Figure 2 below shows how drivers are guided into the straight through lane and that vehicles stopped in the left-turn lane are protected from inadvertently being rear-ended by straight-trough drivers.

Figure 2 Looking northbound at northern refuge island

Figure 3 Northbound vehicles at southern refuge island

Figure 3 shows the narrow travel lane used to slow down northbound traffic. However, the right-side delineation is a striped area rather than a curb, and drivers have no difficulties maneuvering here at speeds considerably above the speed limit. Still, passing slow-moving vehicles has been made impossible with the refuge island, reducing the speed of some vehicles. Also, the refuge island makes it clear that there is an intersection here which will slow down some drivers as well. **Error! Reference source not found.** figure also shows the crosswalk across Route 1 which has a pedestrian activated flashing light.

Speeds

Speed Limit

The speed limit through the studied intersection was 45 mph in the before study and 35 mph in the after study. The speed limit changes to 50 mph about 250 meters (800 feet) north of the intersection.

Before and After Data

The speeds of free-moving vehicles along Route Rte 1 passing Camden Hills Park were measured on Wednesday, August 20, 2003 (before the reconstruction) and on Thursday, August 24, 2006 (after the reconstruction). The results are summarized in the tables below. The complete speed distribution for the studied periods is shown in Figure 4.

Table 1 Average speeds of free vehicles

	Before	After	Reduction
Northbound	42.7 mph	40.7 mph	2.0 mph
Southbound	46.3 mph	42.7 mph	3.6 mph

Table 2 85%-ile speeds of free vehicles

	Before	After	Reduction
Northbound	48 mph	45 mph	3 mph
Southbound	51 mph	47 mph	4 mph

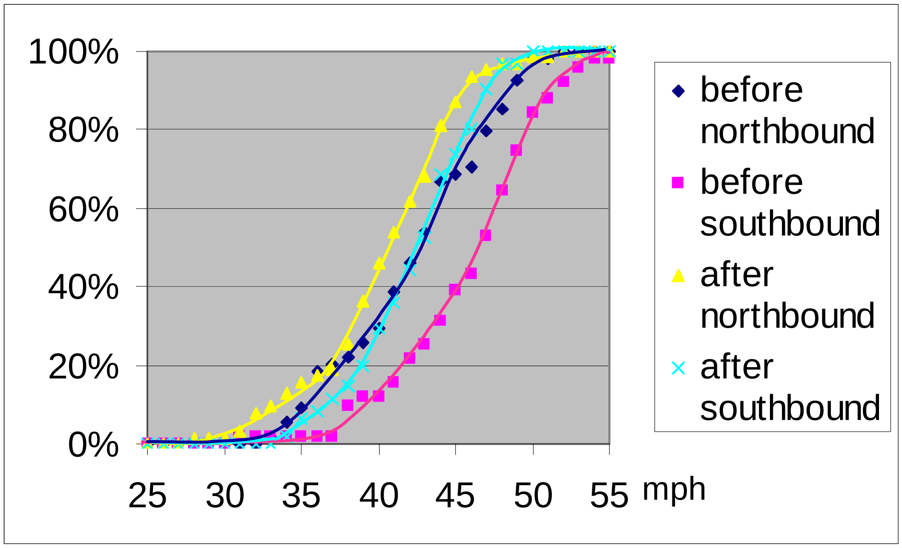

Figure 4 Speed distributions

It can be seen that the overall speeds are reduced as a result of the reconstruction in combination with the reduction in speed limits. However, the reduction in actual speed is much less than the 10-mph reduction in the speed limit. In the before study, vehicles were moving at speeds relatively close to the speed limit of 45 mph. In the after study, very few drivers were traveling at or below the speed limit of 35 mph.

Safety

The safety has been assessed primarily through traffic conflict studies and crash data analysis.

Crash Estimates Based on Conflict Data

FHWA-Technique Conversions

The approximate conversion from conflicts to crashes can be found in Table 13 of FHWA's Engineer's Guide. There were 20 FHWA conflicts recorded in the 12-hour before period. Two of them involved 'perpendicular' conflicts, three were opposing left-turn conflicts and the other 15 of rear-end/sideswipe type. In the before period, we recorded, in the summertime, during a 12-hour period, 20 conflicts. This gives us an estimate of around 2350 conflicts a year. With 75% of the conflicts being of rear-end type we would expect around $0.75 \times 2350 \times 15 \times 10^{-6} = 0.03$ rear-end crashes per year. We would also expect around $0.10 \times 2350 \times 490 \times 10^{-6} = 0.12$ side-impact collisions per year and $0.15 \times 2350 \times 212 \times 10^{-6} = 0.07$ opposing left-turn collisions per year. Over a four-year period, the FHWA studies indicate that we would have expected very few if any rear-end crashes and about 0.8 collisions involving side impacts (or head-on collisions) when drivers turn left. The conflict studies from the before period indicate that a clear majority of crashes would occur at the T-intersection on the mountainside.

There were seven conflicts in the 12-hour after period, none of them of 'perpendicular type.' This indicates that the number of conflicts has been reduced by roughly 65%.

The type of conflict that remains is rear-end with right-turning vehicles whereas rear-end conflicts with left-turning vehicles have been more or less eliminated. For the after period, with only seven rear-end conflicts and no side-impact conflicts in 12 hours of observations, we will expect no or very few collisions in the next several years.

Crash estimates based on the Swedish Technique

There were ten serious conflicts according to the Swedish LTH technique in the before study and three in the after study. This indicates a 70% reduction in potential collisions. For the before period, we would expect 0.45 reportable crashes per year or 1.8 reported crashes in four years based on the Swedish conflict observations. For the after period, the Swedish technique predicts around 0.15 crashes per year.

Expected Number of Crashes Based on Modeling of Traffic Volumes

Before Reconstruction

Route 1 at this location has a daily two-way flow of approximately 7610 (AADT just north of the park entrance in 2005 according to Maine Department of Transportation). The counts performed within this project shows that the entering volume from the park entrances were 10% of the entering volume along Route 1 in the before study (August 2003) and 14% in the after study (August 2006). These percentages would be lower at nights and during non-summer months. An estimate would be that around 3% of all traffic enters from the minor approaches.

According to a model developed by VTI in Sweden, that applies to T-intersections with no channelization and 70-km/h (44-mph) speeds, the expected number of crashes in the before period would be around 0.27 crashes per year or 1.1 crashes in four years for the mountainside and around 0.16 crashes per year or 0.6 crashes in four years for the beachside approach. The total number of crashes in four years here would be 1.7.

After Reconstruction

With 30-mph traffic (about 50 km/h) and separate left-turn lanes, the applicable VTI model shows that the number of crashes per year at a four-legged intersection becomes 0.27 crashes per year. This is a reduction in crashes by about 35% compared to the previous layout with two T-intersections.

Actual Crash Data Before

In the four-year period January 1, 2002 through December 31, 2005, there were four reported crashes in between the two nodes (intersections) 07127 and 07191, see Figure 5. There were no reported crashes at node 07191 but three at node 07127 for a total of seven crashes in this area. Five of these were property damage only while the remaining two involved possible injuries.

Figure 5 Node designations

Out of the seven crashes, one occurred during construction when one lane was closed down. Since this crash is construction related, it should not be included in an assessment of the before safety. Another crash was caused by traffic backing up from a serious crash some distance away. A driver got irritated by waiting and was hit while making a U-turn. Again, this crash has little if anything to do with the design of the Park entrance. There were two more crashes, which did occur right at or very close to the intersection, that are of questionable interest. They both involved deer running across Route 1. However, a lower speed may here possibly have made these crashes less likely to occur. The three remaining crashes were all directly related to movements in or out of the State park.

A March 23, 2003 crash involved a northbound driver making a left turn into the State park. This driver collided with a vehicle that was passing from behind. The turning vehicle “slowed as if to make a right hand turn ….[but] changed direction and went to make a left turn.”

On August 26, 2004, a northbound driver made a left-turn into the park without yielding to a southbound driver on Route 1. Two people sustained possible injuries. The crash was by police attributed to driver inattention.

On October 14, 2004, a north-bound driver was making a left turn into the State park. The driver following him, an 82-year-old man, “did not see Vehicle 1 making the turn” and struck it.

Comparison of Results for Estimating the Before Safety Situation

The VTI model using only traffic flow and basic design as predictors, forecasted 1.1 and 0.6 crashes per year for the two T-intersections, or a total of 1.7 crashes in the four-year before period. Details in design parameters can obviously mean that the actual number of crashes would be expected to be greater or smaller than this estimate.

The Swedish conflict technique predicted 1.8 crashes in a four-year period. Roughly half of them were predicted to be of Type A while the rest predominately would be of Type B and Type C.

The FHWA conflict technique estimated 0.9 crashes in a four-year period. A majority of these would involve vehicles turning left from Route 1 into the park.

The actual crash data showed that there were three collisions related to the roads leading into the park. There were also two deer collisions, one construction related crash and one secondary crash that occurred in the vicinity of the studied area.

Likely Effect of Reconstruction on Reported Before Crashes

Only three of the actually reported before-period crashes were in any direct way related to the layout of the intersections. The March 23, 2003 crash involving a northbound driver making a left turn into the State park colliding with a vehicle that was passing from behind would not have happened had the design been the current one. The August 26, 2004 crash, involving a northbound driver making a left-turn without yielding to a southbound driver could still have happened. However, with less 'stress' of being hit from behind, and slightly lower speeds, this crash would be less likely to have occurred with the new layout. The October 14, 2004 crash, involving a northbound driver preparing for a left turn into the State park being struck from behind, is much less likely to occur with the new layout. It is possible that the added refuge islands could cause single-vehicle collisions. Still, overall, the author of this report estimates that the net effect of the reconstruction, based on this qualitative discussion of individually reported crashes, would lead to a reduction in crashes by roughly two-thirds.

The Swedish conflict technique also predicts an improvement of 67% while the observations using the FHWA-technique suggest an even greater improvement in safety.

Using a Swedish traffic flow model alone, without any consideration of details in the layout, predicts a 35% improvement because of the reconstruction. However, this estimate must be considered less valid than the other since actual observations of driver behavior was not included.

Conclusions

Speeds were reduced only marginally by the context-sensitive redesign. Actually, the reduction in speeds was only around 3 mph, far from the 10-mph reduction in speed limit that was posted in connection to the reconstruction. Still, in the before situation, almost 20% of southbound drivers exceeded a speed of 50 mph. In the after situation, almost no drivers exceeded this speed. The reduced average speed by itself would contribute to roughly a 9% reduction in the expected number of crashes. The channelization and narrowed roadway width will most likely produce far greater benefits on the safety of this location. The conflict studies indicate that the safety has improved by about 67%. The best estimate of the future crash rate would be around 0.25 reported crashes per year.

Obviously, crashes not related to the intersection, such as deer collisions can also happen to occur here as they did in the before period. Furthermore, no pedestrian conflicts were observed—and the number of pedestrians crossing here is very small. But, the new bike/pedestrian path from downtown Camden will make pedestrian and bicycle crossings more likely here in the future than they were in the past. Still, with the low volumes, and the design of the active-sign crosswalk, the risk of such collisions must be considered very low.

Overall, it can be concluded that the reconstruction has been very successful in improving the safety situation at the Camden Hills State Park entrances.

TRAFFIC CONFLICT STUDIES AT CAMDEN HILLS STATE PARK ENTRANCES

Background

Route 1 has been reconstructed as a Context Sensitive Design Project in the Camden, Maine area. The purpose of this project is to evaluate the safety effect of the reconstruction of the highway at the entrance to the Camden Hills State Park, about two miles north of the center of Camden.

Research Methodology

Crash data analysis complemented with traffic conflict studies form the basis of this study. The conflict studies covered 720 minutes spread out over two days before reconstruction and 720 minutes after reconstruction. These counts were used as an alternative way to estimate the crash rates before and after the reconstruction of the area. The traffic conflict studies used manual observations in the field rather than video analysis. Limited traffic volume counts and speed measurements were also taken as indirect safety measures.

Layout Before

Error! Reference source not found. shows the general area with the layout before the reconstruction. with the intersection of interest in the center of picture (from Maine Office of GIS accessed through Google Earth). As can be seen here and in Figure 7, there were two T-intersections, separated by approximately 250 feet (80 meters), serving as park entrances.

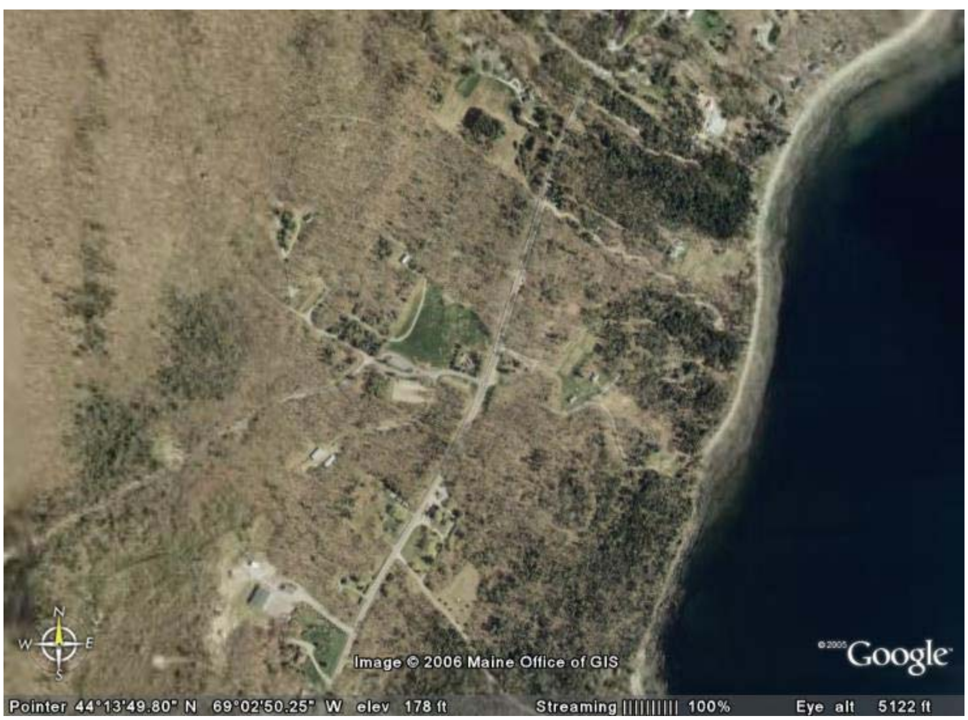

Figure 6 Aerial photo of layout before reconstruction

Figure 7 Detail of layout before reconstruction (from Maine Office of GIS)

The two T intersections were located so that people traveling from one part of the park to the other (beachside to mountainside or vice versa) made right turns only from Route 1. However, few movements were of that type. A majority of movements into the park consisted of northbound traffic turning left into the park. Before reconstruction, Route 1 widened from one to two northbound lanes about 300 feet (90 meters) south of the westbound entry, enabling turning and slow-moving vehicles to be passed. Left-turning vehicles could be passed on the right whereas right-turning northbound vehicles (using the second driveway towards the beach) had to be passed on the left. This could potentially lead to conflicts when faster moving vehicles caught up with slow-moving vehicles not indicating which direction they would be turning.

Layout After

The two T-intersections were replaced with a standard cross intersection with stop control on the park driveways. The new intersection is located where the southern T-intersection used to be. The driveway towards the mountainside has not been relocated or redesigned. However, two refuge islands were placed in Route 1, protecting left-turning vehicles and narrowing down the travel lanes. Figure 8 shows the northern refuge island as seen by a southbound driver just north of the no-longer-existing northern T-intersection. Figure 9 shows the drivers view for left-turning drivers just south of the northern refuge island.

Figure 8 Northern refuge island approached from the north

Figure 9 Southbound left-turn lane photographed just south of Figure 8

Figure 10, below, shows how drivers are guided into the straight through lane seen on the right in Figure 9. Vehicles stopped in the left-turn lane, in center of Figure 9, are therefore protected from inadvertently being rear-ended by straight-trough drivers.

Figure 10 Looking northbound at northern refuge island

Figure 11 Looking northbound at the northern refuge island, showing ‘narrow’ lane

Figure 12 Northbound vehicles at southern refuge island

Figure 13 Crosswalk with flashing sign activated by pedestrian push button

Figure 12, as well as Figure 13, shows the narrow travel lane used to slow down northbound traffic. However, the right-side delineation is a striped area rather than a curb, and drivers have no difficulties maneuvering here at speeds considerably above the speed limit. Still, passing slow-moving vehicles has been made impossible with the refuge island, reducing the speed of some vehicles. Also, the refuge island makes it clear that there is an intersection here which will slow down some drivers as well.

Figure 14 Detail of crosswalk are with drainage grates

Note, that there at the time of the after study, late August 2006, still were orange traffic cones on the east side near the northern refuge island, where the old T-intersection to the beachside of the Camden Hills Park was located. It is the opinion of the author that these cones barely if at all influenced speeds and behavior of drivers.

Speeds

Speed Limit

The speed limit through the studied intersection was 45 mph in the before study and 35 mph in the after study. The speed limit changes to 50 mph about 250 meters (800 feet) north of the intersection. It has been discussed to have different summertime and wintertime speed limits through the intersection.

Before and After Data

The speeds of free-moving vehicles along Route Rte 1 passing Camden Hills Park were measured between 1:00 and 3:00 PM on Wednesday, August 20, 2003 (before the reconstruction) and between 1:00 and 3:00 PM on Thursday, August 24, 2006 (after the reconstruction). It was sunny and warm, ‘nice’ days at both occasions. The temperature was in the low 80’s in the before study and around 75 degrees in the after study. A majority of vehicles going trough the intersection—in both directions—were free-moving vehicles in the before as well as after study. Including vehicles traveling closely behind other vehicles would most likely not have changed the results much.

The results are summarized in the tables below. The complete speed distribution for the studied periods is shown in Figure 15.

Table 3 Average speeds of free vehicles

	Before	After	Reduction
Northbound	42.7 mph	40.7 mph	2.0 mph
Southbound	46.3 mph	42.7 mph	3.6 mph

Table 4 85%-ile speeds of free vehicles

	Before	After	Reduction
Northbound	48 mph	45 mph	3 mph
Southbound	51 mph	47 mph	4 mph

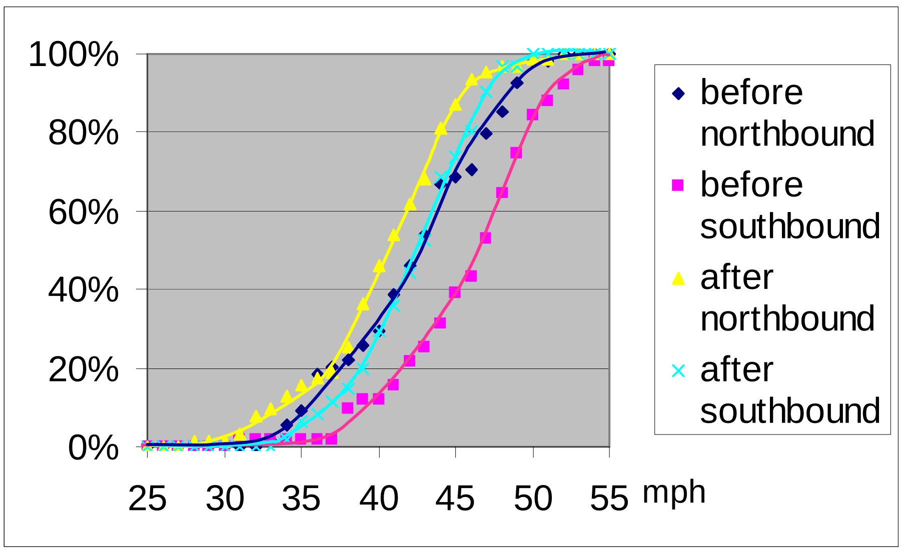

Figure 15 Speed distributions

It can be seen that the overall speeds are reduced as a result of the reconstruction in combination with the reduction in speed limits. However, the reduction in actual speed is much less than the 10-mph reduction in the speed limit. In the before study, vehicles were moving at speeds relatively close to the speed limit of 45 mph. In the after study, very few drivers were traveling at or below the speed limit of 35 mph.

It is impossible to tell what reduction in actual speed the lowered speed limit by itself would have produced but it is clear that the physical reconstruction here was not sufficient to reduce speeds to the new limit. The striped areas outside the travel lanes mean that the travel lanes still are perceived as wide.

Traffic Flows

Manual counts of the traffic flows are shown in the figures below.

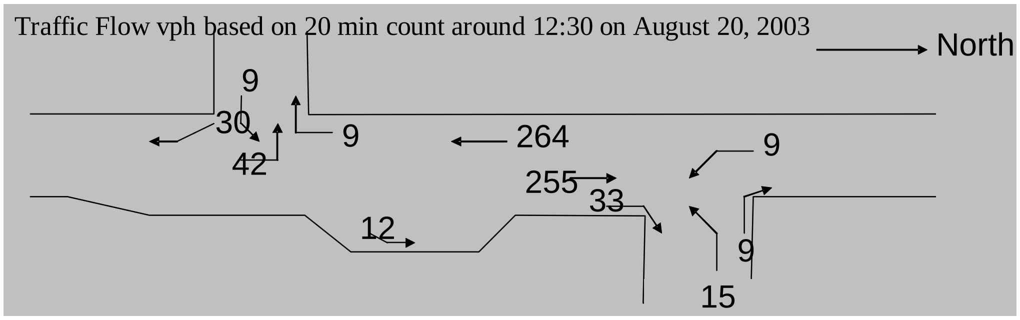

Figure 16 Before flows in vehicles per hour,12:20 to 12:40 PM on August 20, 2003

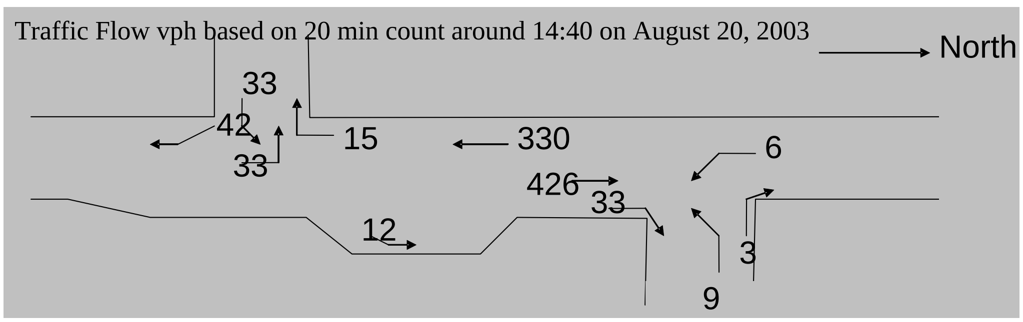

Figure 17 Before flows in vehicles per hour, 2:30 to 2:50 PM on August 20, 2003

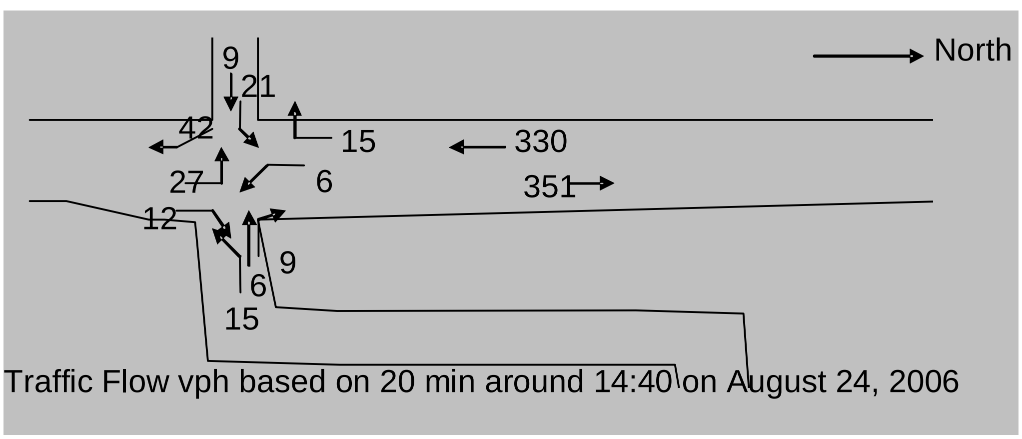

Figure 18 After flows in vehicles per hour, 2:30 to 2:50 PM on August 24, 2006

It can be concluded that there are not any significant changes in traffic flows between the before and after study.

Safety

Besides the indirect measure of speed, the safety has been assessed through traffic conflict studies and crash data analysis.

Speed measurements

The reduction in speed by itself is, according to an empirical model developed by VTI in Sweden, would indicate that the expected number of crashes would be reduced by roughly the reduction in speed squared. That is:

$$A_1=A_0\ (1+(v_1-v_0)/v_0)^2$$

That is, for every crash in the before period, we would for the northbound direction expect $1(1+(40.7-42.7)/42.7)^2 = 0.91$ crashes. For the southbound direction, we would expect a slightly greater improvement. However, this model predicts the change in safety if only speed is changed. The modifications to the layout—protected left turns—may produce greater benefits.

Conflict Studies

Traffic conflict studies using the Swedish technique, developed by LTH, as well as the FHWA technique were used. These techniques are outlined in "Evaluation of a Vehicle-Actuated Warning System for Stop-Controlled Intersections Having Limited Sight Distances," by Dale Peabody, Per Garder, Gerry Audibert, William Thompson, Michael Redmond, and Michael S. Smith, presented at the International Conference on Rural Advanced Technology and Transportation Systems, Burlington, Vermont, August 25-28, 2001, see http://www.maine.gov/mdot/safety-programs/pdf/norridgewocksignsratt.pdf

The FHWA technique is described in detail in *Traffic Conflict Techniques for Safety and Operations—Observers Manual.* Publication No. FHWA-IP-88-027 January 1989, U.S. Department of Transportation, Federal Highway Administration. It is available at http://www.fhwa.dot.gov/tfhrc/safety/pubs/88027/88027.pdf

Conflicts Before

Twelve hours of conflict observations were made before the reconstruction in late August 2003. The observed conflict types were classified according to Figure 19.

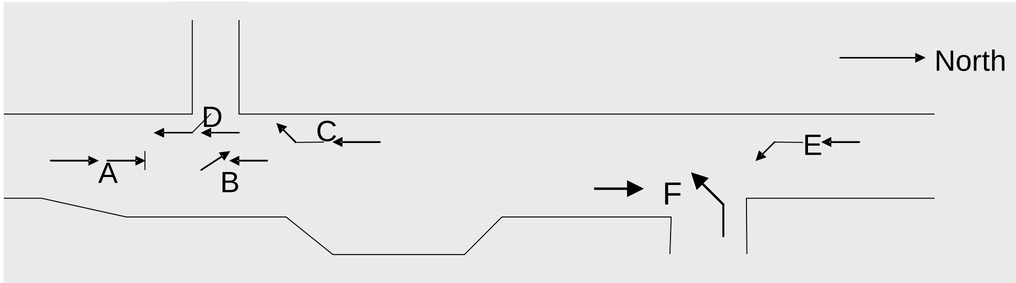

Figure 19 Observed conflict types in the before period

The frequency of the observed conflicts were as follows during the before period.

Type A: about one every 90 minutes, four serious, about once every three hours. A variety is when a third or fourth car moves out onto the right-most lane to pass a stopped car and then the second car suddenly moves out into that lane too at low speed in front of the high-speed vehicle attempting to pass it.

Type B: about one every four hours, two were serious.

Type C: about one every two hours. Two of them were quite serious and this is therefore not an unlikely type of crash.

Type D: One fairly serious conflict wass observed and frequent slight braking, about once every 90 minutes.

Type E: A conflict about once every four hours, one serious.

Type F: One FHWA conflict involving a left-turning vehicle from the beachside versus a northbound vehicle along Route 1 and one marginal conflict involving a vehicle from the campground/mountainside of the park versus a southbound through vehicles. There were a few situations with short post-encroachment times but these were not recorded since they did not produce conflicts.

Conflicts after

Type A: What remains involves only right-turning vehicles towards the ocean-side. No serious ones were observed.

Type B: No serious conflicts were observed but potentially these could still happen.

Type C: Roughly unchanged frequency, about one every two hours. One very serious conflict observed when opposite direction left-turn vehicle made passing in middle impossible (or at least unsafe) so braking became the only option. Another less serious similar conflict was observed.

Type D: No conflict observed

Type E: Should be eliminated, and no serious ones observed.

Type F: Still a potential conflict but none observed.

A new type of conflict was observed: A left-turning vehicle from the oceanside turned onto Route 1 and was almost rear-ended by a southbound through vehicle traveling at 47 mph, which braked but could not swerve. One of these was definitely an FHWA conflict and a borderline LTH conflict.

Crash Estimates Based on Conflict Data

FHWA-Technique Conversions

The approximate conversion from conflicts to crashes can be found in Table 13 of FHWA's Engineer's Guide. For conflicts involving "cross traffic" there are around 490 x 10^{-6} crashes per conflict at low to moderate volume two-way stop-controlled intersections (AADT 2,500 – 10,000, where this intersection falls). A similar ratio could be expected for a left turn from the minor approach. This means that we will have roughly 2000 conflicts per crash for this type of situation.

For rear-end situations (left-turn and right-turn same direction), the conversion factor is around 15 x 10^{-6} crashes per conflict at two-way stop location with 10,000 to 25,000 AADT. The AADT here is slightly below 10,000 but the manual gives no conversion factor for that volume.

For opposing left-turn at two-way stop, Table 13 of the Manual gives a conversion factor of 212 x 10^{-6} crashes per conflict.

There were 20 FHWA conflicts recorded in the 12-hour before period. Two of them involved 'perpendicular' conflicts, three were opposing left-turn conflicts and the other 15 of rear-end/sideswipe type.

There were seven conflicts in the 12-hour after period, none of them of 'perpendicular type.' This indicates that the number of conflicts has been reduced by roughly 65%. The type of conflict that remains is rear-end with right-turning vehicles whereas rear-end conflicts with left-turning vehicles have been more or less eliminated. Right-turning vehicles do not stop—but slow down to around 15 mph—which means that the relative speed of such collisions typically is lower than collisions involving left-turn vehicles which frequently have to stop while yielding to oncoming traffic.

The conflict studies from the before period indicate that a clear majority of crashes would occur at the T-intersection on the mountainside.

In the before period, we recorded, in the summertime, during a 12-hour period 20 conflicts. With an estimated 90 such days a year, and the remaining 275 days with 10% of that conflict frequency, we would expect around 2350 conflicts a year, if the number of nighttime conflicts were negligible. With 75% of the conflicts being of rear-end type we would expect around $0.75 \times 2350 \times 15 \times 10^{-6} = 0.03$ rear-end crashes per year. We would also expect around $0.10 \times 2350 \times 490 \times 10^{-6} = 0.12$ side-impact collisions per year and $0.15 \times 2350 \times 212 \times 10^{-6} = 0.07$ opposing left-turn collisions per year. Over a four-year period, the FHWA studies indicate that we would have expected very few if any rear-end crashes and about 0.8 collisions involving side impacts (or head-on collisions) when drivers turn left.

For the after period, with only seven rear-end conflicts and no side-impact conflicts in 12 hours of observations, we will expect no or very few collisions in the next several years.

Crash estimates based on the Swedish Technique

The Swedish technique is validated for Swedish conditions against injury crash data. Roughly one in three crashes here would be expected to have injuries, and the calculated number should therefore be multiplied by 3.0 after the conversion is done using the ratio 125×10^{-6} injury accidents/conflict which is a mid-range value for intersections with a moderate number of conflicts per day. Speed also influences this ratio. For high-speed conflicts, a higher value should be used; for low-speed a lower value might be recommended.

There were ten serious conflicts according to the Swedish LTH technique in the before study and three in the after study. This indicates a 70% reduction in potential collisions.

Observations from the summertime, during a 12-hour period, gave 10 serious conflicts during the before period. With an estimated 90 such days a year, and the remaining 275 days with 10% of that conflict frequency, we would expect around 1175 serious conflicts a year, if the number of nighttime conflicts were negligible. This means that we would expect $1175 \times 125 \times 10^{-6} = 0.15$ injury crashes per year or 0.45 reportable crashes per year. In a four-year period, we would expect around 1.8 reported crashes based on the Swedish conflict observations.

For the after period, the Swedish technique predicts around 0.15 crashes per year.

Expected Number of Crashes Based on Modeling of Traffic Volumes

Before Reconstruction

Route 1 at this location has a daily two-way flow of approximately 7610 (AADT just north of the park entrance in 2005 according to Maine Department of Transportation). The counts performed within this project shows that the entering volume from the park entrances were 10% of the entering volume along Route 1 (87 vs 855 vph) in the before study (August 2003) and 14% (102 vs 741) in the after study (August 2006). These percentages would be lower at nights and during non-summer months. A guesstimate would be that around 3% of all traffic enters from the minor approaches.

This number can be compared to official counts of visitors to the park. In 2005, Camden Hills State Park attracted nearly 120,000 visitors[1] according to official data. My observations show that there are many people who enter the driveway and turn around when they find out that they have to pay to enter the park. The actual number of movements into the park is therefore significantly higher than that which would be based on 120,000 visitors per year. Assuming that there are two people per car, would give us 60,000 movements into and out from the park per day, if no one entered without becoming an official vistor. The number of vehicles entering along Route 1 was in 2005, 365 x 7610 = 2,777,650 vehicles. The percentage coming from the minor road would be 60,000/(2,777,650+60,000) = 2.1%. If we add movements of drivers who do not officially enter the park, the above assumed 3% seems reasonable.

So, my final estimate is that the percentage coming from the minor approaches is about 3% of the total flow, and that 75% of the minor flow comes from the mountainside leg.

According to a model[2] developed by VTI in Sweden, that applies to T-intersections with no channelization and 70-km/h (44-mph) speeds, the expected number of crashes per year in the before period would be around A, where A is calculated as:

$A = 0.0000199\ (TOT^{1.25})(port^{0.45})$

This gives for the mountainside approach $A = 0.0000199\ ((1.03*7610)^{1.25}(0.0225^{0.45})$ = 0.27 crashes per year or 1.1 crashes in four years.

For the beachside approach, we would according to the model expect A = 0.16 crashes per year or 0.6 crashes in four years.

The total number of crashes expected in four years here would be 1.7.

As a sensitivity study, we can test what would happen if the minor flow volume were 6% of traffic along Route 1. This would lead to about 0.36 and 0.22 crashes per year for the two T-intersections, for a total 0.58 crashes per year or 2.3 crashes per four years.

After Reconstruction

With 30-mph traffic (about 50 km/h) and separate left-turn lanes, the applicable VTI model shows that the number of crashes per year (A) at a four-legged intersection becomes:

$A= 0.00000493\ (TOT^{1.45})(port^{0.6})$

Assuming that the minor flow is still 3% of the total flow gives A = 0.27 crashes per year. This is a reduction in crashes by about 35% compared to the previous layout with

[1] http://pressherald.mainetoday.com/

[2] Ulf Brüde and Jörgen Larsson, *Korsningar på Landsbygd och i Tätort*, VTI Trafikavdelningen, Latest Revision September 15, 1991

two T-intersections.

Actual Crash Data Before

In the four-year period January 1, 2002 through December 31, 2005, there were four reported crashes in between the two nodes (intersections) 07127 and 07191, see Figure 20. There were no reported crashes at node 07191 but three at node 07127 for a total of seven crashes in this area. Five of these were property damage only while the remaining two involved possible injuries. Two of the crashes happened in 2002, one in 2003, and four in 2004.

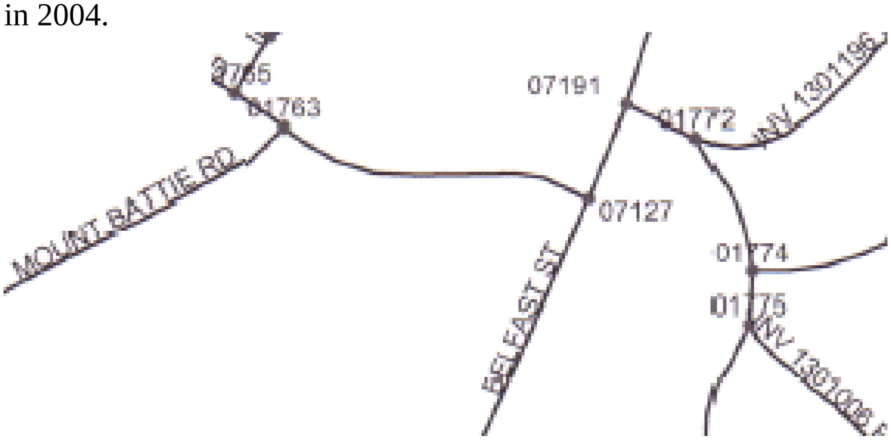

Figure 20 Node designations

Out of the seven crashes, one occurred on December 23, 2004, during construction when one lane was closed down. This was a possible-injury, rear-end crash caused by the second vehicle not noticing that the one in front was stopping for a queue. Since this crash is construction related, it should not be included in an assessment of the before safety.

Another crash, on March 4, 2004, was caused by traffic backing up from a serious crash some distance away. A driver got irritated by waiting and was hit while making a U-turn, about 500 feet north of Springbrook Hill (and therefore not at the location studied here; though the sketch and narrative states that it occurred close to the Springbrook Lane rather than Springbrook Road which is an identifiable road on maps). Again, this crash has little if anything to do with the design of the Park entrance.

There were two more crashes, which did occur right at or very close to the intersection (on November 11, 2002 and on October 4, 2004 respectively), that are of questionable interest. They both involved deer running across Route 1. However, a lower speed may here have made these crashes less likely to occur, and the crashes should therefore possibly be included as relevant.

The three remaining crashes were all directly related to movements in or out of the State park.

A March 23, 2003 crash involved a northbound driver making a left turn into the State park. This driver collided with a vehicle that was passing from behind. The turning vehicle “slowed as if to make a right hand turn ….[but] changed direction and went to make a left turn.” This is a sideswipe rather than a rear-end collision and therefore a slightly modified version of a Type A conflict according to the classification for the conflict studies.

On August 26, 2004, a northbound driver made a left-turn into the park without yielding to a southbound driver on Route 1 (what is observed as Conflict Type B in the studies above). Both drivers were in their sixties and from out of state. Two people sustained possible injuries. The crash was by police attributed to driver inattention.

On October 14, 2004, a north-bound driver was making a left turn into the State park. The driver following him, an 82-year-old man, "did not see Vehicle 1 making the turn" and struck it. This is what is classified as a Type A conflict in Figure 19 above.

Comparison of Results for Estimating the Before Safety Situation

The VTI model using only traffic flow and basic design as predictors, forecasted 1.1 and 0.6 crashes per year for the two T-intersections, or a total of 1.7 crashes in the four-year before period. Details in design parameters can obviously mean that the actual number of crashes would be expected to be greater or smaller than this estimate.

The Swedish conflict technique predicted 1.8 crashes in a four-year period. Roughly half of them were predicted to be of Type A while the rest predominately would be of Type B and Type C.

The FHWA conflict technique estimated 0.9 crashes in a four-year period. A majority of these would involve vehicles turning left from Route 1 into the park.

The actual crash data showed that there were three collisions related to the roads leading into the park. Two were Type A collisions (as defined in Figure 19) and one was a Type B collision. There were also two deer collisions, one construction related crash and one secondary crash that occurred in the vicinity of the studied area.

Likely Effect of Reconstruction on Reported Before Crashes

Only three of the actually reported before-period crashes were in any direct way related to the layout of the intersections. The March 23, 2003 crash involving a northbound driver making a left turn into the State park colliding with a vehicle that was passing from behind would not have happened had the design been the current one. The August 26, 2004 crash, involving a northbound driver making a left-turn without yielding to a southbound driver could still have happened. However, with less 'stress' of being hit from behind, and slightly lower speed, this crash would be less likely to have occurred with the new layout. The October 14, 2004 crash, involving a northbound driver preparing for a left turn into the State park being struck from behind, is much less likely to occur with the new layout.

It is possible that the added refuge islands could cause single-vehicle collisions. Still, overall, the author of this report estimates that the net effect of the reconstruction, based on this qualitative discussion of individually reported crashes, would lead to a reduction in crashes by roughly two-thirds.

The Swedish conflict technique, also predicts an improvement of 67% while the observations using the FHWA-technique suggests an even greater improvement in safety.

Using a Swedish traffic flow model alone, without any consideration of details in the layout, predicts a very modest improvement of the channelization. However, this estimate must be considered less valid than the other since actual observations of driver behavior was not included.

Conclusions

Speeds were reduced only marginally by the context-sensitive redesign. Actually, the reduction in speeds was only around 3 mph, far from the 10-mph reduction in speed limit that was posted in connection to the reconstruction. Still, in the before situation, almost 20% of southbound drivers exceeded a speed of 50 mph. In the after situation, almost no drivers exceeded this speed. The reduced average speed by itself would contribute to roughly a 9% reduction in the expected number of crashes. The channelization and narrowed roadway width will most likely produce far greater benefits on the safety of this location. The uncertainty of the estimates means that it is impossible to give an exact estimate of future crash frequency, but the conflict studies, as well as analysis of crashes before the reconstruction, leads the author to conclude that the crash frequency has been cut to roughly one-third of the one existing prior to the reconstruction. With only three intersection-related crashes in the four-year before period, we would anticipate the *before* expected frequency to have been in between 1.4 and 8 crashes in four years or between 0.35 and 2 crashes per year (p=0.05). With an estimate of the safety improvement to be 67% (which certainly is an uncertain estimate by itself) we would expect between 0.1 and 0.7 crashes per year at this location from now on. The best estimate of the future crash rate would be around 0.25 reported crashes per year.

Obviously, crashes not related to the intersection, such as deer collisions can also happen to occur here as they did in the before period. Furthermore, no pedestrian conflicts were observed—and the number of pedestrians crossing here is very small. But, the new bike/pedestrian path from downtown Camden will make pedestrian and bicycle crossings more likely here in the future than they were in the past. Still, with the low volumes, and the design of the active-sign crosswalk, the risk of such collisions must be considered very low.

Overall, it can be concluded that the reconstruction has been very successful in improving the safety situation at the Camden Hills State Park entrances.