Roundabout Feasibility Study for the Intersection of US Route 2 and Vermont Route 12

By NE ROUNDABOUTS

DRAFT

Table of Contents

1. Introduction

2. Existing Intersection Conditions

3. Single Lane Roundabout Consideration

4. Multi-lane Roundabout Consideration
    a. Geometric Alterations
    b. CDMP Impact
    c. Site Constraints
    d. Pedestrian and Bicyclist Accommodations
    e. Design Vehicle

5. Future Considerations
    a. Geometric Revisions
    b. Construction
    c. Cost

6. Conclusion

1. Introduction

The City of Montpelier and the Central Vermont Regional Planning Commission requested that a roundabout feasibility study be performed for the intersection of US Route 2 and Vermont Route 12. NE ROUNDABOUTS was contracted to provide this service, to determine if a roundabout is a feasible alternative. Should the roundabout be determined a feasible alternative it should be given a more thorough evaluation or, if deemed infeasible, dismissed as a consideration. NE ROUNDABOUTS, located in Cohoes, New York, is a consultancy dedicated to the education, promotion, design and implementation of modern roundabouts.

This report summarizes the study conducted to determine whether or not a roundabout is a feasible intersection alternative for the intersection of US Route 2 and Vermont Route 12. US Route 2 is comprised of Memorial Drive to the west of the intersection and Berlin Street to the east of the intersection. Vermont Route 12 is comprised of Main Street to the north of the intersection and Northfield Street to the south of the intersection. A site visit made it clear that Right-of-Way (ROW) was a limiting factor for this location. Previous project plan sheets and aerial photographs were used as backgrounds for developing possible roundabout design solutions in CAD.

2. Existing Intersection Conditions

The existing intersection is a signalized four-way intersection. Pedestrian accommodations are provided by a push button actuated exclusive pedestrian phase. The intersection fails today, operating at LOS F – this means the intersection has extreme delays and backs up traffic significantly. Exclusive turn lanes has been implemented at this intersection but the intersection still can't adequately handle the current traffic, not to mention the expected growth in traffic over the next coming years.

The phasing of a signalized intersection itself causes delay, stopping certain movements as others are allowed to proceed through the intersection. Throughout the cycle of a signal there is time wasted, some between the different phases and some when vehicles are stopped for no other reason than the light went red. The operation of a roundabout is described as continuous flow, meaning vehicles only yield when conflicting vehicle movements require the approaching vehicle to slow down. The roundabout may improve the operation of this intersection since it does not require vehicles to stop unnecessarily.

3. Single Lane Roundabout Consideration

In order to develop a 2D roundabout layout traffic counts need to be analyzed to determine how many lanes are needed for each approach and where they need to be able to go. Traffic counts for 2010 and 2020, with and without the Capital District Master Plan (CDMP), were used for this study. The CDMP will be further explained in section 4. b. Two different roundabout capacity modeling software packages were used for this analysis, SIDRA and VISSIM. A single lane roundabout design was first considered since it is the safest at-grade intersection possible and would be the easiest fit for this ROW constrained intersection. SIDRA was utilized for the single lane roundabout analysis, the results for 2010 volumes are shown below:

Table S.15 - Capacity and Level of Service

Mov ID	Mov Typ	Total Flow (veh /h)	Total Cap. (veh /h)	Deg. of Satn (v/c)	Aver. Delay (sec)	LOS	Longest Queue 95% Back (vehs)	(m)
South: Northfield Street								
1	L	76	73	1.041	114.5	F	35.7	250
2	T	176	169	1.041	107.4	F	35.7	250
3	R	182	175	1.040	108.8	F	35.7	250
East: Berlin Street								
4	L	88	87	1.011	58.6	E	46.1	323
5	T	396	392	1.010	51.6	D	46.1	323
6	R	382	378	1.011	53.0	D	46.1	323
North: Main Street								
7	L	339	319	1.063	102.2	F	52.2	365
8	T	119	112	1.062	95.1	F	52.2	365
9	R	220	207	1.063	96.5	F	52.2	365
West: Memorial Drive								
10	L	152	115	1.322*	313.5	F	157.9	1105
11	T	638	484	1.318	306.5	F	157.9	1105
12	R	116	88	1.318	307.9	F	157.9	1105
ALL VEHICLES:		2884		1.322	152.3	F	157.9	1105

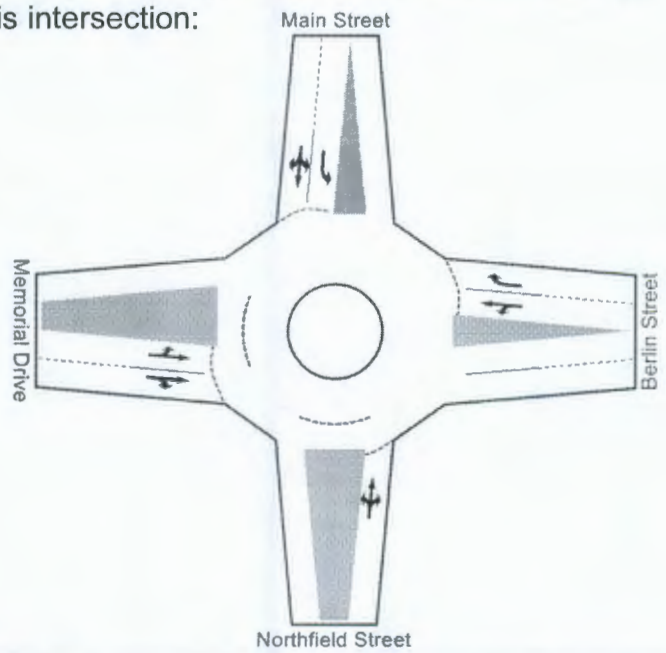
Level of Service calculations are based on
average control delay including geometric delay (HCM criteria),
independent of the current delay definition used.
Movement Level of service has been determined using adjacent lane

As can be clearly seen from the results above, the single lane roundabout does not provide sufficient capacity for the 2010 volumes, not to mention the 2020 volumes. Every movement operated at a level of service (LOS) D or worse, nine movements had a LOS F with well over 90 seconds of delay per vehicle. The single lane roundabout alternative not having enough capacity was somewhat disappointing since it would have been the easiest fit and safest design but when US and State routes are being considered it is common for the volumes to be beyond what a single lane roundabout can handle. Most single lane roundabouts have an Inscribed Circle Diameter (ICD) ranging between 110 and 150 feet – this is the distance from outside curb to outside curb across the roundabout. Between the site visit, the digital files, and the aerial images it appears that the available ROW at this intersection can accommodate a roundabout with an ICD of around 140 to 145 feet. The rock ledge to the northeast, the Winooski River Bridge, and the Mobil Station prevent the intersection from handling a roundabout design with a larger ICD. The range for most two lane roundabout ICDs is between 150 and 230 feet. A two lane roundabout can be designed with an ICD of 140 feet; the challenge with such a small ICD is to be able to provide sufficient deflection of approaching vehicles to ensure slow and safe operating speeds.

4. Multi-lane Roundabout Consideration

4. a Geometric Alterations

The need for additional capacity was investigated approach by approach in an attempt to only require certain roads to be expanded to two lane approaches. Below is the final layout proposed for this intersection:



The approach that was most obvious in need of additional capacity was Memorial Drive. Memorial Drive as a two lane approach worked quite well capacity wise. Distributing the through volume on this approach between two lanes allowed Northfield Street to remain as a single lane approach with an acceptable amount of delay, ranging between 40 and 57 seconds for the different 2020 volumes. Below are the results from SIDRA for 2020 with CDMP being implemented:

Table S.15 - Capacity and Level of Service
2020 WITH CDMP

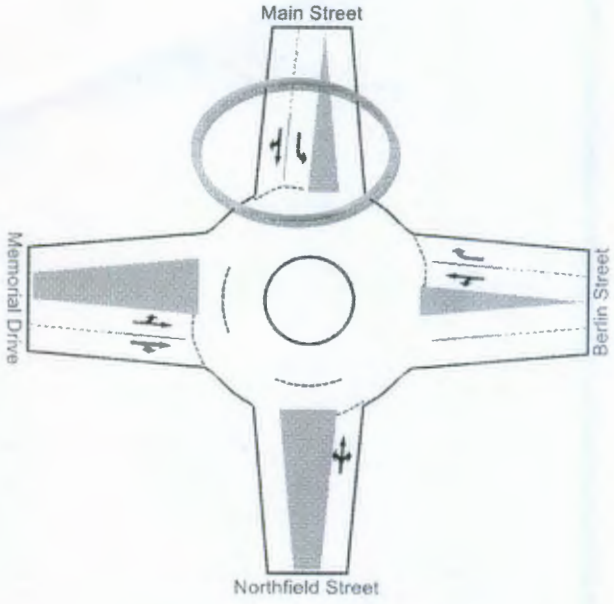
Mov ID	Mov Typ	Total Flow (veh /h)	Total Cap. (veh /h)	Deg. of Satn (v/c)	Aver. Delay (sec)	LOS	Longest Queue 95% Back (vehs)	(m)
South: Northfield Street								
1	L	76	78	0.974	56.8	E	19.6	137
2	T	187	191	0.979*	49.8	D	19.6	137
3	R	206	211	0.976	50.9	D	19.6	137
East: Berlin Street								
4	L	112	210	0.533	13.9	B	5.5	39
5	T	474	889	0.533	6.8	A	5.5	39
6	R	429	930	0.461	8.7	A	4.2	29
North: Main Street								
7	L	487	843	0.578	18.7	B	7.0	49
8	T	193	334	0.578	10.6	B	7.0	49
9	R	227	393	0.578	12.2	B	7.0	49
West: Memorial Drive								
10	L	134	206	0.650	17.3	B	6.1	43
11	T	726	1116	0.651	10.0	B	6.4	45
12	R	123	189	0.651	10.9	B	6.4	45
ALL VEHICLES:		3374		0.979	17.0	B	19.6	137

Level of Service calculations are based on
average control delay including geometric delay (HCM criteria),
independent of the current delay definition used.
For the criteria, refer to the "Level of Service" topic in the
SIDRA Output Guide or the Output section of the on-line help.

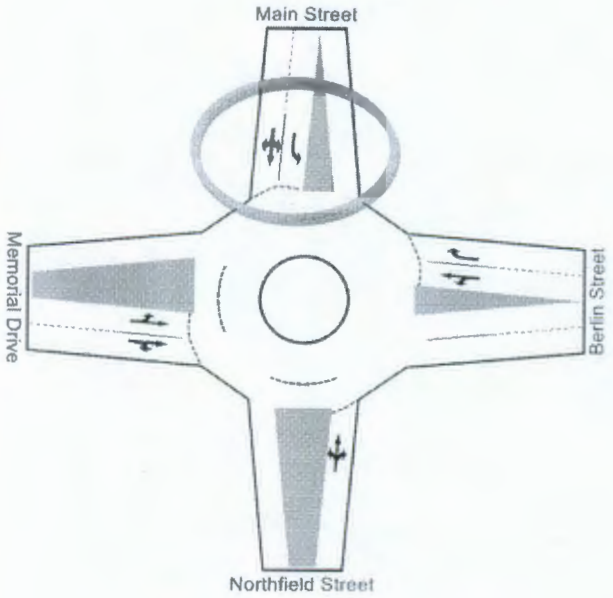
Being able to keep Northfield Street as a single lane approach was extremely important because of the limited ROW available on Northfield Street, it does not appear that Northfield Street could be modified into a two lane approach without significant ROW impacts. Berlin Street was the next approach to be investigated, somewhat in hopes that the same condition would exist – where an improved mainline (Berlin Street) would allow the lower volume road (Main Street) to remain a single lane approach. The volumes on Berlin Street are almost an even split between the right turn volume and the through volume. This allowed the approach to be modeled as a right turn only (RTO) lane and a through/left turn lane. This helped minimize the overall size and ROW impact for this intersection since there would only be one lane leaving the roundabout onto Memorial Drive. Berlin Street was determined to operate very well with this design. Main Street on the other hand, was still going to experience significant delay and had to be modified to a two lane approach as well.

4. b CDMP Impact

The Capital District Master Plan (CDMP) envisions an expansion of the state office and full build-out of all commercial property within the capital district in the City of Montpelier. The CDMP also includes alterations to the street network within Montpelier, most notably a city street across the North Brach of the Winooski River between Taylor Street and Main Street. Main Street had quite different volumes between the 2020 projected numbers, depending on whether or not the CDMP was implemented. Main Street was the only approach that experienced a difference in volumes that was considered significant enough to have an effect on the proposed design. Both 2020 projections required a two lane approach for Main Street but where the lanes needed to be allowed to go changed based on which projection was analyzed. Without the CDMP being implemented the right lane worked as a right/through lane and the left lane as a left turn only (LTO) lane. With the CDMP being implemented, 106 more vehicles want to make a left turn towards Berlin Street during the peak hour. The additional 106 vehicles made the left lane fail but the right lane still operated at a decent LOS. The right lane still had a significantly lower entering volume than the projected capacity of the right lane. The 2020 volumes with the CDMP implemented require the right lane to be a right/through/left turn lane and the left lane being a left turn only (LTO) lane. This difference doesn't affect the overall size of the roundabout at all, both lanes from Main Street need to enter the roundabout and Berlin Street already has a two lane exit. The final differences between the two proposed designs to accommodate the 2020 volumes would be the lane use signing on the Main Street approach and a little striping within the roundabout. The following images show the different lane destinations for Main Street between the two designs:



2020 without CDMP

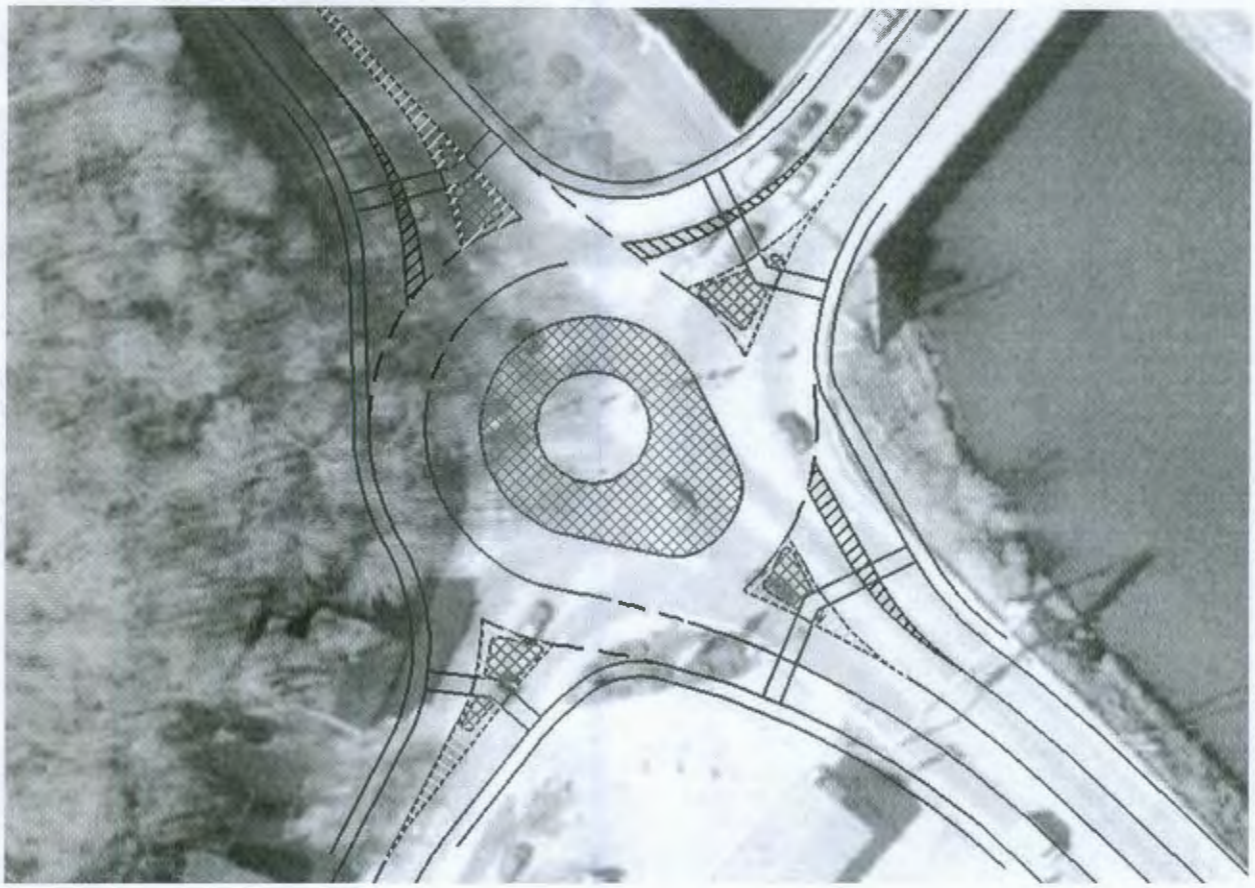


2020 with CDMP

4. c Site Constraints

The geometric layout process went through a few iterations due to the competing goals of minimizing the ROW impacts and providing desirable roundabout design conditions. Some of the desirable design conditions for this intersection are: getting appropriate deflection, accommodating the WB-67 design vehicle, providing pedestrian access and safe refuge within the splitter islands, and providing safe and reasonable access to the Mobil Station in the southwest corner of the intersection.

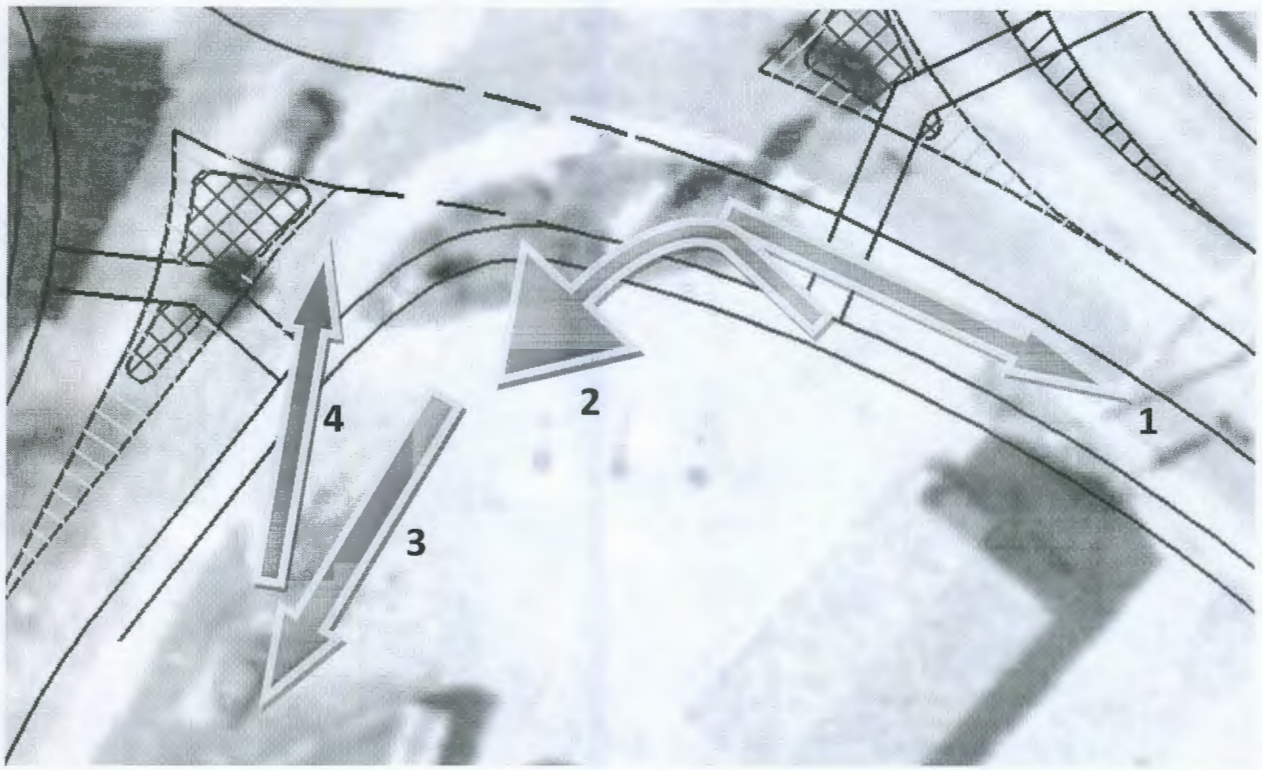
Below is the layout that was developed that seems to do the best job balancing these competing goals:



The current access allows permitted lefts near a signalized intersection which is a situation that is prone to accidents. The Mobil Station access will need to be modified to provide right-in/right-out only access management. The real challenge for the right-in/right-out layout is the ability for the tanker trucks to make fuel deliveries. The deliveries can be accommodated by using a mountable surface area, similar to a truck apron, just beyond the sidewalk in the northern corner of the lot near the in-ground tank filler caps. This is likely to be the method used by the delivery vehicles.

Depending on how frequently gas deliveries are made, as well as at what time the gas deliveries are made, it could be worth considering having the delivery truck back into the lot from Berlin Street, fill the tanks, continue to back up along Northfield Street, pull out onto Northfield Street, and proceed to the roundabout where all the other roadways are accessible.

Below is a diagram showing the movement pattern for the possible filling technique described above:



Step 1 – Truck pulls past the right turn in only access point on Berlin Street
Step 2 – Truck backs into northern corner of gas station lot to fill tanks
Step 3 – Truck continues backing up, parallel to Northfield Street
Step 4 – Truck now pulls out onto Northfield Street

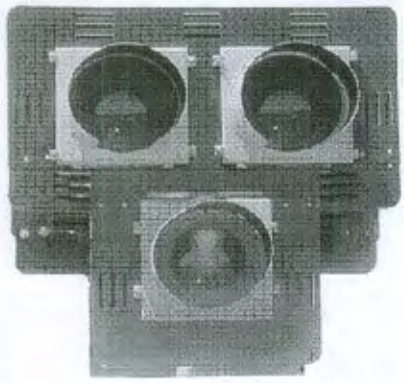
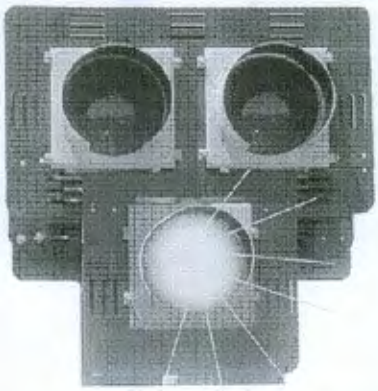
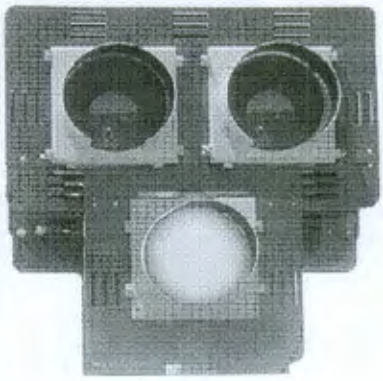
4. d Pedestrian and Bicyclist Accommodations

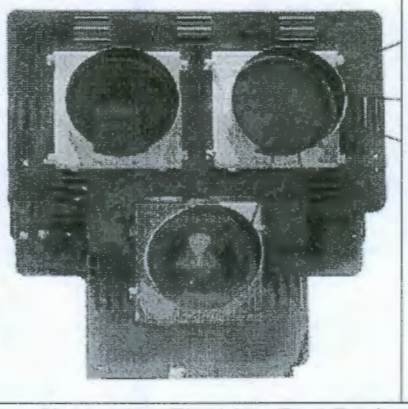
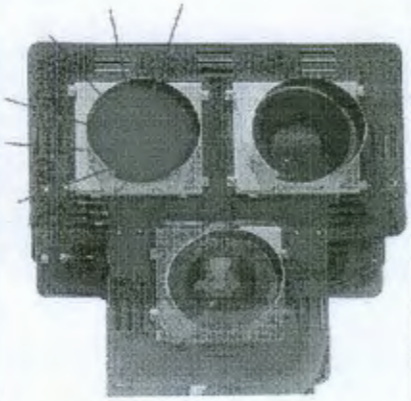
Providing pedestrian accommodations and the necessary pedestrian access refuge within the splitter islands was challenging because of the ROW restrictions at this intersection. The proposed design does provide sidewalks all the way around the intersection and acceptable pedestrian refuge within all the splitter islands. Bicyclists are allowed to choose between riding through the roundabout, operating as a motor vehicle, or leaving the roadway and using the sidewalks as a pedestrian.

There has been a recent push by the US Access Board to make all two lane roundabout crossings require some form of signalization. The US Access Board was created in 1973 and is an independent Federal agency devoted to ensuring accessible designs for people with disabilities. The motivation for this potential policy developments are concerns regarding how accessible a two lane roundabout crossing is to a visually impaired pedestrian. Many pedestrian orientation and mobility specialists believe that the current crossing techniques utilized by the visually impaired are not sufficient to

provide them with safe and efficient crossings at roundabouts. The accessibility issues include the continuous flow of traffic, the non-linear orientation of the crossing locations, and the overall unacceptable yielding rate for vehicles at roundabouts. The continuous flow of traffic at a roundabout makes it nearly impossible for a visually impaired pedestrian to accurately detect potential vehicle conflicts by using audible cues. At typical signalized intersections visually impaired pedestrians can listen for the mass flows of traffic, crossing when traffic is moving parallel with their desired movement and yielding when traffic is moving perpendicular to their desired direction of travel. The roundabout has curved sidewalks and "kinked" pedestrian crossings, both of which can make locating and properly navigating the pedestrian crossing a challenge for the visually impaired. Even with the "yield to pedestrian" laws that exist throughout Vermont and other states, most National studies have reported less than desirable driver yielding rates, even to pedestrians that are visually and/or physically impaired.

A likely potential solution to the above conditions is the use of signalized pedestrian crossings at roundabouts. The HAWK signal system, shown below, seems to be one of the more desired choices at this time:

		
Dark Until Activated	Flashing Yellow for 3 to 6 sec	Steady Yellow for 3 to 6 sec

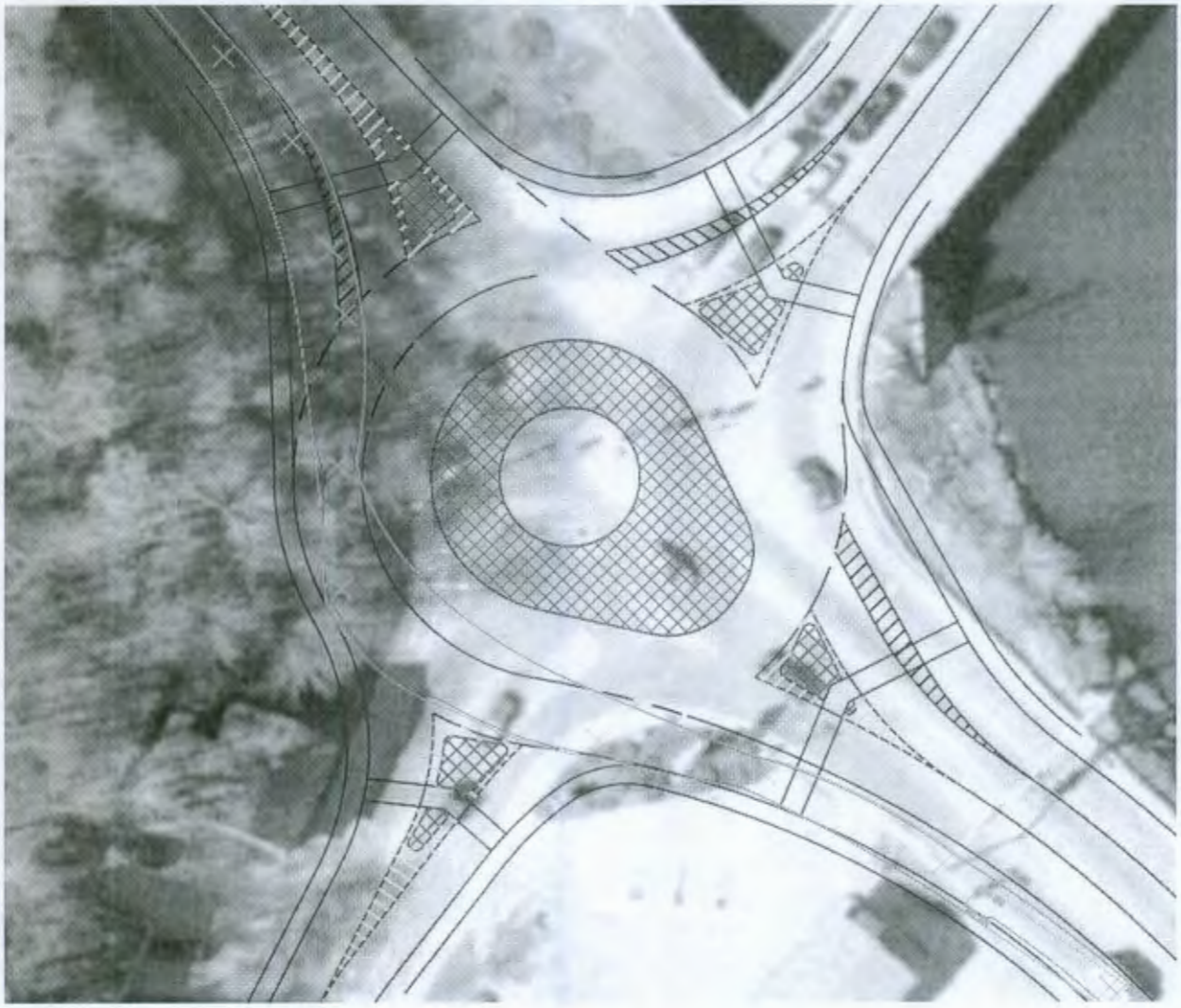
		
Steady Red during Pedestrian Walk Interval	Alternating Flashing Red During Pedestrian Clearance Interval	

This system, or one very similar, does address the undesirable conditions experienced by the visually impaired at multi-lane roundabout crossings. It would be pedestrian activated, have locator tones on both sides of the crossings, and in an even stronger fashion, legally require all vehicles to stop while a pedestrian is crossing. A signalized crossing solution, if desired and implemented, will not have an adverse affect on the roundabouts operations since it will only stop one movement per approach, the incoming or outgoing movement, at a time.

4. e Design Vehicle

US Route 2, Memorial Drive to the west and Berlin Street to the east of the intersection is on the National Highway System, The design vehicle for this intersection is the WB-67, an interstate type tractor-trailer with the 53 foot long box. This design vehicle requires a substantial area to turn right at the roundabout and a greater width than a typical car when entering and circulating around a roundabout. One design technique that helps provide the necessary approach width is the use of a center truck gore hatching between the approach lanes. The only movement within the roundabout where the WB-67 design vehicle encroaches into the adjacent lane is the through movement on US Route 2 in the right entering lane. This over-tracking, only within the roundabout, is shown

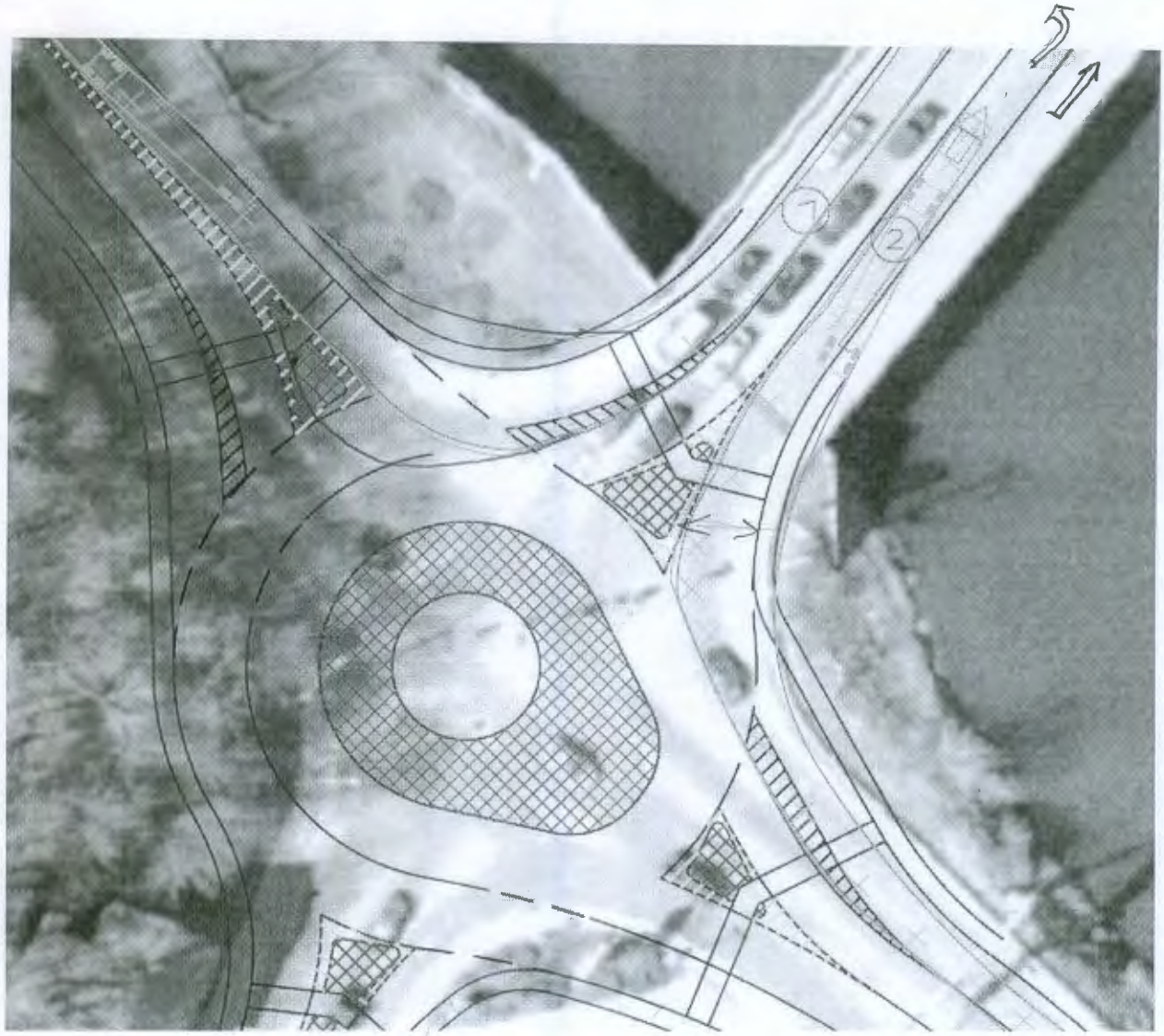
below:



Many roundabouts are designed with this over-tracking situation. The lower speeds within the roundabout combined with the reluctance of the typical driver to proceed side by side with the tractor-trailer make this a safe and acceptable condition. The right turns are typically only problematic when the exit is a single lane and at an angle around 90 degrees or less from the approach. The right turn movements from and to Main Street fit this condition. Many roundabouts are designed with similar type right turning conditions for large vehicles, the following sign has been implemented at some of these designs:

The WB-67 design vehicle will typically drive over part of the adjacent lane on the approach and use some of the splitter island out the exit to make this maneuver without jumping the outside curb. WB-67 vehicles having issues making right turns is not unique to roundabouts, it is just that a roundabout is a little less forgiving for these vehicles making these maneuvers. At a typical signalized intersection a WB-67 design vehicle will use the adjacent approach lane and commonly briefly uses the approach lane as it swings a wider arc than what the lane configurations can accommodate. Drivers will try to avoid jumping the outside curb as the paths show above, previous experience at other similar designs reveals that drivers do swing into the approach lane to the left and use some of the splitter as the go out the exit. Signs should be located where they will not prevent this type maneuver and not be damaged or destroyed during this maneuver. The right turn from Main Street can be further accommodated by placing an outside apron beyond the typical curb line location. The potential downside to this option is that it uses more of the northern quadrant and it pushes the sidewalk further into the shrub beds.

Below is an image showing how far the tractor-trailer would track beyond the exterior curb if it was kept within the approach lane markings for the movements to and from Main Street:



5. Future Considerations

5. a Geometric Revisions

The basic reason why a roundabout is safer than most other intersection types is because the roundabout is designed to operate in a lower speed environment than most of those other intersection types. This low speed environment is caused by deflection on the approach and/or around the center island. The only approach with less than desirable deflection is from the east on Berlin Street. There isn't a simple way to adjust the design to better the situation. The Winooski River Bridge doesn't allow the roundabout to be pushed to the northeast to increase the amount of deflection around the center island and businesses along Berlin Street do not allow the roadway to get pushed to the west in order to increase the amount of approach deflection. The

proposed design, utilizing the approach truck gore striping, does provide a decent design. The concern is that a driver could decide to "cheat" the designed deflection by using the right lane to go through the intersection, straightening out the curve by driving over the gore striping between the approach lanes. One potential way to address this is to make Berlin Street a single lane approach and implement a reverse curve on the approach to the roundabout. Berlin Street will need to be two lanes at the roundabout in order to operate at an acceptable LOS but Berlin Street can carry the roughly 960 vehicles expected to be on this approach in 2020 to the roundabout on one lane. If this design is considered the major decision will be where to create the one westbound approach lane on Berlin Street.

5. b Constructability

A common challenge with the implementation of roundabouts is the ability to construct the roundabout while maintaining traffic operations at the intersection. The best scenario is to close the intersection entirely, allowing for the safest and fastest construction of the roundabout. Incentive clauses, bonuses for the contractor to finish quickly, could be used to expedite the roundabout construction process. It could be possible to use the bridges on either side of this intersection to get traffic across the Winooski River. Traffic to and from Northfield Street could be directed to use Prospect Street and either School Avenue and/or Hill Street to get access to US Route 2. Maintaining traffic at the intersection during construction would require multiple phases and temporary signals and/or flagger control.

5. c Cost

The total cost for the construction of a roundabout at this intersection could vary greatly based on the techniques used to maintain traffic during construction and the cost for any ROW necessary for the footprint of the roundabout. The construction only cost for a roundabout of this size is typically between $500,000 and $900,000. All other costs would have to be determined through a more detailed study and a more complete design.

6. Conclusion

The roundabout option for this intersection is a viable alternative. The existing intersection does have physical constraints: the Winooski River, the Main Street bridge, a rock ledge, and commercial properties, making the design more challenging than some other roundabout designs but not impossible. The design isn't so compromising that the roundabout should not be considered for a thorough and complete design

project. This roundabout should provide the City of Montpelier with a very safe and efficient intersection for many years to come.