The Modern Roundabout Is The Solution

To Traffic Congestion At The Y.

(The Tribal Trail Connector Road Is Not!)

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1.0 Introduction

Over the past several years, I've written and handed out multiple versions of a research paper about the Tribal Trail Connector Road, the "TTCR", and the plans to widen WY22 and WY390 (the Village Road). In these documents I've stated that the TTCR does not solve traffic congestion at the US26/89/191-WY22 intersection, the "Y". Instead, the TTCR will cause more traffic problems and numerous other negative effects. As an alternative, I've proposed the following plan.

- Build a 2-lane modern roundabout at the Y.
- And, due to its close proximity to the Y, the WY22-Spring Gulch Road intersection affects traffic at the Y and must be addressed. So, build a single-lane modern roundabout or an underpass at the WY22-Spring Gulch Road.

And, using data from many sources, I've demonstrated that this alternative plan will substantially reduce, if not eliminate, the traffic congestion at the Y and have several other positive effects.

> (Further, using the same data, I would like to also state that building a single-lane modern roundabout at the WY22-WY390 intersection would significantly relieve and quite possibly eliminate traffic congestion at that intersection as well.)

In this paper, I will focus on the TTCR. To do so, I will reiterate and add to what I've covered in my previous papers and further elaborate on the issue.

To begin, here's a brief review of the history of the TTCR project.

In the 1990's, Teton County and the town of Jackson developed the Jackson Hole Transportation Plan, the "JHTP", to meet the projected future transportation needs of the county and the town. The TTCR was among the projects listed in the plan. It was proposed in order to reduce traffic congestion at the Y and provide a redundant route for WY22. Basically, the TTCR project consisted of the following:

- Build a road extension from the end of Tribal Trail Road to WY22 and connect it to WY22 with an underpass.
- Improve South Park Loop Road by widening the pavement and shoulders from the intersection of South Park Loop Road, Tribal Trail Road, and Boyles Hill Road to the US26/89/191-South Park Loop Road intersection south of Jackson.
- The TTCR would be built as part of or after the project to widen WY22 from two to five lanes between Jackson and Wilson.

In 2004, according to Craig Jackson, a Teton County Engineer, the Wyoming Department of Transportation, "WYDOT", stated that the congestion at the Y and at the WY22-WY390 intersection were the only traffic problems in the valley. Since then, a traffic signal has been installed at the WY22-Spring Gulch Road intersection, causing congestion at that intersection, affecting the traffic flow at the Y, and creating a third traffic problem in the valley. (Note that all three of these traffic problems are on WY22 and all are at traffic signal-controlled intersections.)

In 2005, also according to Craig Jackson, the projects to widen WY22 and build the TTCR were not scheduled to start before 2013.

In 2008, WYDOT prepared and published a report on a traffic demand model study done about the Y for Teton County. The report predicted that the TTCR would reduce traffic numbers at the Y by 28%. Based on this prediction, the Transportation Advisory Committee, "TAC", proposed that the TTCR should become a standalone project and be built as soon as possible.

Since issuing the proposal, the TAC has conducted a number of public meetings about the TTCR. Unfortunately, the discussions have centered on addressing public concerns about the TTCR. There hasn't been any <u>serious</u> discussion about whether the TTCR is a good solution to traffic congestion at the Y.

Recently, the TTCR proposal was tabled due to higher priority projects and a limited budget.

2.0 The Tribal Trail Connector Road Is Not A Solution.

Since I've already stated that the TTCR is not a solution, in this section I will explain why that's so. Here are the topics I will discuss.

- 2.1 The TTCR Proposal – An Analysis
- 2.2 Predicted Impacts of the TTCR
- 2.3 Conclusion
- 2.4 References

2.1 The TTCR Proposal – An Analysis

According to the WYDOT traffic demand model report and the JHTP, the TTCR will meet the following requirements,

- The TTCR will reduce traffic numbers at the Y.
- The connector will provide a redundant route for traffic travelling between south of Jackson and west of Jackson.

And, according to the Teton County Engineering Department, when the TTCR is built,

- The forecast daily traffic flow on the TTCR will be between 7,000 and 9,000 vehicles. (Recently, the county revised the estimated traffic flow down to 5,000 vehicles a day. How the county arrived at this new figure is unknown. So, I will use the previous estimate for now.)
- Only 10% to 15% of the traffic will be non-local, consisting mainly of commuters, and won't cause any significant delays.

2.11 Reduce Traffic Numbers at the Y

The TTCR will reduce traffic numbers at the Y. However, the TTCR will not reduce congestion on WY22. Instead, the TTCR will just move part of the congestion from the Y to the proposed WY22-TTCR intersection and generate additional congestion at the new intersection. And, the TTCR will create congestion at the existing US26/89/191-South Park Loop Road intersection south of Jackson and along the roads in the TTCR-Tribal Trail Road-South Park Loop Road corridor, especially during the morning and evening commute periods. Here's an example.

> During the evening commute period, vehicles traveling eastbound on WY22 will approach the WY22-TTCR intersection at between 45 mph and 55 mph. Vehicles that intend to exit onto the TTCR will have to slow down to less than 25 mph in order to exit safely. So, traffic will arrive at the intersection at about twice the rate that they will be able to exit onto the TTCR. In a perfect world the vehicles decelerating and exiting would not cause any problems. There would be only a reduction in the distance separating vehicles. However, in the real world drivers do not behave in exactly the same way under the same circumstances. (And, due to differences in handling, vehicles will not maneuver in the same way.) So, variations in driver behavior (and vehicle handling) will adversely affect the traffic flow by creating waves of slowing, sometimes stopped, then, accelerating vehicles similar to the ripples created when a stone is tossed into water. And, these waves will more than likely move back along the entire length of the traffic flow. This effect could occur every time a vehicle exits. So, there will be accordion-like, rolling backups and at times stopped traffic on WY22 during the evening commute period. And, there may be times when these backups could stretch to and quite possibly beyond the Snake River Bridge, affecting the WY22-WY390 intersection. In addition, backups will also occur on South Park Loop Road getting onto US26/89/191. Further, because vehicles will have to come to a stop before turning right onto US26/89/191, backups at this intersection could be even longer than the WY22-TTCR intersection backups.

This same scenario will also occur on US26/89/191 when vehicles turn left off the highway onto South Park Loop Road and on the TTCR getting onto WY22 during the morning commute. And, congestion will also occur on all these roads at other times of moderate to heavy traffic.

This kind of traffic behavior have been well-documented by engineers, mathematicians, physicists, and other scientists involved in the study of road systems, traffic, and traffic control using a variety of scientific methods, including computer modeling using one or more mathematical techniques derived from chaos theory, fluid and gas dynamics, computer and cellular networking theory, and other sources, also, by conducting controlled experiments on closed circuit roads and studying real traffic. And, this traffic behavior is also well-known through direct experience by millions of ordinary drivers.

2.12 Provide a Redundant Route

The requirement that there needs to be a redundant route to connect US26/89/191 to WY22 in the case of an emergency or some other unforeseen circumstance is a good idea. However, this is not a sufficient reason to build the TTCR. First, redundancy already exists for US26/89/191 from the south end of South Park Loop Road to the Y via South Park Loop Road and Jackson streets. Second, on the short, about a mile and a half, section of WY22 from the Y to the Indian Springs Ranch turnoff, which is the approximate location of the proposed WY22-TTCR intersection, an accident could close the highway for a significant period of time. However, I've lived within sight of this section of the highway for twelve years. And, I've seen only one accident which has closed the highway. (Tragically, it was a fatal accident which occurred this year.) So, do we build the TTCR to handle a circumstance that occurs every twelve years? I think not.

Further, there are many other sections of the road system that are more in need of redundancy, including:

- US26/191 north of Gros Ventre Junction,
- US287 east of Moran Junction,
- Two sections of US26/89/191 between the US26/89/191-South Park Loop Road intersection south of Jackson and Hoback Junction,
- US26/89 from Hoback Junction to Alpine Junction,
- US191 from Hoback Junction to Daniel Junction, and
- WY22 and ID33 from Jackson to Victor.

Now, given enough time and the willingness to drive long distances, all of these highways have some sort of alternative route, as well as the short section of WY22 touted as needing the TTCR for redundancy. And, because some of the highways on this list have more hazards and more frequent accidents due to terrain, road characteristics, and weather conditions, these highways are far more likely to need a redundant route at any time. And, lastly, if there really was an emergency that made it absolutely necessary to re-route traffic off WY22 between the Indian Springs Ranch turnoff and the Y, traffic could be routed through the Indian Springs Ranch. The TTCR would only shorten the route slightly. So, a shorter redundant route is only a minor benefit to building the TTCR.

2.13 Traffic Flow and Origins

The forecast daily traffic volume on the TTCR, Tribal Trail Road, and South Park Loop Road of 7,000 to 9,000 vehicles is far higher than the number of local South Park users. This means that many others will use the connector, including commuters living outside of South Park, commercial vehicles, and tourist traffic. So, the 10% to 15% estimate for non-local traffic is much too low.

2.14 Commuters and Delays

The forecast that building the TTCR won't cause any significant delays in South Park is not realistic. Using the assumption that all traffic is round trip, this means that there will be between 3,500 and 4,500 vehicle round trips per day. Using the forecast that 10% to 15% of this traffic will be commuters, means that there will between 350 and 675 vehicles using the TTCR, Tribal Trail Road, and South Park Loop Road for about 30 to 45 minutes each morning and evening. Using these estimates, during a 30 minute commute period, assuming the vehicles are spaced equally, a vehicle will pass by any given point on these roads every 5.1 seconds down to as little as every 2.7 seconds. For a 45 minute period that's 7.7 seconds down to 4 seconds. This short interval leaves very little room for a vehicle to safely enter or cross the TTCR, Tribal Trail Road, and South Park Loop Road during the commute period. So, there will be delays (backups) on streets intersecting these roads.

2.2 Predicted Impacts of the TTCR

When the TTCR is built, what will happen to the people, wildlife, and the environment in South Park? Here are some predictions,

- Increased traffic numbers and higher traffic speeds
- Increased health risks
- Loss of the natural environment
- Loss of livability and housing values
- Increased residential density
- Commercialization

2.21 Increased Traffic Numbers and Higher Traffic Speeds

Increased traffic numbers and higher traffic speeds on the TTCR, Tribal Trail Road, and South Park Loop Road will increase hazards to vehicles, pedestrians, cyclists, and wildlife. It will be necessary to post a speed limit that's "reasonable" for the TTCR, Tribal Trail Road, and South Park Loop Road. However, the TTCR and the improvements to the section of South Park Loop Road from the intersection of South Park Loop Road, Tribal Trail Road, and Boyles Hill Road south to the US26/89/191-South Park Loop Road intersection will create a roadway that's similar to Tribal Trail Road. And, Tribal Trail Road was designed to handle highway speeds of 50 mph or more. To keep vehicles at some speed below highway speeds will be difficult, if not impossible. So, due to speeding traffic, vehicles attempting to enter or cross the roads and pedestrians, cyclists and wildlife trying to cross the roads will find it difficult to do so. And, during the commute period the heavy traffic may make these roads nearly impossible to enter or cross.

The pathways adjacent to Tribal Trail Road and South Park Loop Road are used by many people within and outside the immediate neighborhoods largely due to the safety of the pathway and the relative peace and quiet of the area. If the TTCR is built, the close proximity of the road to the pathway, the higher traffic speeds, increased traffic numbers, higher noise levels, greater volumes of exhaust fumes, additional dust, dirt and gravel kicked-up by passing vehicles, and the reduction in the margin of safety will contribute to a significant drop in pathway usage, down to only those few who presently commute by bicycle. This effect can be seen on the pathway alongside US26/89/191 between Jackson and South Park Loop Road.

And, with the increased traffic numbers and higher traffic speeds wildlife will have a lot of trouble moving around and migrating safely. There will be a significant increase in the number of vehicle-animal collisions.

2.22 Loss of the Natural Environment

What small portion of the natural environment that's left in South Park will be further reduced and degraded when South Park Loop Road is rebuilt as part of the TTCR project. To rebuild South Park Loop Road will the removal of the cottonwoods, willows, and other vegetation on both sides of the road in order to accommodate the widening of the pavement and shoulders, leaving a barren corridor. Also, the increased traffic and higher speeds will increase the noise level, pushing the wildlife away from areas along the roads that may still have some natural features. And, having its two longest sides bordered by heavily used roads, the Teton Science School's property south of WY22 will suffer from the ill effects of the increased traffic.

2.23 Increased Health Risks

Many medical studies have found a wide range of negative health effects due to living near busy roads.

- A 2005 study found that the risk of asthma increased 89% for each quarter-mile closer children lived to a major roadway.
- A 2007 follow-up study found decreased lung air flow function for children living within 1,500 feet of a major roadway.
- Researchers have found that children who attend schools near high-traffic areas are 45 percent more likely to develop asthma.
- A higher exposure to traffic emissions was associated with an increased risk of breast cancer among women in Erie and Niagara Counties in New York.
- A study in Stockholm found a 40% increase in lung cancer risk for the group with the highest average traffic-related nitrous oxide exposure.
- A Danish study reported rates of Hodgkin's disease increasing by 51% in children whose mothers were exposed to higher levels of nitrous oxide during pregnancy.
- Multiple studies have found serious health effects from exposure to heavy-duty diesel trucks, including increased mortality rates. Diesel emissions on busy roads have been associated with triggering asthma attacks and may play a role in the initial onset of asthma.
- A just released American Heart Association survey of studies conducted over the last six years found that the air pollution emanating from busy roads caused a 50% increase in the risk of heart disease in people living within 100 yards of these roads when compared to people living further away.
- Multiple studies have found that traffic noise adversely affects health, including sleep patterns, stress levels, blood pressure, and mood.

So, considering the large volume of traffic that will use the TTCR, Tribal Trail Road, and South Park Loop Road, the increased air and noise pollution that will occur and the prevailing south to southwest winds, which will extend the affected area, many South Park residents will face increased health risks when the TTCR is built.

2.24 Loss of Livability and Property Values

In addition to the health risks, the TTCR will bring a substantial loss of basic quality of life in South Park. The increased traffic will make it difficult to access the residential areas along the road. The traffic noise will make going to bed early or sleeping late difficult. The increased air and noise pollution and the additional dust and dirt will make being outdoors unpleasant. Under these conditions it will be difficult to sell property that's located within a short distance of a heavily used road for what would be considered a fair price elsewhere in the valley.

2.25 Increased Residential Density

In the past there has been pressure from various individuals and commercial interests to build additional large housing projects in South Park. The TTCR and the rebuilt South Park Loop Road will help facilitate bringing such large projects to the area, further degrading livability and the environment by adding more traffic, increasing congestion, and producing more pollution.

2.26 Commercialization

Because the TTCR will be a bypass around Jackson, there will be efforts made to allow retail businesses in areas along the roads to service the traffic, in particular gas stations and mini-marts. These efforts are in direct conflict with the stated mission of the Teton County Comprehensive Plan of having the "town as heart" and keeping commercialization away from county residential areas.

2.3 Conclusion

Building the TTCR will do many things, none of them positive, except that it provides another redundant route for a short section of WY22. Here's what else the TTCR will do:

- The TTCR won't relieve traffic congestion on WY22. It will just move a small part of the congestion at the Y to the proposed WY22-TTCR intersection and generate additional congestion at the new intersection, creating a fourth traffic problem on WY22.
- The TTCR will create congestion at the US26/89/191-South Park Loop Road intersection south of Jackson.
- The TTCR will cause congestion at other locations in the TTCR-Tribal Trail Road-South Park Loop Road corridor.
- The TTCR will add to the negative health effects of traffic in South Park.
- The TTCR will increase the traffic hazard for pedestrians, cyclists, and wildlife in South Park.
- The TTCR will reduce the quality of life in South Park.
- The TTCR will lower property values in South Park.
- The TTCR will enable an increase in residential density in South Park, increasing traffic, adding to congestion, and producing more pollution.
- The TTCR will facilitate adding commercialization to South Park.

Clearly, the TTCR is not a solution to relieving congestion on WY22. And, it will cause significant irreversible harm to the South Park community. In essence, if the TTCR is built, it will become a new problem that the valley will have to deal with in the future.

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3.0 The Modern Roundabout Is The Solution.

To understand why modern roundabouts will work, in this section I will discuss these traffic control structures in detail.

3.1 <u>What Is a Modern Roundabout? A Definition</u>

There's a lot of misunderstanding about what a modern roundabout is. Many people confuse modern roundabouts with traffic circles. There are big differences between these two traffic control structures. To provide a better understanding of what a modern roundabout is, this sub-section will cover the following topics:

3.11 A brief history of modern roundabouts
3.12 A discussion of the significant differences between modern roundabouts and traffic circles
3.13 Examples of modern roundabouts and traffic circles with discussion
3.14 An analysis of three Idaho Falls roundabouts

3.11 History

The traffic circle was one of the first structures designed to control motor vehicle traffic at intersections. The first traffic circle was Columbus Circle in New York City which opened in 1905. Many traffic circles were built in subsequent decades in the United States, Canada, and Europe.

> (It was during these early times that the confusion between roundabouts and traffic circles began. Back then, all circular and semi-circular traffic structures had interchangeable names, including gyratory (the earliest name), traffic circle, rotary, and roundabout. Now, "real" roundabouts are referred to as "modern" roundabouts to distinguish them from the earlier names and designs.)

In the 1950's, due to their inherent problems, construction of traffic circles basically stopped in the U.S. and Canada. And, many traffic circles in these countries were converted to conventional intersections using traffic signals or stop signs. Applying the lessons learned from traffic circles and based on studies of various methods of traffic control around traffic circles, traffic engineers in the United Kingdom developed the modern roundabout design in the 1960's. First, the "yield to circulating traffic within the roundabout" rule was adopted which increased traffic capacity and decreased the accident rate. Next, the size of the roundabout was reduced which added more traffic capacity and further decreased the accident rate. Then, in 1971, the U.K. government issued the first modern roundabout design guidelines. Within 10 years, other European countries had adopted their own guidelines. And, within a few years the rest of the world followed suit. Today, there are more than 20,000 roundabouts in France, 15,000 in Australia, and 10,000 in the United Kingdom. And, roundabouts are becoming more prevalent than traffic lights or stop signs to control intersections in the rest of the world.

The first modern roundabouts in the United States were built in Nevada in 1990. Since then, more than 1,000 modern roundabouts have been built in this country. There are active state roundabout construction programs in more than half the states. For example, since 1997, the Washington State Department of Transportation has built 120 modern roundabouts on state highways with more being planned for the future. In addition, others have been built by road departments in counties, cities and towns all around the state. And, in Wyoming, there's a 5-way, 2-lane modern roundabout being built in Cheyenne at the large triangular intersection of East Pershing Boulevard, Converse Avenue, and 19th Street which is scheduled to be completed this year. The modern roundabout was designed by Ourston Roundabout Engineering, the premier roundabout engineering firm in North America. (The company's web address can found on page 19.)

3.12 The Differences Between Modern Roundabouts and Traffic Circles

There are three basic design principles that distinguish modern roundabouts from traffic circles:

1. Yield at Entry
   In modern roundabouts entering traffic must yield to circulating traffic. This allows the roundabout to continue to function when the traffic becomes heavy.

Most traffic circles do not have this basic rule. So, entering traffic can cut off and stop circulating traffic. And, when the traffic is heavy, traffic circles can suffer gridlock. In fact, there are a few traffic circles which use traffic signals and/or stop signs to control traffic, making them not much different than conventional intersections.

2. Deflection

   Traffic entering a modern roundabout is deflected around the center island. This slows traffic and allows entering vehicles to find a gap in the circulating traffic and move into it.

   Traffic circles do not have deflection entries. So, entering traffic moves ahead at speed which results in merging problems with the circulating traffic.

3. Flare

   Many modern roundabouts are built along roads with limited space for expansion. To provide more capacity, roads are often flared at a roundabout's entrance to accommodate one or more additional lanes which adds capacity and eliminates the need for widening roads between roundabouts.

   Traffic circles do not have flared entrances. This keeps capacity low even with a large traffic circle. So, roads must be widened to provide additional capacity.

There are two other related characteristics that differentiate modern roundabouts from traffic circles, size and circulating speed.

Modern roundabouts are designed for low speed entry, low speed "gapping", rather than merging, and low speed exiting. To accomplish these objectives, first, the center islands are much smaller than those in traffic circles, generally 15 feet to 120 feet in diameter with a few as large as 200 feet, enforcing the lower circulating speeds of 15 mph to 25 mph. Lower speeds lead to much lower accident rates and the accidents that do occur are rarely serious.

Traffic circles are designed for high speed entry, high speed merging, and high speed exiting. This is accomplished by the use of a large center island, usually 300 feet or more in diameter. This design allows speeds of 25 mph to more than 40 mph within the circle and actual speeds can be much higher. (The very large MacArthur Drive South Traffic Circle in Alexandria, Louisiana has circulating speeds of close to 50 mph.) The high-speed conditions within the circle force entering vehicles to merge with circulating vehicles at high speeds which require long distances to be safe. At 40 mph, 240 feet is required for safe merging. Traffic circles are very seldom large enough for safe merging, which can lead to numerous and serious accidents. And, in multi-lane traffic circles vehicles in the inner lane must make dangerous, high-speed maneuvers to weave through traffic to get to the outer lane(s) in order to exit. This condition can also lead to numerous and serious accidents.

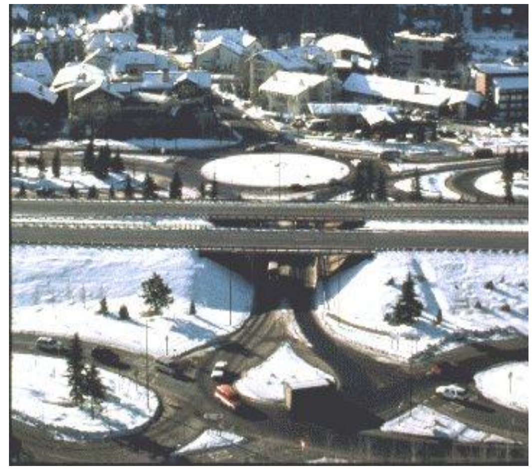
3.13 Modern Roundabout and Traffic Circle Examples

The following pages show photo examples of modern roundabouts and traffic circles. Each photo has an accompanying description of the structure, pointing out features and benefits and/or problems.

This is an aerial photo of a 5-way, 2-lane modern roundabout near I65 in Branson, Missouri.

In the photo you can see the triangular medians at each street that deflect vehicles to slow traffic. Notice that the two entrances at the bottom of the photo are flared from one lane to two lanes to increase capacity. And, note that vehicles in the inner lane do not need to change lanes to exit the roundabout. Also, the relatively small size of the modern roundabout allows entering vehicles to see circulating traffic in the entire structure. And, the crosswalks only cross one direction of traffic at a time and are set back from the circulating roadway.

Here are two views of the I70 interchange at Vail Road with two modern roundabouts in Vail, Colorado.



This interchange and another at I70 and Chamonix Road further west had ramp intersections that were controlled by stop signs before conversion. On weekends during the ski season traffic would backup onto I70 for a considerable distance. The town of Vail was forced to use law enforcement personnel to manually control traffic in an attempt to manage the congestion. The town spent as much as $85,000 a year on manual traffic control at these two interchanges. When the intersections at both interchanges were converted to modern roundabouts, the backups were reduced to a level that no longer required manual traffic control, saving Vail a lot of money. Note that the large roundabout in the photos is at a 6-way intersection with a traffic capacity of 5,200 vehicles an hour and the smaller, teardrop-shaped roundabout is at a 4-way intersection with a capacity of 2,700 vehicles an hour.

This is Avon Road in Avon, Colorado.

There are five modern roundabouts on Avon Road. This photo shows four of them, stretching from the interchange intersection on the south side of I70 at the bottom left corner of the photo to the intersection with US6 at the top edge of the photo. (The fifth roundabout is at the interchange intersection on the north side of I70 off the bottom of the photo.) The interchange roundabout at the bottom left corner of the photo has a capacity of 5,800 vehicles an hour. The oval-shaped roundabout in the center of the photo with the “Wal-Mart” tractor trailer rig in it has a capacity of 6,000 vehicles an hour. The roundabout just above the oval-shaped roundabout has a capacity of 4,300 vehicles an hour. And, the roundabout at the top of the photo has a capacity of 4,900 vehicles an hour.

Here's an aerial view of a single-lane modern roundabout at the intersection of Lineville Road and Rockwell Lane adjacent to a school in Brown County, Wisconsin, north of Green Bay.

This intersection is quite similar to both the WY22-Spring Gulch Road and the WY22-WY390 intersections. Clearly, this modern roundabout design would work at the WY22-WY390 intersection.

This is an aerial view of a traffic circle, the well-known Dupont Circle in Washington, D.C.

In the picture you can see that an entering vehicle has only a short distance to merge into the circulating traffic before encountering another intersecting street. And, note at the top of the picture the problem that a vehicle in the inner lane would have trying to weave through the traffic in the outer lane and exit the circle. Also, notice that some of the streets intersecting the circle do not have long enough sight distances to see oncoming traffic well enough to safely enter the circle. Now, look at the crosswalks. Pedestrians crossing the street in the same direction as the circulating traffic in the circle cannot see vehicles exiting the circle. And, the crosswalks that cross the circle are in place to reduce the large distance required to get from one side of the traffic circle to the other, which is very hazardous due to short sight distances and circulating traffic speeds.

Here's the world's first traffic circle, Columbus Circle in New York City.

This photo shows the complexity of a traffic circle. To emphasize the difficulty in navigating this traffic circle by both vehicles and pedestrians, there are traffic signals controlling vehicle entries and crosswalks within the circle which further delays traffic through the circle. Notice that a vehicle in the inner lane must cross two lanes to exit the circle at two of the four street exits. And, two lanes of traffic at the intersection at the top left of the photo must merge into one lane as vehicles enter the circle.

Here's an aerial view of MacArthur Drive South Traffic Circle in Alexandria, Louisiana.

3.0 The Modern Roundabout Is The Solution.

As the photo on the previous page shows, traffic circles can be very large. As I stated in sub-section 3.12, circulating speeds in this traffic circle are close to 50 mph. (I have driven through this circle and experienced the racetrack-like conditions first-hand.) Such high speeds make maneuvering difficult during times of moderate to heavy traffic and can lead to numerous accidents. In 2009, there were 109 accidents in this circle. Through May 20th of this year, there have been 53 accidents or about one every three days.

This is an aerial photo of a conversion project just off the New York State Thruway in Kingston, New York, where the outer traffic circle is being replaced with the much smaller, inner 2-lane modern roundabout.

This photo shows quite clearly the difficulties and hazards of traffic circles with short merging distances at the three intersections at the top of the photo and the necessity for circulating vehicles in the inner lane to move to the outer lane to exit in the same short distance used for merging. As can be observed, the smaller modern roundabout does not have these problems. In fact, there are bypasses around the roundabout for through traffic which increases the roundabout's capacity for turning traffic and further reduces traffic delays.

Here's a photo of another type of circular traffic control structure that's being used in some urban and suburban areas in this country; it's usually called a "calming circle". This one is located at North 36th Street and Meridian Avenue North in Seattle, Washington. (I've driven through this intersection.)

These structures are basically very small traffic circles. These circles are intended to slow, "calm", traffic through intersections which have no other traffic control structures, such as stop signs or yield signs. In most cases, local residents consider these circles nuisances. Depending on the size of the surrounding streets, these structures can be difficult to make turns around. Large vehicles, such as delivery trucks, garbage trucks and fire trucks (and vehicles traveling too fast) usually have to drive over the curbs to get around these structures. (Notice the tire marks on the edge of the curb of this circle.) And, there have been accidents around these structures where vehicles have lost control after hitting the circle's curb and veered into yards near the circle. In a few cases, vehicles have hit homes. (I've personally seen the aftermath of such accidents.) So, these so-called "calming circles" aren't effective in controlling traffic.

3.14 An Analysis of Three Idaho Falls Roundabouts

The only experience that many Teton County residents have with roundabouts is driving through the few that have been built in the Idaho Falls area. An analysis of three of these roundabouts would assist in understanding modern roundabouts. One is located on South Utah Avenue at Taylor's Crossing across the Snake River from downtown. The other two roundabouts are east of Idaho Falls on North 25th East, one at the intersection with East Lincoln Road and the other at the intersection with East Ione Road.

The roundabout on South Utah Avenue is a 3-way, single-lane roundabout. It surrounds a fountain containing a large sculpture. The roundabout is quite large for the street size and could possibly be converted to a two lane roundabout. However, due to the fact that the intersecting street with South Utah Avenue is not used by much traffic, the roundabout only serves as a bypass around the fountain. It's not a good example of a modern roundabout.

The roundabout at North 25th East and East Lincoln Road is a 4-way, single-lane modern roundabout. This intersection is heavily used by commuters and commercial traffic. It works. However, the roundabout is poorly designed. It's too small, limiting the efficient circulation of traffic within the roundabout, especially large commercial vehicles. And, the small size hampers the proper deflection of entering traffic. So, it operates more like a traffic circle than a roundabout. The design should have been similar to the other roundabout located further north on North 25th East at the intersection of East Ione Road.

The roundabout at North 25th East and East Ione Road is an example of a 4-way, single-lane modern roundabout. This roundabout works better than the East Lincoln Road roundabout. It has the correct design for its size, including proper deflection for entering traffic and smooth exits. Unfortunately, as with the other roundabout, its size limits efficient traffic flow.

As these Idaho Falls' roundabouts demonstrate, proper design is essential for efficient modern roundabout operation. But, in spite of these shortcomings, these roundabouts still work better than traffic signals or stop signs at these intersections.

3.2 Improved Safety

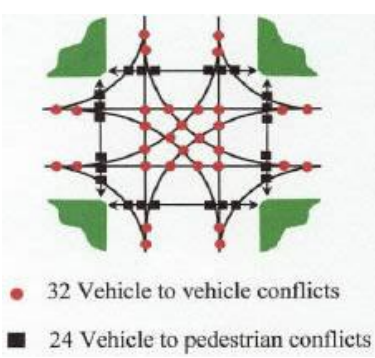
When compared to conventional types of intersections which use traffic signals or stop signs to control traffic flow, modern roundabouts are much safer for vehicles, pedestrians, and cyclists. In this sub-section the following topics will be discussed.

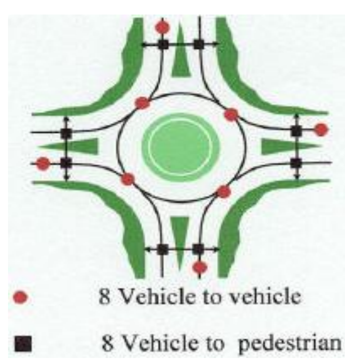
- 3.21 Vehicle-to-vehicle, vehicle-to-pedestrian, and vehicle-to-cyclist conflicts
- 3.22 Vehicle accident and injury rates
- 3.23 Pedestrian accident and injury rates
- 3.24 Cyclist accident and injury rates

3.21 Vehicle, Pedestrian, and Cyclist Conflicts

Because there's no crossing traffic in a modern roundabout, vehicle-to-vehicle, vehicle-to-pedestrian, and vehicle-to-cyclist conflict points are reduced, which also reduces the risk of accidents. In nearly all cases, cyclists traveling roads without bicycles lanes are considered vehicles and must obey the same traffic rules and laws. So, vehicle-to-vehicle conflicts can also be considered vehicle-to-cyclist conflicts.

- At a conventional 4-way intersection with 2-lane roads there are 32 possible vehicle-to-vehicle (or cyclist) conflict points and 24 possible vehicle-to-pedestrian conflict points. A modern single-lane roundabout reduces those numbers to 8 for both types of conflicts or a 75% reduction for vehicle-to-vehicle (or cyclist) and a 67% reduction for vehicle-to-pedestrian. (See the diagrams below.)





3.0 The Modern Roundabout Is The Solution.

- At a conventional 4-way intersection with 4-lane roads there are 48 possible vehicle-to-vehicle (or cyclist) conflict points and 32 possible vehicle-to-pedestrian conflict points. A 2-lane modern roundabout reduces those numbers to 16 for both types of conflicts or a 67% reduction for vehicle-to-vehicle (or cyclist) and a 50% reduction for vehicle-to-pedestrian.

3.22 Vehicle Accident and Injury Rates

Modern roundabouts have significantly lower vehicle accident and injury rates than conventional intersections.

- In 2001, the Insurance Institute for Highway Safety conducted a study of 23 intersections in the U.S. that had been converted from traffic signals or stop signs to modern roundabouts. The study found a 37% lower accident rate and an 80% lower injury rate at these converted intersections.
- A 2002 study of 15 single-lane modern roundabouts in Maryland showed a 60% decrease in accident rates, an 82% reduction in injury rates, and a 100% decrease in fatalities.
- Another study conducted by the National Cooperative Highway Research Program found that installing modern roundabouts led to a 35% reduction in the accident rate and a 76% reduction in accidents causing injuries or fatalities.
- Studies in the other countries have reported the following results:

Country	All Crashes	Injury Crashes
Australia	41-61%	45-87%
France		57-78%
Germany	36%	
Netherlands	47%	
United Kingdom		25-39%

- In 2004, there were more than 2.7 million intersection-related accidents in the United States. That same year, there were 9,117 intersection accident fatalities. Based on this data and the findings of the National Cooperative Highway Research Program study for accident and injury rate reductions in the U.S. for modern roundabouts, converting just 25% of the conventional intersections in the United States to modern roundabouts could reduce the annual number of intersection accidents by more than 236,000 and could save more than 1,700 lives per year.

3.23 Pedestrian Accident and Injury Rates

The pedestrian accident and injury rates at modern roundabouts are lower than for conventional intersections. There are four principle factors for the improved safety.

1. Pedestrians travel on walkways around the perimeter of the circulatory road.
2. Pedestrians cross only one direction of traffic at a time.
3. Roadway crossing distances are relatively short.
4. And, approach, circulating, and exit speeds are significantly lower than for conventional intersections.

Currently, there are no U.S. studies available concerning pedestrian safety improvements at modern roundabouts. However, there are a few studies from Europe.

- A United Kingdom study found about a 46% reduction in pedestrian crash rates at modern roundabouts compared to conventional intersections.
- A study in the Netherlands of 181 intersections converted to modern roundabouts found a 73% reduction in pedestrian accidents and an 89% reduction in injuries.
- An analysis was conducted on accident data, dating from 1985 through 1989, on 59 modern roundabouts and 124 traffic signal-controlled intersections in Norway. There were 33 crashes involving personal injury recorded at the modern roundabouts. Only 1, or 3%, of these crashes involved a pedestrian. There were 287 personal injury crashes at the traffic signal-controlled intersections with 57, or 20%, involving pedestrians. So, roundabouts reduced the pedestrian injury rate by 96%.

3.24 Cyclist Accident and Injury Rates

There's conflicting data about the safety of cyclists at modern roundabouts.

- A study in the Netherlands of 181 intersections converted to modern roundabouts found an 8% reduction in accidents and a 30% reduction in injuries.
- Studies in the United Kingdom and France show much higher cyclist accident and injury rates at modern roundabouts than at conventional intersections, 78% higher in the United Kingdom and 16% higher in France.

3.0 The Modern Roundabout Is The Solution.

Several factors have been found for the lack of safety improvement for cyclists in modern roundabouts.

1. Failure of vehicles entering a roundabout to yield to circulating cyclists,
2. Failure of vehicles exiting a multi-lane roundabout to yield to circulating cyclists,
3. Circulating speeds higher than cyclist speeds,
4. Having a cyclist lane on the outside edge of the circulatory roadway,
5. Lack of awareness of cyclists by drivers, and,
6. Insufficient driver experience with cyclists.

Based on these findings and those from other studies, most European countries have implemented modern roundabout design policies to reduce the accident and injury risks for cyclists.

1. Avoid having a cyclist lane on the outside edge of the circulatory roadway.
2. Build separate cyclist lanes away from the circulatory roadway.
3. Have cyclists use the pedestrian crossings.
4. Allow cyclists only in roundabouts with low levels of traffic and slower circulating speeds.

A study in the Netherlands found that there was a 90% reduction in cyclist injury crashes where there were separate cyclist pathways adjacent to modern roundabouts and cyclists did not have the right of way at crossings.

Note: In Teton County, there are separate pathways for cyclists and pedestrians in some areas. So, the concern for cyclist safety at modern roundabouts may not be a significant factor. And, with proper design safety can be improved significantly.

3.3 Increased Intersection Capacity

Modern roundabouts can handle much more traffic than a traffic signal system or a stop sign at the same intersection.

- Modern roundabouts, depending on size and design, can handle flow rates of up to 2,800 vehicles per hour for a single-lane modern roundabout. And, flow rates as high as 8,000 vehicles per hour for a 4-lane modern roundabout have been achieved in the United Kingdom.
- There's a 2-lane modern roundabout in Avon, Colorado that has a capacity of 6,000 vehicles per hour. (See the photo on page 10.) A modern roundabout of this size could handle 144,000 vehicles per day which is 6.5 times the peak measured traffic at the Y and nearly 5 times the forecast for 2020.

3.4 Decreased Vehicle Delays

Vehicle delays at intersections are significantly reduced with modern roundabouts.

- A 2001 study of two conventional intersections converted to modern roundabouts in Maryland reported vehicle delays were reduced by 81% and 87%.
- A 2004 study of three diverse conventional intersections converted to modern roundabouts in Nashua, New Hampshire, Greenwich, New York, and Bellingham, Washington found that vehicle delays were reduced by 83% to 93%.
- An Insurance Institute for Highway Safety study documented missed opportunities to improve traffic flow and safety at 10 urban intersections which were deemed suitable for modern roundabouts where either traffic signals were installed or major modifications were made to intersections with traffic signals. The study concluded that the use of modern roundabouts instead of traffic signals at these 10 intersections would have reduced vehicle delays by an estimated 62% to 74%, which is equivalent to about 325,000 fewer hours of vehicle delay annually.

3.5 Reduced Emissions

Stopped vehicles emit more than 7 times the carbon monoxide as vehicles traveling 10 mph. And, total emissions from stopped vehicles are 4.5 times greater than for vehicles moving at 5 mph. Since modern roundabouts reduce delays, vehicles using these structures have fewer emissions.

- Studies in the United Kingdom have found that even when delays at a modern roundabout and a traffic signal-controlled intersection are similar, the emissions from the traffic signal-controlled intersection are always greater because the stop time at a traffic signal is longer than at in a modern roundabout.
- One study found that when compared to a traffic signal-controlled intersection a modern roundabout reduced carbon monoxide emissions by 29% and nitrous oxide emissions by 21%.
- Another study reported that replacing traffic signals and stop signs with modern roundabouts reduced carbon monoxide emissions by 32%, nitrous oxide emissions by 34%, carbon dioxide emissions by 37%, and hydrocarbon emissions by 42%.

3.6 Higher Fuel Efficiency

Replacing traffic signals and stop signs with modern roundabouts can reduce fuel consumption by up to 30%.

- A study of 10 intersections in Virginia found that the fuel consumption savings amounted to about 235,000 gallons per year.
- A report on the status of research and opportunities for modern roundabouts, emissions reductions, and global warming in North America found that fuel consumption savings amounted to about 30,000 gallons per year for a small single-lane roundabout in Brattleboro, Vermont to as high as 579,000 gallons per year for a large multi-lane roundabout in Clearwater, Florida.

3.7 Improved Public Health

As detailed in 2.33, the negative health effects of traffic, in particular air pollution and noise, are many and can be quite serious. Through the use of modern roundabouts, public health can be positively affected in a number of ways.

- As discussed in 3.4, modern roundabouts significantly reduce vehicle emissions at intersections, which benefits public health.
- Modern roundabouts also reduce the noise from acceleration away from traffic signals and stop signs, benefiting public health.
- Because of the lower speeds through modern roundabouts, regular moving traffic noise is reduced at intersections, which also benefits public health.

So, building modern roundabouts, instead of the TTCR, will keep a busy road away from South Park residential areas, which will prevent increased negative health effects in the area. Further, a modern roundabout at the Y will reduce the negative health effects of traffic in that area as well.

3.8 Lowered Costs

Modern roundabouts are less expensive to construct, operate, and maintain than conventional intersections. And, roundabouts save on accident costs. Also, roundabouts can save money for local governments.

3.81 Construction, Operations, and Maintenance Costs

- In 2004, the Alaska Department of Transportation and Public Facilities finished constructing two roundabouts on Dowling Road at the intersections of the on and off ramps of the New Seward Highway in Anchorage. These roundabouts greatly eased traffic problems at this interchange. And, the state saved approximately $1 million in construction costs and associated signal and lighting costs.
- The average conventional traffic signal system costs $3,000 to $5,000 a year to operate and maintain. Modern roundabouts do not have these costs.

According to information supplied by WYDOT, the traffic signal system at the Y costs more than $100,000. The system at the WY22-Spring Gulch Road intersection costs between $70,000 and $80,000. If these two intersections were converted to modern roundabouts, over 10 years that's a savings of upwards of $280,000. Further, this figure does not take into account the savings from not having to do maintenance on the new and expanded road surfaces and shoulders on the TTCR and South Park Loop Road.

3.82 Accident Costs

Because modern roundabouts reduce accident rates substantially, they also would reduce the costs of accidents. In 2004, there were more than 2.7 million intersection accidents in the United States resulting in $96 billion of financial loss. By converting just 25% of the country's conventional intersections to modern roundabouts the United States would save around $8.4 billion annually in accident costs.

3.83 Government Costs

Because modern roundabouts do not have any electrical control systems (i.e. traffic signals and crosswalk controls), local governments will save the costs of electricity to run these systems. And, there will be cost savings since law enforcement will not have to manually control intersections when the electrical supply is cut off or during special events. As mentioned in 3.13, when modern roundabouts replaced conventional stop sign-controlled intersections at two I70 interchanges in Vail, Colorado, the town saved $85,000 a year in law enforcement costs.

3.9 Better Aesthetics

Landscaping a modern roundabout's center island provides enhanced benefits of an attractive focal and entrance point within a community. This distinguishing feature gives a modern roundabout an aesthetic advantage over conventional intersections. And, it has been found that landscaping increases safety by lowering speeds as vehicles approach modern roundabout intersections.

3.10 Public Perception and Acceptance

The public's perception and acceptance of modern roundabouts becomes quite positive after only a short period of adjustment.

- 2002 Insurance Institute for Highway Safety study in three communities where single-lane modern roundabouts replaced intersections with stop signs found 31% of drivers supported the roundabouts before construction and 41% were strongly opposed. After construction and a short period of adjustment, 63% supported the roundabouts and only 15% were strongly opposed.
- Another study surveyed drivers in three additional communities where single-lane modern roundabouts replaced stop signs or traffic signals. Overall, 36% of drivers supported the roundabouts before construction compared with 50% shortly afterwards.
- Follow-up surveys conducted in all six of these communities after the modern roundabouts had been in place for more than one year found the level of public support increased to about 70% on average.

3.11 Modern Roundabout Use

There are a number of parameters that need to be considered to determine whether or not a modern roundabout is suitable for a particular intersection. Here are some of them.

- The proportion of left turning traffic at the intersection
- Does the main route go straight through the intersection?
- Sight distances at intersection entry points
- The contours and geometry of the intersection and its approaches
- Traffic signal progression at successive intersections along the road corridor(s)
- Will the traffic signal system or stop sign(s) have more delays than a modern roundabout?
- Land availability
- The importance of emphasizing the transition between town and rural environments (i.e. gateways)

Examining the suitability of the Y for a modern roundabout, here are the results.

- The intersection has a large proportion of left turning traffic.
- Nearly all of the eastbound WY22 traffic does not go straight through the intersection.
- The traffic signal system has long delays.
- There is no traffic signal progression in the US26/89/191-Broadway corridor.
- The intersection's entry point sight distances are sufficient.
- The contours and geometry of the intersection and its approaches are ok.
- There seems to be enough land available.
- And, it's a gateway for traffic eastbound on WY22.

So, the Y is a very good site for a modern roundabout.

At the WY22-Spring Gulch Road intersection does meet some of the parameters for using a modern roundabout. However, there are a few that will need additional study and data before a decision can be made.

- There's a large enough proportion of left turning traffic off of eastbound WY22 to northbound Spring Gulch Road,
  (There is enough left turning traffic off of southbound Spring Gulch Road to eastbound WY22.)
- The contours and geometry of the intersection and its approaches are workable,
- And, there's enough land available.

If the WY22-Spring Gulch Road intersection doesn't meet the criteria, then, an underpass will have to be used.

3.12 Conclusion

As the data clearly demonstrate, properly designed modern roundabouts are far superior to conventional intersections in virtually all aspects of traffic control and on the effects of traffic on people and the environment. And, modern roundabouts are significantly less expensive in construction, maintenance, and accident costs. So, it's obvious that a modern roundabout should be the first type of traffic control structure to be considered at the Y and possibly at the WY22-Spring Gulch Road intersection (and at the WY22-WY390 intersection as well) to relieve traffic congestion at the Y and on WY22.

3.13 References

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http://www.alaskaroundabouts.com/akRound.html
Alaska Roundabouts, "History of Roundabouts",
http://www.alaskaroundabouts.com/history.html#history
Alaska Roundabouts, "Lineville Road Roundabout Study", Brown County Planning Commission, Brown County, Wisconsin
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S.A.V.E. (Safety, Agriculture, Villages, and Environment, Inc., "The Modern Roundabout: Enticing Planners, Engineers, & Drivers To Think Outside The Box",
http://www.save41.org/roundabouts/index.htm
The diagrams on page 14 are from the information web page of the Engineering Department, River Falls, Wisconsin,
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http://www.wsdot.wa.gov/Safety/roundabouts/washingtons.htm
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http://www.wyomingnews.com/articles/2010/08/13/news/19local_08-13-10.txt)

4.0 Summary

To summarize, first, I will compare the relative value of the TTCR proposal to the modern roundabout proposal using a cost benefit analysis. Second, I will compare the intersection characteristics of the Y with its existing traffic signal system and the TTCR to the Y with a 2-lane modern roundabout and a single-lane modern roundabout or an underpass at the WY22-Spring Gulch Road intersection. And, finally, I will state my conclusions.

4.1 Cost Benefit Analysis

To demonstrate the advantage of modern roundabouts versus building roads, a comparison of the relative value of the two proposals can be made using a cost benefit analysis. However, two assumptions must be made for such a comparison to work.

- The WYDOT traffic demand model's prediction that the TTCR would reduce traffic numbers at the Y by 28% must also mean a 28% reduction in traffic delays at the Y.
- The construction costs to build the TTCR project, which includes building an extension of Tribal Trail Road from its end to WY22, building an underpass to connect the TTCR to WY22, and rebuilding South Park Loop Road from the Tribal Trail Road-Boyles Hill Road-South Park Loop Road intersection south to the US26/89/191-South Park Loop Road intersection, have to be equal to the costs of building a 2-lane modern roundabout at the Y and a single-lane modern roundabout or an underpass at the WY22-Spring Gulch Road intersection. Obviously, the costs are not the same. The TTCR project will cost more.

So, given these assumptions, since studies have shown that modern roundabout intersections reduce traffic delays by between 62% and 93% when compared to traffic signal-controlled intersections, then, the modern roundabout proposal has from 2.2 to 3.3 times more cost benefit in reducing traffic delays (i.e. congestion) at the Y than the TTCR proposal.

4.2 Characteristics Comparison Table

Intersection Characteristics	The Y With The TTCR	The Y With A 2-Lane Modern Roundabout And A Single-Lane Modern Roundabout Or An Underpass At The WY22-Spring Gulch Road Intersection
Vehicle-Vehicle Accident Rate	At best no change	36% to 61% lower
Vehicle-Vehicle Injury Accident Rate	At best no change	25% to 87% lower
Vehicle-Vehicle Fatality Accident Rate	At best no change	Up to 100% lower
Vehicle-Pedestrian Accident Rate	At best no change	47% to 73% lower
Vehicle-Pedestrian Injury Accident Rate	At best no change	89% to 96% lower
Vehicle-Cyclist Injury Accident Rate	At best no change	One study, 90% lower
Intersection Capacity	~22,000 vehicles a day recorded peak	As high as 144,000 vehicles a day
Vehicle Delay	Increased due to added congestion	62% to 93% less
Vehicle Emissions	Higher due to added congestion	21% to 42% lower
Vehicle Fuel Efficiency	Reduced due to more stop-and-go	Up to a 30% increase
Public Health Risks	Added risk in South Park, small risk reduction at the Y	Unchanged risk in South Park, lowered risk at the Y
Construction Costs	55% to 70% less cost benefit	2.2 to 3.3 times more cost benefit
Maintenance Costs	Higher due to more road surface	As much savings as $280,000 over 10 years at the Y and the WY22-Spring Gulch Road intersection combined
Accident Costs	At best no change	Lowered costs due to accident rate reductions

As this table clearly shows, the TTCR does very little for the Y. Only a 2-lane modern roundabout at the Y and a single-lane modern roundabout or an underpass at the WY22-Spring Gulch Rd intersection have substantial benefits.

4.3 Conclusion

First, I will state the obvious. The only solution that will reduce, and possibly eliminate, traffic congestion at the Y and on WY22 is building a 2-lane modern roundabout at the Y and a single-lane modern roundabout or an underpass at the WY22-Spring Gulch Road intersection (and a single-lane roundabout at the WY22-WY390 intersection). The TTCR is no solution; it's a problem in the making. Further, it must be apparent that, given all the negative effects of the TTCR, doing nothing would be a better "solution" than building the TTCR!

4.0 Summary

Second, there's another issue to be considered. If the TTCR is built, what happens when the TTCR-Tribal Trail Road-South Park Loop Road corridor becomes too congested and needs relief? Here are some ideas.

- Do we continue the obsolete, mid-20th century method of building more and bigger roads by widening the TTCR to four or five lanes? This will require enlarging the underpass at the WY22-TTCR intersection or building a cloverleaf-type interchange at that intersection. And, the stop sign at the US26/89/191-South Park Loop Road intersection will have to be removed and the intersection enlarged to accommodate the installation of a large traffic signal system, which will add another bottleneck to valley traffic.
- Or, do we petition the Forest Service to allow WYDOT and Teton County to improve Fall Creek Road, which would include re-grading, widening, and paving the road surface, and rebuilding all the bridges, so that it can be used the year around as a bypass around the Y and the TTCR? This will require rebuilding the US26/89-Fall Creek Road intersection to accommodate the additional turning traffic. And, the stop sign at the WY22-Fall Creek Road intersection in Wilson will have to be removed and a traffic signal system installed, adding another traffic problem to the WY22 corridor.
- Or, do we find a smarter solution now to meet 21st century needs?

I think being smarter is the only good answer. And, modern roundabouts are clearly smarter. As the data plainly demonstrate, a properly designed, modern roundabout is safer for all users, increases capacity, reduces delays, pollutes less, saves fuel, improves public health, costs less to build, operate and maintain, saves on governmental and accident costs, and offers better community aesthetics.

Finally, given the budget constraints that the federal, state, county, and town governments will have for the foreseeable future, the much higher cost benefits of a modern roundabout alone should make it the only solution to consider for the Y.

5.0 Additional References

This section provides additional references about modern roundabouts, including,

- 5.1 State and local government web sites and pages
- 5.2 Other institutional web sites and pages, including governmental and non-governmental agencies, universities, and foreign governments
- 5.3 Private sector web sites and pages
- 5.4 Other references

Note: There's a lot of redundant information here. However, it's important to show the diversity of interpretation and ingenuity in the design and use of modern roundabouts.

5.1 State and Local Government Web Sites and Pages

Arizona Department of Transportation, Communication and Community Partnerships,
http://www.dot.state.az.us/CCPartnerships/Roundabouts/index.asp

California Department of Transportation, District 1,
http://www.dot.ca.gov/dist1/roundabouts/

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Kansas Department of Transportation, Roundabout Design Guide and Video,
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Maryland Department of Transportation, State Highway Administration,
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New South Wales, Australia Roads and Traffic Authority,
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5.0 Additional References

5.3 Private Sector Web Sites and Pages

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http://www.roundabouts.net

DLZ Roundabouts,
http://www.dlzroundabouts.com/index.php

Modern Roundabouts, The Web Site,
http://roundabout.kittelson.com/

MTJ Engineering,
http://mtjengineering.com/home.html

NE Roundabouts,
http://www.roundabouts.cc/default.htm

5.4 Other References

The first comprehensive roundabout reference used by many engineers in the United States was the book, "The Design of Roundabouts – State of the Art Review 1995", by Mike Brown. It's a review of roundabout guidelines worldwide and was published by the independent Transport Research Laboratory in the United Kingdom. Unfortunately, it's no longer in print.

Another publication used by professionals and lay-people is "Roundabouts: An Informational Guide" document # FHWA-RD-00-67, June 2000, published by the Federal Highway Administration and available through the FHWA Report Center. Check the FHWA's Turner-Fairbank Highway Research Center web site: http://www.tfhrc.gov/safety for more information.

Many of the web pages listed in this document have publications that can be printed out or ordered.