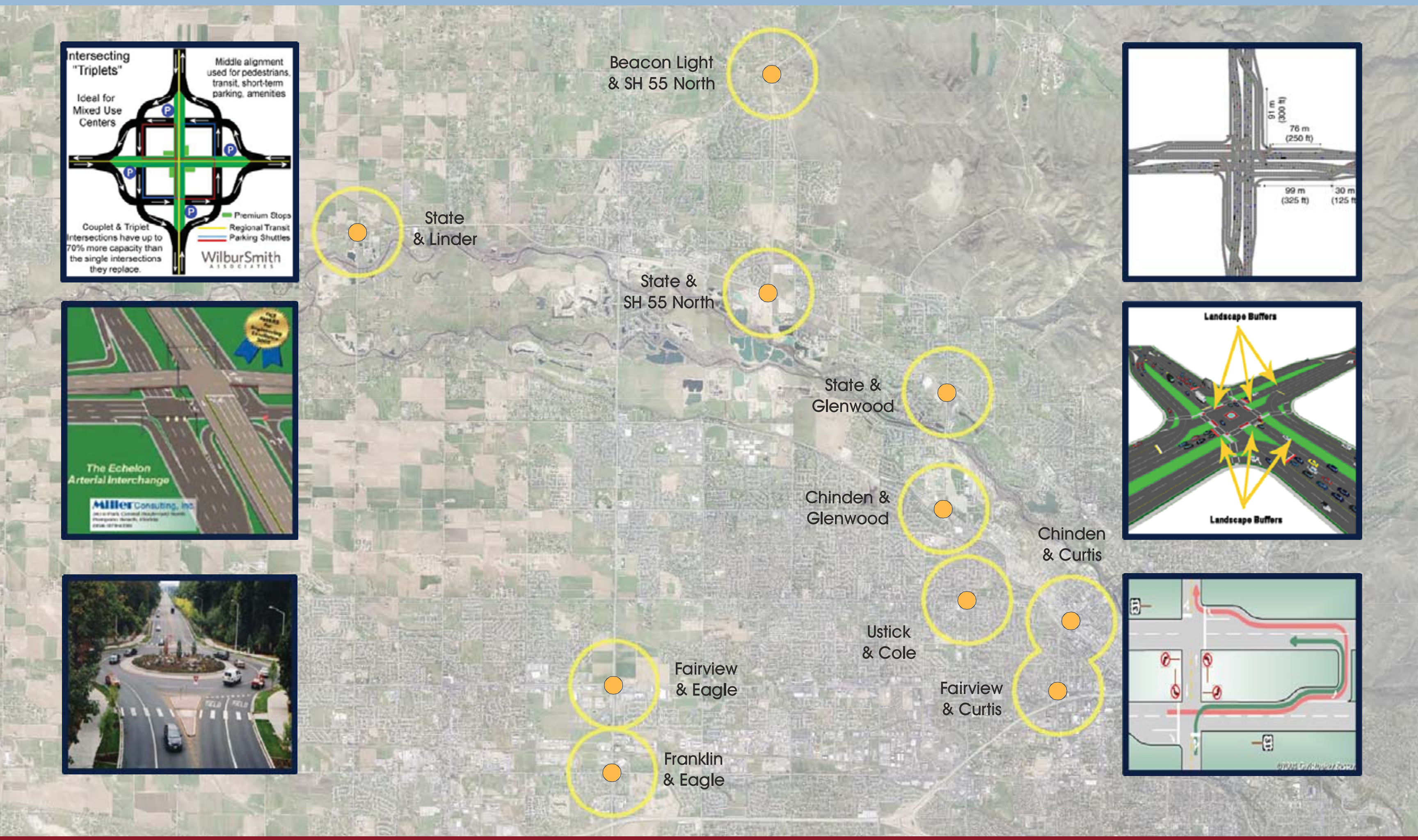
High Volume Intersection Study, Vol. I

Innovative Intersections: Overview and Implementation Guidelines

COMPASS
COMMUNITY PLANNING ASSOCIATION
of Southwest Idaho



prepared for
Community Planning Association of Southwest Idaho

submitted by
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in association with
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The ***High Volume Intersection Study*** (HVIS) consists of three volumes:

Vol. I Innovative Intersections: Overview and Implementation Guidelines, broadly outlines information about a variety of innovative intersection concepts and provides more specific implementation guidelines for intersection types that appear to be most applicable to southwest Idaho.

Vol. II Intersection Concept Layout Report, features spotlighted high volume intersection concepts at nine different intersections in Ada County.

Vol. III Additional Materials, includes a compatibility matrix between intersection types and urban forms and street functional classifications.

The Community Planning Association of Southwest Idaho (COMPASS) contracted with Wilbur Smith Associates for this study, with additional contributions by Thompson Transportation, HDR, and Joseph E. Hummer, Ph.D., P.E.

Table of Contents

Acronyms and Terms

Acronym or Term	Meaning
ACHD	Ada County Highway District
Additional Materials	A companion to this document and Volume III of the HVIS. The *Additional Materials* document includes a compatibility matrix between intersection types and urban forms and street functional classifications.
ADT	Average daily traffic
Arterial interchange	Characterized by grade separation (overpass or underpass), but designed specifically to fit within the context of a typical intersection. Much smaller footprint than a freeway interchange, simple signal timing, high capacity or even free flow for the major movement, and relatively high flow for the minor movement.
At-grade intersection	An intersection where all vehicles traverse the intersection at ground level, or "at grade." There is no grade separation (overpass or underpass).
Bowtie	A bowtie intersection is fundamentally similar to a Median U-Turn (MUT), but roundabouts or tear drops are used at the turn around points.
Communities in Motion (CIM)	*Communities in Motion: Regional Long-Range Transportation Plan 2030*, adopted by COMPASS in August 2006.
COMPASS	Community Planning Association of Southwest Idaho, the metropolitan planning organization (MPO) for Ada County and Canyon County.
Continuous Flow Intersection (CFI)	An innovative intersection design in which left-turning vehicles cross over the travel lanes of the opposing through movement in advance of the intersection, so left turns and through movements at the main intersection can proceed simultaneously. Also referred to as a "crossover displaced left turn" or XDL.
Continuous Green "T"	A design option at T intersections where oncoming traffic from the right need not be stopped to allow left turns from the T-approach to enter. Instead, left turns have an extended merge lane. See "Quadrant Roadways" for details.
Conventional intersection	A conventional intersection is any design that is very typical for a given area. For this study, it is generally considered to be the intersection of two major streets, where left turns are handled by a protected left-turn signal phase from lanes in the median. At high volumes, dual left-turn lanes and right-turn bays are common, in addition to through lanes. Also, they usually have four "legs" or approaching streets, and all the lanes proceeding in a common direction are next to each other.
HVIS	High Volume Intersection Study
Innovative intersection	An innovative intersection, for the purposes of this project, is any of a series of at-grade or grade-separated intersections that are significantly different from a conventional intersection in some way. Common differences include: a reduction or spreading of conflict points, restriction and/or rerouting of movements, and reduction of the complexity of traffic signal phasing.

Acronym or Term	Meaning
Intersection Concept Layout Report	A companion to this document and Volume II of the HVIS. The *Intersection Concept Layout Report* includes spotlighted concepts at 9 different intersections in Ada County.
ITD	Idaho Transportation Department
LOS	Level of service of a roadway or intersection. Expressed in ranges from A to F, with A meaning no delay for vehicles, F meaning failure: long waits at intersections and/or stop-and-go traffic conditions.
Metropolitan Planning Organization (MPO)	The regional planning entity responsible for transportation planning and approval of federal transportation funding for a given region.
Median U-Turn (MUT)	An innovative intersection design that provides a turnaround point to which left-turning vehicles are routed. From the street on which the turnaround occurs, left turns are made by first passing through the main intersection, making a U-turn at the turnaround point, then making a right turn at the main intersection. From the cross street, left turns are made by first turning right, then making a U-turn at the turnaround point and continuing through the main intersection.
NB, SB, EB, WB	Northbound, Southbound, etc., describing direction of traffic flow.
NW, NE, SW, SE	Northwest, Northeast, etc., describes different intersection quadrants.
Parallel flow intersection (PFI)	Similar to the CFI although with a smaller footprint. See more in the PFI section of this document.
Proof of concept	A high-level analysis to demonstrate that a concept for an intersection can be feasibly implemented and will have beneficial results. Spotlighted concepts at the ten sites of this study meet this definition, but need more thorough analysis to develop the concepts and competing concepts.
Quadrant Roadway Intersection (QRI)	An innovative intersection design that creates a connection between two legs of the main intersection. Left turns are routed along the connecting roadway, bypassing the main intersection.
Right-of-way (ROW)	The amount of space required by an intersection or roadway, normally includes travel lanes, gutter, sidewalk, etc.
SH	Idaho State Highway
Town Center Intersection (TCI)	Actually consists of four intersections resulting from the crossing of two one-way couplets. May also include a middle alignment that can be reserved for non-vehicular traffic.
Two-way left-turn lane (TWLTL)	A median lane on a two-way road that is not for through travel but rather provides a place for vehicles traveling in either direction to make left turns into midblock driveways.

1. Introduction

The Community Planning Association of Southwest Idaho (COMPASS) adopted *Communities in Motion: Regional Long-Range Transportation Plan 2030* (CIM) in August 2006. COMPASS, as a part of its metropolitan planning organization (MPO) responsibilities, developed the plan for the region with the assistance of its member agencies. The High Volume Intersection Study (HVIS) was initiated in response to findings and policy statements that appear in CIM.

A key objective of the HVIS is to develop guidelines and recommendations for implementing innovative intersection designs in the region. The project team prepared this report as a means of helping COMPASS achieve that objective.

The recommendations in this report are suitable for use by highway agencies, cities, counties, and by other agencies/jurisdictions throughout the COMPASS region. This report's recommendations will help land use agencies establish standards for innovative intersection types, which will facilitate implementation of innovative intersections throughout the COMPASS region. Information from the report may also be useful for updating the regional travel demand model.

1.1. What is an "Innovative Intersection"?

For this document, a conventional high-capacity intersection typically would have a dedicated pocket for right turns, 2-3 through lanes per direction, and double left-turn pockets with left-turn arrows. This results in a 4-phase signal (a left phase and a through phase for the two directions of one street, and the same on the cross street). An innovative intersection is generally defined as any at-grade design concept that is able to reduce the number of phases at the main intersection, thereby increasing the efficiency and capacity of the signal. In most cases this is accomplished by rerouting left turns at a point well ahead of the main intersection, or to require the driver to do something unusual, such as first go through, then make a U-turn, and finally a right turn. They tend to be uncommon for several reasons:

Why are innovative intersections uncommon?

- Lack of industry awareness – many are relatively new ideas.
- Though the cost/benefit ratio is often very good, they still typically cost more than a conventional intersection.
- In some cases they are out of context or don't work in a particular location.
- Usually requires turning movements that differ from typical driver expectations.
- Problems at conventional intersections have historically been tolerable in spite of their inefficiency.

How are these reasons changing?

- Rate of implementation is increasing, and so is exposure and confidence.
- Cost/benefit ratio improves as traffic increases.
- Solutions are tailored to each site.
- Driver reaction is generally positive (prefer a change if it saves significant time).
- Major congestion is motivating many to search for solutions that are better than a conventional intersection but not as expensive/intrusive as an interchange.

In spite of these challenges, the major redeeming virtue of all innovative intersections is that congestion relief is often extremely good, and their relative cost is in many cases very modest. They often improve safety by reducing the number of conflict points. Some concepts reduce the pressure on a single large intersection by creating a number of smaller intersections to help handle left turns. In these cases, the number of conflict points may remain unchanged or even increase, but the overall safety and flow of the system is nonetheless improved because each intersection is much simpler. Many of these designs are not new, and are "tried and true" in certain parts of the U.S., in which cases they enjoy good driver expectancy because they are common.

Typical conditions under which a conventional intersection may fail include:

- Heavy traffic volumes on opposing movements, such as left turns in one direction and the opposing through movement.
- A high number of conflict points, resulting both from movements at the intersection itself and at upstream driveways and weaving areas (ie, areas where significant numbers of vehicles are making conflicting lane change maneuvers).
- High traffic volume on several movements requires complex traffic signal phasing, leading to longer cycle lengths, more "lost time" between phases, and longer delays.

Innovative at-grade designs typically address such problems by:

- Reducing the number of conflict points, or improving safety and capacity by spreading them out
- Restricting and/or rerouting movements
- Reducing the complexity of traffic signal phasing

1.2. Public Acceptance of Innovative Intersections

Regardless of how attractive any particular innovative intersection appears in the analysis phase, implementing agencies must first be convinced that drivers in their area can safely navigate the design. Because so many of the concepts require restricted access or circuitous movements, agencies must also gain confidence that the public understands the benefits and is willing to accept the negative aspects to obtain the positive. Therefore, it is critical that any serious proposal to try something new in a given region be accompanied by a significant public awareness campaign. Such a campaign should not shy away from highlighting the negative aspects of agency-preferred solutions, because it is critical for the public to comprehend all angles so they can respond from an informed position.

The accompanying study of 10 high-volume intersections in the Boise area has generated several preliminary concepts that involve innovative intersections. The study has developed high-quality graphics, proof-of-concept planning-level analysis, and identified needed right-of-way to help generate excitement and allow for corridor preservation. However, agencies should spend significantly more time and resources refining all of the top two or three concepts to truly arrive at a complete understanding of the myriad of issues surrounding each design.

1.3. Advancing From Concept to Construction

In a recent survey of 26 state highway officials, 16 (62%), rated concerns over driver expectancy and safety as the top reason they would hesitate to advocate an innovative design in spite of any other positive aspects. The second highest concern, with 8 number one votes (31%), was concern over the likely cost. Clearly concerns over safety and driver expectancy must be taken extremely seriously if anything other than an inefficient-but-familiar design style is to be adopted.

Suggestions for advancing beyond the "proof of concept" stage:

1. **Local demonstration:** Select the most promising location for a particular concept.
2. **System analysis:** Expand the analysis beyond just an intersection, but to a contained system that may involve nearby intersections, driveways, etc.
3. **Expert simulation:** Enlist a respected expert to test all the top-tier concepts in a high-accuracy simulation tool.
4. **3-D animations:** In the simulations, develop 3-D renderings complete with landscaping, etc. so that stakeholders and the public at large can better understand what they're actually getting with a given proposal.
5. **Near-term performance:** Test potential solutions in the far future, but also against conditions expected in the next five years so the public can see immediate value.
6. **Detailed impacts study:** Study the access effects to adjacent properties in detail. Refine cost estimates and right-of-way needs for each concept.
7. **Well-crafted information:** Present both positive and negative findings through a well-crafted process to engage key stakeholders, and randomly selected focus-groups to better understand public concerns and opinions once they are well educated on the subject.
8. **Focus group feedback:** Propose signage and other features to improve driver expectancy; obtain focus-group feedback on the level to which they value expectancy vs. efficiency, and whether proposed mitigations are sufficient to win their support.

If it appears the design will be at least as safe as conventional alternatives, stakeholders will likely be more willing to incur the cost, and the public can tolerate less than perfect driver expectancy to improve the overall operation of the intersection. The drive expectancy can be improved through good signage, vehicle channeling, and driver awareness campaigns as construction nears completion. The next step is to select the most promising design at the most promising location and construct it as a demonstration project to show the benefits of the improvement. To the extent that it is well-received and performs as expected, carry the concept to other locations. As noted in item #2 above, system considerations should count heavily in the determination of suitable locations, particularly in the near term. Agency and public enthusiasm for a new and promising intersection type will disappear quickly if the problems at one location are solved only to create an intensified problem at a nearby location.

1.4. Driver Expectancy

Since agencies have noted that driver expectancy is their top concern, a discussion on driver expectancy is warranted. By definition, perfect driver expectancy can only be achieved with a locally common design. This is because part of what makes the intersection easy for most drivers to navigate is that it is very similar to dozens if not hundreds of others that they're familiar with elsewhere. However, intersections with perfect driver expectancy are often unacceptably congested, invoking a need to make tradeoffs.

Driver expectancy for making a left turn on an arterial

Perfect expectancy: Driver enters the left lane just ahead of the intersection, or intersection navigation is typical of many others in the region.
Good expectancy: Driver enters left-turn pocket ahead of the intersection, but sometimes considerably ahead. Paths to complete left turns are not typical in the region, but locals are quickly accustomed. Visitors who miss signs can safely find a course correction.
Unusual expectancy: Making a left turn ahead of the intersection is not possible, and the navigation style is not common. Left turns are accomplished as "Right-U-Through," "Through-U-Right," "3-Rights is a Left," or any system that requires a driver to do something they are not accustomed to doing in that environment.

It is possible for intersection types to move between these categories, depending on their level of use in an area. The Median U-Turn (MUT) would qualify as unusual in Boise, but in many locales in Michigan it is so common as to achieve near perfect expectancy. Jughandles (mini-cloverleafs) are similarly unusual for Boise, but perfectly common in New Jersey.

In Boise, the traditional double left-turn pocket with a protected arrow phase would qualify as perfect expectancy. Roundabouts once qualified as unusual, but are quickly moving to the good if not perfect expectancy category. Continuous Flow Intersections (CFI), Parallel Flow Intersections (PFI), Town Center one-ways, and 4-quadrant roadways would all qualify as having good expectancy in Boise because they require entering a left pocket ahead of the intersection. MUTs, Bowties, Jughandles, and one- or two-quadrant roadways would be considered unusual both because they are uncommon, and because they require an unconventional left-turn maneuver. Grade-separated intersections are "unusual" in a non-freeway context, because they require an unexpected exit from the right-hand ramp to make a left.

How Important is Driver Expectancy?

Unusual driver expectancy should not automatically disqualify a concept from consideration unless for some reason it creates an unsafe situation. These options are often far less costly to implement relative to other choices, and in some cases require only changing signs, striping, and signal timing. Perfect driver expectancy also comes with high congestion at high volumes. Most drivers would prefer to get used to a new expectancy if it means they'll save a lot of time.

The next section introduces a number of innovative intersection concepts. Later chapters provide more in-depth discussion of several types that appear attractive for general application in the Boise area.

2. Innovative Intersection Concepts

Continuous Flow, Parallel Flow, Town Center, Bowties, Superstreets, Quadrants, MUTs, and Roundabouts – these are promising new designs for urban intersections that are context sensitive, incredibly efficient, and often surprisingly affordable especially if such a design is envisioned when adjacent land uses are first established. Compared to a freeway interchange, these intersections can often accommodate 70% (or more) of the traffic served by a grade separated option and cost about 30% (sometimes less) of what it costs to construct a grade separated intersection/interchange. This section provides a brief description of some of these emerging innovative intersections.

2.1. Continuous Flow Intersection (CFI)

The CFI was first seen in Mexico in the mid-1980s, and there are approximately 50 in operation today. At one time the CFI design was patented, though the patent has since expired. There are currently five CFIs in operation in the U.S. **Figure 2-1** shows the first CFI in the U.S., opened in 1996 in Shirley, New York.

For comparison, a standard signal with protected left turn arrows must serve eight major movements – four left turns and four through movements, but only two movements can occur at a time (opposing left turns or opposing through movements). The magic of a CFI is that it allows opposing left turns and opposing through movements to occur at the same time using one signal at the main intersection, and up to four interconnected mid-block signals.

Figure 2-1: First U.S. CFI in Shirley, NY

It has proven to be simple for drivers to get used to, and in some cases can fit within existing rights-of-way. A full 4-approach CFI or PFI with 2-3 lanes per approach can handle about 10,000-14,000 vehicles per hour at LOS E, as compared to a standard intersection with the same number of through lanes and with dual left-turn lanes on all approaches, which can handle about 6,000-8,000 per hour at the same level of service.

The third U.S. CFI opened in April 2006 in Baton Rouge, LA for a total cost of $4.4 million. Where vehicles had been delayed an average of four minutes before the project, the delay was reportedly reduced to less than one minute after. Excellent information on CFIs is available from the designer of the Baton Rouge CFI at www.abmb.com/cfi.html . Utah and Missouri recently opened the fourth and fifth CFIs in September and October 2007 respectively. See Utah DOT at www.udot.utah.gov/cfi and look for a "tutorial demonstration" in the lower-left. Information about the St. Louis CFI is at: www.modot.org/stlouis/links/ContinuousFlowIntersections2.htm.

2.2. Parallel Flow Intersection (PFI)

A similar intersection was recently patented in 2004 by Quadrant Engineering, and is known as a Parallel Flow Intersection, or PFI (see **Figure 2-2**). It offers comparable capacity and driver expectations to the CFI; the main difference is demonstrated in the diagram below. As illustrated in **Figure 2-3**, the CFI provides turn pocket storage and transition area in advance of the main intersection, whereas the PFI's transition area is located on the receiving leg of the left turn. The PFI configuration reduces the overall footprint of the intersection. The smaller footprint could fit better with existing adjacent land uses or when there simply isn't room to fit a CFI.

Figure 2-2: Typical PFI Layout

While the design is patented, it has never as yet been fully implemented. Communications with Quadrant Engineering suggest they are anxious to work out a very attractive deal, perhaps free, on the first few implementations of a PFI to give the concept publicity. See www.quadranteng.com. Both CFIs and PFIs can be challenging to set up for pedestrians and bicyclists, but not necessarily more than a typical high-volume intersection with double left arrows.

Another potentially significant difference between the two intersections is that the left-turn transition area for the CFI is at the main intersection where a right-turning driver might normally enter. This issue is helped by providing a separate right-turn lane ahead of that left-turn pocket so that drivers don't mistakenly turn right into the left-turn lane. This additional lane increases the size of the footprint. The PFI shown in **Figure 2-3** has the same dedicated right-turn lane, but it may be easier to do away with it because the "T" entry-point at the second left-turn lane is well separated from the main intersection. This means it is less likely that right-turning drivers would mistakenly enter the left-turn lane and would allow the PFI to fit into an even tighter spot.

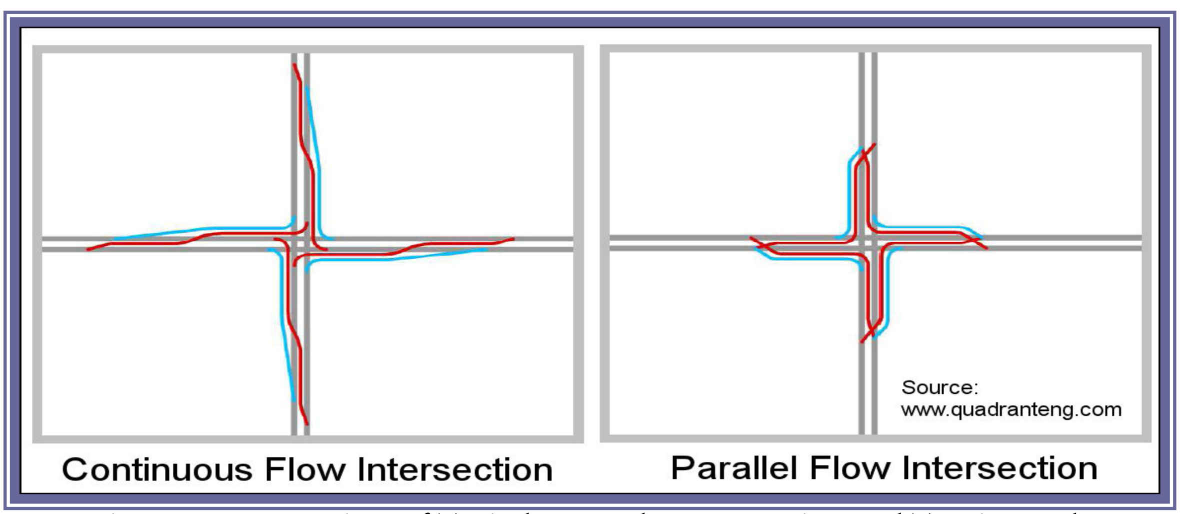


Figure 2-3: Comparison of Typical CFI and PFI Footprints and Turning Paths. (Red illustrates left turns and blue illustrates right turns.)

2.3. Town Center Intersections (TCI)

How well would your body's circulatory system work if blood entering your arm had to return via the same "right-of-way?" One consequence would be turbulence and extra pressure. Handling two-directional flow on a single-roadway artery is in many ways not unlike this example. One-way streets have long been recognized as far more efficient for vehicles, and also as more friendly to transit and pedestrians.

Figure 2-4: Completed TCI in San Marcos, CA

The TCI is really four separate intersections of one-way streets that merge back to two-way streets a block or two downstream. It can be designed as a couplet, or even a triplet as shown in the diagrams, where a triplet has a middle alignment that is not critical for traffic, so the former pavement can be relinquished for short-term parking and/or a well-streetscaped transit and pedestrian mall. Each one-way leg has only half the traffic of the upstream roadway that feeds it, and can therefore be much narrower and offer more space for amenities.

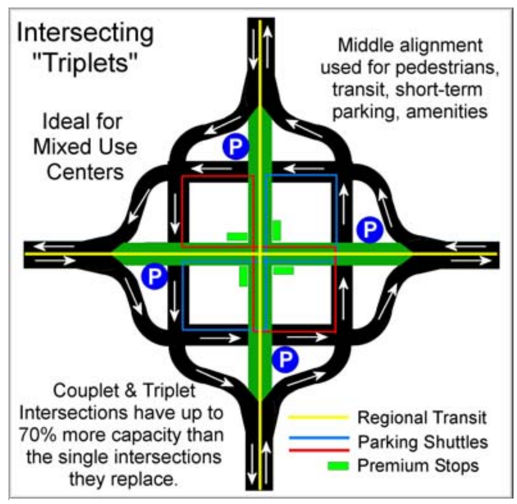


Figure 2-5: Triplet Intersection

Not only does the design offer a platform on which to build a "Town Center" sense of place and Transit-Oriented Development amidst cookie-cutter suburbs, but it also has excellent traffic flow and excellent bike/pedestrian safety features. Where a standard super-sized intersection with double left turns on all approaches can handle about 7,000 vehicles per hour, this design creates four smaller, simpler, safer intersections with fewer conflict points. Each handles 5,000 vehicles, for a system that handles about 13,000 vehicles (note that most vehicles traverse more than one intersection).

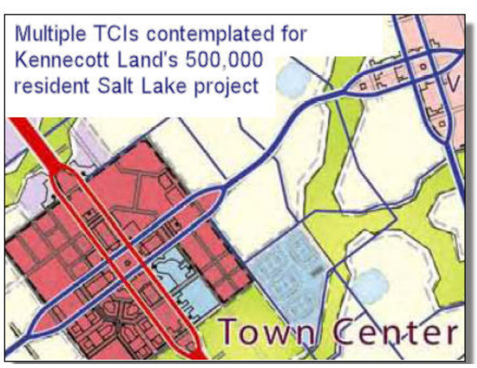


Figure 2-6: Planned TCIs near Salt Lake City, UT

Pedestrians benefit from this design since they need to look only one way to cross, cross fewer lanes per signal, and have fewer conflict points with vehicles. Drivers are typically forced to slow in respect to the character of the Town Center, enhancing pedestrian safety. Drivers will also encounter two signals instead of just one. However, in spite of slower speed limits and more signals, they will on average have better overall speeds in part because one-way streets are very simple to synchronize, and also because vehicles do not remain stopped for nearly as long as with a single congested signalized intersection. Safety is also improved because of lower free-flow speeds, reduced conflict points, and less intersection turbulence.

This design is proving very popular in many of the latest high-end mixed-use developments in many western cities such as San Diego, Las Vegas, and Salt Lake City. Developer interest represents an opportunity for public-private partnering for construction. While this "new design" is gaining popularity, the simple intersection of one-way couplets has existed for decades in cities like New York and Portland. Downtown Boise has the equivalent of a TCI, with the four intersections of Front & Myrtle with 9th & Capitol—which together handle the highest system volumes in the downtown area.

Figure 2-7: Existing TCI in Downtown Boise

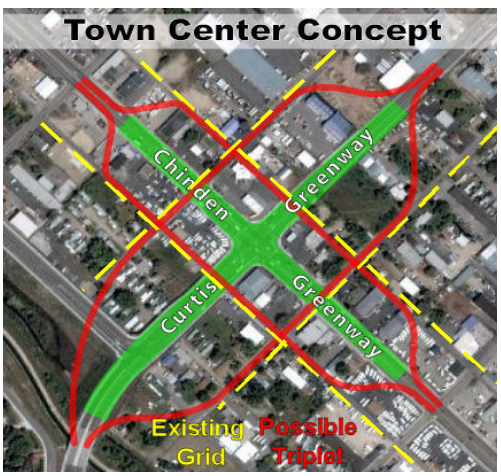


Figure 2-8: TCI Concept at Chinden & Curtis in Garden City

TCIs are extremely low-cost in Greenfield settings, but they are not just for Greenfield areas. A Greenfield is land, often at the fringe of urban areas that has never been developed. Greenfields may or may not be slated for eventual development. Greenfield sites may have only minimal urban infrastructure services available, including roadways. There are many locations in need of urban renewal where parallel streets can be used or developed for this new high-efficiency design. Depicted here is such a concept for Chinden & Curtis. In this case, the impacts would be large enough that if moving traffic is the primary goal, other options are better at this site. However if interest can be generated for an urban renewal project, this concept can help achieve both urban renewal and congestion relief.

The TCI offers excellent return on investment across an array of urban planning objectives, and should be considered in both new suburban areas where traffic levels could become very high, or in older urban areas where traffic is already high: also where developer assistance in urban renewal is desired and could ultimately create high volumes.

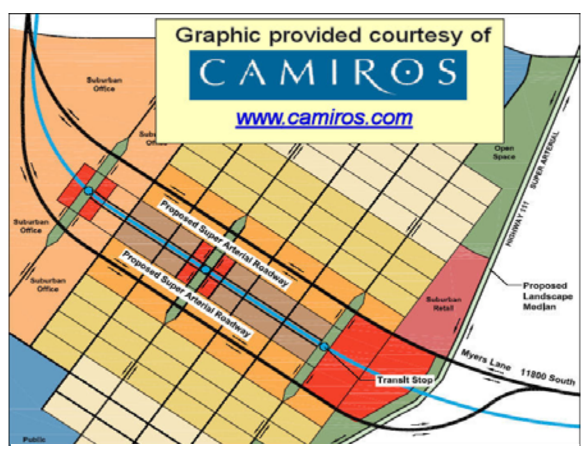


Figure 2-9: Multiple TCIs considered near Salt Lake City, UT

The TCI works best if the couplets are separated by at least 400 feet. The concept can also be implemented with as much as ½ mile between the couplets, as shown at the right with a grid of interior streets. **Figure 2-9** shows the application of the TCI concept to a much larger urban center served by three transit stations and three smaller, collector-size cross couplets.

A half-TCI triplet is at the foundation of Denver's highly acclaimed success of the 16th Street transit/pedestrian mall, which is shown in **Figure 2-10**.

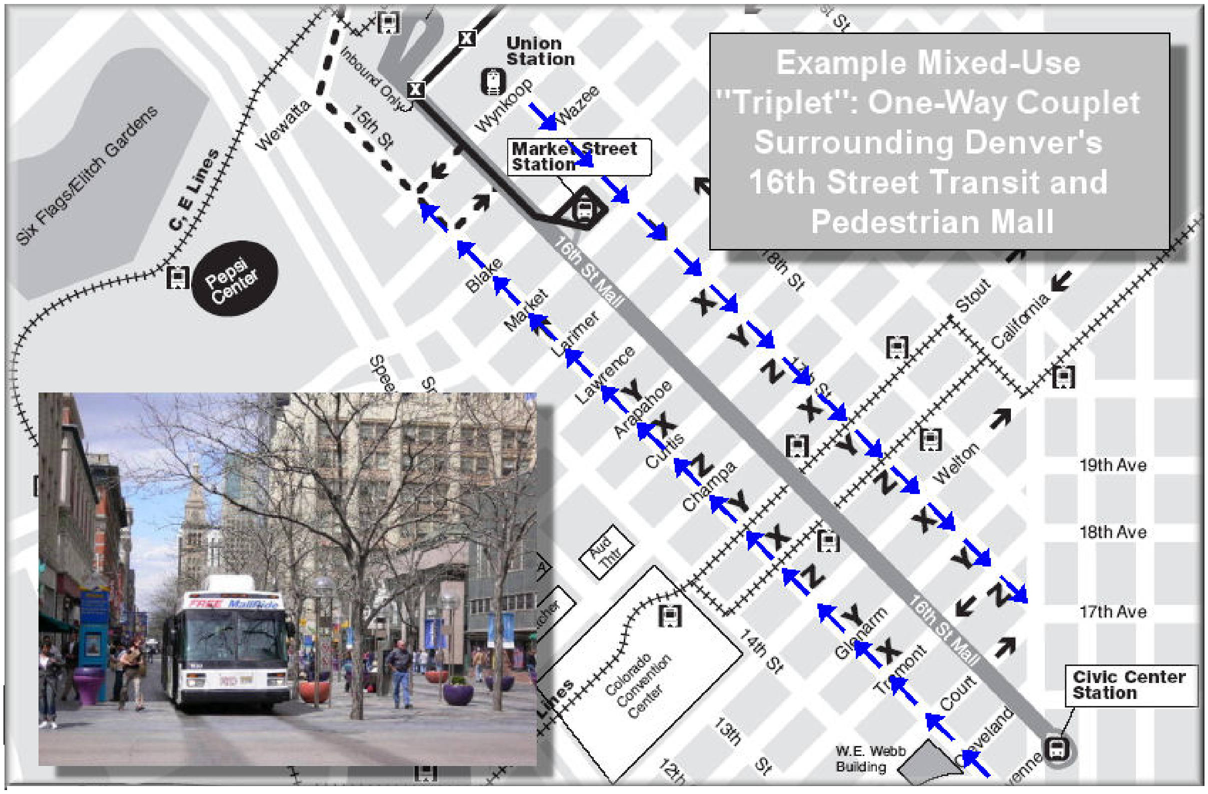


Figure 2-10: Existing Triplet in Denver, CO

2.4. Median U-Turn (Michigan Left Turn)

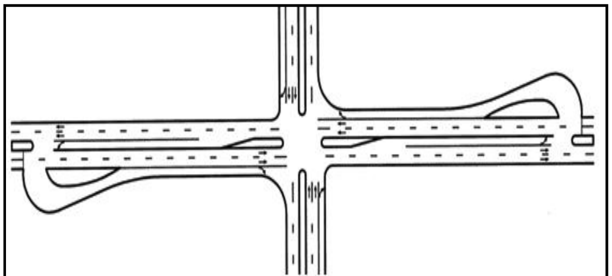
With the Median U-Turn (MUT), left turns are prohibited at the main intersection and must instead be completed either by "Through-U-Right" or "Right-U-Through." This type of intersection was nicknamed the "Michigan Left" because of its extensive use in Michigan following the success of a pilot project by the Michigan Department of Transportation. The collision rate is about 20% lower than that of a conventional intersection.

Figure 2-11: Aerial View of Median U-Turn Intersection

Unusual driver expectancy and out-of-direction travel to complete a left turn is the most significant drawback to this design. The "Right-U-Through" movement requires a weave to get to the

U-turn, which can be an issue on high-speed, high volume arterials. When approaching speeds exceed 50 miles per hour, it is best to prevent right turns on red, lengthen the weave area, or select another design. In spite weaving, this system typically has 20% fewer collisions than a comparable double left-turn system, as mentioned above.

The MUT requires a fairly large radius to allow larger vehicles to complete the turn. In cases where the median isn't wide enough to create the turning radius, the MUT can often still be implemented by creating a turning basin, as shown in **Figure 2-12**.



Source: Signalized Intersections: Informational Guide

Figure 2-12: MUT with Turning Basins

This design converts left turns to right and through movements. Therefore, it may be necessary to enhance the capacity for right and through movements. Former left-turn pockets can often be converted to through lanes to further enhance the capacity of this design. The combination of simpler signals and more through capacity can allow this design to achieve 50% or more capacity than a comparable double left-turn. In cases where heavy congestion is occurring, this extra capacity will greatly reduce delay for everyone, including left-turners on a circuitous path. In Michigan, the general public has been well aware of this benefit for decades and has been willing to accept awkward movements to help save travel time.

2.5. Bowtie – an Enhanced Median U-Turn

The Bowtie is fundamentally similar to the MUT in the way that left turns are routed through it. However, the Bowtie uses the latest innovations emerging from roundabout designs. Shown at the right (**Figure 2-13**) is a system with typical roundabouts. On the following page is an image manipulated to demonstrate what a complete Bowtie system would look like with large oval roundabouts (only the oval on the right actually exists – see **Figure 2-14**). There are very few existing Bowties, though it is an exciting improvement upon the older MUT which is very popular in Michigan. The arrows show how just the two ovals make it possible to eliminate all four left-turn arrows at the main intersection. Solid lines show the conventional left turn movement, and dashed lines show how that same movement is routed through the Bowtie.

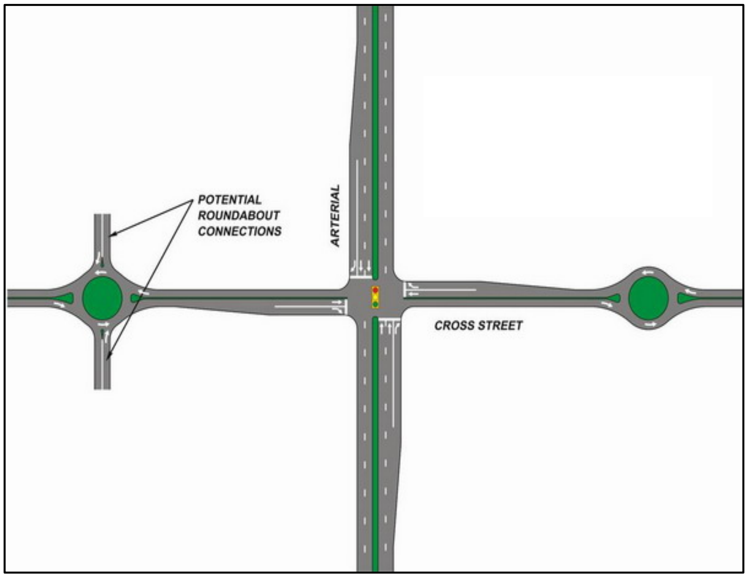


Figure 2-13: Bowtie Intersection with Roundabouts

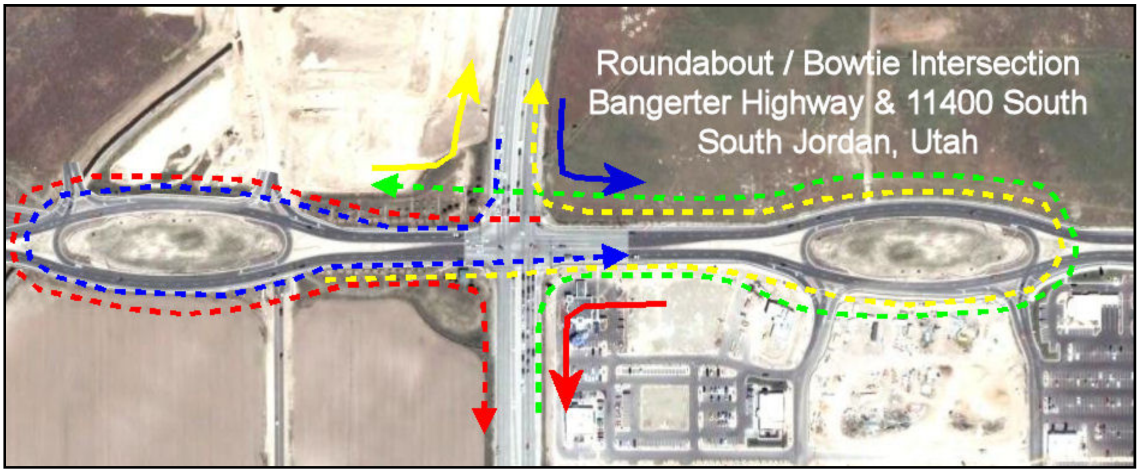


Figure 2-14: Movements on partially finished Bowtie (left side not complete)

Normal driver expectation is to pull into a left-turn pocket ahead of the intersection. This is not possible with both the Bowtie and MUTs, so they always have unusual driver expectancy, at least until there are enough of them in an area that the 85th percentile driver is very aware of how to navigate this design. Drivers traveling east or west and wishing to turn left would first pass through the intersection and make a U-turn using the roundabout. Drivers traveling north or south would first make a right turn, then use the roundabout to complete a left turn maneuver. All left turns involve a bit more travel length, but even these circuitous movements will nonetheless traverse the intersection in significantly less time simply because the resulting two-phase signal can serve many more vehicles per hour.

Center Oval – Aesthetically Pleasing, Functionally Efficient

As mentioned earlier, the MUT requires vehicles to cross over the path of on-coming vehicles, often to a turning basin on the other side. If on-coming volumes are so high that U-turns cannot get safe gaps, then oncoming traffic must be stopped to clear the U-turn. This oval design of a Bowtie provides the turning radius needed to make the U-turn, but the Us do not cross over on-coming vehicles. Instead there is a wrap-around lane that simply makes a third lane merging along side the others to go through the intersection. This is different than a roundabout, because oncoming traffic does not need to yield to vehicles in the wrap-around lane (an important feature if the oval is installed on a high-volume road where a roundabout would tend to fail). Trees, monuments, and so on can be used to provide good aesthetics on the large island. If the oval is large enough (say a city block) it could even accommodate development inside like a TCI. The island also forces vehicles to slow somewhat around the circle, which will diminish their speed as they enter the main intersection, which in turn improves safety (as any crashes would be at lower speeds).

Accommodates both Conventional and Efficient Operation

Recall that Baton Rouge spent $4.4 million, and the Utah DOT recently spent $8 million further north on this same highway, both to implement 2-leg CFIs (effectively achieving 3-phase signals instead of the previous 4-phases). This Bowtie can create a 2-phase signal, and at a far lower cost because the tear-drops would not yet conflict with pre-existing development. Yet another advantage is that the Bowtie function can be built at anytime, meaning the geometry allows the existing 4-phase signal to continue while congestion is low. When congestion worsens, it will be relatively simple to update signage, prohibit left turns in the main intersection, and reduce the signal to 2 or 3 phases. This design also allows the flexibility to further improve the intersection with grade separation and roundabouts serving the ramp terminal intersections, should the additional capacity provided by grade separation be necessary in the future.

2.6. Superstreet

A superstreet resembles a MUT, but the cross street is closed to all through traffic with the intersection at the main road.

To make a left turn:

- Turn right onto the divided highway
- Make a U-turn
- Go straight through the intersection

To go straight:

- Turn right onto the divided highway
- Make a U-turn
- Turn right onto the cross street

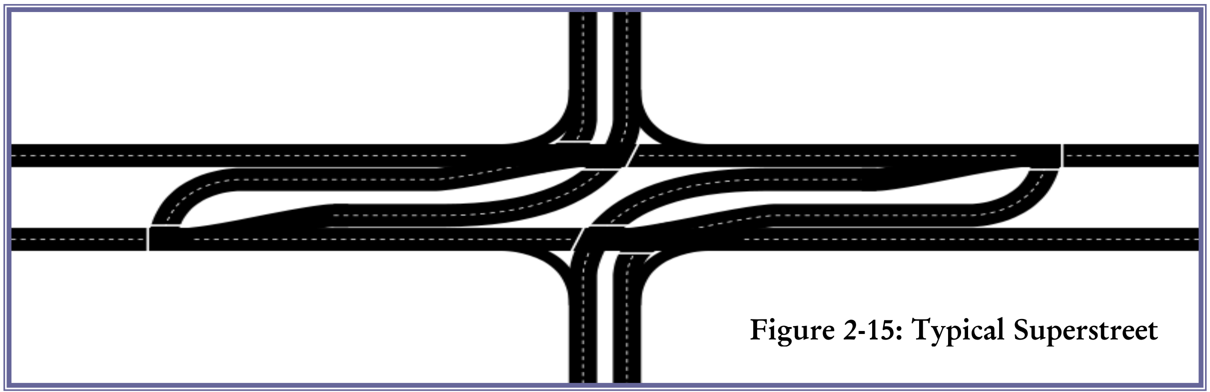


Figure 2-15: Typical Superstreet

This intersection style has similar advantages and disadvantages to those of the MUT. One unique advantage is that the signals for opposite directions of travel can operate independently from each other. In other words, on an arterial or highway with several consecutive Superstreet intersections, the signals could be timed for perfect two-way signal progression in both directions, just as can be achieved with one-way couplets. The progression speed and signal spacing could even vary by direction. Superstreets are well suited to intersections where the cross-street volume is relatively low, and there is a need to maintain excellent flow on the major highway. It is not a good choice for the intersection of two significant arterials.

2.7. Quadrant Roadway Intersection (QRI)

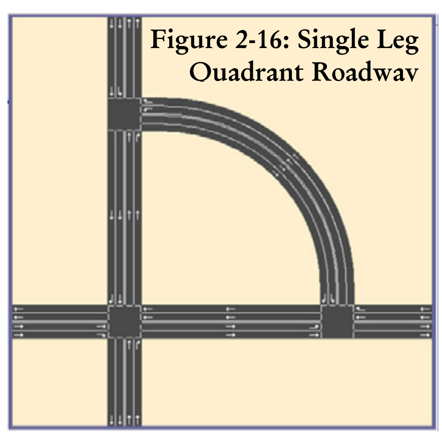


Figure 2-16: Single Leg Quadrant Roadway

Have you ever seen people cut through a parking lot or take a back-way because congestion was so bad? A quadrant roadway formalizes this creative way to make a left turn. Much as with the others, the goal is to eliminate the need for left-turn arrows at the main intersection by serving left turns somewhere else.

The graphical series of **Figure 2-17** on the following page shows the versatility of quadrant roadways as applied to the intersection of Chinden and Glenwood – a location dominated by traditional strip-malls and Big Boxes with numerous driveways near the intersection. (Note that this is not the spotlighted concept recommended for further pursuit, and is used here only to illustrate how movements on quadrants can be accommodated.)

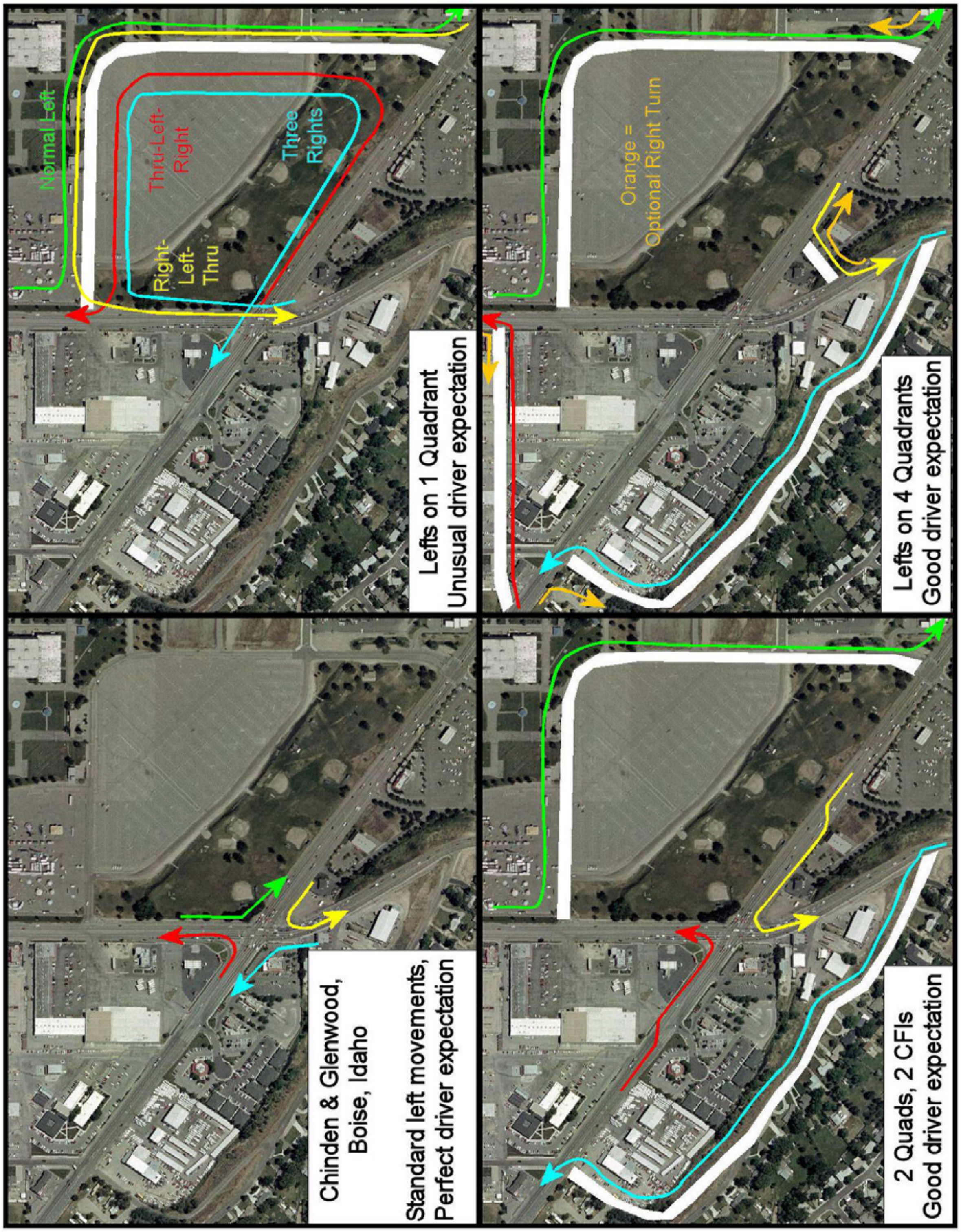


Figure 2-17: Quadrant Roadway turn movements

There are innumerable urban settings across America where intersection land uses are very similar to this site. There are often very simple ways to create a QRI by using existing "back-way" streets, or by developing such streets through existing parking lots.

Traits of a Single Quadrant Roadway

It is possible to eliminate all four left turns from the main intersection with just one quadrant roadway. The routing for such is shown in the upper-right image in the series (Figure 2-16). As with a CFI, SB to EB makes a normal left, but in a pocket well ahead of the intersection (green). Like a MUT, EB to NB goes "Through-left-right" (red). WB to SB is similar as a "Right-left-through" (yellow). Finally, NB to WB does what some delivery drivers are told to do to make a faster left: "three right turns make a left" (blue). Confusing? On paper, yes. In the beginning, yes. But people get used to it, and they may well prefer it if the alternatives invoke too much delay time or are more expensive. It is important to have good signing. It is also possible that the quadrant roadway itself will become unacceptably busy handling all four movements.

Traits of Two Roadways in Opposite Quadrants

If just two roadways in opposite quadrants can be created, then a 4-phase signal can be dropped to three phases without compromising driver expectation (by accommodating two left turns at mid-block locations, and the other two as standard double left turns at the main intersection). The image in the lower-left also shows how the 3-phase signal could further be dropped to two phases by using CFIs instead of standard double left turns. All of these allow the quadrant concept to move from unusual driver expectancy to much better if not very good expectancy. It also greatly reduces the pressure on any single quadrant, which may be operationally as well as politically important.

Traits of Four Quadrant Roadways

Normally in a developed setting, it will be very difficult to identify acceptable alignments for four quadrant roadways. However, if affordable and politically acceptable alignments can be found, the combination of four roadways has several very attractive properties. First, movements are very similar to a 4-leg CFI, but vehicles travel behind development instead of in front of it. Where all movements are made from a left pocket ahead of the main intersection, this achieves near-perfect driver expectancy with no out-of-direction travel. Four roadways also have much higher overall capacity because all left turns and many or even all right turns can be completely removed from the main intersection (where fewer quadrants converts former left turns to easier-to-manage through and right-turn movements).

Four and even two roadways also have much in common with TCIs. A 4-leg CFI requires a massive footprint at the main intersection, major restrictions on adjacent access, and is somewhat intimidating to pedestrians. Four roadways allow for the most minimal footprint at the main intersection because with left and right turns removed, that former pavement can be used for aesthetic and pedestrian enhancements. Property access is much easier also, because access is easily provided from each quadrant roadway. The system creates "four blocks" almost like a mini-downtown. It has far higher capacity, excellent access to adjacent properties, and is very pedestrian and transit friendly. All of these features can serve as catalysts for mixed-use urban renewal.

Safety Concerns and Access Management

It is almost counter-intuitive, but quadrant roadways improve efficiency and safety in large part by creating more intersections, where each one is much simpler. Many express concern that since crashes occur at intersections, introducing more intersections will introduce more crashes, and therefore, the system will be less safe than single-intersection alternatives. This is not the case. First, the main intersection will have far fewer conflict points, and in the case of two or four quadrants, also much less volume. This alone will greatly improve safety at the main intersection. It is true that conflict points are transferred to adjacent T-intersections, but again these intersections each have very few conflict points which make it easier for both pedestrians and drivers to keep track of the directions from which they face conflicts.

Also, it is often the case that poor access control upstream of the intersection, allowing multiple uncontrolled access points on the roadway, which are well known to be dangerous in high-volume settings. Relocating uncontrolled driveways to the low-volume, low-speed quadrant roadways funnels traffic to a much safer signalized T-intersection. When looking at the whole system of uncontrolled driveways and a single intersection versus simpler intersections and fewer uncontrolled entry points, the second system is safer.

Delay Concerns

Many are also concerned that instead of stopping just once, the new T-intersections created by quadrant roadways may require drivers to stop several times, negating some of the efficiency improvements at the main intersection. There is certainly some truth in this. To some level, the T-intersections can be synchronized with the main intersection just as with a CFI. However, the signals on a CFI are typically closer together and equi-distant from the main intersection, which simplifies coordination. If the drive lengths on each quadrant are significantly different, and if the T-intersections are not equidistant from the intersection, then coordination will be more challenging and many drivers will indeed find they must stop at two or even three signals. However, the overall system delay, and the delay experienced by any single driver, will be far less than with a congested traditional double-left intersection. To truly understand the tradeoffs, build and no-build alternatives must be simulated in high-performance traffic modeling software like VISSIM, with qualified expert oversight.

Continuous Green-T

One way to reduce system delay is to create Continuous Green-T intersections where each quadrant intersects the main roadway. This treatment allows one direction of the arterial street continuous movement without signal control as shown in **Figure 2-18**. The vehicles (in the case of this illustration) making a northbound left turn would turn left on a green light and merge with westbound traffic. This type of intersection can reduce the average intersection delay, especially if the uninterrupted movement is heavy.

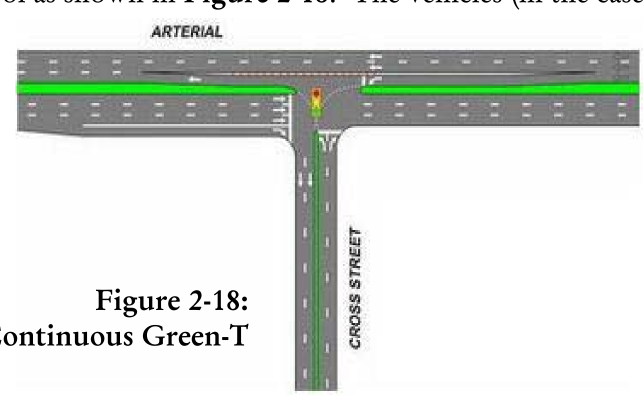


Figure 2-18: Continuous Green-T

2.8. Jughandle/Mini-Cloverleaf Intersections

A close cousin to the quadrant concept is the jughandle intersection, or mini-cloverleaf, which is common in New Jersey. Here the concept is applied to Ustick and Cole, in all four quadrants. This design would function similarly to a full cloverleaf interchange, although at lower speeds. Rather than the T-intersections created by 4-quadrants, here all left turns are accomplished as three right turns. The right-of-way that was formerly a left-turn pocket would then be used as a through lane dedicated to the cloverleaf so that vehicles in the cloverleaf need not wait for a gap into oncoming traffic.

Figure 2-19: Jughandle turn movements

Existing driveways inside a jughandle may need to be relocated from the main road to the jughandle route. To be more compatible with existing land uses, speeds on the jughandle should be 10-15 miles per hour. This particular site may only impact one or two homes and some parking. Note that a freeway cloverleaf is always one-way. In an urban setting, any of the jughandle "ramps" could be two-way (like a quadrant roadway) as shown by the black arrow in the northwest quadrant, as a means of removing right-turning vehicles from weaving with vehicles merging from the cloverleaf. Other quadrants could remain one-way if by minimizing the footprint homes or businesses could be saved.

2.9. Roundabouts

Figure 2-20: Modern Roundabout

Modern roundabouts have become wildly popular in the last decade. Roundabouts replace older, European-style traffic circles largely by shifting the entry rules so that one yields upon entry, rather than yielding to entering vehicles as in the past: a concept that better meets driver expectation and improves efficiency. Roundabouts are attractive and can help calm traffic in neighborhood areas.

Single-lane roundabouts have significantly better capacity than what a four-way stop can provide and even work well as replacements for lower-volume signals. There are only a few multi-lane roundabouts thus far in the U.S., but they are able to handle volumes equivalent to those at the intersection of a minor arterial and a major collector. Roundabout capacity improves as the roundabout itself becomes larger, since there is more opportunity inside the circle to weave and position for the needed movement. A multi-lane roundabout has lower overall capacity than a traditional double-left intersection, unless the roundabout is extremely large to create more opportunity inside the circle to weave and position for the needed movement. For additional information on roundabouts, please visit www.roundaboutsusa.com.

2.10. Grade-Separated Innovative Designs (Arterial Interchanges)

Like at-grade intersections, grade-separated solutions can be designed to fit into narrow rights-of-way and non-freeway settings. These are unlike designs used for freeways which create incredible capacity in one direction, but do little for congested cross traffic.

Designs that create a free movement often encourage higher speeds, have more access restrictions, and are often overly large and out of context as candidates to upgrade an at-grade urban intersection. They also do little for congested cross traffic and often create more capacity on the free movement than neighboring intersections can supply. However many arterial interchange designs distribute the benefits of grade separation across all movements more evenly—an attractive feature when volumes on both roadways are very high, and very similar. Disadvantages common to all arterial interchanges include the need for expensive and visually obstructing structures and challenging access to adjacent land uses.

Although no grade-separated designs are spotlighted or recommended in the Concept Layout Report, there will be locations and conditions in the future where an arterial interchange may be the preferred solution. The intersection treatments in this section are intended to introduce additional improvement possibilities to further develop the "toolbox" of options, providing information about possible solutions in a variety of situations.

Two arterial interchanges that fit with typical driver expectations when navigating an arterial street are the center left-turn overpass and the echelon interchange. In both of these, all movements are still subject to signals, to which one might respond "Why did we build a structure?" At very high-volume intersections in built-up areas, where no at-grade innovative intersection designs have sufficient capacity, these arterial interchanges provide a higher-capacity option that may fit within right-of-way constraints and cost considerably less than a freeway-style interchange.

Center Left-Turn Overpass

The Center Left-Turn Overpass effectively removes the left-turn phases from a signalized intersection by placing those movements above (or below) the intersection. The result is much more green time for all movements.

The minimim median requirements are at least 50 feet wide (where a double-left median is typically 28 feet wide). This would provide two 12-foot lanes (one up the ramp, one down), and space for small shoulders, retaining walls, and a barrier between ramp directions.

Figure 2-21: Center Left-Turn Overpass

This ramp design concept is similar to T-ramp designs on high-occupancy vehicle facilities. It is believed that none have yet been built.

Echelon Interchange

The Echelon Interchange creates a similar effect as the four intersections of a TCI noted earlier, but does so vertically rather than horizontally. The design creates two separated intersections of one-way streets, similar to how a TCI does so horizontally. However with the Echelon vehicles encounter just one signal, where in the TCI most encounter at least two. There is only one known partial Echelon Interchange, in Aventura, Florida (**Figure 2-22**).

Figure 2-22: Echelon Interchange Diagram and Aerial

a: Oblique Rendering of an Echelon Interchange

b: Aerial Photo View of Partial Echelon Interchange in Aventura, Florida

Other Arterial Interchanges

There is another group of arterial interchanges that results in free-flow for the major movement, but can also be fit into much more context-sensitive locations than a typical freeway interchange would.

The ***CFI-Diamond Hybrid Interchange*** is shown at the right. The right-of-way and bridge structure are much tighter than required for a typical freeway interchange. The structures typically span just two or three lanes per direction, or about 80-90 feet total. The CFI feature improves the overall green time of cross traffic for potentially nominal additional cost.

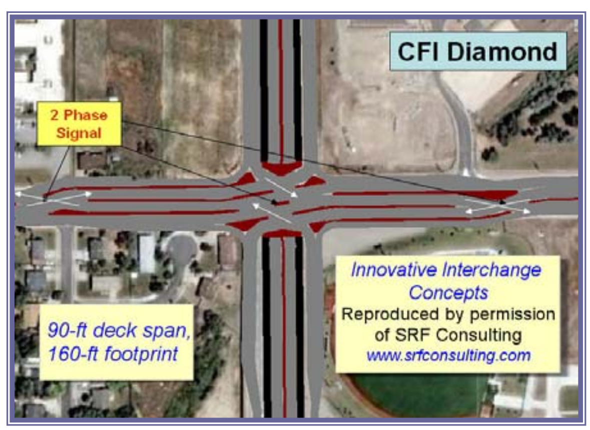


Figure 2-23: CFI Diamond

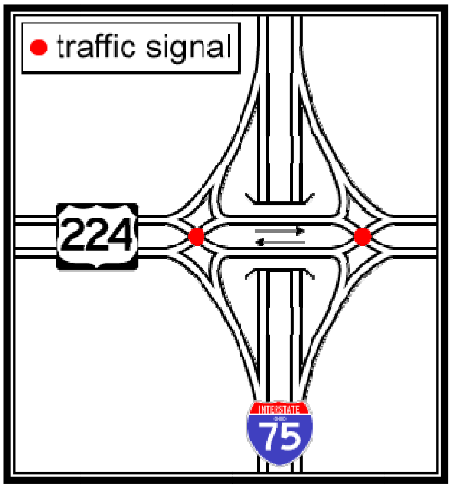


Figure 2-24: Diverging Diamond

The ***Diverging Diamond Interchange (DDI)*** is another concept receiving significant attention of late. All traffic is temporarily routed from the right side to the left side of the road, again to remove left turns from conflict with opposing traffic. According to their website (www.435ddi.com) The Missouri Department of Transportation plans to begin construction of a DDI in the Kansas City area in 2008, believed to be the first instance of a DDI outside of France. However, this design is currently under strong consideration in Lexington, KY as well as other places. Not long ago it was recommended as the preferred option for a site in Oregon.

2.11. Summary of Comparative Advantages and Disadvantages

Listed below are the more significant advantages and disadvantages of various intersection types relative to automobile movements in a typical intersection that has dual left turns on all approaches (an inefficient, 4-phase signal). See also **Table 2-1** at the end of this chapter and *Vol. III Additional Materials*.

At-Grade Intersections

Continuous Flow/Parallel Flow

Advantages of CFIs/PFIs

- Two legs always achieve 3-phases, increasing capacity and reducing delay considerably.
- Four legs always achieve 2-phases – even better results.
- Good driver expectancy.
- Operationally, CFIs and PFIs are very similar, but one or the other may be easier to build within existing constraints.

Disadvantages of CFIs/PFIs

- Requires a considerably large footprint. This can be an advantage in situations where future grade separation is considered.
- Safe for pedestrians, but can be intimidating and would not be considered "pedestrian friendly."
- Can be expensive if acquiring buildings, parking, or removing accesses is required.

Town Center

Advantages of TCIs

- Two legs create two 3-phase signals, each more efficient than a single 4-phase.

- Four legs create four 2-phase signals, where the four together can handle much more volume than a single intersection.
- The most pedestrian and transit friendly of all high-volume systems discussed.
- Design lends itself well to defining a higher-density, mixed-use "Place." Very low cost when designed on open ground as part of a master-planned area.

Disadvantages of Town Center Intersections

- The sum of the right-of-way is higher, due mostly to more sidewalk area.
- Numerous impacts and very expensive in developed settings. Cost is largely mitigated if private funds can be attracted as part of a general redevelopment strategy, or if tax-increment financing is used for the same purpose.
- More signals, but they're easily coordinated.

Median U-Turn/Bowtie

Advantages of MUTs/Bowties

- Reduces 4-phase signal to 2-phase signal.
- Impacts typically limited just to the location of the U-turn or bulb out.
- Can be very low cost, depending on adjacent development.

Disadvantages of MUT/Bowties

- Results in unusual driver expectancy.
- Vehicles still traverse intersection at least once, sometimes twice. Can be mitigated by converting former left pockets to through lanes.
- Can result in too many right turns, and too much weaving.

Superstreet

Advantages of Superstreets

- Reduces 4-phase signal to 2-phase signal.
- Signals for opposite directions of travel can be timed for progression independently.
- Pedestrian-friendly.

Disadvantages of Superstreets

- Results in unusual driver expectancy.
- Cuts off through traffic on cross street - not suitable where large volumes exist.
- Left turns require out of direction travel.

Quadrant Roadway

Advantages of a Single Quadrant Roadway

- Makes it possible to achieve 3-phase signal if two left turns are routed on the quadrant. A 2-phase is possible if four left turns are routed on the quadrant.
- Candidate roadway often already exists. Implementation may be extremely low cost.
- Result is less intimidating for pedestrians than Baseline, CFI/PFI.

Disadvantages of a Single Quadrant Roadway

- Routing all four left turns onto the roadway creates unusual driver expectancy. However the public may prefer to get used to awkward paths if it means they'll save a lot of time and the implementation cost is low.
- The quadrant roadway will itself become very busy if it is functioning for all 4-left movements.
- Three of four left-turn paths still require drivers to traverse the main intersection – sometimes twice. Thus left turns are eliminated, but there are more right turns and through movements. The former left-turn lanes may be used as through lanes to handle higher through volume.

Advantages of Multiple Quadrant Roadways

- Provides great access to adjacent properties, very good pedestrian and transit environment.
- Each quadrant handles less volume.
- 4-quadrant intersections have very good driver expectancy – all approaches can turn left ahead of intersection. No circuitous paths.
- With four quadrants, left turns never enter the main intersection – making four quadrants among the highest overall capacity.

Disadvantages of Multiple Quadrant Roadways

- Can be expensive to find alignments for multiple quadrants.
- Introduces T-intersections – more signals that are more challenging to coordinate than some others, such as a CFI.
- Mitigate by making Continuous Green-Ts.

Jughandle/Mini-Cloverleaf

Advantages of Jughandles/Mini-Cloverleafs

- Narrower right-of-way requirements on the major street.
- Reduces number of signal phases.
- Conflict points are reduced and spread out.

Disadvantages of Jughandles/Mini-Cloverleafs

- Indirect left turns and potential driver confusion.
- Driver disregard of left-turn prohibition.
- Additional right-of-way required for jughandle ramp.

Roundabout

Advantages of Multi-Lane Roundabouts

- Reduced number of conflict points.
- Lower operational speeds decreases accident occurrence and severity.
- Aesthetically pleasing.

Disadvantages of Multi-Lane Roundabouts

- Driver unfamiliarity.
- May be difficult for visually impaired pedestrians.
- No preemption for emergency vehicles.
- Lower overall capacity than a conventional intersection – not recommended for intersection volumes expected to exceed 4,000 vehicles per hour.

Arterial Interchanges

Listed below are the more significant advantages and disadvantages of various grade-separated intersection types relative to a typical tight-diamond interchange.

Center Left-Turn

Advantages of Center Left-turn Overpasses

- Preserves access to adjacent properties.
- Pedestrian-friendly – remove conflicts with left-turn vehicles, shorter wait times.
- New capacity shared more evenly between all movements (i.e. more suited to intersecting arterials of similar volumes).
- All movements subject to stop, which discourages high speeds that tend to occur when one movement is free.

Disadvantages of Center Left-turn Overpasses

- Snow/ice removal from overpass.
- Provision for U-turns may be difficult.
- Potential sight distance issues/visual obstruction.
- More expensive to construct (larger and more challenging deck, potentially more in retaining walls).

Echelon

Advantages of Echelon Interchanges

- Two efficient 2-phase signals.
- Easier for pedestrians than a diamond interchange.
- Good land access in two of four quadrants.
- New capacity shared more evenly between all movements (i.e. more suited to intersecting arterials of similar volumes).
- All movements subject to stop, which discourages high speeds that tend to occur when one movement is free.

Disadvantages of Echelon Interchanges

- Driver unfamiliarity.
- Provision of U-turns requires longer bridge span.
- Less appropriate when one roadway has significantly higher volume than the other.

CFI Diamond/Diverging Diamond

Advantages of CFI-Diamond/Diverging Diamond Interchanges (over just a Diamond)

- Improves flow and capacity of cross-street traffic.

Disadvantages of CFI-Diamond/Diverging Diamond Interchanges

- Driver unfamiliarity.
- Potentially more expensive.

2.12. Intersection Toolbox: What, When, Where, Why

All innovative designs create more “green time” by somehow removing the need for left arrows in the main intersection, leaving the simplest possible signals. They each have additional pros and cons that should be considered by location as noted above. The paragraphs below describe situations when one or the other intersection type may be more appropriate. At the end of the section is a “Toolbox” table (**Table 2-1**) that compares capacity, costs, and other key attributes to help planners and engineers determine which designs may be appropriate to a given situation.

Town Center Intersection – good “Place Making” design that is very compatible with transit and pedestrians. Among the most able to attract developer investment: At any suburban fringe location where place-making is desired and ultimate demand could be far higher than a standard intersection can deliver, TCIs should be a top consideration because: **1)** They handle high volumes even at low pedestrian friendly design speeds; **2)** It is easier to design architecturally pleasing, transit-oriented “Places” around them; **3)** Less stringent access control standards does not degrade the safety or flow as much as with other options; **4)** They are extremely affordable – especially if developers construct all or part of the system from a belief the system will enhance access and character for their development. It is also among the best choices to help motivate urban renewal of blighted areas.

Quadrant – locations near older retail centers that want to encourage mixed-uses and become more pedestrian friendly: At hundreds of locations it is relatively simple to create quadrant paths behind existing buildings or through parking lots. This also can enhance access to land uses on those quadrants, and like TCIs, spur place-making development if such is desired.

Bowties – great for aesthetics and both conventional and unconventional operation: Tear-drop ovals and roundabouts are great for landscaping and flexible enough for 2, 3, or 4-phase signal operation. Can be built as 4-phase (perfect driver expectation); converted later to a 2-phase (less delay, but unusual expectations).

CFI/PFI – locations with good existing access control, large setbacks, and where vehicle movement is a higher priority than any other objective: Because of the larger footprint and stricter access controls, they may be easier to upgrade to arterial interchanges. Data from recently opened sites is still emerging, but they are generally performing as anticipated. They have good driver expectation and should be strongly considered at many locations.

Roundabouts in lieu of 4-way stops, lower-grade signals: Not recommended as a “regional high volume” intersection. Well proven in last decade to fit nicely with neighborhood-level major collectors. They can be integrated as part of a TCI or modified as a Bowtie for higher efficiency.

Arterial Interchanges – locations where total volume simply overwhelms other systems: Since at-grade options exist that can provide as much as 75% of the benefit for much less than 75% of the cost, arterial interchanges would be recommended only in unique situations, such as when two roadways are each nearing volumes that can't be handled otherwise.

Opportunity for Transit-ways/HOV: Stakeholders are often reluctant to sacrifice existing lanes on a congested roadway to transit because it will exacerbate existing congestion. These innovative intersection options may open a window to obtain exclusive right-of-way for HOV or transit. By allowing the vehicles currently served by three lanes to have the same or better service in just two lanes it thereby opens a window for transit and HOV to claim the third lane.

Lower cost than widening?: Historically lanes have been added to an entire roadway in spite of the utility and development conflicts, when the real problem may have just been inefficient signals. While some designs are costly, it may clear up congestion enough that there is no longer a need to widen an entire road – achieving the desired results with an overall lower cost and with fewer impacts.

Table 2-1"Intersection Toolbox": Generalized capacity, geometry, and cost by intersection type. Left to right by increasing capacity.

Scenario (all assume both arterials have two thru lanes per direction)	"Double-left", 4-approaches (base case)	Roundabout, 2-entering lanes all approaches	"Triple-left" Intersection	Rerouting lefts on single quadrant	Bowtie / Median U	CFI/PFI, four approaches	Town Center oneways, four approaches	Rerouting lefts using four quadrants	Tight diamond Interchange
Signal phases at main intersection	4	All yield	4	2	2	2	2	2	3
Additional intersections / signals created by design	None	None	None	2 T's	0, 2*	4 mid-block	4 total	8 T's**	2 at ramps
Hourly System Capacity (LOS E - approx 60 sec delay/veh)	6,500	4,500	7,500	9,000	9,500	12,000	12,000	12,000	14,500
Percent change over base	-	*-31%*	*15%*	*38%*	*46%*	*85%*	*85%*	*85%*	*123%*
Major arterial daily volume supported (if peak hour is 8% of daily)	40,000	30,000	45,000	60,000	65,000	75,000	80,000	80,000	120,000
Minor arterial daily volume supported	35,000	25,000	40,000	45,000	45,000	70,000	70,000	70,000	55,000
Corresponding intersection AADT (Daily sum of all 4 approaches)	75,000	55,000	85,000	105,000	110,000	145,000	150,000	150,000	175,000
Corresponding peak hour, peak dir. approach volume (Major street)	1,600	1,300	1,800	3,200	3,200	3,100	3,300	3,300	4,850
Total approach lanes (left pockets + thru lanes + right pockets)	6 (2+3+1)	3 (0+2+1)	7 (3+3+1)	5 (0+4+1)	5 (0+4+1)	6 (2+3+1)	5 (1+3+1)	4 (0+3+1)	5(2+2+1+shldr)
Capacity per hour per approach lane at LOS E (Major street only)	270	430	260	640	640	510	650	650	970
Capacity per hour per thru lane (for travel demand models)	530	430	600	1,070	1,070	1,030	1,100	1,100	2,200
Percent change over base	-	*-19%*	*13%*	*102%*	*102%*	*94%*	*108%*	*108%*	*315%*
Typical mainline width in feet (at mid-point between two intersections)	106-120	80-100	120-130	84-110	84-110	106-120	66-80	84-110	120-150
Typical flare-out width at the intersection on Major Street (feet)	128-132	84-110	150-160	84-110	84-110	140-160	80-84	84-110	170-200
Ideal limited access length (driveway and center island restrictions)	50-200	50-200	100-300	100-200	300-600	300-600	50-100	100-200	1000-5280
Bike / Ped / Mixed-Use friendly? (Great, Good, Ok, Poor)	Ok	Good	Poor	Ok-Good	Good	Ok-Poor	Great	Good	Poor
Signal coordination (Great, Good, Ok, Poor)	Ok	N/A	Poor	Ok	Ok-Good	Ok	Great	Ok-Good	No signals
Driver Expectations (Perfect, Good, Unusual)	Perfect	Perfect	Perfect	Unusual	Unusual	Good	Good-Perfect	Good	Ok
Other key features	Low cost, very common	Good aesthetics	May be only option	Often near-zero cost	Good aesthetics	Easy to grade separate	Redevelop-ment tool	Direct paths	One movement is free-flow
Other key detractants	Inefficient, high delay	Poor choice for major arterials	Inefficient, high delay	Circuitous	Weaves could be an issue	Large footprint	Greyfield high impacts	Usually has impacts	Most mvmnts. mediocre
Cost range (Varies by development & utility conflicts, etc.)	Default	$1-3 M	$2-4 M	$0.3-$1 M	$1-$5 M	$4-12 M	$4-15 M	$2-10 M	$15-25 M
Cost relative to other options	Default	Low	Low-Medium	Very Low	Low-Medium	Medium	Medium-High	Low-Medium	Very High

Lower Capacity	Up to 35% better	Up to 70% better	70% better or more

1. All scenarios but Roundabout were measured with Synchro. Volumes were selected such that the average delay per vehicle is about 60 seconds (LOS E). Roundabouts are based on observations at other sites
2. Quadrants and Medians remove two left bays, but require one extra through because lefts are converted to through

* Median requires signal to make U, Bowtie has wrap-around lane that does not require signal.

** A quadrant creates 2-T's, so 4 creates 8. They can be coordinated, and 4 of 8 can be Green-Ts.

Note: Planning-level Synchro estimates. Sites should be independently verified using expected volumes, and/or Vissim-type analysis

ENGINEERS PLANNERS ECONOMISTS
WilburSmith ASSOCIATES

See also *Intersection Compatibility* in *Vol. III Additional Materials*.

3. Implementing Continuous Flow Intersections

Figure 3-1: An Existing CFI

Regarding the Continuous Flow Intersection, highway agencies will be concerned primarily with the design of the intersection itself, and with upstream roadway and access-related elements such as medians and driveways. Land use agencies will be concerned primarily with access- and site-related issues. Because of the strong interrelationships between transportation and land use, all users are encouraged to become familiar with the entire contents of this chapter. A knowledge of both sets of issues is key to the ultimate success of helping agencies establish and enforce appropriate standards for CFIs and facilitating their implementation throughout the COMPASS region.

3.1. Intersection and Roadway Design

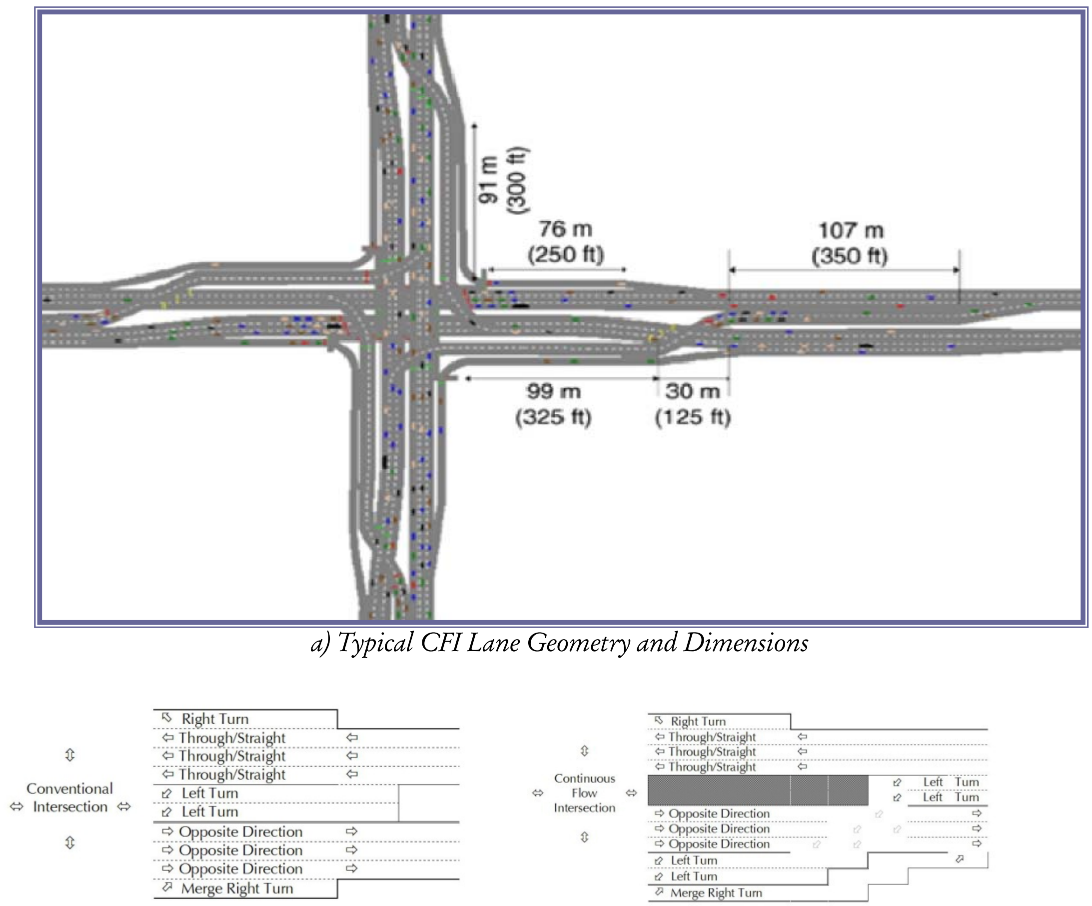
General Description

The CFI is an intersection design that is just beginning to be widely recognized and implemented in the United States. The first CFI was implemented in 1994 at a T-intersection in Long Island, New York; since that time, a handful of other CFIs have been implemented or are under design or construction. A CFI treatment can be applied to all or just some of the legs at an intersection.

The main difference between the design of this intersection and a conventional intersection is the removal of the conflict between the left-turn movements and the opposing through movements. The left-turn traffic is moved across the oncoming traffic lanes several hundred feet before the main intersection. This allows the through and left-turn movements to operate simultaneously at the main intersection, simplifying traffic signal timing from 4-phases to just 3-phases if two legs are CFIs, and 2-phases if four legs are CFIs. This, in turn, allows shorter cycle lengths, better signal progression, and shorter delay times for the users. The CFI can be a good interim solution for an at-grade expressway that may someday be grade separated. It is also a good choice when volumes from both streets are nearly equal.

Lane Geometry and Footprint

A diagram showing typical CFI lane geometry and some key dimensions is shown in **Figure 3-2** (following page). The treatment of the left turns at a CFI leads to significant differences in lane geometry from a conventional intersection. A conventional 4-way intersection nearing maximum capacity would typically have a right-turn lane, two or three through lanes and double left-turn lanes in one direction (say westbound), and two or three through lanes in the opposite direction (say eastbound), on all legs of the intersection. At the main intersection of a CFI, a typical setup would be one right-turn lane and two or three through lanes in the westbound direction, then two or three through lanes in the eastbound direction, then two left-turn lanes for westbound to southbound, then one right-turn lane for northbound to eastbound. The sum of the lanes is identical, with the exception of the northbound to eastbound right-turn "ramp" which is necessary largely to avoid driver confusion (as right-turners otherwise tend to enter the wrong way into the holding bay for the westbound to southbound movement).



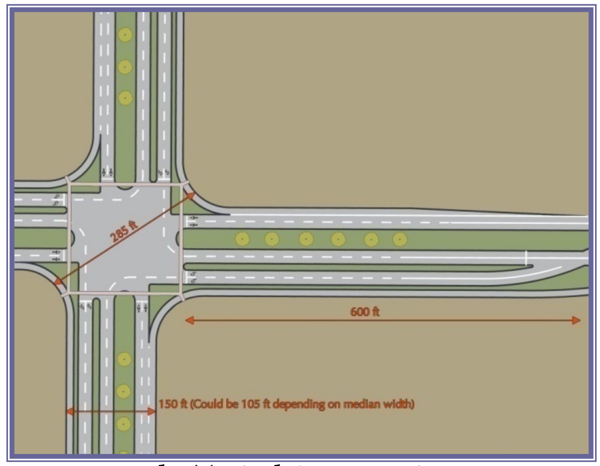
a) Typical CFI Lane Geometry and Dimensions

b) Comparison of Typical Lane Geometry, Conventional Intersection Versus CFI

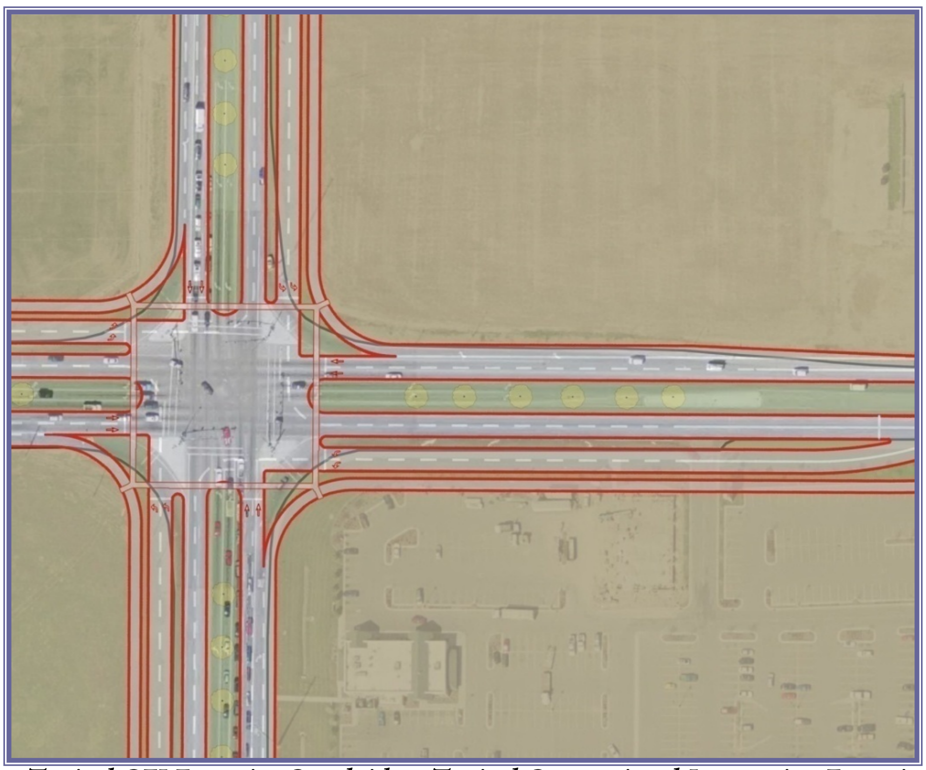
Figure 3-2: Typical Lane Geometry and Dimensions

It sounds and looks confusing, but it actually proves relatively easy for drivers to navigate. It needs only one more lane than a conventional intersection (for the right-turn ramp). Ideally it would have significant space for medians and islands to minimize the curvature of movements, but it can be designed very tightly to minimize right-of-way impacts. **Figure 3-3** (following page) compares the footprints of a conventional intersection versus a CFI.

a: Typical Conventional Intersection Footprint



b: Typical CFI Footprint



c: Typical CFI Footprint Overlaid on Typical Conventional Intersection Footprint

Figure 3-3: Comparison of CFI and Conventional Intersection Footprints

While a CFI has many traffic capacity and operational advantages over a conventional intersection, one commonly noted disadvantage is the increased right-of-way requirements to accommodate the intersection design. These costs, however, usually pale in comparison to the costs of the structures and right-of-way required for a grade-separated interchange. Depending on the type of interchange, a CFI requires up to 75% less right-of-way. The CFI is also often more context-sensitive than a grade-separated interchange.

In a situation where traffic volumes do not appear to warrant a CFI treatment on all four legs of an intersection and/or where right-of-way costs for a 4-leg CFI are prohibitively expensive, it may still be a good idea to provide CFI treatment on just two opposing legs, while preserving normal left turns on the other two legs. See **Figure 3-4** for a diagram of such a layout.

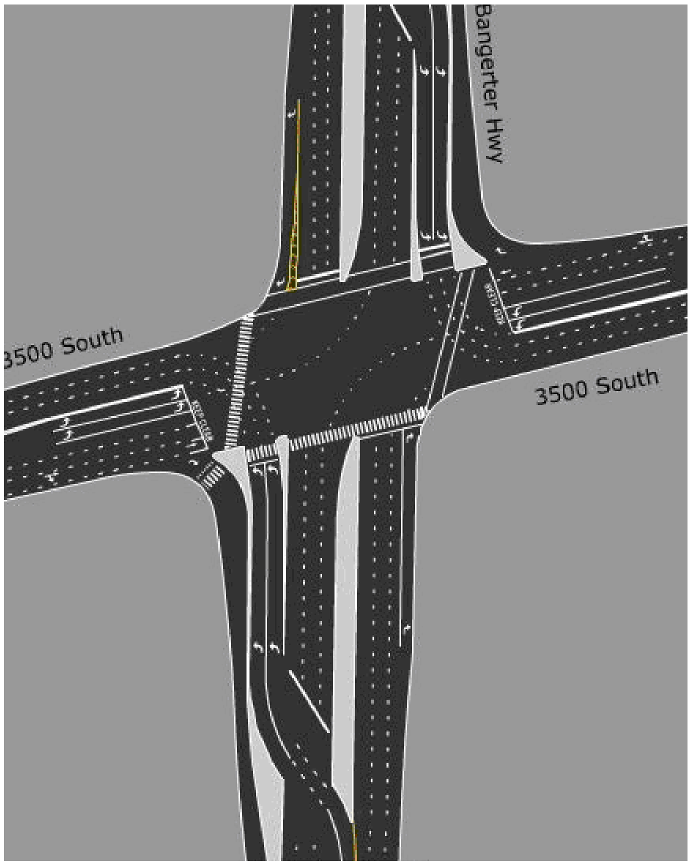


Figure 3-4: CFI Treatment on Only Two Legs of a Four-Leg Intersection

Operations and Signalization

The operational benefit of the CFI is that the simultaneous operation of through and left-turn movements allows the traffic signal timing to be simplified. In a standard 4-way high volume intersection, a traffic signal could have four or more signal phases. More phases leads to more "lost time" at the intersection as traffic responds to the yellow and red "transition times" between phases. On average, stopped traffic is delayed longer as they must wait through longer signal cycles and a larger portion of the cycle before they can clear the intersection. For a CFI, the average delay decreases from 50% to 90% when compared to a conventional intersection—depending on the hour of operation.

It is of utmost importance that the signal timing of a CFI is done correctly. At a conventional intersection, there is only one actual intersection, so only one set of traffic signals is necessary. A full CFI, on the other hand, would have a total of five sets of traffic signals operating together: one set for the main intersection and one at each of the four mid-block left turn movements. A typical high-volume conventional intersection is timed to allow the left-turn movements on the major street approaches to have green time, then the major street through movements, followed by the left turns on the secondary approaches (the cross street), and finally the secondary through movements. A CFI is timed to allow green time for the major street through and left-turn movements at the same time, then the secondary through and left-turn movements at the same time. For a portion of the major street phase, the secondary left-turn movements would have green time to move across oncoming traffic to queue for their left turn in the next signal phase. Likewise, during the secondary phase, the major street's left turns move across oncoming traffic and queue. In each case the left turns are made at an advantageous time and place, at which the oncoming traffic is comparatively light.

Capacity

One of the advantages of the CFI is its high capacity: the number of cars that can traverse the intersection per hour. For the intersection of two six-lane roadways, with a lane configuration on each approach of one right-turn lane, three through lanes and two left-turn lanes, a conventional intersection has a capacity of about 7,000 vehicles per hour. An equivalent intersection with CFI treatment on all four approaches can accommodate approximately 12,000 vehicles per hour, increasing capacity by some 63%. An equivalent intersection with CFI treatment on only two opposing approaches can accommodate about 10,000 vehicles per hour, increasing capacity by 25%.

12,000 vehicles per hour represents capacity to handle about 65,000 per day on the lower volume road, and up to 75,000 vehicles per day on the higher volume road. 7,000 vehicles per hour represents capacity to handle about 35,000 per day on the lower volume road, and up to 45,000 vehicles per day on the higher volume road.

Typical Cost Range

Overall, engineering and construction costs on the new CFI recently completed at Bangerter Highway and 3500 South in Salt Lake City are estimated at $5.3 million. **Figure 3-5** charts the major cost components of this CFI. The Baton Rouge CFI reportedly cost $4.4 million, and no additional right-of-way was required. This is significantly less than the costs of grade separated solutions which may reach well upwards of $20 or even $30 million. Another advantage to the

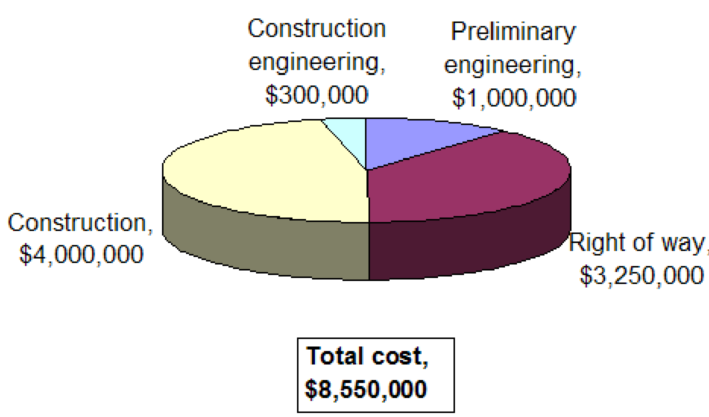


Figure 3-5: CFI Costs - Bangerter Highway and 3500 South in Salt Lake City

CFI is the reduced indirect costs associated with the impacts on adjacent businesses and passing traffic during construction. On average, a CFI can be constructed in six months, while an interchange usually takes 18 to 24 months.

3.2. Streetscape, Access and Site Design

Streetscaping and Multimodal Accommodations

Building Setbacks: CFIs are often implemented on higher-speed roadways. Once the ultimate footprint required for a CFI is preserved for, building setbacks are a function of the need for higher-speed drivers to see all aspects of the intersection so they have time to react to anything unusual. In most cases, building setbacks of 40 feet beyond the sidewalks should be sufficient. In cases where the CFI could ultimately lead to a grade-separated intersection, setbacks and access control should be set according to grade-separation standards.

Landscaping: The CFI tends to have a number of interior islands for navigation and vehicle separation, which represent good opportunities for landscaping. While it can look very "park-like," this is very much an auto-oriented intersection and does not lend itself to a comfortable pedestrian environment as do other designs. Landscaped medians reduce noise and provide an attractive addition to the streetscape for all users of the intersection, whether driving, riding or walking.

Signing Policies: Based on public feedback about CFIs, the public requires ample and descriptive signage of the intersection layout. Signs should be provided well in advance of the intersection; this is especially important for left-turning vehicles. An example CFI with all appropriate signage is represented in **Figure 3-6**.

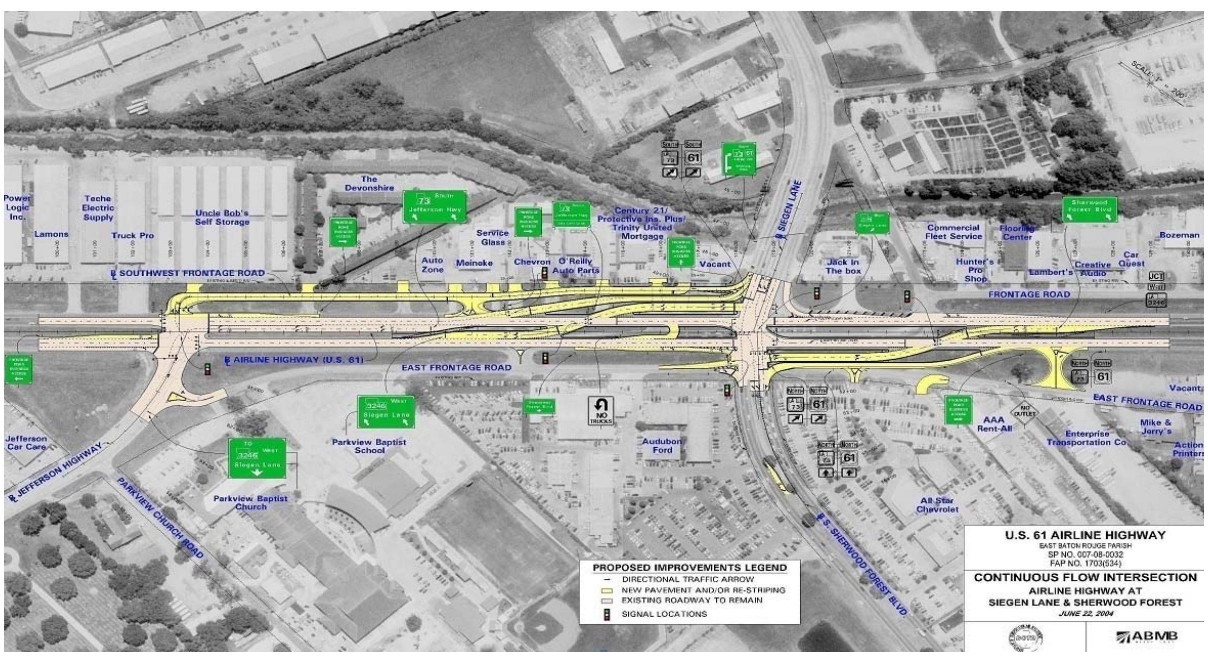


Figure 3:6: Directional Signs for a CFI

CFIs require an increased number of traffic signals, each of which require standard signal-related signage. Power outages create a challenging situation for CFIs as there are more signalized crossing points requiring the attention of law enforcement officers.

Existing commercial signs may encroach on required "visibility triangles" as intersections are converted to a CFI; such signs would need to be moved or removed.

Pedestrian and Bicyclist Accommodations: The CFI can be designed to safely serve pedestrians and bicyclists, but there is much to be learned in this area, and it is normally an intimidating environment. CFIs are a better choice where there are relatively few pedestrians. The intersection recently constructed at Bangerter Highway and 3500 South in Salt Lake City is the first one built specifically to accommodate pedestrians. **Table 3-1** summarizes factors that may enhance or detract from pedestrian and bicyclist safety at CFIs.

Table 3-1. Potential Factors Influencing Pedestrian and Bicyclist Safety at CFIs

Potential Factors Enhancing Safety	Potential Factors Detracting From Safety
• Drivers making left turns are physically closer to crossing pedestrians, resulting in improved visual contact • Medians between right turns and left turns can function as pedestrian refuges • Shorter cycle time at CFIs reduces pedestrian waiting time between crossing phases	• Wider intersection legs to cross - crossings need to occur in two "phases" • Unfamiliar vehicle flows may confuse pedestrians, including the visually impaired

As depicted in **Figure 3-7**, the intersection of Bangerter Highway and 3500 South has been designed with only two legs having CFI treatment, the north leg and the south leg. Consider a pedestrian beginning at circle 1 in the northeast quadrant. Vehicles making the westbound right turn are not signalized but would be required to yield to crossing pedestrians. The pedestrian would be given a "green hand" indication and cross to circle 2 when the northbound and southbound vehicle movements have the green light. A pedestrian continuing west would proceed on the very next signal phase when the eastbound and westbound vehicle movements have the green light, while a pedestrian continuing to the south would wait at circle 2 until the next northbound and southbound phase.

Other important points to consider in the design of pedestrian crossing facilities at or near a CFI are:

- Medians used as pedestrian refuges should have non-mountable curbs at an appropriate height. Use wider median refuges to accommodate heavy pedestrian flows.
- Signalization of right-turn lanes on CFI approaches is recommended. At a "mixed CFI" with not all legs having CFI treatment, signalization of right-turn lanes on non-CFI approaches may be desirable.
- Pedestrian crossings should be placed as close as possible to the tangential approach instead of the curved section for improved pedestrian-driver visual contact.
- Mid-block pedestrian crossings should not be provided within a CFIs footprint; they may be acceptable beyond the footprint area.

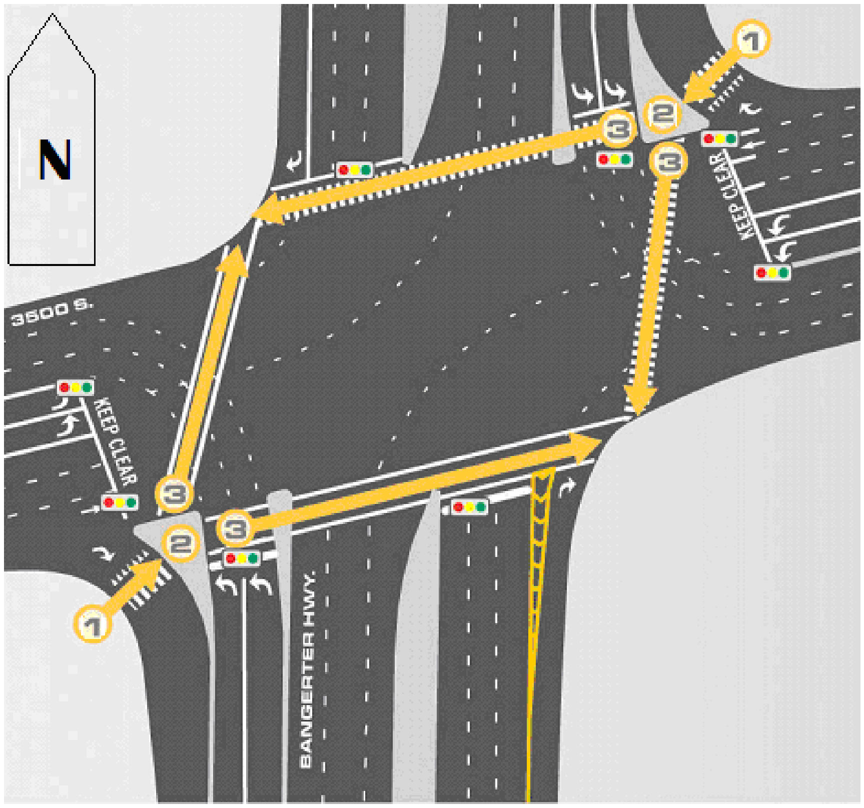


Figure 3-7: Example Sequential Pedestrian Crossing at a CFI

The results from modeling studies conducted in 2005 indicate an acceptable pedestrian level of service B or C on the basis of the average delay per stop experienced by any pedestrian for pedestrian crossings at the typical CFI geometries modeled. Modeled pedestrians were accommodated within two cycles for a typical signal cycle length ranging from 60 to 100 seconds (see Reference 1).

Little research seems to be available concerning CFIs and bicycle traffic. Bicyclists may utilize pedestrian crosswalks to successfully maneuver a left turn in a CFI, but placement of on-road bicycle lanes at CFIs has yet to be identified.

Transit Accommodations: Bus service in Ada County currently operates on a flag stop basis, although there are plans to implement a more formal system with marked bus stops in the near future. The geometry of CFIs presents some challenges that impact both bus stop placement and routing. First of all, there is the question of whether the stop should be placed on the near side or the far side of the intersection. While either location is possible, a far side stop would probably have to be positioned beyond the CFIs footprint, several hundred feet downstream. Near side stop placement is more flexible.

As shown in **Figure 3-8**, bus stops may be placed at any of three potential locations. Due to the median separation of lanes in a CFI, the closer a bus stop is to the intersection, the fewer movements the bus will be able to make at the intersection.

- Bus Stop Location 1, at a distance of 250 feet from the intersection, would limit bus movements only to the right-turn movement.

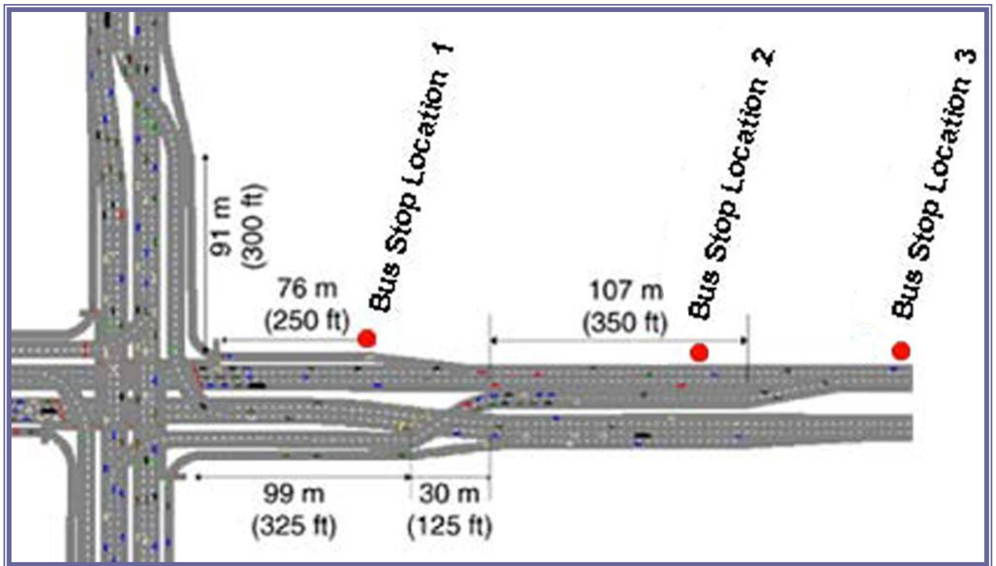


Figure 3-8: Potential Bus Stop Locations at a CFI

- Bus Stop Location 2, at approximately 600 feet from the intersection, would offer buses the ability to make both the through and right-turn movements.
- Bus Stop Location 3, at approximately 950-1000 feet from the intersection, would allow buses to make all three turning movements. This location offers the most flexibility for handling future changes in bus routes or for handling multiple bus routes that need to turn in different directions.

Any of these locations can function with or without a bus pullout. Proximity to rider attractions may be another consideration when placing bus stops.

Access Management

Access issues to adjacent parcels surrounding the CFI may arise, as longer travel lanes with increased median separation occur at CFIs, direct accessibility to adjacent land uses decreases. On the other hand, the enhanced movement of traffic through these intersections may actually improve business exposure and safety of access. Many businesses that participated in public surveys concerning a new CFI in Louisiana felt there was little to no change in daily business operations (**see Reference 2**). Agencies should

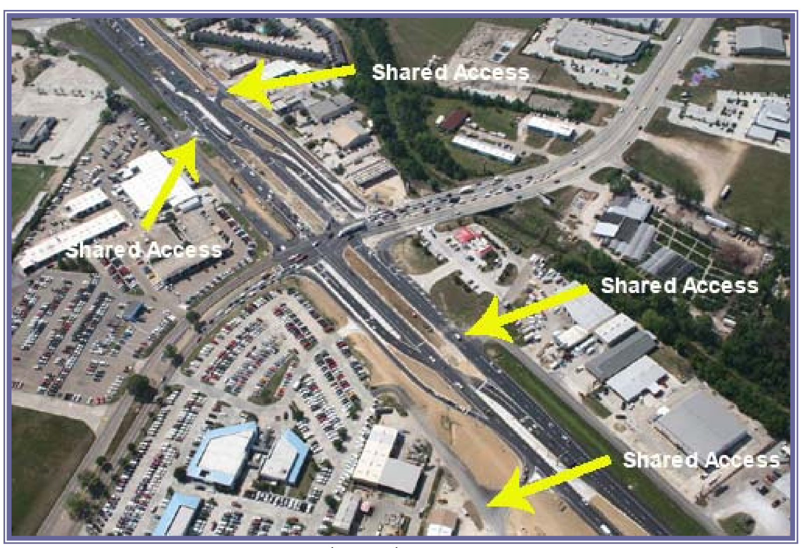


Figure 3-9: Shared Access Near a CFI

strictly enforce shared access policies within and near the CFI's footprint. **Figure 3-9** (previous page) shows an example CFI with potential shared access points.

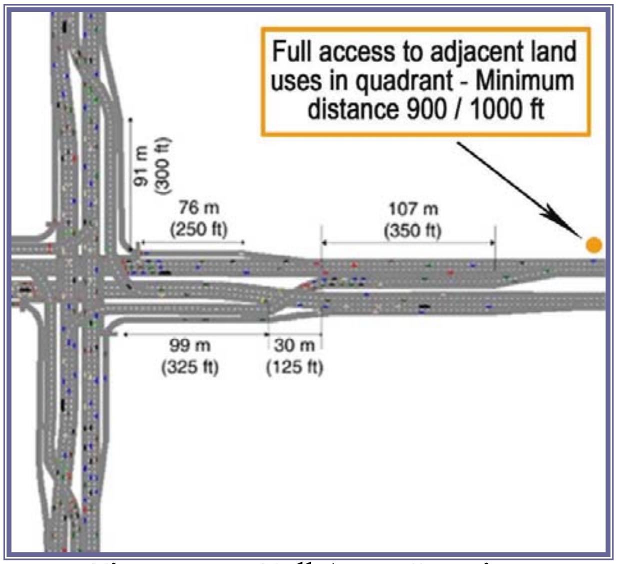


Figure 3-10: Full Access Location

The geometry of CFIs results in considerations for placement of shared access driveways that are somewhat analogous to the considerations for placement of bus stops. As with the bus stops, the closer a shared access is placed to the main intersection, the fewer options an exiting vehicle will have for subsequent turning movements at the intersection. As indicated in **Figure 3-10**, a shared access providing full access for all traffic on an approach must be located some 900 to 1,000 feet upstream of a CFI. Accesses placed closer than this will not be able to capture all traffic on the approach. A good way to mitigate this problem is for developments to provide internal circulation or backage roads that connect properties with access points too close to the intersection, to properties with full access points farther away from the intersection. See also the following section about site design on adjacent land.

Site Design on Adjacent Land

Because the footprint of a CFI is greater than that of a conventional intersection, a conversion to CFI may encroach upon the area required by building setback policies. However, implementation of CFIs does not require a change in the building setback policies themselves.

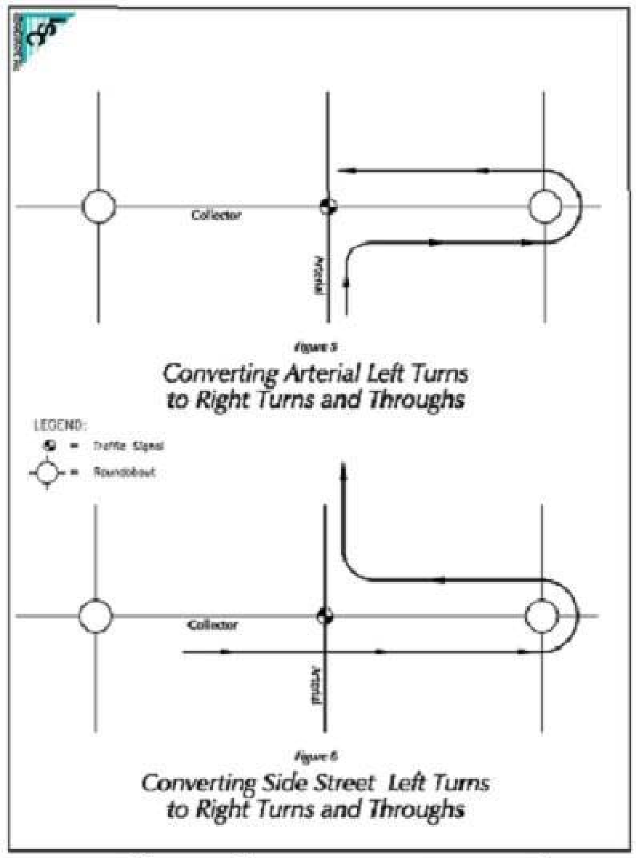
Site design and accessibility go hand in hand. A CFI will restrict the number of access points close to the intersection. While this is highly desirable from a traffic safety and operations standpoint, it also requires mitigation in the form of a well-developed internal circulation network that enhances connectivity between sites and accommodates short trips that would otherwise occur on the arterials. While building setbacks from the CFI itself are necessary, along the internal circulation network small setbacks or no front setback may be appropriate to foster a walkable environment.

4. Implementing Median U-Turns and Bowties

4.1. Intersection and Roadway Design

General Description

A Median U-Turn (MUT) eliminates left turns from intersections by prohibiting them at the main intersection, instead requiring a driver to go through, then make a U-turn at a designated spot, then go right (and in the opposite direction drivers first go right, then make a U-turn, then go through). The procedure for making these turns is detailed in **Figure 4-1**.



Source: Waldman et. al., LSC Transportation Consultants

Figure 4-1: MUT Left Turn Equivalents

The MUT is also known as a "Michigan Left." Efforts to preserve right-of-way in excess of current demands led to the development of a network of divided highways across Michigan. These large medians allowed them to easily implement the design.

Lane Geometry and Footprint

The treatment of the left turns at an MUT leads to significant differences in lane geometry from a conventional intersection. Each leg of a conventional 4-way intersection nearing maximum capacity would typically have a right-turn lane, two or three through lanes and double left-turn lanes in on one side of the median, and two or three through lanes on the opposite side of the median.

In comparison, a MUT will typically have the same or more through lanes, a right-turn lane, and a U-turn lane located after the intersection to facilitate left turns. **Figure 4-2** shows a full MUT and gives dimensions for an arm. Because the system converts left turns to through movements, it is often useful to use the space that was once reserved for double-left pockets, and instead use this as a single extra through lane that merges back to normal beyond the intersection. Estimates of expected volumes should confirm whether this extra through lane is necessary or not.

The main design disadvantage of an MUT is the additional right-of-way required for the U-turn pullout. But unlike a conventional intersection, there is greater flexibility in selecting the location of the additional right-of-way, allowing for a more context sensitive solution.

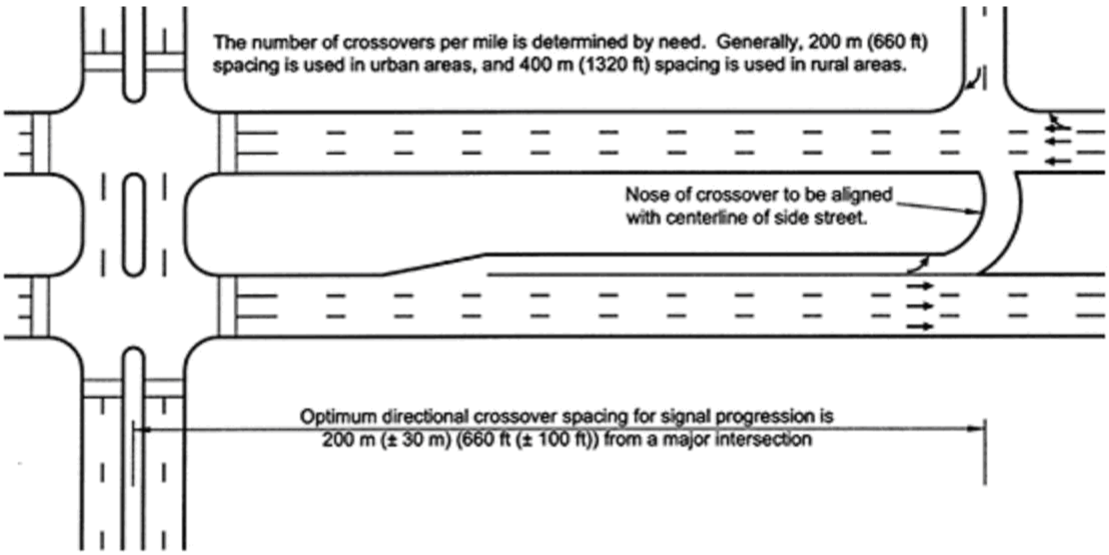


Figure 4-2: MUT Geometry and Dimensions

The outside radius for the U-turn should track with the right front tire of the design vehicle. On larger roadways, a typical WB-62 tractor with a single trailer would require an outside radius of 46 feet. This means that from the yellow dividing line that separates the turn pocket from through lanes (the right front tire), there must be about 92 feet of pavement (46 x 2) for a large vehicle to complete the turn. If existing right-of-way is insufficient, consider providing a turning basin that carves the required space perhaps out of an existing parking lot, as shown in **Figure 4-3**.

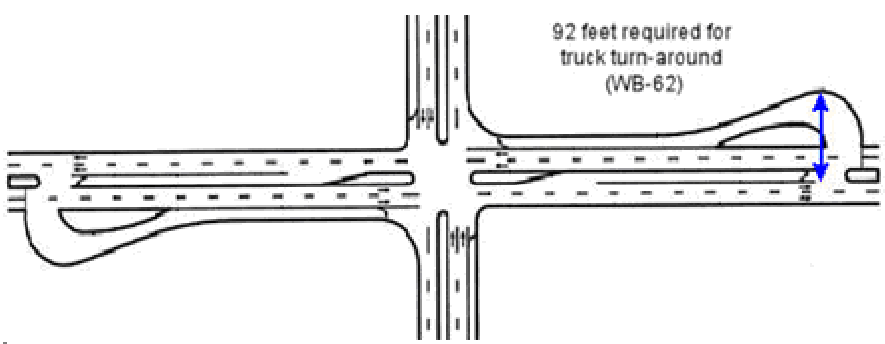


Figure 4-3: MUT with Turning Basin

Operations and Signalization

The operational benefit of the MUT is the relocation of all left-turn movements to outside the main intersection by transforming them to through movements and relocating the left-turn movement to a secondary location. This allows the primary signal to behave as a two-phase signal, simplifying signal timing and reducing the portion of the cycle length that must be devoted to left turns. However, re-routing left turns beyond the intersection requires drivers to make an additional U-turn, so that the turn maneuver actually takes more time. However, studies have shown MUT intersections to have significantly higher efficiency than a double-left intersection during peak hours, and similar efficiency during non-peak hours (circuitous paths nearly offset efficiency gained by 2-phase signal in off-peak hours).

If there are insufficient gaps in the upstream traffic to the intersection, it becomes impossible for drivers to make the left-hand turn necessary to complete their U-turn. In such circumstances, it is possible for spillback from the U-turn lane to occur back into the main intersection. In such circumstances, signalizing the U-turn pull-out may become necessary. Signalized crossovers can be synchronized with other signals in a corridor to provide progression. Signalized crossovers should have the maximum possible design queue to avoid spillback into the main intersection. Signalizing the intersection would also reduce the conflicts resulting from cars performing the weaves necessary to reach the out right-turn lane. Because Bowtie-style MUT intersections have an independent lane added, they could be expected to reduce the need for signalization.

Capacity

For the intersection of two six-lane roadways, with a lane configuration on each approach of one right-turn lane, three through lanes and two left-turn lanes, a conventional intersection has a maximum capacity of about 7,000 vehicles per hour. An equivalent intersection with a MUT on the major street can accommodate approximately 10,500 vehicles per hour, a 50% increase in capacity.

Studies done in Virginia and North Carolina using a variety of intersection configurations suggested an overall change in travel time for all movements through an intersection was a 20% to 2% reduction during non-peak hours, and during peak conditions it ranged from a 21% reduction to a 6% increase. MUT intersections also resulted in a 20% reduction to a 76% increase in stops during off-peak conditions, and 2% decrease to 30% increase during peak conditions. Because MUT intersections decrease the number of stops for through movements, while increasing them for left-turn movements, they are more suitable for intersections with high through volumes. Bowtie intersections could be expected to mitigate the increase in number of stops by allowing for continuous flow for vehicles making left-hand turns.

Typical Cost Range

Where an adequate median already exists or where a turn basin can be developed if necessary for the design vehicle, the conversion can be done at a relatively low cost. Bowtie intersections may require considerable additional right of way, also dependent on the radius required for the design vehicle. A simple installation may be less than $1 million for signals to clear the U-turn and only minor construction if large trucks are prohibited from making the left. Bowtie designs or MUTs accommodating trucks will likely run into the $3-5 million range after right-of-way acquisition and construction.

4.2. Streetscape, Access and Site Design

Streetscaping

Because of the presence of medians within a MUT, opportunities exist to enhance the aesthetic and place-making value of an intersection through innovate landscaping, signage or monuments. Properly landscaped medians can also serve to reduce traffic noise.

Signage

Based upon surveys of Michigan visitors, MUTs do not seem to provoke an undue level of outrage among visitors. Making a U-turn in the median is a very similar procedure to one for simply having missed the turn for an intended left. The presence of available U-turn pull-outs may actually serve to increase navigational ease for those unfamiliar with the area. However, the procedure for making a left-turn onto the median divided road is less intuitive, because it requires users to "make a right to make a left" and may require additional signage.

Figure 4-4: Directional Sign for MUT

Multimodal Accommodations

The pedestrian environment with MUTs and Bowties is greatly enhanced. Safety and aesthetics are improved, and shorter cycle lengths reduce the pedestrian waiting time. Bike lanes for through movements are also easily accommodated, but to make a left turn a bicyclist must take a circuitous path like vehicles, or cross with pedestrians.

Bus stop locations must be carefully considered to avoid selecting a spot that would require a bus to make a weave across multiple lanes to reach the MUT. Bus bays just beyond the intersection as shown in **Figure 4-5** are generally most appropriate.

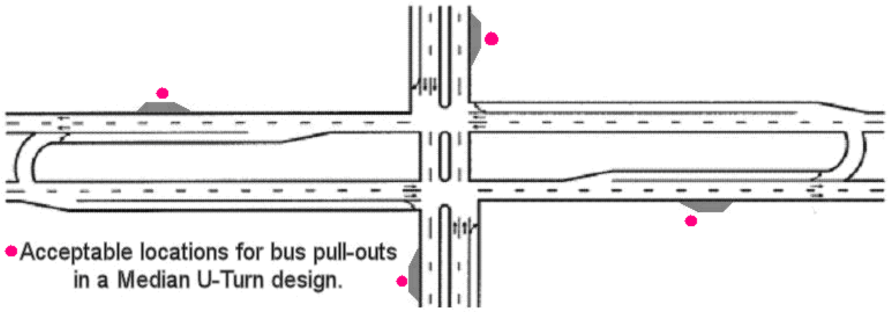


Figure 4-5: MUT Bus Pull-out Locations

Access and Land Use Standards

Ideally, driveways would be first located beyond the U-turn, but right-in, right-out can be accommodated at the same standards as with a standard intersection. However, it may be important to avoid creating a short weave by locating the first driveway beyond any opportunity to enter the left-turn pocket. Pedestrian-oriented land uses are more easily accommodated due to fewer vehicle-pedestrian conflicts.

5. Implementing Quadrant Roadways

5.1. Intersection and Roadway Design

General Description

A quadrant roadway intersection eliminates left turns from intersections by prohibiting them at the main intersection and rerouting them along a two-way roadway joining two of the legs of the main intersection. The ideal quadrant roadway features:

- Spacing of the quadrant roadway tie-in points at least 500 feet from the main intersection, yet not so far that drivers perceive excessive out of direction travel (i.e. between 500 and 1,000 feet is ideal);
- The termini of the roadway are both T-intersections (i.e. avoid 4-leg intersections that might require a 4-phase signal because the result could be lower efficiency at the main intersection and bottlenecks at the quadrant tie-in);
- The three signals (at the main intersection and at the roadway termini) are operated as a fixed-time interconnected system, with two phases at the main intersection and three phases at each of the roadway termini; and
- Application at intersections where turning movements are relatively small compared to through movements.

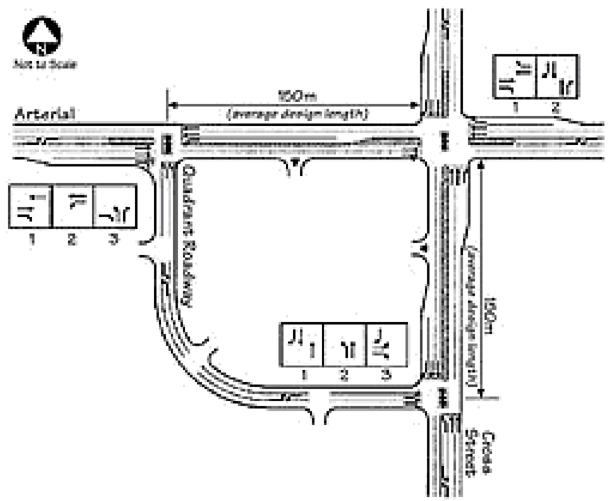
Based on the simulations prepared by the consultant team, quadrant roadway designs with variations from the ideal can still function quite well and provide a good performance boost, although they will not function at the level of the ideal quadrant roadway. The simulations indicate that quadrant roadways can provide significant benefits in non-ideal cases such as larger spacing, termini with four legs, and signals not necessarily controlled by a single controller (although still carefully coordinated). Such cases may come about when highway agencies wish to use an existing roadway to keep costs low, yet it may be politically difficult to close or restrict movements at an existing fourth leg at either or both termini.

Another interesting possibility that was explored in simulations was to implement multiple quadrant roadways at the same intersection. In the case of two quadrant roadways, the simulations indicate that it is advisable to place the roadways in opposite quadrants. The simulations support the idea that multiple quadrant roadways may provide operational benefits beyond that afforded by a single quadrant roadway. This is particularly true in cases where the turning movement volumes are high, potentially exceeding the capacity of a single roadway. Also, multiple (two or four) quadrant roadways would allow left turns to be made in a manner more consistent with driver expectancy. Part of Chapter 2 addresses concepts related to multiple quadrant roadways in some depth; the remainder of this chapter focuses on the quadrant roadway as it was originally conceived: a roadway in a single quadrant.

Lane Geometry and Footprint

The treatment of the left turns at a quadrant roadway intersection leads to significant differences in lane geometry from a conventional intersection. Each leg of a conventional 4-way intersection nearing maximum capacity would typically have a right-turn lane, two or three through lanes and double left-turn lanes on one side of the median, and two or three through lanes on the opposite side of the median.

In comparison, a quadrant roadway intersection will typically have a main intersection with the same number of through lanes and a right-turn lane on each approach, but no left-turn lanes. Two new intersections are formed at the quadrant roadway termini, at which a single or dual left-turn bay is provided for entry onto the roadway. Depending on volumes, two or three turning lanes (one or two for left turns, one for right turns) would be the norm for exiting the roadway. The roadway itself might commonly have a 3-lane cross section (one lane per direction, with a median turning lane). **Figure 5-1** shows a typical quadrant roadway with key dimensions.

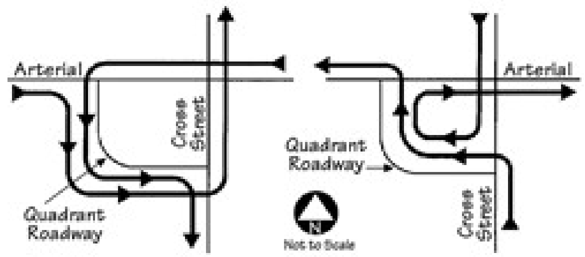


Source: Using Quadrant Roadways to Improve Arterial Intersection Operations
Figure 5-1: Quadrant Roadway Geometry, Dimensions and Signal Phasing

The main design disadvantage of a quadrant roadway is the additional right-of-way required for the new roadway alignment and intersections and the associated costs. Taking advantage of an existing roadway that is well-situated to serve as a quadrant roadway may reduce the required cost. However, existing roadways may also present challenges (such as the four-leg issue mentioned earlier or insufficient width) that would need to be addressed.

Operations and Signalization

The operational benefit of the quadrant roadway is the transformation of all left-turn movements at the main intersection to through and/or right-turn movements at the main intersection (with left and/or right turns occurring at the roadway termini). This allows the primary signal to be reduced to two phases, simplifying signal timing. **Figure 5-2** shows how left turns would be made on each of the four approaches of a quadrant roadway intersection.

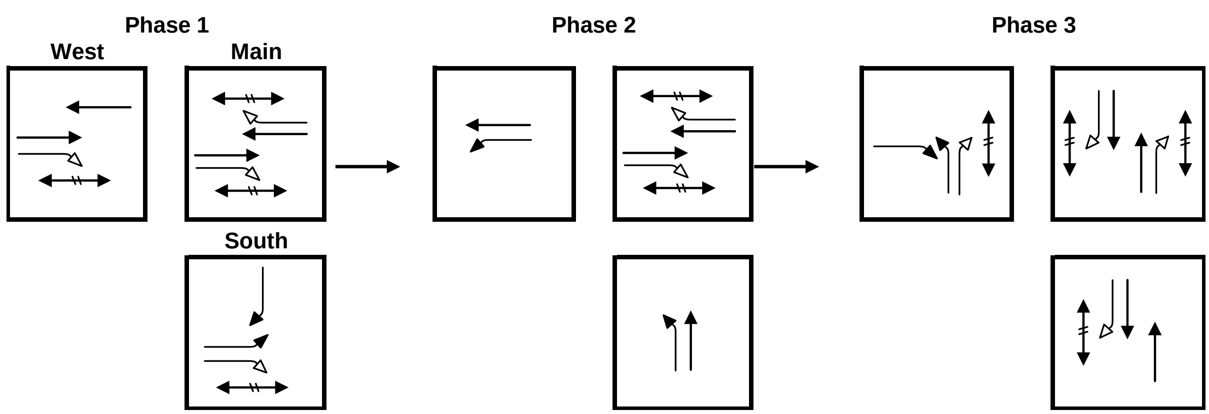


Source: Using Quadrant Roadways to Improve Arterial Intersection Operations

Figure 5-2: Left-turn Routing at a Quadrant Roadway Intersection

Most of the left-turning vehicles experience increased left-turn travel distance, and there is potential for increased left-turn travel times and stops. This negative impact is mitigated by the overall increase in the intersection's efficiency from reducing the signal to two phases. Simulation studies suggest a reduction in overall travel time through a quadrant roadway intersection when compared to a conventional intersection: 21% less to 1% more during off-peak conditions, and 21% less to 1% less during peak conditions. The studies also show a general increase in the overall percent of stops when compared to a conventional intersection: 12% less to 96% more during off-peak conditions, and 3% less to 33% more during peak conditions.

Figure 5-3 provides a summary of the signal phasing recommended for use in the three-signal system required at a quadrant roadway intersection. The figure represents phasing for when the roadway is in the southwest quadrant.



Source: Signalized Intersections: Informational Guide

Figure 5-3: Signal phasing at a Quadrant Roadway Intersection, Roadway in SW Quadrant

Capacity

For the intersection of a six-lane road with a four-lane road, with one right-turn lane and two left-turn lanes on each approach, a conventional intersection has a maximum LOS E capacity of about 7,000 vehicles per hour. An equivalent quadrant roadway intersection can accommodate approximately 10,500 vehicles per hour, a 50% increase in capacity.

Typical Cost Range

Where an adequate roadway already exists, the conversion to a quadrant roadway intersection can be done at very low cost, perhaps little more than the cost of adding new traffic signals at the roadway termini, with the appropriate signage and pavement markings. These costs can go up considerably if the roadway requires widening, if new turning bays onto the roadway are required, and even more if a new roadway is required. Overall, costs might be well under $1 million to $3 million or more. This excludes any other incidental costs not directly associated with the quadrant.

5.2. Streetscape, Access and Site Design

Streetscaping

In one sense, a quadrant roadway is a type of "backage road," which presents an opportunity to design a relatively low-speed, pedestrian-friendly connection between two legs of an intersection with an eye toward aesthetics and sense of place. Due to the roadway's curvature, it naturally provides a sense of "inside" and "outside" which can be accented as desired with streetscape elements such as sidewalks, benches, lighting and so on.

Signage

Because each approach makes a left turn differently at the main intersection, good advance signing is critical to help drivers prepare for the required movements. Good signage, combined with a well organized public education effort, will mitigate the unusual driver expectancy and potential confusion created by the various ways that left turns are made at the intersection.

Multimodal Accommodations

The pedestrian environment offered by quadrant roadways can be very good. The quadrant roadway itself can be a relatively low-speed environment that reduces noise and enhances pedestrian safety. At the main intersection, pedestrians enjoy shorter cycle lengths, reduced waiting time, and fewer conflicting vehicular movements. Bike lanes for through movements are easily accommodated, but to make a left turn a bicyclist must take a circuitous path like vehicles, or cross with pedestrians.

Bus stop locations must be carefully considered to avoid selecting a spot that would require a bus to make a weave across multiple lanes to reach a left-turn bay. Since all the left turns at the intersection pass along the quadrant roadway, it may make sense to reduce the number of bus stops needed by placing them on the roadway, perhaps near the corner, rather than on either of the streets that the roadway connects. Also, the quadrant roadway can easily be designed to accommodate heavy vehicles.

Access and Land Use Standards

Left turns from driveways between the main intersection and the roadway termini should be restricted (possibly by raised medians) in order to reduce potential conflict points. In particular, a median is required for protection of the left-turn storage for vehicles entering the quadrant roadway. Existing driveways in sensitive areas could be converted to right-in, right-out only or could be consolidated and relocated to less sensitive areas.

Pedestrian-oriented land uses at a quadrant roadway intersection are easily accommodated due to fewer vehicle-pedestrian conflicts. Quadrant roadways also offer great potential for transit-oriented development.

References

Several of these sources were used in completion of this report, and should also be researched prior to designing any innovative intersection.

1. Jagannathan, Ramanujan and Joe Bared, "Design and Performance Analysis of Pedestrian Crossing Facilities for Continuous Flow Intersections," 2005. Transportation Research Record: Journal of the Transportation Research Board, No. 1939, pp 133-144.

2. Kalivoda III, Nick, "A Presentation on Louisiana's Continuous Flow Intersection (CFI)." Presented at the AASHTO Subcommittee on Design Annual Meeting. June 11, 2007. http://www.transportation.org/sites/design/docs/Nick%20Kalivoda_Kalivoda%202007%20AASHTO%20SCOD%20Presentation.pdf.

3. Federal Highway Administration, "Signalized Intersections: Informational Guide." August 2004. FHWA-HRT-04-091 http://www.tfhrc.gov/safety/pubs/04091/index.htm

4. Wikipedia contributors, "Michigan left," *Wikipedia, The Free Encyclopedia,* http://en.wikipedia.org/w/index.php?title=Michigan_left&oldid=181969625 (accessed January 10, 2008).

5. Reid, Jonathan D. and Joseph E. Hummer, "Analyzing System Travel Time in Arterial Corridors with Unconventional Designs Using Microscopic Simulation." TRB Annual Meeting Preprint CD 1999. http://trafficware.com/assets/pdfs/00036.pdf

6. Waldman, Benjamin, Alex Ariniello, and S.M. Alam, "Eliminating Left-Turns at a Signalized Intersection With The Use of Nearby Roundabouts." May 30, 2007. Oregon ITE. http://www.oregonite.org/2007D6/paper_review/E6_106_Waldmanpaper.pdf

7. Reid, Jonathan D. and Joseph E. Hummer, "Unconventional Left-Turn Alternatives for Urban and Suburban Arterials: *An Update."* TRB Circular E-C019: Urban Street Symposium. http://onlinepubs.trb.org/onlinepubs/circulars/ec019/EC019_E3.PDF

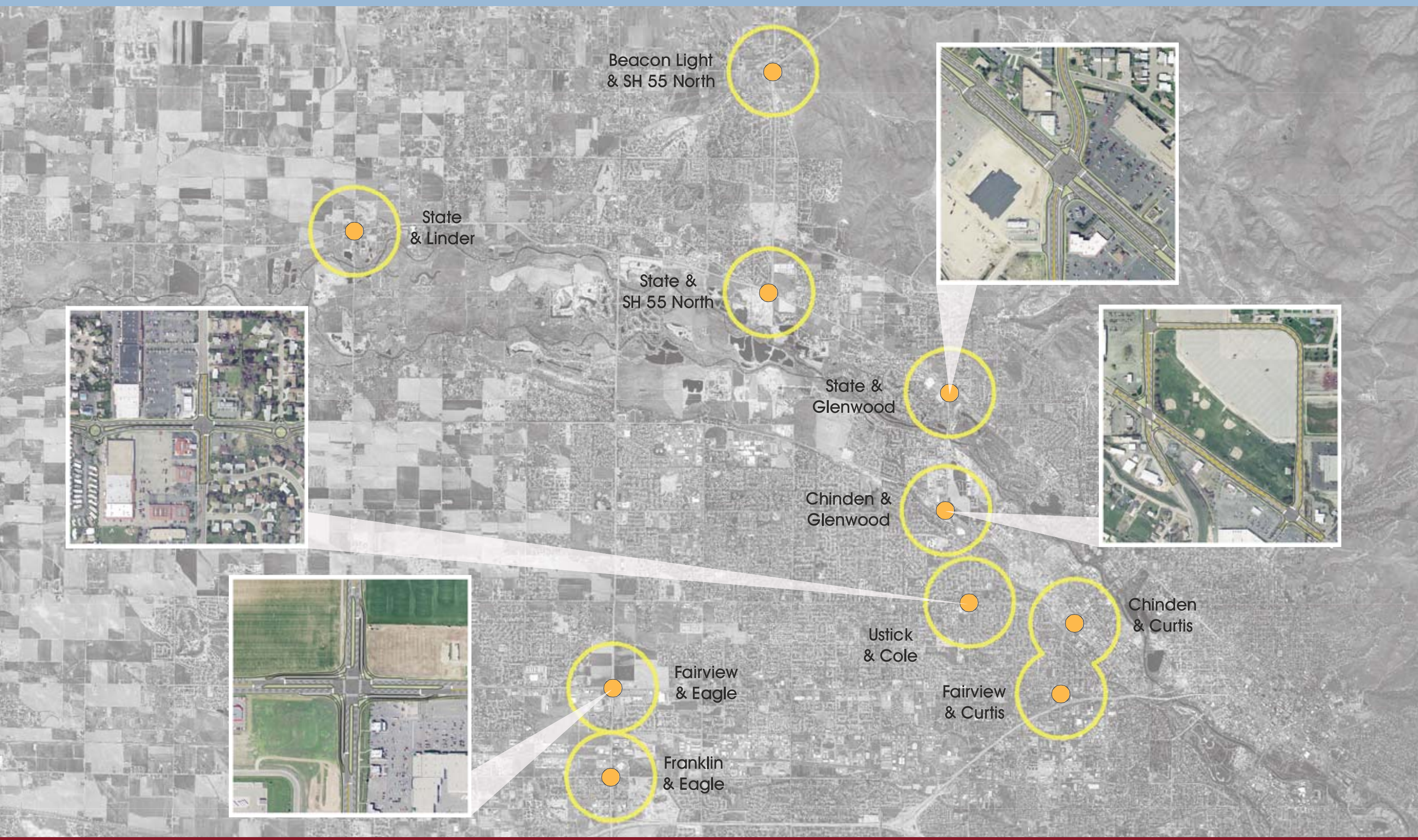
8. Thompson, Cipriana D. and Joseph E. Hummer, "Guidance on the Safe Implementation of Unconventional Arterial Designs." September 17, 2001. Prepared for University of Tennessee at Knoxville.

9. Reid, Jonathan D., "Using Quadrant Roadways to Improve Arterial Intersection Operations." http://www.pbworld.com/news_events/publications/network/Issue_50/50_35_ReidJ_QuadrantRoadways.asp (accessed February 7, 2008).

High Volume Intersection Study, Vol. II

Intersection Concept Layout Report

COMPASS
COMMUNITY PLANNING ASSOCIATION
of Southwest Idaho



prepared for
Community Planning Association of Southwest Idaho

submitted by
Wilbur Smith Associates

in association with
HDR
THOMPSON TRANSPORTATION ENGINEERING & PLANNING

WilburSmith ASSOCIATES
ENGINEERS PLANNERS ECONOMISTS

April 21, 2008

The ***High Volume Intersection Study*** (HVIS) consists of three volumes:

Vol. I Innovative Intersections: Overview and Implementation Guidelines, broadly outlines information about a variety of innovative intersection concepts and provides more specific implementation guidelines for intersection types that appear to be most applicable to southwest Idaho.

Vol. II Intersection Concept Layout Report, features spotlighted high volume intersection concepts at nine different intersections in Ada County.

Vol. III Additional Materials, includes a compatibility matrix between intersection types and urban forms and street functional classifications.

The Community Planning Association of Southwest Idaho (COMPASS) contracted with Wilbur Smith Associates for this study, with additional contributions by Thompson Transportation, HDR, and Joseph E. Hummer, Ph.D., P.E.

Table of Contents

List of Maps

Acronyms and Terms

Acronym or Term	Meaning
ACHD	Ada County Highway District
Additional Materials	A companion to this document and Volume III of the HVIS. The *Additional Materials* document includes a compatibility matrix between intersection types and urban forms and street functional classifications.
ADT	Average daily traffic
Arterial interchange	Characterized by grade separation (overpass or underpass), but designed specifically to fit within the context of a typical intersection. Much smaller footprint than a freeway interchange, simple signal timing, high capacity or even free flow for the major movement, and relatively high flow for the minor movement.
At-grade intersection	An intersection where all vehicles traverse the intersection at ground level, or "at grade." There is no grade separation (overpass or underpass).
Bowtie	A bowtie intersection is fundamentally similar to a Median U-Turn, but roundabouts or tear drops are used at the turn around points.
Capital Improvements Plan (CIP)	ACHD's *Capital Improvements Plan*, adopted July 2006. The projects listed are improvements that will be needed by 2027, and are not scheduled for construction in the Five Year Work Plan (FYWP). They are listed as needs in 6 – 10 years (2013–2017) or 11 – 20 years (2018-2027). The CIP was based on several factors, including deficiencies identified in the COMPASS regional travel demand model.
Communities in Motion (CIM)	*Communities in Motion: Regional Long-Range Transportation Plan 2030*, adopted by COMPASS in August, 2006.
COMPASS	Community Planning Association of Southwest Idaho, the metropolitan planning organization (MPO) for northern Ada County and Canyon County.
COMPASS travel demand forecast model	Two forecasts are relevant: 1) Community Choices 2030 represents current plans for demographics and roadway networks. It is the official model reflected in *CIM*. 2) The Preservation model is unofficial and adds additional population to the north foothills, south Meridian, and other areas. Intersections were designed for Community Choices, but recognizing they may potentially need to serve higher volumes shown in Preservation.
Continuous Flow Intersection (CFI)	An innovative intersection design in which left-turning vehicles cross over the travel lanes of the opposing through movement in advance of the intersection, so left-turns and through movements at the main intersection can proceed simultaneously. Also referred to as a "crossover displaced left-turn" or XDL.
Continuous Green "T"	A design option at T intersections where oncoming traffic from the right need not be stopped to allow left-turns from the T-approach to enter. Instead, left turns have an extended merge lane.

Acronym or Term	Meaning
Conventional intersection	A conventional intersection is any design that is very typical for a given area. For this study, it is generally considered to be the intersection of two major streets, where left-turns are handled by a protected left-turn signal phase from lanes in the median. At high volumes, dual left-turn lanes and right turn bays are common, in addition to through lanes. Also, they usually have four "legs" or approaching streets, and all the lanes proceeding in a common direction are next to each other.
EIS	Environmental Impact Statement
FYWP	ACHD's *Five Year Work Plan 2008-2012*, dated February 28, 2007
HVIS	High Volume Intersection Study
Innovative intersection	An innovative intersection, for the purposes of this project, is any of a series of at-grade or grade-separated intersections that are significantly different from a conventional intersection in some way. Common differences include: a reduction or spreading of conflict points, restriction and/or rerouting of movements, and reduction of the complexity of traffic signal phasing.
Innovative Intersections: Overview and Implementation Guidelines	A companion to this document and Vol. I of the HVIS. The *Overview and Implementation Guidelines* document broadly outlines information about a variety of innovative intersection concepts and provides more specific implementation guidelines for intersection types that appear to be most applicable to southwest Idaho.
ITD	Idaho Transportation Department
LOS	Level of Service of a roadway or intersection. Expressed in ranges from A to F, with A meaning no delay for vehicles, F meaning failure: long waits at intersections and/or stop-and-go traffic conditions.
LRCIP	ITD's *Idaho Horizons - Long Range Capital Improvement and Preservation Program*, dated September 2006.
Median U-Turn (MUT)	An innovative intersection design that provides a turnaround point to which left-turning vehicles are routed. From the street on which the turnaround occurs, left-turns are made by first passing through the main intersection, making a U-turn at the turnaround point, then making a right turn at the main intersection. From the cross street, left-turns are made by first turning right, then making a U-turn at the turnaround point and continuing through the main intersection.
Metropolitan Planning Organization (MPO)	The regional planning entity responsible for transportation planning and approval of federal transportation funding for a given region
Mixed Use Development	A development that contains space for more than one type of use, such as residential or office space over ground-floor retail space, or condos intermixed with office and retail building.
MOE	Measures of Effectiveness
NB, SB, EB, WB	Northbound, Southbound, etc., describing direction of traffic flow
NRCS	Natural Resources Conservation Service, a branch of the U.S. Department of Agriculture whose mission is to "help people help the land". The agency works to enable people to be good stewards of soil, water, and related natural resources on non-Federal lands.

Acronym or Term	Meaning
NW, NE, SW, SE	Northwest, Northeast, etc., describes different intersection quadrants
Parallel Flow Intersection (PFI)	Similar to the CFI although with a smaller footprint. See the PFI section of *Innovative Intersections*: *Overview and Implementation Guidelines*, a companion to this report.
Project Review Committee (PRC)	A committee of representatives from ACHD, Ada County, City of Boise, COMPASS, Garden City, ITD, and Valley Regional Transit which served to provide feedback on the HVIS.
Quadrant Roadway Intersection (QRI)	An innovative intersection design that creates a connection between two legs of the main intersection. Left-turns are routed along the connecting roadway, bypassing the main intersection.
Right-of-way (ROW)	The amount of space required by an intersection or roadway, normally includes travel lanes, gutter, sidewalk, etc.
Roadways to Bikeways Plan - *Draft*	The *Draft Roadways to Bikeways Plan* is ACHD's ongoing bicycle planning project.
SH	Idaho State Highway
Synchro/SimTraffic	Synchro, SimTraffic, and VISSIM are software programs used to analyze traffic performance. Synchro is used to optimize signal settings; SimTraffic has animation capability, and is used to assess MOEs and LOS. SimTraffic is the simulation component of Synchro. VISSIM is a detailed simulator used for presentation graphics, and refined operations analysis.
Town Center Intersection (TCI)	Actually consists of four intersections resulting from the crossing of two one-way couplets. May also include a middle alignment that can be reserved for non-vehicular traffic.
Transit Oriented Development (TOD)	A catch-all phrase for styles and types of buildings that are more likely to improve transit ridership to/from the development. Usually includes higher densities, pedestrian oriented architecture, and may include limitations on parking supply. Street design may have more pedestrian and passenger amenities.
VISSIM	VISSIM, Synchro, and SimTraffic are software programs used to analyze traffic performance. Synchro is used to optimize signal settings; SimTraffic has animation capability, and is used to assess MOEs and LOS. VISSIM is a detailed simulator used for presentation graphics, and refined operations analysis.

Introduction

This report provides details about the application of specific innovative intersection concepts at the ten study intersections, which are all identified on the overview map at the end of this section.

Process

The concepts advanced were identified during earlier alternative screening as meeting several important criteria:

- They provide good traffic performance potential.
- They have a cost that is reasonable, although in many cases higher than that required by standard intersection designs.
- They are compatible with the surrounding area.
- They have relatively low impacts.

Based on the alternative screening and feedback from the Project Review Committee (PRC), one or two concepts were identified at each study intersection to analyze in greater detail and spotlighted in the final report. For each spotlighted concept, a concept layout drawing was prepared, and a detailed operational analysis using Synchro was performed. VISSIM was also used in some cases to provide a more realistic representation of intersection types that are difficult to model properly using Synchro. In addition to the spotlighted concepts, this report addresses other attractive concepts at each study intersection. Any of these options may emerge as preferred upon more in-depth inspection. See also *Vol. III Additional Materials*.

Environmental Scans

A brief scan of documents and imagery was undertaken to identify the presence of land uses, wildlife habitat, and other sensitive sites and features that may need special consideration. This environmental scan included themes that are required for inclusion in common environmental reports and studies. Any issues are identified at each site in the intersection discussions in this Report.

Spotlighted Concepts

Most of the ten study intersections have a single spotlighted concept drawing that shows the lanes, basic geometry, and likely right-of-way (ROW) required to implement the concept. Also shown are basic performance expectations, cost expectations, a cost/benefit ratio, and an overall maximum capacity (the threshold between Level Of Service [LOS] E and F).

The concept drawing also includes a table reporting measures of effectiveness (MOE) that describe the performance of the intersection under various conditions (existing conditions, future no-build and future build). The reported MOEs were based on an average of MOEs from multiple simulation runs of SimTraffic (the simulation component of Synchro).

Average delay per vehicle is used as the basis for assigning (LOS) "grades" to signalized intersections. In addition to average delay and LOS, the MOE table also shows "Percent demand served," which gives an indication of the level of congestion at the intersection. As an intersection grows more congested, it is less able to serve the traffic demand on a single cycle, so the percent of the demand served falls. Vehicle queues grow longer and "cycle failures" occur, in which a vehicle must wait through more than one signal cycle to traverse the intersection.

Exact placement of roadway features would be determined in a future design project. This study focused more on traffic efficiency and on overall ROW needs. Thus drawings may show impacts that can ultimately be avoided.

Other Concepts

Most intersections also had a number of other noteworthy design concepts that were not spotlighted. For these concepts, key observations and routing plans are discussed.

These other concepts are not necessarily inferior to the spotlighted concepts, but are good designs that are competitive with the others noted. Spotlighted layouts are preferred at the moment, given that no concept has been thoroughly examined to the level that must occur prior to any final decisions.

When there is funding for a more in-depth analysis of each intersection, all of these competitive options should be re-evaluated to determine:

- Which options are still feasible?
- Which can gain public support?
- Have volume expectations changed significantly from what was predicted?
- Would a more thorough review of costs, performance, fatal flaws, etc. allow a concept that wasn't spotlighted to emerge as the locally preferred option?

Cost-Benefit Assumptions

Cost-benefit comparisons are helpful in comprehending the full impact of a proposal. To calculate such a ratio fairly, it is important to compare the incremental cost of constructing the spotlighted concept relative to a conventional or the adopted plan, versus the incremental value of time and fuel savings over the life of the project. Construction costs are discussed below, along with the value of time and fuel that was assumed. There is also a small incremental maintenance cost associated with most spotlighted concepts, assumed to be 10% of the incremental construction cost.

Construction Cost Estimates

Each spotlighted concept includes a concept-level estimate of what it would cost to construct in today's dollars. In many cases, implementing the concept will not stray outside existing of planned ROW except at a few isolated spots. Therefore sidewalks and existing pavement may not need to be altered in those sections. However, this study assumes a maximum cost that reflects a complete reconstruction of all pavement, sidewalks, and utilities to the full extents shown in each featured drawing.

To better understand the incremental cost of each concept, an estimate of the costs required to provide a complete reconstruction of pavement, sidewalks, and utilities given the planned number of lanes organized at a conventional intersection is also provided in many cases. For example a complete rebuild to implement a spotlighted concept might cost $10 million. The same rebuild to implement the adopted plan or a conventional plan might cost $7 million. The incremental cost of $3 million becomes the basis for a cost/benefit estimate. It is also closer to what you might expect to pay to implement the concept if much of the existing infrastructure need not be fully replaced.

Other major assumptions are:

- ROW costs were estimated based on the value of the square footage of land that lies outside existing or planned right of way.
- If an entire parcel may be required, costs reflect the full value of land and improvements.
- Construction and engineering costs were estimated based on unit cost information obtained from Ada County Highway District (ACHD) and Idaho Transportation Department (ITD).
- ROW and construction costs are all expressed in 2007 dollars.

Calculation of Benefit-Cost Ratio

The total amount of user benefit (cost savings) due to reduced delay and fuel consumption over a presumed 20-year intersection lifespan from 2010 to 2030 was estimated as follows:

1. Ten SimTraffic simulations of the future 2030 baseline conditions in the PM peak hour were run, and the results were averaged.
2. Ten SimTraffic simulations of the future 2030 concept conditions in the PM peak hour were run, and the results were averaged.
3. From each set of ten simulation runs, the total vehicle-hours of delay occurring at the main intersection were obtained, and the difference in delay was calculated.
4. The reduction in delay is not as dramatic in the AM period, because volumes are smaller. It was assumed that the AM period would see only 70% of the benefit that occurs in the PM peak.
5. For traffic in the other 22 off-peak hours, it was assumed there would be no congestion in either the base or the build. However, because the build systems all convert 4-phase signals to two-phases, it was assumed that traffic in uncongested periods would always get a 30-second benefit because they eliminate two sets of left-turn phases that might typically be running for 15-seconds each.
6. In some cases, the left-turning traffic (which averages 18% of all traffic in the future 2030 forecast volumes) experiences out-of-direction travel. This was accounted for by assigning a 50 second penalty to left-turning traffic at median U-turn, bowtie and double-quadrant roadway intersections. An 80 second penalty was assigned to left-turning traffic at single quadrant roadway intersections.
7. The sum of the delay savings from the PM peak hour (item #4), the AM peak hour (item #5) and the off-peak hours (item #6) was tallied, and the delay penalty for left-turns (item #7) was subtracted to obtain the total daily delay savings in vehicle hours.
8. The next step was to convert daily delay savings to annual cost savings. To do so, different rules were applied for commercial and non-commercial vehicles. In both cases, however, 300 was used as the basis to represent the number of "days" per year. The loss of 65 days is to account for the conversion of weekday traffic to annual average daily traffic (weekday is higher), and to represent that the peak delay savings do not occur on Sundays, and only to a small extent on Saturdays.
9. For commercial vehicles, the average 2006 Boise area salary of $17.91 per hour was used, plus a typical overhead multiplier of 2.8, equating to $50.15 per hour of delay. Also assumed was that 5% of vehicles being driven for a commercial purpose, a value typical for urban arterials.
10. For non-commercial vehicles, travel surveys typically find that drivers value their time at about ½ of their salary. Half of $17.91 = $8.955 per hour. This applies to the other 95% of vehicles that are non-commercial.
11. Add the results of #10 and #11 to obtain total yearly cost savings due to reductions in delay.
12. In order to calculate cost savings due to reduced fuel consumption, assume 0.2 gallons of gas consumed per vehicle-hour of delay and $3.00 per gallon of gas.
13. Add #12 and #13 to obtain total user cost savings.

Note that there are other benefits that are not quantified here such as air quality improvements, greenhouse gas reductions, a potentially more competitive economy and the associated benefits, etc.

In order to calculate the benefit-cost ratio, the total 20-year value of time and fuel saved was then divided by the total 20-year incremental ROW and construction cost (difference between full rebuild under the baseline and spotlighted concept). A result of 10 would mean "$10 worth of time and fuel savings for every $1 spent on the proposed improvement."

Summary of Benefit-Cost Analysis of Spotlighted Concepts

As noted earlier, the user benefits were computed as the 20-year accumulated value of time and fuel savings. The incremental cost of the project (relative to planned improvements that would be incurred anyway) was also computed as the difference between the cost of the concept and baseline. The total benefit of the concept, or return on investment, is the value of the incremental benefit divided by the incremental cost. This table shows how each concept compares.

Details of each concept are provided in the following chapters.

Key Observations

All concepts show very good returns on investment. The highest rated project is Beacon Light and SH 55, with an estimated return of over $45 on every dollar invested to upgrade from the base to the spotlighted concept. This case is extreme for several reasons. First, it assumes a beyond 2030 volume, because the 2030 COMPASS forecast did not support much more than a conventional design, but the potential beyond 2030 volume as forecast by the Preservation travel demand model certainly does (see COMPASS 2030 model descriptions under Acronyms and Terms, page iii). Also, the baseline assumes only what is currently planned for the intersection (single-left turns on both legs, two through lanes per direction), however, a conventional upgrade to handle the beyond 2030 demand would likely include double-left turns and three through lanes.

State and Linder is similar in that post-2030 volumes were assumed for purposes of corridor preservation. Clearly these top two intersections are excellent projects, but their full-build isn't needed for a long time.

Intersection 2010-2030 Return on Investment*

ID	Intersection	Concept	User benefits	Concept cost	Baseline cost	Incremental cost	User benefits over incremental cost
1	Beacon Light & SH55	CFI	$122.9	$4.3	$1.6	$2.7	**45.6**
2	State & Linder	CFI	$120.0	$11.7	$4.9	$6.7	**17.8**
3	State & SH55	CFI	$93.9	$15.5	$8.1	$7.4	**12.6**
4	State & Glenwood	MUT	$15.5	$8.8	$7.8	$1.0	**14.9**
5	Chinden & Glenwood	QR	$37.3	$6.2	$0.0	$6.2	**6.0**
6	Ustick & Cole	Bowtie	$17.8	$2.2	$0.0	$2.2	**8.0**
8	Fairview & Curtis	QR	$26.5	$9.9	$5.6	$4.3	**6.1**
9a	Fairview & Eagle	QR	$61.5	$12.8	$5.3	$7.5	**8.2**
9b	Fairview & Eagle	CFI	$95.5	$13.6	$5.3	$8.3	**11.5**
10a	Franklin & Eagle	QR	$42.6	$9.8	$5.9	$3.9	**10.9**
10b	Franklin & Eagle	CFI	$93.4	$15.4	$5.9	$9.5	**9.8**

* Benefits and costs shown in millions of dollars

State and Glenwood as a Median U-Turn (MUT) would only cost about $1 million more than the planned improvements, and the user savings results in a return ratio of nearly $15.

Intersections on Eagle give excellent return as either CFIs or Quadrants.

As a single quadrant roadway, Chinden and Glenwood is ranked lower because the out-of-direction time lost to three left-turn movements during the uncongested portion of the day is more significant than the time they gain due to getting through the main intersection in less time. Also because while there is an existing street in the NW quadrant, the volume on that street becomes so high serving four left-turns that the street must be widened, potentially adding substantially to the cost.

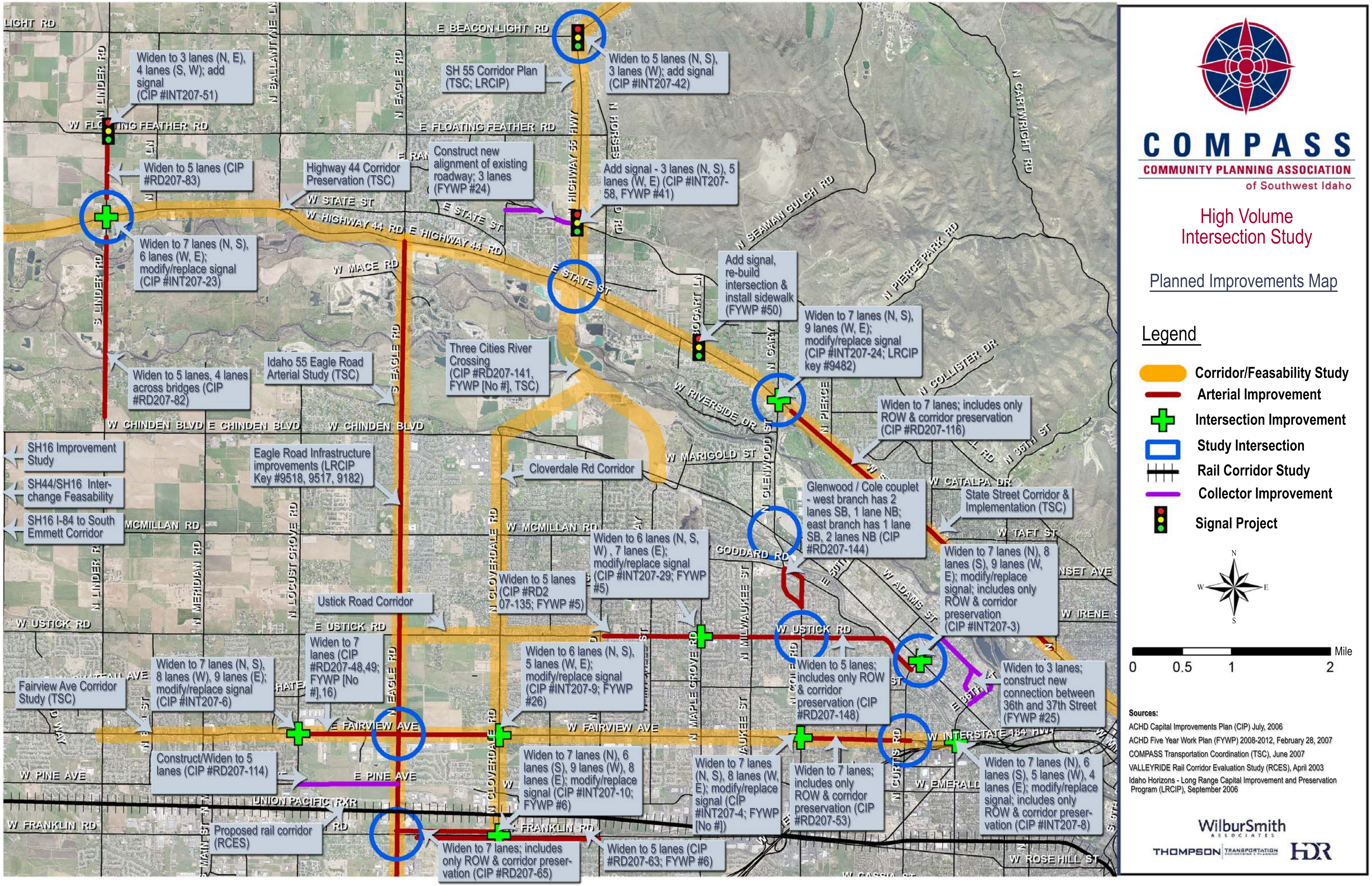
Fairview and Curtis rates very well because even though two of four left-turns require out of direction travel to achieve a two-phase signal, those same movements benefit greatly during congestion, and are outweighed by the benefits to other movements when there is no congestion.

Ustick and Cole is expected to cost just over $2-million to install two roundabouts, making it one of the lowest cost projects. However, because it is serving lower volumes, and because all left turns lose time to out-of-direction travel even in uncongested periods; the accumulated benefits are less significant.

Planned Improvements

The ten study intersections are located in areas that will be strongly impacted over the years ahead by a large number of construction and planning projects. This includes a number of programmed and planned construction projects and studies such as roadway and intersection expansion, traffic signal installation, and corridor feasibility studies. These projects, if completed, will impact the ten study intersections (see **Map #1** on the following page). Improvements are identified on an individual intersection basis and are subject to change.

The planned improvements listed with each intersection in this Report illustrate the potential impacts of the various planning and construction projects on an individual intersection basis.



COMPASS
COMMUNITY PLANNING ASSOCIATION of Southwest Idaho
High Volume Intersection Study
Planned Improvements Map
Legend
Corridor/Feasability Study
Arterial Improvement
Intersection Improvement
Study Intersection
Rail Corridor Study
Collector Improvement
Signal Project
0 0.5 1 2 Mile
Sources:
ACHD Capital Improvements Plan (CIP) July, 2006
ACHD Five Year Work Plan (FYWP) 2008-2012, February 28, 2007
COMPASS Transportation Coordination (TSC), June 2007
VALLEYRIDE Rail Corridor Evaluation Study (RCES), April 2003
Idaho Horizons - Long Range Capital Improvement and Preservation Program (LRCIP), September 2006
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THOMPSON TRANSPORTATION
HDR
Widen to 3 lanes (N, E), 4 lanes (S, W); add signal (CIP #INT207-51)
Widen to 5 lanes (N, S), 3 lanes (W); add signal (CIP #INT207-42)
SH 55 Corridor Plan (TSC; LRCIP)
Widen to 5 lanes (CIP #RD207-83)
Highway 44 Corridor Preservation (TSC)
Construct new alignment of existing roadway; 3 lanes (FYWP #24)
Add signal - 3 lanes (N, S), 5 lanes (W, E) (CIP #INT207-58, FYWP #41)
Widen to 7 lanes (N, S), 6 lanes (W, E); modify/replace signal (CIP #INT207-23)
Add signal, re-build intersection & install sidewalk (FYWP #50)
Widen to 7 lanes (N, S), 9 lanes (W, E); modify/replace signal (CIP #INT207-24; LRCIP key #9482)
Widen to 5 lanes, 4 lanes across bridges (CIP #RD207-82)
Idaho 55 Eagle Road Arterial Study (TSC)
Three Cities River Crossing (CIP #RD207-141, FYWP [No #], TSC)
Widen to 7 lanes; includes only ROW & corridor preservation (CIP #RD207-116)
SH16 Improvement Study
SH44/SH16 Inter-change Feasability
SH16 I-84 to South Emmett Corridor
Eagle Road Infrastructure improvements (LRCIP Key #9518, 9517, 9182)
Cloverdale Rd Corridor
Glenwood / Cole couplet - west branch has 2 lanes SB, 1 lane NB; east branch has 1 lane SB, 2 lanes NB (CIP #RD207-144)
State Street Corridor & Implementation (TSC)
Widen to 6 lanes (N, S, W), 7 lanes (E); modify/replace signal (CIP #INT207-29; FYWP #5)
Widen to 5 lanes (CIP #RD2 07-135; FYWP #5)
Widen to 7 lanes (N), 8 lanes (S), 9 lanes (W, E); modify/replace signal; includes only ROW & corridor preservation (CIP #INT207-3)
Ustick Road Corridor
Widen to 7 lanes (CIP #RD207-48,49; FYWP [No #],16)
Widen to 6 lanes (N, S), 5 lanes (W, E); modify/replace signal (CIP #INT207-9; FYWP #26)
Widen to 5 lanes; includes only ROW & corridor preservation (CIP #RD207-148)
Widen to 3 lanes; construct new connection between 36th and 37th Street (FYWP #25)
Fairview Ave Corridor Study (TSC)
Widen to 7 lanes (N, S), 8 lanes (W), 9 lanes (E); modify/replace signal (CIP #INT207-6)
Construct/Widen to 5 lanes (CIP #RD207-114)
Widen to 7 lanes (N), 6 lanes (S), 9 lanes (W), 8 lanes (E); modify/replace signal (CIP #INT207-10; FYWP #6)
Widen to 7 lanes (N, S), 8 lanes (W, E); modify/replace signal (CIP #INT207-4; FYWP [No #])
Widen to 7 lanes; includes only ROW & corridor preservation (CIP #RD207-53)
Widen to 7 lanes (N), 6 lanes (S), 5 lanes (W), 4 lanes (E); modify/replace signal; includes only ROW & corridor preser-vation (CIP #INT207-8)
Proposed rail corridor (RCES)
Widen to 7 lanes; includes only ROW & corridor preser-vation (CIP #RD207-65)
Widen to 5 lanes (CIP #RD207-63; FYWP #6)

1. Beacon Light Road and State Highway 55 North

Key Facts

- Three-leg intersection in Eagle City; rural setting; on horizontal curve.
- Beacon Light: ACHD-owned, 50 mph minor arterial, one through lane per direction, 3,000 ADT.
- SH 55 North: ITD-owned, 55 mph principal arterial, two through lanes per direction through the intersection, narrowing to one per direction about 1,500 feet to the north, 9,000 ADT.
- Presently stop controlled, but is planned to be upgraded to signal control. Has potential for very high volumes.
- A significant bluff on the eastern side prevents a fourth leg.
- The intersection of Beacon Light & Horseshoe Bend occurs about 150 feet west of the main intersection. Depending on the future configuration at the main intersection, the proximity of this intersection could be problematic.

Existing Plans

The intersection of North Brookside & SH 55 North occurs about 350 feet north of the main intersection. The 2007 Eagle Comprehensive Plan includes a plan to eliminate this intersection by rerouting Brookside to tie into Beacon Light some 900 feet west of the main intersection **(see Figure 1-1).** Several direct individual property access points onto SH 55 north of the Brookside & SH 55 intersection would also be eliminated by constructing a new frontage/backage road parallel to SH 55 North. The plan also encompasses a new grade-separated interchange at the current intersection of West Brookside & SH 55 North, some 7000 feet to the north.

ACHD's Capital Improvement Plan (CIP) identifies an improvement project at the intersection of Beacon Light & SH 55 North (Project INT207-42). The project includes widening and installation of a new traffic signal, to be performed by 2010 at a cost of $1.623 million.

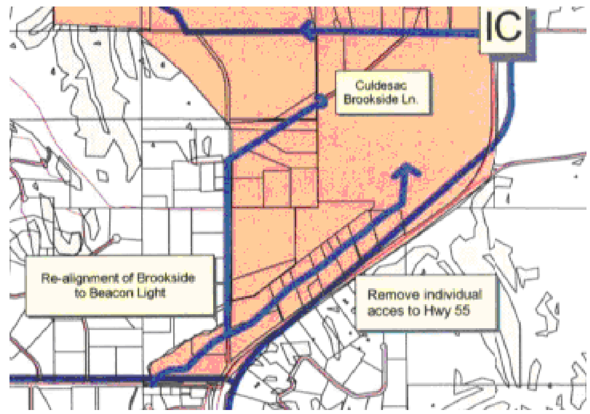


Figure 1-1 Planned Brookside Realignment
(Source: 2007 Eagle Comprehensive Plan)

The intersection also falls within the study area of the SH 55 Corridor Plan, currently in progress.

ACHD's Draft *Roadways to Bikeways Plan* indicates that the south leg of Beacon Light & SH 55 is a marked bike route, and bike lanes are proposed on the west leg.

The 2030 Community Choices travel demand model shows two through lanes per direction on SH 55 North from SH 44 to Brookside Ln. The Preservation model shows three through lanes per direction on SH 55 North between State St. and Beacon Light Rd., and two through lanes per direction north of Beacon Light Rd.

Environmental Scan

- The intersection is about 250 feet from a 500 year floodplain and approximately 550 feet from a 100 year floodplain.

- No wetland areas, cultural sites, or historic properties were identified within a ½ mile radius.
- Dry Creek lies about 900' Northwest of the intersection.

Spotlighted Concept: CFI on one leg

- A CFI on one leg will be an effective means of managing this intersection, if no new alignments are created such as with a quadrant.
- A CFI on the south leg was selected for analysis as it appears it may be lower cost, but a CFI on the west leg is also possible and would likely provide significant benefits as well. Though there are two legs, the full benefits of a CFI at a T-intersection are achieved with a CFI on just one of the two legs.
- ROW should be reserved to allow three through lanes on SH 55 in any design. This six-lane cross-section, which is intended to maximize the new signal's throughput in the event that future volumes warrant it, should extend for a minimum length of ¼ mile north and south of the intersection.

See **Map 2** on page 10.

Other Concepts

Quadrant Roadway

There is an opportunity to create a quadrant roadway as shown in **Figure 1-2** that has many very attractive properties. Because this is a T-intersection, a quadrant in this setting can achieve near-perfect driver expectation. There is no awkward geometry that could potentially confuse drivers. Only a sign is necessary advising that the path to reach NB SH 55 is on the quadrant.

Like a CFI, this system allows the NB to WB left-turn and the EB to NB left-turn to happen at the same time. Therefore it could be made to perform similar to a CFI.

With this system, existing local roads and driveways on Beacon Light between the quadrant and SH 55 may be easier to preserve than under other scenarios, because the traffic volumes and conflict points are greatly reduced.

It would require two coordinated signals to stop SB traffic to allow both the NB and EB left-turns to occur.

This system concept was not developed further largely because it would require creating a new alignment, and as a result may have more impacts and potentially more cost than the spotlighted concept; and there was some desire to contain all improvements to existing alignments. However, this concept seems easily adaptable to the realignment of Brookside that was shown in **Figure 1-1.** If so, this option should be investigated more in the future.

Continuous Green T

A continuous green T intersection treatment could be applied at this location. This would allow the EB left-turns to use a dedicated median lane to accelerate and merge with NB through traffic. The NB through movement would not have to stop at the signal, which would result in a large savings in delay. However, a number of issues make application of the continuous green T at this location challenging:

- The high speed on SH 55 North (55 mph) would require a long median lane for the eastbound (EB) left-turns to accelerate to merging speed.
- The future forecast volumes indicate that the EB left-turn movement (with 650 vehicles) could eventually require a dual left-turn. The dual left-turn would of course require a dual median lane for acceleration and merging, requiring even more space both laterally and longitudinally, and correspondingly higher ROW costs.

- The intersection occurs about halfway along a long horizontal curve. A continuous green T in any case presents a challenging situation for both merging and through movement drivers; the curve adds another undesirable level of complexity.

For these reasons, a continuous green T at this location is not recommended for the final design. However, it may still be worth researching further as an incremental improvement that may function well for a number of years.

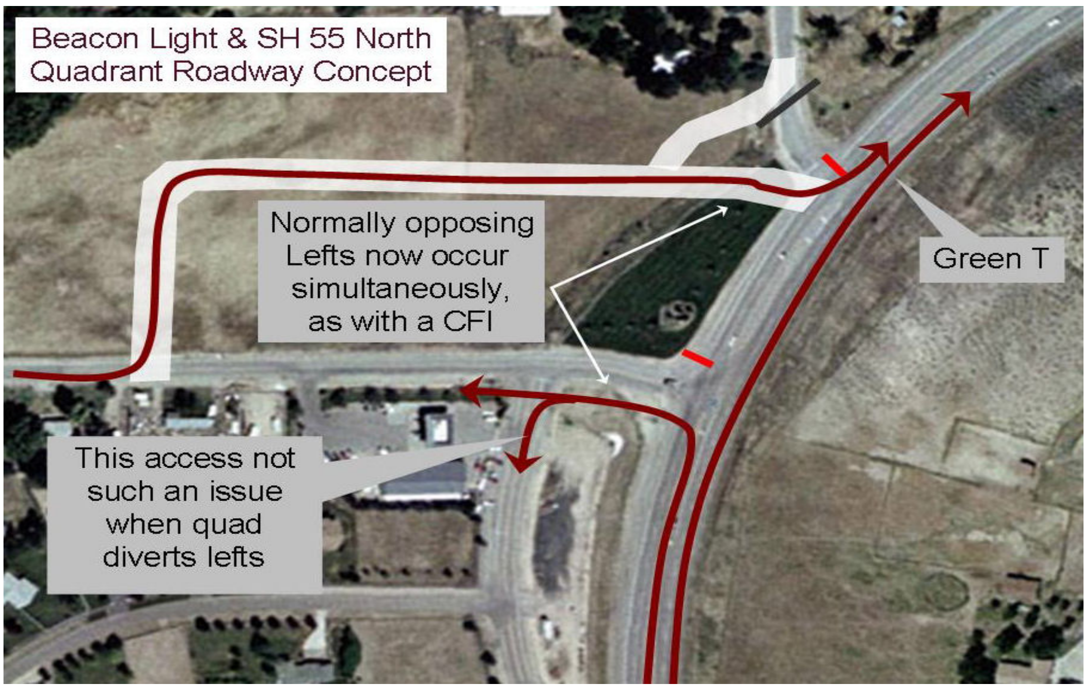


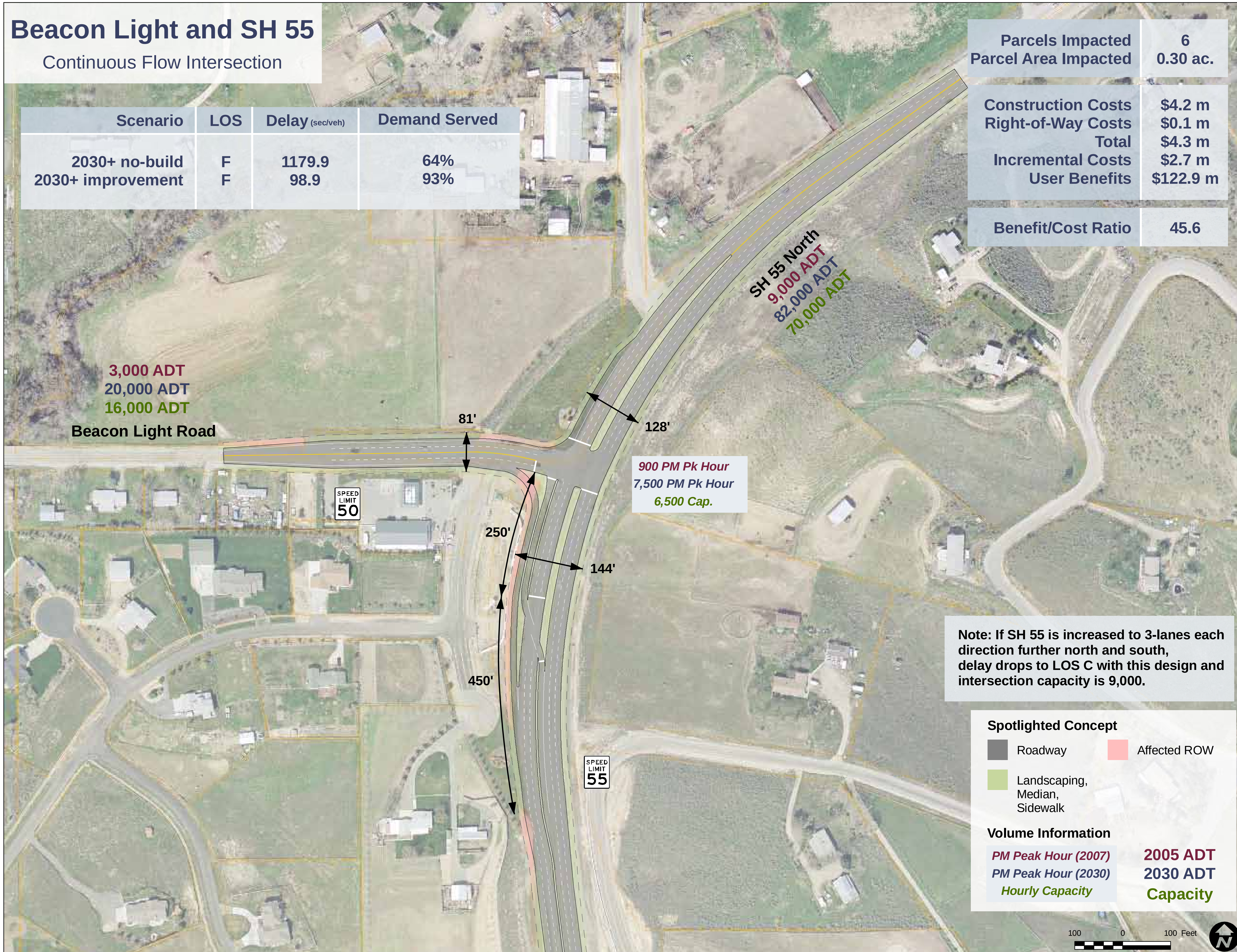
Figure 1-2 Beacon Light and SH 55 Quadrant and Green-T Concept

Beacon Light and SH 55

Continuous Flow Intersection

Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	1179.9	64%
2030+ improvement	F	98.9	93%

Parcels Impacted	6
Parcel Area Impacted	0.30 ac.
Construction Costs	$4.2 m
Right-of-Way Costs	$0.1 m
Total	$4.3 m
Incremental Costs	$2.7 m
User Benefits	$122.9 m
Benefit/Cost Ratio	45.6



Note: If SH 55 is increased to 3-lanes each direction further north and south, delay drops to LOS C with this design and intersection capacity is 9,000.

Spotlighted Concept

- Roadway
- Affected ROW
- Landscaping, Median, Sidewalk

Volume Information

PM Peak Hour (2007)	2005 ADT
PM Peak Hour (2030)	2030 ADT
Hourly Capacity	Capacity

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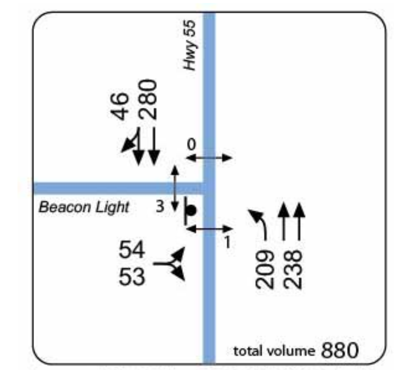
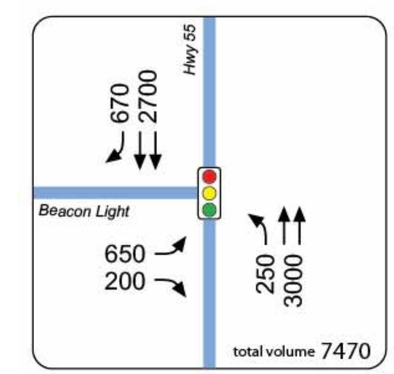
High Volume Intersection Study



Beacon Light & Hwy 55 2007 PM Peak Hour



Beacon Light & Hwy 55 Future PM Peak Hour

WilburSmith ASSOCIATES

THOMPSON TRANSPORTATION ENGINEERING & PLANNING HDR

2. State Street and Linder Road

Key Facts

- Four-leg intersection in Eagle City; rural setting; streets meet at an angle slightly off of 90 degrees.
- State: ITD-owned, 55 mph principal arterial, two lanes west of Linder, three lanes east of Linder, 23,000 ADT.
- Linder: ACHD-owned, 50 mph minor arterial, one through lane per direction, 7000 ADT.
- Signal controlled; may experience large traffic volume increase from developments to the north.

Existing Plans

The CIP identifies four construction projects directly or indirectly impacting this intersection:

- RD207-82, with a cost estimated at $22 million and planned for construction in 6-10 years, will expand Linder from Chinden to State to a five lane cross-section (four over bridges).
- RD207-83, with a cost estimate of $3.181 million and planned for construction in 11-20, will expand Linder from State to Floating Feather to a five lane cross-section.
- INT207-23, with a cost estimate of $4.928 million and planned for construction in 11-20 years, will widen the intersection and modify the existing traffic signal.
- INT207-51, with a cost estimate of $1.367 million and planned for construction in 11-20 years, will install a new traffic signal at Floating Feather & Linder, 4400 feet north of State & Linder.

Additionally, at least four corridor studies potentially have significant impacts on State & Linder:

- The Highway 44 Corridor Preservation study is considering the acquisition of up to 200 foot of ROW for State in the area around State & Linder, which would be sufficient to provide at least a six-lane cross-section on State.
- The SH 16 Improvement Study (completed in 2005) and the SH 16 I-84 to South Emmett Corridor (ongoing) may lead to significant improvements on SH 16, located about two miles west of Linder. Improvements such as north-south connectivity across the Boise River and to I-84 would provide additional capacity, potentially reducing traffic demands on Linder.
- The State Street Corridor & Implementation study is currently limited in extent to between Glenwood and 27th Street. However, there is some desire to expand the reach of the project farther west, to Linder and beyond. In any case, the current project envisions creating a transit corridor along at least part of State, which may take the form of two dedicated transit lanes in the center of the street.

The draft *Roadways to Bikeways Plan* shows proposed bike lanes on the north and south legs of State and Linder. Also, based on an interview on January 16, 2008 with ITD, it is likely that bike lanes will be included in future upgrades on State (along the east and west legs of the intersection).

The 2030 Community Choices travel demand model shows two through lanes per direction on State and on Linder in the vicinity of the intersection.

Environmental Scan

- The Middleton Mill Canal crosses east to west approximately 75 feet north of the intersection.
- The 500 year floodplain occurs approximately 300 feet south of the intersection.
- The 100 year floodplain is located approximately 525 feet south of the intersection.
- No wetland areas, cultural sites, or historic properties were identified within a ½ mile radius.
- The Boise River flows approximately 1600' south of the intersection.

Spotlighted Concept: Four-leg CFI

This location is likely to have less volume than other sites through the horizon of this study, but because Linder is one of just a few river crossings, this site may ultimately prove to be one of the busiest of all.

State is the most critical east-west highway in the northern portion of the region. It may ultimately be a good candidate to grade separate at some point beyond the horizon of this study.

For both of these reasons, preserve space for a full four-leg CFI at this site. It can then be constructed incrementally if necessary (first two legs, then four, and ultimately the full CFI footprint will make it easier to grade separate if the need arises.

See **Map 3** on the following page.

Other Concepts

Median U-Turn

A MUT would be easy to develop with the turnaround points on State, but high speeds may make the necessary weaving movements unsafe. The turnarounds could instead be developed on Linder where speeds and volumes are lower.

Bowtie

If turnaround points on Linder are desired, a Bowtie with oval-shaped roundabouts that do not impede through movements, such as in the example below, would be more functionally efficient and aesthetically pleasing than a standard MUT.

Figure 2-1 Example Bowtie with wrap-around lanes

The CFI concepts were preferred over the MUT and Bowtie concepts for several reasons:

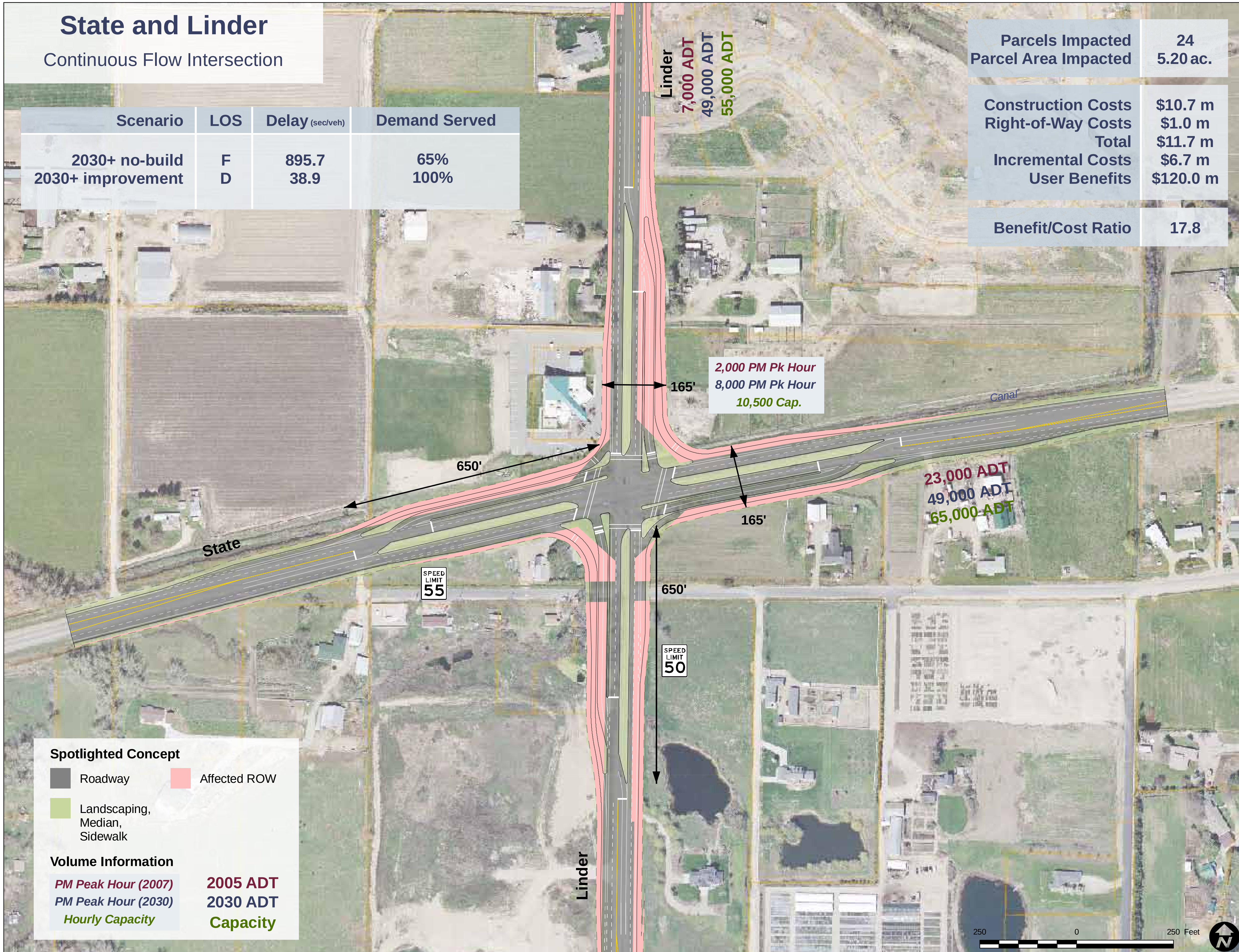
- CFI's offer better driver expectancy.
- CFI's are less pedestrian friendly, but the level of pedestrian activity seems likely to be low (could change depending on ultimate land uses).
- CFI's preserve ROW that make grade separation easier – a potentially important feature for State. (However, a roundabout interchange could also be easily developed from the basis of a Bowtie installation.)
- Developing such a Bowtie may conflict with at least one existing home.

State and Linder

Continuous Flow Intersection

Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	895.7	65%
2030+ improvement	D	38.9	100%

Parcels Impacted	24
Parcel Area Impacted	5.20 ac.
Construction Costs	$10.7 m
Right-of-Way Costs	$1.0 m
Total	$11.7 m
Incremental Costs	$6.7 m
User Benefits	$120.0 m
Benefit/Cost Ratio	17.8



Spotlighted Concept

- Roadway
- Affected ROW
- Landscaping, Median, Sidewalk

Volume Information

PM Peak Hour (2007)	2005 ADT
PM Peak Hour (2030)	2030 ADT
Hourly Capacity	Capacity

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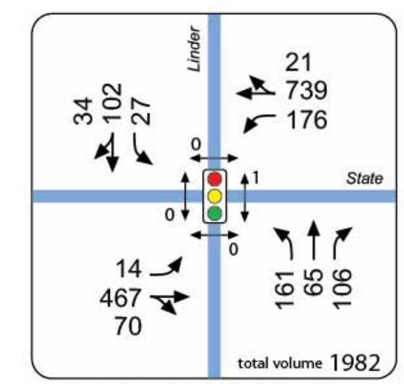
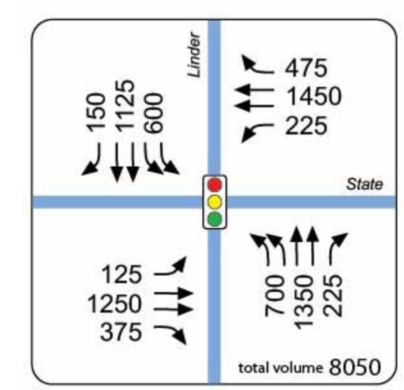


State & Linder 2007 PM Peak Hour



State & Linder Future PM Peak Hour

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3. State Street and State Highway 55 North

Key Facts

- Three-leg intersection in Eagle City; urban setting; streets meet at a 90 degree angle.
- Fourth leg may be developed as a result of the Three Cities River Crossing study.
- State: ITD-owned (SH 44), 55 mph principal arterial, five lanes, 36,000 ADT.
- SH 55 North: ITD-owned, 50 mph principal arterial, four lanes, 14,000 ADT.
- Signal controlled.

Existing Plans

The CIP and ACHD's Five Year Work Plan (FYWP) identify two construction projects indirectly impacting this intersection:

- INT207-58 (CIP)/#41 (FYWP): This signal project, with a cost estimate of $97,000 and planned for construction in 6-10 years, will install a new traffic signal at Hill & SH 55 North. The new signal, 3300 feet north of State & SH 55 North, will be close enough to have an impact on operations.
- #24 (FYWP); This collector improvement project, with a cost estimate of $5.775 million and planned for construction in 2010, will widen Hill west of SH 55 North to a three lane cross-section and realign the road.

Additionally, at least two corridor studies potentially have significant impacts on State & SH 55 North:

- The State Street Corridor Strategic Plan study is currently limited in extent to between SH 55 and 23rd Street. However, there is some desire to expand the reach of the project farther west, to beyond Eagle Rd. In any case, the current project envisions creating a transit corridor along at least part of State St., which may take the form of two dedicated transit lanes in the center or outside lanes of the street.
- The draft EIS for the Three Cities River Crossing study has been completed and is currently in a comment period (until March 3, 2008). If approved, this project, providing a north-south connection between State and Chinden (crossing the Boise River), will provide a fourth leg at this intersection.

The draft *Roadways to Bikeways Plan* shows that the north and west legs of State & SH 55 North are currently marked bike routes. Also, based on an interview on January 16, 2008 with ITD, it is likely that bike lanes will be included in future upgrades on State (along the east and west legs of the intersection).

The 2030 Community Choices travel demand model shows two through lanes per direction on State and on SH 55 North in the vicinity of the intersection.

Environmental Scan

- The area directly north of the intersection is identified as prime agricultural land, but has been developed. In general, prime agricultural land may require coordination with the Natural Resources Conservation Service (NRCS), but previously developed land is unlikely to raise major concerns.
- The area directly south of the intersection is located within the 100 year floodplain.
- The Dry Creek Canal crosses State Street directly east of the intersection then crosses west across SH 55 directly north of the intersection with State Street.
- No wetland areas, cultural sites, or historic properties were identified within a ½ mile radius.

- The Boise River flows 2000' to the south of the intersection.

Spotlighted Concept: Four-leg CFI

This situation is very similar to State and Linder, and as might be expected the best performing concepts are also very similar. If SH 55 is extended south, it will be one of just a few river crossings which will tend to draw more volume than may otherwise be expected, but because it is closer to the heart of the city, high volumes will be reached much sooner than on Linder.

A four-leg CFI is an ideal solution at this site for several reasons:

- Because State needs to maintain a high design speed, it may someday be a candidate for grade separation. A CFI best protects that option. Significant ROW already exists, along with ideal setbacks and access control for a CFI.
- A CFI offers better driver expectancy than the next best options.

See **Map 4** on the following page.

Other Concepts

Median U-Turn

A MUT would be easy to implement at this intersection, but high speeds on both State and SH 55 would make the necessary weaving movements unsafe.

Bowtie

A Bowtie similar to that described earlier for Linder is possible on SH 55. While it has inferior driver expectation, it is more pedestrian friendly. The value of pedestrian friendliness versus driver expectancy at this site could be debated in greater detail at a later date.

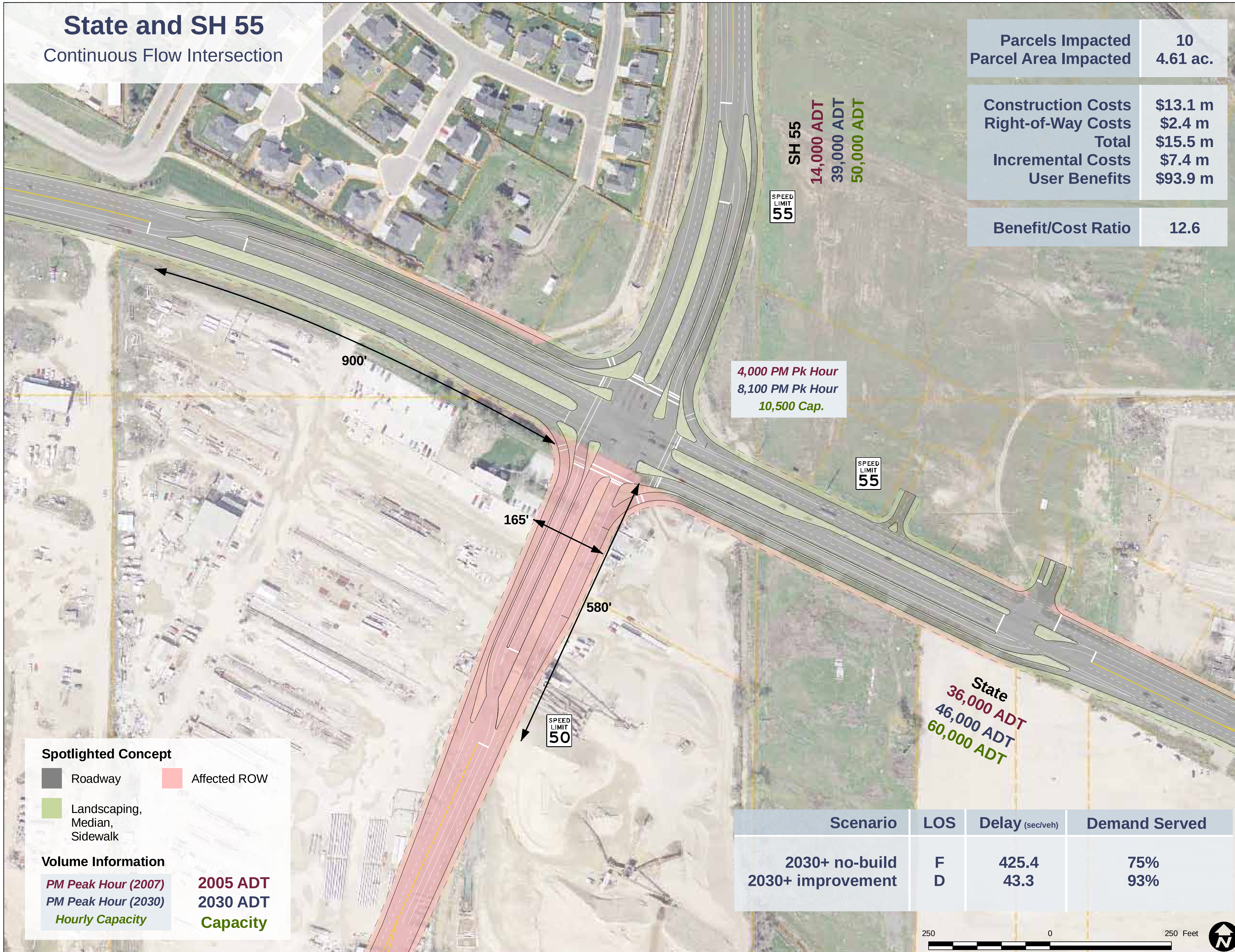
A few other concepts are possible, but do not offer anything more attractive than these.

State and SH 55
Continuous Flow Intersection

Parcels Impacted	10
Parcel Area Impacted	4.61 ac.

Construction Costs	$13.1 m
Right-of-Way Costs	$2.4 m
Total	$15.5 m
Incremental Costs	$7.4 m
User Benefits	$93.9 m

Benefit/Cost Ratio	12.6



Spotlighted Concept

- Roadway
- Affected ROW
- Landscaping, Median, Sidewalk

Volume Information

PM Peak Hour (2007)	2005 ADT
PM Peak Hour (2030)	2030 ADT
Hourly Capacity	Capacity

Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	425.4	75%
2030+ improvement	D	43.3	93%

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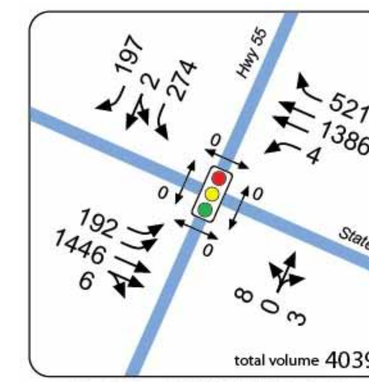
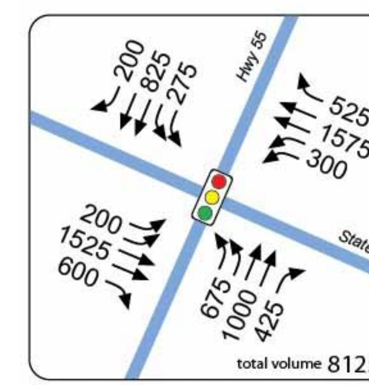


State & Hwy 55 2007 PM Peak Hour



State & Hwy 55 Future PM Peak Hour

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4. State Street and Glenwood Street

Key Facts

- Four-leg intersection at the border of Boise and Garden City; urban setting; streets meet at an angle slightly off of 90 degrees.
- State Street: 45 mph principal arterial, five lanes, 36,000 ADT. ITD-owned west of Glenwood (SH 44); ACHD-owned east of Glenwood.
- Glenwood (south of State): ITD-owned (SH 44), 35 mph principal arterial, five lanes, 36,000 ADT.
- Gary (north of State): ACHD-owned, 35 mph minor arterial, three lanes, 14,000 ADT.
- Signal controlled.

Existing Plans

The CIP and FYWP identify two construction projects directly or indirectly impacting this intersection:

- INT207-24 (CIP): This intersection improvement project, with a cost estimate of $7.776 million and planned for construction by 2020, will widen State & Glenwood and modify the traffic signal.
- #50 (FYWP); This signal project, with a cost estimate of $675,000 and planned for construction by 2012, will install a new traffic signal at State & Bogart. The new signal, 4800 feet west of State & Glenwood, will be close enough to have an impact on operations.
- The State Street Corridor Strategic Plan study is currently considering the creation of a transit corridor along this part of State St., which may take the form of two dedicated transit lanes in the center or outside lanes of the street. The CIP identifies the need for an arterial improvement project (RD207-116) for ROW and corridor preservation for a seven-lane cross-section along State east of Glenwood, at a cost of $2.448 million, to be completed by 2020.

The draft *Roadways to Bikeways Plan* shows that there are currently bike lanes on the north leg of State & Glenwood. The Plan also shows a proposed bike lane on the south leg. Based on aerial photographs, a bike lane exists on the east leg, at least in the westbound (WB) direction. Also, based on an interview on January 16, 2008 with ITD, it is likely that bike lanes will be included in future upgrades on State (along the east and west legs of the intersection).

The 2030 Community Choices travel demand model shows two through lanes per direction on State St. west of Glenwood St. and three through lanes per direction east of Glenwood St. Also, Gary (north of State) has one lane per direction in the model, while Glenwood St. (south of State St.) has two travel lanes per direction. The additional travel lanes on State St. east of Glenwood St. may be transit only, but are dependent upon the transit oriented land uses implemented along the corridor.

Environmental Scan

- The intersection is located within an area identified as prime agricultural land. In general, prime agricultural land may require coordination with the NRCS, but previously developed land is unlikely to raise major concerns.
- Approximately 250 feet south of the intersection is the 500 year floodplain, associated with the Boise River.
- A section of the Boise Valley canal is located approximately 400-450 north of the intersection.

- A portion of the 100 year floodplain is located approximately 1150 feet southeast of the intersection.
- No wetland areas, cultural sites, or historic properties were identified within a ½ mile radius.
- The Boise River flows approximately 2300' south of the intersection.

Spotlighted Concept: MUT

This intersection is challenging due to the number of driveways near the intersection, relatively tight ROW, skewed crossing, and a higher than average number of pedestrians.

In this environment, Quadrant Roadways and MUTs appear to be the most realistic options, and the latter was selected for a more detailed analysis largely because it appears to be the easiest to implement.

Because there are existing parking lots on State, it is easier to find an acceptable spot to create the turning basin necessary for larger trucks to complete the turn. Speeds on State in this area are lower so any weaving that occurs can be done safely.

This is a more pedestrian friendly option than a CFI, but comes with unusual driver expectation.

See **Map 5** on page 20.

Other Concepts

Bowtie

An oval-shaped Bowtie is an attractive modification of the spotlighted MUT. Where the U-turn would require stopping oncoming traffic with a signal to allow vehicles to turn, **Figure 4-1** shows how an oval creates a wrap-around lane so that neither the U-turns nor the oncoming traffic will need to stop. The oval itself can then be landscaped to help revitalize the area.

There are locations along State with large parking lots on both sides that may allow such ovals to be developed. They may not need to be as wide or long as this, but only conform to minimum standards of design in order to minimize ROW. This option was not spotlighted because of the larger ROW required, but it may be an enhancement worth the extra cost.

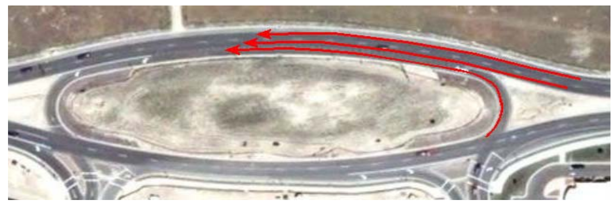


Figure 4-1 Bowtie that avoids impeding oncoming traffic

Quadrant Roadways

Innovative Intersections: Overview and Implementation Guidelines articulates how a single quadrant, two opposing quadrants, or even four quadrants can all be used to greatly improve the efficiency of a system. **Figure 4-2** shows that there are potentially four realistic alignments that could be used at this intersection to obtain all the benefits of a full four-quadrant system (or any subset).

A full four-quadrants is the most pedestrian-friendly of all options, as it removes the most conflicts with pedestrians and may allow some existing pavement to be reclaimed for landscaping. It is also transit friendly because it is easier for buses to reach stops on the quadrants than to try and maneuver to stops on the mainlines. This system shares much in common with Town Center Intersections (TCI) – driveways on the quadrants are no problem, and the enhanced auto access makes the system very business friendly.

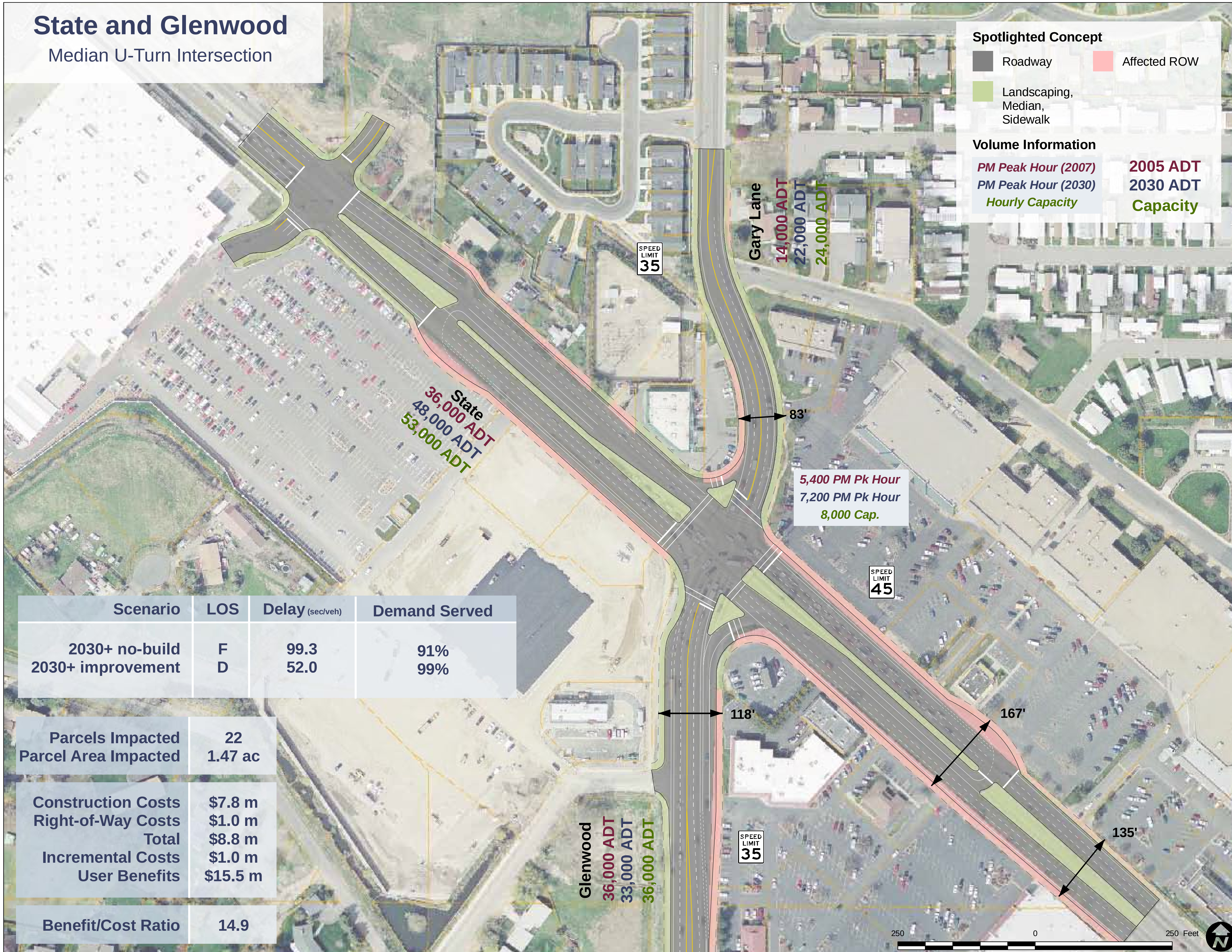
Many driveways near the intersection may be relocated to the quadrants, further enhancing the safety and efficiency of the mainline. This is a very good option, but it was not spotlighted for detailed analysis largely because it would be more expensive to implement than the MUT. Although Saxton

Drive exists and could serve as a roadway for the northwest quadrant, potential roadways in the other quadrants would all be on private property. This single quadrant was also not analyzed, partly because of the relatively high turning volume from northbound (NB) Glenwood St. to westbound State St. and the narrow ROW of Gary Ln.

Figure 4-2 Four-quadrant system at State and Glenwood

State and Glenwood

Median U-Turn Intersection



Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	99.3	91%
2030+ improvement	D	52.0	99%

Parcels Impacted	22
Parcel Area Impacted	1.47 ac

Construction Costs	$7.8 m
Right-of-Way Costs	$1.0 m
Total	$8.8 m
Incremental Costs	$1.0 m
User Benefits	$15.5 m

Benefit/Cost Ratio	14.9

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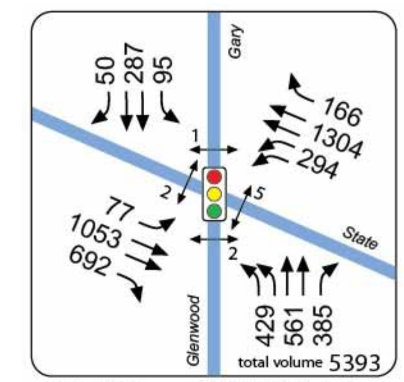
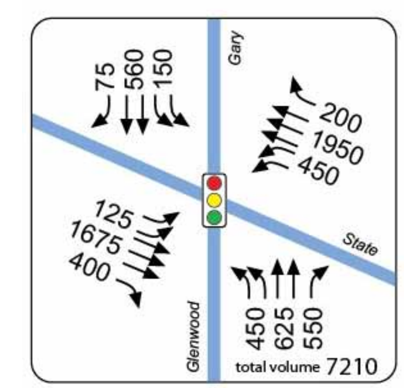


State & Glenwood 2007 PM Peak Hour



State & Glenwood Future PM Peak Hour

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5. Chinden Boulevard and Glenwood Street

Key Facts

- Four-leg intersection in Garden City; urban setting; streets meet at an angle well off of 90 degrees.
- Chinden: ITD-owned (US 20/26), 35 mph principal arterial, five lanes, 32,000 ADT.
- Glenwood north of Chinden: ITD-owned (SH 44), 35 mph principal arterial, five lanes, 34,000 ADT.
- Glenwood south of Chinden: ACHD-owned, 35 mph principal arterial, four lanes, 34,000 ADT.
- Signal controlled.
- Kent Ln.: ACHD-owned south of Alworth St; north of Alworth St., county-owned as part of the park/fairgrounds complex.
- Lorimer Ln.: county-owned as part of park/fairgrounds complex.

Existing Plans

The CIP identifies one construction project indirectly impacting this intersection:

- RD207-144: This arterial improvement project, with a cost estimate of $1.493 million and planned for construction in 6-10 years, will create a two-way couplet along Cole and a new alignment to the east. The northern terminus of the project is about 2000 feet south of Chinden & Glenwood. The project will improve north-south capacity with a better connection between Cole and Glenwood, possibly increasing traffic demand at Chinden & Glenwood.

Additionally, at least one corridor study potentially has significant impact on Chinden & Glenwood:

- The draft EIS for the Three Cities River Crossing study has been completed and the comment period ended March 3, 2008. If approved, this project, providing a north-south connection between State and Chinden (crossing the Boise River), will provide additional north-south capacity, potentially increasing traffic demands on Chinden.

The draft *Roadways to Bikeways Plan* shows that there is currently a multi-use path running parallel to Glenwood north of Chinden. Measurements from aerial photographs locate this path at about 40 feet east of the edge of pavement on Glenwood. The Plan also shows proposed bike lanes on the east leg of Chinden & Glenwood.

Discussions with Ada County Development Services indicate that land in the northeast quadrant of Chinden & Glenwood is currently being considered for annexation to the City of Garden City.

The 2030 Community Choices travel demand model shows two through lanes per direction on all four intersection legs.

Environmental Scan

- The intersection is located within an identified extent of prime agricultural land. In general, prime agricultural land may require coordination with the NRCS, but previously developed land is unlikely to raise major concerns.
- The Thurman Drain crosses east to west approximately 350 feet south of the intersection on the Boise bench.
- The Thurman Mill Canal is located approximately 575 feet north of the intersection.
- The intersection is located approximately 525 feet from the 500 year floodplain.
- Ada County parkland and property is located at the northeast corner of the

intersection, which could pose special environmental concerns.

- The Expo Center is under lease by the County until 2010 and may be considered for annexation to the City beyond this date. The Garden City Comprehensive Plan identifies the abutting land for future Mixed-Use or Transit-Oriented Development.
- No wetland areas, cultural sites, or historic properties were identified within a ½ mile radius.

Spotlighted Concept: Single Quadrant Roadway

Like the previous intersection further north on Glenwood, this one is also challenging due to the number of driveways near the intersection, relatively tight ROW, skewed crossing, and a higher than average number of pedestrians.

Again, Quadrant Roadways and MUTs are good options. This time the former was selected for more detailed analysis because there is an excellent existing candidate in the northeast quadrant that could be implemented almost immediately at a very low cost.

The analysis suggests that the existing quadrant could easily handle today's volume with only minor construction to install signals and enhance turn pockets at the intersections. However, if all four left turns continued to be routed on just this one quadrant, then by 2030 the quadrant itself would need to be widened to five lanes, perhaps making some of the other options that were not examined in detail more attractive.

See **Map 6** on page 24.

Other Concepts

Multiple Quadrants

While the spotlighted option would be extremely low cost, its big drawback is unusual and circuitous paths to complete the four left turns, and the single quadrant itself may become congested by 2030.

There are various obstacles, but possibilities exist for roadways in the other three quadrants. With multiple quadrant roadways, driver expectancy improves greatly and circuitous paths are reduced by each quadrant that is added.

Figure 5-1 Four-quadrant possibility at Chinden and Glenwood

There appears to be enough room to improve the north side of the southwest roadway to handle a bit more volume without touching the property of existing homes. However residents would not welcome the prospect of a busier street, even if it is handling just the NB to WB movement.

MUT/ Bowtie

Preliminary screening suggested this concept would have high operational performance at this site. It would be relatively low cost (higher cost as a Bowtie, lower as a MUT). It may prove more acceptable to the public than the circuitous paths of a single quadrant, or the cost and perceived impacts of multiple quadrants.

Show in **Figure 5-2** is a concept for a Bowtie on Chinden, where it appears it would impact only parking. If such were pursued, it would be necessary to avoid connecting to major driveways or side streets that may require designing them as roundabouts. This would impede traffic flow on Chinden. The point is merely to create a wrap-around lane for left turns that were prohibited at the main intersection. If the Bowtie is used to serve many more movements, it will itself become a problem.

Note that a traditional MUT could also be located at the same spots shown. It would impact less parking, but would also require a signal to stop oncoming traffic for the U-turning vehicles.

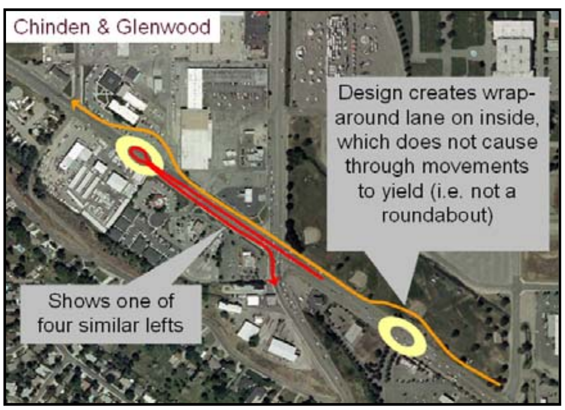


Figure 5-2 Bowtie option and routing on Chinden and Glenwood

Chinden and Glenwood

Quadrant Roadway Intersection

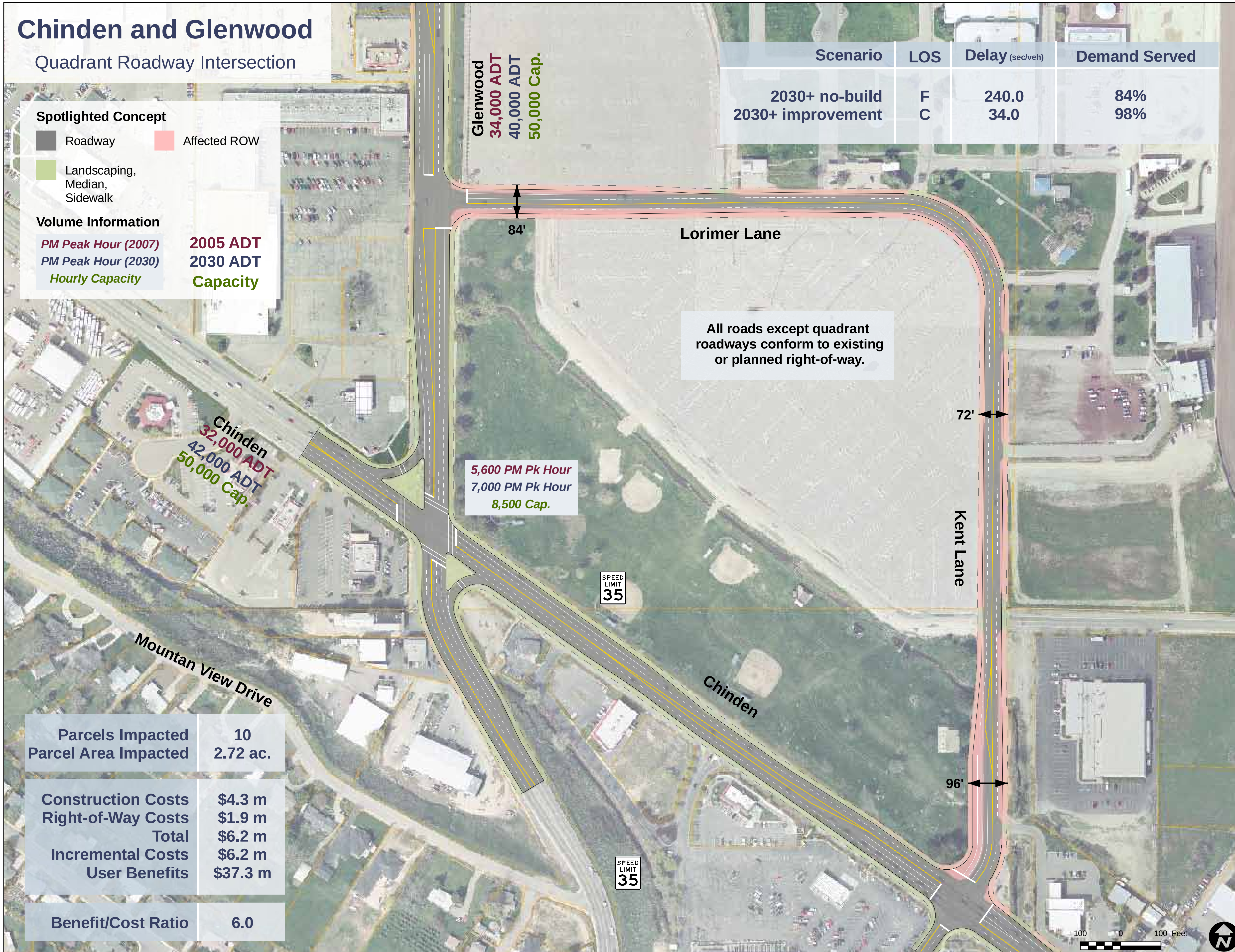
Spotlighted Concept

- Roadway
- Affected ROW
- Landscaping, Median, Sidewalk

Volume Information

PM Peak Hour (2007)	2005 ADT
PM Peak Hour (2030)	2030 ADT
Hourly Capacity	Capacity

Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	240.0	84%
2030+ improvement	C	34.0	98%



Parcels Impacted	10
Parcel Area Impacted	2.72 ac.
Construction Costs	$4.3 m
Right-of-Way Costs	$1.9 m
Total	$6.2 m
Incremental Costs	$6.2 m
User Benefits	$37.3 m
Benefit/Cost Ratio	6.0

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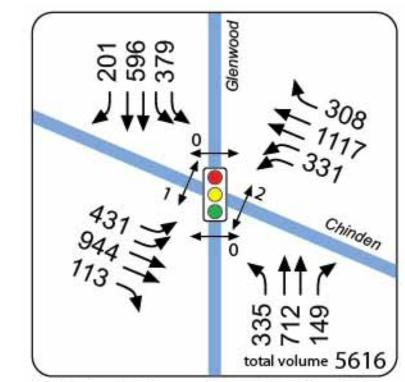
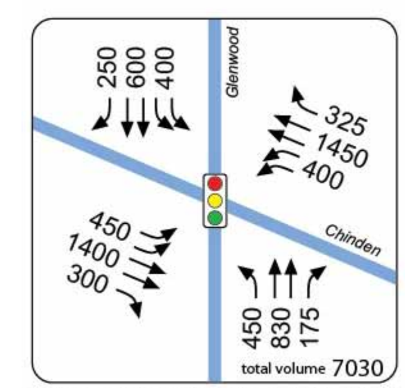


Chinden & Glenwood 2007 PM Peak Hour



Chinden & Glenwood Future PM Peak Hour

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6. Ustick Road and Cole Road

Key Facts

- Four-leg intersection in Boise; urban setting; streets meet at a 90 degree angle.
- Ustick: ACHD-owned, 35 mph minor arterial, three lanes, 17,000 ADT.
- Cole: ACHD-owned, 35 mph minor arterial, four lanes, 19,000 ADT.
- Signal controlled.

Existing Plans

The CIP and FYWP identify several construction or ROW preservation projects directly or indirectly impacting this intersection:

- RD207-144 (CIP): This arterial improvement project, with a cost estimate of $1.493 million and planned for construction in 6-10 years, will create a two-way couplet along Cole and a new alignment to the east. The southern terminus of the project is about 1700 feet north of Ustick & Cole. The project will improve north-south capacity with a much better connection between Cole and Glenwood, possibly increasing traffic demand at Ustick & Cole.
- RD207-135 (CIP)/INT207-29/#5 (FYWP)/: This arterial and intersection improvement project, with a cost estimate of $15.795 million (per the FYWP) and under construction, will widen Ustick west of Cole to five lanes and widen Ustick & Maple Grove and modify the traffic signal there. The now completed signal, 5300 feet west of Ustick & Cole, is close enough to have an impact on operations.
- RD207-148 (CIP): This arterial improvement project, with a cost estimate of $5 million and planned for construction in 6-10 years, will preserve ROW for a five lane cross-section on Ustick east of Cole.
- INT207-4 (CIP): This intersection improvement project, with a cost estimate of $8.016 million and planned for construction in 11-20 years, will widen Fairview & Cole and modify the traffic signal. The signal, 5300 feet south of Ustick & Cole, is close enough to have an impact on operations.

The draft *Roadways to Bikeways Plan* shows that there are currently bike lanes on the east and west legs of Ustick & Cole.

The 2030 Community Choices travel demand model shows two through lanes per direction on all four intersection legs.

There are plans to build a new branch library (the Boise West Branch Library) in the southwest quadrant of this intersection.

Environmental Scan

There are no identified environmental constraints within a ½ mile radius of the intersection.

Spotlighted Concept: Bowtie

The tight ROW and the pedestrian/ neighborhood atmosphere make this intersection very challenging. Many choices simply won't work well. However, a tight Bowtie will be functionally efficient and will also fit in with the context of the area better than any other choice.

In this case using the smallest possible roundabouts is preferred over the oval designs discussed earlier. The oval designs are more important on larger streets where much higher volumes are expected and where higher speeds need to be maintained.

In this environment, a single roundabout in the main intersection would fail, but two roundabouts on either side of the main intersection to handle mostly left-turn movements are appropriate to the entering volumes. Roundabouts will have smaller impacts than ovals, and provide access to attached driveways or local streets. It appears possible to install roundabouts using vacant lots and some parking to minimize the impacts to just one or two homes.

To be conservative in the necessary footprint, the roundabouts shown here are large enough to allow a semi with a single trailer to make the turn. If the concept is carried further, consider tighter roundabouts if necessary to lower costs and avoid impacts. Trucks would then be prohibited from making left turns or U-turns, and would need to utilize parking lots or approach from different directions as necessary to maneuver. In an area with relatively few trucks, this may be a reasonable restriction.

See **Map 7** on the following page.

Other Concepts

Jughandles (Mini-Cloverleaf)

Jughandles share much in common with quadrant roadways, but are typically much tighter and are often one-way streets. **Figure 6-1** shows how the concept would look in this case. To make a left turn, all vehicles would instead make three rights on a "loop ramp" as with a cloverleaf freeway interchange. Unlike a loop ramp on a freeway, this would be very low speed (15-20 mph).

It would also allow driveways on the loop as necessary to improve property access. **Figure 6-1** also shows an orange arrow noting how loops can be two-way streets to allow right-turns to use it (making it more like a quadrant roadway). If there is sufficient space to make it two-way, this creates better property access and removes the risk of someone entering the wrong way. This would cost more to develop than roundabouts, but would likely be less impacting than a traditional intersection widening and in the end would be much more efficient.

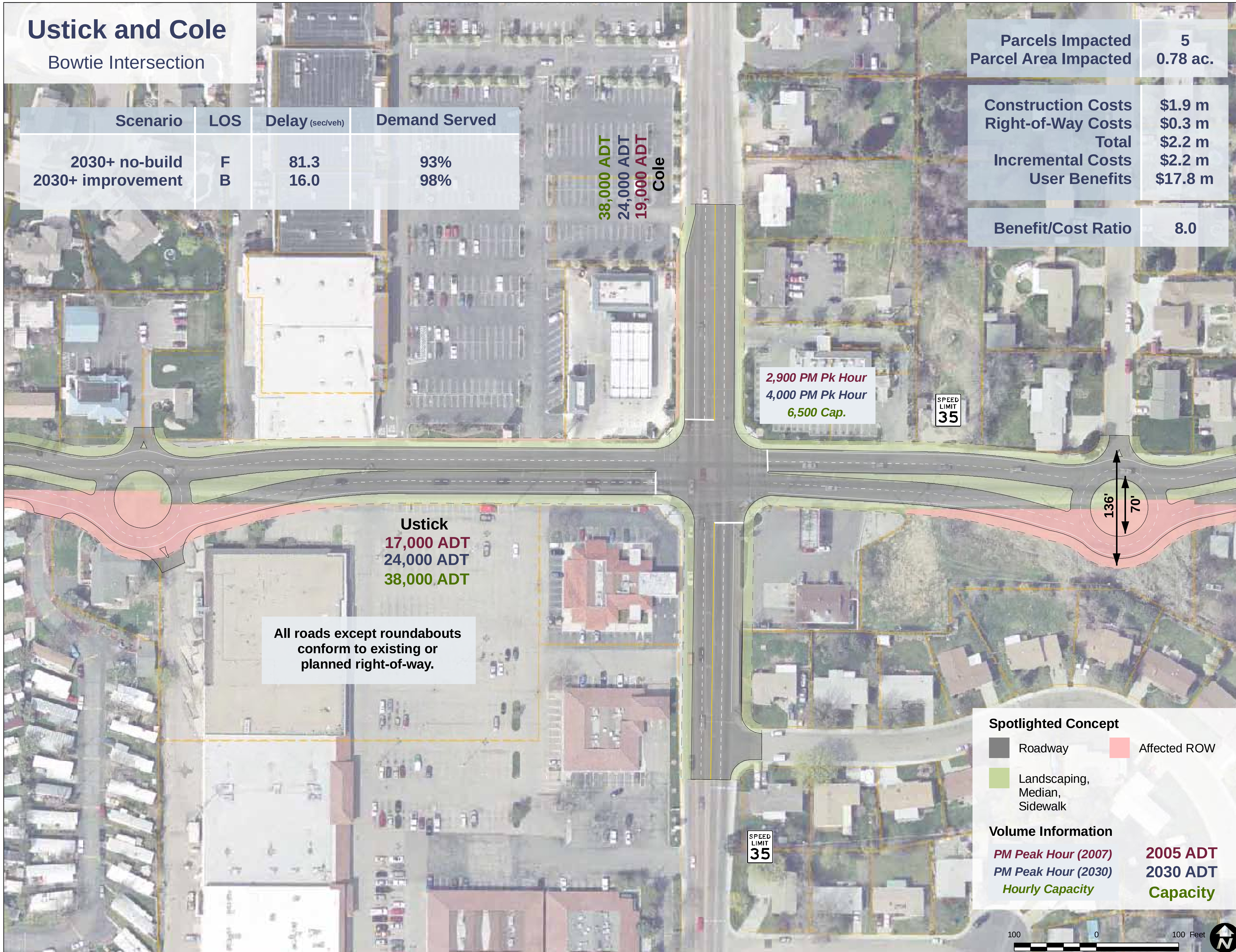
Figure 6-1 Routing left turns on four jughandles at Ustick and Cole

Ustick and Cole

Bowtie Intersection

Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	81.3	93%
2030+ improvement	B	16.0	98%

Parcels Impacted	5
Parcel Area Impacted	0.78 ac.
Construction Costs	$1.9 m
Right-of-Way Costs	$0.3 m
Total	$2.2 m
Incremental Costs	$2.2 m
User Benefits	$17.8 m
Benefit/Cost Ratio	8.0



Spotlighted Concept

- Roadway
- Affected ROW
- Landscaping, Median, Sidewalk

Volume Information

PM Peak Hour (2007)	2005 ADT
PM Peak Hour (2030)	2030 ADT
Hourly Capacity	Capacity

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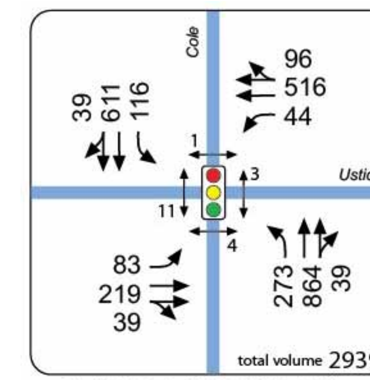
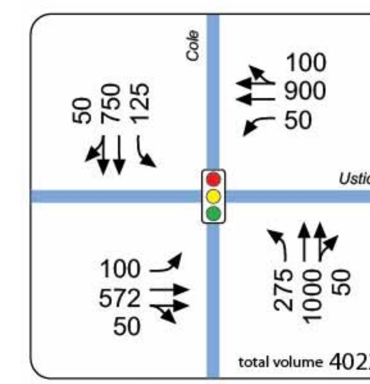


Ustick & Cole 2007 PM Peak Hour



Ustick & Cole Future PM Peak Hour

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7. Chinden Boulevard and Curtis Road

Key Facts

- Four-leg intersection in Garden City; urban setting; streets meet at a 90 degree angle.
- Chinden: ITD-owned (US 20/26), 35 mph principal arterial, five lanes, 34,000 ADT.
- Curtis (south of Chinden): ACHD-owned, 35 mph minor arterial, four lanes, 32,000 ADT.
- Veterans Memorial (north of Chinden): ACHD-owned, 35 mph minor arterial, four lanes, 26,000 ADT.
- Signal controlled.

Existing Plans

The CIP and FYWP identify several construction or ROW preservation projects directly or indirectly impacting this intersection:

- RD207-148 (CIP): This arterial improvement project, with a cost estimate of $5 million and planned for construction in 6-10 years, will preserve ROW for a five lane cross-section on Ustick east of Cole. The improved east-west capacity eventually provided on Ustick could lead to increased traffic at Ustick & Curtis; a signalized T-intersection located 600 feet south of Chinden & Curtis.
- #25 (FYWP): This collector improvement project, with a cost estimate of $3.990 million and planned for completion by 2012, will widen Adams to three lanes and create a new connection between 36th and 37th. This route runs parallel to Chinden, thus increasing east-west capacity, and possibly reducing traffic demand at Chinden & Curtis.
- INT207-3 (CIP): This intersection improvement project, with a cost estimate of $900,000 and planned for construction in 11-20 years, will preserve ROW for widening Chinden & Curtis.

The draft *Roadways to Bikeways Plan* shows that there are currently bike lanes on the south leg of Chinden & Curtis (along Curtis). The north leg (along Veterans Memorial) features a multi-use path.

The 2030 Community Choices travel demand model shows two through lanes per direction on all four intersection legs.

This intersection is included in current planning efforts by Garden City and ACHD.

Environmental Scan

- The intersection is located within the 500 year floodplain.
- The Settlers Canal is located approximately 1110 feet south of the intersection.
- No wetland areas, cultural sites, or historic properties were identified within a ½ mile radius.

Potential Concepts

Due to Garden City's ongoing planning efforts directed at Chinden & Curtis and the wide range of options, no specific "spotlighted" concept was advanced at this location. However, this site has a number of possible arrangements that should all be researched in more depth. The following pages show a wide variety of potential applications and some of the more interesting concepts to be evaluated in greater depth at a later date.

Town Center Intersections (TCI)

This intersection style has a strong ability to encourage urban renewal. The need for renewal in this area makes this an exciting site at which to apply this concept, and there are numerous alignment options to choose from. Access control can be less stringent with a TCI than is necessary with a CFI or MUT, which is important in dealing with existing properties in the area. High-level operational analysis suggests it may be at least as efficient as other reasonable choices.

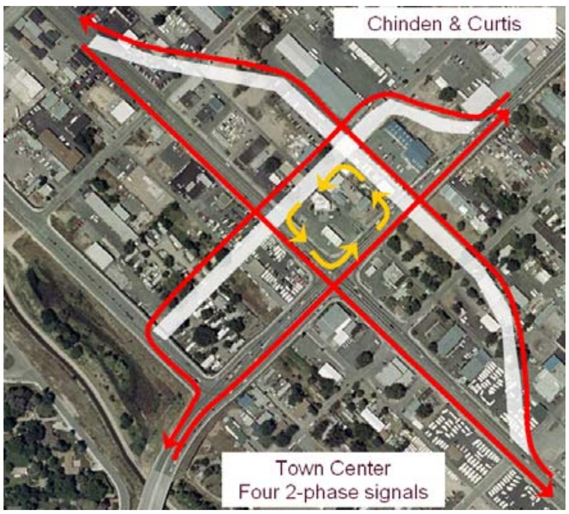

Figure 7-1 TCI, Option A

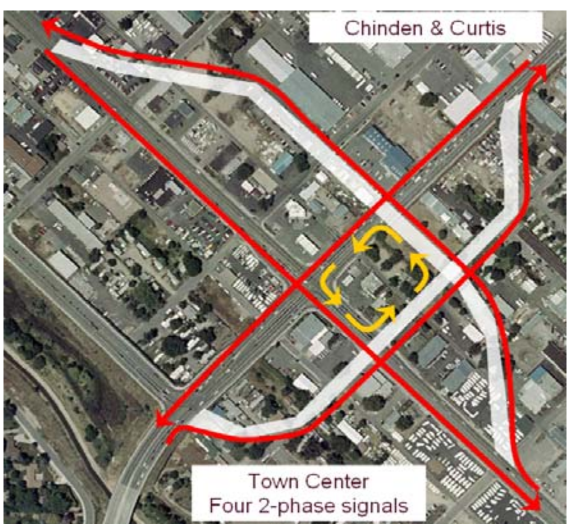

Figure 7-2 TCI, Option B

Figure 7-1 and **Figure 7-2** are essentially the same, with the major difference being whether a new alignment would parallel Curtis on the north or south side. The red shows thru movements, and the orange shows where left turns would occur. This is a typical TCI with four intersections replacing today's single intersection, but each intersection would have efficient two-phase signals and the system could handle much higher volumes than exist today.

Developing either of these choices will impact property and may need a sponsor willing to utilize tax-increment financing, perhaps followed up by a public-private partnership.

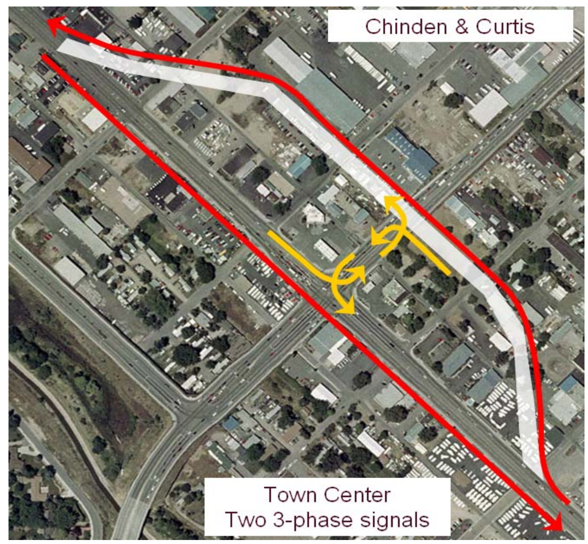

Figure 7-3 Half TCI, Two three-phase signals

Figure 7-3 shows a half TCI. In orange are the conflicting left turns that create two three-phase signals. This is a more efficient system than exists today, and could be a first step towards a full TCI.

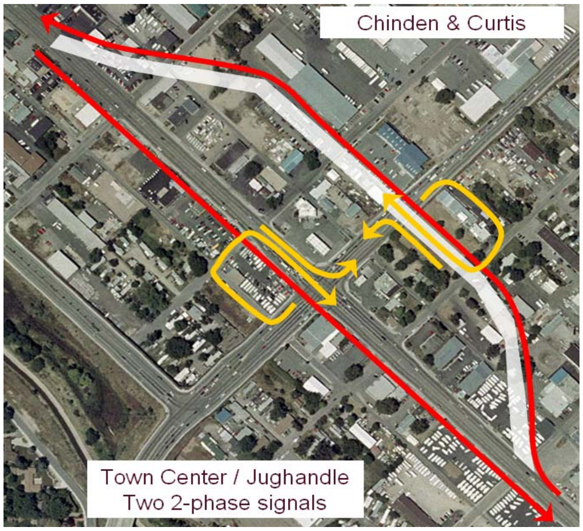

Figure 7-4 Half TCI with Jughandles, Two 2-phase signals

Figure 7-4 shows how the half TCI can be combined with jughandles to achieve two two-phase signals. This is a very efficient system that will achieve most of the benefits of the full TCI, but with significantly less cost.

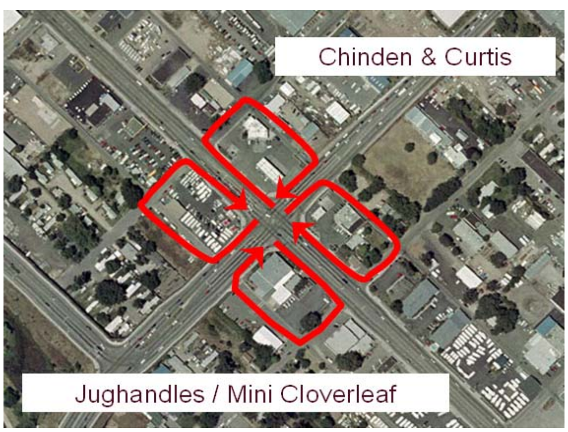

Figure 7-5 Chinden and Curtis Full Jughandles

There are two low-cost solutions that may be possible to implement in the near term. Both could improve the situation for ten years or so while a more ideal solution is identified and funded.

The first is the jughandle/mini-cloverleaf shown in **Figure 7-5**. There are existing alleyways and local streets that could serve this purpose. If they are restricted to one-way movements, they may not need much new ROW.

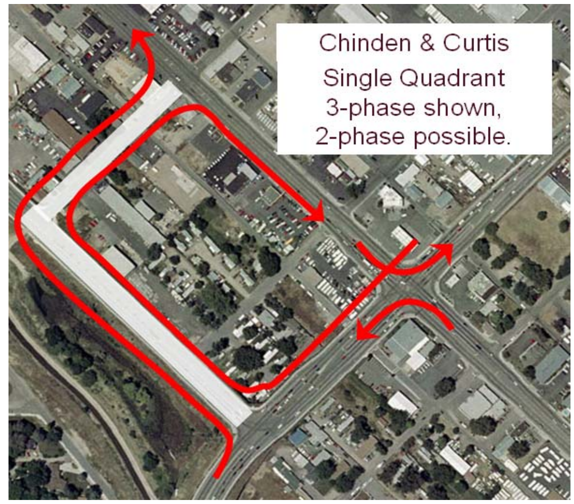

Figure 7-6 Low cost, short term benefits using existing quadrant and three-phase operation

The second is to operate a single quadrant along the white path in **Figure 7-6.** Both roads already exist, and would require only signal installation, signing/striping, and minor construction. A single quadrant can serve all four left turns, but this creates unusual driver expectancy and may overly congest the quadrant. The figure shows how two left turns could use the quadrant, and the remaining two would operate as standard left turns achieving a three-phase signal. Note that transportation departments around the country are beginning to spend millions to reduce from 4-phase to three-phase signals. This one could be done on less than half a million dollars.

MUTs on Chinden are also a reasonable, fairly low cost option here as well.

For illustration, the CFI and Parallel Flow Intersection (PFI) options are shown in **Figure 7-7** and **Figure 7-8**. The CFI is more restrictive on access for a longer distance and requires a right-turn ramp (orange) so that drivers don't mistakenly turn into the left storage bay. The PFI would have fewer access impacts, and would not need the right-turn ramp (reducing the footprint) because there is much less risk drivers would mistakenly turn into the left bay. However, the entry point of the southern-most left storage bay is likely too close to the T-intersection to make it work.

Neither of these options offers significant advantages over the others discussed, and should probably not be pursued further at this site.

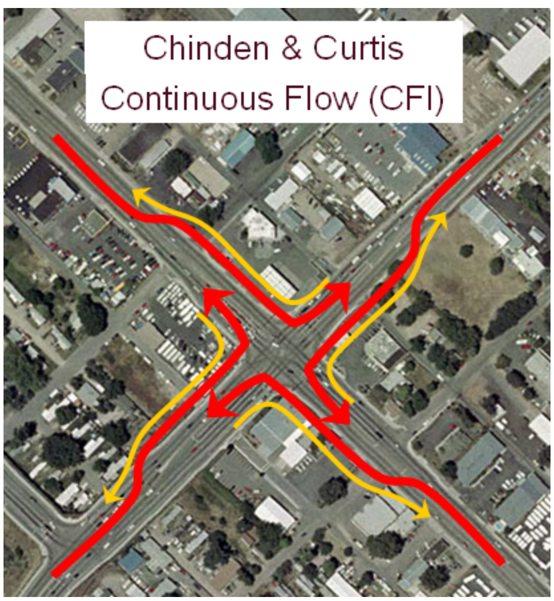

Figure 7-7 CFI routing and likely impacts

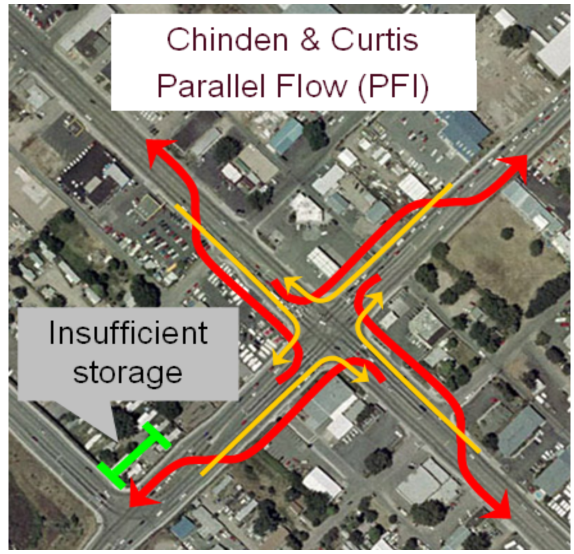

Figure 7-8 PFI routing and likely impacts

8. Fairview Avenue and Curtis Road

Key Facts

- Four-leg intersection in Boise; urban setting; streets meet at a 90 degree angle.
- Fairview: ACHD-owned, 35 mph principal arterial, five lanes, 27,000 ADT.
- Curtis: ACHD-owned, 35 mph minor arterial, four lanes, 33,000 ADT.
- Signal controlled.

Existing Plans

The CIP identifies three construction or ROW preservation projects directly or indirectly impacting this intersection:

- RD207-53: This arterial improvement project, with a cost estimate of $3.316 million and planned for construction in 11-20 years, will preserve ROW for a 7 lane cross-section on Fairview both west and east of Curtis.
- INT207-4: This intersection improvement project, with a cost estimate of $8.016 million and planned for construction in 11-20 years, will widen Fairview & Cole and modify the traffic signal. The signal, 5300 feet west of Fairview & Curtis, is close enough to have an impact on operations.
- INT207-8: This intersection improvement project, with a cost estimate of $800,000 and planned for construction in 11-20 years, will preserve ROW for widening Fairview & Orchard. The signal, 2650 feet east of Fairview & Curtis, is close enough to have an impact on operations.

Additionally, at least one corridor study potentially has significant impact on Fairview & Curtis, the Fairview Avenue Corridor Study, with completion expected in 2009.

The draft *Roadways to Bikeways Plan* shows that there are currently bike lanes on the north and south legs of Fairview & Curtis. The Plan also shows proposed bike lanes extending farther south on the south leg (across the I-184 overpass) and on the west leg.

The 2030 Community Choices travel demand model shows two through lanes per direction on Curtis and three lanes per direction on Fairview.

Environmental Scan

- There are no identified environmental constraints within the direct vicinity of the intersection.
- The North Slough passes approximately 750 feet south of the intersection.

Spotlighted Concept: Single Quadrant Roadway Plus Roadway Realignment

This intersection appeared the most challenging intersection because of its proximity to the freeway. There was reluctance to adopt it as one of the ten study intersections out of concern it may take much more resources than available to identify a reasonable solution. However, a very attractive solution emerged nonetheless.

Figure 8-1 describes the major problem of this intersection. Two major streams of left-turns bound for WB Fairview merge and there are just 400 feet (about 15 car lengths), to serve 500 vehicles per hour today and over 800 per hour in the future. The inefficiency of a 4-phase signal, the need to dedicate major portions of the cycle to this left-turn, combined with the lack of space to store vehicles, present a major challenge.

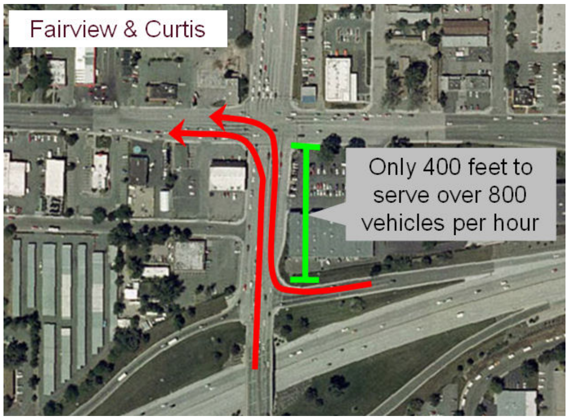

Figure 8-1 Fairview and Curtis: huge demand, no storage space

Some of the solutions for improving signal efficiency such as a CFI simply won't work here because there is not enough length for the run-out. A PFI treatment on the north and south legs can create the required storage, but would likely impact three significant businesses in the SW quadrant and two in the NE quadrant. A MUT on Fairview is challenging because of a nearby intersection, and because converting left-turns to a right-U-through pattern would overwhelm the capacity to turn right. A quadrant roadway in the northeast is possible and would be better than the status quo, but may not fully address the problem.

Figure 8-2 shows what emerged as the most practical solution to advance in the near term. It requires re-routing the northbound left-turns behind existing businesses to a T-intersection using Opohonga Street. To accomplish this, Opohonga must be realigned to the intersection of the freeway ramps so that it can receive those movements.

Figure 8-2 Routing plan with three-phase operation on two quadrants

The intersection of Curtis with the ramps would then appear at first glance to be a five-leg intersection, creating some worry that it may become problematic. However, Opohonga would be just one-way at this point as is the on-ramp, so in reality it is just a three-phase signal, and good channelization and signage can easily direct drivers where to be to enter either the freeway or Opohonga.

On the spotlighted concept drawing, Opohonga is shown as just one-way clear to the T, but it could be two-way from the T eastward to close to Curtis, to provide better property access if necessary. Do not allow two-way travel on Opohonga all the way to Curtis, as the eastbound movements would complicate operations at the critical intersection of I-184 and Curtis.

This is a satisfactory solution to one of three left-turns. **Figure 8-2** shows how a quadrant roadway in the NE would handle the opposing left, resulting in a three-phase signal where all movements maintain perfect or near-perfect driver expectation. In this case, the NE quadrant can be easily implemented with no widening to either Bond or Amber street if those segments are converted to one-way. There are enough other streets in the area that converting small portions of these two to one-way would not significantly hinder local access.

Figure 8-3 shows how the same quadrant could also take on the two additional left-turns to obtain a two-phase signal. Two directions plus additional volume would certainly require widening the quadrant and impacting a number of properties.

Figure 8-3 Routing plan with two-phase operation on two quadrants

Figure 8-3 is the routing that would create the most capacity, and hence, it is the concept that was analyzed in detail for purposes of estimating the costs and benefits of the full design. However, the routing of **Figure 8-2** is a very attractive interim solution that has much lower overall costs, and would clear up intersection congestion for a number of years.

The concept drawing shows dual left-turns on the northbound approach of I-184 and Curtis. It appears possible to use the existing bridge deck to accommodate the resulting six lanes of traffic (two through lanes per direction and two left-turn lanes), although at the sacrifice of any accommodation for pedestrian or bicycle traffic over the bridge. If it is necessary to continue to provide a means for north-south pedestrian and bicycle access in this area, it may be required to build a separate structure parallel to the existing bridge.

See **Map 8** on the following page.

Other Attractive Concepts

No other concepts appeared to offer anything as attractive as this, so they were not studied in any detail.

Fairview and Curtis

Quadrant Roadway Intersection

Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	109.5	89%
2030+ improvement	C	26.0	94%

All roads except quadrant roadways conform to existing or planned right-of-way.

Parcels Impacted	21
Parcel Area Impacted	1.31 ac.

Construction Costs	$9.0 m
Right-of-Way Costs	$0.9 m
Total	$9.9 m
Incremental Costs	$4.3 m
User Benefits	$26.5 m

Benefit/Cost Ratio	6.1

Spotlighted Concept

- Roadway
- Affected ROW
- Landscaping, Median, Sidewalk

Volume Information

PM Peak Hour (2007)	2005 ADT
PM Peak Hour (2030)	2030 ADT
Hourly Capacity	Capacity

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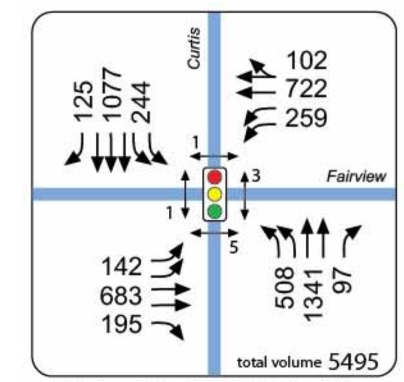
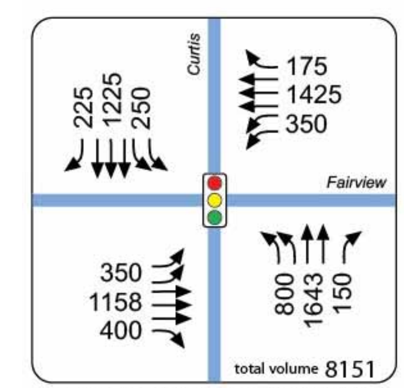
High Volume Intersection Study



Fairview & Curtis 2007 PM Peak Hour



Fairview & Curtis Future PM Peak Hour

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HDR

9. Fairview Avenue and Eagle Road

Key Facts

- Four-leg intersection in Meridian; urban setting; streets meet at a 90 degree angle.
- Fairview: ACHD-owned, 40 mph principal arterial, five lanes, 41,000 ADT.
- Eagle: ITD-owned (SH 55), 50 mph principal arterial, five lanes, 46,000 ADT.
- Signal controlled.

Existing Plans

The CIP, FYWP and LRCIP identify several construction projects directly or indirectly impacting this intersection:

- Key #9518/9517/9182 (LRCIP): These three adjacent projects, each at a cost from $20 million to $40 million and planned for construction in ITD's "Far Horizon" (2023 or beyond), are to provide infrastructure improvements on Eagle both south and north of Fairview.
- RD207-48 (CIP)/Unnumbered FYWP project: This arterial improvement project, with a cost estimate of $7.054 million (per the FYWP) and planned for construction in 6-10 years, will widen Fairview to 7 lanes west of Eagle.
- RD207-49 (CIP)/#16 (FYWP): This arterial improvement project, with a cost estimate of $6.632 million and planned for construction in 6-10 years, will widen Fairview to 7 lanes east of Eagle.
- RD207-114 (CIP): This collector improvement project, with a cost estimate of $5.328 million and planned for construction in 6-10 years, will widen Pine to five lanes west of Eagle. The improved east-west capacity provided on Pine could lead to increased traffic at Pine & Eagle, a signalized intersection located 2650 feet south of Fairview & Eagle, close enough to impact operations.
- INT207-6 (CIP): This intersection improvement project, with a cost estimate of $5.453 million and planned for construction in 11-20 years, will widen Fairview & Locust Grove and modify the traffic signal. The signal, 5300 feet west of Fairview & Eagle, is close enough to have an impact on operations.
- INT207-9 (CIP): This intersection improvement project, with a cost estimate of $4.395 million and under construction, is to widen Fairview & Cloverdale and modify the traffic signal. The signal, 5300 feet east of Fairview & Eagle, is close enough to have an impact on operations.

Additionally, several completed or ongoing corridor studies potentially have or will have significant impacts on Fairview & Eagle:

- The Fairview Avenue Corridor study, with completion expected in 2009, will likely result in recommendations for improvements on Fairview both west and east of Eagle.
- The Cloverdale Road Corridor study (currently on hold) will lead to recommendations for improvements along Cloverdale, which runs parallel to Eagle one mile to the east. At Chinden, Cloverdale would tie in to the southern terminus of the Three Cities River Crossing project (if it is approved). Cloverdale could thus become a very important "relief valve" for north-south traffic, possibly reducing traffic demand on Eagle.
- The Idaho 55 Eagle Road Arterial Study (completed in 2004) and the SH 55 Corridor Plan (with expected completion in 2009) both deal with issues on Eagle north and south of Fairview.

The draft *Roadways to Bikeways Plan* shows that there are proposed bike lanes on the west and east legs of Fairview & Eagle.

The 2030 Community Choices travel demand model shows three lanes per direction on all four legs of Fairview and Eagle. However, Eagle is shown narrowing to two through lanes per direction to the north of Fairview and south of Ustick.

Environmental Scan

- The intersection is located within a large area identified as prime agricultural land. In general, prime agricultural land may require coordination with the NRCS, but previously developed land is unlikely to raise major concerns.
- No wetland areas, cultural sites, or historic properties were identified within a ½ mile radius.

Spotlighted Concepts: CFI and Two Quadrant Roadways

This is a high-profile intersection with dramatic development occurring nearby, and decisions need to be made rather soon. Two concepts showed enough merit to warrant deeper analysis.

The first concept is to preserve a footprint for a four-leg CFI. The access control and property setbacks are already well situated to allow a CFI to fit easily. A CFI will fit well with driver expectation, but it can be intimidating for pedestrians, which may be a significant issue as there is a major proposal for a mixed-use residential development in the northeast quadrant.

See **Map 9** on page 39.

The second concept is for two quadrants – one in the northeast and one in the southwest. This performs very well also. It is much more pedestrian friendly. Two left turns are standard, and two are a bit more circuitous as shown in **Figure 9-1.**

See **Map 10** on page 40.

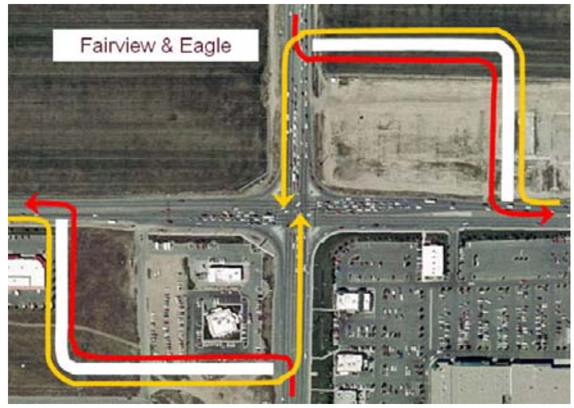

Figure 9-1 Fairview and Eagle routing plan with two opposing quadrants

The path in the northwest quadrant would pass through a proposed mixed-use development. This may at first be perceived negatively by a land owner or developer, but much like the TCI concept, it could also be a very good opportunity.

The featured concept design drawing shows the basic path and number of lanes necessary to serve the movements. It is not shown connecting to other internal streets, but it easily could. **Figure 9-2** shows that it is less important how the path between Fairview and Eagle is defined.

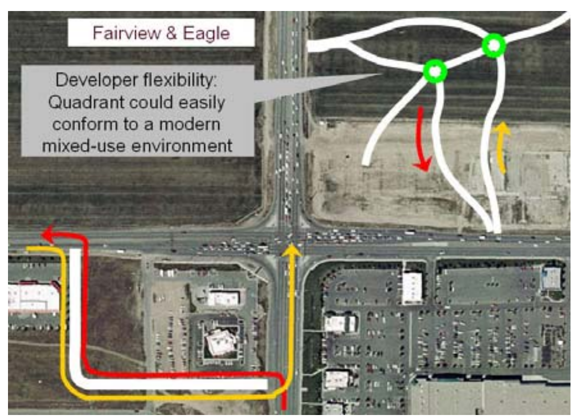

Figure 9-2 Mixed-use friendly quadrant design

A new development might want to take advantage of the traffic routed through the development. This could create two pedestrian-friendly one-way streets lined with retail and short-term parking that would all get good visibility. It might even have interior roundabout intersections, for example. It would be necessary to adopt a design appropriate to a mixed-use environment, but with an eye to avoid impeding these left-turn movements more than is reasonable.

Two quadrants also create two ways for any driver to complete a left-turn. This feature also enhances the ability of the intersection to adapt to unusual circumstances like construction or accident detours. **Figure 9-3** shows how the left turns that might normally occur using the NE quadrant can be shifted temporarily to the SW. The light blue line shows how even through movements can be rerouted if there were an accident.

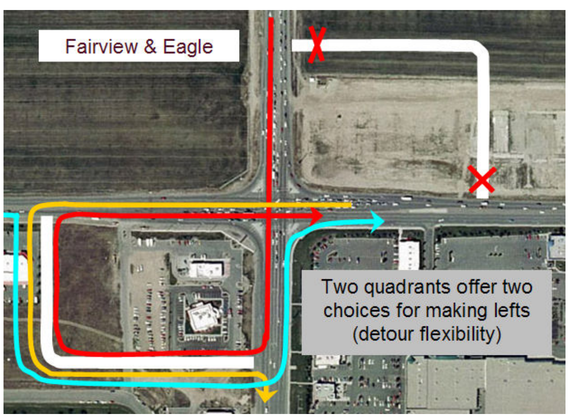

Figure 9-3 Detour flexibility inherent in quadrant designs

Fairview and Eagle

Continuous Flow Intersection

Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	214.7	90%
2030+ improvement	D	40.7	99%

Parcels Impacted	9
Parcel Area Impacted	2.20 ac.
Construction Costs	$12.5 m
Right-of-Way Costs	$1.1 m
Total	$13.6 m
Incremental Costs	$8.3 m
User Benefits	$95.5 m
Benefit/Cost Ratio	11.5

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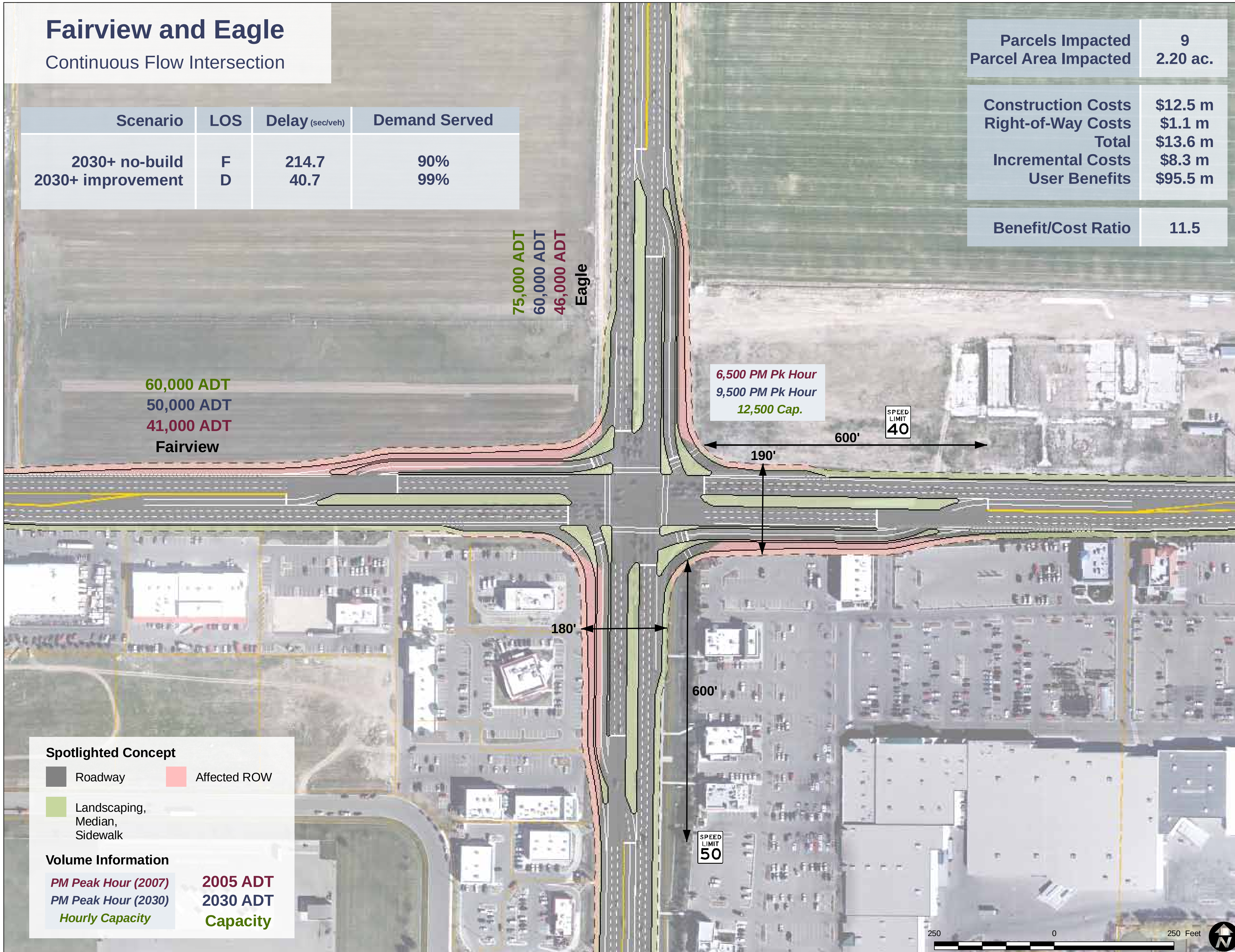
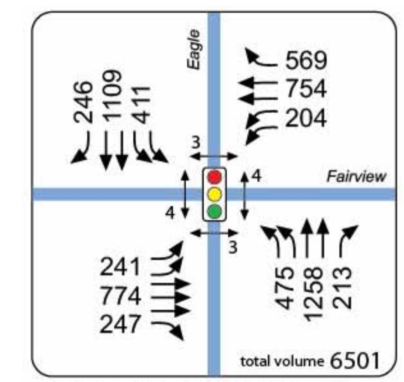
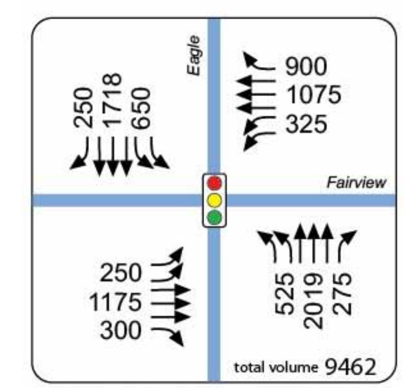




Fairview & Eagle 2007 PM Peak Hour



Fairview & Eagle Future PM Peak Hour

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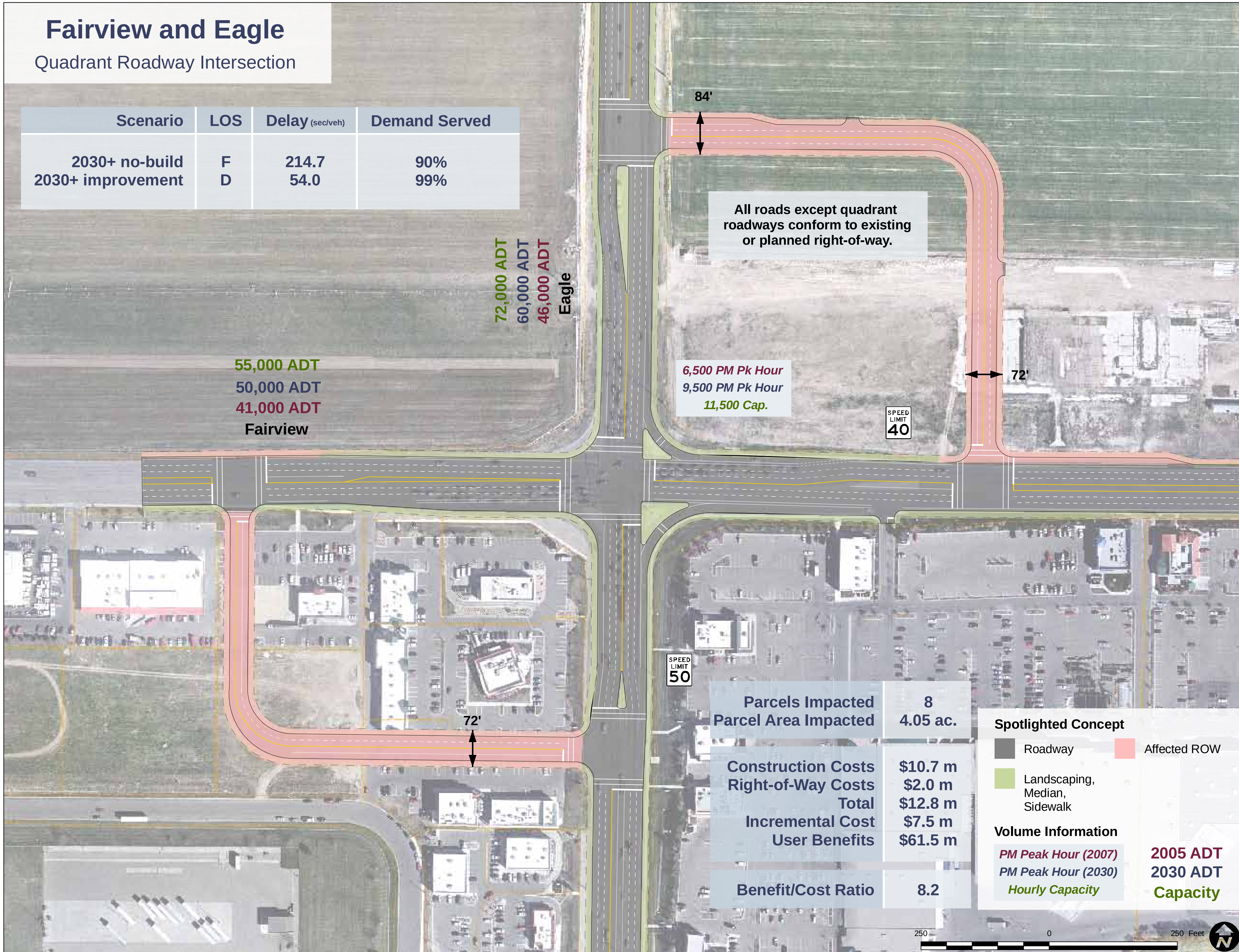
Fairview and Eagle

Quadrant Roadway Intersection

Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	214.7	90%
2030+ improvement	D	54.0	99%



Parcels Impacted	8
Parcel Area Impacted	4.05 ac.
Construction Costs	$10.7 m
Right-of-Way Costs	$2.0 m
Total	$12.8 m
Incremental Cost	$7.5 m
User Benefits	$61.5 m
Benefit/Cost Ratio	8.2

Spotlighted Concept

- Roadway
- Affected ROW
- Landscaping, Median, Sidewalk

Volume Information

PM Peak Hour (2007)	2005 ADT
PM Peak Hour (2030)	2030 ADT
Hourly Capacity	Capacity

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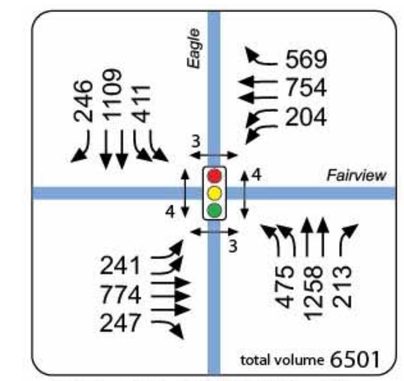
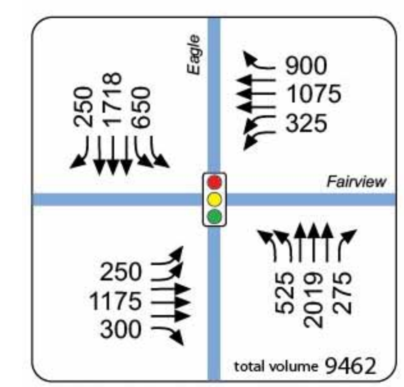


Fairview & Eagle 2007 PM Peak Hour



Fairview & Eagle Future PM Peak Hour

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10. Franklin Road and Eagle Road

Key Facts

- Four-leg intersection in Meridian; urban setting; streets meet at a 90 degree angle.
- Franklin: ACHD-owned, 40 mph principal arterial, five lanes, 17,000 ADT.
- Eagle: ITD-owned (SH 55), 50 mph principal arterial, five lanes north of Franklin, six lanes south of Franklin, 53,000 ADT.
- Signal controlled.

Existing Plans

The CIP, FYWP and LRCIP identify several construction projects directly or indirectly impacting this intersection:

- Key #9518/9517/9182 (LRCIP): These three adjacent projects, each at a cost from $20 million to $40 million and planned for construction in ITD's "Far Horizon" (2023 or beyond), are to provide infrastructure improvements on Eagle both south and north of Franklin.
- RD207-63 (CIP) / #6 (FYWP) / INT207-10 (CIP): This arterial improvement project, with a cost estimate of $12.319 million (per the FYWP) and planned for construction by 2009, will widen Franklin to five lanes east of Eagle. Also included in the project is intersection work at Franklin & Cloverdale, which at 5300 feet east of Franklin & Eagle is close enough to impact operations.
- RD207-65 (CIP): This arterial improvement project, with a cost estimate of $1.027 million and planned for construction in 11-20 years, will preserve ROW for widening Franklin to a 7-lane cross-section east of Eagle.
- RD207-114 (CIP): This collector improvement project, with a cost estimate of $5.328 million and planned for construction in 6-10 years, will widen Pine to five lanes west of Eagle. The improved east-west capacity provided on Pine could lead to increased traffic at Pine & Eagle, a signalized intersection located 2650 feet north of Franklin & Eagle, close enough to impact operations.

Additionally, several completed or ongoing corridor studies potentially have or will have significant impacts on Fairview & Eagle:

- The Fairview Avenue Corridor study, with completion expected in 2009, will likely result in recommendations for improvements on Fairview both west and east of Eagle. Improvements on Fairview (which runs parallel to Franklin one mile to the north) may reduce traffic demand on Franklin.
- The Cloverdale Road Corridor study (currently on hold) will lead to recommendations for improvements along Cloverdale, which runs parallel to Eagle one mile to the east. At Chinden, Cloverdale would tie in to the southern terminus of the Three Cities River Crossing project (if it is approved). Cloverdale could thus become a very important "relief valve" for north-south traffic, possibly reducing traffic demand on Eagle.
- The Idaho 55 Eagle Road Arterial Study (completed in 2004) and the SH 55 Corridor Plan (with expected completion in 2009) both deal with issues on Eagle north and south of Fairview.

The draft *Roadways to Bikeways Plan* shows that there are proposed bike lanes on the west and east legs of Franklin & Eagle. Based on aerial photographs of the intersection, there is an existing bike lane running northbound only on the south leg of Franklin & Eagle.

The 2030 Community Choices travel demand model shows three lanes per direction on the south, north and east legs of Franklin and Eagle, and two through lanes per direction on the west leg.

Environmental Scan

- Prime agricultural land is located approximately 400 feet north of the intersection. In general, prime agricultural land may require coordination with the NRCS, but previously developed land is unlikely to raise major concerns.
- The Snyder Lateral is located approximately 450 feet south of the intersection.
- The Gruber Lateral is located approximately 1 080 feet north of the intersection.
- The Union Pacific Railroad is located approximately 1200 feet north of the intersection.

Spotlighted Concepts: CFI and Single Quadrant Roadway

The choices that appear the most promising here are the same as those at Fairview and Eagle. There are more single-family homes at this intersection, but many of them will likely be redeveloped into other uses as this intersection becomes more popular. Assuming that will be the case, then the footprint and access control necessary for a CFI should be relatively easy to obtain through the normal requirements imposed on developers.

See **Map 11** on page 44.

Figure 10-1 shows an existing roadway in the NE quadrant. Creating an opposing quadrant in the SW would result in the same configuration as the option further north at Fairview and Eagle – very attractive in terms of consistency and enhancing driver expectancy.

See **Map 12** on page 45.

However there is a neighborhood of homes in the SW that may be far enough from the main intersection as to avoid redevelopment. Residents would not welcome higher volumes on the street, and to complete the quadrant would require at least one home. An alternative diagonal path appears to be available behind an existing business that may not require any homes. However the connections to the main roadways may be too close to the main intersection.

Figure 10-1 NE and SW quadrant options

Figure 10-2 shows the possibility of NW and SE quadrants. The NW is easily developed. The SE quadrant is being redeveloped at this moment, and it may or may not be feasible to develop a quadrant roadway there after the development is complete.

Figure 10-2 NW and SE quadrant options

Consistency

There is something to be said for making the same decision for Eagle at both Fairview and Franklin, to provide better uniformity and enhance driver expectancy. The quadrant at Fairview could be attractive to the pedestrian nature of a forthcoming mixed-used development there, but it is more difficult to create at Franklin. The CFI concept is relatively straight forward to develop at both sites. CFIs can also create more steady flow on Eagle because they do not introduce additional stops as would the T-intersections of the quadrant concepts.

A Note About Pine Street and Eagle Road

The benefits of improved flow created by improvements on Eagle at Fairview and Franklin can be partially lost if there are other inefficient intersections, as may be the case at Pine Street. However Pine is a lower volume intersection and may not need as much time to serve. This may allow it to be well synchronized to the other intersections so as not to impede overall flow on Eagle. This issue should be studied further in a more detailed analysis of the corridor.

Franklin and Eagle

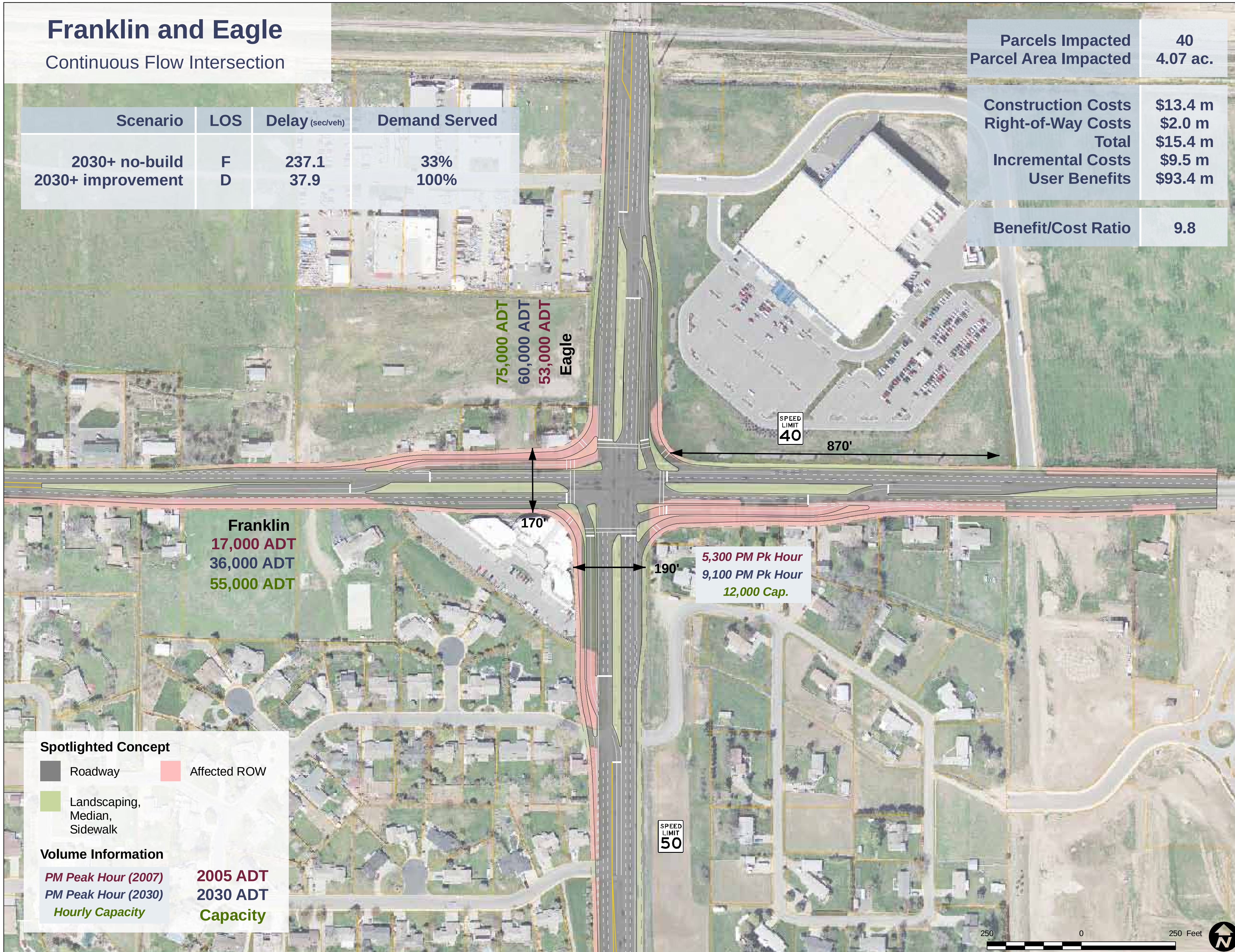
Continuous Flow Intersection

Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	237.1	33%
2030+ improvement	D	37.9	100%

Parcels Impacted	40
Parcel Area Impacted	4.07 ac.

Construction Costs	$13.4 m
Right-of-Way Costs	$2.0 m
Total	$15.4 m
Incremental Costs	$9.5 m
User Benefits	$93.4 m

Benefit/Cost Ratio	9.8



Spotlighted Concept

- Roadway
- Affected ROW
- Landscaping, Median, Sidewalk

Volume Information

PM Peak Hour (2007)	2005 ADT
PM Peak Hour (2030)	2030 ADT
Hourly Capacity	Capacity

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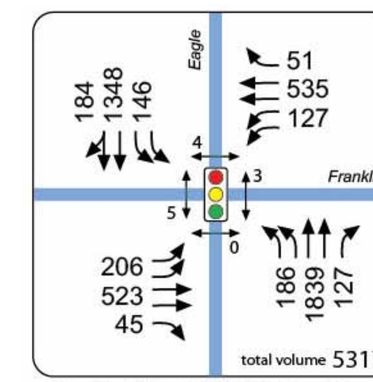
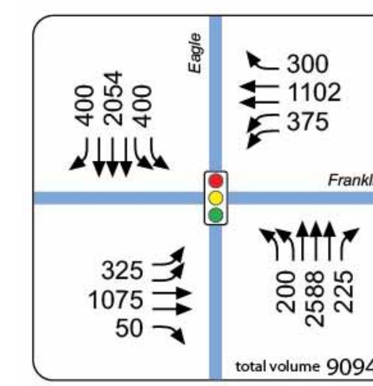


Franklin & Eagle 2007 PM Peak Hour



Franklin & Eagle Future PM Peak Hour

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Franklin and Eagle

Quadrant Roadway Intersection

Spotlighted Concept

- Roadway
- Affected ROW
- Landscaping, Median, Sidewalk

Volume Information

PM Peak Hour (2007)	2005 ADT
PM Peak Hour (2030)	2030 ADT
Hourly Capacity	Capacity

Parcels Impacted	28
Parcel Area Impacted	2.29 ac.

Construction Costs	$8.8 m
Right-of-Way Costs	$1.0 m
Total	$9.8 m
Incremental Costs	$3.9 m
User Benefits	$42.6 m

Benefit/Cost Ratio	10.9

Scenario	LOS	Delay (sec/veh)	Demand Served
2030+ no-build	F	237.1	83%
2030+ improvement	E	55.2	99%

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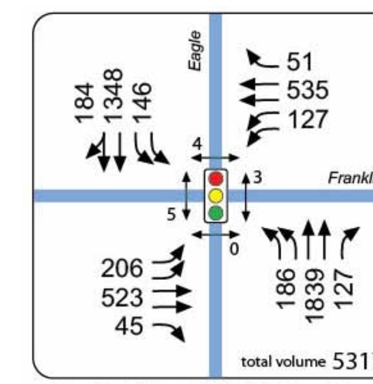
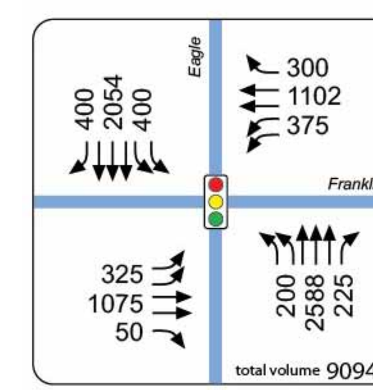


Franklin & Eagle 2007 PM Peak Hour



Franklin & Eagle Future PM Peak Hour

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Appendix: Cost Estimates

Detailed concept level cost estimates were computed for each spotlighted intersection concept. Most assume a full reconstruction of all pavement, utilities, sidewalks, etc. within several hundred feet of the intersection (i.e. the full drawings). A similar estimate is typically provided to replace all of the above given the baseline planned assumptions. In some cases the cost of planned improvements was estimated by ACHD.

In two cases, Chinden and Glenwood and Ustick and Cole, there are no plans to widen or replace existing pavement, utilities, and sidewalks. Hence, the baseline cost is zero. In these cases, it was assumed that for the corresponding intersection concept, nothing would be reconstructed except those elements that are a direct function of implementing the roundabouts in the case of Ustick and Cole, and widening the quadrant roadway in the case of State and Glenwood.

SHORT RANGE PROJECT COST SUMMARY SHEET

Project:	**Beacon Light Rd. and State Hwy 55**		
Date:	3/8/2006	*Functional Classification:*	Intersection Only
Federal Aid or non-Federal Aid:	non-Federal Aid	*Segment Description: (project limits)*	Widen, add signal
Rural or Urban Bridge:	Urban/Bridge Project		
Intersection Surfacing Material	Asphalt		
CIP Number:	INT207-42		
Total # of Existing Lanes:		*Existing RW Width (ft):*	
Total # of Proposed Lanes:	5	*Proposed RW Width (ft):*	
Project Length (miles):	0.0		
Existing Roadway Width (ft):			

Leg of Intersection	North	East	South	West
Existing PavementWidth:	68	0	68	26
Existing RW Width:	0	0	64	92
Proposed # Lanes:	6	0	5	3
Proposed RW Width:	108	0	96	70
Proposed Length:	800	0	800	300

	non-Fed Aid Unit Costs	Unit	Quantity	Total Item Cost	% TIF Eligible	Total TIF Cost
1. Preliminary Engineering (10% line 25 for Rural -- 15% for Urban/Bridge)				$202,844	30.70%	$62,277
2. Right-of-Way Costs (costs determined by RW contractor or ACHD RW Dept)				$0	30.00%	$0
3. Utility Adjustments (cost per project)				$19,408	33.00%	$6,405
4. Removal of Obstructions (trees, irrigation boxes, bridges, etc.)						
Trees (assumed all are 6"+ all)	$350.00	EA	0.0	$0	0.00%	$0
Irrigation Boxes	0	MI	0.0			
Bridges:						
Small (10' - 20' span)	$5,000.00	EA	0.0			
Medium (20' - 50' span)	$180.00	SF	0.0			
Large (50'+ span)	$15,000.00	EA	0.0			
Bituminous Surface	0.00	SY	12,956.0			
Other						
6. Storm Sewer (urban and semi-urban only)	$342,140.00	MI	0.4	$136,856	33.00%	$45,162
7. Earthwork	$14.00	CY	15,101.9	$211,426	33.00%	$69,771
8. Intersection and Roadway Surfacing				$168,925	33.00%	$55,745
Asphalt Surfacing	$50.00	TN	3,378.5			
Concrete Surfacing	$4.00	SF	139,800.0			
9. Aggregate Base Course	$25.00	CY	1,726.0	$45,306	33.00%	$14,951
10. 6" Minus Uncrushed Aggregate Subbase Course	$12.50	CY	11,650.0	$152,906	33.00%	$50,459
11. Structures				$0	33.00%	$0
Box Culverts	$180.00	SF	0			
Minor Bridge	$180.00	SF	0			
Major Bridge	$100.00	SF	0			
Grade Separation	$100.00	SF	0			
12. Traffic Signals	$50,000.00	EA	1	$50,000	33.00%	$16,500
13. Illumination	$5,000.00	EA	$5,000.0	$0	30.70%	$0
14. Curb / Gutter / Approaches				$72,653	33.00%	$23,975
Rural Approaches (assumes 20'x30'x3" approaches)	$0.00	mile/side	$0.0			
Curb/Gutter/Approaches (cost/mile/side)	$90,816.00	mile/side	$1,720.0			
15. Sidewalk				$65,707	0.00%	$0
Sidewalk (assumes 7' side sidewalk at back of curb)	$82,133.80	mile/side				
16. Roadside Development				$20,424	33.00%	$6,740
Fencing	$20.00	LF	0			
Seeding	$20,037.60	AC	$14,520.0			
17. Delineators / Signing / Channelization (0% of items 4 thru 16)	0.00	%	$924,203	$0	30.70%	$0
18. Const Stormwater Pollution Prevention Plan (0% of items 4 thru 17)	0.00	%	$924,203	$0	30.70%	$0
19. Construction Traffic Control (5% of items 4 thru 18)	5.00	%	$924,203	$46,210	30.70%	$14,187
20. Special Project Features (see field data summary sheet)				$0	30.70%	$0
21. Cost of Construction (items 3 thru 20)				$989,821	30.70%	$303,895
22. Other Miscellaneous Construction Items (15% of item 21)				$148,473	30.70%	$148,473
23. Mobilization (8% of items 21 + 22)				$91,064	30.70%	$27,958
24. Construction Engineering and Inspection (10% of Items 21+22+23)				$122,936	30.70%	$37,744
25. Total Construction Costs (21+22+23+24)				$1,352,293	30.70%	$415,181
26. Construction Contingency (5% of item 25)				$67,615	30.70%	$20,759
27. Total Project Cost (1+2+25+26)				**$1,622,752**	**30.70%**	**$498,217**
28. Project Cost Per Mile (27 / project length in miles)				**#Div/0!**		
29. Project Cost Per Lane Mile (28 / # of proposed lanes)				**#Error**		

1/9/2008 *CIP Number:* INT207-42 Page 10

SOURCE: ACHD estimate, 2006

Beacon Light & SH 55 - CFI

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	40,423	SY	$8	$ 323,387
Excavation	27,084	CY	$6	$ 162,502
Granular subbase	15,669	CY	$18	$ 282,037
3/4" Aggr Ty A/B for base	6,894	CY	$32	$ 220,615
PL Mix Pav CL I	13,444	Ton	$65	$ 873,844
Conc sidewalk - 4" depth	0	SF	$6	$ -
Comb curb & gutter ty A 2	0	Ft	$20	$ -
Median Island	2,309	SY	$90	$ 207,850
Signal	1	Each	$250,000	$ 250,000
Sub Total				$ 2,320,235
Drainage	1	LS	10% of construction	$ 232,023
Utilities	1	LS	8% of construction	$ 185,619
Landscaping	1	LS	2% of construction	$ 46,405
Signing & Striping	1	LS	3% of construction	$ 69,607
Mobilization	1	LS	10% of construction	$ 232,023
Traffic control	1	LS	5% of construction	$ 116,012
PE & CEI	1	LS	15% of construction	$ 348,035
Contingencies	1	LS	30% of construction	$ 696,070
Construction Total				**$ 4,246,029**
Right-of-Way (Residential)	0.20	Acre	$175,000	$ 35,000
Right-of-Way (Commercial)	0.10	Acre	$350,000	$ 35,000
Right-of-Way Total				**$ 70,000**
Total Project				**$ 4,316,029**

SOURCE: Wilbur Smith Assoc. est., 2008

LONG RANGE PROJECT COST SUMMARY SHEET

Project:	State Hwy 44 and Linder Rd.		
Date:	3/8/2006	*Functional Classification:*	Intersection Only
Federal Aid or non-Federal Aid:	non-Federal Aid	*Segment Description: (project limits)*	Widen, modify/replace signal
Rural or Urban Bridge:	Urban/Bridge Project		
Intersection Surfacing Material	Concrete		
CIP Number:	INT207-23		
Total # of Existing Lanes:		*Existing RW Width (ft):*	
Total # of Proposed Lanes:	6.50	*Proposed RW Width (ft):*	
Project Length (miles):	1.0		
Existing Roadway Width (ft):			

Leg of Intersection	North	East	South	West
Existing PavementWidth:	40	40	40	40
Existing RW Width:	0	0	0	0
Proposed # Lanes:	7	6	7	6
Proposed RW Width:	120	108	120	108
Proposed Length:	800	800	800	800

	non-Fed Aid Unit Costs	Unit	Quantity	Total Item Cost	% TIF Eligible	Total TIF Cost
1. Preliminary Engineering (10% line 25 for Rural -- 15% for Urban/Bridge)				$586,482	50.63%	$296,926
2. Right-of-Way Costs (costs determined by RW contractor or ACHD RW Dept)				$236,000	50.00%	$118,000
3. Utility Adjustments (cost per project)				$56,115	50.00%	$28,057
4. Removal of Obstructions (trees, irrigation boxes, bridges, etc.)						
Trees (assumed all are 6"+ all)	$350.00	EA	0.0	$135,820	#######	$135,820
Irrigation Boxes	0	MI	0.0			
Bridges:						
Small (10' - 20' span)	$5,000.00	EA	0.0			
Medium (20' - 50' span)	$180.00	SF	0.0			
Large (50'+ span)	$15,000.00	EA	0.0			
Bituminous Surface	0.00	SY	14,222.0			
Other						
6. Storm Sewer (urban and semi-urban only)	$342,140.00	MI	0.6	$205,284	50.00%	$102,642
7. Earthwork	$14.00	CY	31,111.1	$435,556	50.00%	$217,778
8. Intersection and Roadway Surfacing				$1,152,000	50.00%	$576,000
Asphalt Surfacing	$50.00	TN	6,960.0			
Concrete Surfacing	$4.00	SF	288,000.0			
9. Aggregate Base Course	$25.00	CY	3,556.0	$93,333	50.00%	$46,667
10. 6" Minus Uncrushed Aggregate Subbase Course	$12.50	CY	24,000.0	$315,000	50.00%	$157,500
11. Structures				$17,280	50.00%	$8,640
Box Culverts	$180.00	SF	96			
Minor Bridge	$180.00	SF	0			
Major Bridge	$100.00	SF	0			
Grade Separation	$100.00	SF	0			
12. Traffic Signals	$50,000.00	EA	1.5	$75,000	50.00%	$37,500
13. Illumination	$5,000.00	EA	$5,000.0	$0	50.63%	$0
14. Curb / Gutter / Approaches				$108,979	50.00%	$54,490
Rural Approaches (assumes 20'x30'x3" approaches)	$0.00	mile/side	$0.0			
Curb/Gutter/Approaches (cost/mile/side)	$90,816.00	mile/side	$1,720.0			
15. Sidewalk				$98,561	0.00%	$0
Sidewalk (assumes 7' side sidewalk at back of curb)	$82,133.80	mile/side				
16. Roadside Development				$35,328	50.00%	$17,664
Fencing	$20.00	LF	0			
Seeding	$20,037.60	AC	$14,520.0			
17. Delineators / Signing / Channelization (0% of items 4 thru 16)	0.00	%	$2,672,141	$0	50.63%	$0
18. Const Stormwater Pollution Prevention Plan (0% of items 4 thru 17)	0.00	%	$2,672,141	$0	50.63%	$0
19. Construction Traffic Control (5% of items 4 thru 18)	5.00	%	$2,672,141	$133,607	50.63%	$67,643
20. Special Project Features (see field data summary sheet)				$0	50.63%	$0
21. Cost of Construction (items 3 thru 20)				$2,861,863	50.63%	$1,448,915
22. Other Miscellaneous Construction Items (15% of item 21)				$429,279	50.63%	$429,279
23. Mobilization (8% of items 21 + 22)				$263,291	50.63%	$133,300
24. Construction Engineering and Inspection (10% of Items 21+22+23)				$355,443	50.63%	$179,955
25. Total Construction Costs (21+22+23+24)				$3,909,877	50.63%	$1,979,508
26. Construction Contingency (5% of item 25)				$195,494	50.63%	$98,975
27. Total Project Cost (1+2+25+26)				**$4,927,852**	**50.63%**	**$2,494,893**
28. Project Cost Per Mile (27 / project length in miles)				**$4,927,852**		
29. Project Cost Per Lane Mile (28 / # of proposed lanes)				**$758,131**		

1/9/2008 *CIP Number:* INT207-23 Page 6

SOURCE: ACHD estimate, 2006

State & Linder - CFI

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	91,369	SY	$8	$ 730,951
Excavation	61,217	CY	$6	$ 367,303
Granular subbase	37,676	CY	$18	$ 678,159
3/4" Aggr Ty A/B for base	16,577	CY	$32	$ 530,471
PL Mix Pav CL I	32,326	Ton	$65	$ 2,101,163
Conc sidewalk - 4" depth	0	SF	$6	$ -
Comb curb & gutter ty A 2	0	Ft	$20	$ -
Median Island	10,189	SY	$90	$ 917,036
Signal	2	Each	$250,000	$ 500,000
Sub Total				$ 5,825,083
Drainage	1	LS	10% of construction	$ 582,508
Utilities	1	LS	8% of construction	$ 466,007
Landscaping	1	LS	2% of construction	$ 116,502
Signing & Striping	1	LS	3% of construction	$ 174,752
Mobilization	1	LS	10% of construction	$ 582,508
Traffic control	1	LS	5% of construction	$ 291,254
PE & CEI	1	LS	15% of construction	$ 873,762
Contingencies	1	LS	30% of construction	$ 1,747,525
Construction Total				**$ 10,659,901**
Right-of-Way (Residential)	4.68	Acre	$175,000	$ 819,000
Right-of-Way (Commercial)	0.52	Acre	$350,000	$ 182,000
Right-of-Way Total				**$ 1,001,000**
Total Project				**$ 11,660,901**

SOURCE: Wilbur Smith Assoc. est., 2008

State & SH 55 - Baseline

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	60,271	SY	$8	$ 482,168
Excavation	40,382	CY	$6	$ 242,290
Granular subbase	23,700	CY	$18	$ 426,600
3/4" Aggr Ty A/B for base	10,428	CY	$32	$ 333,696
PL Mix Pav CL I	20,335	Ton	$65	$ 1,321,775
Conc sidewalk - 4" depth	49,925	SF	$6	$ 299,550
Comb curb & gutter ty A 2	11,031	Ft	$20	$ 220,620
Median Island	2,137	SY	$90	$ 192,330
Signal	1	Each	$250,000	$ 250,000
Sub Total				$ 3,769,029
Drainage	1	LS	10% of construction	$ 376,903
Utilities	1	LS	8% of construction	$ 301,522
Landscaping	1	LS	2% of construction	$ 75,381
Signing & Striping	1	LS	3% of construction	$ 113,071
Mobilization	1	LS	10% of construction	$ 376,903
Traffic control	1	LS	5% of construction	$ 188,451
PE & CEI	1	LS	15% of construction	$ 565,354
Contingencies	1	LS	30% of construction	$ 1,130,709
Construction Total				**$ 6,897,323**
Right-of-Way (Residential)	0.00	Acre	$262,500	$ -
Right-of-Way (Commercial)	2.24	Acre	$525,000	$ 1,176,000
Right-of-Way Total				**$ 1,176,000**
Total Project				**$ 8,073,323**

SOURCE: Wilbur Smith Assoc. est., 2008

State & SH 55 - CFI

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	96,371	SY	$8	$ 770,967
Excavation	64,569	CY	$6	$ 387,411
Granular subbase	39,852	CY	$18	$ 717,335
3/4" Aggr Ty A/B for base	17,535	CY	$32	$ 561,115
PL Mix Pav CL I	34,193	Ton	$65	$ 2,222,542
Conc sidewalk - 4" depth	64,840	SF	$6	$ 389,040
Comb curb & gutter ty A 2	31,285	Ft	$20	$ 625,700
Median Island	11,107	SY	$90	$ 999,649
Signal	2	Each	$250,000	$ 500,000
Sub Total				$ 7,173,759
Drainage	1	LS	10% of construction	$ 717,376
Utilities	1	LS	8% of construction	$ 573,901
Landscaping	1	LS	2% of construction	$ 143,475
Signing & Striping	1	LS	3% of construction	$ 215,213
Mobilization	1	LS	10% of construction	$ 717,376
Traffic control	1	LS	5% of construction	$ 358,688
PE & CEI	1	LS	15% of construction	$ 1,076,064
Contingencies	1	LS	30% of construction	$ 2,152,128
Construction Total				**$ 13,127,979**
Right-of-Way (Residential)	0.10	Acre	$262,500	$ 26,250
Right-of-Way (Commercial)	4.51	Acre	$525,000	$ 2,367,750
Right-of-Way Total				**$ 2,394,000**
Total Project				**$ 15,521,979**

SOURCE: Wilbur Smith Assoc. est., 2008

LONG RANGE PROJECT COST SUMMARY SHEET

Project:	State St. and Glenwood St.		
Date:	3/8/2006	Functional Classification:	Intersection Only
Federal Aid or non-Federal Aid:	non-Federal Aid	Segment Description: (project limits)	Widen, modify/replace signal
Rural or Urban Bridge:	Urban/Bridge Project		
Intersection Surfacing Material	Concrete		
CIP Number:	INT207-24		
Total # of Existing Lanes:		Existing RW Width (ft):	
Total # of Proposed Lanes:	8.11	Proposed RW Width (ft):	
Project Length (miles):	1.0		
Existing Roadway Width (ft):			

Leg of Intersection	North	East	South	West
Existing PavementWidth:	68	90	90	80
Existing RW Width:	0	0	0	0
Proposed # Lanes:	7	9	7	9
Proposed RW Width:	120	144	120	144
Proposed Length:	800	1000	800	1000

Item	non-Fed Aid Unit Costs	Unit	Quantity	Total Item Cost	% TIF Eligible	Total TIF Cost
1. Preliminary Engineering (10% line 25 for Rural -- 15% for Urban/Bridge)				$792,577	50.67%	$401,592
2. Right-of-Way Costs (costs determined by RW contractor or ACHD RW Dept)				$1,435,000	50.00%	$717,500
3. Utility Adjustments (cost per project)				$75,834	50.00%	$37,917
4. Removal of Obstructions (trees, irrigation boxes, bridges, etc.)						
Trees (assumed all are 6"+ all)	$350.00	EA	0.0	$183,548	#######	$183,548
Irrigation Boxes	0	MI	0.0			
Bridges:						
Small (10' - 20' span)	$5,000.00	EA	0.0			
Medium (20' - 50' span)	$180.00	SF	0.0			
Large (50'+ span)	$15,000.00	EA	0.0			
Bituminous Surface	0.00	SY	32,933.0			
Other						
6. Storm Sewer (urban and semi-urban only)	$342,140.00	MI	0.7	$239,498	50.00%	$119,749
7. Earthwork	$14.00	CY	44,246.9	$619,457	50.00%	$309,728
8. Intersection and Roadway Surfacing				$1,638,400	50.00%	$819,200
Asphalt Surfacing	$50.00	TN	9,898.7			
Concrete Surfacing	$4.00	SF	409,600.0			
9. Aggregate Base Course	$25.00	CY	5,057.0	$132,741	50.00%	$66,370
10. 6" Minus Uncrushed Aggregate Subbase Course	$12.50	CY	34,133.0	$448,000	50.00%	$224,000
11. Structures				$0	50.00%	$0
Box Culverts	$180.00	SF	0			
Minor Bridge	$180.00	SF	0			
Major Bridge	$100.00	SF	0			
Grade Separation	$100.00	SF	0			
12. Traffic Signals	$50,000.00	EA	1.5	$75,000	50.00%	$37,500
13. Illumination	$5,000.00	EA	$5,000.0	$0	50.67%	$0
14. Curb / Gutter / Approaches				$127,142	50.00%	$63,571
Rural Approaches (assumes 20'x30'x3" approaches)	$0.00	mile/side	$0.0			
Curb/Gutter/Approaches (cost/mile/side)	$90,816.00	mile/side	$1,720.0			
15. Sidewalk				$114,987	0.00%	$0
Sidewalk (assumes 7' side sidewalk at back of curb)	$82,133.80	mile/side				
16. Roadside Development				$32,384	50.00%	$16,192
Fencing	$20.00	LF	0			
Seeding	$20,037.60	AC	$14,520.0			
17. Delineators / Signing / Channelization (0% of items 4 thru 16)	0.00	%	$3,611,158	$0	50.67%	$0
18. Const Stormwater Pollution Prevention Plan (0% of items 4 thru 17)	0.00	%	$3,611,158	$0	50.67%	$0
19. Construction Traffic Control (5% of items 4 thru 18)	5.00	%	$3,611,158	$180,558	50.67%	$91,487
20. Special Project Features (see field data summary sheet)				$0	50.67%	$0
21. Cost of Construction (items 3 thru 20)				$3,867,550	50.67%	$1,959,657
22. Other Miscellaneous Construction Items (15% of item 21)				$580,132	50.67%	$580,132
23. Mobilization (8% of items 21 + 22)				$355,815	50.67%	$180,288
24. Construction Engineering and Inspection (10% of Items 21+22+23)				$480,350	50.67%	$243,389
25. Total Construction Costs (21+22+23+24)				$5,283,847	50.67%	$2,677,283
26. Construction Contingency (5% of item 25)				$264,192	50.67%	$133,864
27. Total Project Cost (1+2+25+26)				**$7,775,616**	**50.67%**	**$3,939,842**
28. Project Cost Per Mile (27 / project length in miles)				**$7,775,616**		
29. Project Cost Per Lane Mile (28 / # of proposed lanes)				**$958,639**		

1/9/2008 CIP Number: INT207-24 Page 7

SOURCE: ACHD estimate, 2006

State & Glenwood - Median U-Turn

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	58,177	SY	$8	$ 465,416
Excavation	38,979	CY	$6	$ 233,874
Granular subbase	23,835	CY	$18	$ 429,030
3/4" Aggr Ty A/B for base	10,487	CY	$32	$ 335,584
PL Mix Pav CL I	20,450	Ton	$65	$ 1,329,250
Conc sidewalk - 4" depth	42,598	SF	$6	$ 255,588
Comb curb & gutter ty A 2	13,120	Ft	$20	$ 262,400
Median Island	4,907	SY	$90	$ 441,630
Signal	2	Each	$250,000	$ 500,000
Sub Total				$ 4,252,772
Drainage	1	LS	10% of construction	$ 425,277
Utilities	1	LS	8% of construction	$ 340,222
Landscaping	1	LS	2% of construction	$ 85,055
Signing & Striping	1	LS	3% of construction	$ 127,583
Mobilization	1	LS	10% of construction	$ 425,277
Traffic control	1	LS	5% of construction	$ 212,639
PE & CEI	1	LS	15% of construction	$ 637,916
Contingencies	1	LS	30% of construction	$ 1,275,832
Construction Total				**$ 7,782,573**
Right-of-Way (Residential)	0.00	Acre	$350,000	$ -
Right-of-Way (Commercial)	1.47	Acre	$700,000	$ 1,029,000
Right-of-Way Total				**$ 1,029,000**
Total Project				**$ 8,811,573**

SOURCE: Wilbur Smith Assoc. est., 2008

Chinden & Glenwood - Quadrant Roadway

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	30,383	SY	$8	$ 243,063
Excavation	20,357	CY	$6	$ 122,139
Granular subbase	11,325	CY	$18	$ 203,852
3/4" Aggr Ty A/B for base	4,983	CY	$32	$ 159,457
PL Mix Pav CL I	9,717	Ton	$65	$ 631,601
Conc sidewalk - 4" depth	30,018	SF	$6	$ 180,108
Comb curb & gutter ty A 2	6,278	Ft	$20	$ 125,568
Median Island	0	SY	$90	$ -
Signal	2.75	Each	$250,000	$ 687,500
Sub Total				$ 2,353,288
Drainage	1	LS	10% of construction	$ 235,329
Utilities	1	LS	8% of construction	$ 188,263
Landscaping	1	LS	2% of construction	$ 47,066
Signing & Striping	1	LS	3% of construction	$ 70,599
Mobilization	1	LS	10% of construction	$ 235,329
Traffic control	1	LS	5% of construction	$ 117,664
PE & CEI	1	LS	15% of construction	$ 352,993
Contingencies	1	LS	30% of construction	$ 705,986
Construction Total				**$ 4,306,517**
Right-of-Way (Residential)	0.00	Acre	$350,000	$ -
Right-of-Way (Commercial)	2.72	Acre	$700,000	$ 1,904,000
Right-of-Way Total				**$ 1,904,000**
Total Project				**$ 6,210,517**

SOURCE: Wilbur Smith Assoc. est., 2008

Ustick & Cole - Bowtie

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	11,266	SY	$8	$ 90,130
Excavation	7,548	CY	$6	$ 45,290
Granular subbase	4,272	CY	$18	$ 76,894
3/4" Aggr Ty A/B for base	1,880	CY	$32	$ 60,148
PL Mix Pav CL I	3,665	Ton	$65	$ 238,244
Conc sidewalk - 4" depth	11,545	SF	$6	$ 69,270
Comb curb & gutter ty A 2	3,830	Ft	$20	$ 76,600
Median Island	1,742	SY	$90	$ 156,814
Signal	1	Each	$250,000	$ 250,000
Sub Total				$ 1,063,391
Drainage	1	LS	10% of construction	$ 106,339
Utilities	1	LS	8% of construction	$ 85,071
Landscaping	1	LS	2% of construction	$ 21,268
Signing & Striping	1	LS	3% of construction	$ 31,902
Mobilization	1	LS	10% of construction	$ 106,339
Traffic control	1	LS	5% of construction	$ 53,170
PE & CEI	1	LS	15% of construction	$ 159,509
Contingencies	1	LS	30% of construction	$ 319,017
Construction Total				**$ 1,946,006**
Right-of-Way (Residential)	0.50	Acre	$262,500	$ 131,250
Right-of-Way (Commercial)	0.28	Acre	$525,000	$ 147,000
Right-of-Way Total				**$ 278,250**
Total Project				**$ 2,224,256**

SOURCE: Wilbur Smith Assoc. est., 2008

LONG RANGE PROJECT COST SUMMARY SHEET

Project:	Chinden Blvd. and Veterans Memorial Parkway
Date:	3/8/2006
Functional Classification:	Intersection Only
Federal Aid or non-Federal Aid:	non-Federal Aid
Segment Description: (project limits)	Widen, modify/replace signal
Rural or Urban Bridge:	Urban/Bridge Project
Intersection Surfacing Material	Asphalt
CIP Number:	INT207-3
Total # of Existing Lanes:	
Existing RW Width (ft):	
Total # of Proposed Lanes:	8.25
Proposed RW Width (ft):	
Project Length (miles):	1.0
Existing Roadway Width (ft):	

Leg of Intersection	North	East	South	West
Existing PavementWidth:	80	90	90	90
Existing RW Width:	0	0	0	0
Proposed # Lanes:	7	9	8	9
Proposed RW Width:	120	144	132	144
Proposed Length:	1000	1000	1000	1000

	non-Fed Aid Unit Costs	Unit	Quantity	Total Item Cost	% TIF Eligible	Total TIF Cost
1. Preliminary Engineering (10% line 25 for Rural -- 15% for Urban/Bridge)				$600,136	50.08%	$300,562
2. Right-of-Way Costs (costs determined by RW contractor or ACHD RW Dept)				$1,800,000	50.00%	$900,000
3. Utility Adjustments (cost per project)				$57,421	50.00%	$28,711
4. Removal of Obstructions (trees, irrigation boxes, bridges, etc.)						
Trees (assumed all are 6"+ all)	$350.00	EA	0.0	$138,982	#######	$138,982
Irrigation Boxes	0	MI	0.0			
Bridges:						
Small (10' - 20' span)	$5,000.00	EA	0.0			
Medium (20' - 50' span)	$180.00	SF	0.0			
Large (50'+ span)	$15,000.00	EA	0.0			
Bituminous Surface	0.00	SY	38,889.0			
Other						
6. Storm Sewer (urban and semi-urban only)	$342,140.00	MI	0.8	$273,712	50.00%	$136,856
7. Earthwork	$14.00	CY	50,555.6	$707,778	50.00%	$353,889
8. Intersection and Roadway Surfacing				$565,500	50.00%	$282,750
Asphalt Surfacing	$50.00	TN	11,310.0			
Concrete Surfacing	$4.00	SF	468,000.0			
9. Aggregate Base Course	$25.00	CY	5,778.0	$151,667	50.00%	$75,833
10. 6" Minus Uncrushed Aggregate Subbase Course	$12.50	CY	39,000.0	$511,875	50.00%	$255,938
11. Structures				$0	50.00%	$0
Box Culverts	$180.00	SF	0			
Minor Bridge	$180.00	SF	0			
Major Bridge	$100.00	SF	0			
Grade Separation	$100.00	SF	0			
12. Traffic Signals	$50,000.00	EA	1.5	$75,000	50.00%	$37,500
13. Illumination	$5,000.00	EA	$5,000.0	$0	50.08%	$0
14. Curb / Gutter / Approaches				$145,306	50.00%	$72,653
Rural Approaches (assumes 20'x30'x3" approaches)	$0.00	mile/side	$0.0			
Curb/Gutter/Approaches (cost/mile/side)	$90,816.00	mile/side	$1,720.0			
15. Sidewalk				$131,414	0.00%	$0
Sidewalk (assumes 7' side sidewalk at back of curb)	$82,133.80	mile/side				
16. Roadside Development				$33,120	50.00%	$16,560
Fencing	$20.00	LF	0			
Seeding	$20,037.60	AC	$14,520.0			
17. Delineators / Signing / Channelization (0% of items 4 thru 16)	0.00	%	$2,734,353	$0	50.08%	$0
18. Const Stormwater Pollution Prevention Plan (0% of items 4 thru 17)	0.00	%	$2,734,353	$0	50.08%	$0
19. Construction Traffic Control (5% of items 4 thru 18)	5.00	%	$2,734,353	$136,718	50.08%	$68,471
20. Special Project Features (see field data summary sheet)				$0	50.08%	$0
21. Cost of Construction (items 3 thru 20)				$2,928,492	50.08%	$1,466,659
22. Other Miscellaneous Construction Items (15% of item 21)				$439,274	50.08%	$439,274
23. Mobilization (8% of items 21 + 22)				$269,421	50.08%	$134,933
24. Construction Engineering and Inspection (10% of Items 21+22+23)				$363,719	50.08%	$182,159
25. Total Construction Costs (21+22+23+24)				$4,000,906	50.08%	$2,003,750
26. Construction Contingency (5% of item 25)				$200,045	50.08%	$100,187
27. Total Project Cost (1+2+25+26)				**$6,601,087**	**50.08%**	**$3,305,983**
28. Project Cost Per Mile (27 / project length in miles)				**$6,601,087**		
29. Project Cost Per Lane Mile (28 / # of proposed lanes)				**$800,132**		

1/9/2008 *CIP Number:* INT207-3 Page 9

SOURCE: ACHD estimate, 2006

Fairview & Curtis - Baseline

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	43,186	SY	$8	$ 345,488
Excavation	28,935	CY	$6	$ 173,610
Granular subbase	17,534	CY	$18	$ 315,612
3/4" Aggr Ty A/B for base	7,715	CY	$32	$ 246,880
PL Mix Pav CL I	15,044	Ton	$65	$ 977,860
Conc sidewalk - 4" depth	29,965	SF	$6	$ 179,790
Comb curb & gutter ty A 2	6,568	Ft	$20	$ 131,360
Median Island	196	SY	$90	$ 17,640
Signal	1	Each	$250,000	$ 250,000
Sub Total				$ 2,638,240
Drainage	1	LS	10% of construction	$ 263,824
Utilities	1	LS	8% of construction	$ 211,059
Landscaping	1	LS	2% of construction	$ 52,765
Signing & Striping	1	LS	3% of construction	$ 79,147
Mobilization	1	LS	10% of construction	$ 263,824
Traffic control	1	LS	5% of construction	$ 131,912
PE & CEI	1	LS	15% of construction	$ 395,736
Contingencies	1	LS	30% of construction	$ 791,472
Construction Total				**$ 4,827,979**
Right-of-Way (Residential)	0.00	Acre	$350,000	$ -
Right-of-Way (Commercial)	1.14	Acre	$700,000	$ 798,000
Right-of-Way Total				**$ 798,000**
Total Project				**$ 5,625,979**

SOURCE: Wilbur Smith Assoc. est., 2008

Fairview & Curtis - Quadrant Roadway

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	68,539	SY	$8	$ 548,310
Excavation	45,921	CY	$6	$ 275,526
Granular subbase	25,832	CY	$18	$ 464,984
3/4" Aggr Ty A/B for base	11,366	CY	$32	$ 363,721
PL Mix Pav CL I	22,164	Ton	$65	$ 1,440,675
Conc sidewalk - 4" depth	66,735	SF	$6	$ 400,410
Comb curb & gutter ty A 2	15,789	Ft	$20	$ 315,780
Median Island	1,448	SY	$90	$ 130,280
Signal	4	Each	$250,000	$ 1,000,000
Sub Total				$ 4,939,685
Drainage	1	LS	10% of construction	$ 493,969
Utilities	1	LS	8% of construction	$ 395,175
Landscaping	1	LS	2% of construction	$ 98,794
Signing & Striping	1	LS	3% of construction	$ 148,191
Mobilization	1	LS	10% of construction	$ 493,969
Traffic control	1	LS	5% of construction	$ 246,984
PE & CEI	1	LS	15% of construction	$ 740,953
Contingencies	1	LS	30% of construction	$ 1,481,906
Construction Total				**$ 9,039,624**
Right-of-Way (Residential)	0.04	Acre	$350,000	$ 14,000
Right-of-Way (Commercial)	1.27	Acre	$700,000	$ 889,000
Right-of-Way Total				**$ 903,000**
Total Project				**$ 9,942,624**

SOURCE: Wilbur Smith Assoc. est., 2008

Fairview & Eagle - Baseline

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	45,989	SY	$8	$ 367,912
Excavation	30,813	CY	$6	$ 184,878
Granular subbase	18,976	CY	$18	$ 341,568
3/4" Aggr Ty A/B for base	8,350	CY	$32	$ 267,200
PL Mix Pav CL I	16,282	Ton	$65	$ 1,058,330
Conc sidewalk - 4" depth	32,205	SF	$6	$ 193,230
Comb curb & gutter ty A 2	7,022	Ft	$20	$ 140,440
Median Island	536	SY	$90	$ 48,240
Signal	1	Each	$250,000	$ 250,000
Sub Total				$ 2,851,798
Drainage	1	LS	10% of construction	$ 285,180
Utilities	1	LS	8% of construction	$ 228,144
Landscaping	1	LS	2% of construction	$ 57,036
Signing & Striping	1	LS	3% of construction	$ 85,554
Mobilization	1	LS	10% of construction	$ 285,180
Traffic control	1	LS	5% of construction	$ 142,590
PE & CEI	1	LS	15% of construction	$ 427,770
Contingencies	1	LS	30% of construction	$ 855,539
Construction Total				**$ 5,218,790**
Right-of-Way (Residential)	0.13	Acre	$350,000	$ 45,500
Right-of-Way (Commercial)	0.00	Acre	$700,000	$ -
Right-of-Way Total				**$ 45,500**
Total Project				**$ 5,264,290**

SOURCE: Wilbur Smith Assoc. est., 2008

Fairview & Eagle - CFI

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	95,325	SY	$8	$ 762,597
Excavation	63,867	CY	$6	$ 383,205
Granular subbase	40,393	CY	$18	$ 727,073
3/4" Aggr Ty A/B for base	17,773	CY	$32	$ 568,732
PL Mix Pav CL I	34,657	Ton	$65	$ 2,252,714
Conc sidewalk - 4" depth	56,605	SF	$6	$ 339,630
Comb curb & gutter ty A 2	24,386	Ft	$20	$ 487,720
Median Island	8,743	SY	$90	$ 786,892
Signal	2	Each	$250,000	$ 500,000
Sub Total				$ 6,808,563
Drainage	1	LS	10% of construction	$ 680,856
Utilities	1	LS	8% of construction	$ 544,685
Landscaping	1	LS	2% of construction	$ 136,171
Signing & Striping	1	LS	3% of construction	$ 204,257
Mobilization	1	LS	10% of construction	$ 680,856
Traffic control	1	LS	5% of construction	$ 340,428
PE & CEI	1	LS	15% of construction	$ 1,021,284
Contingencies	1	LS	30% of construction	$ 2,042,569
Construction Total				**$ 12,459,671**
Right-of-Way (Residential)	1.20	Acre	$350,000	$ 420,000
Right-of-Way (Commercial)	1.00	Acre	$700,000	$ 700,000
Right-of-Way Total				**$ 1,120,000**
Total Project				**$ 13,579,671**

SOURCE: Wilbur Smith Assoc. est., 2008

Fairview & Eagle - Quadrant Roadway

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	83,813	SY	$8	$ 670,507
Excavation	56,155	CY	$6	$ 336,930
Granular subbase	33,062	CY	$18	$ 595,114
3/4" Aggr Ty A/B for base	14,547	CY	$32	$ 465,512
PL Mix Pav CL I	28,367	Ton	$65	$ 1,843,862
Conc sidewalk - 4" depth	71,270	SF	$6	$ 427,620
Comb curb & gutter ty A 2	14,543	Ft	$20	$ 290,860
Median Island	1,186	SY	$90	$ 106,784
Signal	4.5	Each	$250,000	$ 1,125,000
Sub Total				$ 5,862,190
Drainage	1	LS	10% of construction	$ 586,219
Utilities	1	LS	8% of construction	$ 468,975
Landscaping	1	LS	2% of construction	$ 117,244
Signing & Striping	1	LS	3% of construction	$ 175,866
Mobilization	1	LS	10% of construction	$ 586,219
Traffic control	1	LS	5% of construction	$ 293,109
PE & CEI	1	LS	15% of construction	$ 879,328
Contingencies	1	LS	30% of construction	$ 1,758,657
Construction Total				**$ 10,727,808**
Right-of-Way (Residential)	2.26	Acre	$350,000	$ 791,000
Right-of-Way (Commercial)	1.79	Acre	$700,000	$ 1,253,000
Right-of-Way Total				**$ 2,044,000**
Total Project				**$ 12,771,808**

SOURCE: Wilbur Smith Assoc. est., 2008

Franklin & Eagle - Baseline

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	51,458	SY	$8	$ 411,664
Excavation	34,477	CY	$6	$ 206,862
Granular subbase	20,968	CY	$18	$ 377,424
3/4" Aggr Ty A/B for base	9,226	CY	$32	$ 295,232
PL Mix Pav CL I	17,990	Ton	$65	$ 1,169,350
Conc sidewalk - 4" depth	37,490	SF	$6	$ 224,940
Comb curb & gutter ty A 2	7,474	Ft	$20	$ 149,480
Median Island	0	SY	$90	$ -
Signal	1	Each	$250,000	$ 250,000
Sub Total				$ 3,084,952
Drainage	1	LS	10% of construction	$ 308,495
Utilities	1	LS	8% of construction	$ 246,796
Landscaping	1	LS	2% of construction	$ 61,699
Signing & Striping	1	LS	3% of construction	$ 92,549
Mobilization	1	LS	10% of construction	$ 308,495
Traffic control	1	LS	5% of construction	$ 154,248
PE & CEI	1	LS	15% of construction	$ 462,743
Contingencies	1	LS	30% of construction	$ 925,486
Construction Total				**$ 5,645,462**
Right-of-Way (Residential)	0.49	Acre	$350,000	$ 171,500
Right-of-Way (Commercial)	0.13	Acre	$700,000	$ 91,000
Right-of-Way Total				**$ 262,500**
Total Project				**$ 5,907,962**

SOURCE: Wilbur Smith Assoc. est., 2008

Franklin & Eagle - CFI

Item Description	Quantity	Units	Average Cost	TOTAL
Removals	100,321	SY	$8	$802,565
Excavation	67,215	CY	$6	$403,289
Granular subbase	42,303	CY	$18	$761,445
3/4" Aggr Ty A/B for base	18,613	CY	$32	$595,620
PL Mix Pav CL I	36,296	Ton	$65	$2,359,212
Conc sidewalk - 4" depth	56,605	SF	$6	$339,630
Comb curb & gutter ty A 2	24,386	Ft	$20	$487,720
Median Island	12,020	SY	$90	$1,081,791
Signal	2	Each	$250,000	$500,000
Sub Total				$7,331,272
Drainage	1	LS	10% of construction	$ 733,127
Utilities	1	LS	8% of construction	$ 586,502
Landscaping	1	LS	2% of construction	$ 146,625
Signing & Striping	1	LS	3% of construction	$ 219,938
Mobilization	1	LS	10% of construction	$ 733,127
Traffic control	1	LS	5% of construction	$ 366,564
PE & CEI	1	LS	15% of construction	$ 1,099,691
Contingencies	1	LS	30% of construction	$ 2,199,382
Construction Total				**$13,416,228**
Right-of-Way (Residential)	2.38	Acre	$350,000	$833,000
Right-of-Way (Commercial)	1.69	Acre	$700,000	$ 1,183,000
Right-of-Way Total				**$2,016,000**
Total Project				**$15,432,228**

SOURCE: Wilbur Smith Assoc. est., 2008

Franklin & Eagle - Quadrant Roadway

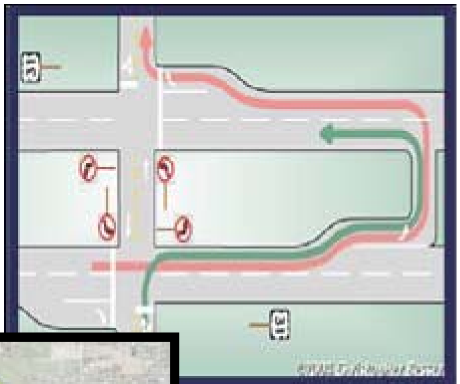
Item Description	Quantity	Units	Average Cost	TOTAL
Removals	73,077	SY	$8	$ 584,616
Excavation	48,962	CY	$6	$ 293,769
Granular subbase	28,277	CY	$18	$ 508,985
3/4" Aggr Ty A/B for base	12,442	CY	$32	$ 398,140
PL Mix Pav CL I	24,262	Ton	$65	$ 1,577,006
Conc sidewalk - 4" depth	65,035	SF	$6	$ 390,210
Comb curb & gutter ty A 2	13,982	Ft	$20	$ 279,640
Median Island	894	SY	$90	$ 80,476
Signal	2.75	Each	$250,000	$ 687,500
Sub Total				$ 4,800,342
Drainage	1	LS	10% of construction	$ 480,034
Utilities	1	LS	8% of construction	$ 384,027
Landscaping	1	LS	2% of construction	$ 96,007
Signing & Striping	1	LS	3% of construction	$ 144,010
Mobilization	1	LS	10% of construction	$ 480,034
Traffic control	1	LS	5% of construction	$ 240,017
PE & CEI	1	LS	15% of construction	$ 720,051
Contingencies	1	LS	30% of construction	$ 1,440,103
Construction Total				**$ 8,784,626**
Right-of-Way (Residential)	1.67	Acre	$350,000	$ 584,500
Right-of-Way (Commercial)	0.62	Acre	$700,000	$ 434,000
Right-of-Way Total				**$ 1,018,500**
Total Project				**$ 9,803,126**

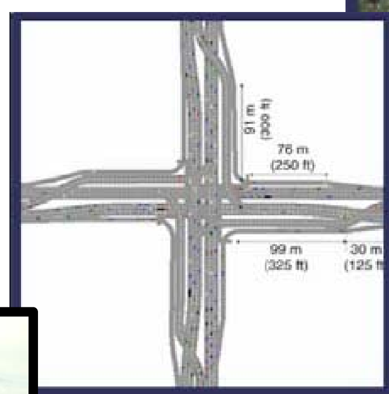
SOURCE: Wilbur Smith Assoc. est., 2008

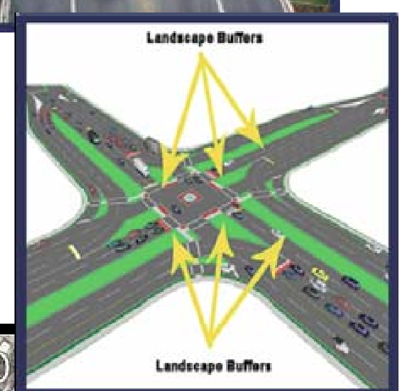
High Volume Intersection Study, Vol. III

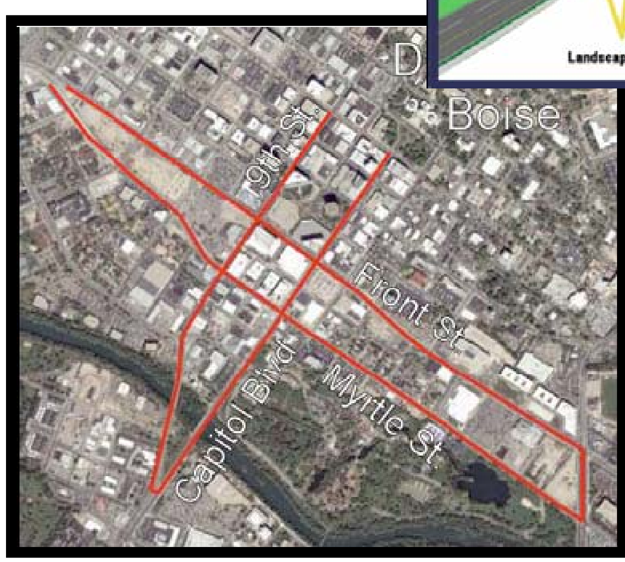
Additional Materials

COMPASS
COMMUNITY PLANNING ASSOCIATION
of Southwest Idaho









May, 2008

The *High Volume Intersection Study* (HVIS) consists of three volumes:

Vol. I Innovative Intersections: Overview and Implementation Guidelines, broadly outlines information about a variety of innovative intersection concepts and provides more specific implementation guidelines for intersection types that appear to be most applicable to southwest Idaho.

Vol. II Intersection Concept Layout Report, features spotlighted high volume intersection concepts at nine different intersections in Ada County.

Vol. III Additional Materials, includes a compatibility matrix between intersection types and urban forms and street functional classifications.

The Community Planning Association of Southwest Idaho (COMPASS) contracted with Wilbur Smith Associates for this study, with additional contributions by Thompson Transportation, HDR, and Joseph E. Hummer, Ph.D., P.E.

Table of Contents

Source: Wilbur Smith Associates

See Vol. I, Innovative Intersections, page 2-21.

"Intersection Toolbox": Generalized capacity, geometry, and cost by intersection type. Left to right by increasing capacity.

Scenario	"Double-left", 4-approaches (base case)	Roundabout, 2-entering lanes all approaches	"Triple-left" Intersection	Bowtie / Median U	Rerouting lefts on single quadrant	CFI/PFI, four approaches	Town Center oneways, four approaches	Rerouting lefts using four quadrants	Tight diamond Interchange
Signal phases at main intersection	4	All yield	4	2	2	2	2	2	3
Additional intersections / signals created by design	None	None	None	0, 2*	2 T's	4 mid-block	4 total	8 T's**	2 at ramps
Hourly System Capacity (LOS E - approx 60 sec delay/veh)	7,000	4,500	8,500	10,500	10,500	12,000	13,000	13,000	14,500
Percent change over base	-	*-36%*	*21%*	*50%*	*50%*	*71%*	*86%*	*86%*	*107%*
Major arterial daily volume supported (if peak hour is 8% of daily)	45,000	30,000	55,000	80,000	80,000	75,000	90,000	90,000	120,000
Minor arterial daily volume supported	40,000	25,000	50,000	50,000	50,000	70,000	75,000	75,000	55,000
Corresponding intersection AADT (Daily sum of all 4 approaches)	85,000	55,000	105,000	130,000	130,000	145,000	165,000	165,000	175,000
Corresponding peak hour, peak dir. approach volume (Major street)	1,900	1,300	2,200	3,200	3,200	3,100	3,500	3,500	4,850
Total approach lanes (left pockets + thru lanes + right pockets)	6 (2+3+1)	3 (0+2+1)	7 (3+3+1)	4 (0+3+1)	4 (0+3+1)	6 (2+3+1)	5 (1+3+1)	4 (0+3+1)	5(2+2+1+shldr)
Capacity per hour per approach lane at LOS E (Major street only)	320	430	310	800	800	510	700	700	970
Capacity per hour per thru lane (for travel demand models)	630	430	730	1,070	1,070	1,030	1,170	1,170	2,200
Percent change over base	-	*-32%*	*16%*	*70%*	*70%*	*63%*	*86%*	*86%*	*249%*
Typical intersection right-of-way on major street (feet)	128-132	84-110	150-160	84-110	84-110	140-160	80-84	84-110	170-200
Typical between intersection right-of-way on major street (feet)	106-120	80-100	120-130	84-110	84-110	106-120	66-80	84-110	120-150
Ideal limited access length (driveway and center island restrictions)	50-200	50-200	100-300	300-600	100-200	300-600	50-100	100-200	1000-5280
Bike / Ped / Mixed-Use friendly? (Great, Good, Ok, Poor)	Ok	Good	Poor	Good	Ok-Good	Ok-Poor	Great	Good	Poor
Signal coordination (Great, Good, Ok, Poor)	Ok	N/A	Poor	Ok-Good	Ok	Ok	Great	Ok-Good	No signals
Driver Expectations (Perfect, Good, Unusual)	Perfect	Perfect	Perfect	Unusual	Unusual	Good	Good-Perfect	Good	Ok
Other key features	Low cost, very common	Good aesthetics	May be only option	Good aesthetics	Often near-zero cost	Easy to grade separate	Redevelop-ment tool	Direct paths	One movement is free-flow
Other key detractants	Inefficient, high delay	Poor choice for major arterials	Inefficient, high delay	Weaves could be an issue	Circuitous	Large footprint	Greyfield high impacts	Usually has impacts	Most mvmnts. mediocre
Planning-level cost (Low = few conflicts, high = many)	Default	$1-3 M	$2-4 M	$1-$5 M	$0.3-$1 M	$4-12 M	$4-15 M	$2-10 M	$15-25 M
Relative Cost	Default	Low	Low-Medium	Low-Medium	Very Low	Medium	Medium-High	Low-Medium	Very High

Lower Capacity	Up to 35% better	Up to 70% better	70% better or more

1. All scenarios but Roundabout were measured with Synchro. Volumes were selected such that the average delay per vehicle is about 60 seconds (LOS E). Roundabouts are based on experience.

* Median requires signal to make U, Bowtie has wrap-around lane that does not require signal.

** A quadrant creates 2-T's, so 4 creates 8. They can be coordinated, and 4 of 8 can be Green-Ts.

Note: Planning-level Synchro estimates. Sites should be independently varified using expected volumes, and/or Vissim-type analysis

WilburSmith ASSOCIATES
ENGINEERS PLANNERS ECONOMISTS

Source: COMPASS and Wilbur Smith Associates

Intersection Compatibility and Land Development

Intersection Type	Bowtie / Median U-turn	Route lefts on Single Quadrant	CFI/PFI 4 approaches	Town Center one-ways 4 approaches	Route lefts using Four Quadrants	Tight Diamond Interchange
Selection Criteria *(satisfies need of highest concern)*						
Capacity/Delay	yes	yes	yes	yes	yes	yes
Pedestrian Crossings	yes	yes	no	yes	yes	no
Available ROW	yes	yes	yes	no	yes	yes
Access	yes	yes	no	yes	yes	no
Construction Cost	yes	yes	yes	yes	yes	no
General Compatibility with Functional Classification *(major street - poor/ok/good/great)*						
Expressway *(restricted access, high speed/high volume)*	poor**	ok	good	good	good	great
Principal Arterial *(limited access, high volume)*	poor**	ok	great	great	great	good
Minor Arterial *(access to non-residential available)*	good	great	good	great	great	good
Major Collector *(access to local streets, parcels)*	great	great	good	great	great	ok
Transit Route *(fixed guideway/HOV lane can be accommodated)*	y - Lturn*	y - Lturn*	yes	yes	yes	yes
Center or outside lane preferred?	either	either	either	outside	either	either

**special design/consideration needed for transit vehicles making left turns*
***high speeds and weaving volumes make application of MUTs and Bowties challenging on this type of roadway*

General Compatibility with Urban Form *(poor/ok/good)**	Bowtie / Median U-turn	Route lefts on Single Quadrant	CFI/PFI 4 approaches	Town Center one-ways 4 approaches	Route lefts using Four Quadrants	Tight Diamond Interchange
Downtown / Urban Core (uniform blocks)	poor-ok	good	poor	good	good	poor
Urban Neighborhood (mixture of street/block types)	good	good	ok	good	good	ok-poor
Mature Suburb (section line grid, strip malls)	good	ok	ok-good	poor-ok	poor-ok	ok-good
Rural Townsite/Agriculture (small towns, farms)**	good	good	poor-ok	ok-good	ok-good	poor-ok
New Suburb/Greenfield (newly developed or developing)	good	good	good	good	good	ok

**compatibility with urban form is noted with only three strata instead of four - it differs from the functional classification topics above, in that there is greater variability/range in the context of urban form and within each category*
***this assumes that rural townsites will not stay rural in the long term - compatibility includes community character*

Land Division / Access	Bowtie / Median U-turn	Route lefts on Single Quadrant	CFI/PFI 4 approaches	Town Center one-ways 4 approaches	Route lefts using Four Quadrants	Tight Diamond Interchange
Observed* Lot/Frontage Width *(minimum range)*	n/a	150-180	350**	150-170	n/a	none
Observed* Intersection Envelope *(1 leg, length from center point)*	450-1000	450-1600	650-1100	900-1500	500-1000	n/a
Ideal Access Within Envelope - If Allowed *(none/restricted movement/consolidated)*	restricted	restricted (quadr consol)	none or restricted	consolidated (and restr)	restricted	none or restricted

**from intersection locations in CA, LA, MD, MI, MO, NJ, NY, TX, UT, VA and from spotlighted intersections in the HVIS*
***most existing CFIs in the US are on limited access roadways with no front access*

Note: It is not anticipated that any change would be necessary to current building setbacks or streetscape standards (incl. signs, landscaping, etc.).

This table is a compilation of recommendations from the consultant and observations of existing conditions. The final design selection process would include additional characteristics and forecasts unique to each site.

Overview of Unconventional Intersection Forms

Source: Dr. Joseph E. Hummer, Ph.D., P.E., North Carolina State University

Workshop presented to COMPASS Board of Directors August 20, 2007

Overview of Unconventional Intersection Forms

Joseph E. Hummer, Ph.D., P.E.
Professor of Civil Engineering
North Carolina State University
Telephone 919-515-7733
Email hummer@eos.ncsu.edu
For COMPASS, August 20, 2007

NC STATE UNIVERSITY

Objectives

- Provide you a glimpse of part of the "menu" of unconventional intersection designs
- Inspire you to strongly consider these in your study of intersection alternatives
- Practice selecting the best form of intersection for a particular location

NC STATE UNIVERSITY

Problem

- Growing demand
- Close to 50/50 directional split
- Conventional solutions exhausted
- Too expensive to widen
- Structures expensive and unpopular
- ITS, transit, demand management, etc. not helpful

NC STATE UNIVERSITY

Potential Solution: Unconventional Designs

- 15 designs on current intersection "menu"
  - Most published
  - Most in use in U.S.
- This presentation highlights those with potential in Idaho

NC STATE UNIVERSITY

Major Principles

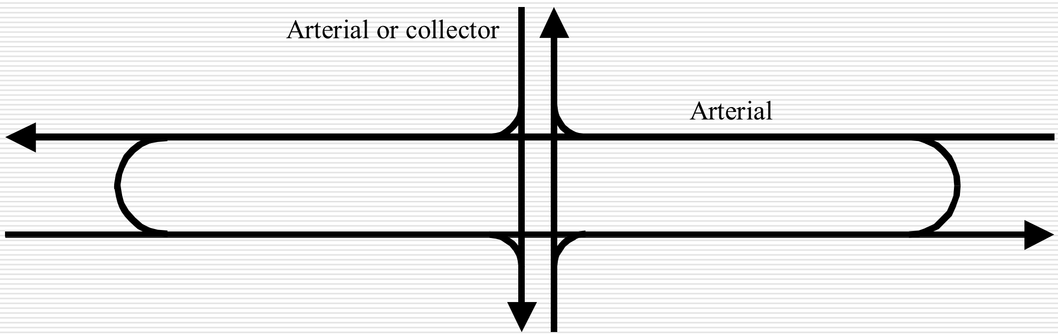
- Reduce delay to through vehicles
- Reduce number of conflict points at intersections
  - Separate remaining conflict points
  - Reduce signal phases

- Accomplished mostly by rerouting left turns

Driver Confusion?

- Potential is there; however…
- Most in place somewhere for years
- Precedent in other new designs
  - Roundabout, single point diamond, etc.
- Traffic control devices helpful
- Design whole corridor

Median U-Turn



Median U-Turn Capacity

		Critical V/C, 30,000 ADT	
Minor ADT	% turns	Med. U-turn	Conventional
15,000	20	0.74	0.86
	40	0.88	0.90
25,000	20	0.90	1.04
	40	1.11	1.14

Median U-Turn Collision Rates (per 100 mil. veh-miles)

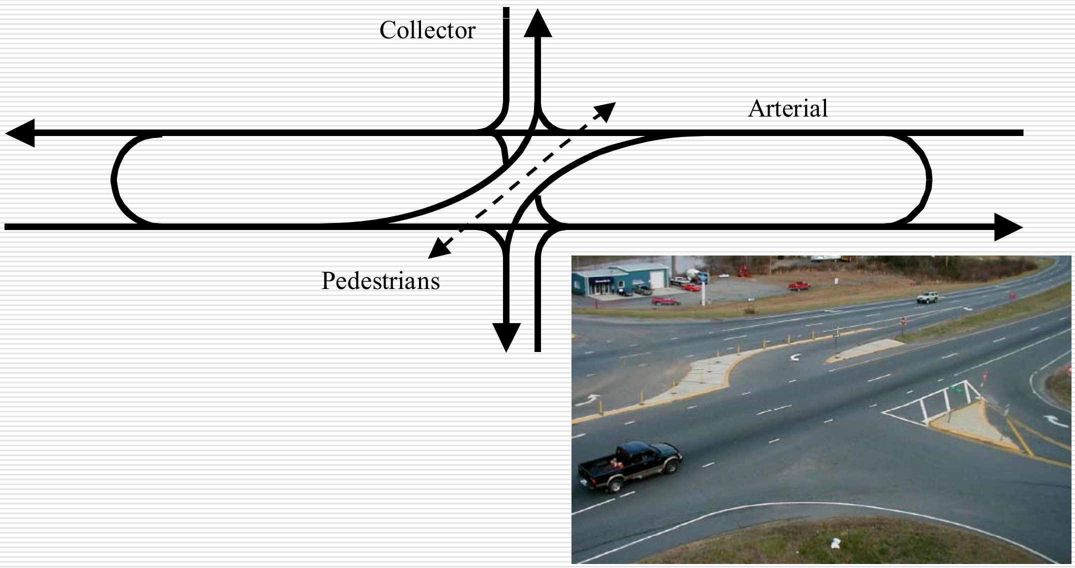
Road	Rate
TWLTL	1220
Conventional with median	750
Median u-turn	600

Also better for pedestrians!

Median U-Turn Disadvantages

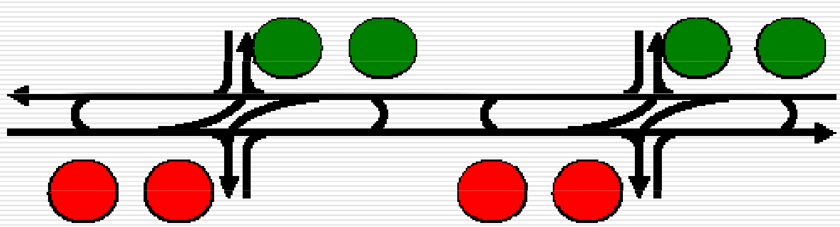
- Left turns penalized
- Wider right-of-way
- Higher minimum green time
- Indirect left turns into businesses
- Wide median means less business visibility

Superstreet



Superstreet Advantages

- Perfect two-way progression at any speed with any signal spacing!
  - Install signals anywhere
  - You set progression speed



- Safer
- All pedestrian crossing controlled

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Superstreet Travel Time

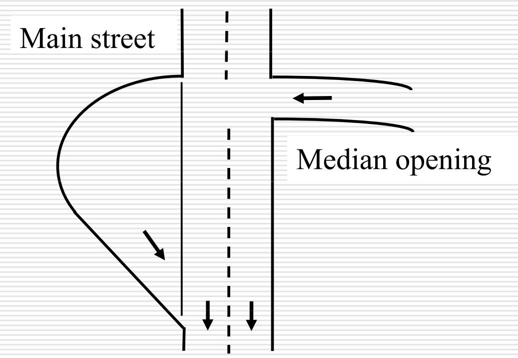
MOE	TWLTL	Median U-Turn	Superstreet
Travel time, veh-hours	403	280	314
Stops per vehicle	2.08	2.19	2.59

Superstreet Disadvantages

- Same as median u-turn plus…
- Less efficient with heavy minor street volumes

Mitigating Superstreet Disadvantages

- High side street through volumes—use median u-turn or bowtie
- Wide right-of-way—use bulb-outs
- Effects on businesses—use slower speeds, more signals, and openings tailored to driveway locations



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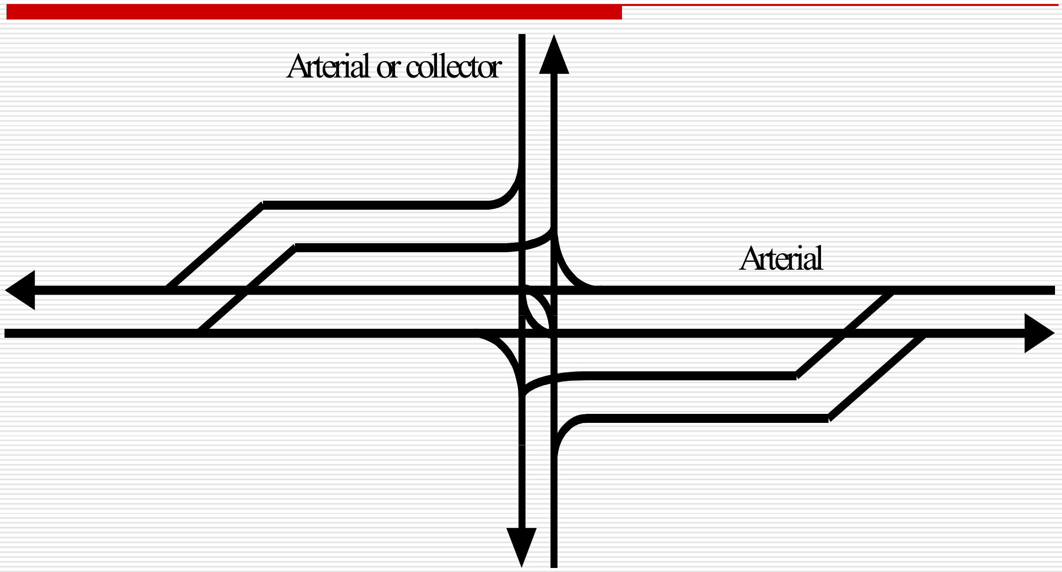
Continuous Flow Intersection



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Continuous Flow Intersection Advantages

- Reduced travel time with high volumes
- Keeps traffic moving
- Enhanced progression
- Narrower major street ROW
- Fewer conflict points

Continuous Flow Intersection Disadvantages

- No u-turns at intersection
- Pedestrians must cross ramps
- Access difficult for parcels next to ramps

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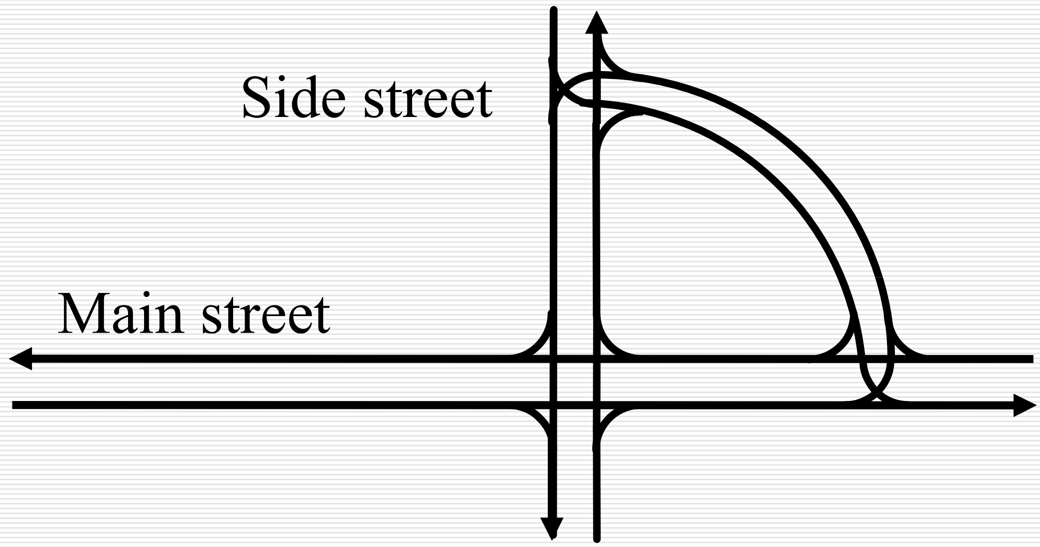
Quadrant Roadway



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Single Quadrant Advantages

- Typically vies with median u-turn as most efficient unconventional design
- Major and minor streets can have narrow rights-of-way
- Connector road provides development opportunity
- Some pedestrians have shorter, simpler crossing

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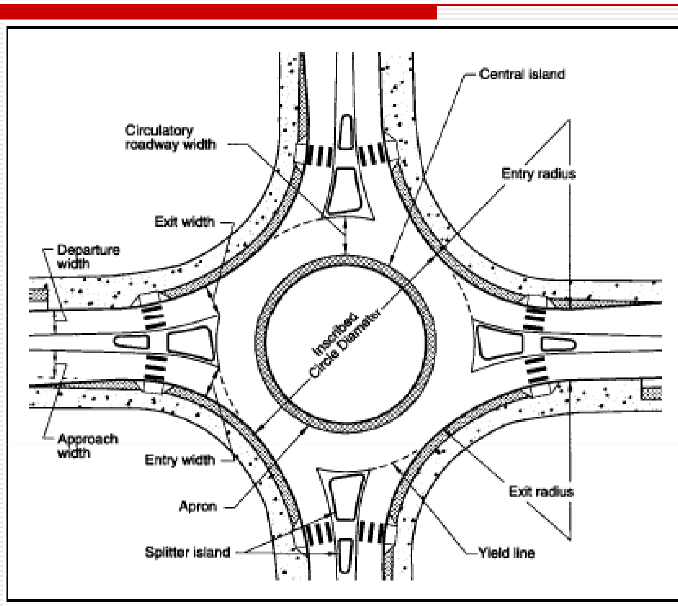
Single Quadrant Disadvantages

- Some left turns have more travel time, distance, stops
- ROW for connector road
- No u-turns at main intersection
- No driveways opposite ends of connector road
- Some pedestrians must cross connector road too

Roundabouts



Roundabout Features

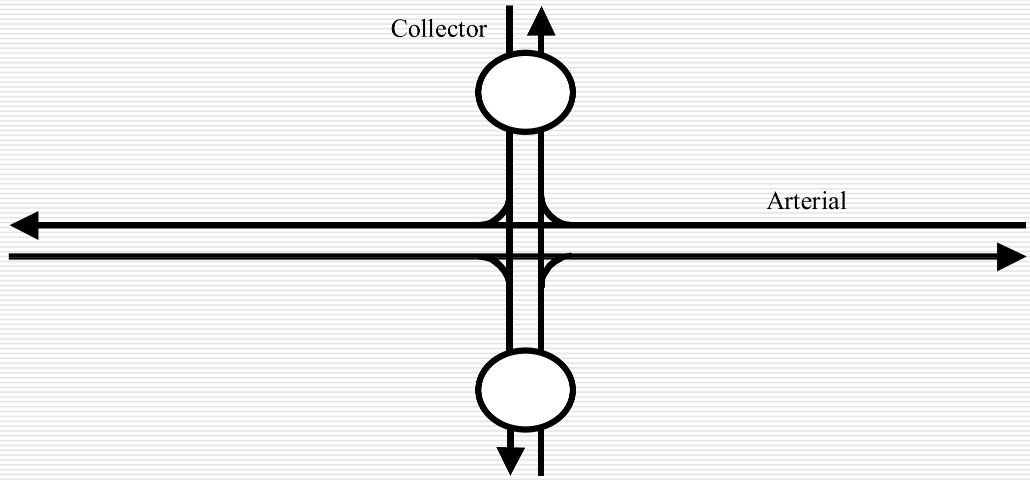
For one-lane design

- If roundabout stays below capacity, delay savings above 50% possible
- Credible studies show 20-40% collision and injury reductions
- Not too large
- Aesthetics
- Calming, gateway function

Roundabout Niche

- Two two-lane roads
- ADTs 5,000-15,000 for each
- Competes with all-way stop control
- Too much traffic for two-way stop control
- Not enough traffic for signal

Bowtie



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Bowtie Advantages

- Narrow major street right-of-way
- Short, simple pedestrian crossing
- Enhanced major street progression
- Aesthetics
- Developments can tie into roundabouts

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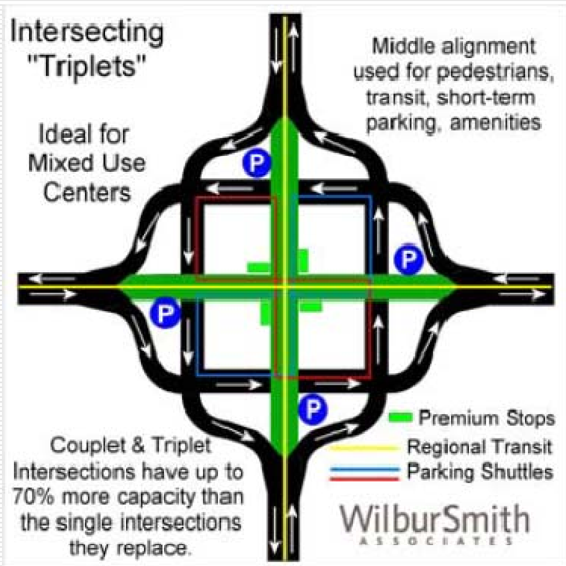
Bowtie Disadvantages

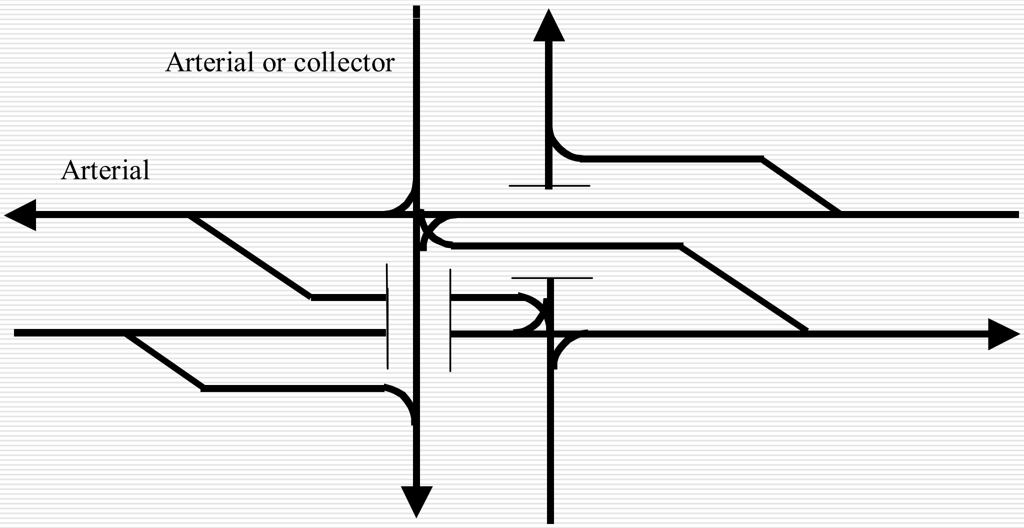
- Low minor street capacity
- Left turn delay
- Left turn travel distance
- Left turn stops
- Difficult arterial u-turn

Town Center Intersection

- High capacity, low delay
- Good for pedestrians
- Frees quality space in middle
- Need new ROW



Echelon Interchange



Echelon Interchange Advantages

- Much higher capacity than at-grade intersections
- Much lower travel time than at-grade intersections
- Enhanced progression for both streets
- Meters traffic to help downstream signals

Echelon Interchange Disadvantages

- High structure cost
- Access impaired to 3 quadrants
- No u-turns at or near interchange
- Pedestrians must climb grades or cross streets unprotected by signals

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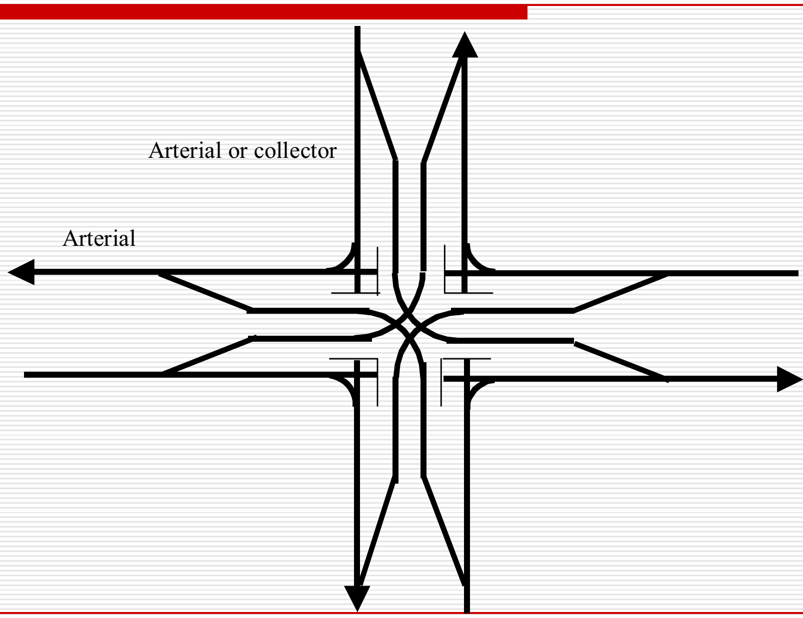
Center Turn Overpass



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Center Turn Overpass Advantages

- Same as echelon plus…
- Direct pedestrian crossing
- Good access to roadside businesses

Typical critical volume/capacity ratios

Intersection volume, veh/day	Median u-turn	Echelon interchange	Center turn overpass
60,000	0.89	0.75	0.80
70,000	1.03	0.86	0.93
80,000	1.19	0.99	1.06

Center Turn Overpass Disadvantages

- High structure cost
- Difficult to design if streets are not perpendicular
- Visibility to businesses blocked by structure
- Cost to obtain rights to design

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A Review of the Menu

- Median u-turn
- Superstreet
- Continuous flow intersection
- Single quadrant
- Bowtie
- Town center
- Echelon
- Center turn overpass

Plus 7 others:

- Jughandle
- Continuous green T
- Double wide
- Synchronized split phasing
- Paired intersections
- Hamburger
- Two-level signalized

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References

- Jonathan Reid, "Unconventional Arterial Intersection Design, Management and Operations Strategies," Sept. 2003, at www.pbworld.com/library/fellowship/reid
- FHWA, "Signalized Intersections: Informational Guide," August 2004, at www.tfhrc.gov/safety/pubs/04091
- "Impacts of Access Management Techniques," NCHRP Report 420, 1999, at www.cutr.usf.edu/ research/access_m/ada70/420NCHRP.pdf

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Selection Criteria

- Capacity and delay
  - Critical lane volume technique
  - Best designs: grade separated, median u-turn, quadrant, continuous flow, town center
- Pedestrian crossing
  - Best designs: bowtie, median u-turn, superstreet, center turn, single quadrant, town center

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More Selection Criteria

- Available right of way
  - Best designs: grade separated, bowtie, single quadrant, continuous flow
- Providing access to nearby parcels
  - Best designs: single quadrant, town center, median u-turn, superstreet, bowtie, center turn
- Construction cost
  - Best designs: at-grade

HVIS Technical Memo 4: Future Alternative Concept Development and Evaluation

Source: Wilbur Smith Associates and Thompson Transportation

Memorandum

To: COMPASS

From: Wilbur Smith Associates & Thompson Transportation

Date: December 13, 2007

Subject: Future Alternative Concept Development and Evaluation

Introduction

In our effort to identify promising improvements at the ten study intersections, shown in **Figure 1**, the consultant team has:

- Developed future year traffic volume projections;
- Analyzed a future baseline scenario;
- Creatively developed and preliminarily screened intersection alternative concepts; and
- Identified recommended alternatives to further evaluate.

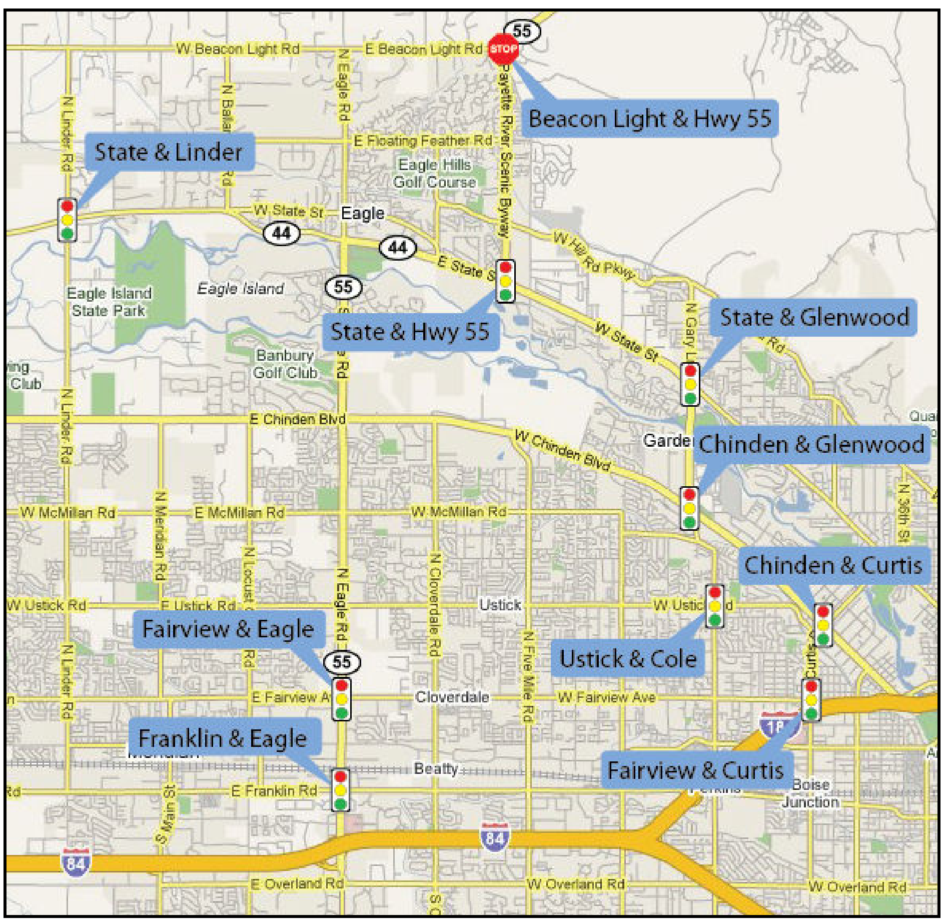


Figure 1: Study Intersection Location Map

ITD and ACHD have plans to upgrade most of the study intersections over the next 25 years or so. In the meantime, traditional intersection upgrades will likely provide an acceptable level of service at many intersections. These typical designs and associated costs are well understood and already planned for implementation in the future.

For this study, we want to identify some innovative and less conventional intersection improvement concepts to consider at the busy study intersections. These intersection treatments have the potential to provide longer life and improved operations over the traditional approach to widening and adding lanes at congested intersections. Based on this approach, this memo provides an overview of the process and:

- Documents the development of future traffic volumes and a baseline scenario for the study intersections;
- Documents the consultant team's process of developing future alternatives (brainstorming);
- Provides an overview of the preliminary screening process used to identify the future alternatives recommended for further evaluation;
- Lists the recommended intersection alternative concepts; and
- Identifies the next steps to finalize the alternative concept selection.

For the intersection specific details, we provided supplement pages to this memo containing more detailed information about each intersection and the selection process. The information provided in the supplement:

- Compares existing and future baseline conditions at each study intersection;
- Presents our screening analysis of the future alternative concepts; and
- Provides pros and cons for the promising intersection concepts.

Future Baseline Conditions

Future Volume Forecasting

A thorough future traffic volume forecast effort was made to develop traffic volumes that would help us best develop solutions that would accommodate traffic growth through 2030 and beyond in some instances. In support of this effort, COMPASS provided projected traffic volumes from several of their travel demand models including:

- 2002 calibrated model
- 2007 current conditions model
- 2030 Community Choices model
- 2030 Trend model
- 2030 Constrained model
- Preservation model (post 2030)

While our approach to forecasting future traffic volumes centers on the 2030 Community Choices model volume outputs (as directed by COMPASS), we also adjusted for significant differences observed between the various 2030 modeled volumes where we, as the study team, felt some instances may be under-forecasting and others over-forecasting future growth. We also made efforts to adjust the forecasted volumes with respect to actual counts collected as part of this study. The following are the steps we took to identify the future traffic volumes to be used with this study.

1. We determined the difference between the 2007 model volumes and the 2030 Community Choices volumes to determine a model based growth.
2. The difference in the models was added to the 2007 count data to create the initial future volumes.

3. Manual adjustments were made at some intersections to account for perceived deficiencies in the 2030 Community Choices model outputs, particularly where other future models differed substantially from the Community Choices model.
4. As a final adjustment, the developed approach volumes were compared against the 2030 Community Choices approach volumes. On approaches where the study volumes were less than the 2030 Community Choices volumes, the difference in volume was added to the through movement on that approach.

Because of the relatively low volumes occurring at Beacon Light & SH55 North in the 2030 Community Choices model and the very large volumes occurring in the Preservation model, we determined that the volumes at this location should be calculated differently than at the other study intersections. For this intersection only, we used future volumes based on those obtained from the Preservation model. Our goal with this study is to identify cost effective intersection concepts that will operate well at varying traffic volume levels but are also easily upgradable should larger growth occur beyond that forecasted by the Community Choices model.

Identify Future Geometry

To define what the future baseline conditions should be, we consulted a number of sources to develop appropriate intersection and roadway geometries for the future baseline conditions. These sources included:

- A revised "2030 Community Choices" travel demand model run by COMPASS on August 31, 2007 that accounts for recent amendments to their plan.
- The ACHD Five-Year Work Program, dated February 28, 2007.
- "Idaho Horizons," ITD's FY 2007 Long Range Capital Improvement and Preservation Program, dated September 2006.
- The ACHD Capital Improvements Plan, dated July 26, 2006.

We reviewed these documents and identified projects impacting the geometry of the study intersections and the roadways leading to them. Based on the planned improvements identified in these plans, we developed the future geometries. These are identified and shown next to the existing intersection geometries in the supplement pages to this memo. Where clarifications were required, we made contact with staff from COMPASS and the highway agencies (ITD and ACHD).

Future Baseline Operations Analysis

Having identified future volumes and geometries at the study intersections, we developed Synchro models representing future baseline conditions. These operation models were developed from the calibrated existing conditions models previously developed. We also made reasonable signal timing adjustments that would occur to accommodate the changing volumes as the intersections.

The existing and future baseline volumes, geometries, and traffic conditions are summarized in the Supplement to this memo.

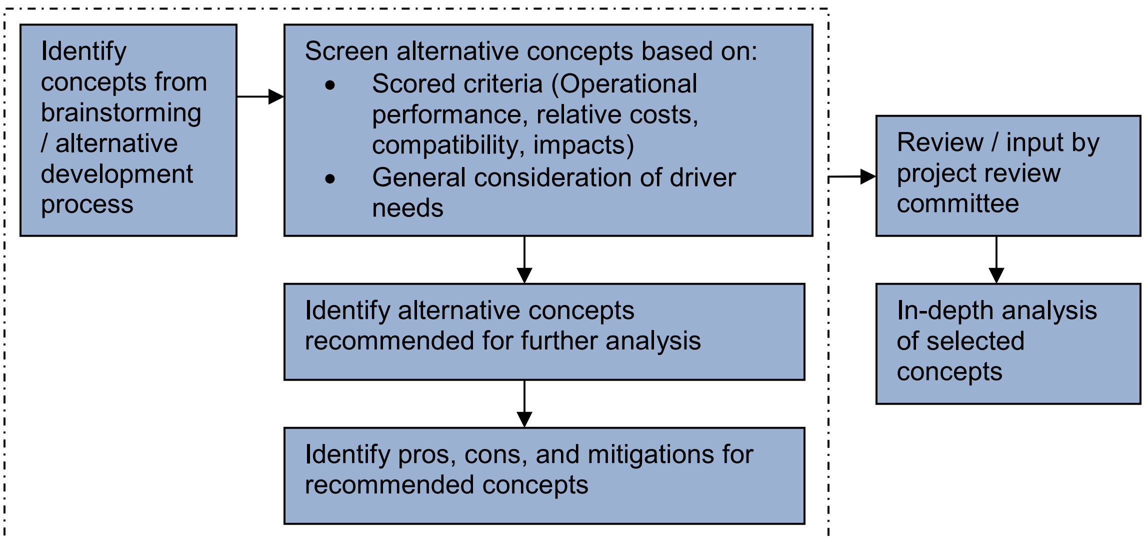
Brainstorming / Alternative Development Process

We conducted the brainstorming / alternative development process with openness to the entire universe of concepts available, including but not limited to those that were discussed in Chapter 2 of the Draft Intersection Guidelines Report. At-grade concepts in that report include the continuous flow intersection, parallel flow intersection, town center intersection, median U-turn, superstreet, quadrant roadway, and multi-lane roundabout. Because of strong local preferences and cost concerns, we focused primarily on developing innovative, well-tailored at-grade concepts for the study intersections. We only roughly developed the grade separation concepts at pertinent locations to provide a comparison for the at-grade concepts.

Using a creative engineering approach and considering a variety of location-specific information (such as aerial photographs of the intersection locations, right of way boundaries, and current and expected future volumes), we developed a number of concepts at each of the ten study intersections. Concepts were developed in sufficient detail that they could be preliminarily evaluated with Synchro.

Overview of Alternative Selection Process

The flow chart below provides an overview of the process that we followed to identify alternative concepts to be further evaluated in the final stages of the project. Upon approval from the project review committee, the selected alternative concepts will be further evaluated in greater detail.



With feedback from COMPASS, the consultant team developed four scoring criteria to evaluate the various concepts quantitatively. The criteria shown in **Table 1** give a good feel for how well the solution would work and fit the local situation. For each alternative concept, each of the scored criteria was assigned a point value from 1 (poor) to 5 (excellent), from which a weighted composite score was calculated. The concepts at each study intersection were then ranked based on the composite score.

Table 1: Scored Criteria for Alternative Screening		
Criteria	**Definition**	**Assigned Weighting**
Operational Performance	Operational performance of intersection with future volumes	40%
Relative Costs	Order of magnitude costs of each alternative relative to others considered at the intersection	30%
Compatibility	Fit within intersection geometry and within the broader geographical context of the area – out of direction travel was also considered here	20%
Impacts	ROW impacts; utility impacts; access impacts; aesthetics; environmental impacts	10%

At this level of evaluation, detailed cost estimates were not developed; rather, application of engineering experience provided good relative order of magnitude costs. Also, refer to the supplement pages to this memo for discussion of the operational analysis effort conducted in support of assigning values for the operational performance criterion. In addition to these scored criteria, the consultant team considered the needs of drivers. Innovative intersections by nature require at least some drivers to do things not typical at conventional intersections. However, the driver-friendliness of the concepts was heavily considered as we reviewed the results of scoring the criteria and influenced our recommendations.

Based on the results of the preliminary screening process, the consultant team developed a list of recommended concepts to further evaluate in the next steps of this study.

Future Alternative Concepts Recommendations for Further Evaluation

The details of our screening analysis are presented in the Supplement to this memo. Table 2 summarizes the concepts that we recommend for further evaluation at the study intersections.

Table 2: Future Alternative Concept Recommendations	
Intersection Location	**Future Alternative Concepts**
1 – Beacon Light & SH55 North	1. TSM improvements – adding a NB and SB lane 2. Continuous Green T
2 – State & Linder	1. Continuous flow intersection – 2 approaches 2. Median U-turn
3 – State & SH55 North	1. Continuous flow intersection – 4 approaches 2. Continuous flow intersection – 2 approaches
4 – State & Glenwood	1. Median U-turn 2. Quadrant Roadway – 2 Quadrants
5 – Chinden & Glenwood	1. Quadrant Roadway – Northeast Quadrant 2. Median U-turn / Continuous flow intersection (tie)
6 – Ustick & Cole	1. Bowtie – Ustick 2. Continuous flow intersection
7 – Chinden & Curtis	1. Median U-turn 2. Quadrant Roadway – Southwest Quadrant
8 – Fairview & Curtis	1. Realign Opohonga & Quadrant 2. Quadrant Roadway – Northeast Quadrant
9 – Fairview & Eagle	1. Quadrant Roadway 2. Continuous flow intersection
10 – Franklin & Eagle	1. Quadrant Roadway – Northeast Quadrant 2. Continuous flow intersection

In the attached supplement, there are details of the various alternatives above along with some discussion of other concepts that could emerge as the best option upon more study, changing conditions, or depending upon what stakeholders value the most. We include them in part because the concepts themselves are solid and would potentially provide great benefit but would also require significant political support to implement.

Next Steps

Having presented this information (and the details of the Alternative Screening Analysis in the Supplement to this memo) to the Project Review Committee, we desire the committee's input on our findings and recommendations. Upon approval or modification of our recommendations, a more detailed evaluation of the approved alternative concepts will begin. Results from this analysis will be included in the Draft Intersection Concept Layout Report. The evaluation will include a refined operational analysis along with preliminary cost estimates for the concepts in order to identify the cost/benefit of the concepts.

Supplement to Technical Memo 4: Screening Analysis Details and Future Baseline Conditions

Source: Wilbur Smith Associates and Thompson Transportation

Supplement to Technical Memo 4 - Screening Analysis Details and Future Baseline Conditions

Introduction
This supplement provides details about:
- The operational analysis of alternative concepts;
- The role of driver expectancy in concept evaluation;
- Typical advantages and disadvantages of various intersection types; and
- For each study intersection:
  - Summary of the existing and future baseline conditions analyses
  - Alternative concept screening analysis, including:
    - Concept scores and rankings;
    - Pros, cons and mitigations for recommended concepts; and
    - An explanation of why other concepts were not recommended

Operational Analysis of Alternative Concepts

Overview
We approached the operational analysis of alternative concepts in as comprehensive a manner as feasible given budget and time constraints, yet also with an eye toward efficiency and being mindful of the "high-level" / planning nature of this project. This approach manifested itself in a number of ways, for instance:
- We limited our analysis to Synchro. Thus, we assessed concept performance based on Synchro outputs (level of service and delay), not SimTraffic. Synchro outputs, while useful, do not provide the full picture, particularly in cases where an intersection does not have sufficient capacity to meet demand on all movements. Nevertheless, the Synchro results were sufficiently clear to assign points satisfactorily to each analyzed concept under the "Operational Performance" criterion.
- We did not perform an operational analysis every concept that we brainstormed. Several intersection types did not require modeling at all because of limited application potential (multi-lane roundabouts, superstreet, town center intersection).
- We used some analyses as surrogates for other analyses, both within intersection types (especially quadrant roadways) and between types (parallel flow intersections), basing the "Operational Performance" points assignment for un-analyzed concepts on that for similar concepts.
- For several intersection types (continuous flow intersections, median U-turns, bowties), we made blanket assumptions about the spacing of elements.

These and other details, grouped by intersection type, are discussed in the next section.

Notes on Analysis and Scoring of Specific Intersection Types
<u>Continuous flow intersection</u>
- Default geometric assumption is CFI treatment on all 4 legs
  - CFI treatment on all 4 legs was not feasible at some intersections
- Typically analyzed 4 leg treatment but did not analyze 2 leg treatment directly, assuming a 1 point decrease in operational performance score
- Assumed all left turn crossovers at 500 ft in advance of main intersection
- Coded new intersections at left turn crossovers and modified volumes and geometry at main intersection

<u>Parallel flow intersection</u>

- Not analyzed directly
- Operational performance considered identical to that of the CFI

Quadrant roadway
- The default geometric assumption is only one quadrant roadway.
- If multiple quadrants would allow a quadrant roadway, we analyzed only the option with the highest system-level volume. The operational performance of options with lower volumes was assumed identical since system volumes typically don't vary significantly.
- Concepts that would involve two quadrant roadways were not modeled directly but were given a 1 point increase in the operational performance score. Four-quadrant-roadway scenarios were given a 2 point increase.
- Quadrant roadways were positioned as seemed reasonable given existing roadways and / or logical new roadway paths.

Median U-turn
- Analyzed directly
- U-turns were assumed to be 500 ft away from the main intersection

Bowtie
- Analyzed directly
- Roundabouts were assumed to be 500 ft away from the main intersection

Superstreet
- Not analyzed; very limited application potential for the study intersections

Town center intersection
- Not analyzed directly; operational performance is typically very good.
- Potential applications at study intersections appear very limited.

Multi-lane roundabout
- Not analyzed; all study intersections appear to have future demand forecasts well beyond the range in which a multi-lane roundabout would operate well. There may be some locations where it could operate for a while (as an interim solution).

TSM improvements
- We limited our consideration of TSM improvements to just two intersections. Other intersections may benefit at least temporarily from such improvements.

The Role of Driver Expectancy in Concept Evaluation

Driver expectancy was considered in ranking concepts. Definitions of driver expectancy are below:

Degrees of driver expectancy for making a left turn on an arterial
Perfect expectancy: Driver gets into left lane just ahead of the intersection. Intersection geometry is typical of others in the region. Typical double-lefts and perhaps roundabouts fit this, but neither can handle high volumes.

Good expectancy: Driver gets into left lane ahead of the intersection, but paths to complete left are not typical. CFI, PFI, Town Center one-ways, and 4-quadrant roadways all fit this definition.

Unusual expectancy: Making a left ahead of the intersection is not possible. With Median U-turns, Bowties, and when there are just one or two quadrant roadways, drivers on some approaches must travel through, then make a U-turn and a right. In opposite approaches they must first turn right, then make a U-turn and travel trough. In the case of a single quadrant, one movement has good expectancy (left occurs ahead of the intersection). The next two movements are "through-U-right", and "right-U-through", and the last left equates to "three rights makes a left". Grade separated intersections also are "unusual" in a non-freeway context, because they require an exit from the right lane to make a left.

Unusual driver expectancy should not automatically disqualify a concept from consideration unless for some reason it creates an unsafe situation. These options are often far less money to implement relative to other choices, and in some cases require only changing signs, striping, and signal timing. Perfect driver expectancy also comes with high congestion at high volumes. Most drivers would prefer to get used to a new expectancy if it means they'll save a lot of time.

General Advantages and Disadvantages of Various Intersection Types

This describes the general advantages and disadvantages of various intersection types relative to a typical baseline that has dual lefts on all approaches (an inefficient, 4-phase signal).

General Advantages of CFI's/PFI's

- 2-legs always achieve 3-phases, increasing capacity considerably.
- 4-legs always achieve 2-phases, increasing capacity even more.
- Good driver expectancy
- Operationally, CFI's and PFI's are very similar, but one or the other may be easier to build within existing constraints.

General Disadvantages of CFI's/PFI's

- Require a considerably large footprint. This can be an advantage in situations where future grade separation is considered.
- Safe for pedestrians, but can be intimidating and would not be considered "pedestrian friendly".
- Can be expensive if acquiring buildings, parking, or removing accesses is required.

General Advantages of Town Center Intersections

- Two legs creates two 3-phase intersections, each more efficient than a single 4-phase.
- Four legs creates four 2-phase signals, where the four together can handle much more volume than a single intersection.
- The most pedestrian-oriented of all high-volume systems.
- Design lends itself well to defining a higher-density, mixed-use "Place". Very low cost when designed on open ground as part of a master-planned area.
- More signals, but they're easily coordinated

General Disadvantages of Town Center Intersections

- The sum of the right-of-way is higher, due mostly to more sidewalk area.
- Numerous impacts and very expensive in developed settings. Cost is largely mitigated if private funds can be attracted as part of a general redevelopment strategy, or if tax-increment financing is used for the same purpose.

General Advantages of a Single Quadrant Roadway

- Makes it possible to achieve high-efficiency 2-phase signal
- Candidate roadway often already exists. Hence implementation is extremely low cost.

- Result is less intimidating for pedestrians than Baseline.

General Disadvantages of a Single Quadrant Roadway

- Creates unusual driver expectancy. However the public may prefer to get used to awkward paths if it means they'll save a lot of time and the implementation cost is low.
- The quadrant roadway will itself become very busy, as it is functioning for 4-left movements.
- 3 of 4 left paths still require drivers to traverse the main intersection – sometimes twice. Thus lefts are eliminated, but there are more rights and throughs. The former left-turn lanes may be used as through lanes to handle higher through volume.

General Advantages of Multiple Quadrant Roadway

- Makes it possible to achieve high-efficiency 2-phase signal
- May require construction to develop roads on more quadrants
- Each quadrant handles less volume.
- With 4-quadrants, there is very good driver expectancy (all approaches can turn left ahead of intersection. No circuitous paths)
- With 4-quadrants, lefts never enter the main intersection – making 4 quadrants among the highest overall capacity of all.

General Disadvantages of Multiple Quadrant Roadways

- Can be expensive to develop more quadrants.
- Introduces T-intersections
- Mitigate by making Continuous Green-Ts.

Note: The bowtie is essentially the same as median U-turn, but utilizes a bulb-out/roundabout to create a wrap-around lane that need not conflict with oncoming traffic, as a median U-turn typically would. Thus it is operationally superior and aesthetically more pleasing but also requires more space.

General Advantages of Median U-Turns / Bowties

- Reduces 4-phase signal to 2-phase signal
- Impacts typically limited just to the location of the U-turn or bulb out.
- Can be very low cost, depending on adjacent development

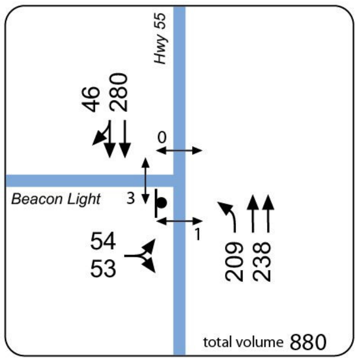
General Disadvantages of Median U-Turns / Bowties

- Results in unusual driver expectancy
- Vehicles still traverse intersection at least once, sometimes twice. Can be mitigated by converting former left pockets to through lanes.

Intersection 1 – Beacon Light & SH55 North

Summary of the Existing and Future Baseline Conditions Analyses

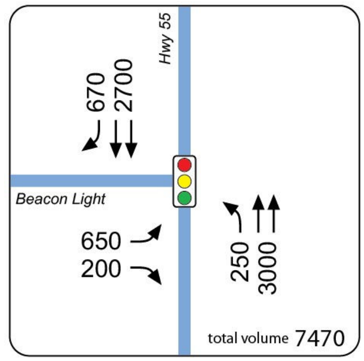
Existing Conditions



Beacon Light & Hwy 55 2007 PM Peak Hour

LOS A - Average delay 9 sec

Future Baseline Conditions



Beacon Light & Hwy 55 Future PM Peak Hour

LOS F - Average delay >100 sec

Alternative Concept Screening Analysis and Recommendations

Table 1: Future Design Alternatives at Beacon Light & SH 55 North

Design Alternative	Specific Details	Operational Performance (Weight 40%)	Relative Costs (Weight 30%)	Compatibility (Weight 20%)	Impacts (Weight 10%)	Composite Score (100%)	Rank
At-Grade Alternatives							
No build	Add right turn bays on eastbound and southbound approaches	1	5	5	5	3.4	4
TSM improvements	Add through lanes northbound and southbound	4	4	4	4	4.0	1
Realign west leg	Realign west leg of roadway to the north; relocate accesses					0.0	9
Relocate access	Relocate Horseshoe Bend Rd access					0.0	9
Continuous flow intersection	Apply to south leg	3	4	3	4	3.4	3
Continuous flow intersection	Apply to west leg	3	4	3	3	3.3	5
Parallel flow intersection	See CFI analysis					0.0	9
Quadrant roadway	Northwest Quadrant	3	2	4	3	2.9	7
Median U-turn	Apply to south and north legs	2	4	1	4	2.6	8
Continuous green T	Provide acceleration lanes	2	4	5	5	3.5	2
Grade-Separated Alternatives							
Grade-separated	Grade separate northbound left turns and southbound throughs	5	1	3	2	3.1	6

Beacon Light / 55, General Analysis

Baseline is a 3-phase signal that stops NB and SB both. Baseline has 2 lanes both NB and SB. The result is an extremely long queue long queue.

TSM (3 NB and SB through lanes on 55)
Advantages:

- Reduces delay considerably – 55 could use three lanes each direction if both NB and SB are stopped for a 3-phase signal.

Disadvantages:

- NB need not stop in other designs
- Does not solve poor connections of nearby streets
- Other designs can attain two-phase signal

Continuous Green T
Advantages:

- Channelization allows northbound to never stop
- Right of way and access control are not a problem
- Cost is very low
- Very traditional – no driver expectancy problems

Disadvantages:

- Requires SB to stop at three-phase signal
- Does not resolve poor roadway connections to 55 and Beacon

CFI (either on west leg or south leg, not both. South leg easier to fit)
Advantages:

- Allows EB to NB left and NB to WB left to occur at same time (2-phase signal)
- Does not require new alignments
- Fairly low cost if right-of-way is preserved

Disadvantages:

- Could make property access more difficult
- Does not resolve poor roadway connections to 55 and Beacon

Single Quadrant in the NW
Advantages:

- Allows EB to NB left and NB to WB left to occur at same time (2-phase signal)
- Eliminates poor access to 55, and poor access to Beacon becomes less significant.
- Easily combined with Green-T
- Very conventional – nothing unusual
- Avoids property access problems of CFI

Disadvantages:

- Requires constructing .2 miles of a local street, making it potentially more expensive than CFI.

Recommendations for further study

- Definitely do Green-T. It is compatible with any solution.
- Three lanes on SB or NB 55 are not necessary if 2-phase signal is achieved.
- If the quadrant roadway can be shown on local plans and constructed when the area develops, this becomes the lowest cost solution with the most advantages.
- If agencies must bear cost of quadrant, CFI may end up lower cost.

Other concepts reviewed and dropped

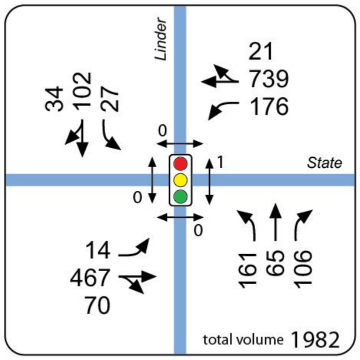
Grade separated: Would perform best of all and would easily fit if ROW is preserved. The required bridge would be lower cost as far as bridges go, but other solutions are far lower cost and get very good performance.

Median U-Turn: Requires a weave with significant differentials in speeds. Very unsafe, and poor driver expectation (right to make a left).

Intersection 2 – State & Linder

Summary of the Existing and Future Baseline Conditions Analyses

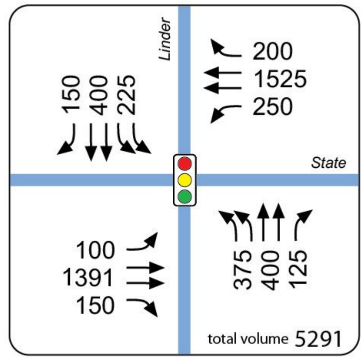
Existing Conditions



State & Linder 2007 PM Peak Hour

LOS D - Average delay 51 sec

Future Baseline Conditions



State & Linder Future PM Peak Hour

LOS F - Average delay >100 sec

Alternative Concept Screening Analysis and Recommendations

Table 2: Future Design Alternatives at State & Linder							
		Weight					
		40%	30%	20%	10%	100%	
Design Alternative	Specific Details	Operational Performance	Relative Costs	Compatibility	Impacts	Composite Score	Rank
At-Grade Alternatives							
No build	Upgrade all four approaches - additional through and turn lanes	2	5	5	5	3.8	1
Continuous flow intersection	Apply to west and east legs	3	4	4	4	3.6	2
Continuous flow intersection	Apply to all four legs	4	3	3	3	3.4	4
Parallel flow intersection	See CFI analysis					0.0	8
Quadrant roadway	Northwest Quadrant	3	3	2	2	2.7	7
Median U-turn	Apply to west and east legs	4	4	2	4	3.6	3
Bowtie	Apply to north and south legs	4	2	3	3	3.1	6
Grade-Separated Alternatives							
Grade separated	Stop or signal control on Linder; State St would have free movement	5	1	4	2	3.3	5
Screened Out for 2030; May Be Good Interim Solution							
Superstreet	Close off northbound and southbound throughs; provide median U-turn on east and west legs	2	4	3	4	3.0	

State / Linder, General Analysis

Baseline assumes 2 throughs and double lefts on all approaches. Long-range volumes fail the intersection, but not as bad as at other locations. This is a reasonable configuration perhaps for the next 15-years, but given the nature of State and the vast developable land, this is a poor long-term choice.

The model shows lower volumes on Linder, but this could change given that Linder is one of few river crossings. Linder may also become a retail corridor as is typical of streets like this, which may not be reflected in today's model. We recommend preserving space for a high-capacity option, along with lower-cost, short-term improvements.

2 or 4-leg CFI/PFI on State
Advantages:

- General advantages apply
- Could be low additional cost, if included as part of larger right of way on State.
- Fits with potential vision to grade-separate for State.

Disadvantages:

- General disadvantages apply
- Could be challenging with existing development, canal, etc.

Median U-Turn on State
Advantages:

- General advantages apply
- Performs very well in early tests
- Very low cost – especially if State expands right-of-way to 200 ft as may occur
- Consistent with longer vision for State.

Disadvantages:

- General disadvantages apply
- Potential high-speed weave

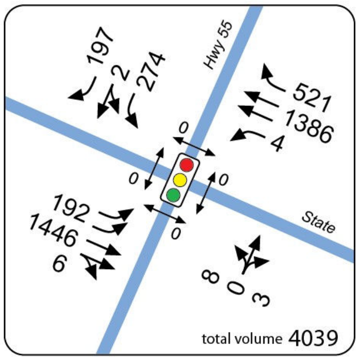
Points of Merit on others considered

Bulb-out bowtie/roundabouts on Linder may be very aesthetic and would improve function considerably. We don't plan to investigate this further, but future studies may want to consider this.

Intersection 3 – State & SH55 North

Summary of the Existing and Future Baseline Conditions Analyses

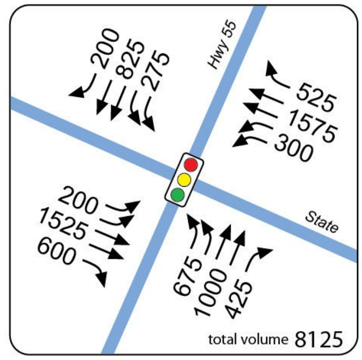
Existing Conditions



State & Hwy 55 2007 PM Peak Hour

LOS C - Average delay 27 sec

Future Baseline Conditions



State & Hwy 55 Future PM Peak Hour

LOS F - Average delay >100 sec

Alternative Concept Screening Analysis and Recommendations

Table 3: Future Design Alternatives at State & SH55 North

Design Alternative	Specific Details	Operational Performance	Relative Costs	Compatibility	Impacts	Composite Score	Rank
		Weight 40%	30%	20%	10%	100%	
At-Grade Alternatives							
No build	Expand south leg; all approaches to be upgraded to dual left turns, two through lanes, and right turn bay	1	5	5	5	3.4	4
Continuous flow intersection	Apply to west and east legs	3	4	4	4	3.6	2
Continuous flow intersection	Apply to all 4 legs	4	3	4	4	3.7	1
Parallel flow intersection	See CFI analysis					0.0	7
Quadrant roadway	Southwest Quadrant	3	3	2	3	2.8	6
Median U-turn	Apply to west and east legs	3	4	3	4	3.4	3
Grade-Separated Alternatives							
Grade separated	Stop or signal control on SH55 North; State St would have free movement	5	1	4	2	3.3	5

State / Hwy 55, General Analysis

Baseline is a complete failure.

2 or 4-leg CFI/PFI on State
Advantages:

- General advantages apply
- Both 2 and 4-leg options are easily implemented, due to existing restricted access, ample space.
- Easily upgradable to grade-separated, which may be worth protecting on State
- Pedestrian issues less significant, as this location has few pedestrians

Disadvantages:
General disadvantages apply

Single Quadrant, SW corner
Advantages:

- General advantages apply
- Low cost relative to CFI.
- Could be coordinated with development

Disadvantages:

- General disadvantages apply
- Considerably less attractive than CFIs, but lower cost

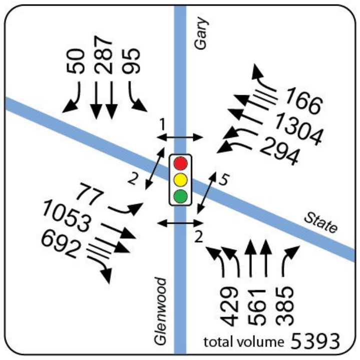
Points of Merit on others considered

Grade separation seems fairly compatible with the context. Cost is the only reason this is not attractive.

Intersection 4 – State & Glenwood

Summary of the Existing and Future Baseline Conditions Analyses

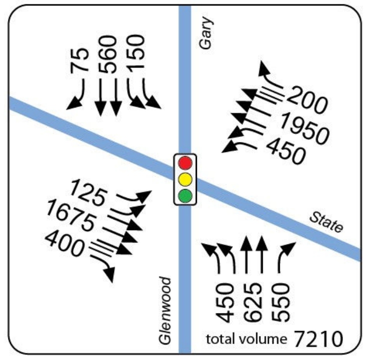
Existing Conditions



State & Glenwood 2007 PM Peak Hour

LOS D - Average delay 48 sec

Future Baseline Conditions



State & Glenwood Future PM Peak Hour

LOS F - Average delay 99 sec

Alternative Concept Screening Analysis and Recommendations

Table 4: Future Design Alternatives at State & Glenwood								
		Weight 40%	30%	20%	10%	100%	
Design Alternative	**Specific Details**	**Operational Performance**	**Relative Costs**	**Compatibility**	**Impacts**	**Composite Score**	**Rank**
At-Grade Alternatives							
No build	Eastbound and westbound approaches to have three through lanes; all approaches to have dual left turns	2	5	5	5	3.8	4
Continuous flow intersection	Apply to west and east legs	3	3	3	3	3.0	7
Continuous flow intersection	Apply to all 4 legs	4	2	2	2	2.8	8
Parallel flow intersection	See CFI analysis					0.0	10
Quadrant roadway	Northwest Quadrant	3	5	3	5	3.8	3
Quadrant roadway	Use 2 Quadrants	4	4	4	4	4.0	2
Quadrant roadway	Use 4 Quadrants	4	3	5	3	3.8	4
Median U-turn	Apply to west and east legs	5	4	4	4	4.4	1
Bowtie	Apply to south and north legs	4	3	4	3	3.6	6
Grade-Separated Alternatives							
Grade separated	Stop or signal control on Glenwood; State St would have free movement	4	1	1	1	2.2	9

State / Glenwood, General Analysis

Baseline is a complete failure. Something should be done.

Median U-Turns on State

Advantages:

- General advantages apply
- Fairly easy to implement with existing conditions.
- Tests suggest performance would improve significantly

Disadvantages:

General disadvantages apply

Single Quadrant Roadway

Advantages:

- General advantages apply
- Northwest quad already exists

Disadvantages:

- General disadvantages apply
- Other quadrants are possible but difficult

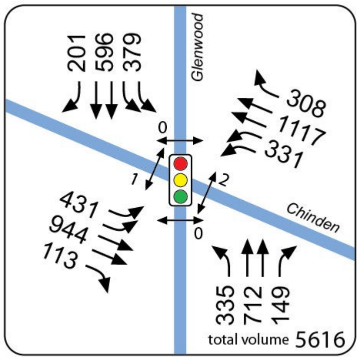
Points of Merit on others considered

Nothing else is very attractive. Bowtie is generally an enhancement of the Median U-Turn, and would work here, but requires more space and would conflict with existing parking lots.

Intersection 5 – Chinden & Glenwood

Summary of the Existing and Future Baseline Conditions Analyses

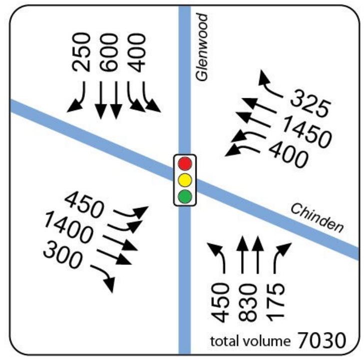
Existing Conditions



Chinden & Glenwood 2007 PM Peak Hour

LOS F - Average delay 96 sec

Future Baseline Conditions



Chinden & Glenwood Future PM Peak Hour

LOS F - Average delay >100 sec

Alternative Concept Screening Analysis and Recommendations

Table 5: Future Design Alternatives at Chinden & Glenwood

Design Alternative	Specific Details	Weight 40% Operational Performance	30% Relative Costs	20% Compatibility	10% Impacts	100% Composite Score	Rank
At-Grade Alternatives							
No build	No planned change from existing geometry	1	5	5	5	3.4	5
Continuous flow intersection	Apply to west and east legs	4	3	4	3	3.6	3
Parallel flow intersection	See CFI analysis					0.0	8
Quadrant roadway	Northeast Quadrant	3	5	4	5	4.0	1
Quadrant roadway	Northeast & Southwest Quadrants	4	3	3	3	3.4	4
Median U-turn	Apply to west and east legs	3	4	4	4	3.6	2
Grade-Separated Alternatives							
Grade separated	Traditional Interchange	4	1	1	1	2.2	7
Grade separated	Chinden access via Quadrant	5	1	3	2	3.1	6

Chinden / Glenwood, General Analysis

Baseline is a complete failure. Something should be done.

Median U-Turns on State

Advantages:

- General advantages apply
- Fairly easy to implement with existing conditions.
- Tests suggest performance would improve significantly

Disadvantages:

- General disadvantages apply

Single Quadrant Roadway

Advantages:

- General advantages apply
- Northeast quad already exists

Disadvantages:

- General disadvantages apply
- Other quadrants are possible. SW quad exists, but resident anxiety is likely.

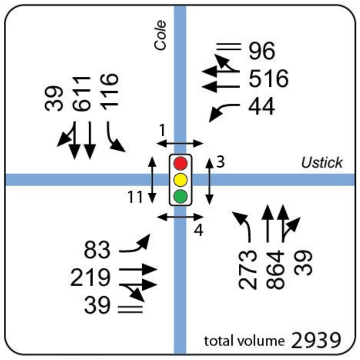
Points of Merit on others considered

Nothing else is very attractive. Bowtie is generally an enhancement of the Median U-Turn, and would work here, but requires more space and would conflict with existing parking lots.

Intersection 6 – Ustick & Cole

Summary of the Existing and Future Baseline Conditions Analyses

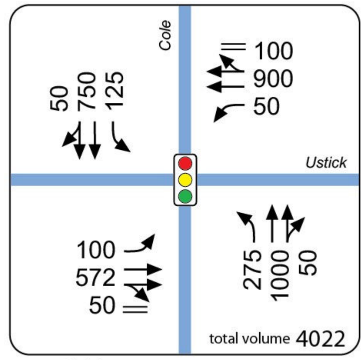
Existing Conditions



Ustick & Cole 2007 PM Peak Hour

LOS C - Average delay 29 sec

Future Baseline Conditions



Ustick & Cole Future PM Peak Hour

LOS F - Average delay 81 sec

Alternative Concept Screening Analysis and Recommendations

Table 6: Future Design Alternatives at Ustick & Cole

Design Alternative	**Specific Details**	**Operational Performance** (Weight 40%)	**Relative Costs** (30%)	**Compatibility** (20%)	**Impacts** (10%)	**Composite Score** (100%)	**Rank**
At-Grade Alternatives							
No build	No planned change from existing geometry	1	5	5	5	3.4	3
Continuous flow intersection	Apply to west and east legs	4	3	3	3	3.4	2
Continuous flow intersection	Apply to all 4 legs	5	2	2	2	3.2	5
Parallel flow intersection	See CFI analysis					0.0	8
Quadrant roadway	Southwest Quadrant	4	2	3	3	3.1	6
Jug-handle	One way right turn only in 4 quadrants	4	3	3	2	3.3	4
Median U-turn	Apply to west and east legs	3	3	3	4	3.1	7
Bowtie	Apply to west and east legs	4	3	4	3	3.6	1
Grade-Separated Alternatives							
None							

Ustick / Cole, General Analysis

Baseline assumes some widening, but it is still likely to fail, though not as badly as at some locations.

Many options can likely improve flow without a general widening, which may cost less than the baseline and help maintain the character of the area.

Bowtie (either Cole or Ustick –TBD)
Advantages:

- General advantages apply
- Very aesthetically appealing

Disadvantages:

- General disadvantages apply
- Will conflict with existing parking somewhat, and may require a home or two

CFI or PFI
Advantages:

- General advantages apply
- Performance indications are very good.
- May be possible to create a "tight design" that would not impact businesses

Disadvantages:

- General disadvantages apply
- High potential of conflicting with development

Points of Merit on others considered

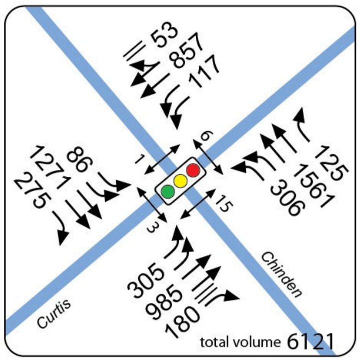
Jughandle Quadrants
Note: It appears possible to develop four very tight jughandles encircling the first businesses on the corners. This would achieve two-phase signals and clear congestion from the intersection. Some could be two-way, allowing access to parking lots as occurs today. The one by the gas station could be one-way to make it narrower, and avoid taking homes behind the station.

This could be a very good option, that should be considered further, even if resources in this study don't allow much more.

Intersection 7 – Chinden & Curtis

Summary of the Existing and Future Baseline Conditions Analyses

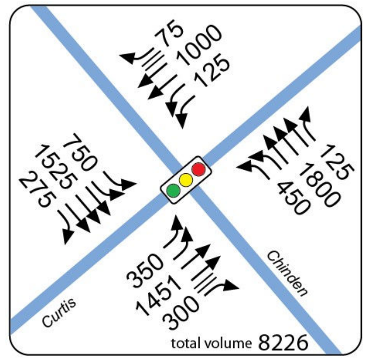
Existing Conditions



Chinden & Curtis 2007 PM Peak Hour

LOS F - Average delay >100 sec

Future Baseline Conditions



Chinden & Curtis Future PM Peak Hour

LOS F - Average delay >100 sec

Alternative Concept Screening Analysis and Recommendations

Table 7: Future Design Alternatives at Chinden & Curtis

Design Alternative	Specific Details	Operational Performance (Weight 40%)	Relative Costs (Weight 30%)	Compatibility (Weight 20%)	Impacts (Weight 10%)	Composite Score (100%)	Rank
At-Grade Alternatives							
No build	Eastbound and westbound approaches to have three through lanes; add right turn bay to southbound approach	1	5	5	5	3.4	3
Quadrant roadway	Southwest quadrant	2	5	4	5	3.6	2
Quadrant roadway	2 quadrants	3	3	4	3	3.2	4
Quadrant roadway	4 quadrants	4	2	4	1	3.1	5
Jughandle / cloverleaf	Right turn only one-way treatments to each quadrant	2	4	4	3	3.1	6
Median U-turn	Apply to west and east legs	3	4	4	4	3.6	1
Town center intersection	One variation: sections of Chinden and Curtis become pedestrian-friendly greenways. The traffic would be re-routed onto one-way roadways running parallel with the current roadways.					0.0	8
Grade-Separated Alternatives							
Grade separated	Stop or signal control on Chinden; Curtis would have free movement	5	1	1	2	2.7	7

Chinden / Curtis, General Analysis

Baseline assumes some widening, but there is still extreme failure in spite of widening Chinden.

Many options can likely improve flow to acceptable levels, and not require a general widening of Chinden.

Median U-Turns, either Chinden or Curtis
Advantages:

- General advantages apply
- Among the easiest of all options to implement at this site.

Disadvantages:

- General disadvantages apply
- Will have some impacts, but far less than most other options.
- Performance would be much better, but there are other options that would perform even better, though at a higher cost.

Single Quadrant, SW corner
Advantages:

- General advantages apply
- Very low cost to implement

Disadvantages:

- General disadvantages apply

Points of Merit on others considered

Jughandle Quadrants
Note: As at Ustick/Cole, it similarly appears possible to develop four very tight jughandles encircling the first businesses on the corners. This would achieve two-phase signals and likely clear congestion from the intersection.

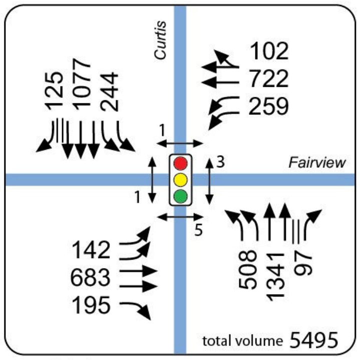
These jughandles would be designed as free rights, and they likely need their own through lanes in the main intersection.

This could be a very good option that should be considered further, even if resources in this study don't allow much more.

Intersection 8 – Fairview & Curtis

Summary of the Existing and Future Baseline Conditions Analyses

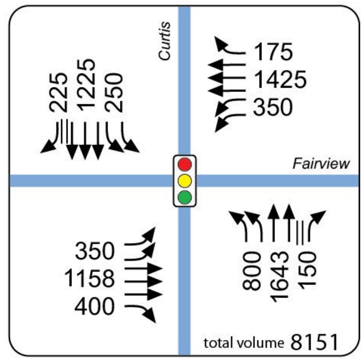
Existing Conditions



Fairview & Curtis 2007 PM Peak Hour

LOS D - Average delay 54 sec

Future Baseline Conditions



Fairview & Curtis Future PM Peak Hour

LOS F - Average delay >100 sec

Alternative Concept Screening Analysis and Recommendations

Table 8: Future Design Alternatives at Fairview & Curtis

Design Alternative	Specific Details	Operational Performance (Weight 40%)	Relative Costs (Weight 30%)	Compatibility (Weight 20%)	Impacts (Weight 10%)	Composite Score (100%)	Rank
At-Grade Alternatives							
No build	Eastbound and westbound approaches to have three through lanes; add right turn bay to westbound approach	1	5	5	5	3.4	3
TSM improvements	Triple northbound left turns 3 northbound through lanes	2	4	4	4	3.2	4
Continuous flow intersection	Apply to west and east legs	3	3	3	2	2.9	6
Parallel flow intersection	See CFI analysis					0.0	8
Quadrant roadway	Northeast Quadrant	3	4	4	4	3.6	2
Median U-turn	Apply to west and east legs	3	3	3	3	3.0	5
Realign Opohonga St / Quadrant roadway	Realign Opohonga St to the I-184 WB ramp intersection and provide northeast quadrant treatment.	5	2	4	3	3.7	1
Grade-Separated Alternatives							
Grade separated	Stop or signal control on Fairview; Curtis would have free movement	4	1	1	1	2.2	7

Fairview / Curtis, General Analysis
Baseline and conventional options simply won't work in this setting.

Realign Opohonga to meet with off-ramp
Advantages:
- Creates a quadrant road in SW
- Allows I-84 to WB Fairview volume to completely avoid intersection

Disadvantages:
- May be tricky to design

Single Quadrant, NE corner
Advantages:
- General advantages apply
- Very low cost to implement
- Good combination with Opohonga realignment

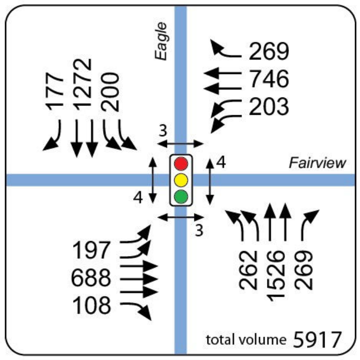
Disadvantages:
- General disadvantages apply

These options combined, or a variation, appears to be by far the most attractive

Intersection 9 – Fairview & Eagle

Summary of the Existing and Future Baseline Conditions Analyses

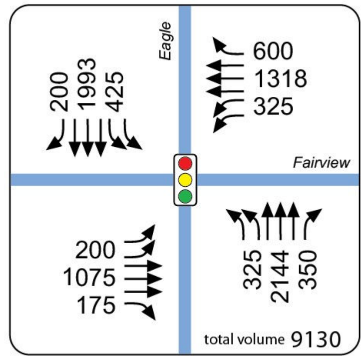
Existing Conditions



Fairview & Eagle 2007 PM Peak Hour

LOS F - Average delay 93 sec

Future Baseline Conditions



Fairview & Eagle Future PM Peak Hour

LOS F - Average delay >100 sec

Alternative Concept Screening Analysis and Recommendations

Table 9: Future Design Alternatives at Fairview & Eagle							
		Weight					
		40%	30%	20%	10%	100%	
Design Alternative	**Specific Details**	**Operational Performance**	**Relative Costs**	**Compatibility**	**Impacts**	**Composite Score**	**Rank**
At-Grade Alternatives							
No build	All approaches to have three through lanes	1	5	5	5	3.4	5
Continuous flow intersection	Apply to all 4 legs	4	3	4	3	3.6	2
Parallel flow intersection	See CFI analysis					0.0	7
Quadrant roadway - 1	Northeast Quadrant	3	4	4	4	3.6	1
Quadrant roadway - 2	Northeast and Southwest Quadrant	4	3	4	3	3.6	2
Median U-turn	Apply to west and east legs	3	4	4	3	3.5	4
Grade-Separated Alternatives							
Grade separated	Stop or signal control on Fairview; Eagle would have free movement	5	1	1	1	2.6	6

Fairview / Eagle, General Analysis

Baseline and conventional options simply won't work in this setting.

CFI

Advantages:

- General advantages apply
- Very compatible with existing conditions.

Disadvantages:

- General disadvantages apply

Single Quadrant, NW or NE corner

Advantages:

- General advantages apply
- Can be built as the corner develops
- More pedestrian friendly than CFI

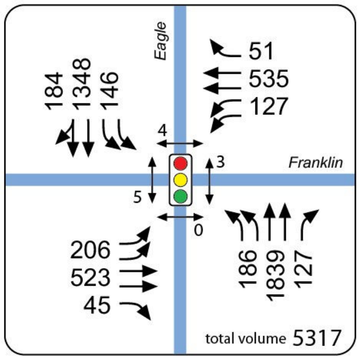
Disadvantages:

- General disadvantages apply

Intersection 10 – Franklin & Eagle

Summary of the Existing and Future Baseline Conditions Analyses

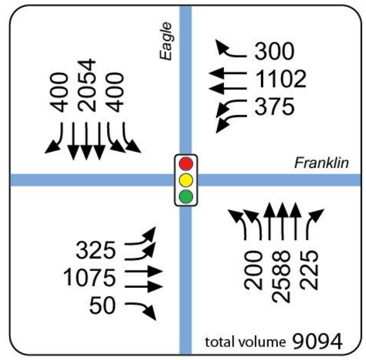
Existing Conditions



Franklin & Eagle 2007 PM Peak Hour

LOS E - Average delay 70 sec

Future Baseline Conditions



Franklin & Eagle Future PM Peak Hour

LOS F - Average delay >100 sec

Alternative Concept Screening Analysis and Recommendations

Table 10: Future Design Alternatives at Franklin & Eagle

Design Alternative	Specific Details	Operational Performance (Weight 40%)	Relative Costs (Weight 30%)	Compatibility (Weight 20%)	Impacts (Weight 10%)	Composite Score (100%)	Rank
At-Grade Alternatives							
No build	Northbound and southbound approaches to have three through lanes; add right turn bay to southbound approach	1	5	5	5	3.4	2
Continuous flow intersection	Apply to south and north legs	3	3	4	4	3.3	3
Continuous flow intersection	Apply to all 4 legs	4	2	3	3	3.1	4
Parallel flow intersection	See CFI analysis					0.0	7
Quadrant roadway	Northeast Quadrant	4	5	4	5	4.4	1
Median U-turn	Apply to west and east legs	2	3	3	4	2.7	5
Grade-Separated Alternatives							
Grade separated	Stop or signal control on Franklin; Eagle would have free movement	5	1	1	1	2.6	6

Franklin / Eagle, General Analysis

Baseline and conventional options simply won't work in this setting.

CFI

Advantages:

- General advantages apply
- Very compatible with existing conditions.

Disadvantages:

- General disadvantages apply

Single Quadrant, NE corner

Advantages:

- General advantages apply
- NE quad already exists
- More pedestrian friendly than CFI

Disadvantages:

- General disadvantages apply