3.0 Design Concept Alternatives

3.1 Introduction

The No Build Alternative and Build Alternatives were developed and evaluated for mainline I-40. In addition, alternatives for improvements to several existing traffic interchanges were developed and evaluated, as well as alternative configurations for proposed new interchanges. Proposed improvements to existing interchange and proposed new interchanges for which alternatives were not developed are discussed in Chapter 4.

The alternatives are presented from west to east in the order listed below.

- Mainline Widening Alternatives (Inside versus Outside Widening)
- Improvements to Existing Traffic Interchanges
  - Bellemont TI (MP 185.15)
  - Butler TI (MP 198.28)
  - Walnut Canyon TI (MP 204.87)
  - Cosnino TI (MP 207.24)
  - Winona TI (MP 211.16)
- Proposed New Traffic Interchanges
  - New Camp Navajo TI (MP 183.66)
  - New Woody Mountain TI (MP 193.47)
  - New Lone Tree Rd TI (MP 196.70)
  - New US 89 TI (MP 202.31)

3.2 No Build Alternative

The No Build Alternative assumes that no major improvements would be made to I-40. Under the No Build Alternative, traffic flow within the study area would continue to deteriorate due to increasing congestion. This congestion would intensify in future years from traffic growth generated by ongoing land development and urbanization near Flagstaff and from increased interstate traffic. Therefore, the No Build Alternative would not fulfill the purpose and need for the project of reducing traffic congestion and improving the capacity and traffic operational characteristics of the route for regional traffic.

3.3 Mainline Widening Alternatives (Inside Versus Outside Widening)

3.3.1 Introduction

The build alternatives were developed to add capacity and upgrade the roadway to meet a 75 mph design speed between MP 183.0 and 193.0 and between MP 203.0 and MP 214.0, or from approximately the western project limit to Flagstaff Ranch TI and from the new US 89 TI to the eastern project limit. The remaining middle segment is classified as urban/fringe urban and was designed to meet a minimum 65 mph design speed. In the outer segments with more gentle terrain, the existing highway geometry can be improved to meet a 75 mph design speed through several geometric spot improvements.

The existing eastbound and westbound roadways are parallel to each other for the majority of the project length, with a median width of 176 feet (measured between the inside travel lanes of the eastbound and westbound roadways). This section of the Initial DCR will evaluate improvements for widening the existing pavement to three lanes. The widening alternatives differ in the amount of median width provided and the impacts to the adjacent properties and R/W. These alternatives are referred to as *Inside Widening Alternative* and *Outside Widening Alternative*.

The alternatives were developed and evaluated with input from the City of Flagstaff (City) and the FMPO, who shared goals of preserving the existing wide median and the rural character of I-40; preserving existing trees and other vegetation; establishing meadows where existing trees cannot be preserved; and preserving or mitigating land formations and rock outcroppings to maintain visual interest, create visual separation, provide landscaping opportunities, and shield headlights of oncoming traffic. In addition, the City considers the areas near Bellemont and Winona to be "gateways" to the Flagstaff area. The design should preserve as much of the median area as feasible, balancing the median width and tree preservation elements with constructability, clear zone policies, impacts to adjacent properties, and cost elements for construction and for long-term maintenance.

3.3.2 Inside Widening Alternative (Recommended Alternative)

The Inside Widening Alternative would widen the mainline pavement to the inside from MP 183.6 to MP 208.4, adding pavement to the median side of the eastbound and westbound roadways and maintaining the outside edge of pavement in its current location to limit the impacts to the outside of the existing roadway. The new inside travel lanes for each direction would be separated by minimum 148 feet of median width (measured between travel lanes) for much of the project length.

Evaluation

Design elements considered for the Inside Widening Alternative include interchange impacts, earthwork requirements, constructability, structural layouts, and preliminary R/W estimates. Interchange impacts from inside widening would be minimal where existing underpass bridge spans can accommodate the widened roadway. Existing ramps meeting current design criteria could remain in place with only gore areas needing modification, although conversion of taper-type to parallel-type entrance and exit ramps, as well as the addition of auxiliary lanes, would require some reconstruction on the outside.

ADOT and FHWA have mandated that, where feasible, an open, natural median should be maintained in rural areas. This alternative would reduce the width but maintain much of the existing open median, providing an open, wide cross section with a rural character that allows drivers to appreciate the scenic views.

Earthwork requirements for this alternative would be minor for widening west of the Arizona Divide (MP 190.0) since the existing median is graded within several feet of the required grade. Some remaining segments of the

corridor would require more extensive earthwork, including rock removal. Where the horizontal alignments for eastbound and westbound I-40 parallel one another, the earthwork requirements would be less extensive.

Several existing cut slopes on the outside would be modified with both build alternatives to provide increased space for rockfall containment and roadside drainage. New R/W would be required to accommodate these cut slope modifications.

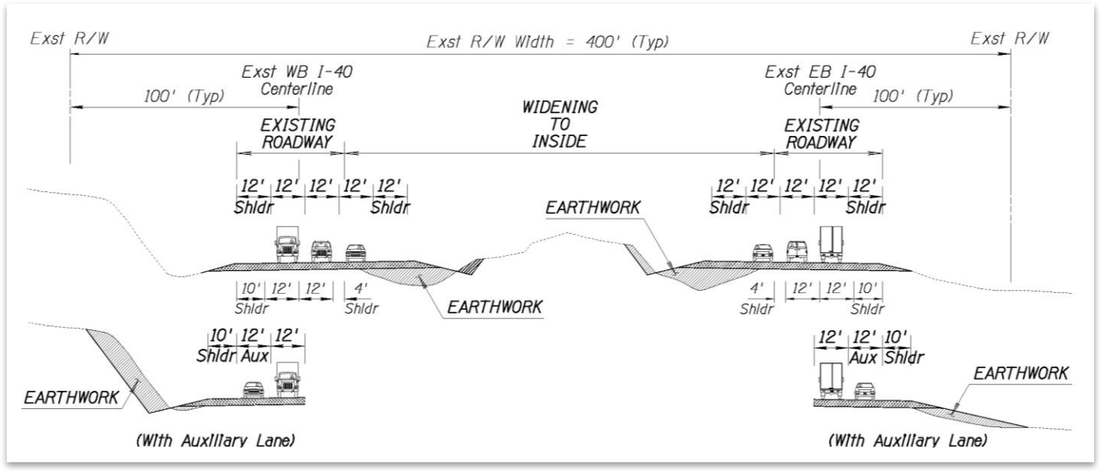
Structures would be replaced or widened to the inside with this alternative.

ADOT's *Roadway Design Guidelines* specify that median barrier is warranted for divided highways with three lanes or more in each direction and median widths less than 75 feet wide. Therefore, median barrier would be required wherever the median width was less than 75 feet, which would occur in the area of the Riordan railroad crossing. Crossover movements by emergency vehicles would not be restricted by the inside widening except where median barrier is constructed.

Construction would need to occur in phases to maintain traffic flow. Median construction would occur first with traffic shifted to the outside. Traffic would then be shifted to the inside so that the existing pavement could be rehabilitated. During this phase, temporary provisions for traffic to cross the work zone to access the interchange ramps would be required. Construction equipment and workers would be confined to the work zone between the existing cross roads. Transportation of borrow, waste, and construction materials would need to cross mainline traffic. Some equipment may not fit under the existing structures and access from the mainline may be required in order to enter the construction area.

Figure 23 illustrates the typical section for the Inside Widening Alternative.

Figure 23 – Inside Widening Alternative



3.3.3 Outside Widening Alternative

The Outside Widening Alternative would widen the mainline to the outside from MP 183.6 to MP 208.4, maintaining the existing inside edge of pavement location.

Evaluation

The Outside Widening Alternative would preserve the existing open, natural median width, maintaining the rural character of the median. Issues considered for the Outside Widening Alternative include interchange impacts, earthwork requirements, constructability, structural layouts, and right-of-way needs.

Interchange impacts from widening to the outside would be extensive. Existing ramps would need to be shifted outward to provide space for mainline widening. Some ramps would be partially reconstructed; others would be encroached upon by mainline side slopes and would require total reconstruction. Structures would be replaced or widened to the outside with this alternative.

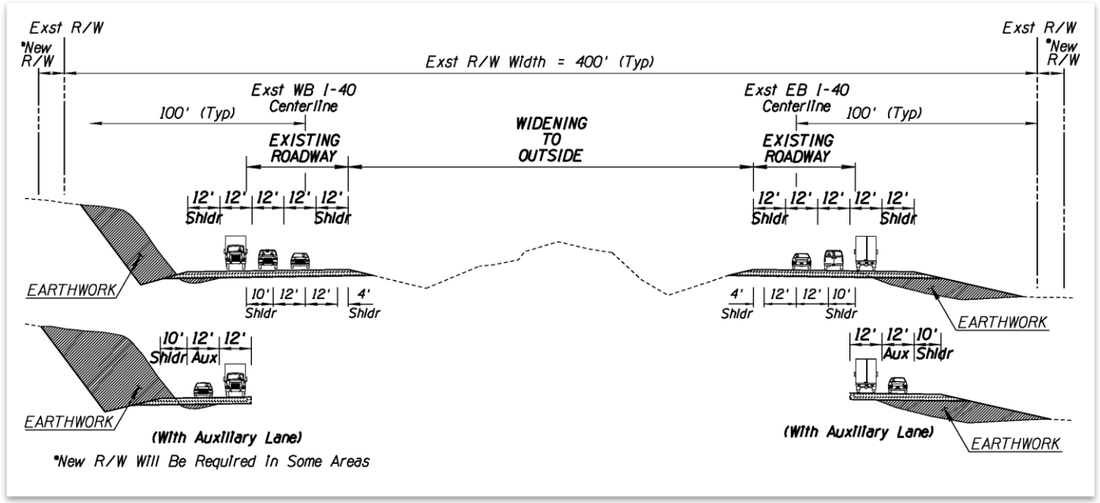
New R/W would be required in various locations from the Forest Service and private owners to accommodate slope modifications and ramp realignments. Frontage road realignment would be required between the new Camp Navajo TI and the Bellemont TI and between the Walnut Canyon TI and the Cosnino TI, as well as realignment of approximately two miles of W. Beatons East Road east of Bellemont and one mile of Soliere Avenue. Approximately two miles of BNSF double track would be affected, and the new roadway elements would encroach into the railroad R/W in several locations. The Outside Widening Alternative would require approximately 136 acres more R/W than the Inside Widening Alternative.

Several existing and planned residential developments would be affected. Even though the corridor is generally rural, there are numerous residential developments adjacent to the ADOT R/W. Outside widening in these segments would place embankment fills and cut slopes adjacent to residences, or would necessitate property acquisitions or retaining walls to prevent encroachment. Commercial properties would be similarly affected.

Major earthwork required for this alternative would include side slope modifications to provide adequate space for the mainline pavement, drainage ditches, and rockfall containment areas. Construction would need to occur in phases to maintain traffic. Outside construction would occur first, followed by reconstruction of existing pavement areas. Construction equipment and workers would have an open work zone with nearly unrestricted access when working in the new pavement areas. Provisions for traffic to cross the work zone to access the interchanges would be required.

Figure 24 illustrates the typical section for the Outside Widening Alternative.

Figure 24 – Outside Widening Alternative



Recommendations

The Outside Widening Alternative is not recommended for further consideration, except in specific areas, for the following reasons:

- Impacts to adjacent properties and forest lands would increase.
- Extensive modifications would be required for existing interchange ramps.
- Need for retaining walls where cut slopes would impact existing underpass structures and ramp fill slopes.
- Additional outside drainage elements in existing pavement substructure would require reconstruction (MP 185 to MP 188).
- Requires much more R/W than the Inside Widening Alternative.

The Inside Widening Alternative is recommended for further consideration throughout the length of the project because:

- The existing rural characteristics of I-40 would be retained and a wide median would remain.
- Impacts to adjacent properties and forest lands would be minimized.
- Initial constructability would not impact access to existing interchange ramps, despite the added challenges of the confined work zone.

Although the Inside Widening Alternative is recommended as a corridor-wide alternative, many segments should be considered for outside widening or reconstruction where terrain constraints exist in the median or opportunities exist for improvement of the existing roadway geometry.

3.4 Improvements to Existing Traffic Interchanges

3.4.1 Introduction

Alternative design concepts were developed for five of the ten existing interchanges within the project limits. The following sections will describe the alternatives which were developed and evaluated for the Bellemont, Butler, and Cosnino traffic interchanges. Multiple alternatives were not developed for the Walnut Canyon and Winona TIs; however, they are included in this chapter since major reconstruction is proposed.

3.4.2 Bellemont TI (MP 185.15)

At the existing Bellemont TI (MP 185.15), the need to improve the capacity and safety features of the existing interchange was identified. A project assessment prepared for this location in 2009 recommended reconstruction of the interchange in its current location. However, the previous recommendations are re-evaluated in this report with emphasis on the proposed I-40 widening and development of the adjacent properties.

Existing Conditions

Within the interchange limits, I-40 consists of two 12-foot lanes, a 10-foot outside shoulder, and a 4-foot inside shoulder in each direction. The eastbound and westbound mainlines are separated by a 162-foot wide, naturally-vegetated median. The typical section is rural with roadside ditches. The posted speed of the mainline in this area is 75 mph. The terrain at the interchange is level with an average elevation of 7130 feet.

The entrance and exit ramps are taper type ramps. The entrance ramp widths vary from 18 feet to 22 feet. The exit ramps are 22 feet wide. The ramps widen at the intersections with the cross road to provide left and right turn lanes. The ramp intersections are spaced 600 feet apart. Ramp gore lighting is present.

The existing cross road, Transwestern Road, varies in width from 28 to 38 feet, wider south of the eastbound ramp intersection and narrower north of the westbound ramp intersection. Two three-span steel girder bridges cross over I-40. The bridges and the roadway between the ramp intersections are 34 feet wide. Transwestern Road was constructed on a horizontal tangent and both structures are located within a 400-foot crest vertical curve. The approach grades are 1.25% from the south and 3.12% from the north. The speed limit is not posted on the cross road within the limits of the interchange.

There are existing frontage roads to the north and south of the interchange. The cross road and the north frontage road intersect roughly 300 feet north of the westbound ramp intersection at a 30° skew. The north frontage road, Shadow Mountain Drive, is 26 feet wide and carries two-way traffic. The south frontage road, Bellemont Camp Road, intersects the cross road approximately 300 feet south of the eastbound ramp intersection. Bellemont Camp Road is a 22-foot wide two-way roadway. Both frontage roads are located outside of the ADOT R/W and are under the jurisdiction of Coconino County.

Photograph 3-1. Bellemont TI looking north toward truck stop.

The adjacent land use affects traffic operations. The fueling operations of the truck stop located directly north of the northern frontage road intersection in the northwest quadrant of the interchange and the residential development in the northeast quadrant create a mix of vehicle types. The close proximity of the truck stop to the westbound ramps and queuing vehicles cause congestion and interrupt traffic flow. The line of trucks often blocks the cross road intersection and even extends onto the ramps. The land to the south of the interchange is zoned for commercial use along the frontage road. Camp Navajo to the south is accessed from this interchange as well. Planned future development at Camp Navajo is anticipated to generate substantial volumes of mixed traffic, which will cause the operations of this interchange to deteriorate further if left in its current configuration.

Bellemont TI Alternatives

Two alternatives were developed to improve the operations and geometric features of this interchange.

Realigned Diamond Alternative – This alternative would shift the cross road approximately 800 feet to the east of the existing cross road. New ramps would be constructed in all four quadrants. The frontage road to the south would need to be raised to connect the railroad bridge to the south and the new interchange structures to the north. The maximum grade on the cross road south of the ramps would be 3%; the maximum grade on the south frontage road (Bellemont Camp Road) would be 5%.

During the development of this alternative, different intersection types were proposed at the cross road/ramp intersections. Traffic projections indicate that stop-controlled ramp intersections would not provide an adequate LOS for the design year traffic. Two intersection types, roundabout and signalized, would provide an adequate LOS. Figure 25 illustrates the two intersection sub-alternatives.

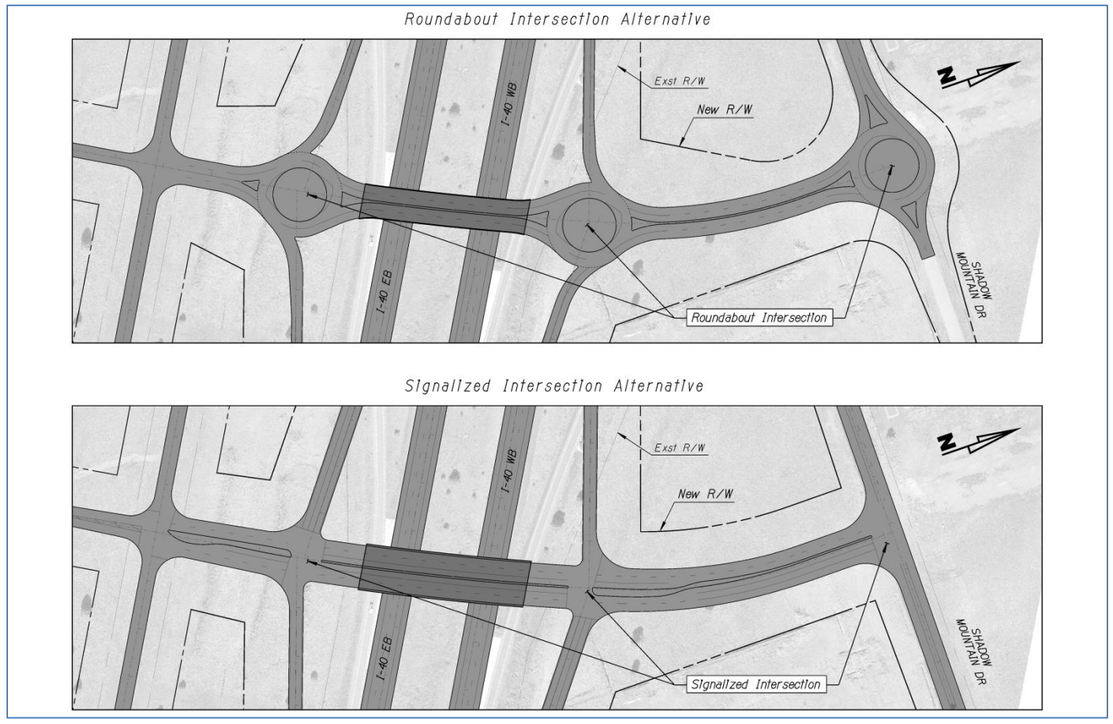
The roundabout sub-alternative would eliminate the need for the left-turn lanes and would require a 64-foot roadway cross section including two 12-foot lanes and a 4-foot outside shoulder in each direction separated by a 4-foot median.

The signalized sub-alternative would require an 88-foot cross road, which would include two 12-foot travel lanes, one 12-foot left-turn lane, and a 4-foot outside shoulder in each direction separated by a 4-foot median.

The approximate R/W required for both sub-alternatives is 19.3 acres.

The evaluation of the intersection types included LOS, consistency with setting, construction cost, maintenance requirements, and lighting impacts.

Figure 25 – Bellemont Intersection Sub-Alternatives



The signalized intersection sub-alternative is not recommended for further study for the following reasons:

- Inconsistency with rural setting. Signals are not typical in rural areas in Arizona.
- Higher bridge cost due to wider cross road.
- Higher cost for traffic signals and the maintenance costs associated with them.

While the signalized intersection layout would provide a comparable LOS and better accessibility for large trucks, the disadvantages outweigh those factors.

The roundabout intersection sub-alternative is recommended for the following reasons:

- The yield-control nature of a roundabout would be more consistent with a rural setting that would typically be stop-controlled without signals.
- Reduced bridge cost due to narrower cross road.
- Reduced maintenance requirements without signals.

The Realigned Diamond with Roundabouts Alternative is illustrated on Figure 26.

Split Diamond Alternative – This alternative was developed to better separate heavy truck traffic and residential traffic. This concept would include two separate crossings of I-40 and a system of one-way directional roadways (Figure 27).

This alternative would realign the interchange to provide more space for trucks to queue in advance of the truck stop. However, instead of moving the entire cross road east, this alternative would move only the eastern half. The west-side diamond ramps would be re-used while the eastern ramps would be shifted east along with the northbound cross road. A pair of connector ramps would link the ramps and cross road half-streets to complete the one-way network. The northbound half-street would be shifted 500 feet east. This distance would create a nearly-square circulatory network resulting in desirable signal timing.

North of the interchange, Shadow Mountain Drive would be realigned to curve into the northbound cross road half-street. Brannigan Park Road would be realigned to a "T" intersection with Shadow Mountain Drive.

This alternative would require two new bridges, with two southbound lanes and three northbound lanes. Even though the existing cross road would be used for the southbound half-street, the existing bridge would need to be replaced in order to widen I-40.

The approximate R/W required for this alternative would be 12.6 acres.

Evaluation

The evaluation of the interchange alternatives included the following criteria:

- LOS
- Consistency with setting
- Structure requirements
- Roadway geometrics
- R/W needs

Table 40 – Bellemont TI Evaluation Matrix

Criterion	No Build	Bellemont TI Realigned Diamond	Bellemont TI Split Diamond
Description	Would maintain existing TI at current location.	New compact diamond TI shifted 800 feet east of the existing TI.	New interchange with two separate structures 500 feet apart.
2040 Level of Service	LOS F	LOS D	LOS E
Consistency with Rural Setting	Consistent with rural setting.	Consistent with rural setting (roundabout).	Signals not consistent with rural setting. One-way traffic patterns would cause potential for confusion.
Geometry	Sharp curves on Hughes Ave. would remain.	Sharp curves on Hughes Ave. would be eliminated.	Sharp curves on Hughes Ave. would remain.
Structures	Existing structures would remain.	One new 5-lane structure would be required. Existing structures would be removed.	New 2- and 3-lane structures would be required. Existing structures would be removed.
Estimated R/W (Preliminary)	0 acres	19.3 acres	12.6 acres
Earthwork	None	More	Less

Recommendations

The Split Diamond Alternative is not recommended for the following reasons:

- Lower LOS than the Realigned Diamond Alternative; wouldn't meet RDG LOS goal for urban/fringe urban classification.
- Inconsistent with rural setting.
- Users could be confused by one-way traffic movements.
- Higher cost associated with construction of two independent bridges with larger combined area.
- Higher construction and maintenance costs for traffic signals.

Based on the evaluation, the Realigned Diamond with Roundabouts Alternative is recommended.

Figure 26 – Bellemont TI Realigned Diamond with Roundabouts Alternative

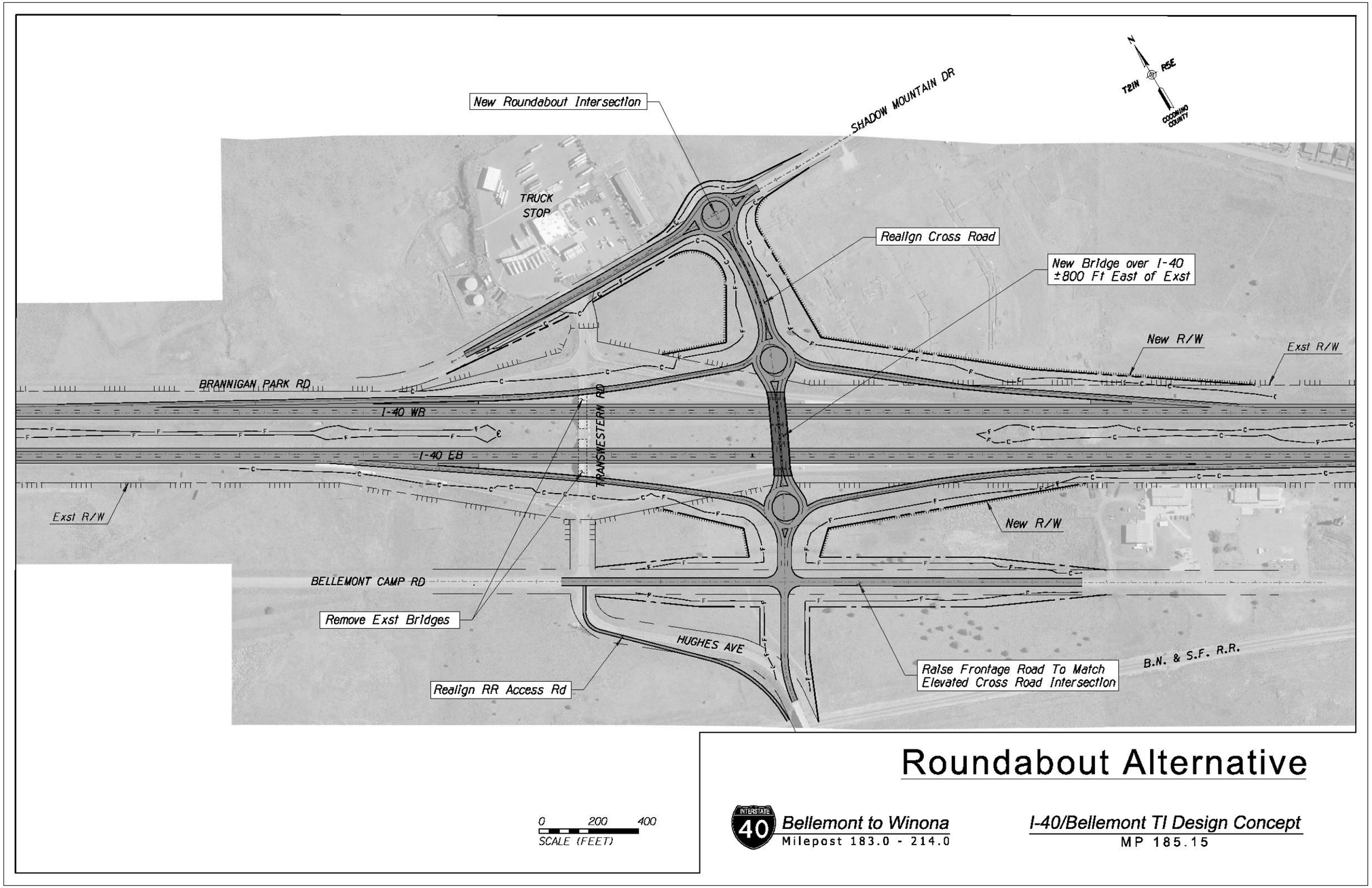
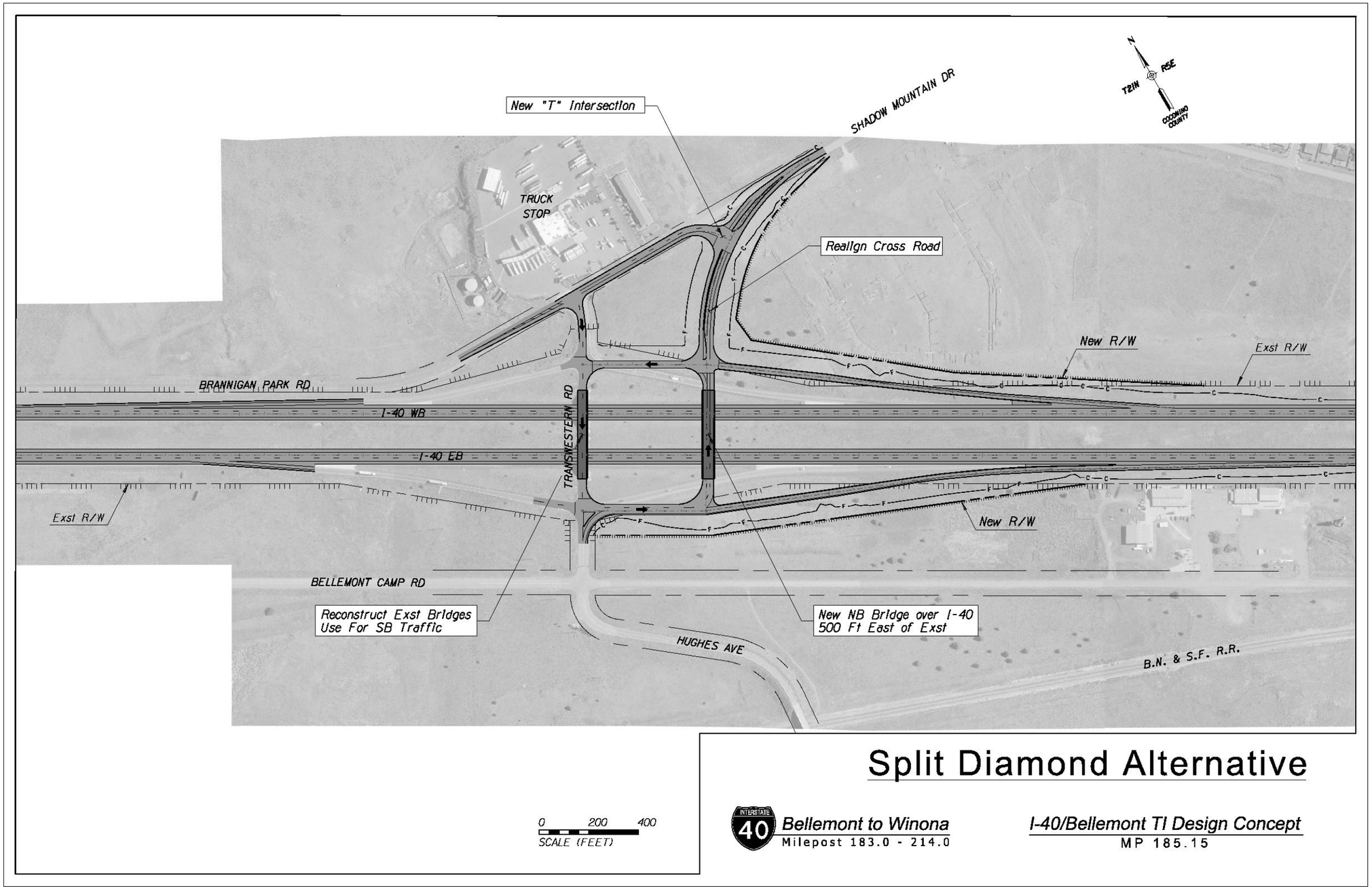


Figure 27 – Bellemont TI Split Diamond Alternative



3.4.3 Butler Avenue TI (MP 198.28)

Existing Conditions

The Butler TI provides access to a minor arterial that runs generally east-west through Flagstaff. The interchange was constructed as a diamond-type interchange in 1988. Because the Little America hotel and truck stop are immediately adjacent to I-40 and Butler Avenue in the southeast quadrant of the interchange, the interchange serves a large number of trucks. Access points to other businesses are located very near the ramp/ cross road intersections.

The existing ramps are single-lane ramps, with the exit ramps widening to two lanes near the intersections with the cross road. Because the ramps are skewed, left-turning traffic from the exit ramps must perform a 120-degree turning movement, which is a slow and difficult movement for large trucks.

The need to improve the capacity and operations of the existing Butler TI was identified because of the interchange geometrics and the heavy truck volumes. A project assessment was prepared for this interchange in 2007 which recommended widening the existing exit ramps to help mitigate the skewed intersections and improve truck turning movements.

Roundabouts at the Butler Avenue/ramp intersections were also evaluated in a previous study for the City of Flagstaff. Coordination with the intersection to the west at Enterprise Road, and to the east at Herold Ranch Road, was recommended, and a series of four roundabouts with a raised median in between was discussed. However, the study was not completed and the final evaluation for the Butler TI was deferred to this I-40 study.

In accordance with the mainline recommendations, the I-40 bridges over Butler Avenue would need to be widened to add mainline capacity.

Butler TI Alternatives

Four alternatives were developed to improve the operations and geometric features of this interchange. The alternatives are shown in Figures 28 through 31.

Diamond with Roundabouts Alternative – This configuration is similar to the concept developed in the previous study which evaluated roundabouts at several locations along the Butler Avenue corridor.

Because the existing Butler Avenue cross section would not need to be widened for the roundabout alternative, replacement of the I-40 bridges would not be required. However, the profile of Butler Avenue would need to be lowered approximately three inches to provide adequate vertical clearance. No external storage for turn lanes would be required.

The City of Flagstaff or its developer may construct a roundabout at Herold Ranch Road east of the interchange; however, a roundabout to the west is not currently planned. The roundabout alternative would function best with a raised median between the roundabouts at the ramps and at Herold Ranch Road to control access for turning vehicles near the interchange.

This alternative would provide good LOS (A-C) at the ramp intersections. Lower speeds with roundabouts generally translate to less-severe crashes. Signalization is not required for this alternative; therefore, there would be no signal maintenance costs, although signing and pavement marking requirements could increase with roundabouts.

Roundabouts could present more challenges for pedestrians and bicycles than other alternatives. Pedestrians traveling along Butler Avenue could have difficulty crossing the yield-controlled ramps. Bicycle movements could be accommodated; bicycles would either exit the roadway prior to entering the roundabouts via bike ramps and proceed through the interchange on the wider mixed-use sidewalk, or ride through the roundabouts on the roadway with other vehicles.

Approximately 0.6 acre of R/W would be required for this alternative in the northwest and southeast quadrants. Access at the westernmost Little America driveway should be limited to right-in/right-out. The City of Flagstaff has recently limited Lucky Lane to right-in/right-out access at Butler Avenue as mitigation for a new development.

The roundabout would have the lowest construction cost of the Butler TI alternatives because there would be no signals, there would be no need to widen Butler Avenue under I-40 or replace the I-40 bridges, and a minimal amount of new R/W would be required. However, signing and pavement marking costs would likely be higher for the roundabout alternative.

Sidewalks would be provided on both sides of the cross road. Grade-separated pedestrian crossings could be provided for the south side of Butler Avenue at the ramp intersections. The depressed crossings would extend the separation for pedestrians from vehicular traffic eastward from a similar grade separation at Enterprise. Concerns about the pedestrian grade separations include the following:

- There may not be a heavy demand for pedestrian crossings on Butler Avenue. Current pedestrian counts are not available.
- Depressed pedestrian crossings could have safety and maintenance issues, e.g., attraction to homeless people, roadway icing in winter months.
- Snow removal would increase maintenance costs.
- Draining the undercrossings would require approximately 4100 feet of pipe.
- The pedestrian crossings would reduce the storage area for snow that has been removed from the roadway and sidewalk.

Signalized Diamond Alternative – This configuration would require widening Butler Avenue to seven lanes under I-40, which would require the mainline bridges to be replaced. Two westbound lanes and two eastbound lanes with dual left-turn lanes in each direction would be needed on the cross road in the interchange area. No external storage would be required, but a third lane in each direction extending beyond the ramp intersections would be converted into a turn lane under the mainline bridges.

The Diamond Alternative would provide good LOS (B-C) at the ramp/cross road intersections in the AM and PM peak hours.

New R/W would be required in all four quadrants of the interchange, including full acquisition of the gas stations in the northeast and southwest quadrants. Approximately 1.4 acres of new R/W would be required. The access to the properties in the southeast and northwest corners would be restricted to right-in/right-out with raised medians.

Pedestrian crossings of the yield-controlled entrance ramps could be difficult. Bicycles would also cross the yield-controlled entrance ramps.

Double Crossover (Diverging Diamond) Alternative – The double crossover configuration would widen Butler Avenue to three lanes in each direction and "cross" the eastbound and westbound traffic lanes to the opposite sides through the interchange to facilitate left-turn operations to and from the ramps. The "crossover" intersections would be signalized; the ramp intersections would be stop- or yield-controlled. No external turn storage would be required, although the third lane in each direction would be added beyond the ramp intersections.

Figure 28 – Butler TI Diamond with Roundabouts Alternative

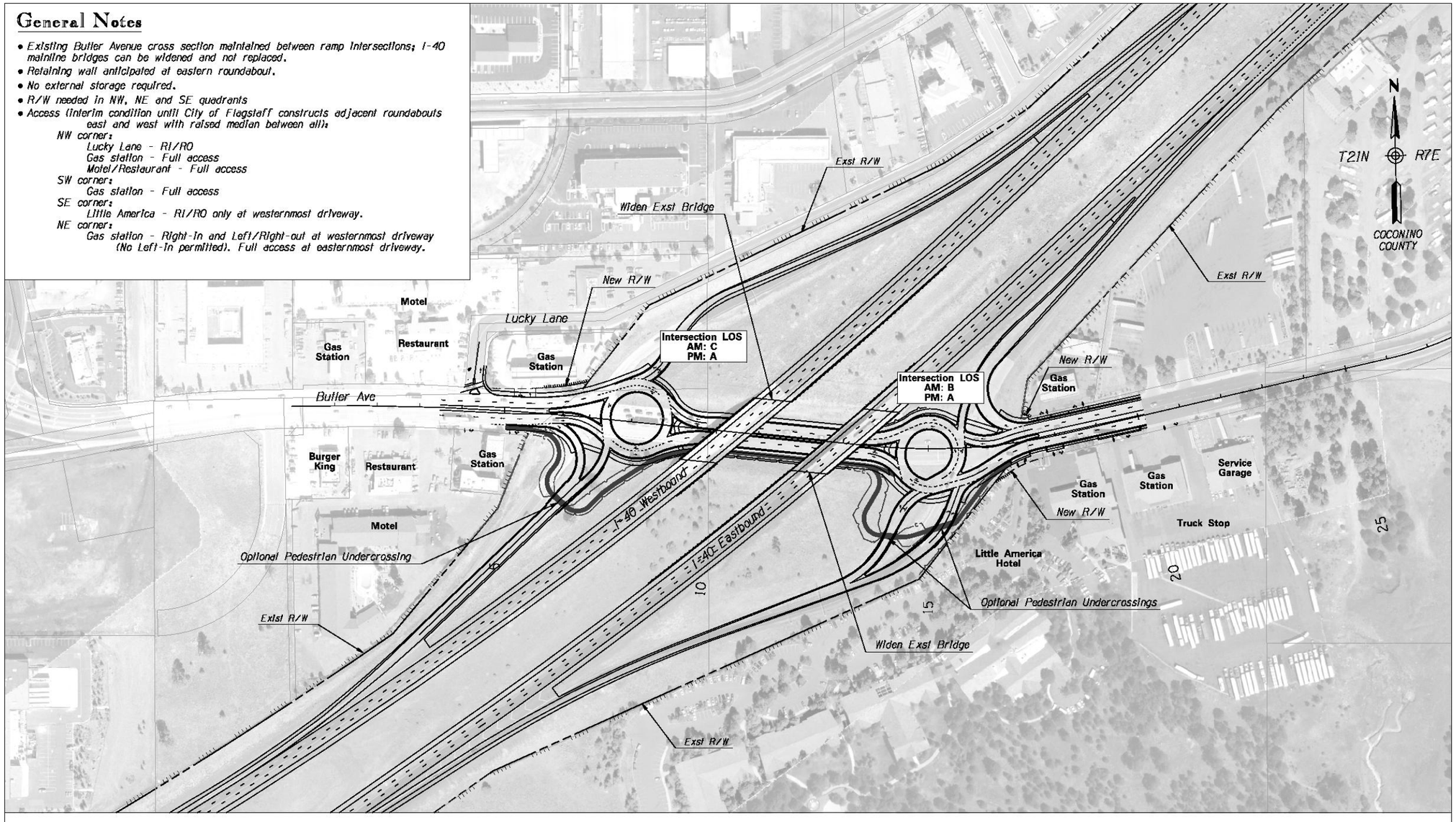


Figure 29 – Butler TI Signalized Diamond Alternative

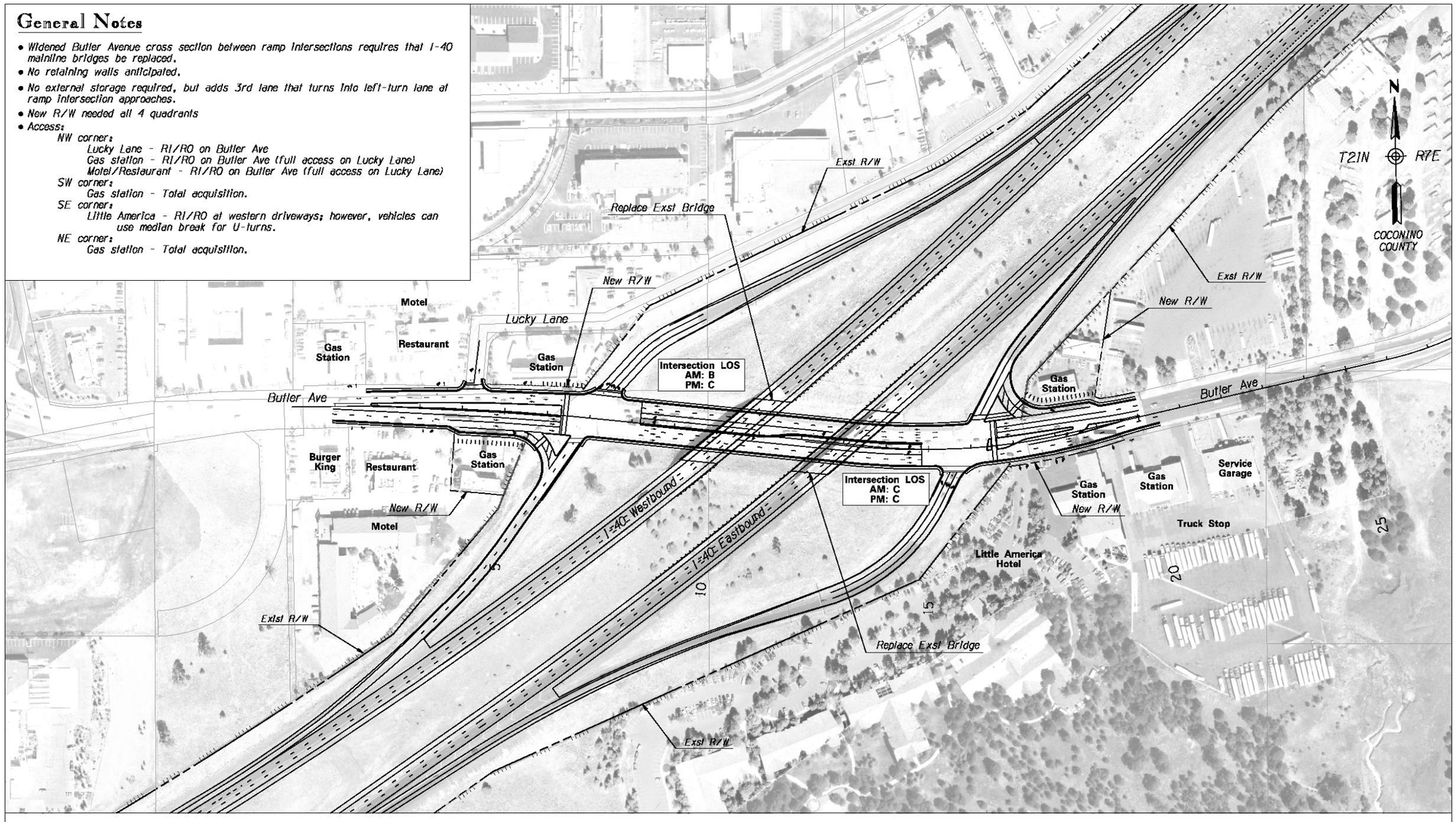


Figure 30 – Butler TI Double Crossover Alternative

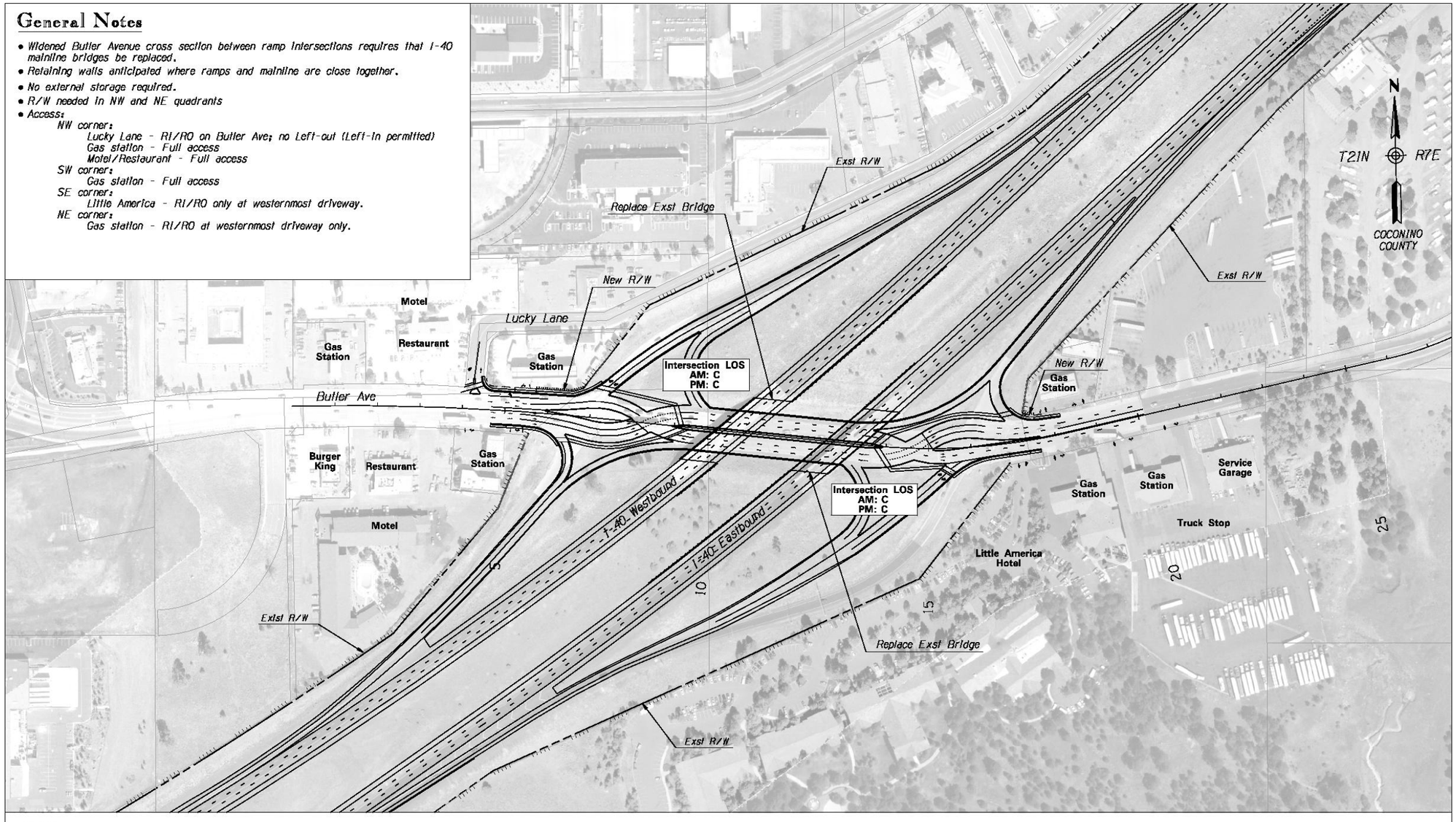
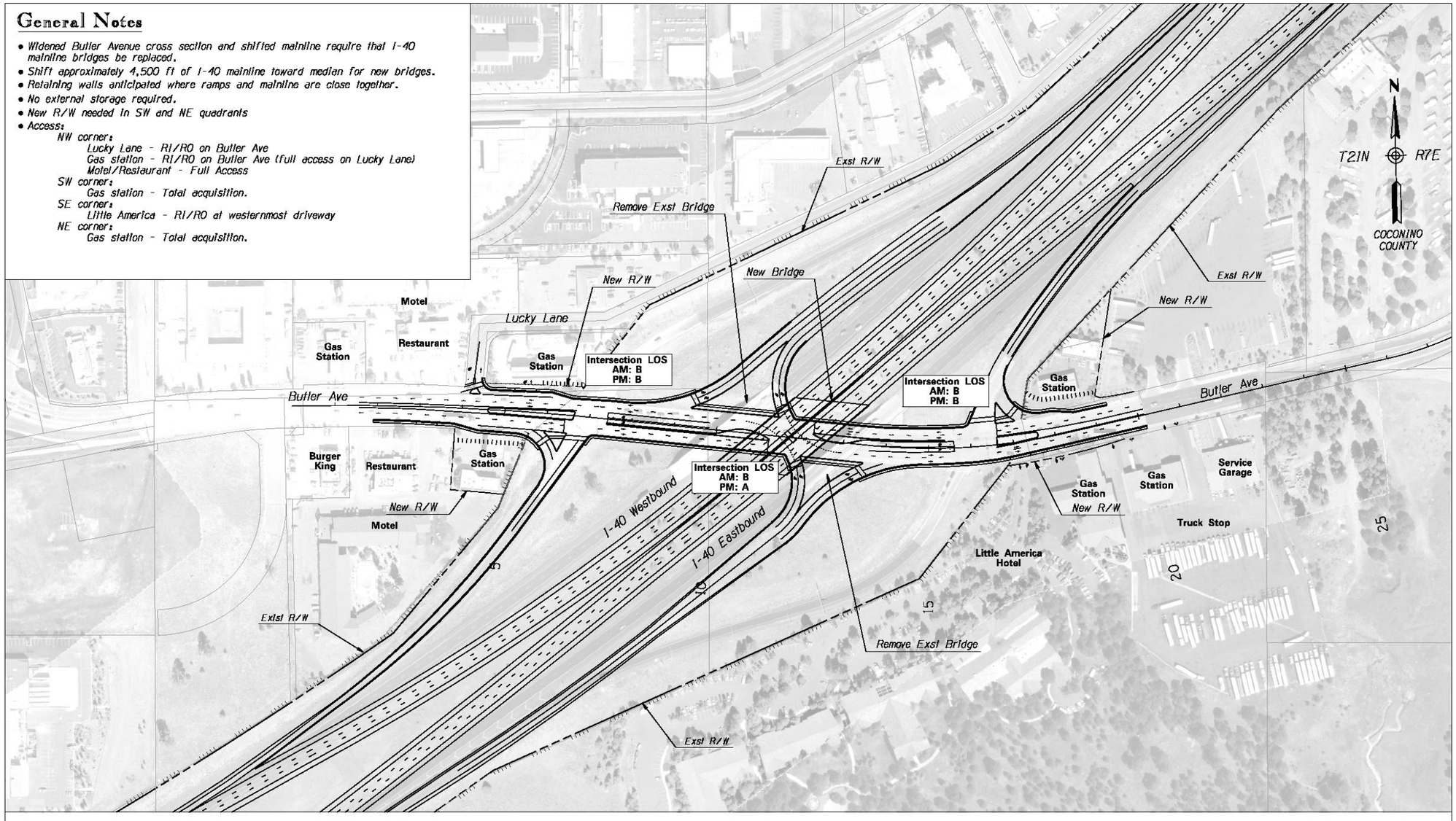


Figure 31 – Butler TI Three-Point Urban Interchange Alternative



Because of the widened cross road, this configuration would require replacement of the mainline bridges. Retaining walls could be required.

The Double Crossover Alternative would provide fair LOS (C) in the AM and PM peak hours.

Less than 0.1 acre of R/W would be required for this alternative in the northwest and the northeast quadrants. Access to the properties in the southeast and northeast corners would be restricted to right-in/right-out with raised medians.

All pedestrian movements would be accommodated. Pedestrians would be channeled to the median of the roadway between the crossover intersections. This area would be protected by barrier on both sides. Pedestrians would need to cross yield-controlled right turns. All bicycle movements would be accommodated. Bicyclists would remain in the outside lane before the crossover intersections. This lane would become the inside lane between the crossover intersections, separating the bicycle traffic from the merging/diverging ramp traffic.

No similar interchange configurations exist in Arizona; however, double crossover interchanges have been constructed elsewhere in the US.

Three-Point Urban Interchange Alternative – This alternative would re-align the eastbound and westbound I-40 roadways toward the median and re-align the exit ramps toward the mainline to intersect the cross road under the mainline in a single intersection. The entrance ramps would intersect the cross road in approximately the locations of the existing ramp intersections. All three intersections would be signalized.

This configuration would require that approximately 4500 feet of the eastbound and westbound I-40 roadways be shifted toward the median to create distance between the outer intersections and to bring together the left-turn movements of the exit ramps onto Butler Avenue. Retaining walls would likely be needed near the bridge abutments.

The Three-Point Urban Interchange Alternative would provide good LOS (A-B) in the AM and PM peak hours. The three signals could be operated with one controller to effectively coordinate the movements.

New R/W would be required in all four quadrants of the interchange, including full acquisition of the gas stations in the northeast and southwest quadrants. Approximately 1.3 acres of new R/W would be required. The access to the properties in the southeast and northwest corners would be restricted to right-in/right-out with raised medians.

Pedestrians and bicycles along Butler would need to cross the yield-controlled right turn ramps movements. The crossing of the left-turn ramps would be signal controlled. Pedestrians would not be able to cross Butler Avenue without additional signal control, which could reduce the LOS of the intersections and increase delay, depending on the amount of pedestrian traffic.

Because of the required mainline re-alignment and new bridge, this alternative would be the most expensive of the Butler TI alternatives.

Evaluation

The evaluation of the Butler interchange alternatives (Table 41) included the following criteria:

- LOS
- Pedestrian and bicycle movements
- Construction implementation
- Access impacts
- R/W needs

Recommendations

The Three Point Urban Interchange Alternative is not recommended for further study for the following reasons:

- Potential impacts to business access are relatively high.
- Pedestrian crossings across Butler Avenue would decrease intersection LOS.
- Mainline realignment/reconstruction required.
- Much higher construction cost than other alternatives.

The Roundabout, Signalized Diamond, and Double Crossover alternatives are recommended for further study and discussion for the following reasons:

- Acceptable operations for pedestrians and bicyclists.
- Good LOS.
- Relatively low to moderate construction costs.

Table 41 – Butler TI Evaluation Matrix

Criterion	No Build Signalized Diamond (5-lane) Alternative	Roundabouts Alternative	Signalized Diamond (7-lane) Alternative	Double Crossover Alternative	Three Point Urban Interchange Alternative	Advantage / Comment
Description	Maintain existing interchange configuration. No improvements to existing infrastructure.	Reconfigure diamond interchange with roundabouts at the ramp intersections.	Widen existing diamond interchange to 7 lanes.	Shift cross road traffic to opposite sides of the roadway between the ramp intersections to eliminate the need for left turn signal phases.	Similar to a Single Point Urban interchange, but because of the skew, the entrance ramp intersections would be located to the outside. Two-phased signal control at all three intersections.	--
Ramp Intersection Level of Service Design Year 2040 LOS (Delay in seconds/vehicle)	<u>EB Ramps LOS</u> AM: F PM: F <u>WB Ramps LOS</u> AM: F PM: F	<u>EB Ramps LOS</u> AM: B (13.0) PM: A (7.0) <u>WB Ramps LOS</u> AM: C (16.7) PM: A (7.5)	<u>EB Ramps LOS</u> AM: C (28.1) PM: C (27.7) <u>WB Ramps LOS</u> AM: B (17.4) PM: C (24.1)	<u>EB Ramps LOS</u> AM: C (22.9) PM: C (22.1) <u>WB Ramps LOS</u> AM: C (21.7) PM: C (33.7)	<u>EB On Ramp LOS</u> AM: B (13.0) PM: B (11.4) <u>EB/WB Off Ramps LOS</u> AM: B (10.3) PM: A (7.6) <u>WB On Ramp LOS</u> AM: B (10.2) PM: B (14.3)	Advantage: **Roundabout** and **Three Point Urban** alternatives. They both offer slightly better LOS and lower delay times.
Pedestrian and Bicycle Movement The ability for pedestrians and bicyclists to be able to move through the interchange. Factors include ease or familiarity with operations, ability to cross intersections, affects on vehicle traffic. (Good-Fair-Poor)	Pedestrian crossings of Butler can be accommodated. Pedestrian travel along Butler across the yield-controlled ramp entrances may be difficult. Bicycles must cross the yield-controlled entrance ramps. Good	Pedestrian crossings of Butler can be accommodated. Pedestrian travel along Butler across the yield-controlled ramp entrances and exits may be difficult. Mitigated with pedestrian grade separation option. All bicycle movements can be accommodated. Bicycles can either exit the roadway prior to entering the roundabouts via bike ramp and proceed through the interchange on the wider mixed-use sidewalk, or ride through the interchange on the roadway with other vehicles. Fair	Pedestrian crossings of Butler can be accommodated. Pedestrian travel along Butler across the yield-controlled ramp entrances may be difficult. Bicycles must cross the yield-controlled entrance ramps. Good	All pedestrian movements can be accommodated. Pedestrians are funneled to the median of the roadway between the crossover intersections. This area is protected by barrier on both sides. Pedestrians must cross yield-controlled right turns. All bicycle movements can be accommodated. Bicyclists would remain in the outside lane before the crossover intersections. This lane would become the inside lane between the crossover intersections, separating the bicycle traffic from the merging/diverging ramp traffic. Good	No pedestrian access across Butler Avenue without additional signal control. This could reduce the LOS of the intersections and increase delay, depending on the amount of pedestrian traffic. Pedestrians and bicycles along Butler must cross the yield-controlled right turn ramps movements. The crossing of the left-turn ramps is signal controlled. Fair	Advantage: **Signalized Diamond** and **Double Crossover** alternatives. Also **Roundabout** Alternative if optional pedestrian undercrossings implemented.

Criterion	No Build Signalized Diamond (5-lane) Alternative	Roundabouts Alternative	Signalized Diamond (7-lane) Alternative	Double Crossover Alternative	Three Point Urban Interchange Alternative	Advantage / Comment
Construction Phasing Opportunities **I-40 Mainline Structures** (Widen - Replace)	N/A	Mainline and interchange/cross road improvements could be constructed independently. Cross road widening not required. I-40 structures would be widened to accommodate added lanes on I-40 only.	No opportunities for phasing interchange construction. Mainline bridges would need to be replaced in order to widen cross road.	No opportunities for phasing interchange construction. Mainline bridges would need to be replaced in order to widen cross road.	No opportunities for phasing interchange construction. Mainline bridges would need to be replaced in order to widen cross road and reconstruct interchange. Approximately 4500' of mainline I-40 would need to be realigned and reconstructed to accommodate interchange type.	Advantage: **Roundabout** Alternative. Interchange can be reconfigured separate from I-40 widening.
Relative Construction Cost (Low - Medium - High)	N/A	Low	Medium	Medium	High	Advantage: **Roundabout** Alternative
Potential Crash Severity (# vehicle conflict points; merge, diverge, & crossing)	Normal (26 conflict points total; 8 crossing conflicts)	Expected to result in fewer and less severe crashes than a conventional intersection. Lower-speed operation, reduced right-angle collision potential (18 conflict points total; 0 crossing conflicts)	Normal (26 conflict points total; 8 crossing conflicts)	Expected to result in fewer crashes than a conventional intersection. (14 conflict points total, 2 crossing conflicts) Potential wrong-way movements onto ramps are eliminated.	Expected to result in fewer crashes than a conventional intersection. (12 conflict points total; 4 crossing conflicts.)	Advantage: **Roundabout, Double Crossover, and Three Point Urban** Alternatives
Pedestrian Conflicts (# conflict points)	(10 crossing conflicts at signalized intersections) Pedestrians **can** cross Butler Avenue	(11 crossing conflicts at median splitter islands) Pedestrians **can** cross Butler Avenue	(10 crossing conflicts total; 8 crossings at signalized intersections and 2 crossings at yield-controlled ramps) Pedestrians **can** cross Butler Avenue	(8 crossing conflicts total; 4 crossings at signalized intersections and 4 crossings at yield-controlled ramps) Pedestrians **can** cross Butler Avenue	(8 crossing conflicts total; 4 crossings at signalized intersections and 4 crossings at yield-controlled ramps) Pedestrians **cannot** cross Butler Avenue without introducing a separate pedestrian phase.	Advantage: **Double Crossover** Alternative
Driver Expectancy	Common interchange type; good driver expectancy.	Complex geometry could cause some driver confusion.	Common interchange type; good driver expectancy.	Potential for some confusion due to crossing traffic between interchange ramps.	Potential for some confusion due to unique configuration but has familiar interchange operations.	Advantage: **Signalized Diamond** Alternative
Maintenance Cost (Low - Medium - High)	Maintenance costs for two signalized intersections. Snow removal costs for 5-lane cross road. Medium	Roundabouts eliminate the cost associated with maintenance of traffic signals. Additional signage is required for roundabouts; and their maintenance costs are much less compared to traffic signals. Snow removal costs for 4-lane cross road. Low	Maintenance costs for two signalized intersections. Snow removal costs for 7-lane cross road. High	Maintenance costs for two signalized intersections. Snow removal costs for 6-lane cross road. Medium	Maintenance costs for three signalized intersections. Snow removal costs for 6-lane cross road. High	Advantage: **Roundabout** Alternative
Estimated R/W Acquisition Measured 10' behind back of sidewalk (Low - Medium - High)	N/A	Low (0.6 acres) New R/W needed in NW, NE, and SE quadrants. Depending on existing utility/landscape easements adjacent to Butler Ave, potential temporary construction easements are needed for improvements.	High (1.4 acres) New R/W needed all 4 quadrants (acquisition of part or all of 3 gas station properties adjacent to the ramp intersections and a sliver of the Little America property is necessary).	Low (0.1 acres) New R/W needed in NW and NE quadrants. Depending on existing utility/landscape easements adjacent to Butler Ave, additional potential temporary construction easements for improvements in NW and NE quadrants.	High (1.3 acres) New R/W needed in all 4 quadrants (acquisition of part or all of 3 gas station properties adjacent to the ramp intersections and a sliver of the Little America property is necessary).	Advantage: **Roundabout** and **Double Crossover** Alternatives

Criterion	No Build Signalized Diamond (5-lane) Alternative	Roundabouts Alternative	Signalized Diamond (7-lane) Alternative	Double Crossover Alternative	Three Point Urban Interchange Alternative	Advantage / Comment
Potential Impacts to Adjacent Business Access (Listed by quadrants: NW,SW,SE,NE)	No change	Access (interim condition until City of Flagstaff constructs adjacent roundabouts east and west with raised median between all): *NW quadrant:* Lucky Lane – Right in/right out Gas station - Full access Motel/Restaurant - Full access *SW quadrant:* Gas station - Full access *SE quadrant:* Little America - RI/RO only at westernmost driveway *NE quadrant:* Gas station – RI/RO and left in at westernmost driveway. Full access at eastern driveway.	*NW quadrant:* Lucky Lane - Right in/right out Gas station - RI/RO on Butler Ave (full access on Lucky Lane) Motel/Restaurant - RI/RO on Butler Ave (full access on Lucky Lane) *SW quadrant:* Gas station – Total acquisition. *SE quadrant:* Little America - RI/RO at western driveways; however, vehicles can use median break for U-turns *NE quadrant:* Gas station – Total acquisition.	*NW quadrant:* Lucky Lane - Right in/right out Gas station - Full access Motel/Restaurant - Full access *SW quadrant:* Gas station - Full access *SE quadrant:* Little America - RI/RO at westernmost driveway *NE quadrant:* Gas station - RI/RO at westernmost driveway only	*NW quadrant:* Lucky Lane - Right in/right out Gas station - RI/RO on Butler Ave (full access on Lucky Lane) Motel/Restaurant - Full access *SW quadrant:* Gas station - Total acquisition. *SE quadrant:* Little America - RI/RO at westernmost driveway *NE quadrant:* Gas station - Total acquisition.	Advantage: **Roundabout** and **Double Crossover** Alternatives.
Magnitude of Potential Access Impacts (Listed by quadrants: NW,SW,SE,NE) Magnitude of Potential Impact Scale: (Low – Medium – High)	No change	*NW quadrant:* Low *SW quadrant:* Low *SE quadrant:* Medium *NE quadrant:* Low	*NW quadrant:* Medium *SW quadrant:* High *SE quadrant:* Medium *NE quadrant:* High	*NW quadrant:* Low *SW quadrant:* Low *SE quadrant:* Medium *NE quadrant:* Medium	*NW quadrant:* Medium *SW quadrant:* High *SE quadrant:* Medium *NE quadrant:* High	Advantage: **Roundabout** and **Double Crossover** Alternatives.

3.4.4 Walnut Canyon TI (MP 204.87)

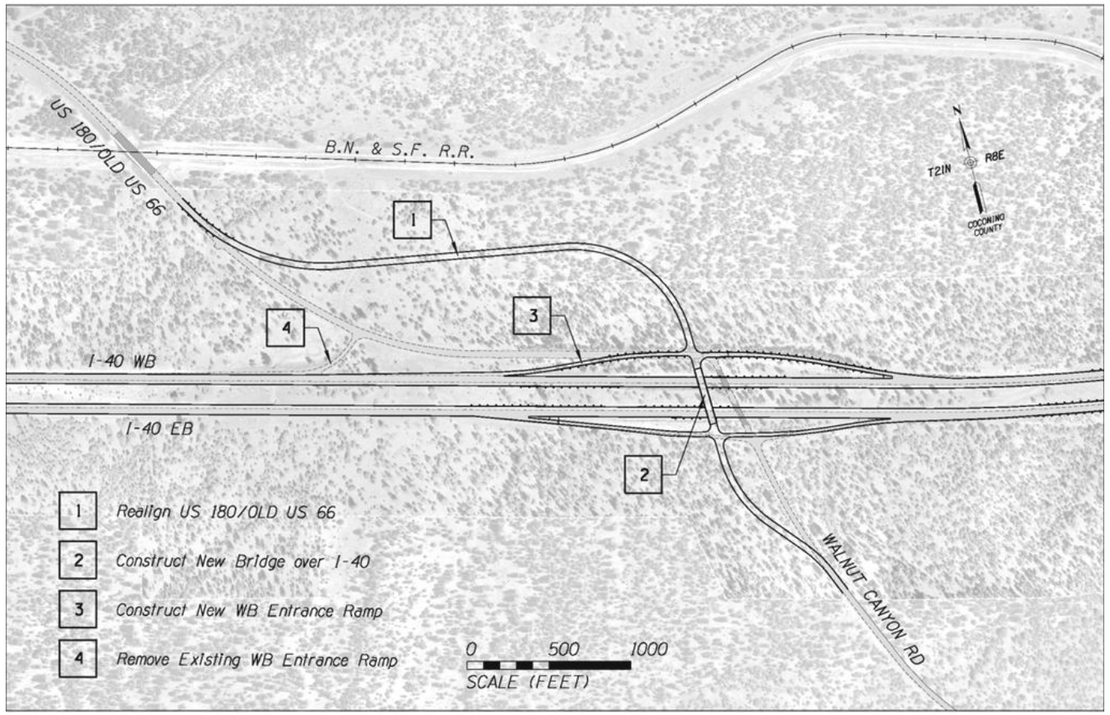
Existing Conditions

This interchange was originally constructed in 1966 and provides access to Walnut Canyon National Monument to the south and an alternate route to Flagstaff via Old US 66 to the north. The existing interchange is a diamond interchange, with the eastbound ramps and the westbound exit ramp in typical configurations, but with the westbound entrance ramp intersecting Walnut Canyon Road approximately 1300 feet west of the other ramp/ cross road intersections.

The structures at the Walnut Canyon TI (MP 204.87) are recommended for replacement because of vertical clearance and span lengths, which will not accommodate the proposed three-lane mainline roadway section (60 feet). Since the bridges need to be replaced for the mainline widening, it is recommended that the interchange reconstruction also include improving the cross road skew and reconfiguring the westbound entrance ramp to a standard diamond configuration.

The new configuration would re-align the cross road approximately 200 feet to the west and reduce the skew angle between I-40 and the existing cross road. This reduced skew would improve the sight distance and turning radii at the ramp intersections. A new three-span bridge would replace the existing bridges.

Figure 32 – Walnut Canyon TI Alternative



North of I-40, approximately 3600 feet of Walnut Canyon Road should be realigned to provide a longer tangent section north of the westbound ramp intersections and to increase the design speed of the roadway by increasing the horizontal curve radius immediately north of the westbound ramps. The realignment would shift the roadway approximately 750 feet north of I-40.

South of I-40, approximately 1300 feet of Walnut Canyon Road will be realigned to the west to connect the relocated cross road to the existing roadway alignment. The US Forest Service and National Park Service are conducting a study on the potential boundary expansion of Walnut Canyon National Monument. The Walnut Canyon National Monument visitor center may be relocated closer to I-40; however, a relocated visitor center should not be affected by the recommended improvements unless the relocation site is very near I-40.

Approximately 14.5 acres of new R/W would be required for the recommended Walnut Canyon TI improvements if the new R/W width for realigned US 180 would be 200 feet and the area between the existing ADOT R/W and realigned US 180 (16.8 acres) would not be acquired.

3.4.5 Cosnino TI (MP 207.24)

The existing Cosnino interchange was constructed as a partial cloverleaf, with diamond ramps in the northwest, southwest, and southeast quadrants. The westbound exit ramp is a loop ramp in the northwest quadrant.

The Cosnino TI UP bridge is a 311-foot long, five-span steel girder bridge. According to the 2008 ADOT bridge inspection report, the bridge is in good condition but has been classified as functionally obsolete because of 16.4-foot vertical clearance over the eastbound lanes and 15.8-foot clearance over the westbound lanes. The westbound mainline lanes and the loop ramp deceleration lane are in Span 2; the eastbound lanes occupy Span 4.

The widened mainline and the deceleration ramp would not fit within the space between the existing piers. Record drawings reflect a clear dimension of 68'-6" in Span 2. This provides adequate clear space for the typical 60-foot mainline roadway section between the piers, but not for the loop ramp deceleration lane.

A new bridge would be required to accommodate the widened roadway and achieve lateral clearances. The new bridge would need to have a deeper section than the existing bridge to span the wider mainline, requiring the profile of Cosnino Road to be raised several feet and requiring reconstruction of the cross road for nearly 0.5 mile. Ramps would also be reconstructed to match the elevated cross road.

Two alternatives were developed and are shown in Figures 33 and 34.

Loop Alternative **–** This alternative would maintain the existing loop geometry while widening the mainline by one additional lane in each direction. While initially envisioned as requiring minimal interchange reconstruction, this alternative would require reconstruction of much of the interchange due to the effect of raising the bridge elevation on the cross road and ramp profiles.

With the addition of the third mainline lane and the wider inside and outside shoulders, a new cross road structure with longer spans is proposed. The longer spans would result in a deeper structure depth, requiring the cross road profile to be raised. Raising the cross road profile would require reconstruction of the ramps to match the higher elevation. The existing 5% cross road approach grades would be steepened slightly. The limits of the reconstructed cross road would not impact the BNSF railroad structure to the north of the interchange.

Ramp horizontal alignments would be retained with this alternative. Design exceptions would be required for existing curves that exceed the maximum curvature per the RDG as shown in the following table:

Figure 33 – Cosnino TI Loop Alternative

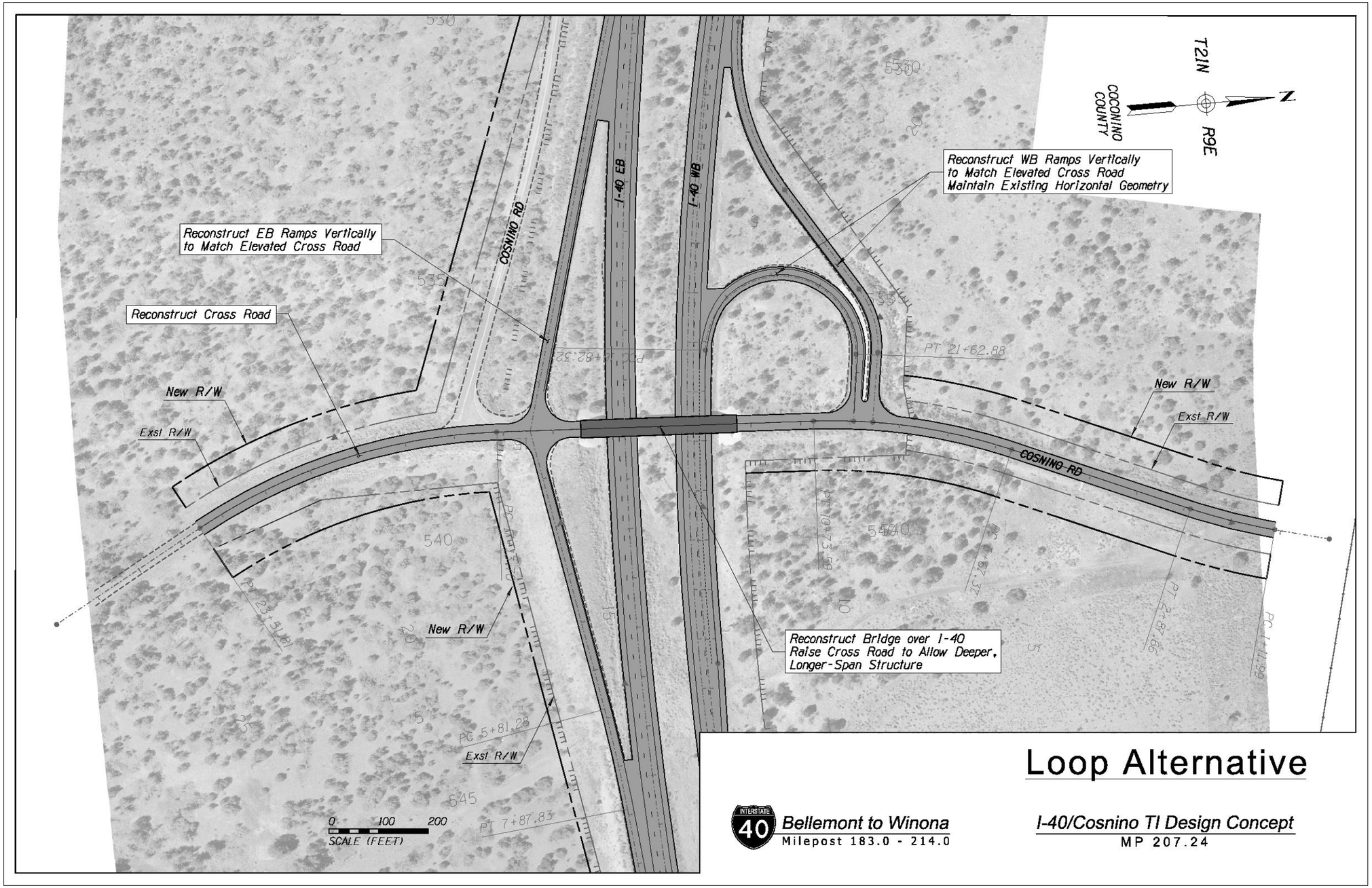
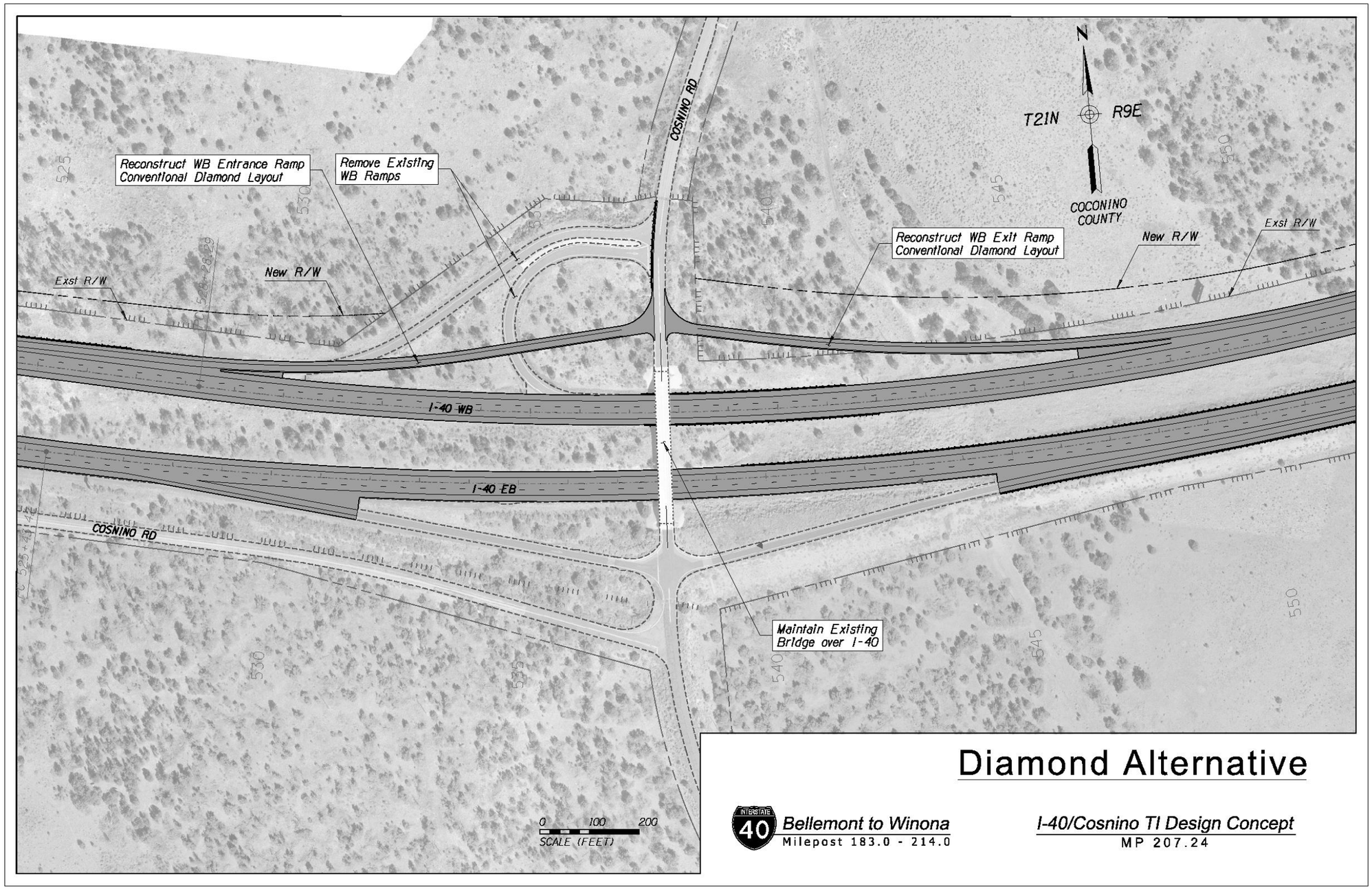


Figure 34 – Cosnino TI Diamond Alternative



	Existing Curve	Maximum Allowable
WB entrance ramp (near mainline)	12°-00’	6°-53’
WB entrance ramp (near cross road)	30°-13’	18°-20’
WB exit ramp (loop)	37°-42’	24°-55’

The design exceptions may be justified because the interchange serves low traffic volumes and there has not been a demonstrated safety problem.

This alternative would require new R/W along Cosnino Road and the eastbound ramps to contain embankment slopes from the elevated roadways. The total amount of new R/W would be approximately 4.7 acres.

Diamond Alternative **–** This alternative would eliminate the loop ramp in favor of a conventional diamond ramp (Figure 34). Loop ramps are frequently considered undesirable because of low speeds and sharp turning radii. By eliminating the loop ramp, several major advantages over the loop alternative would be achieved. First, the sharp horizontal curvature and low 30 mph design speed associated with the loop would be eliminated. Second, the need to replace the bridge would also be eliminated since the space for the three lanes that currently pass under the bridge (two mainline through lanes and one ramp exit lane) could be used for three mainline through lanes. The vertical clearance could be improved by lowering the mainline profile.

This alternative would replace the westbound loop exit ramp with a diagonal ramp and would re-align the westbound entrance ramp to line up with the new diagonal exit ramp. The existing cross road structure would remain in place. The westbound mainline would be shifted 12 feet to the north and the profile lowered approximately one foot to accommodate the new 60-foot wide roadway between the existing spread footings.

The new diamond ramp would require substantial embankment material to cross the depressed terrain below. The amount of embankment is inversely related to the profile grade, with a steeper grade requiring less earthwork. For this alternative, a westbound exit ramp grade of 5% would be recommended, which is steeper than the desirable maximum grade of 4% but less than the absolute maximum of 6%. Approximately 55,000 cubic yards of embankment material with fill heights of nearly 20 feet would be required.

A total of 3.1 acres of new R/W in the northeast quadrant and 0.9 acre in the northwest quadrant would be required to contain the embankment material for the new westbound exit ramp.

Evaluation

The evaluation of the Cosnino TI alternatives included the following criteria:

- Geometrics
- Traffic operations
- R/W needs

Table 42 – Cosnino TI Alternatives Evaluation Matrix

Criterion	No Build Alternative	Loop Alternative	Diamond Alternative
Description	No change to existing interchange	Reconstruct structure to provide lateral clearance for widened mainline.	WB ramps removed and replaced with conventional diamond ramps.
Geometry	Maintains existing ramps with non-conforming horizontal curvature	Vertical reconstruction of the interchange required to accommodate the deeper section of the bridge. Existing non-conforming horizontal curvature to remain.	All interchange geometrics conform to RDG. Shift WB mainline north and lower profile.
Profile Grade	Existing grades to remain	New bridge with deeper section raises cross road elevation. A cross road grade of 5.7% is proposed.	Existing cross road grade to remain.
Traffic Operations/Level of Service	No change	Maintenance of loop ramp propagates poor operational situation.	Optimal geometrics for rural interchange result in desirable traffic operations.
Structures	Existing structure to remain.	Existing structure removed and replaced with new structure.	Existing structure to remain.
Estimated R/W (Preliminary, Rounded)	None	4.7 acres	4.0 acres
Earthwork (None, Major, Minor)	None	Major embankment material required for elevated cross road.	Major embankment material required for realigned ramps.

Recommendations

The Loop Alternative is not recommended for the following reasons:

- Design speed of the loop is 30 mph; higher ramp speeds are desirable.
- More new R/W is required versus the diamond alternative.
- Vehicles decelerating in parallel exit lane prior to loop curvature have substantial difference in speed compared to through traffic, causing potential safety and operational problems.
- More reconstruction is required versus the diamond alternative.

The Diamond Alternative is recommended for the following reasons:

- No design exceptions are required.
- Ramp body design speed would be 50 mph. Horizontal geometry of both westbound ramps would be improved.
- Straightest path for traffic.
- Diamond ramps offer improved sight distance versus loop ramps.

3.4.6 Winona TI (MP 211.16)

This interchange was originally constructed as a diamond-type interchange in 1967 and provides access to US 89 via Townsend-Winona Road to the north and a forest road and borrow pit road to the south. The existing westbound entrance ramp is unconventional in that it provides two-way access between the cross road and the gas station in the northwest quadrant of the interchange. The ramp/cross road intersections are stop-controlled.

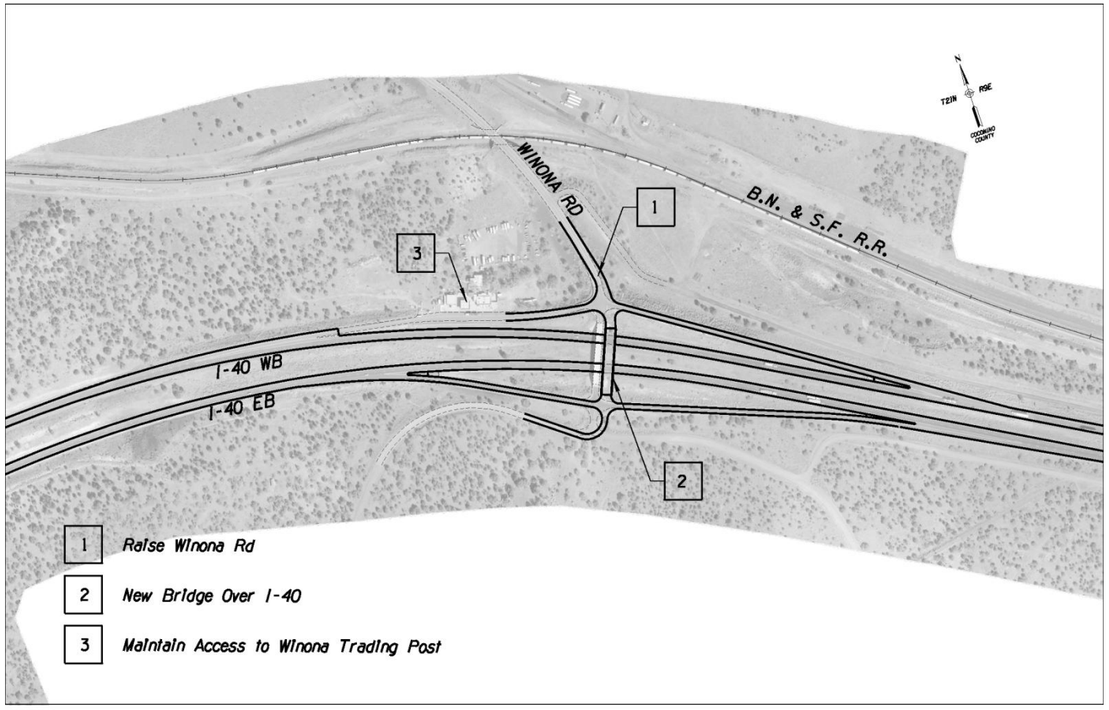
The recommended widening for I-40 ends west of the Winona TI; therefore, I-40 will remain at its current 38 feet in width in both directions at this location. AGFD is planning a new shooting range southwest of the Winona TI.

The Winona TI UP bridge is a 277-foot long, five-span steel girder bridge with a sufficiency rating of 91.65. According to the 2008 bridge inspection report, the bridge has been classified as functionally obsolete due to non-conforming underclearances and an Inventory Load Rating of HS-16.7. The westbound mainline lanes are in Span 2; the eastbound lanes occupy Span 4. Superstructure modifications may be possible to increase the load-carrying capacity of the bridge and re-profiling the mainline could improve vertical clearance issues. However, the existing structure is more than 40 years old and existing span lengths over I-40 are such that future widening of the mainline in this area would require replacing the bridge. Therefore, it is recommended that the existing bridge be replaced.

The proposed configuration (Figure 35) would reconstruct the underpass structure to improve the lateral and vertical clearances and provide the required load capacity necessary for the heavy truck volumes at this interchange. The new structure would be constructed 50 feet to the east of the existing structure to maintain access during construction activities. The new structure would have fewer spans and a deeper structure, resulting in ramp and partial cross road reconstruction to match the raised elevation.

The cross road improvements would match into the existing cross road south of the intersection with Winona Ranch Road. In addition, the short frontage road in the northwest quadrant would be reconstructed and would match the existing two-way two-lane roadway section east of the gas station.

Figure 35 – Winona TI Alternative



3.5 Proposed New Traffic Interchanges

Four new traffic interchanges were proposed to provide new access to I-40 as determined by the FMPO and the City of Flagstaff.

Alternatives were developed and evaluated for the new interchanges at Woody Mountain Road (MP 193.47) and New Lone Tree Road (MP 196.70).

Only one alternative each was developed for the proposed new interchanges at Camp Navajo (MP 183.66) and US 89 (MP 202.31) because of the rural setting and adjacent frontage roads at Camp Navajo and numerous site constraints (railroad, Route 66, rockfall area) at US 89.

3.5.1 New Camp Navajo TI (MP 183.66)

The New Camp Navajo TI would provide access to I-40 from planned development at Camp Navajo. Plans for expansion of the Camp Navajo facility are detailed in Section 2.1.4 of this report. The expansion plans include increasing the camp's building area by 50,000 square feet and building a new fire station. Other potential developments in the area include an industrial/business park and additional government facilities. The location of the interchange may need to be shifted to align the new cross road with planned roadways within Camp Navajo.

Within the interchange limits, I-40 consists of two 12-foot lanes, a 10-foot outside shoulder and a 4-foot inside shoulder in each direction. The eastbound and westbound mainlines are separated by a wide, naturally vegetated median. The typical section is rural with roadside ditches. The posted speed of the mainline in this area is 75 mph. The terrain at the interchange is level with an average elevation of 7180 feet.

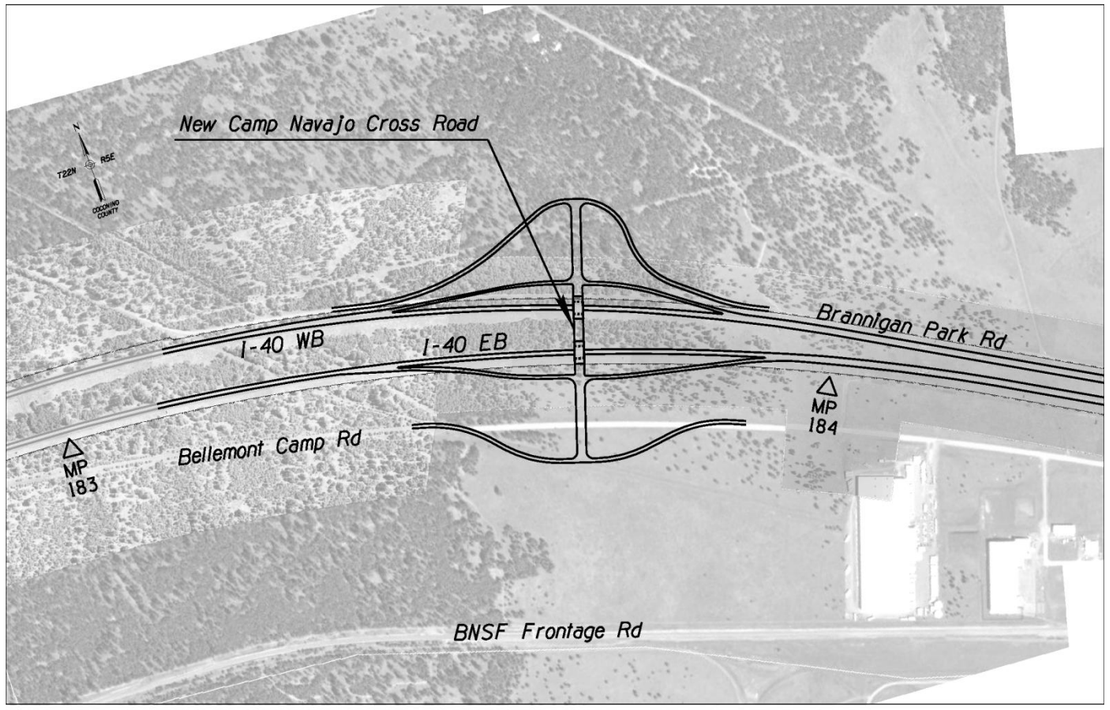
A diamond interchange is recommended for the new interchange configuration. Constraints include development to the southeast along East Bellemont Camp Road and the closed Parks Rest Area to the west at MP 181.5. Brannigan Park Road closely parallels I-40 on the north side.

New bridges would be required to span eastbound and westbound I-40. Although the added mainline lanes would begin at the eastern end of the new ramps, the mainline bridges should be sized to accommodate a future widened mainline to the west of the project limit.

The north and south frontage roads would be re-aligned to provide approximately 700 feet between the ramp intersections and the frontage road intersections with the cross road. The ramp/cross road intersections would be stop-controlled.

Approximately 41.5 acres of new R/W would be required for the new interchange.

Figure 36 – New Camp Navajo TI Alternative



3.5.2 New Woody Mountain TI (MP 193.47)

The existing Woody Mountain Road grade separation crosses above I-40 at MP 193.47. The existing bridges do not provide the required lateral and vertical clearances to accommodate the widened I-40 mainline cross section (60 feet each direction). In addition, the Flagstaff 2030 Regional Transportation Plan calls for a new connection to I-40 at Woody Mountain Road. Two alternatives were developed to provide new access to I-40 at this location.

Existing Conditions

Within the interchange limits, I-40 consists of two 12-foot lanes, a 10-foot outside shoulder, and a 4-foot inside shoulder in each direction. The eastbound and westbound mainlines are separated by a 320-foot wide naturally vegetated median. The typical section is urban/fringe urban with roadside ditches. The posted speed on the mainline in this area is 65 mph. The terrain is rolling with an average elevation of 7100 feet.

The existing Woody Mountain Road cross road has approach grades of 4.25% with a 700-foot vertical curve centered south of the existing westbound I-40 mainline.

The need to flatten the existing steep grades on Woody Mountain Road was addressed for both alternatives. Because of added structure depth for a longer bridge and desirable intersection approach grades, consideration was given to lowering the I-40 mainline profile in addition to flattening the cross road profile. The crest vertical curve on the cross road would be lengthened, resulting in grades less than 3% near the ramp/cross road intersections. The cross road vertical curve lengthening would also increase the sight distance sufficiently to correspond to a 60 mph design speed. In addition, widening or shifting the mainline roadways toward the median is recommended to reduce the skew of the cross road and reduce potential R/W impacts from the new ramps.

This location was identified as a potential wildlife crossing; however, the large parcel to the northwest of the interchange is under development with 1,400 residential units. Because this area will be filled in with development in the foreseeable future, it is recommended that wildlife be channeled to another location.

Alternatives

Two alternatives were developed for the new Woody Mountain TI.

Diamond with Roundabouts – This alternative would provide standard roundabouts at the ramp/cross road intersections, with a third roundabout approximately 300 feet to the north at Presidio Drive to provide access to proposed commercial properties. Another roundabout would be constructed farther north at the intersection with Patio del Presidio Drive to provide access to an existing residential community. The cross road alignment generally would follow the existing horizontal alignment of Woody Mountain Road, which is skewed approximately 28° to I-40. A roundabout intersection could accommodate intersections with large skew angles, resulting in lower R/W needs than the Diamond Alternative. A stop-controlled or signal-controlled intersection would be limited to a 15° skew at the ramp/cross road intersections.

Presidio Drive will provide access to commercial properties and Patio del Presidio provides access to residential properties. The control of access limits on the north would be at the Presidio Drive intersection.

The I-40 mainline profile would be lowered and the cross road profile flattened to accommodate added structure depth and provide desirable intersection approach grades on the cross road. The mainline roadways would be shifted toward the median to reduce R/W impacts.

The required structures for this alternative would be narrower than for the diamond alternative since no left-turn lanes are required.

The approximate R/W required for this alternative would be 11.6 acres.

Diamond with Signalized Intersections – This alternative would create a standard diamond interchange with the cross road alignment shifted slightly to the west to shorten the structure lengths. The ramp intersections would be signalized to accommodate future traffic demands. The skew of the cross road and desirable maximum skew angle at a ramp intersection with the cross road would require the horizontal alignments of the proposed exit ramps to be shifted away from the mainline to better align with the cross road.

Similar to the Roundabout Alternative, the overall footprint of the proposed interchange would be reduced because the I-40 mainline alignments would be shifted toward the median. The interchange ramps would be located closer to existing R/W line because of the skew limitations at the ramp intersections. The I-40 mainline profile would be lowered and the cross road profile flattened to accommodate added structure depth and provide desirable intersection approach grades on the cross road.

The intersection to the north of the westbound ramp intersection (Presidio Drive) would be restricted to right-in and right-out movements. The Presidio del Patio intersection farther to the north would be converted to a roundabout to allow traffic to make a U-turn.

Approximately 14.3 acres of new R/W would be required for this alternative.

Evaluation

The new Woody Mountain TI alternatives were evaluated using the following criteria:

- Geometrics
- R/W needs
- Consistency with urban/fringe urban setting/driver expectancy
- Structure requirements
- Maintenance impacts

Table 43 – New Woody Mountain TI Evaluation Matrix

Criterion	No Build Alternative	Woody Mountain TI Diamond w/ Roundabouts	Woody Mountain TI Diamond w/ Signals
Description	Maintains existing grade separation at current location; no access to I-40.	New diamond TI with roundabouts at ramp/cross road intersections.	New diamond TI with signalized ramp/cross road intersections.
Interchange Geometry	N/A	The ramp/cross road intersections would be limited to a skew angle of 15°.	The diamond ramps would be compact and minimize new R/W along I-40.
Consistency with Fringe Urban Setting	Maintains existing grade separation at current location; no access to I-40.	New diamond TI with roundabouts at ramp/cross road intersections.	New diamond TI with signalized ramp/cross road intersections.
Cross Road Geometry	Existing cross road crest vertical curve corresponds to a 45 mph design speed.	The crest vertical curve would be lengthened so grades are 3% or less near the ramp/ cross road intersections. The lengthening would increase the sight distance to correspond to a 60 mph design speed.	The crest vertical curve would be lengthened so grades are 3% or less near the ramp/ cross road intersections. The lengthening would increase the sight distance to correspond to a 60 mph design speed.
Maintenance	No change.	Roundabouts typically require less maintenance than signalized intersections.	Signalized intersections require more maintenance than roundabouts – signal timing coordination, electrical.
Structures	Existing structures to remain.	Allows narrower bridge structure.	Requires wider bridge structure for added left-turn lanes.
Estimated R/W (Preliminary, Rounded)	0 acres	11.6 acres	14.3 acres

Recommendations

The diamond configuration with signalized intersections alternative is not recommended for the following reasons:

- Requires more R/W.
- Inconsistent with rural setting.
- Higher bridge cost due to wider cross road.
- Higher cost for traffic signals and the associated maintenance costs.

The diamond configuration with roundabout intersections alternative is recommended at the new Woody Mountain TI for the following reasons:

- Consistency with setting. There are few signals in this developing rural area and they may not be anticipated by drivers. In addition, there is an existing roundabout at the nearby Woody Mountain Road/Patio del Presidio intersection.
- Reduced bridge cost because of narrower cross road.
- Reduced construction and maintenance costs for signals.
- Less R/W required.

Figure 37 – Woody Mountain TI Diamond with Roundabouts Alternative

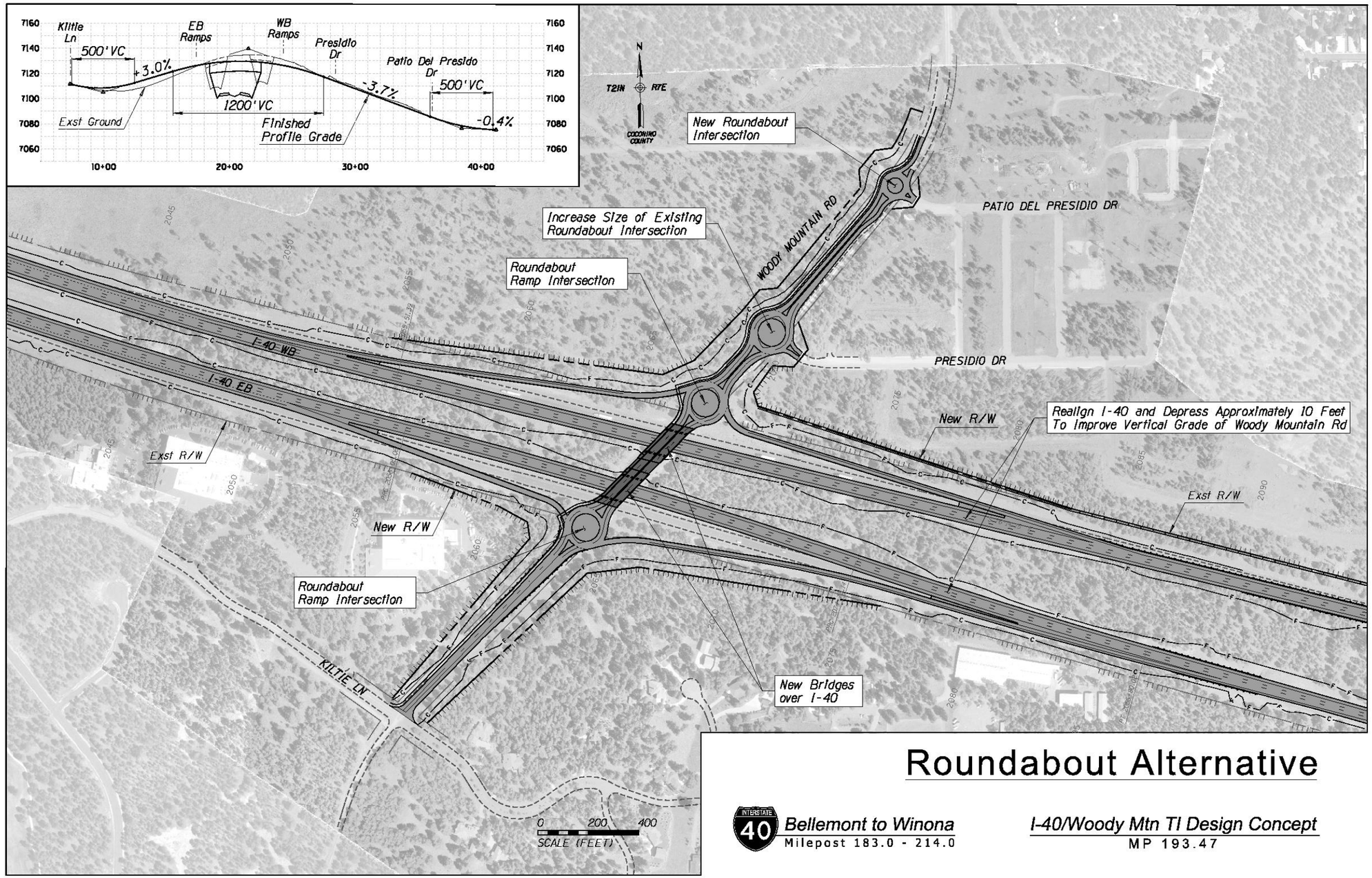
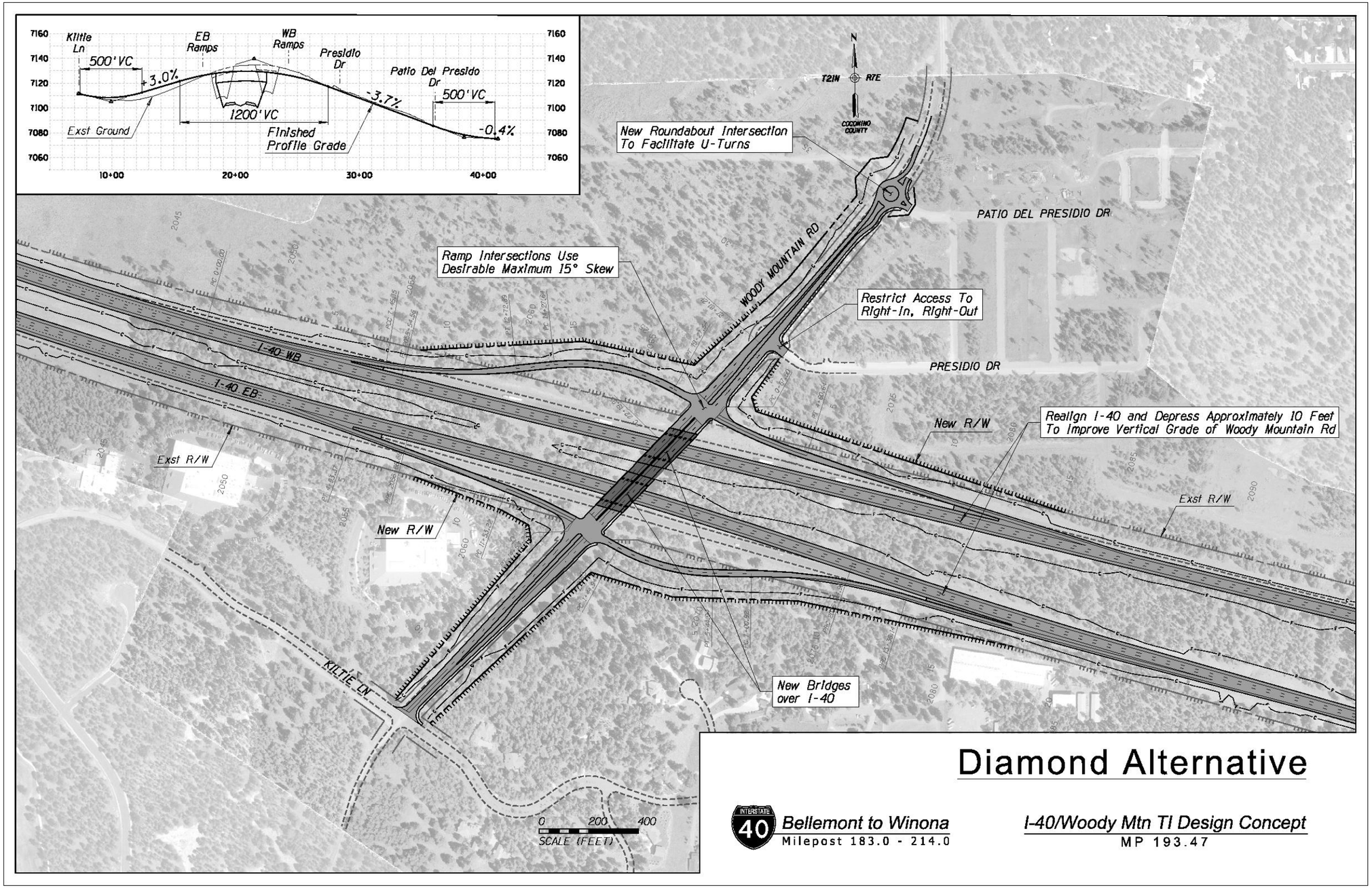


Figure 38 – New Woody Mountain TI Diamond with Signalized Intersections Alternative



3.5.3 New Lone Tree TI (MP 196.70)

In the early 1990s, Lone Tree Road was formally identified as a candidate location for a new interchange along I-40 to serve Flagstaff and Northern Arizona University. The *I-17/I-40 System Interchange Change of Access Report* (ADOT, May 1993) stipulated that the location of the new Lone Tree TI be shifted away from the system interchange for improved mainline traffic operations. A realignment of Lone Tree Road approximately 1300 feet west of the existing grade separation was proposed in the 1993 report and also shown in the *Lone Tree Corridor Study* (City of Flagstaff, 2006). This study developed and evaluated seven preliminary alternatives for the new Lone Tree TI based on the alignment location shown in the previous documents.

Coconino Community College and a new development, Juniper Point, are located south of I-40 in the interchange area. The land in the northwest quadrant of the interchange is owned by the Arizona Board of Regents, with a new apartment complex under construction in the northeast quadrant.

ADOT Materials Group has noted the presence of a perched water table in the new Lone Tree TI area. The high water table is seasonal. Additional geotechnical investigation will be required in the area of the proposed interchange, especially if the cross road is to be depressed beneath I-40.

Diamond Under I-40 Alternative

This alternative is a diamond interchange with the new Lone Tree Road crossing under I-40 (Figure 39). This concept was shown in the City of Flagstaff's 2006 *Lone Tree Corridor Study* as the preferred configuration by the city.

I-40 has a relatively flat profile grade near the existing Lone Tree Road grade separation and descends at approximately 3.0% toward the east. The existing elevation of the mainline is approximately 11 feet lower in the westbound direction and 29 feet lower in the eastbound direction at the proposed Lone Tree Road location than at existing Lone Tree Road. This elevation difference would require steeper grades for the western ramps versus the eastern ramps. The western ramps would be designed to hold maximum grades of 4.0%, which would result in ramps approximately 1800 feet long. The eastern ramps would be approximately 1300 feet long and have grades less than 3%. The existing Lone Tree bridges would need to be widened to the inside to accommodate the added I-40 lanes and ramps. However, bridge replacement would be recommended because of the age of the bridges (constructed in 1966) and to improve vertical and horizontal clearance and superelevation.

The proximity of the westbound entrance ramp and the I-17 system ramp would provide a weaving length estimated at 1000 feet, which would result in LOS E in the 2040 design year. Since LOS E is below the minimum design LOS, additional alternatives were developed.

The approximate R/W required for this alternative would be 18.9 acres.

Diamond Over I-40 Alternative

With this alternative, Lone Tree Road would cross over I-40 (Figure 40). Reversing the stacking order of the interchange would help the ramp grades of the western ramps. The western ramps could be shortened as much as 700 feet, although the eastern ramps would need to be lengthened. In addition, this configuration with the cross road over the mainline would assist vehicles on the exit ramps decelerate (upgrade) and vehicles on the entrance ramps accelerate (downgrade). The shortened western ramps would increase the weaving length, thereby improving traffic operations of the nearby system interchange. The weave LOS would be D for this alternative. The grades of the ramps would be a maximum of 5%.

The total new R/W required for this alternative would be approximately 14.5 acres.

Loop Alternative

The Loop Alternative would replace the diamond ramp with a loop ramp for the westbound entrance movement (Figure 41). The westbound exit would shift outward, around the loop ramp, and would intersect new Lone Tree Road approximately 400 feet farther north than the regular diamond. There would be no changes to the eastbound mainline roadway with this alternative. The loop geometrics would result in an increase in the weaving distance at the expense of a lower design speed for entering traffic. Approximately 2900 feet would be provided for weaving, which would result in LOS D. The loop design speed would be 30 mph; traffic would use a portion of the weaving area to accelerate to mainline speed.

When compared to a standard diamond interchange, the loop configuration would require an increase in new right-of-way in the northeast quadrant but a decrease in R/W in the northwest quadrant. For this alternative, approximately 25.4 acres of new R/W would be required.

Along new Lone Tree Road, the loop would intersect the cross road on the opposite side of the roadway compared to a typical diamond ramp. This would require carefully-designed signing and marking to instruct drivers how to negotiate the interchange. Additionally, traffic signal phasing would be more complicated and signal progression along Lone Tree Road could be degraded.

Diamond with Loop Alternative

This alternative would be a hybrid between the Diamond Under I-40 Alternative and the Loop Alternative. The interchange would have four diagonal ramps, similar to the Diamond Under I-40 Alternative (Figure 42). Additionally, a westbound entrance loop ramp would be provided. The loop ramp would be signed for traffic destined for I-40 westbound, and the diamond ramp would be used for traffic destined for the I-17 system ramp. Traffic analyses assumed drivers would follow the signage, which resulted in LOS D for the weave. However, once drivers become familiar with the interchange, they could opt to disregard signage and use the diagonal entrance ramp for all movements, regardless of the shorter weave length. This would result in a condition similar to the Diamond Under I-40 Alternative weave, which would operate at LOS E.

The total new R/W required for this alternative is approximately 33.7 acres.

Loop with C-D Road Alternative

This alternative would use a loop ramp for the westbound entrance movement (Figure 43). However, instead of connecting the loop directly into the westbound mainline, a collector-distributor (C-D) road would be added and the loop connected to the C-D road. The C-D road would remove westbound system ramp traffic destined for I-17 and Milton Road from the mainline in advance of the New Lone Tree TI.

Traffic destined for I-17 (southbound) or Milton Road (northbound) would exit westbound I-40 approximately 4500 feet in advance of the existing departure point. The C-D road would occupy the same position as the existing westbound mainline roadway, requiring relocation of the westbound I-40 roadway toward the median. Entering traffic from Lone Tree Road would connect to the C-D road. Vehicles not destined for the system interchange would weave to a slip ramp to connect to the mainline. In this configuration, the weaving operation would take place on the C-D road only and not the mainline. The weave LOS on the C-D road would be D+, and the mainline would be LOS B.

Figure 39 – New Lone Tree TI Diamond Under I-40 Alternative

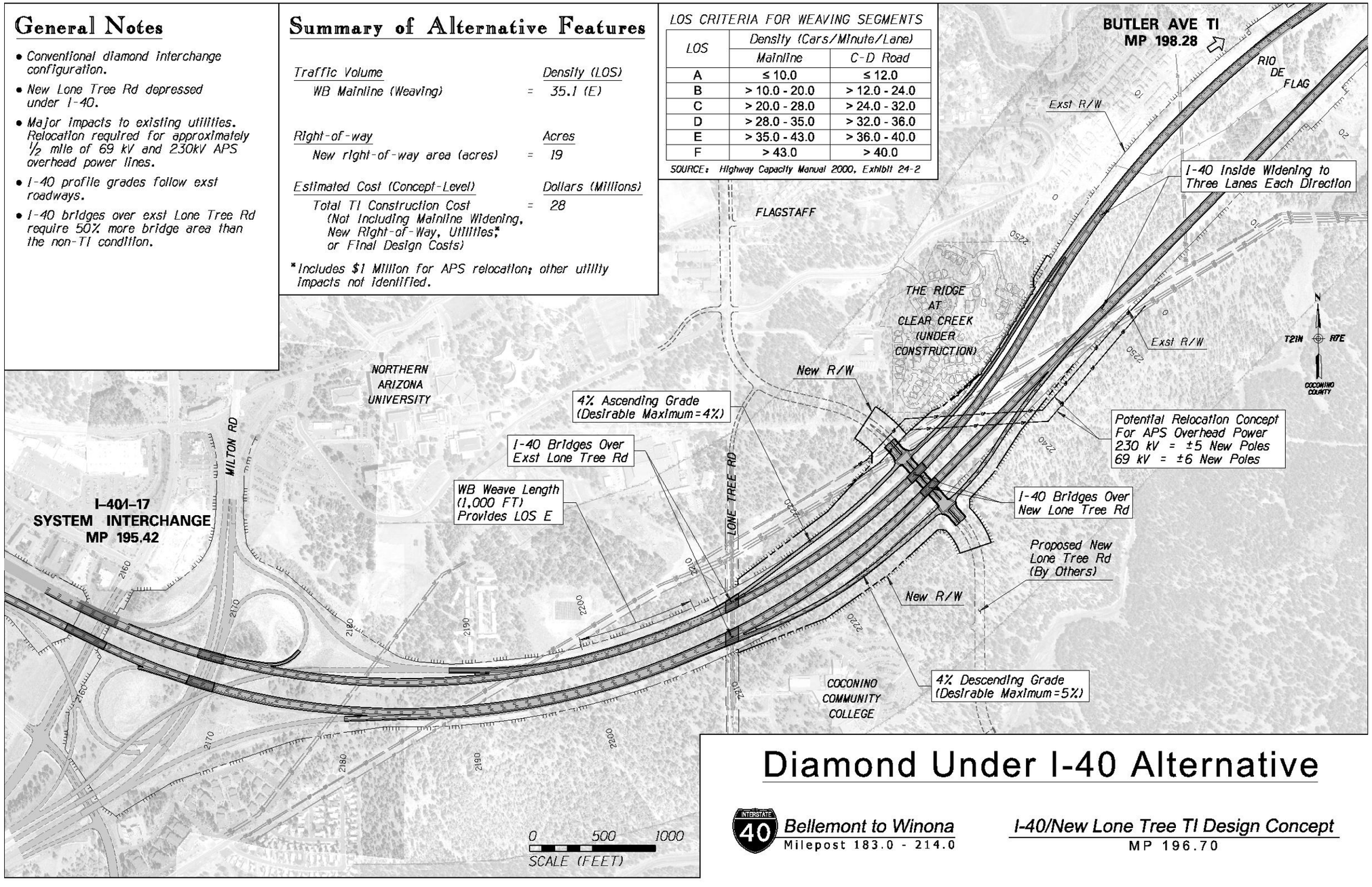


Figure 40 – New Lone Tree TI Diamond Over I-40 Alternative

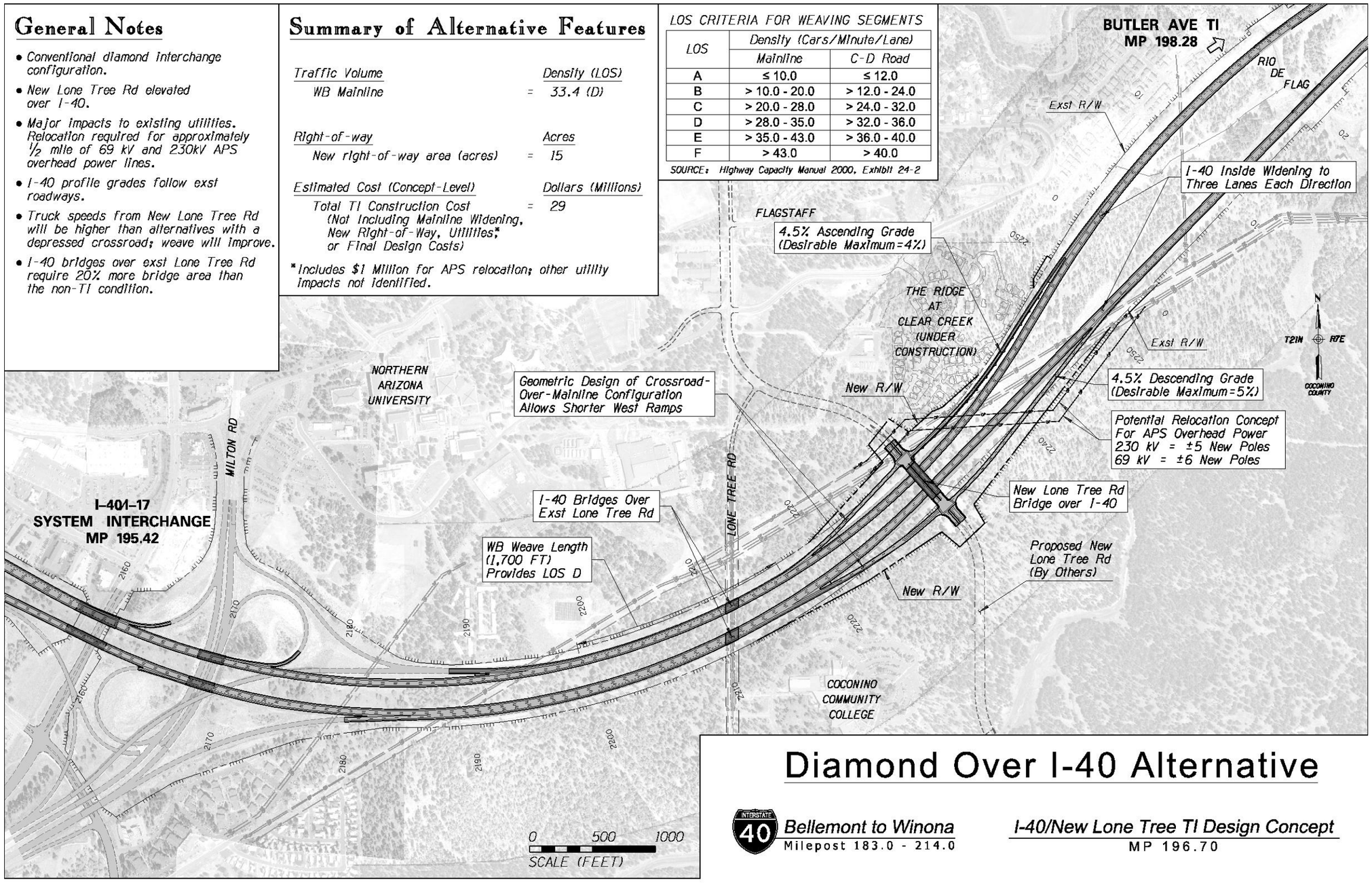


Figure 41 – New Lone Tree TI Loop Alternative

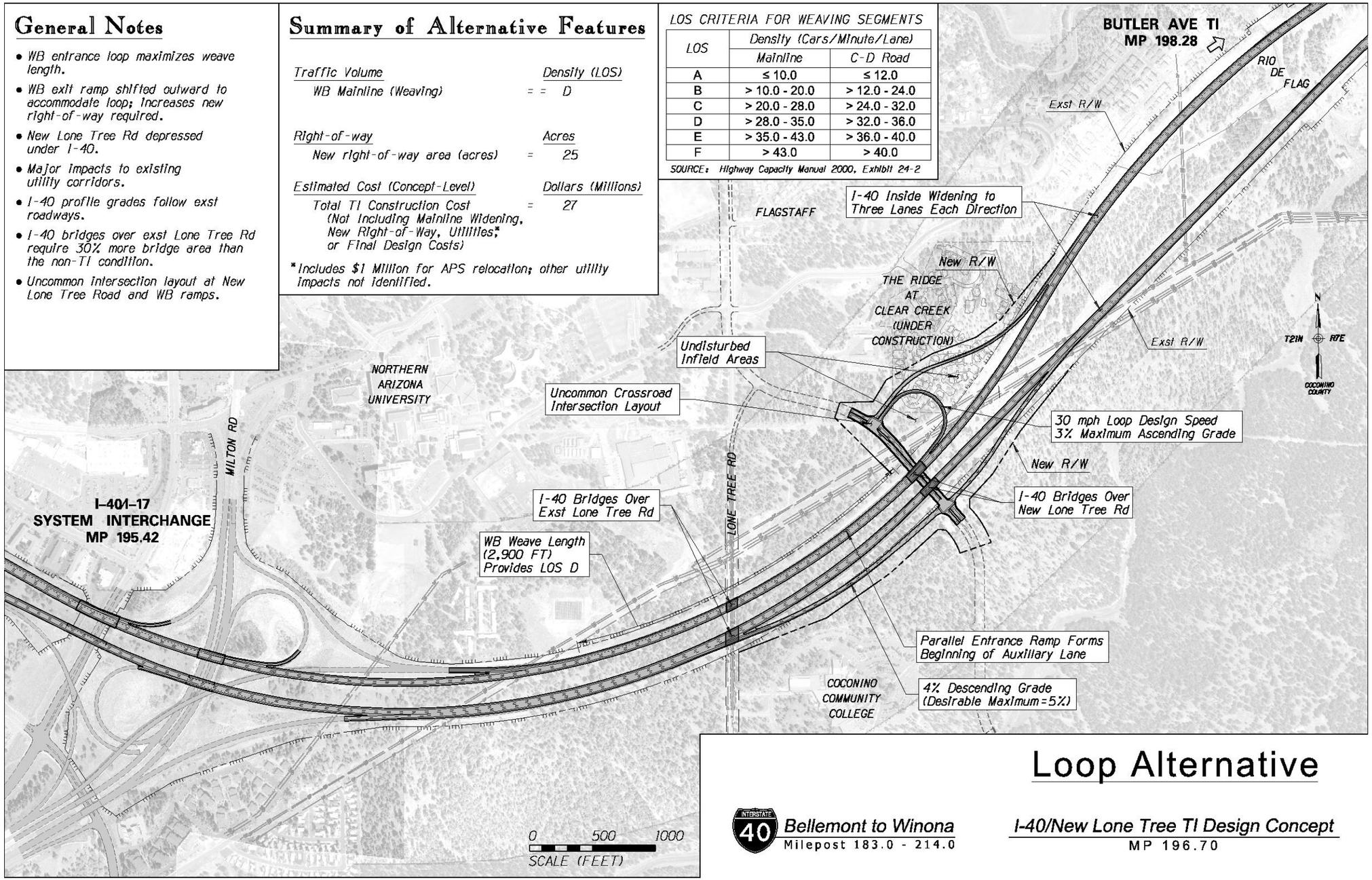


Figure 42 – New Lone Tree TI Diamond with Loop Alternative

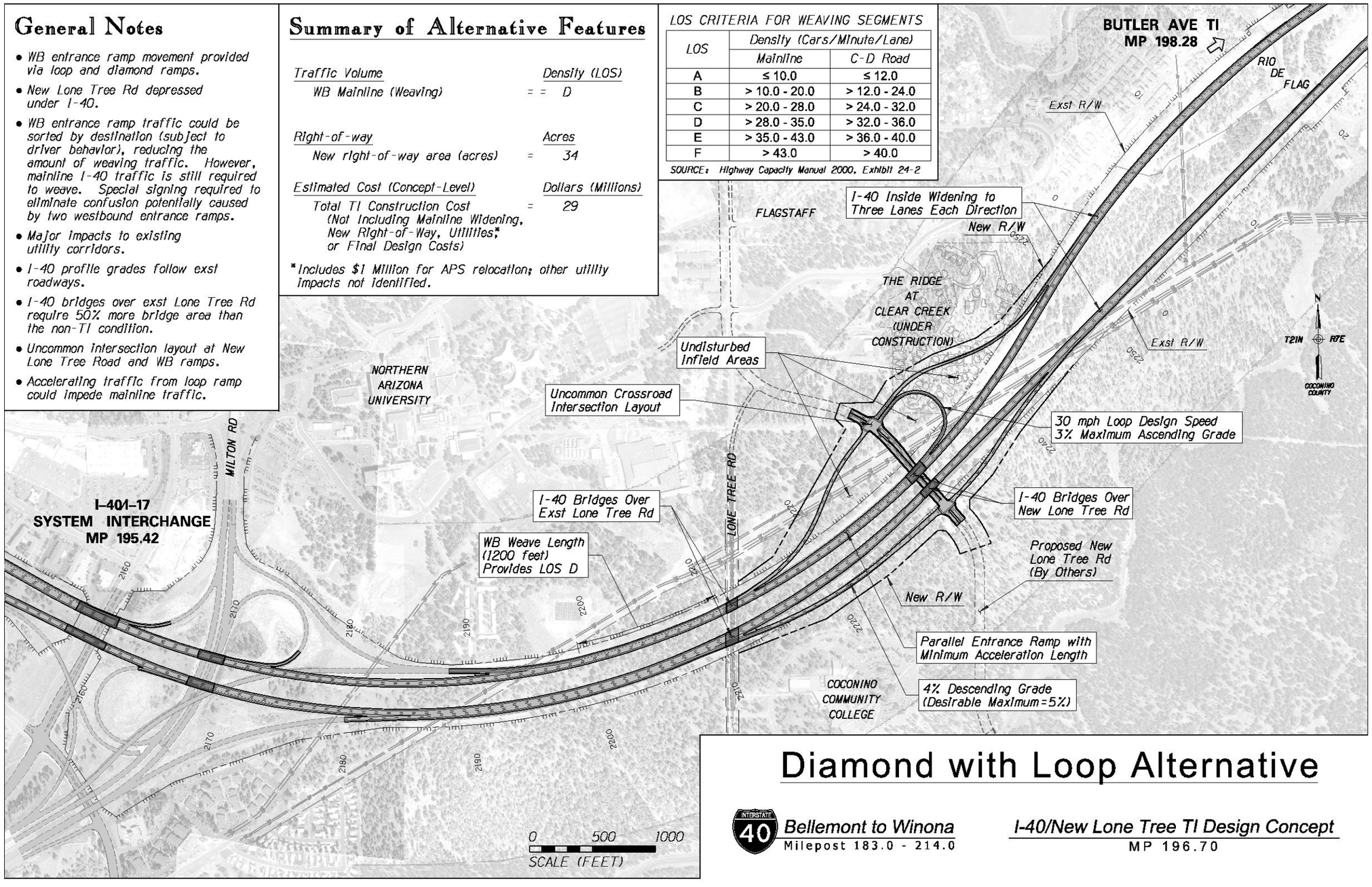


Figure 43 – New Lone Tree TI Loop with C-D Road Alternative

General Notes

- WB C-D road and loop ramp added to separate weaving & accelerating traffic from mainline through traffic.
- New Lone Tree Rd depressed under I-40.
- WB I-40 shifted up to 110' toward median.
- Major impacts to existing utility corridors.
- I-40 bridges over exst Lone Tree Rd require 70% more bridge area than the non-TI condition.
- Uncommon intersection layout at New Lone Tree Road and WB ramps.

Summary of Alternative Features

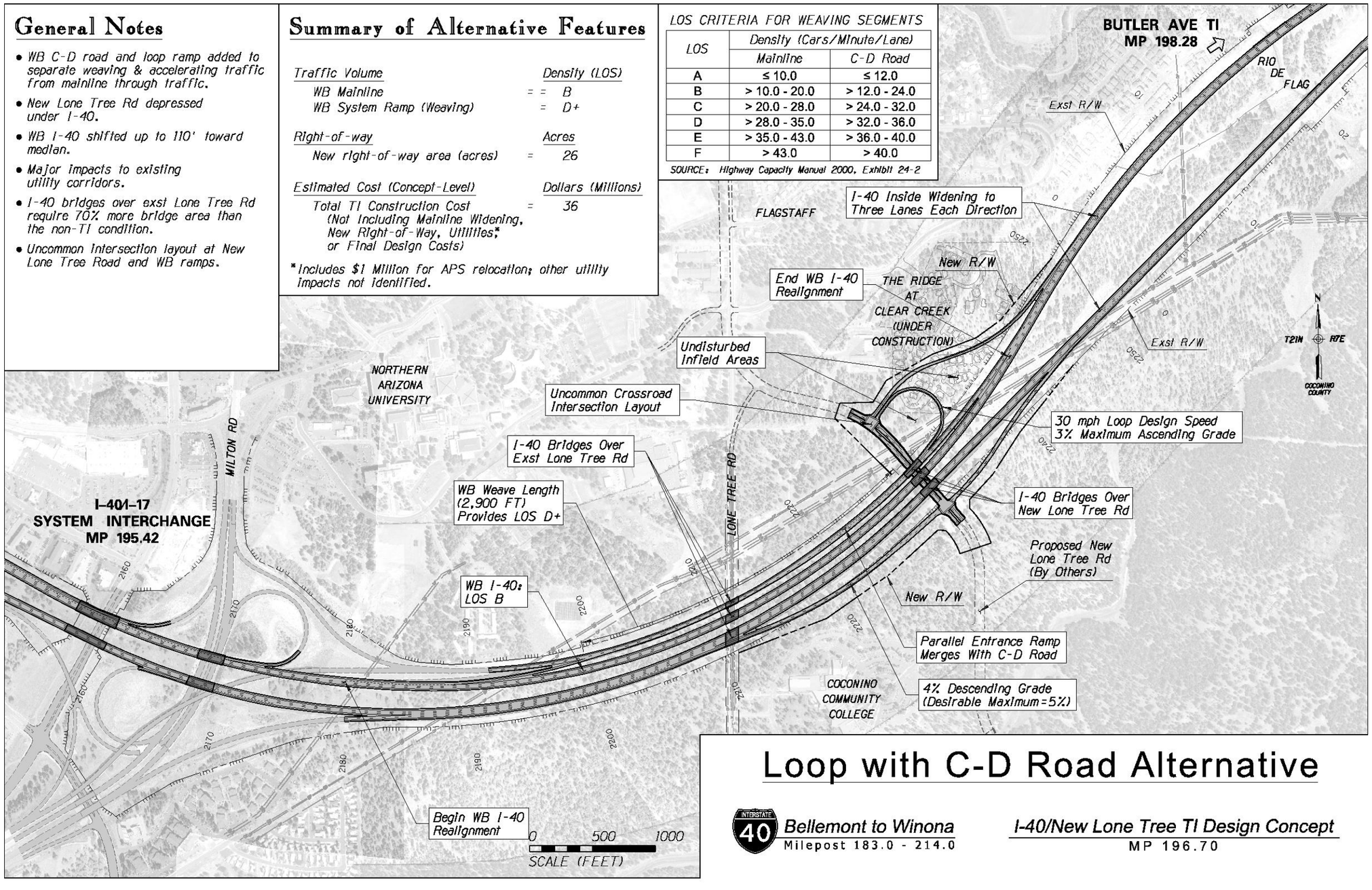
Traffic Volume		Density (LOS)
WB Mainline	= =	B
WB System Ramp (Weaving)	=	D+
Right-of-way		Acres
New right-of-way area (acres)	=	26
Estimated Cost (Concept-Level)		Dollars (Millions)
Total TI Construction Cost (Not Including Mainline Widening, New Right-of-Way, Utilities*, or Final Design Costs)	=	36

*Includes $1 Million for APS relocation; other utility impacts not identified.

LOS CRITERIA FOR WEAVING SEGMENTS

LOS	Density (Cars/Minute/Lane)	
	Mainline	C-D Road
A	≤ 10.0	≤ 12.0
B	> 10.0 - 20.0	> 12.0 - 24.0
C	> 20.0 - 28.0	> 24.0 - 32.0
D	> 28.0 - 35.0	> 32.0 - 36.0
E	> 35.0 - 43.0	> 36.0 - 40.0
F	> 43.0	> 40.0

SOURCE: Highway Capacity Manual 2000, Exhibit 24-2



Loop with C-D Road Alternative

Bellemont to Winona
Milepost 183.0 - 214.0

I-40/New Lone Tree TI Design Concept
MP 196.70

Similar to the loop alternative, the loop design speed would be 30 mph and traffic would use a portion of the C-D road to accelerate to ramp speed. This alternative would share other features with the loop alternative along the cross road and east of new Lone Tree Road.

The Loop with C-D Road Alternative would require approximately 25.4 acres of new R/W.

Braided Alternatives

The Braided Under I-40 and Braided Over I-40 alternatives (Figures 44 and 45, respectively) would provide a braided ramp configuration for the westbound I-40 to southbound I-17/Milton Road system interchange. The braided concept would eliminate mainline widening by shifting all entering and exiting traffic to a parallel C-D road. The C-D road would be a separate, long exit ramp for traffic destined for southbound I-17 or Milton Road. It also would accommodate entering westbound New Lone Tree TI traffic destined for either the I-17/Milton ramp or to westbound I-40. For both the Braided Over and Braided Under alternatives, the LOS for the westbound system ramp weave would be C and the westbound I-40 mainline would be LOS B.

Approximately one mile of westbound I-40 would need to be reconstructed in the median area. The existing westbound I-40 bridge over Lone Tree Road would need to be replaced to accommodate the shifted horizontal alignment and raised mainline profile. The existing eastbound bridge over Lone Tree Road would need to be widened to the inside; however, replacement of this bridge would also be recommended. An additional bridge for the westbound braided ramp over or under the New Lone Tree westbound entrance ramp and retaining walls would be required.

Features of the non-braided diamond alternatives would also be part of these alternatives. The approximate R/W requirements would be 19.9 acres for the Braided Under Alternative and 18.9 acres for the Braided Over Alternative.

Evaluation

The alternatives with loop ramps in the northeast quadrant (Loop Alternative, Loop with Diamond Alternative, Loop with C-D Road Alternative) were eliminated early in the alternatives development phase because of poor performance of operations (LOS D), R/W needs, impacts to planned development in the northeast quadrant of the interchange, and irregular intersection configurations.

The Diamond and Braided alternatives were developed further, discussed with the agency stakeholders, and evaluated. The evaluation matrixes on the following pages explore several cases:

Case 1: Build interchange without widening mainline

Case 1A: Sensitivity analysis to test Case 1 with traffic volumes increased 20%

Case 2: Build interchange and reconstruct/widen mainline

Case 2A: Sensitivity analysis to test Case 2 with traffic volumes increased 20%

The evaluation of the Diamond and Braided alternatives included the following evaluation criteria:

- LOS/sensitivity to changes in traffic volumes
- Estimated construction cost
- R/W needs
- Implementation opportunities
- Vehicle weave conflicts

Recommendations

The Loop alternatives (Loop, Loop with Diamond, and Loop with C-D Road) are not recommended for the following reasons:

- Similar/low LOS compared to other conventional alternatives.
- Likely impacts to planned apartments to the north.
- Uncommon cross road intersection layout
- 30 mph maximum design speed for loop ramp. Traffic must accelerate and merge onto the mainline in a short distance.
- Large amount of new R/W required.

The Diamond Over I-40 Alternative is not recommended for the following reasons:

- LOS D weave in the design year.
- Braided alternatives provide better LOS and higher capacity well into future years.
- Requires ramp grades of 5% maximum.

The Diamond Under I-40 Alternative is not recommended for the following reasons:

- LOS requirement not met in design year.
- Perched water table issues could increase construction and maintenance costs.
- Longer western ramps result in shorter weave lengths adjacent to system interchange.
- Roadside snow storage areas restricted by retaining walls and concrete barrier.

The Braided Alternatives (Over and Under) are recommended for further study for the following reasons:

- LOS requirements are exceeded in the design year, even without westbound mainline widening.
- Braided alternatives provide high LOS beyond design year.
- Could be constructed in phases.
- Ramp grades of 4% maximum (3% C-D road maximum).

Figure 44 – New Lone Tree TI Braided Under I-40 Alternative

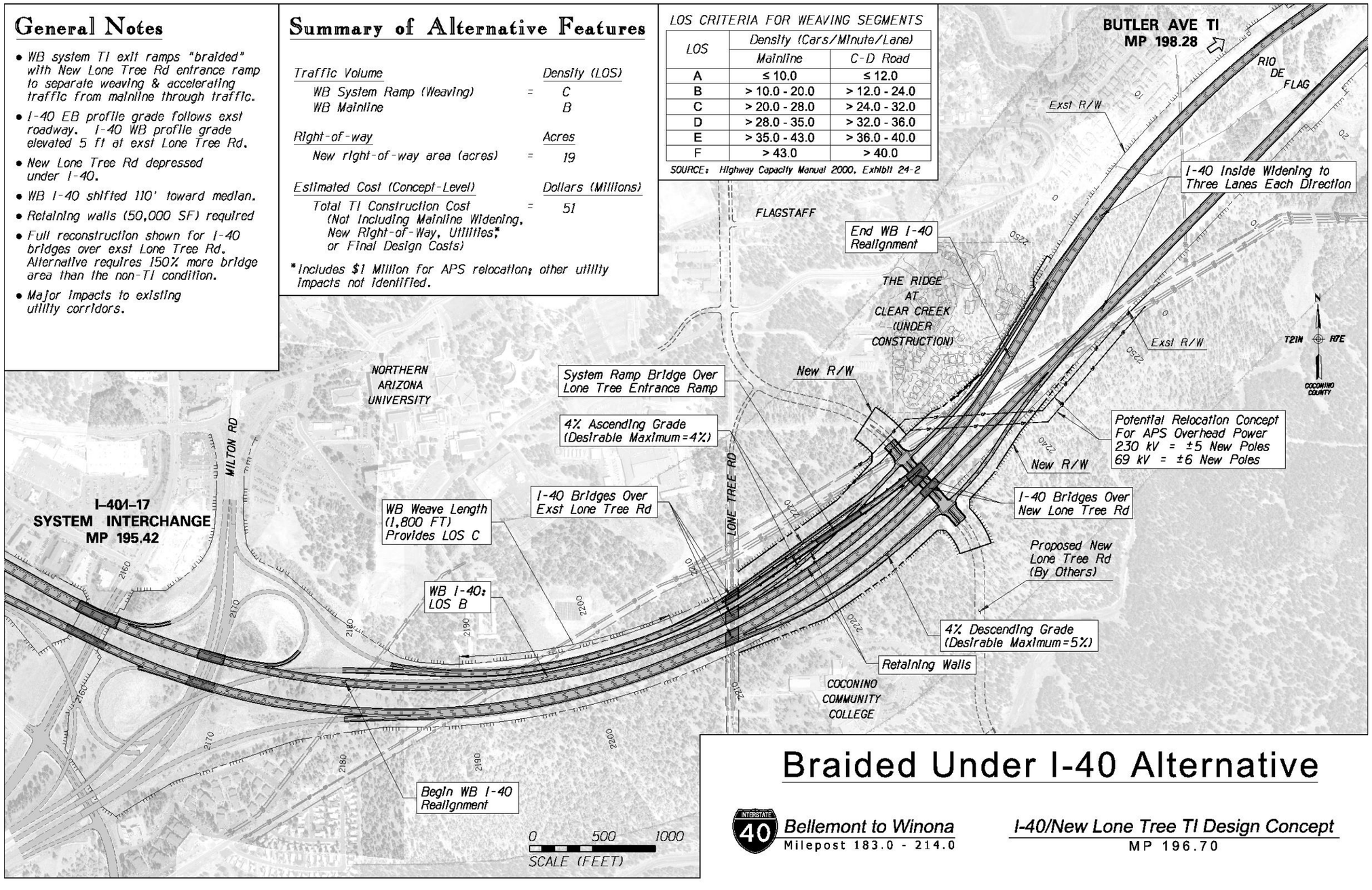


Figure 45 – New Lone Tree TI Braided Over I-40 Alternative

General Notes

- WB system TI exit ramps "braided" with New Lone Tree Rd entrance ramp to separate weaving & accelerating traffic from mainline through traffic.
- I-40 EB profile grade follows exst roadway. I-40 WB profile grade elevated 5 ft at exst Lone Tree Rd.
- New Lone Tree Rd elevated over I-40.
- WB I-40 shifted 110' toward median.
- Retaining walls (50,000 SF) required
- Full reconstruction shown for I-40 bridges over exst Lone Tree Rd. Alternative requires 150% more bridge area than the non-TI condition.
- Major impacts to existing utility corridors.

Summary of Alternative Features

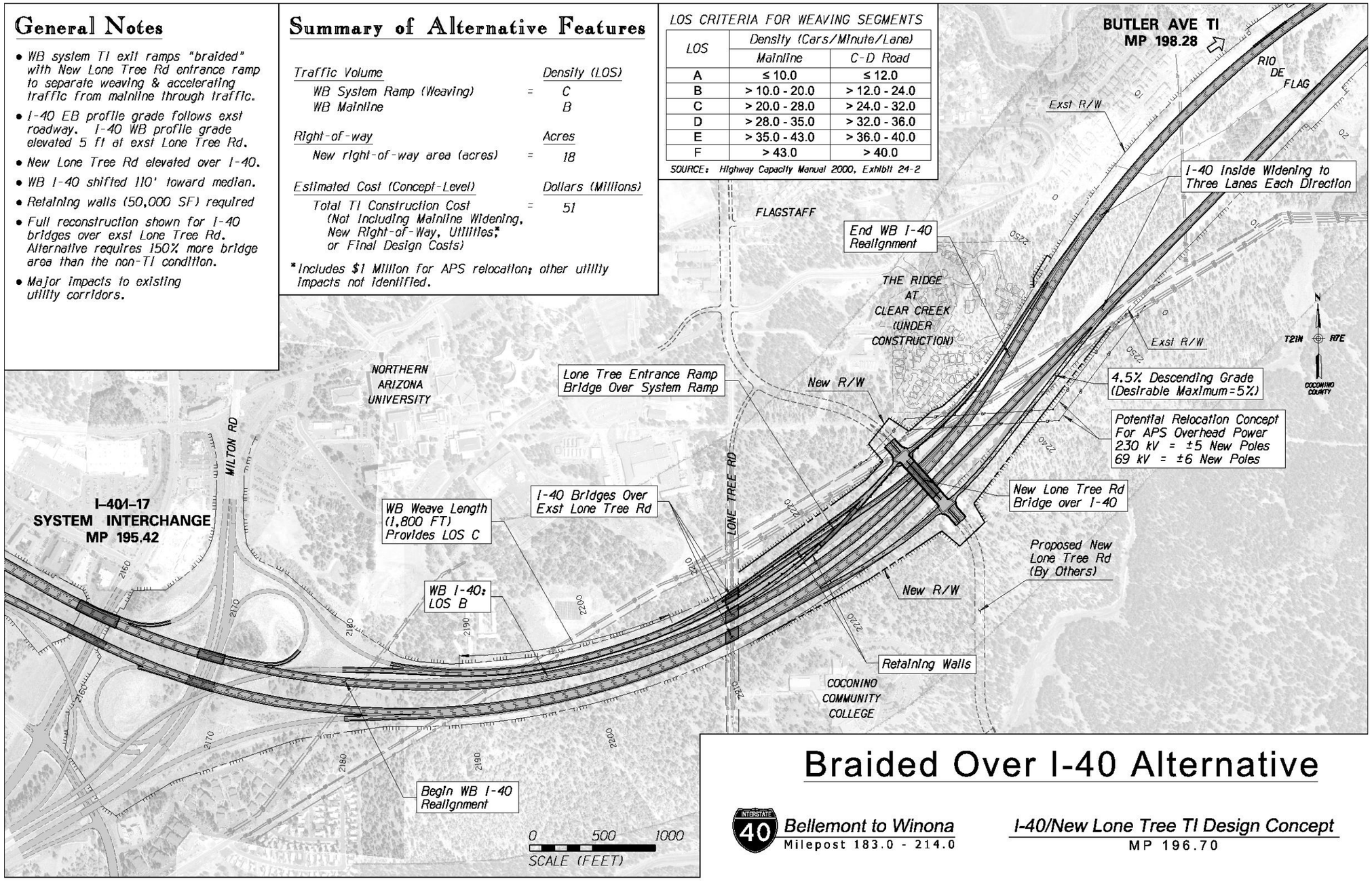
Traffic Volume		Density (LOS)
WB System Ramp (Weaving)	=	C
WB Mainline		B
Right-of-way		Acres
New right-of-way area (acres)	=	18
Estimated Cost (Concept-Level)		Dollars (Millions)
Total TI Construction Cost (Not Including Mainline Widening, New Right-of-Way, Utilities*, or Final Design Costs)	=	51

*Includes $1 Million for APS relocation; other utility impacts not identified.

LOS CRITERIA FOR WEAVING SEGMENTS

LOS	Density (Cars/Minute/Lane)	
	Mainline	C-D Road
A	≤ 10.0	≤ 12.0
B	> 10.0 - 20.0	> 12.0 - 24.0
C	> 20.0 - 28.0	> 24.0 - 32.0
D	> 28.0 - 35.0	> 32.0 - 36.0
E	> 35.0 - 43.0	> 36.0 - 40.0
F	> 43.0	> 40.0

SOURCE: Highway Capacity Manual 2000, Exhibit 24-2



Braided Over I-40 Alternative

Bellemont to Winona
Milepost 183.0 - 214.0

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MP 196.70

Table 44 – New Lone Tree TI Alternatives Evaluation Matrixes – Case 1 and Case 1A

CASE 1 – BUILD INTERCHANGE WITHOUT WIDENING MAINLINE

The following evaluation matrix is based on New Lone Tree TI construction occurring without I-40 mainline widening and reconstruction. The diamond alternatives would connect to the existing I-40 roadways; however, the braided alternatives would require shifting/reconstructing approximately 1.3 miles of westbound I-40.

Criterion	No-TI Alternative	Diamond Under I-40	Diamond Over I-40	Diamond with Braided Ramps Under I-40	Diamond with Braided Ramps Over I-40	COMMENT/ CONCLUSION
Description	Maintains existing grade separation for Lone Tree Road. No improvements to existing infrastructure.	New compact diamond TI. Mainline not widened.	New compact diamond TI. Mainline not widened.	New diamond TI with system ramp braided across diamond entrance ramp. I-17 system ramp traffic diverted to C-D road through TI. Reconstruct approx. 1.3 miles of WB I-40.	New diamond TI with system ramp braided across diamond entrance ramp. I-17 system ramp traffic diverted to C-D road through TI. Reconstruct approx. 1.3 miles of WB I-40.	--
New Lone Tree Road Over/Under I-40	N/A	Under	Over	Under	Over	2006 Lone Tree Road corridor study recommended "Under."
Level of Service / Sensitivity Note that the LOS are subject to change by varying input parameters. Assumed opening in 2015.	N/A	I-40 Weave LOS 2015: E (37.2) 2026: Transition to F 2040: F (50.5)	I-40 Weave LOS 2015: E (35.3) 2030: Transition to F 2040: F (47.9)	I-40 Mainline LOS 2015: B (13.6) 2040: C (24.1) C-D Road Weave LOS 2015: B (23.9) 2040: C (24.6)	I-40 Mainline LOS 2015: B (13.6) 2040: C (24.1) C-D Road Weave LOS 2015: B (23.9) 2040: C (24.6)	The **BRAIDED** alternatives are the only alternatives that offer an acceptable LOS. The Diamond alternatives have an unacceptable LOS in the opening year (2015 assumed).
Safety / Conflict Evaluation Estimate of the number of vehicles required to weave and the number of vehicles impacted by an uphill truck merging over a 30-second timeframe. A lower number is better. *Total is multiplied by 3 when LOS = F	No change	Number of weaving veh: 2686 Impact of uphill trucks: 2094 Total: 14,339 *	Number of weaving veh: 2686 Impact of uphill trucks: 0 Total: 8058 *	Number of weaving veh: 1305 Impact of uphill trucks: I-40 mainline: 568 C-D Road: 479 Total: 2352	Number of weaving veh: 1305 Impact of uphill trucks: I-40 mainline: 0 C-D Road: 0 Total: 1305	The **BRAIDED** alternatives require fewer vehicles to weave. The alternatives with New Lone Tree Road **OVER** I-40 eliminate conflict with uphill/slow trucks merging with high speed traffic.
Estimated R/W (Preliminary, rounded)	0 acres	19 acres	15 acres	19 acres	18 acres	No major difference; **DIAMOND OVER** requires the least amount of new R/W.
Estimated Construction Cost (Preliminary, Rounded; does not include R/W, final design, remaining utility relocation, or env. mitigation costs)	$0	$31,000,000 (TI) +$3,000,000 (I-40*) $34,000,000 (Total) *Cost for interim tie-in to existing I-40.	$32,000,000 (TI) +$3,000,000 (I-40*) $35,000,000 (Total) *Cost for interim tie-in to existing I-40.	$51,000,000 (TI) +$15,000,000 (I-40*) $66,000,000 (Total) *Cost for interim tie-in to existing EB I-40 and reconstruction of one mile of WB I-40.	$51,000,000 (TI) +$15,000,000 (I-40*) $66,000,000 (Total) *Cost for interim tie-in to existing EB I-40 and reconstruction of one mile of WB I-40.	Diamond alternatives have nearly identical costs; Braided alternatives have nearly identical costs.
Visual Impacts	Not measured.	Depressed interchange offers lower visual impact.	Elevated interchange has higher visual impact.	Depressed interchange offers lower visual impact.	Elevated interchange has higher visual impact.	**UNDER** alternatives recommended.
Noise Impacts	Not measured.	Depressed interchange results in higher noise impact.	Elevated interchange has lower noise impact.	Depressed interchange results in higher noise impact.	Elevated interchange has lower noise impact.	**OVER** alternatives recommended.

CASE 1A – BUILD INTERCHANGE WITHOUT WIDENING MAINLINE – INCREASE TRAFFIC VOLUMES 20%

The following evaluation is based on a scenario where projected traffic volumes are increased 20% evenly throughout the Case 1 network to test the sensitivity of the projections.

Criterion	No-TI Alternative	Diamond Under I-40	Diamond Over I-40	Diamond with Braided Ramps Under I-40	Diamond with Braided Ramps Over I-40	COMMENT/ CONCLUSION
Level of Service Traffic volumes increased 20% from Case 1 base model.	N/A	Not computed; LOS is E without increased volumes.	Not computed; LOS is E without increased volumes.	I-40 Mainline LOS 2015: B (16.3) 2018: Transition to C 2030: Transition to D 2040: D (32.0) C-D Road Weave LOS 2015: C (30.3) 2040: C (31.0)	I-40 Mainline LOS 2015: B (16.3) 2018: Transition to C 2030: Transition to D 2040: D (32.0) C-D Road Weave LOS 2015: C (30.3) 2040: C (31.0)	Only the **BRAIDED** alternatives offer an acceptable LOS in the design year.

Table 45 – New Lone Tree TI Alternatives Evaluation Matrixes – Case 2 and Case 2A

CASE 2 – BUILD LONE TREE TI AND RECONSTRUCT/WIDEN MAINLINE

The following evaluation matrix is based on New Lone Tree TI construction occurring simultaneously with I-40 mainline widening and reconstruction. Alternatives with loop ramp in northeast quadrant were eliminated because of impacts to apartments under construction and uncommon ramp/cross road intersection configurations.

Criterion	No-TI Alternative	Diamond Under I-40	Diamond Over I-40	Diamond with Braided Ramps Under I-40	Diamond with Braided Ramps Over I-40	COMMENT/ CONCLUSION
Description	Maintains existing grade separation for Lone Tree Road. Reconstruct/widen I-40 to improve mainline capacity.	New compact diamond TI. Reconstruct/widen I-40 to improve mainline capacity.	New compact diamond TI. Reconstruct/widen I-40 to improve mainline capacity.	New diamond TI with system ramp braided across diamond entrance ramp. I-17 system ramp traffic diverted to C-D road through TI. Reconstruct/widen I-40 to improve mainline capacity.	New diamond TI with system ramp braided across diamond entrance ramp. I-17 system ramp traffic diverted to C-D road through TI. Reconstruct/widen I-40 to improve mainline capacity.	--
New Lone Tree Road Over/Under I-40	N/A	Under	Over	Under	Over	2006 Lone Tree Road corridor study recommended "Under."
Implementation	N/A	Construct improvements with one project.	Construct improvements with one project.	Improvements can be constructed as one project or in two phases.	Improvements can be constructed as one project or in two phases.	Project is less complicated to construct and less expensive if only one phase is involved.
Level of Service / Sensitivity Assumed opening in 2015. Note that LOS are subject to change by varying input parameters.	N/A	I-40 Weave LOS 2015: C (25.9) 2021: Transition to D 2040: Transition to E 2040: E (35.1)	I-40 Weave LOS 2015: C (24.7) 2025: Transition to D 2040: D (33.4)	I-40 Mainline LOS 2015: A (9.1) 2040: B (15.4) C-D Road Weave LOS 2015: C (24.3) 2040: C (24.6) **Interim Phase Only** I-40 Weave LOS 2015: C (26.3) 2020: Transition to D 2038: Transition to E 2040: E (35.7)	I-40 Mainline LOS 2015: A (9.1) 2040: B (15.4) C-D Road Weave LOS 2015: C (24.3) 2040: C (24.6) **Interim Phase Only** I-40 Weave LOS 2015: C (26.6) 2019: Transition to D 2037: Transition to E 2040: E (36.0)	The **BRAIDED** alternatives offer the best level of service; however, the **DIAMOND OVER** meets ADOT criteria.
Safety / Conflict Evaluation Estimate of the number of vehicles required to weave and the number of vehicles impacted by an uphill truck merging over a 30-second timeframe. A lower number is better.	No change	Number of weaving veh: 2686 Impact of uphill trucks: 1396 Total: 4082	Number of weaving veh: 2686 Impact of uphill trucks: 0 Total: 2686	Number of weaving veh: 1305 Impact of uphill trucks: I-40 mainline: 378 C-D Road: 479 Total: 1683	Number of weaving veh: 1305 Impact of uphill trucks: I-40 mainline: 0 C-D Road: 0 Total: 1305	The **BRAIDED** alternatives require fewer vehicles to weave. The alternatives with New Lone Tree Road **OVER** I-40 eliminate conflict with uphill/slow trucks merging with high speed traffic.
Traffic Operations (Weaving Length)	None	Weaving length = 1,200 ft	Weaving length = 1,700 ft	Weaving length (Interim Phase) = 1,000 ft	Weaving length (Interim Phase) = 1,000 ft	**DIAMOND OVER** and **BRAIDED** (ultimate phase) alternatives provide longest weave lengths.
Driver Expectancy	No change	Good driver expectancy.	Good driver expectancy.	Moderate driver expectancy with potential for some confusion due to presence of two westbound entrance ramps.	Moderate driver expectancy with potential for some confusion due to presence of two westbound entrance ramps.	Conventional **DIAMOND** interchanges are more common. Braided alternatives acceptable.

Criterion	No-TI Alternative	Diamond Under I-40	Diamond Over I-40	Diamond with Braided Ramps Under I-40	Diamond with Braided Ramps Over I-40	COMMENT/ CONCLUSION
Utility Impacts (Estimated impacts to APS OH Transmission and distribution lines)	None	Major impacts to APS overhead power. $1,000,000 included in the TI cost estimate for overhead power line relocation. Other utility impacts not quantified.	Major impacts to APS overhead power. $1,000,000 included in the TI cost estimate for overhead power line relocation. Other utility impacts not quantified.	Major impacts to APS overhead power. $1,000,000 included in the TI cost estimate for overhead power line relocation. Other utility impacts not quantified.	Major impacts to APS overhead power. $1,000,000 included in the TI cost estimate for overhead power line relocation. Other utility impacts not quantified.	All alternatives require similar relocations of APS overhead 69kV and 230kV power lines. Other utility impacts not quantified.
Drainage / Snow Removal Issues	No change	Low point on cross road drains to Rio de Flag via storm drain system in I-40 median.	Interchange drains to Rio de Flag via roadside earthen ditches.	Low point on cross road drains to Rio de Flag via storm drain system in I-40 median. Areas next to retaining walls have limited snow storage capacity.	Interchange drains to Rio de Flag via roadside earthen ditches. Areas next to retaining walls have limited snow storage capacity.	The Under alternatives create a sump that requires storm drain system; **OVER** alternatives do not and therefore are preferred. The braided alternatives have a constrained cross section that inhibits snow storage.
Estimated R/W (Preliminary, Rounded)	0 acres	19 acres	15 acres	19 acres	18 acres	**DIAMOND OVER** requires the least amount of new R/W; however, all alternatives are similar.
Right-of-Way Impact to The Ridge at Clear Creek	None	New R/W required; limited to area previously dedicated for interchange improvements.	New R/W required; limited to area previously dedicated for interchange improvements.	New R/W required; limited to area previously dedicated for interchange improvements.	New R/W required; limited to area previously dedicated for interchange improvements.	All alternatives limit the new R/W area to the area previously dedicated for interchange improvements.
Estimated Construction Cost (Preliminary, Rounded) (Does not include R/W, final design, remaining utility relocation, or env. mitigation costs) Note: I-40 costs include reconstruction/widening of mainline from east of I-17 OP structure to west of Rio de Flag bridges, including replacement of bridges over "old" Lone Tree Rd.	$0	$31,000,000 (TI) + $31,000,000 (I-40) $62,000,000 (Total)	$32,000,000 (TI) + $31,000,000 (I-40) $63,000,000 (Total)	$51,000,000 (TI) + $31,000,000 (I-40) $82,000,000 (Total) Or, if built in phases: *Interim:* $43,000,000 (Interim TI) + $31,000,000 (I-40) $74,000,000 (Subtotal Phase 1) *Ultimate:* $8,000,000 (remaining TI elements) + $4,000,000 (re-work) $12,000,000 (Subtotal Phase 2) $86,000,000 (Total)	$51,000,000 (TI) + $31,000,000 (I-40) $82,000,000 (Total) Or, if built in phases: *Interim:* $38,000,000 (Interim TI) + $31,000,000 (I-40) $69,000,000 (Subtotal Phase 1) *Ultimate:* $13,000,000 (remaining TI elements) + $4,000,000 (re-work) $17,000,000 (Subtotal Phase 2) $86,000,000 (Total)	Diamond alternatives have nearly identical costs. Braided alternatives have nearly identical costs.
Retaining Walls (Preliminary, Rounded)	N/A	1 wall 30,000 SF	2 walls 30,000 SF	5 walls 180,000 SF	6 walls 180,000 SF	All alternatives require retaining wall in the northeast quadrant near the apartments. The braided alternatives require additional wall near the braiding structure.
Visual Impacts	Not measured.	Depressed interchange offers lower visual impact.	Elevated interchange has higher visual impact.	Depressed interchange offers lower visual impact.	Elevated interchange has higher visual impact.	**UNDER** alternatives recommended.

Criterion	No-TI Alternative	Diamond Under I-40	Diamond Over I-40	Diamond with Braided Ramps Under I-40	Diamond with Braided Ramps Over I-40	COMMENT/ CONCLUSION
Noise Impacts	Not measured.	Depressed interchange results in higher noise impact.	Elevated interchange has lower noise impact.	Depressed interchange results in higher noise impact.	Elevated interchange has lower noise impact.	**OVER** alternatives recommended.

CASE 2A – BUILD INTERCHANGE AND WIDEN MAINLINE – INCREASE TRAFFIC VOLUMES 20%

The following evaluation is based on a scenario where projected traffic volumes are increased 20% evenly throughout the Case 2 network to test the sensitivity of the projections.

Criterion	No-TI Alternative	Diamond Under I-40	Diamond Over I-40	Diamond with Braided Ramps Under I-40	Diamond with Braided Ramps Over I-40	COMMENT/ CONCLUSION
Level of Service Traffic volumes increased 20% from Case 2 base model.	N/A	I-40 Weave LOS 2015: D (32.6) 2020: Transition to E 2038: Transition to F 2040: F (44.1)	I-40 Weave LOS 2015: D (30.9) 2024: Transition to E 2040: E (41.9)	I-40 Mainline LOS 2015: B (11.0) 2038: Transition to C 2040: C (18.6) C-D Road Weave LOS 2015: C (30.3) 2040: C (31.0)	I-40 Mainline LOS 2015: B (11.0) 2038: Transition to C 2040: C (18.6) C-D Road Weave LOS 2015: C (30.3) 2040: C (31.0)	Only the **BRAIDED** alternatives offer an acceptable LOS in the design year. The Diamond alternatives fall below LOS D in 2020 and 2024.

3.5.4 New US 89 TI (MP 202.31)

This new interchange is proposed approximately 1.5 miles east of the Country Club TI and would connect I-40 to a future roadway linking I-40 to Townsend-Winona Road and US 89 near the Flagstaff Mall.

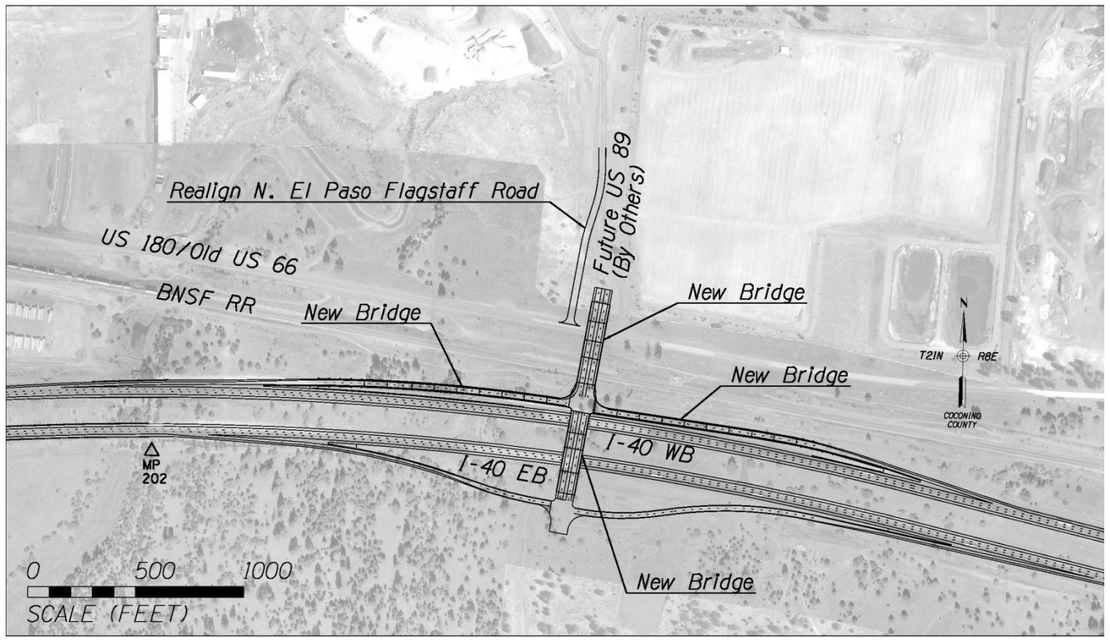
In the area of the new interchange, I-40 consists of two 12-foot lanes, a 10-foot outside shoulder, and a 4-foot inside shoulder in each direction. The eastbound and westbound mainlines are separated by a 176-foot wide naturally vegetated median.

The proposed typical section in this urban/fringe urban area would consist of three lanes (60 feet) in each direction. The posted speed on the mainline in this area is 75 mph. The terrain is rolling with an average elevation of 6800 feet.

The location of the new interchange could be shifted to align with the future connector road once the connector roadway alignment is defined by a separate study, which is anticipated to be conducted by Coconino County. The timing of the alignment study is unknown.

The new TI would be constrained by the railroad and existing roadways to the north. South of I-40, the land is wooded and undeveloped. Overhead electric transmission lines cross I-40 approximately 250 feet west of the cross road location shown in the concept-level plans (Appendix C).

Figure 46 – New US 89 TI Alternative



A tight diamond interchange is recommended at the new US 89 TI. The cross road would bridge eastbound and westbound I-40, the BNSF railroad tracks, and US 180/East Santa Fe Avenue. Because of the narrow R/W and the high cost of an elevated roadway with retaining walls on both sides, bridges would also be recommended for much of the westbound ramp lengths. The eastbound exit ramp would create a cut slope within a rockfall area that could require mitigation.

The ramp/cross road intersections would be signalized.

Approximately 850 feet of North El Paso Flagstaff Road would need to be re-aligned on the north side of I-40 to mitigate conflicts with the cross road alignment. There could be other conflicts between the future connector roadway and North El Paso Flagstaff Road that would need to be addressed by the US 89 alignment study.

The new elevated interchange would likely conflict with the overhead power lines. Approximately $2 million is included in the overall cost estimate for utility relocations at this location.

3.6 Summary of Recommended Alternatives

As detailed in this chapter, the following build alternatives are recommended. In addition, the recommended interchange alternatives are summarized below.

Mainline Widening

In general, the recommended widening concept for the addition of a third lane in each direction is to use inside widening for the three-lane roadways between MP 183.6 and MP 208.4. The outside widening concept or reconstruction would be used at specific locations where terrain or lane configurations dictate:

- From MP 188–MP 189 (S-curve rockfall containment area): Outside widening is recommended for the eastbound and westbound alignments in this segment, as well as re-profiling of the existing roadways. The westbound profile will be flattened to a 4.0% maximum grade and outside rockfall mitigation measures will be incorporated. The eastbound profile will be raised slightly and its horizontal alignment shifted to the outside where a retaining wall will be constructed to avoid impacts to the adjacent railroad.
- MP 190–MP 193 (Riordan Railroad Crossing): The eastbound and westbound horizontal alignments through this section will be modified to straighten the existing S-curve over the BNSF railroad tracks and improve the superelevation. The profiles in both directions will also be adjusted to lengthen vertical curves for improved stopping sight distance and provide the necessary vertical clearances for the new deeper structures at the railroad and the West Flagstaff TI.
- MP 193–MP 194 (Woody Mountain Road): The eastbound and westbound alignments will be re-aligned toward the inside median and lowered to improve the approach grades of the Woody Mountain Road crossing and accommodate the potential new interchange and FUTS crossing.
- MP 199–MP 200 (Fourth Street rockfall containment area): The eastbound and westbound alignments will be re-aligned toward the median to mitigate the outside rockfall issues.

Existing Traffic Interchanges

- **Bellemont TI** – The Realigned Diamond with Roundabouts Alternative is recommended.
- **Butler TI** – A recommended alternative has not been identified; however, it is recommended that the Roundabout, Signalized Diamond, and Double Crossover alternatives be carried forward for

further consideration and public comment and the Three Point Urban Alternative be eliminated from further consideration.

- **Walnut Canyon TI** – Reconstruction of the TI to a standard diamond configuration is recommended, with all four diagonal ramps intersecting the re-aligned cross road at reduced skew angles.

- **Cosnino TI** – The Diamond Alternative is recommended.

- **Winona TI** – Reconstruction of the interchange in a configuration similar to the existing interchange is recommended. The cross road will be shifted to the east.

Proposed New Traffic Interchanges

- **Camp Navajo TI** – A new diamond interchange is recommended.

- **Woody Mountain TI** – The Diamond Interchange with Roundabouts Alternative is recommended.

- **Lone Tree TI** – A recommended alternative has not been identified; however, it is recommended that the Braided Over and Braided Under alternatives be carried forward for further consideration and public comment. It is recommended that the Loop alternatives and the Diamond Over and Diamond Under alternatives be eliminated from further consideration.

- **US 89 TI** – A new tight diamond interchange is recommended.