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MEMORANDUM

To: Jessica Hall and Jennifer Kalt, Humboldt Baykeeper

From: Michael Moule, PE, TE and Magnus Barber

Date: August 6, 2013

Subject: Eureka-Arcata Route 101 Corridor Improvement Project Review

PROJECT BACKGROUND

California Department of Transportation (Caltrans) has proposed alterations to approximately 6 miles of the Highway 101 Safety Corridor between Eureka and Arcata, CA. The Safety Corridor is a 50-mile per hour rural divided highway. Bicyclists and pedestrians use the corridor's shoulder to commute, recreate, and tour the coast. Businesses and feeder roads access Highway 101 primarily from the east, with openings in the highway's median to allow for crossings. Old Arcata Road and Highway 255 are significant streets that connect Eureka and Arcata, through farmland, natural habitat and residential areas. Crash rates prior to the installation of the Safety Corridor were above the state average at Indianola Road and the Mid-Cities Motors access road. Crash rates at other crossings are within state averages, despite weather events, such as a fog, that impact visibility.

Caltrans has proposed several alternatives to address the crash rate along this corridor and meet other project goals. The preferred alternative would close medians at most access locations, install an interchange at Indianola Cutoff, and a partially signalized intersection at Airport Road / Jacobs Avenue. Other alternatives studied included the installation of up to six (6) traffic signals at the access locations.

Humboldt Baykeeper asked Nelson\Nygaard Consulting Associates to review background data, assess some of the alternatives proposed by Caltrans, and recommend other possible alternatives. This memo summarizes the findings of this data review and alternatives assessment.

DATA REVIEW

Observations of Existing Conditions

General Observations

Route 101 between Eureka and Arcata is a 4-lane rural divided roadway with a wide median; sometimes called a rural "parkway" design. The shoulders are typical fairly wide (about 8 feet), with a ground in rumble strip under the edge line. One notable exception is the bridge for the northbound lanes over the Eureka Slough – this bridge is older and has a 2-foot shoulder. It also has a 4-foot sidewalk, which is suggested for bicyclists to use, via shared lane markings as shown in the picture below.

Roadway Continuity

The conditions at each end of this corridor are important, since the context of Highway 101 varies significantly as it travels through Eureka, Arcata, and the rural areas surrounding these cities. In Eureka, Highway 101 is a one-way couplet on 4th and 5th Streets through downtown, a very urban condition. Northbound 101 is on 5th Street, which is primarily a 3-lane one-way street. Southbound 101 is on 4th Street, which is primarily a 2-lane one-way street. In Arcata, Highway 101 is a limited access freeway, starting just north of Bayside Cutoff and continuing north for more than 20 miles. In the existing condition, the project corridor provides a reasonable transition between the downtown urban street context in Eureka and the limited access freeway context in Arcata.

Intersection and Driveway Access

This corridor has seven access points as follows:

- Two "cross" access points that have connections on both the east and west side of the highway. Both of these access points allow all turning movements, but are not at public streets but rather for private properties typically with industrial land use.
- Two "T" access points have roadway connections on the east side, connecting to the larger street network (Indianola Cutoff and Bayside Cutoff). These both allow all turning movements to just the one side.
- Two "T" access points that allow all turning movements for access to private properties on the east side of the highway (Airport Road/Jacobs Avenue and access for the car dealerships.
- One "T" access point that allows only right turn movements at the south end of Jacobs Avenue, providing access to several private properties. Left turn movements are currently made at the access where the north end of Jacobs Avenue connects to Airport Road.

All access points are one-way or two-way stop control, so that Highway 101 has free-flow traffic, and the side streets or driveways have stop control.

From a bicycling perspective, the existing access points are both good and bad. Full movement access at most locations means that bicyclists can arrive at and depart from destinations without any out-of-direction travel. On the other hand, the unsignalized intersections introduce potential hazards for bicyclists. Bicyclists making left turns at the access points must navigate across two lanes of traffic, which at times likely has only a few gaps. Bicyclists traveling on the highway shoulder are potentially endangered when motorists turn onto or off of the highway, especially when motorists make left turns. A common bicycle-motor vehicle crash type occurs when motorists turn left to or from a minor street or driveway; drivers are primarily focused on other motor vehicles and sometimes miss seeing a bicyclist, resulting in a crash.

Alternative Routes for Bicyclists

There are two alternative routes for bicyclists connecting Eureka and Arcata. If bicyclists find that travel along Highway 101 becomes more circuitous and/or less safe, these alternate routes become more important connections:

- Highway 255 provides an alternative to 101, but it is a more circuitous route (about 1.5 miles or 20% longer). It has lower traffic volumes and therefore might be a more desirable route, but it does have narrower (but sufficient) shoulders and a higher speed limit along most of its length than the Safety Corridor on Route 101.
- Myrtle Avenue and Old Arcata Road provide another alternative, but this route is even more circuitous, about 4 miles or 50% longer, and has some elevation changes in terrain. Again it has lower traffic volumes and narrower, but sufficient shoulders. For many recreational cyclists, this route might be preferred due to the more varied terrain, but it is the longest of the three routes. The most circuitous part of this alternative is along Myrtle Avenue near Eureka. Many cyclists likely choose to ride Highway 101 near Eureka, and then use Indianola Cutoff or Bayside Cutoff to connect to Old Arcata Road. This may be especially true since 101 becomes a limited access expressway north of Bayside Cutoff. Using 101 and Old Arcata Road reduces the extra distance dramatically to either about 1 mile (about 10%) if Bayside Cutoff is used, or about 2 miles (about 25%) if Indianola Cutoff is used.

Distances from downtown Eureka to downtown Arcata

Route	Length in Miles	Percentage Greater Than the Direct Route on 101
US 101	7.7	0%
California 255	9.1	18%
Myrtle Avenue + Old Arcata Road	11.6	51%
US 101 + Indianola Cutoff + Old Arcata Road	9.6	25%
US 101 + Bayside Cutoff + Old Arcata Road	8.6	12%

Review of Background Studies, Memos, and Reports

November 2005 Traffic Study Report

In this study, the discussion of the alternatives with signals at Airport Road indicates that there would be separate signal phases for Jacobs Avenue and Airport Road. Providing two signal phases for traffic on the east side of Route 101 could significantly increase the amount of time that traffic on Highway 101 is stopped, delaying traffic on 101 a significant amount, and potentially driving the “need” for more through lanes on 101. In order to maintain the fewest possible lanes on Route 101, it is recommended that only one signal phase be provided for these two streets. This may require geometric changes to these streets, as shown in several of the background documents.

DEIR 2007

This document discusses many of the safety reasons for the proposed alternatives, including eliminating uncontrolled left turn movements to or from Route 101, and also reducing left diverge and merge movements. With respect to left merge issues, this document states the following on page 5 of chapter 1:

> "A left-merge movement is one where traffic on an acceleration lane merges into, or a deceleration lane merges out of, the main flow of traffic from the left-hand side of the road. This can be an unexpected move to motorists since more than 95% of highway merge movements are right hand merges. Left-merge movements have much higher collision rates than that of right-side ramp exits and entrances. Of the total number of rear-end, sideswipe and overturned vehicle collisions occurring at intersections along Route 101 from 1994 to 1999, three times as many occurred in the left lane as the right. The American Association of State Highway and Transportation Officials (AASHTO) 2001 publication "A Policy on Geometric Design of Highways and Streets" states: "Left-side main roadway exit ramps should be avoided because they may appear to be a right side entrance ramp to a confused motorist." and later in the guide: "Left-hand entrances and exits are contrary to the concept of driver expectancy when intermixed with right-hand entrances and exits. Therefore, extreme care should be exercised to avoid left-hand entrances and exits in the design of interchanges."

The concern about left merge movements for the Safety Corridor is perhaps a bit exaggerated. The discussion about the ratio of crashes occurring in the left lane is relevant, although this may or may not be due to left merges. Additionally, the quotes from the AASHTO document (commonly referred to as "the Green Book") are excerpted from the chapter about "Grade Separations and Interchanges." This reference would fully apply if this roadway is or will be a limited access freeway. But for unsignalized or signalized intersections, the concerns about left merges and diverges are not as great as they are for limited access freeways. On highways that are not limited access, there is more driver expectation for "friction" along the roadway, including vehicles entering from the left side. This isn't to say that left merges are completely unproblematic, but perhaps not as bad as the document is making it out to be. For example, when comparing a fully signalized intersection with the Continuous Green T Intersection alternative suggested later in this memo, the tradeoff for southbound 101 is between signal control and occasional vehicles merging into the traffic stream from the left. A traffic signal is likely to be associated with more frequent crashes than the vehicles merging in from the left.

Memo from Troy Arseneau to Kimberly Floyd, July 17, 2012

On page 3, this memo discusses pedestrian crossings at signalized intersections as follows:

> "Another major disadvantage to a "signalized boulevard" alternative would be in facilitating pedestrian traffic across U.S. 101 mainline. In the District 1 Traffic Operations modeling effort, it was assumed that pedestrians would be allowed to cross U.S. 101 mainline at the Indianola Cutoff intersection, with only one crosswalk crossing U.S. 101 being allowed at the intersection. Under this scenario, mainline traffic delay was found to be greatly increased by each pedestrian call due to the large pedestrian crossing distance. Ideally, pedestrians would only cross one direction of U.S. 101 at a time, make an additional pedestrian call (push the pedestrian button) once in the median pedestrian refuge area for the crossing of the opposing mainline travel lanes, and then wait for the next pedestrian phase to occur to finish crossing the highway.

> Challenges would exist by having a raised pedestrian refuge in the U.S. 101 median because of the speeds on mainline U.S. 101. Per the Highway Design Manual, Sixth Edition, California Department of Transportation, Index 405.4 (2), "On facilities with speeds over 45 mph, the use of any type of curb is discouraged," meaning that a raised pedestrian island in the median would not be desirable and less likely to be deemed "acceptable" by Caltrans Headquarters geometrician and traffic liaisons.
>
> Not having a raised pedestrian refuge island would place pedestrians at considerable risk of being struck by vehicular traffic. This would force the need to have a long enough pedestrian phase (about 45 seconds) to ensure that pedestrians could cross both directions of mainline traffic causing considerable delay to mainline traffic. Our engineering analysis used the pedestrian walking speed of 3.5 feet per second as recommend by the California Manual on Uniform Traffic Control Devices, 2012 Edition, California Department of Transportation, Page 948, and required by Caltrans Traffic Operations Policy Directive 12-01, dated March 30, 2012."

It is true that a curbed roadway is discouraged by Caltrans guidelines, but this doesn't necessarily make it impossible to allow pedestrians to cross the roadway in two stages. A pedestrian walkway could be placed in the median, connecting the two legs of the crosswalk. Waiting on this walkway in the wide median is probably not less safe than waiting at the outside edge of the roadway to cross, with or without a raised curb. At 50 mph, no curb is sufficient to adequately deflect an out-of-control vehicle that is running off of the road. But even if the signals are designed to allow pedestrians to cross all of Route 101 in one signal phase, it is unlikely that pedestrian signals would cause significant delay along the corridor. This is due to the fact that pedestrian usage is very low in this area, and this is unlikely to change unless there are significant changes in land use. It is true that providing signal timing for pedestrians to cross an eight lane roadway would result in a long delay for motor vehicles each time a pedestrian pushes the button to actuate the signal. However, the pedestrian signals would likely only be actuated a handful of times per day, so the overall effect on traffic flow on 101 would be small.

On page 5, this memo includes a long statement about the interchange not increasing capacity. It even states: "While the interchange will no longer require vehicles entering the highway from the minor streets to have to stop (but will have to yield upon entering U.S. 101) as they will be able to merge onto the highway at the interchange, the interchange will not increase highway capacity on either U.S. 101 or the minor streets." As noted above, an interchange absolutely increases the capacity for the minor streets. Today, due to high volumes on Highway 101, the capacity for left turns from the minor streets is quickly approaching zero, so it is not surprising that the Caltrans studies reported Level of Service (LOS) F for westbound and eastbound left turns from the side streets and driveways, even those with low volumes of left turning vehicles.

On page 6, this memo refers to the California Coastal Commission staff report: "A statement was also made indicating that the project will "speed up" traffic and make it less safe for bicyclists and impact the bicycle trips length." Troy Arseneau responds to this by stating, "This statement is incorrect because the project geometrical improvements, in themselves, will not cause an increase in vehicular speed on U.S. 101. In addition, speed limits are determined in a separate process, which is mandated by the California Vehicle Code and the California Manual on Uniform Traffic Control Devices (CAMUTCD)." The statement that the geometric changes will not cause an increase in vehicle speeds is likely inaccurate. A roadway with fewer access points, fewer uncontrolled left turn movements, and longer merge and diverge lanes will generally result in faster vehicle speeds, compared to the existing highway with unsignalized intersections that create "friction", which likely reduces motor vehicle speeds. Without left turn conflicts, drivers will experience less friction and will tend to go faster. The reference to speed limits is meaningless because speed limits have little effect on actual travel speeds, unless significant enforcement is provided (as with the Safety Corridor). But it is quite likely that speed limits will increase because the current speed limit is set artificially low due to the safety corridor. As Troy Arseneau stated, CVC and CA-MUTCD standards require speed limits to be set in response to higher measured speeds on the corridor, which is the likely result of reducing friction through the project's proposed improvements.

Letter from Kimberly Floyd to Mark Delaplaine July 25, 2012

This letter includes the following quote: "The construction of an interchange does not increase the capacity of a highway segment." This is not entirely true. It could arguably be true for through movements, but absolutely not for turning movements. The capacity of the proposed interchange is undoubtedly higher than the capacity of the existing stop-controlled intersection. This is evidenced by the LOS F ratings shown for left turning movements in the traffic studies for the project. The reason that these left turn movements show LOS F isn't necessarily because there are a lot of vehicles turning left, but rather because there are so many vehicles on Highway 101, that there are few gaps for left turning traffic to turn across the traffic stream. Consider that if in theory the volume on 101 increased to a point where there are no gaps in the traffic stream, then the left turn capacity would be zero. With an interchange the left turn capacity isn't affected by the through volume on 101 in the same manner. It is MUCH higher.

Coastal Consistency Addendum February 2013

On page 13, this document states, "It would not be appropriate to allow pedestrians to cross Route 101 at each intersection in the corridor." By law, pedestrians are allowed to cross 101 anywhere along the corridor as long as they yield to traffic on the roadway. Caltrans probably intends that they don't recommend providing designated, marked crosswalks at all of the intersections, particularly unsignalized intersections. If either signalized intersections or roundabouts are used, placing crosswalks is more practical. At signalized intersections, traffic can be stopped to allow an occasional pedestrian to cross. At roundabouts, the reduced motor vehicle speeds make it possible for pedestrians to cross much more easily and safely than across an uncontrolled intersection.

This document also discusses challenges with pedestrian crossings at signalized intersections. On pages 13-14, it states: "Simultaneously attempting to maintain acceptable traffic flow, while providing sufficient time for pedestrians to cross Route 101, would be an untenable goal. In order to maintain an acceptable level of service (LOS) on Route 101, additional lanes are required for signalized Eureka-Arcata Corridor Improvement Federal Coastal Consistency intersections. For pedestrians, the signal timing would be set such that there would be insufficient time to allow pedestrians to cross the widened Route 101 because the additional lanes create additional width for pedestrians to cross. If the signal phase time for pedestrians were increased to provide sufficient crossing time, this would result in traffic delay and lower the LOS for the Route 101 through traffic." As discussed above in response to the memo from Troy Arseneau, pedestrian usage is very low along this segment of Route 101, so the overall delay to traffic on 101 is likely to be minimal. In addition, as discussed later in this memo in the section on the signalized boulevard alternative, the additional lanes may not be necessary.

Traffic Volume Data

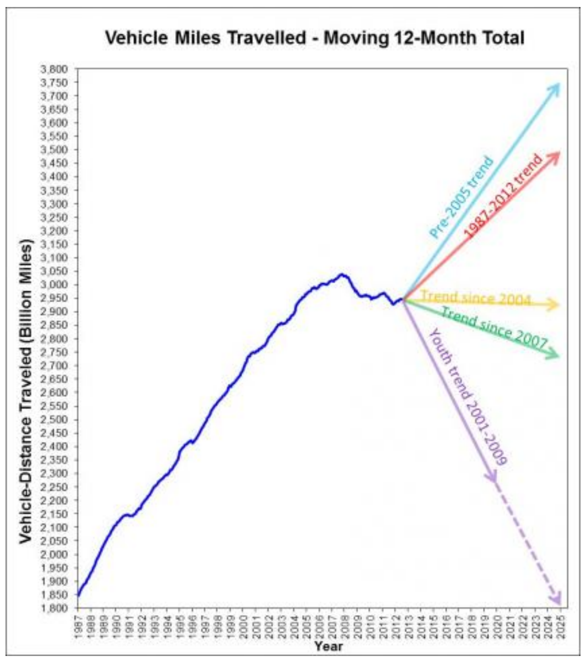
Although there are dozens of background documents and studies that have been provided by Caltrans, thus far very little traffic volume data has been received. There are numerous studies that provide the results of what appear to be very detailed traffic analysis, but the raw count data and detailed analysis results have generally not been received. Thus far, the only actual count data received are total Average Annual Daily Traffic (AADT) for several locations along the corridor, as well as counts of the left and right turning movements at the intersection of Route 101 and Indianola Cutoff.

The turning movement counts at Indianola Cutoff are at the same time both too much and too little information. Caltrans sent a month's worth of counts of all the right and left turning movements at the intersection, at 15 minute intervals. While this detailed 15-minute breakdown is useful to see how turning volumes change throughout the month a typical turning movement count for an intersection such as Indianola and 101 would also include the straight through volumes. As described below in the traffic analysis section of this memo, we have been able to use this detailed information to develop a traditional turning movement count summary for this intersection, but not without some effort and the result is merely an estimate.

Ideally, we would prefer a simple one-page sheet showing the peak hour turning (and through) movements at the intersection, preferably both the existing counts (typically manually counted by a person on site), as well as estimated future counts. Regarding future counts, the main thing we would be looking for is anticipated turning movement (and through) counts based on the change to the road network when the project is built (e.g. when all the left turns are prohibited). They've analyzed this and reported their results, but have not provided the actual count information to easily allow for an independent review.

Increases in Background Traffic

Several of the documents from Caltrans indicate that there will be ongoing traffic growth on the corridor, typically showing an increase factor of 1.4 each year. Using an approximate growth factor has been common practice on projects like this for decades. However, it is critical to note that there has recently been an unprecedented change in the growth in vehicle trips in the United States. The figure at right shows the actual total vehicle miles traveled (VMT) nationwide from 1987 until 2012, with several theoretical trend lines for future years. Since the 1950s until 2004, VMT increased at roughly the same rate (the figure shows this trend from 1987 until 2004. Since 2004, VMT has either grown more slowly or even dropped from year to year. The changes in growth in VMT call into question any predictions on the future growth in traffic on any corridor, including Route 101.



Historical trends for Vehicle Miles Traveled and possible future trends (Sources. Data: Federal Highway Administration. Future trends: interpolated from historical data)

Induced Growth or Development

Many transportation agencies have historically overlooked the potential growth or development inducing effect of roadway construction projects. However, it is now well documented that roadway projects can encourage growth and development, especially projects that increase capacity. But even when the overall mainline capacity isn't increased (e.g. in areas where capacity increases are restricted by the Coastal Act), changes to intersection control can influence future development nearby.

As an example, consider possible signalization of the intersection of Route 101 and Indianola Cutoff or other street or driveway access points to Route 101. The signals on 101 will increase travel time as noted in the Caltrans reports, thus possibly discouraging people from driving on 101, which could have several effects, including drivers shifting to other routes, but also might discourage development in areas that this effects. But on the other hand, right now there is a lot of delay when trying to make a westbound left turn onto Route 101 from the existing access points. Signals at these locations would absolutely make this left turn more convenient, potentially inducing growth on or near these side streets. For the minor streets/driveways on the corridor, signals would absolutely encourage growth on the properties that currently access this stretch of 101, especially compared to the alternatives that eliminate left turns at these locations, which would discourage growth/development at these locations

The installation of roundabouts could have similar traffic inducing effects, and due to lower overall delays might actually induce growth and development more than signals.

SIGNALIZED BOULEVARD ALTERNATIVE

General Evaluation

When compared to other alternatives, the signalized boulevard alternative is by far the worst alternative from an operational perspective. It will result in the most overall delay for traffic on Route 101. From a safety perspective, it falls somewhere in the middle. Traffic signals are better than any alternative that maintains uncontrolled left turns.

But as indicated in several of the documents from Caltrans, signals do result in an increase in rear-end crashes. Therefore, any alternative that eliminates uncontrolled left turn movements without adding signals will be a safer alternative. In addition, reducing the number of signals without allowing uncontrolled left tuning movements will improve safety and operations for Route 101.

Although signals will likely result in more overall crashes than the alternatives that eliminate left turns without using signals, it is important to note that most of these crashes will likely be rear end crashes, which have lower severity than the angle crashes that are currently occurring with vehicles making uncontrolled left turns. This said, it is important to note that signalized intersections also experience angle crashes when drivers fail to stop at red signals. Red light running crashes are relatively rare, but in this case, there are other factors that may result in higher incidence of red light running. The context of this section of highway could potentially negatively affect red light running. North of Bayside Cutoff, Route 101 is a limited access freeway, where drivers expect few interruptions in free-flow conditions. Currently, the Eureka-Arcata segment of Route 101 acts as a transition between the freeway context in Arcata and the urban signalized context in Eureka. Southbound drivers see uncontrolled intersections in this transitional zone before they encounter their first signal. If a series of signals is installed in this segment, this transition would no longer exist. The northernmost signal and possibly other signals would potentially experience higher than normal red light running incidents. This can be mitigated somewhat by installing warning signs with flashing beacons or changeable message signs, both treatments previously used by Caltrans in similar situations.

Number of Traffic Signals

Based on our experience in traffic design and engineering, it is unlikely that Caltrans would build a Signalized Boulevard alternative with six traffic signals. Many of the minor streets or driveways where signals are proposed have traffic volumes well below the thresholds typically necessary to meet the signal warrants in the California Manual on Uniform Traffic Control Devices (CA-MUTCD). It is highly unlikely that Caltrans would install a series of unwarranted signals. Safety and operational goals can absolutely be met with fewer signals. In fact, safety and operations on Route 101 would both be improved if the proposed signals were replaced with intersections with closed medians, prohibiting direct left turn movements. However, as minor street or driveway volumes increase at intersections with median closures, the inconvenience to users becomes greater, so it is more important to provide full movement intersections.

It is recommended that Caltrans consider a signalized boulevard concept with two to four signalized intersections. If a signalized boulevard concept is to be further considered, here are some considerations regarding which intersections should be signalized, listed with the most important intersections to signalize listed first:

1. Indianola Cutoff: This road appears to carry the most traffic of all the access points to Route 101, and this intersection's location would allow it to serve as an appropriate place to make U-turns for nearby lower volume access points where only right-in, right-out movements would be allowed. If a signalized boulevard alternative is used, we recommend that this intersection be the highest priority intersection for signalization.

2. Airport Road / Jacobs Avenue: This access point serves many businesses of various types, so requiring indirect left turns would make it inconvenient for more users than at other locations. Therefore a signalized intersection is recommended here.

3. Bayside Cutoff: This intersection serves as an important access point to the rest of the roadway network, and would be a useful location for a signalized intersection. There is also a long tangent along Route 101 north of this intersection, which makes the intersection visible to southbound drivers for more than a mile. This would make it easier to successfully notify southbound drivers that there is a signal ahead, as they leave the limited access portion of Route 101. On the other hand it is less important to include a signalized intersection here because Bayside Cutoff connects to the larger roadway network, making a full movement intersection here somewhat redundant with one at Indianola Cutoff. Any users who would prefer to access 101 at Bayside Cutoff could detour to Indianola Cutoff. However, users who want to access Bracut would be served by the ability to make U turns at this intersection.

4. Mid-City Motors: Of the remaining access points, Mid-City Motors likely has the highest volume of traffic entering and exiting traffic Route 101. In addition, the nearest U-Turn location to the north (Indianola Cutoff) would require 3 miles of out-of-direction travel. So a signal might be useful here, although it seems unlikely that signal warrants would be met.

5. Bracut: The traffic volumes at this location likely don't meet signal warrants. Additionally, if signals at Indianola Cutoff and Bayside Cutoff allow for U-turns, then the out of direction travel is not all that significant for users wishing to access the land uses here. It is recommended that a signal not be installed here.
6. Simpson Sawmill: The few land uses accessing the highway at this location likely generates very little turning traffic, so a signal is not recommended here.

Number of Travel Lanes

The following recommendations about number of lanes at signalized intersections are based on the intersection of Route 101 and Indianola Cutoff. This intersection carries the highest overall turning volumes, and is the only intersection that we have analyzed. Given the lower volumes at other intersections, we anticipate that the same number of (or fewer) travel lanes would be sufficient at other intersections as well.

Through Lanes

As described in the traffic analysis section at the end of this document, our analysis indicates that two northbound lanes and two southbound lanes would be sufficient for Indianola Cutoff with existing traffic volumes. Our estimated left turn and U-turn volumes require relatively short green intervals for the southbound left turn and the westbound left turn, which means that northbound and southbound traffic would experience sufficient green time to move the existing traffic in two lanes. To achieve the best level of service for northbound and southbound traffic in two lanes, the optimal signal timing includes a long signal cycle length of approximately 120 to 150 seconds. This results in relatively long average delays and poor level of service for the westbound and southbound left turn movements. However, we recommend this signal timing in order to favor the through movements on Route 101. Long cycle lengths may also reduce the phenomenon of induced development.

Turning Lanes

Northbound

Caltrans has recommended a deceleration lane for the northbound right turn movement at signalized intersections. The use of a deceleration lane is important to reduce rear-end crashes when drivers make northbound right turns during the northbound green interval. We recommend that this deceleration lane be included in the signalized intersection design.

Southbound

Caltrans has recommended a southbound double left turn lane at Indianola Cutoff. Our analysis indicates that a single left turn lane would be sufficient. We recommend that the signalized intersection include only a single southbound left turn lane, and therefore only one eastbound receiving lane on Indianola Cutoff.

Westbound

Caltrans has recommended two westbound left turn lanes and one westbound right turn lane. Our analysis indicates that one westbound left turn lane would be sufficient. We recommend that only a single westbound left turn lane be installed at this intersection, along with a single westbound right turn lane. However, the use of a double left turn lane does not appear to increase wetland encroachment, and would further reduce the necessary green time for the westbound left turn movement, increasing green time for the northbound and southbound through movements along 101. So if any additional turn lanes are to be added in order to improve intersection capacity, it is reasonable to add this second left turn lane.

Additional Lanes for Future Year Traffic Volumes

Our analysis did not assume any future growth in background traffic along the Route 101 corridor. Caltrans estimated future traffic growth using a traffic model, and this future growth may be a factor, but they have not provided future estimated turning movement counts. In addition, as we noted in the "increases in background traffic" section of this memo, recent trends in traffic growth indicate that there may not be significant growth in traffic in the future.

Another way to look at the "necessary" number of travel lanes is to compare the through capacity of the existing roadway without signals with the through capacity of Route 101 with traffic signals. This may be especially useful since Coastal Act requirements don't allow capacity increases in wetland areas. In their memos on this subject, Caltrans seems to ignore overall intersection capacity, and focus primarily on the capacity for through movements. The appropriateness of using intersection capacity versus through capacity is something that we won't try to address; it is more of a legal question than a technical question. But for the sake of argument, I'll focus on through capacities for the moment.

The recommendation by Caltrans for three through lanes southbound and four through lanes northbound may be an attempt to maintain the same through capacity for Route 101, even though this roadway is not near its capacity at this time. It is true that signalizing through movement will reduce the capacity of each of the lanes, therefore additional through lanes would be needed to maintain the through capacity. However, we believe that the signal timing at Indianola cutoff can be adjusted in such a way that three through lanes would be sufficient to carry the through traffic at the intersection. This is done by providing a long enough cycle length to ensure that the through movements have a green signal for at least 70% of the signal cycle. Given the low turning volumes, this should be possible if a long cycle length is used. If three through lanes are used for northbound and southbound traffic, it should be possible to add a lane on the approach to the intersection, and drop it again after the signalized intersections, as long as signals are installed at only the three highest ranked intersections in the list provided above. Because these signalized intersections are spaced fairly far apart, it would not be necessary to carry three through lanes for the entire length of the project.

Wetland Encroachment

The discussion of travel lanes above addresses minimizing the highway's footprint in this area. Based on our analysis, the existing traffic can be handled with two through lanes northbound, two through lanes southbound, one southbound left turn lane, one northbound right turn lane, two westbound approach lanes (one for right turns and one for left turns, and one eastbound departure lane. This is a total of 13 approach and departure lanes at the intersection, compared to the total of 23 approach and departure lanes shown in the drawing from Caltrans. This is a significant reduction in the highway's footprint.

If three through lanes for northbound and southbound traffic are used in an effort to maintain the existing through capacity, then the total number of lanes would be 17 lanes.

Other Recommendations

The following recommendations are suggested to minimize crashes, improve traffic flow (maintain existing capacity), maintain pedestrian and bicycle access, and/or reduce wetland impacts.

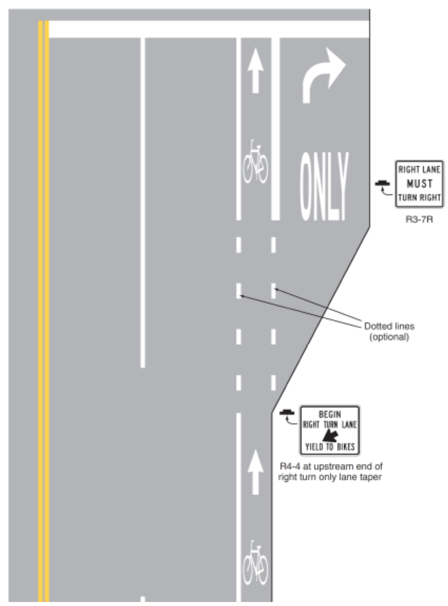
Pedestrian Treatments

As described above in the review of background documents, it is possible to provide designated pedestrian crossings at the signalized intersections. These could be built as two-stage crossings, where pedestrians cross one direction of Route 101 at a time, or could be built to allow pedestrians to cross all the way across in one phase. Two-stage crossings would reduce the impact on motor vehicle traffic operations, but one stage crossings would provide less delay to pedestrians. Either way, the overall impact on traffic flow is likely to be minimal due to the fact that there are (and likely will be) few pedestrians on this corridor.

Bicycle Treatments

Because bicyclists can more easily travel long distances, bicycle travel on Route 101 is much more common than pedestrian travel. The signalized intersection design will allow bicyclists to make left turns to and from the minor streets more easily. Left turns from Route 101 are more difficult because ideally bicyclists should merge across into the left turn lane, which requires merging across two lanes of high speed traffic. As indicated in several of the Caltrans documents, this can be a difficult maneuver, especially as traffic volumes increase and there are few gaps in the traffic stream. If a pedestrian crossing is included at the signalized intersections, bicyclists would have the option of stopping at the intersection and crossing Route 101 like a pedestrian.

Figure 9C-4. Example of Bicycle Lane Treatment at a Right Turn Only Lane



Another challenge for bicyclists with the signalized intersection design is the right turn lanes. In a typical rural intersection design, there would be a shoulder to the right of the right turn lane, and bicyclists would need to merge across the right turn lane. One solution to this problem in areas where consistent bicycle traffic is expected is to provide shoulder space between the through travel lanes and the right turn lane. This would be similar to the standard bike lane design shown at right (figure 9C-4 from the California MUTCD), except there would be no bike lane markings included.

Continuous Green T Intersection

As described below in the Potential Alternatives section of this memo, we recommend that a Continuous Green T Intersection design be considered for each of the possible signalized intersections. This is essentially what has been proposed at Airport Road in Caltrans Preferred Alternative 3A, and called a “half signal”.

CALTRANS PREFERRED ALTERNATIVE 3A

Caltrans Preferred Modified Alternative 3A includes a full interchange at Indianola Cutoff, and a continuous green T intersection (half signal) at Airport Road.

Indianola Interchange

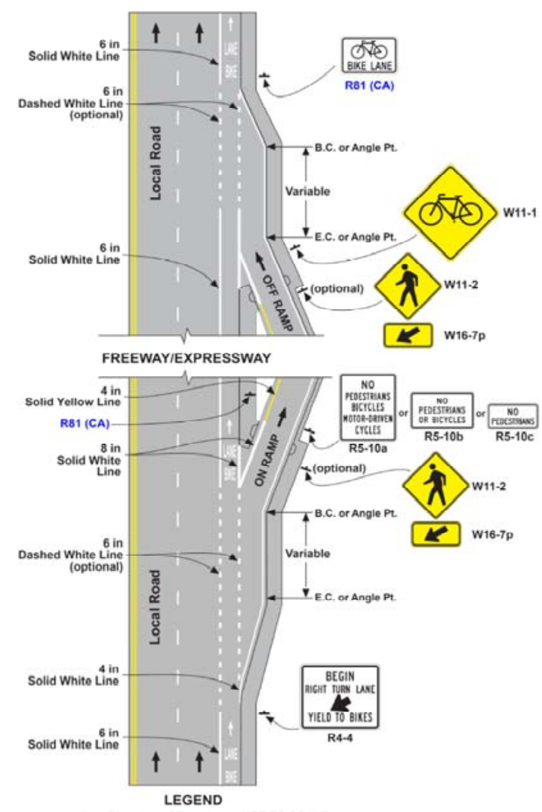
An interchange at Indianola has both positive and negative aspects for all users. This memo doesn't discuss the significant cost of construction, impact on views of Humboldt Bay, wetland encroachment, and several other environmental concerns with the installation of an interchange. This memo focuses on the effects on the roadway users. On the positive side, it eliminates the need for pedestrians, bicyclists, and motorist to cross at grade, thus providing a safer condition for these crossing movements including left turn movements for bicyclists and motorists. On the negative side, the interchange results in out-of-direction travel for all users, as discussed further under Median Closures below.

Interchanges introduce one additional challenge for bicyclists and pedestrians, specifically the high-speed on and off ramp movements by motorists. These concerns are discussed at length in chapter 9 of the Caltrans document Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians. The following is a list of common issues with free-flow ramps from this document:

- Acute intersecting angle limits visibility of pedestrians and bicyclists;
- Crosswalks are not marked across ramps.
- Ramp traffic is not controlled, and motorists traveling at high speed are not likely to yield to bicyclists or pedestrians;
- Bicyclists may not use the best travel path when navigating through the intersection;
- Bicyclists must weave through free-flow turning traffic traveling at a much higher speed.

One mitigating solution to the free-flow ramp problem is to provide bike lanes or undesignated shoulder areas between the right turn deceleration lanes and acceleration lanes, as shown in Figure 9C-103 from the California MUTCD, shown at right.

Figure 9C-103 (CA). Example of Bicycle Lane Treatment Through an Interchange



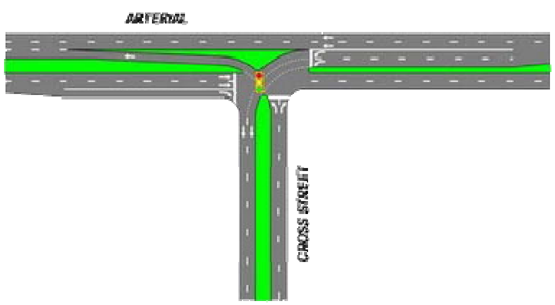
Median Closures

One of the major challenges of this alternative is that it restricts left turning movements to just two locations along the corridor. This will make it increasingly difficult for people to choose to bicycle (or walk) to any of the land uses along this corridor. The theoretical out-of-direction travel for these users can be considered the same as that calculated for motor vehicles in some of the Caltrans documents. However, when people bicycle or walk, they would be much more likely to choose not to take the circuitous route, and simply cross at random locations along the highway in order to take the shortest possible route; this is simply human nature. If a user is able to physically traverse the median including any guardrails that are used, they are quite likely to do so if this activity will save them a significant amount of time or effort. Design for pedestrian and bicyclists should facilitate movement along direct and simple paths.

POTENTIAL ALTERNATIVES

We propose the following ideas for consideration for the Eureka-Arcata segment of Route 101. We recommend that Caltrans evaluate these alternatives more fully, in order to meet the project goals, minimize environmental impacts, and reduce negative impacts to pedestrians and bicyclists.

Continuous Green T-intersection



This is an alternative design for signalized intersections, where the traffic along the top of the T intersection (in this case southbound Route 101 traffic) would not be stopped at the signal, but traffic in the other (northbound) direction would be stopped in order to allow left turns to and from the stem of the T. The image at right (from the Maryland State Highway Administration (MDSHA)) shows this design (Route 101 would be the "Arterial" as labeled on this image). This design has been proposed by Caltrans for Airport Road as Modified Alternative 3A, called a "half signal." We've chosen to use the term "Continuous Green T-intersection" (CGT) since this is what is used by the Federal Highway Administration (FHWA), and "half signal" is more commonly used for a special kind of pedestrian signal. For more information about CGTs, see the case study from FHWA at this link (http://safety.fhwa.dot.gov/intersection/resources/casestudies/fhwasa09016/). Our recommendation would be to consider the design of CGTs at Airport Road, Indianola Cutoff, and Bayside Cutoff, with closed medians at the remaining intersections and driveways.

Advantages

One major advantage of the CGT alternative is that there would be no southbound traffic signals, until beyond Eureka Slough, which is important due to the fact that southbound drivers have just driven on more than 20 miles of limited access freeway.

Disadvantages

Left Side Merges

One possible disadvantage of a CGT alternative is that it would maintain the situation where left side diverges and merges occur at this intersection. As pointed out in several of the background documents, left merges and diverges are discouraged by Caltrans compared to right merges and diverges. The alternative is traffic signals for southbound 101, which would likely have a much worse safety record than these merges and diverges. In fact, the left side diverge would still be in place at a signalized intersection. Merging crashes are typically much less severe than the broadside crashes that occur at a signalized intersection when motorists fail to stop at red signals.

Acceleration Lane May Contribute to Wetland Encroachment

Another disadvantage of the CGT alternative is that there would be an acceleration lane along southbound 101 on the south side of each intersection, a feature that would not be necessary for normal signalized intersections. However, there would not need to be a northbound "left" turn lane (actually a U-turn lane) at the intersections. So unless the southbound acceleration lane would need to be longer than the northbound left turn lane, there wouldn't be a significant difference in wetland encroachment between these two alternatives.

Pedestrian Crossings

The CGT alternative does not provide an easy way to provide a pedestrian crossing at the intersections. There are no pedestrian facilities on Route 101 in the existing condition, and pedestrians who choose to cross at the existing intersections must wait for a gap in traffic to cross each direction of travel. As mentioned above in the discussion about the signalized boulevard alternative, signalized intersections allow for an opportunity to provide pedestrian crossings. In fact, the California MUTCD states that "Signal design shall provide for or prohibit pedestrian movements." For CGTs on Route 101, the southbound movement would typically not have a red signal that would provide a time when pedestrians can cross. There is an example of a CGT with pedestrian crossings in San Francisco at the intersection of Lake Merced Boulevard and Brotherhood Way (http://goo.gl/maps/6dZiE). In this case, the southbound traffic on Lake Merced Boulevard is only stopped when a pedestrian pushes the button to cross the street. This works fine in San Francisco where there are many signals nearby, so a red signal is not unexpected by southbound drivers. But on Route 101, introducing a rarely used red signal would likely result in frequent rear end crashes and red light running incidents, endangering pedestrians and other users. The best recommendation we have for this situation is to provide a signalized pedestrian crossing across the northbound travel lanes and the left turn lane to the island between the southbound through lanes and left turn lanes, and then provide a walkway to the edge of the southbound through lanes. Pedestrians would simply cross the southbound lanes when they found a gap, as they would at an unsignalized intersection. The alternative would be to prohibit pedestrian crossings at this intersection, per the California MUTCD.

Bicycle Treatments

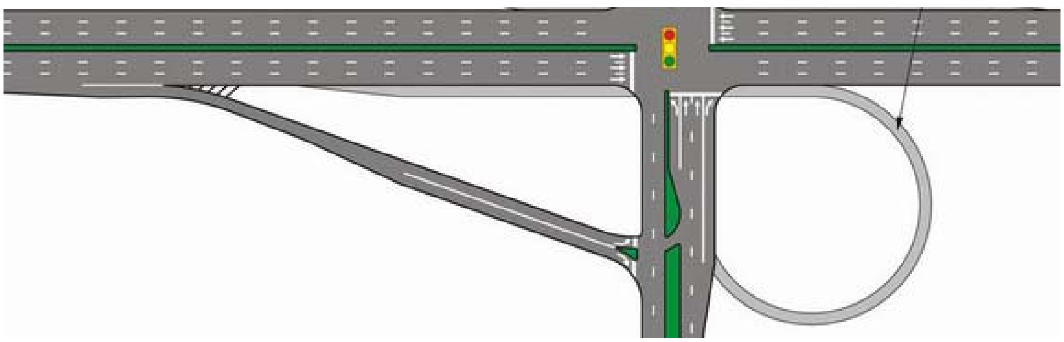
For the most part, the CGT design is the same for bicyclists as a fully signalized intersection. The only difference is that it is difficult to provide a signalized pedestrian crossing as described above, so bicyclists would not have the option of crossing at a signalized pedestrian crossing.

Turning Movements

With the Continuous Green T-intersection, all left and right turning movements would still be possible. Southbound left turns and U-turns would diverge off of southbound 101 to be controlled by the traffic signal, and westbound left turns would go through the traffic signal and then merge onto southbound 101. Caltrans proposed this design for Airport Road but not at other intersections, probably due in part to the desire to allow direct northbound U turns, which are not needed at Airport Road. Indeed there would be no way to allow these U-turns at the intersection. There are several possible ways to allow indirect left turns. Caltrans has already evaluated "Michigan left turns", but this design creates significant wetland encroachment issues, and has other problems. We recommend evaluation of two alternative methods of providing for indirect northbound U-turns, both of which have the advantage of occurring along the cross streets and not on Route 101 itself.

Jughandle Intersection

This type of intersection provides for indirect northbound U-turns. The image below from MDSHA shows two different types of jughandles. For Indianola Cutoff and Bayside Cutoff, the design shown on the left side of this image is the preferred design, primarily due to limited available land outside of existing wetlands. To make a northbound U-turn, drivers would make a right turn off of Route 101 in advance of the intersection, then a left turn onto the cross street, and then a left turn onto Route 101. The distance between the jughandle connection and Route 101 would be relatively short (about 180 feet), but given the anticipated low volume of northbound U turns at these locations, this should not be a major concern. Drivers making the left turn from the jughandle onto either Indianola Cutoff or Bayside Cutoff would only need to wait for gaps in traffic coming from the southbound left turn movement –the signal would provide long gaps that would easily allow this movement.

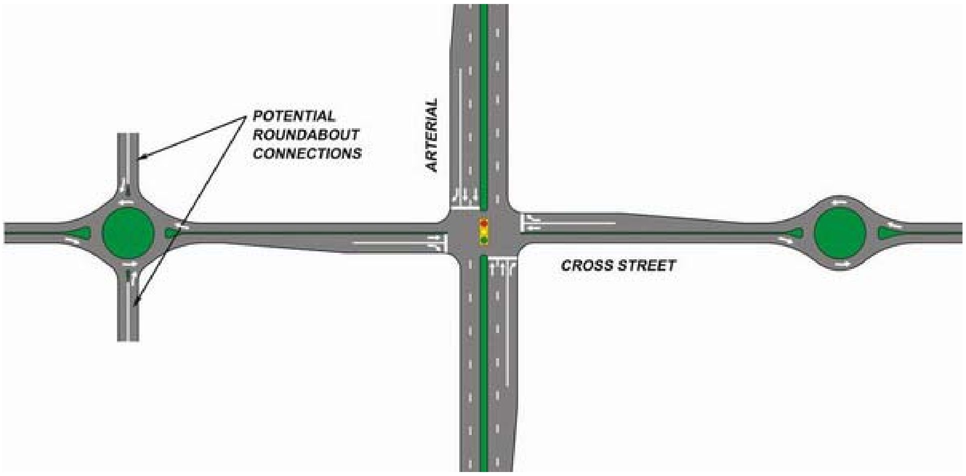


Bowtie Intersection

This type of intersection allows for U-turns at a roundabout (or “fake” roundabout) on the cross street. In this case, there would only need to be one roundabout on the east side of Route 101 (only half of the bowtie). The image below from MDSHA illustrates this solution.

At Indianola Cutoff, it is recommended to evaluate the placement of a roundabout at the intersection of Indianola Cutoff and Indianola Road, east of where 101 Slough crosses underneath Indianola Cutoff. It appears that a roundabout with the necessary 130-foot inscribed circle diameter could be built at this location without significant wetland impacts, and minimal right-of-way requirements, probably just on the north side of Indianola Cutoff.

At Bayside Cutoff, there are two options to evaluate. The first option would include a “fake” roundabout east of the driveway to the residence near this intersection. This option would require a right-of-way on both sides Bayside Cutoff. The second option would include a roundabout at the intersection of Bayside Cutoff and Old Arcata Road, similar to the existing roundabout at Indianola Cutoff and Myrtle Avenue. This option has the disadvantage that this intersection is a half mile away from Route 101.



Roundabout Corridor

In all of the reviewed background information, we did not identify any discussion of using roundabouts along Route 101 itself. There was a mention of a roundabout interchange at Indianola, but nothing on mainline 101. Within the past year, Caltrans has developed a new Intersection Control Evaluation and Selection process that recommends that roundabouts be given more consideration when changes to intersection control are being given. A Caltrans presentation (http://dot.ca.gov/hq/tpp/offices/ocp/ATLC_files/August_2012/6.pdf) about this process identifies several possible performance benefits of roundabouts including the following that are relevant to the Eureka-Arcata segment of Route 101:

- Safety
  - Reduction in Total Crashes by 35%
  - Reduction in Injury and Fatal Crashes by 76%
  - Slower speeds 15-25 mph at and near critical (conflict) area
- Operations
  - Less delay & queuing compared to signalization over a broad range of traffic volumes (for all users)
  - Optimizes intersection efficiency 24hrs a day
- Other
  - Access Management: Facilitate U-turns that can substitute for more difficult midblock left turns.
  - Environmental: Noise, air quality impacts and fuel consumption may be reduced.

Given this, we strongly recommend that Caltrans do a full evaluation of a roundabout corridor along Route 101. We recommend that roundabouts be considered for installation at Indianola Cutoff, Airport Road, and Bayside Cutoff.

Advantages of Roundabouts

Roundabouts have much better safety records than either signalized intersections or two-way stop controlled intersections, as shown in the bullets from the Caltrans presentation above.

Roundabouts would make it very easy for drivers to make U-turns in order to access locations that are anticipated to be restricted by median closures. With roundabouts at the 3 locations mentioned above, the delay created by out-of-direction travel to the other access points would be less than in any other alternative.

Roundabouts would reduce fuel consumption compared to any signalized alternatives.

When compared to signalized intersections, roundabouts are a much better solution when drivers have just left a limited access freeway corridor. With a signalized intersection, drivers may have to brake abruptly when the signal changes from green to yellow to red. The roundabout is always there and familiar drivers would always expect to have to slow down somewhat as they approach and go through the intersection. In addition, the central island of the roundabout can be designed and landscaped in a way to be very visible to drivers as they approach. In the event of an inattentive driver approaching a roundabout, the resulting crash is typically a fixed object crash instead of a high speed angle (broadside) crash at a signalized intersections (both roundabouts and signals can also have rear-end crashes.

Roundabouts are likely safer than signalized intersections in foggy conditions (a common occurrence adjacent to Humboldt Bay), because the roundabout is always there and slowing is anticipated by familiar drivers.

Because traffic doesn't need to be stopped for a specified time to allow other movements, roundabouts don't typically require additional approach lanes and departure at the intersection. And if additional capacity is desirable at roundabouts, the approach lanes and departure lanes can be quite short, sometimes simply flaring to a wider entry width immediately adjacent to the roundabout. This could result in smaller wetland encroachment than signalized intersections.

Disadvantages of Roundabouts

A full interchange like the one proposed at Indianola Cutoff may improve safety even more than a roundabout.

Roundabouts require slow speeds for through movements regardless of whether or not there is cross traffic. This is one of the reasons that they have a significant safety advantage. However, this slowing results in geometric delay, which would be experienced at each roundabout by every motorist who travels the corridor. On the other hand, stopped delay is typically shorter at roundabouts than at signalized intersections.

Roundabouts require a large footprint at the intersection. In this case, an inscribed circle diameter of 160 to 180 feet is recommended, which is wider than the existing width of the highway. The roundabouts would need to be offset to the east somewhat in order to avoid encroaching into Humboldt Bay, but it appears that the roundabout geometry can be designed to make this work at all 3 locations on Route 101. In addition, in order to provide adequate deflection at the roundabouts, the approach and departure roadways would need to be realigned toward the median of the existing highway, encroaching on the wetlands in the median. These encroachments could easily be mitigated by providing wetlands in the central island as well as the areas vacated by realigning the approach and departure roadways.

Bicyclists at Roundabouts

Roundabouts would serve bicyclists who want to make left turns better than signalized intersections because the roundabouts would make it easier for bicyclists to merge properly to make left turns. Motorists would be physically required to slow to about 20 to 25 mph, a speeds that are much more compatible with bicycling.

The disadvantage for bicyclists is that all bicyclists including through bicyclists would need to merge with motor vehicle traffic in order continue through the roundabout. For southbound bicyclists, it might be possible to provide a bypass bike lane on the west side of the road so bicyclists don't have to go through the roundabout. This bike lane would be physically separated from the roundabout, which would make for a nice environment, but make it difficult to maintain.

Pedestrians at Roundabouts

It would be recommended to simply provide pedestrian walkways in the splitter islands of the roundabout, showing pedestrians where to cross at the safest location. Given the low volume of pedestrians, sidewalks and marked crosswalks probably wouldn't be necessary, although it might be beneficial to reserve space for future sidewalks around the roundabout. Even without crosswalks and sidewalks, the roundabouts would make it much easier for pedestrians to cross Route 101, because drivers would be driving only 20 to 25 mph.

TRAFFIC ANALYSIS

The traffic analysis discussed below is only for the intersection of Route 101 and Indianola Cutoff, as this intersection has the highest turning volumes along the corridor.

Traffic Counts

Caltrans provided turning movement counts for the intersection, collected at 15-minute intervals for nearly an entire month during September 2012. We used data from Tuesdays, Wednesday and Thursdays to find the average morning and afternoon peak hour turning volumes for a typical weekday. Mondays and Fridays were not used, as they are usually affected by weekend traffic.

To generate the missing through movements, we used the 2011 traffic volumes published by Caltrans in the 2011 Traffic Volumes on California State Highways[1] as shown in the table below. We used the "Back Peak Hour" and "Ahead Peak Hour" volumes to add to the average turning movement counts for a weekday in September. When balancing the volumes at the intersection, we always chose the highest volume in order to err on the side of more traffic, rather than less traffic. The resulting turning movement counts are shown on the left side of the figure on the next page.

2011 Caltrans Traffic Counts at Indianola Cutoff

Route	County	Post mile	Description	Back Peak Hour	Back Peak Month	Back AADT	Ahead Peak Hour	Ahead Peak Month	Ahead AADT
101	Humboldt	82.68	Indianola	3,450	38,000	36,000	3,950	38,000	36,000

Accounting for U-turns

Several of the proposed designs call for closing the median at several intersections and driveways. However, there are properties at these intersections that generate traffic – south of Indianola Cutoff there is a car dealership and a lumber yard, and north of Indianola Cutoff (Bracut) there is

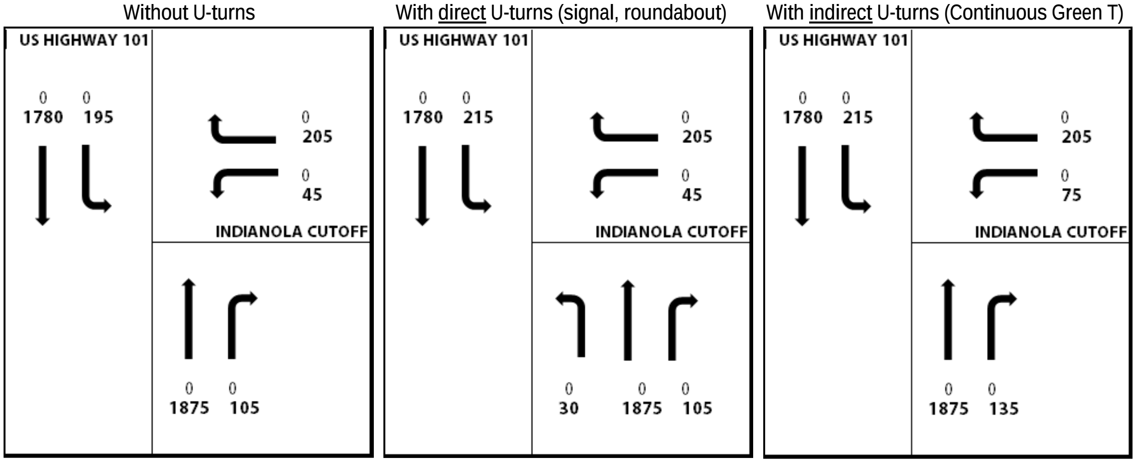
[1] http://traffic-counts.dot.ca.gov/2012TrafficVolumes.pdf

an RV park, bicycle camping, and some industrial uses. With the median closed, people entering or exiting these land uses would need to make U-turns at Indianola. For example, vehicles exiting the car dealership and wishing to turn south would need to first turn north and then make a u-turn at Indianola. For the purposes of this analysis, we assumed that Airport Road and Bayside Cutoff would also be signalized or have roundabouts, allowing left turn and U-turn movements. So no U-turn volumes from these intersections were included in the analysis at Indianola Cutoff.

For the signalized and roundabout alternatives, direct U-turns are possible, resulting in the turning movement counts shown in the middle image below. For the Continuous Green T-intersection alternative, only indirect u-turns would be permitted for northbound to southbound U-turns. That is, first turning right onto Indianola Cutoff, then making the u-turn there, and then turning left back onto 101. We consulted the ITE Trip Generation manual for the land uses at the minor intersections in question, and determined that *at most* these land uses would add 30 northbound U-turns (i.e. 30 right turns and 30 westbound left turns for the CGT alternative), and 20 southbound U-turns.

PM Peak Turning Movements

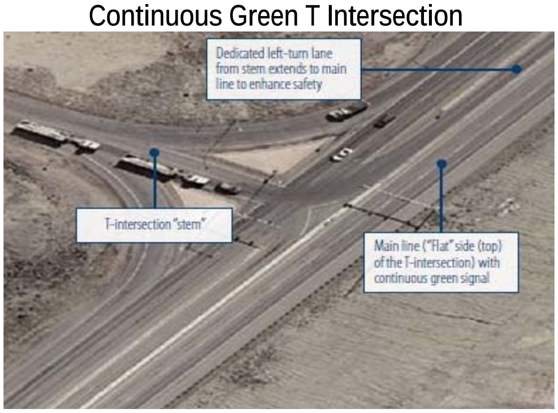
Without U-turns | With direct U-turns (signal, roundabout) | With indirect U-turns (Continuous Green T)



Scenarios

Three different configurations were tested against the existing design – a conventional signalized intersection, a Continuous Green T-intersection, and a two-lane roundabout.

Continuous Green T Intersection



Two-lane Roundabout

Sources. Left: CDOT/FHWA ©. Right: Nelson\Nygaard and Sidra software.

Summary of Results

Intersection performance was analyzed using Synchro and Sidra, two software packages commonly used in the transportation engineering industry to investigate how intersections perform under varying traffic conditions. Only the PM peak was analyzed, as volumes were overall higher for almost all movements than during the AM peak. For the signalized scenario, the signal timing was optimized to produce the best possible results. As can be seen in the table below, a roundabout would provide the lowest overall delays.

		PM Peak		PM Peak + U-turns	
Intersection	Control Type	LOS	Delay (sec)	LOS	Delay (sec)
Route 101 at Indianola Cutoff	Signalized	B	18.3	C	23.6
	Continuous Green T	B	15.9	B	17.4
	Roundabout	A	9.0	B	11.3