CITY OF TUCSON

HOUGHTON ROAD, TANQUE VERDE RD TO SPEEDWAY BLVD

NEEDS ASSESSMENT STUDY



HOUGHTON ROAD, TANQUE VERDE RD TO SPEEDWAY BLVD

NEEDS ASSESSMENT STUDY

CITY OF TUCSON

PROJECT NO.: 11515SP
DATE: SEPTEMBER 11, 2019

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EXECUTIVE SUMMARY

The Houghton Road, Tanque Verde Road to Speedway Boulevard Needs Assessment Study (Study) was requested by the City of Tucson (Transportation) to determine if recommendations from the 2010 Design Concept Report (DCR) are still valid. The study covers the approximately 2-mile segment of Houghton Road from Tanque Verde Road to south of 5th Street in northeast Tucson, including intersection approaches at Tanque Verde Road and Speedway Boulevard. Traffic volumes within the region have not increased at the rates that were assumed at the time of the DCR, and in addition, projected volumes for the 2030 design year are now substantially lower than in the DCR.

Since the DCR, changes to Houghton Road within the study area have been limited to intersection improvements in conjunction with Tanque Verde Road and Speedway Boulevard widening projects and Houghton Road widening to the south. Within the study area, Houghton Road remains two lanes. This Study reviewed the existing operations of this segment of Houghton Road, evaluated 2030 operations with the existing roadway, and developed recommended improvements that maintain satisfactory operations. The west Speedway Boulevard and southernmost Houghton Road segments feature the highest traffic volumes and the most projected growth. The NB left turn at Speedway Boulevard is an especially high volume movement, and the existing single left turn lane already operates at LOS E in the AM peak hour.

The proposed recommendation includes widening Houghton Road to four lanes south of Speedway Boulevard, adding an additional NB left turn lane at Speedway Boulevard, and a NB right turn lane at Tanque Verde Road. The existing two-lane roadway between Tanque Verde Road and Speedway Boulevard will provide satisfactory operations and does not warrant the expense of widening. The two major intersections are projected to operate at LOS C and D in the 2030 peak hours with the improvements. The condition of the bridges over the Tanque Verde Creek and Agua Caliente Wash were also reviewed and found to be in good to satisfactory condition with approximately 45 years remaining in their design life. Maintenance work such as joint replacement and deck sealing is recommended.

With the proposed recommendations, there will be some utility impacts, primarily associated with the widened segment of the project. Intersection geometry at Speedway Boulevard will allow the existing large TEP pole at the southeast corner of the intersection to remain in place. Some additional right of way (ROW) will be required south of Speedway Boulevard, but for most of the project, the existing ROW is sufficient. Updates will be needed to previously prepared environmental studies related to cultural resources, biological evaluations, and Section 404 of the Clean Water Act.

Construction costs of the proposed recommendations were compared to the cost estimate of the recommendations presented in the 2010 DCR.

A summary is as follows:

- DCR cost for Roadway Reconstruction and New Bridges: $21,406,000
- Needs Assessment Study Improvements
    - Houghton Road NB Right Turn Lane at Tanque Verde Road: $628,400
    - Houghton Road / Speedway Boulevard Intersection: $9,289,600
    - Bridge Repair: $1,143,600

$11,061,600

Total (Rounded): $11,062,000

Project improvement do not need to be completed at the same time. Three projects could be progressed and they include: the Houghton Road NB right turn at Tanque Verde Road, the Houghton Road / Speedway Boulevard intersection, and bridge repair work.

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1 PROJECT OVERVIEW

Houghton Road, I-10 to Tanque Verde Road, is a Regional Transportation Authority (RTA) project programmed from Period 1 through Period 3 which spans the years FY2007 through FY 2021. The segment between Tanque Verde Road and Speedway Boulevard is the last segment in the City of Tucson Department of Transportation's (Transportation) implementation plan for Houghton Road. A Design Concept Report (DCR) was prepared for the segment in 2010.

The Houghton Road, Tanque Verde Road to Speedway Boulevard Needs Assessment Study (Study) was requested by Transportation to review this segment of Houghton Road to determine if the recommendations from the DCR are still valid. Traffic volumes within the region have not increased at the rates that were assumed at that time. The Pima Association of Governments (PAG) regional transportation model has been updated since that DCR was completed and projections for 2045 are now available.

This study reviews the existing operations of this segment of Houghton Road, evaluates existing operations for 2030 traffic, and provides a recommended set of improvements to accommodate the projected traffic and maintain satisfactory level of service (LOS). The recommended lane configurations are compared to the 2010 recommendation. Potential impacts to the existing utilities, bridges, and Right-of-Way (ROW) needs are qualitatively assessed for the recommended improvements and a preliminary construction cost estimate is included so that the City of Tucson can evaluate funding needs. The need for new or updated environmental studies is also discussed.

1.1 PROJECT LOCATION

The project is located in the northeast corner of the Tucson metro area (Figure 1). The project limits are the same as the DCR, covering Houghton Road from near 5th Street north to Tanque Verde Road. Included are the approach sections of roadway that would potentially be affected by any improvements. The total length along Houghton Road is approximately 2 miles (Figure 2). Portions of the project are fully within the City of Tucson limits, and the section north of Speedway Boulevard borders unincorporated Pima County land to the east.

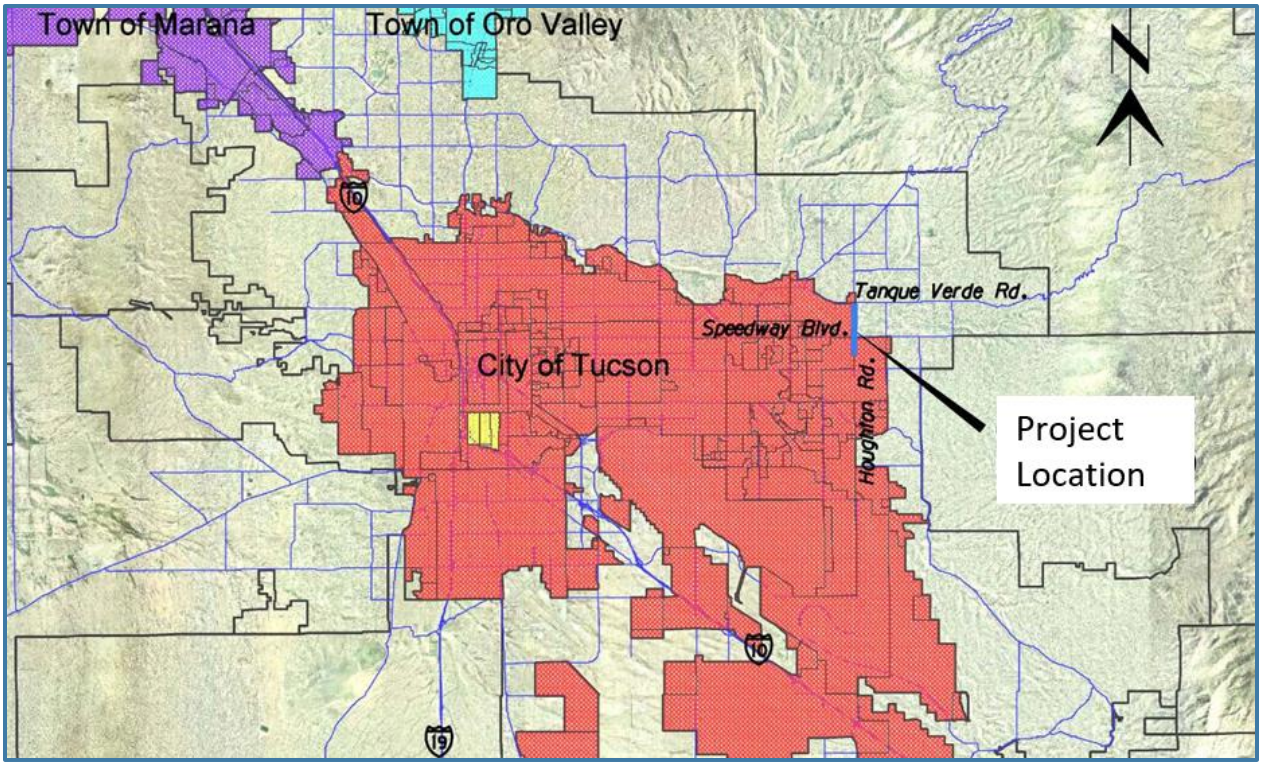


Figure 1 – Project Location

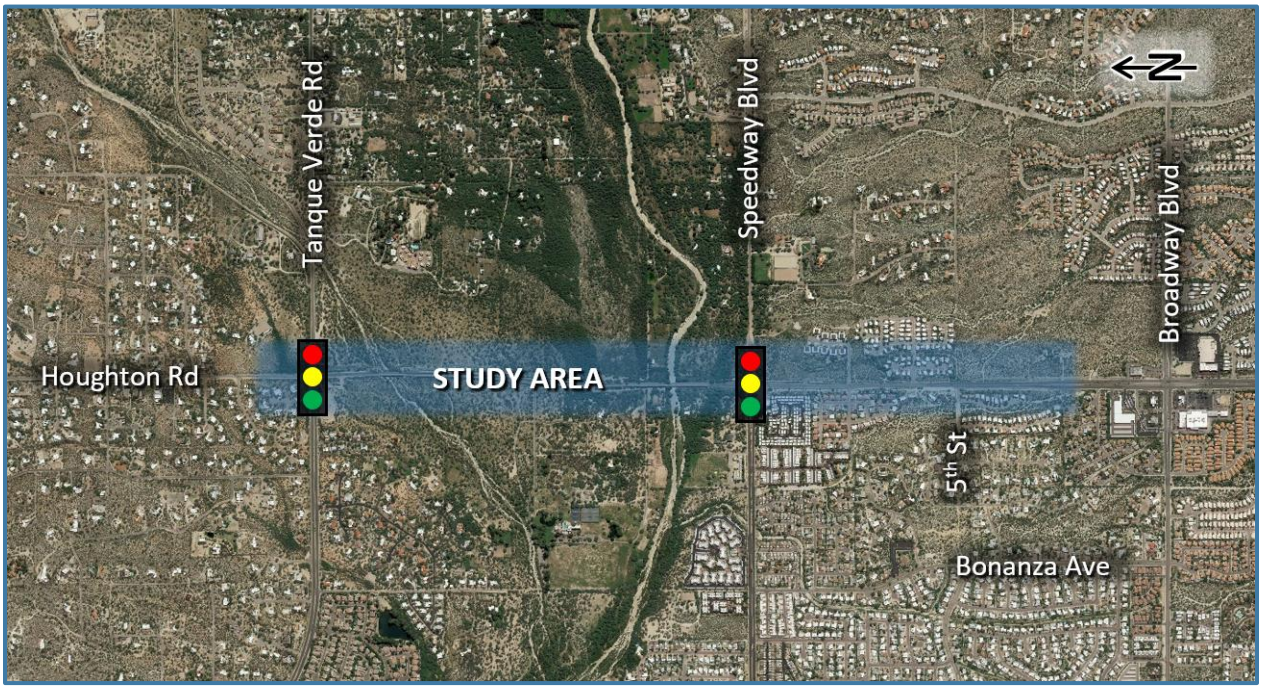


Figure 2 – Project Study Area

2 PROJECT DESCRIPTION

Houghton Road from Tanque Verde Road to Speedway Boulevard was designed in the late 1980s and constructed in the early 1990s under the Pima County Department of Transportation and Flood Control District project: Houghton Road Speedway Boulevard to Tanque Verde Road, Project No. W.O. 4BHTVC. That project constructed half of an "ultimate" four lane divided arterial roadway by shifting the alignment of Houghton Road to the east and building a new two lane roadway and new bridges over the Tanque Verde Creek and Agua Caliente Wash. The existing Houghton Road roadway with dip section across these two drainages was demolished. Typical sections, roadway plans, and bridge plans from the project all show an ultimate roadway centerline with the intent that the future two additional lanes would be constructed to the west and parallel to the new roadway. ROW was purchased to construct the two lane roadway and the existing ROW to the west was retained. The design speed was listed as 55 mph and the design vehicle was selected to be a WB-50.

The purpose of this City of Tucson Needs Assessment Study is to determine what improvements would best maintain traffic operations along Houghton Road between Tanque Verde Road and Speedway Boulevard within the constraints of available funding. Since forecasted traffic volumes have changed since the DCR, updated operational projections and recommended improvements were warranted.

Since the DCR, changes to Houghton Road within the study area have been limited to intersection improvements in conjunction with Tanque Verde Road and Speedway Boulevard widening projects. Houghton Road was widened to six lanes starting at the south end of the study area. The City of Tucson has annexed the portion of Houghton Road between Tanque Verde and Speedway Boulevard.

2.1 DCR RECOMMENDATIONS

The DCR was completed by WSP (formerly Parsons Brinckerhoff) for the segment of Houghton Road from Tanque Verde Road to Speedway Boulevard. Design recommendations from the DCR included:

- Long-term improvements included 4-lanes north of Speedway Boulevard and 6-lanes south of Speedway Boulevard with a raised median to handle the forecasted regional growth and increased respective traffic. A design speed of 50 mph with a posted speed limit of 45 mph was recommended.
- An access management plan will be implemented to the roadway section designated as a major divided arterial. The following were recommended to be included in the plan:
    - Median openings should be spaced no closer than 660 feet and ¼ mile is preferred
    - Traffic signals spaced no closer than ½ mile

  - Most property access fronting Houghton Road to be right-in/right-out with intermediate U-turn opportunities at approximately every ¼ mile

- There will be no need for additional traffic signals along the project, but relocation/upgrades are necessary at the Tanque Verde Road and Speedway Boulevard intersections.
- There will be no need for arterial street lighting for this project segment.
- Asphalt rubber asphaltic concrete (ARAC) was recommended as the surface layer for the roadway pavement based on its noise reduction qualities and the fact that there are residential homes adjacent to Houghton Road.
- A storm drain system was recommended for Houghton Road south of the Tanque Verde Creek along the curbed roadway section.
- A storm drain system south of Speedway Boulevard was recommended to replace the existing concrete lined channels that are on both sides of Houghton Road.
- A 10-foot paved multi-use path was proposed for Houghton Road between Speedway Boulevard and the southern project limit south of 5th Street.
- Construct parallel bridges west of the existing bridges over the Agua Caliente Wash and Tanque Verde Creek using a similar pre-stressed concrete AASHTO girder superstructure and drilled shaft foundations to the existing bridges.
- Remove the east-side parapet of the bridges across the Agua Caliente Wash and Tanque Verde Creek and construct a new railing attached to the outside of the bridge decks to obtain a 5-foot sidewalk width.
- Water harvesting was recommended instead of extensive irrigation due to recent funding issues and dwindling water resources.
- A frontage road was recommended as the solution to consolidating access onto Houghton Road for the five residential parcels on the west side of Houghton Road north of 5th Street.
- A 20-foot open median was recommended between the new and existing bridges at the Agua Caliente Wash and Tanque Verde Creek to minimize bridge costs.
- 5-foot sidewalks were recommended for Houghton Road between Speedway Boulevard and Tanque Verde Road. Sidewalks north of Tanque Verde Road were not included. A 6-foot sidewalk was provided on the west side of Houghton Road south of Speedway Boulevard within the Tucson city limits.
- A variable width median was recommended for Houghton Road south of Speedway Boulevard to minimize alignment shifts for northbound Houghton Road traffic.
- The new bridge over the Tanque Verde Creek and the Houghton Road / Speedway Boulevard intersection were proposed to be constructed at the same time due to the close proximity of the bridge to Speedway Boulevard and the lane requirements of the north approach to Speedway Boulevard.

- The Speedway Boulevard, Camino Seco to Houghton Road project was to address some of the issues at the Speedway Boulevard and Houghton Road intersection, but the majority of the intersection improvements were to be done with the Houghton Road, Tanque Verde Road to Speedway Boulevard project.
- A Phase I Environmental Assessment study will be needed for all parcels with ROW acquisition, prior to the construction, to determine suitable mitigation.

3 PROJECT AREA CHARACTERISTICS

Houghton Road through the project area can generally be described as a suburban two-lane arterial, with two signalized intersections, one at Tanque Verde Road and the other at Speedway Boulevard. The corridor features rolling terrain and bridges over two major wash crossings. There are no transit facilities within the study area.

Land use surrounding the study area is primarily low density residential, and is largely built out. There are no planned developments in the area, and most homes are custom built and located on large lots. Medium density development extends southwest of the study area. Local retail centers are located further south of the study area along Houghton Road, where additional development is likely. Commercial zoning within the study area is limited and primarily confined to the arterial intersections. Several residential driveways are on Houghton Road, mostly near 5th Street.

Houghton Road and Tanque Verde Road are designated as scenic arterial streets in the City of Tucson Major Streets and Routes Plan. Speedway Boulevard is designated as an arterial street west of Houghton Road and a scenic arterial east of Houghton Road. Within the study area, Houghton Road crosses the ephemeral Tanque Verde Creek and Agua Caliente Wash, which are home to desert riparian vegetation. Views of the Santa Catalina Mountains face northbound traffic, with additional views to the Rincon Mountains to the east.

Houghton Road provides the most easterly all-weather crossing of Tanque Verde Creek, and is an important link for local traffic during flooding events, which can last for multiple days. Tanque Verde Road provides the only other bridge crossing of Tanque Verde Creek, approximately three miles to the west.

3.1 EXISTING ROADWAY

The project includes the Tanque Verde Creek and Agua Caliente Wash drainage areas between Speedway Boulevard and Tanque Verde Road. The roadway generally follows the terrain sloping downward toward each of the washes, but then rises above the existing terrain as bridges cross over each of the drainages. From the north, the roadway leaves Tanque Verde Road at an elevation of approximately 2598 feet and slopes downward a foot or so then rises over the Agua Caliente Wash bridge which is at an elevation of approximately 2604 feet. The wash itself is at an elevation of approximately 2585 feet. From the Agua Caliente Wash bridge, the roadway continues to rise slightly to a high point of approximately 2605 feet between the two washes, then slopes downward to a low point of approximately 2584 feet after which it rises and crosses the Tanque Verde Creek on a bridge at an elevation of approximately 2588 feet. The creek below the bridge is at an elevation of approximately 2570 feet. South of Tanque Verde Creek, the roadway slopes downward off the bridge to a low point of approximately 2580 feet at Speedway Boulevard, which is also the project low point. South of Speedway Boulevard the roadway rises 125 feet to the point where this project ends at approximately elevation 2705 feet.

Functional Classification

Houghton Road is classified as a Major-Arterial-Roadway according to the City of Tucson Functional Classification, and is designated as a Scenic Route in the City of Tucson Major Streets and Routes plan. This segment of the Houghton Road Corridor is not part of the 1986 State Route designation and not part of the National Highway System (NHS), as is the case for Houghton Road south of Golf Links Road. Tanque Verde Road and Speedway Boulevard are also classified as Major-Arterial-Roadways.

Roadway

Between Tanque Verde Road and Speedway Boulevard, Houghton Road consists of an uncurbed two lane roadway with 12-foot travel lanes and 8-foot paved shoulders. Superelevation is 2% down to the east from the west edge of the southbound travel lane. The alignment of Houghton Road is centered on the section line south of Speedway Boulevard. North of Speedway Boulevard, the alignment initially closely follows the section line to north of the Tanque Verde Creek crossing. North of Tanque Verde Creek, the alignment shifts approximately 150 feet to the east of the section line through a pair of reverse curves with radii greater than 6000 feet. This shift aligns the roadway with that north of Tanque Verde Road since the section lines north and south of Tanque Verde Road are offset. Additionally, driveways parallel Houghton Road north of the Tanque Verde Creek crossing and tie into Houghton Road at right angles.

The existing Houghton Road typical section south of Speedway Boulevard is a two-lane uncurbed roadway with a continuous two-way left turn lane (TWLTL) which transitions to a six-lane section near Vicksburg Street, with a raised, curbed median, bike lanes, a sidewalk on the west side, and a multi-use path on the east side. This six-lane section extends south of 22nd Street, before transitioning back to a two-lane section with one lane in each direction and a TWLTL. The City of Tucson has multiple projects in various stages of development that will ultimately extend the six-lane section south to Interstate 10.

The existing Houghton Road vertical profile within the study area generally follows the existing terrain. The DCR determined that the vertical profile of Houghton Road generally meets criteria within the 2004 Policy on Geometric Design of Highways and Streets (AASHTO – 'Green Book') and Pima County roadway design standards. The exception is two tangent grades that are below PC/COT minimum standards. Overall, however, there are no major vertical profile deficiencies.

Speed Limits

The following are the posted speed limits for Houghton Road and the intersecting roadways:

- Houghton Road 45 mph
- Tanque Verde Road 45 mph
- Speedway Boulevard 40 mph west of Houghton Road
  45 mph east of Houghton Road
- 5th Street 25 mph

Right of Way

The existing ROW width along Houghton Road within the project limits varies considerably from 115 feet to nearly 375 feet. See Table 1 for details. The current ROW along Houghton Road between Tanque Verde Road and Speedway Boulevard was established as part of the Pima County Houghton Road project 4BHTVC. The existing western ROW line was retained and new ROW acquired to the east resulting in the current ROW corridor. The present Houghton Road roadway lies on the eastern portion of the available existing ROW width.

South of Speedway Boulevard, the ROW was established under Proceedings No. 829 in December 1954 with an 80-foot ROW, 40 feet each side of the section lines. In intervening years, the ROW has been widened along that section as the adjacent land has been developed. Starting approximately 600 feet south of Speedway Boulevard the existing ROW is at least 200 feet wide, 100 feet each side of the section line. Since the DCR, additional ROW was acquired south of 5th Street for the Houghton Road/Broadway Boulevard widening project. This created a 100-foot ROW on the east side of the section line.

The ultimate ROW called for in the current Major Streets and Routes Plan (MS&R) is 200 feet, 100 feet each side of the section lines, although some of the property along the segment south of Speedway Boulevard was developed when the MS&R called for only 150 feet of ROW, 75 feet on each side of the section line.

Table 1 – Existing Right-of-Way Widths on Houghton Road

Location (from section line)	Length	East Side	West Side
	ft.	ft.	ft.
North of Flintlock Trail (Sta 27+85)	---	75	30
Flintlock Trail to Desert Flower Pl.	235	75	75
Desert Flower Pl. to south Shady Rock Ln.	550	30	75
Shady Rock Ln to Tanque Verde Rd	770	45	75
Tanque Verde Rd to Sta 63+52, (Location from existing roadway centerline)	2015	Varies: 147-300	75
Sta 63+52 to 1/2 mile north of Speedway	1565	Varies: 155-300	75
1/2 mile north of Speedway to Sta 82+98	385	Varies: 171-185	120
Sta 82+98 to Sta 86+69	370	Varies: 160-171	100
Sta 86+69 to 500' north of Speedway Blvd.	780	Varies: 152-160	Varies: 45-100
North of Speedway Blvd. to Speedway Blvd.	500	152	127
Speedway Blvd. to 600' south	600	40	100
600' south Speedway Blvd to Windstorm Dr.	1230	Varies: 100-109	100
Windstorm Dr. to 5th Street	705	100	75
From 5th Street southbound	---	100	100

Pedestrian Facilities

There are no sidewalks along this segment of Houghton Road. The bridges over Tanque Verde Creek and Agua Caliente Wash do have 4-foot wide pedestrian walkways, but they end behind guardrail sections and do not connect to any sidewalks. Both the Tanque Verde Road and Speedway Boulevard intersections feature pedestrian push buttons and signals. At the Speedway Boulevard intersection, pedestrian access ramps are present on the northwest and southwest corners of the intersection, with sidewalks extending to the west. A sidewalk was constructed as part of the Tanque Verde Road widening to the west of Houghton Road, but it ends approximately 600 feet short of the intersection.

Bicycle Facilities

Houghton Road, Tanque Verde Road, and Speedway Boulevard all feature shoulders or bike lanes through the study area. On Tanque Verde Road, Speedway Boulevard, and Houghton Road between Tanque Verde Road and Speedway Boulevard, the shoulders are designated as bike lanes by pavement markings. On the EB Tanque Verde Road approach to Houghton Road, the right lane drop currently features dashed bike lane markings with "BEGIN RIGHT TURN LANE, YIELD TO BIKES" signs.

Drainage

The existing drainage patterns along Houghton Road from Tanque Verde Road to 5th Street typically parallels Houghton Road. The existing hydrology was analyzed in the DCR. Drainage has been identified as either major or minor drainage. The minor drainages are located north of Tanque Verde Road and south of Speedway Boulevard. The major drainages are located between the two minor drainage regions and consist of the Agua Caliente Wash located just south of Tanque Verde Road and the Tanque Verde Creek just north of Speedway Boulevard.

Minor Drainage: North of Tanque Verde Road, runoff is collected in two cross drainage structures on each side of Houghton Road. These structures direct runoff toward the Agua Caliente Wash, south of Tanque Verde Road. South of Speedway Boulevard, concrete roadside channels carry runoff towards Speedway Boulevard where it is conveyed through storm drains under Speedway Boulevard to the Tanque Verde Creek.

Major Drainage: Agua Caliente Wash and Tanque Verde Creek are two major FEMA regulated washes located in the region between Tanque Verde Road and Speedway Boulevard. Both of these major drainages convey runoff under existing bridges on Houghton Road. FEMA 100-Year flow rates just upstream of Houghton Road are 10,500 ft3/sec and 23,000 ft3/sec for the Agua Caliente Wash and Tanque Verde Creek, respectively.

3.2 UTILITIES

There are numerous utilities along Houghton Road within the project limits as shown in Table 2 below. Cardno (formerly TBE Group, Inc.) provided base utility mapping for the DCR and had contacted these utilities to confirm their facilities within the project limits. Additional utility relocation information from the Houghton Road/Broadway reconstruction project was reviewed. Individual utilities are summarized below.

Table 2 – Existing Utilities within the Project Limits

Owner	Utility / Facility
Cox Communication	Fiber Optic / Coax Cable TV
Southwest Gas	Natural Gas
Tucson Electric Power	Electric
Tucson Water	Water, Reclaimed Water
CenturyLink (formerly Qwest)	Underground Telephone
Pima County Regional Wastewater Reclamation Department	Sanitary Sewer
City of Tucson	Traffic Signals

Fiber Optic – Cox Communications

Cox Communications has a fiber optic television line on the east side of Houghton Road from Tanque Verde Road to south of Speedway Boulevard. South of Speedway Boulevard, utility locating survey did not pick up a continuation of the line.

Cable – Cox Communication

Cox Communications has limited underground cable TV facilities in the project vicinity. The utility services many of the side streets and residences along the Houghton Road project segment. North of Tanque Verde Road, there is a crossing at Houghton Road from the west which joins a fiber optic television (FOTV) line on the east side.

Natural Gas – Southwest Gas

There are gas lines along the east and west sides of Houghton Road. A detailed location discussion follows:

North of Tanque Verde Road: A 2” polyethylene (PE) gas line crosses Houghton Road near Shady Rock Lane and runs south along the east side to Rancho del Este Drive.

Tanque Verde Road: A 4” and an 8” high pressure steel gas line runs approximately 33’ north of Tanque Verde Road. The 4” steel gas line crosses Houghton Road and continues eastward. The

8” steel gas line crosses Tanque Verde Road approximately 90’ west of Houghton Road where it continues to the south.

Between Tanque Verde Road and Speedway Boulevard: North of the west frontage road at the Tanque Verde Creek, the 8” steel gas line crosses Houghton Road and continues southward along the east side. The 8” steel gas line runs southward east of the Tanque Verde Wash bridge to Speedway Boulevard. A 2” PE gas line parallels the west side of the existing west frontage road and crosses Houghton Road beneath the Tanque Verde bridge to the east side where it turns south and parallels the 8” steel gas line.

Speedway Boulevard: The 8” steel and 2” PE gas line cross Speedway Boulevard from the north at approximately 150’ east of Houghton Road where an 8” steel and a 4” PE continue southward. At the northeast corner of Speedway Boulevard, a 4” PE splits from the 8” steel gas line and runs to the east. Just south of the intersection, an 8” steel and a 4” PE gas line cross Houghton Road from the west where they both join the 8” steel and 4” PE on the east side and continue to the south on the east side.

Between Speedway Boulevard and 5th Street: Utility locating survey was only able to document the 8” steel gas line along the east side of Houghton Road to 5th Street. The 4” PE was identified to approximately 700’ south of Speedway Boulevard.

Electric – Tucson Electric Power (TEP)

All electric lines within the project limits are owned by Tucson Electric Power (TEP). For most of the project length, poles are located within the existing ROW. Between Speedway Boulevard and Broadway Boulevard, there are (9) poles outside the existing ROW with one being a very large metal pole on the southeast corner of the Speedway Boulevard intersection.

North of Tanque Verde Road: Overhead power lines run along the east side of Houghton Road from Flintlock Trail to Tanque Verde Road.

Tanque Verde Road: The overhead power lines run east and west along the north side of Tanque Verde Road. There is an overhead crossing located about 100’ west of Houghton Road at Tanque Verde Road. Just south of Tanque Verde Road, the utility survey was not able to locate this line on the west side of Houghton Road.

Between Tanque Verde Road and Speedway Boulevard: There is an underground electric line beginning north of Speedway Boulevard to the west of Houghton Road at the frontage road which continues south to the Tanque Verde Wash where it crosses Houghton Road to the east via overhead lines. Also, an overhead line begins 75’ west of Houghton Road at the existing frontage road and continues to Speedway Boulevard.

Speedway Boulevard: At Speedway Boulevard, an overhead power line crosses Speedway Boulevard west of Houghton Road and joins with a line running east and west along the south side of Speedway Boulevard. The east-west overhead power lines connect to a tall, metal transmission pole located on the southeast corner of the intersection, outside the existing ROW. There is an underground electric line beginning at the southwest corner of Speedway Boulevard which runs to the east of Houghton Road along the overhead line location.

Between Speedway Boulevard and 5th Street: At the transmission pole on the southeast corner of the Speedway Boulevard intersection, the overhead power lines run south along the east side of Houghton Road to 5th Street. There are overhead power line crossings at Houghton Road located just north and south of 5th Street. Four poles are outside the existing ROW, and five are within the existing ROW

Water – Tucson Water

A Tucson Water waterline travels along the west side of Houghton Road along the entire project length from Tanque Verde Road to 5th Street. From north of Flintlock Trail, a 12" asbestos cement pipe (ACP), heads south along the west side of Houghton Road and a 24" ductile iron (DI) water line runs east and west near the middle of Tanque Verde Road. The 12" (ACP) water main then runs south to Speedway Boulevard along the west side of Houghton Road. At Speedway Boulevard, a 24" concrete cylinder (CC) line and a 12"/16" (DI) reclaimed water (RW) line runs to the east, crossing Houghton Road. From Speedway Boulevard, the 12" (ACP) continues south at the west side of Houghton Road to 5th Street. Along its length, there are service connections to this line to service areas to both the east and west sides of Houghton Road. With regard to the existing water main lines, Table 3 lists the side service location (laterals) and the size of the lines.

Table 3 – Water Services from Houghton Water Main

Location	Size
Flintlock Trail	6" PVC
Desert Flower Place	6" PVC
Shady Rock Lane	6" PVC
Rancho del Este Dr.	6" PVC
North of Frontage Road	8" PVC
Frontage Road	8" PVC
Speedway Boulevard (to east)	6" PVC
South of Speedway Boulevard	8" PVC
Packard St.	8" PVC
East of Packard St.	8" CA
Windstorm Dr.	8" PVC
5th Street	8" PVC

West of the existing Tanque Verde Bridge and just west of the existing west Drachman Street frontage road there is an existing Tucson Water well site.

Telephone - CenturyLink

North of Tanque Verde Road: CenturyLink (formerly Qwest) has an underground telephone line on the west side of Houghton Road north of Rancho del Este Drive. At Rancho del Este Drive, lines cross Houghton Road and there are lines on each side of Houghton Road to Tanque Verde Road.

Tanque Verde Road: There are underground telephone lines along the south side of Tanque Verde Road and they cross Houghton Road just south of the intersection.

Between Tanque Verde Road and Speedway Boulevard: South of Tanque Verde Road, underground telephone lines parallel Houghton Road on the east side to Speedway Boulevard. At the Agua Caliente Wash and Tanque Verde Creek, some lines cross these washes in conduits under the existing bridges. Other lines cross the washes.

There are underground telephone lines west of the frontage road on the west side of Houghton Road and these lines cross Houghton Road beneath the Tanque Verde bridge, just north of the main Tanque Verde Wash channel. South of the main Tanque Verde Creek channel, an underground telephone line was picked up on the west side of Houghton Road. From this area, underground telephone lines are on the east side and west side of Houghton Road to Speedway Boulevard.

Speedway Boulevard: Underground telephone lines cross Speedway Boulevard east of Houghton Road. No lines were found crossing on the west side. Underground telephone lines are on the north side of Speedway Boulevard, east of Houghton Road.

South of Speedway Boulevard: Underground telephone lines are on the east side and west side of Houghton Road to 5th Street. One Houghton Road crossing was found approximately 700’ south of Speedway Boulevard.

Sanitary Sewer – Pima County Regional Wastewater Reclamation Department

Pima County Regional Wastewater Reclamation Department has underground sanitary sewer facilities within segments of the Houghton Road alignment. North of Tanque Verde Road, there is an 8” PVC sewer lateral located west of Houghton Road at Shady Rock Lane. Also, there is a 18” VCP sewer line crossing Houghton Road just north of the Tanque Verde Wash. At Packard Street, south of Speedway Boulevard, there is an 8” PVC sewer line that crosses Houghton Road connecting to residences in the vicinity.

Traffic Signals – City of Tucson

There are two traffic signals within the project limits: one at the Tanque Verde Road intersection and one at the Speedway Boulevard intersection. Both these traffic signals are maintained by the City of Tucson.

3.3 STRUCTURES

There are currently two bridges located within the limits of this Houghton Road segment. The first existing bridge structure spans Agua Caliente Wash along Houghton Road. This structure is 50 feet wide with a 42-foot clear width on a 31-degree left skew. It consists of three cast-in-place spans for a length of 300 feet over prestressed concrete girders. The second existing bridge structure spans Tanque Verde Creek along Houghton Road. This structure is also 50 feet wide with a 42-foot clear width, but without any skew. It consists of eleven cast-in-place spans for a length of 1,100 feet over prestressed concrete girders. Also, each structure contains a 4-foot-wide pedestrian walkway located along the east side of the deck.

Condition Assessment

The latest Arizona Department of Transportation (ADOT) bridge group condition assessment reports for the Tanque Verde Wash and Agua Caliente Wash bridges were reviewed. For the Tanque Verde Wash bridge, the condition ratings are 7 and 8, indicating good/very good condition. There is sufficient lane width and the shoulders are adequate. The inventory and operating are above 1.0 and 2.0 respectively, and the bridge is not load posted. The bridge is not scour critical.

For the Agua Caliente Wash bridge, the condition ratings are 6, 7, and 8, indicating satisfactory/ good/very good condition. There is sufficient lane width and the shoulders are adequate. The inventory and operating are above 1.0 and 2.0 respectively, and the bridge is not load posted. The bridge is not scour critical.

The bridges were built in 1989 with a 75-year design life. Based on the condition assessment, no reduction to the design life are noted. With proper maintenance, 45 years of design life remain.

3.4 SIGNALIZATION AND LIGHTING

Houghton Road's intersections with Tanque Verde Road and Speedway Boulevard each have traffic signals and roadway lighting. Figure 3 shows aerial images of both intersections.

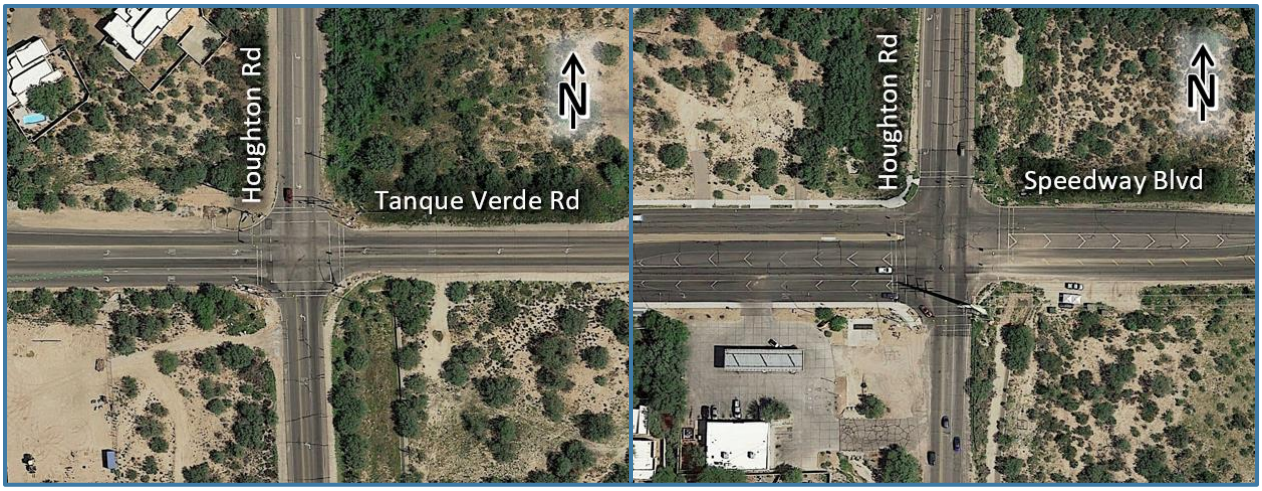


Figure 3 – Signalized Intersection Aerials.

Houghton Road / Tanque Verde Road Intersection

This intersection features left turn signals for EB and WB Tanque Verde Road, with no protected left signals for Houghton Road traffic. All four intersection legs have pedestrian signals.

The NB, WB, and SB approaches each have one shared through/right lane and one left turn lane. The EB approach has a lane drop that turns into a dedicated right turn lane, a through lane, and a left turn lane. All approaches have one departure lane, although a second WB lane is developed approximately 600 feet west of the intersection.

Houghton Road / Speedway Boulevard Intersection

This intersection features left turn signals for all approaches. All four intersection legs have pedestrian signals. This intersection was rebuilt as part of the recent Speedway Boulevard widening, with span wire signals installed.

The NB approach has one left turn lane and one shared through/right lane. The WB approach has one left turn lane, one through lane, and one shared through/right lane. The SB approach has one left turn lane, one through lane, and one right turn lane. The EB approach has one left turn lane, one through lane, and one right turn lane, each separated by a striped buffer.

Roadway Lighting

Both signalized intersections feature roadway lights. Speedway Boulevard extending west from Houghton Road has continuous roadway lighting. Houghton Road south of Speedway Boulevard lacks roadway lighting until the northern limit of the recently reconstructed Houghton Road/ Broadway Boulevard intersection improvement project. All other roadway segments within the study area are not lighted.

3.5 ENVIRONMENTAL RESOURCES

The DCR included a survey of several existing environmental resources of the project. The environmental resources reviewed included vegetation, wildlife, special status species, critical habitat, wildlife crossings, archaeological resources, and community resources. This section provides a summary of these resources from the DCR review. Additional environmental considerations in relation to proposed improvements are discussed in Section 6.2.

Vegetation

The project area lies within the Arizona Upland subdivision of the Sonoran Desert scrub biome, with areas of Sonoran riparian scrubland and Sonoran riparian deciduous forest and woodlands. These vegetation communities result from the proximity to the Agua Caliente Wash and Tanque Verde Creek and their floodplains, which provide additional water to plants beyond that available by direct rainfall. Sonoran riparian scrubland generally features the same species as adjacent, drier upland areas, but with larger plants and denser growth due to higher water availability. Sonoran riparian deciduous forest and woodlands, located along Tanque Verde Creek, also include species not typically found in upland areas, including cottonwood (Populus fremontii) and willow (Salix gooddingii).

Wildlife

Wildlife that is likely to occur in the project area includes small mammals, reptiles, amphibians, and birds. Medium-sized mammal species such as javelina (Tayassu tajacu) or coyote (Canis latrans) may forage in the project vicinity and move through the project area. The lack of permanent water sources precludes the presence of many species associated with aquatic or wet riparian habitats; however, water may accumulate in depressions providing temporary aquatic habitat that may provide breeding sites for amphibians. Undeveloped lands within the project area have a higher habitat value for wildlife than lands associated with human development. The undeveloped areas, Aqua Caliente Wash, and Tanque Verde Creek allow for a moderate degree of wildlife movement, as well as connectivity among habitat areas used for foraging, cover, and reproduction. Several species of bats could forage within the project area if active roosts are located nearby.

Special Status Species

The term special status species in this report refers to species that are listed under the federal Endangered Species Act of 1973 (16 U.S.C. 1531–1544, as amended) with lead management by the US Fish and Wildlife Service, as well as species that are not protected under the Endangered Species Act but have been given special status designations by state or other federal agencies.

Suitable habitats for one candidate species (Western yellow-billed cuckoo [Coccyzus americanus]), and one species listed as sensitive by the US Forest Service, the Bureau of Land

Management, and salvage restricted by the Arizona Department of Agriculture (Tumamoc globeberry [Tumamoca macdougalii]) are present in the project area, as identified in the DCR.

Critical Habitat

Critical habitat that has been designated or proposed by the US Fish and Wildlife Service for the conservation of threatened and endangered species receives special legal protection under the Endangered Species Act. The project area does not include any designated or proposed critical habitat.

Wildlife Crossings

Two washes in the project area were identified (Tanque Verde Creek and Agua Caliente Wash) as potential wildlife crossings because they are the largest and most heavily vegetated within the project area. Both washes provide highly critical wildlife linkages and function as primary movement corridors between large blocks of undeveloped lands. They both originate in the Coronado National Forest on the east side of the Tucson Basin and continue to the west, ultimately connecting to the Santa Cruz River and Tucson Mountains on the west side of the Basin.

Archaeological Resources

Tierra Right of Way Services, Ltd. Conducted a Class III cultural resource survey along the Houghton Road corridor ROW from Speedway Boulevard to Old Spanish Trail. The survey revealed that the project crosses portions of three previously recorded prehistoric sites:

- The Tanque Verde Wash site (AZ BB:13.68[ASM])
- The Houghton Road site (AZ BB:13.398[ASM])
- An unnamed artifact scatter (AZ BB:13.654[ASM]) – since destroyed.

The Tanque Verde Wash site and the Houghton Road site are multi-component prehistoric villages that have been recommended eligible for inclusion in the National Register of Historic Places (NRHP). Previous investigations at both sites have demonstrated that each contains significant buried cultural resources including human burials.

Community Resources

The Desert Springs Academy is the only school located within the study area. It is located on the north side of Speedway Boulevard approximately 1000 feet west of Houghton Road. Several elementary, junior high, and high schools are located within five miles of the study area.

The Club at Mariposa is a private club west of Houghton Road between Tanque Verde Creek and Agua Caliente Wash. Primary all-weather access is off Houghton Road at the north end of the Tanque Verde Creek bridge.

There are no churches located within the study area, although the Rincon Church of God is located west of the study area on Tanque Verde Road, and Saint John on the Desert Presbyterian Church is located ¼ of a mile further north on Houghton Road.

There are no fire station facilities within the project area. Several fire stations are located nearby, including the Tucson Fire Department Station 12 on Harrison Road south of Broadway Boulevard, Rural Metro Fire Station 72 on Houghton Road south of Glenn Street, and Tucson Fire Department Station 21 on Tanque Verde Road west of Bear Canyon Road.

4 TRAFFIC

Traffic counts were collected along the study corridor for evaluating existing conditions and developing future traffic projections. Turning movement counts were collected at the Speedway Boulevard and Tanque Verde Road intersections. Projected volumes were developed using growth rates calculated from PAG's 2045 regional traffic model. 2030 was used as the design year for improvements to compare with the DCR recommendations. A discussion of 2035 to 2045 volumes is also included to evaluate the potential lifetime of the improvements. Traffic count data from PAG is included in Appendix A, and traffic data collected for this study is included in Appendix B.

4.1 EXISTING TRAFFIC - 2019

Figure 4 shows the 24-hour daily volume counts on seven roadway segments in the corridor collected on May 7, 2019. Figure 5 shows the turning movement counts at the Houghton Road intersections with Speedway Boulevard and Tanque Verde Road, also collected on May 7, 2019. The turning movement counts were collected from 6-9 am and 3-6 pm, with one-hour peak periods subsequently determined.

Traffic volumes vary within the study corridor, with the highest volumes on Houghton Road south of Speedway Boulevard. Volumes on Tanque Verde Road and Speedway Boulevard are higher west of Houghton Road than to the east. Directional volumes are generally close to balanced, except for Speedway Boulevard west of Houghton Road, which has an EB volume approximately 15% higher than the WB volume.

The NB Houghton Road to WB Speedway Boulevard left turn movement was significant, with an AM peak hour of 446 vehicles. The PM peak was lower at 275 vehicles. The opposite movement, EB Speedway Boulevard to SB Houghton Road, had smaller but still significant volumes, with a slightly higher PM peak.

For both intersections, the AM peak hour contained larger traffic volumes than the PM peak.

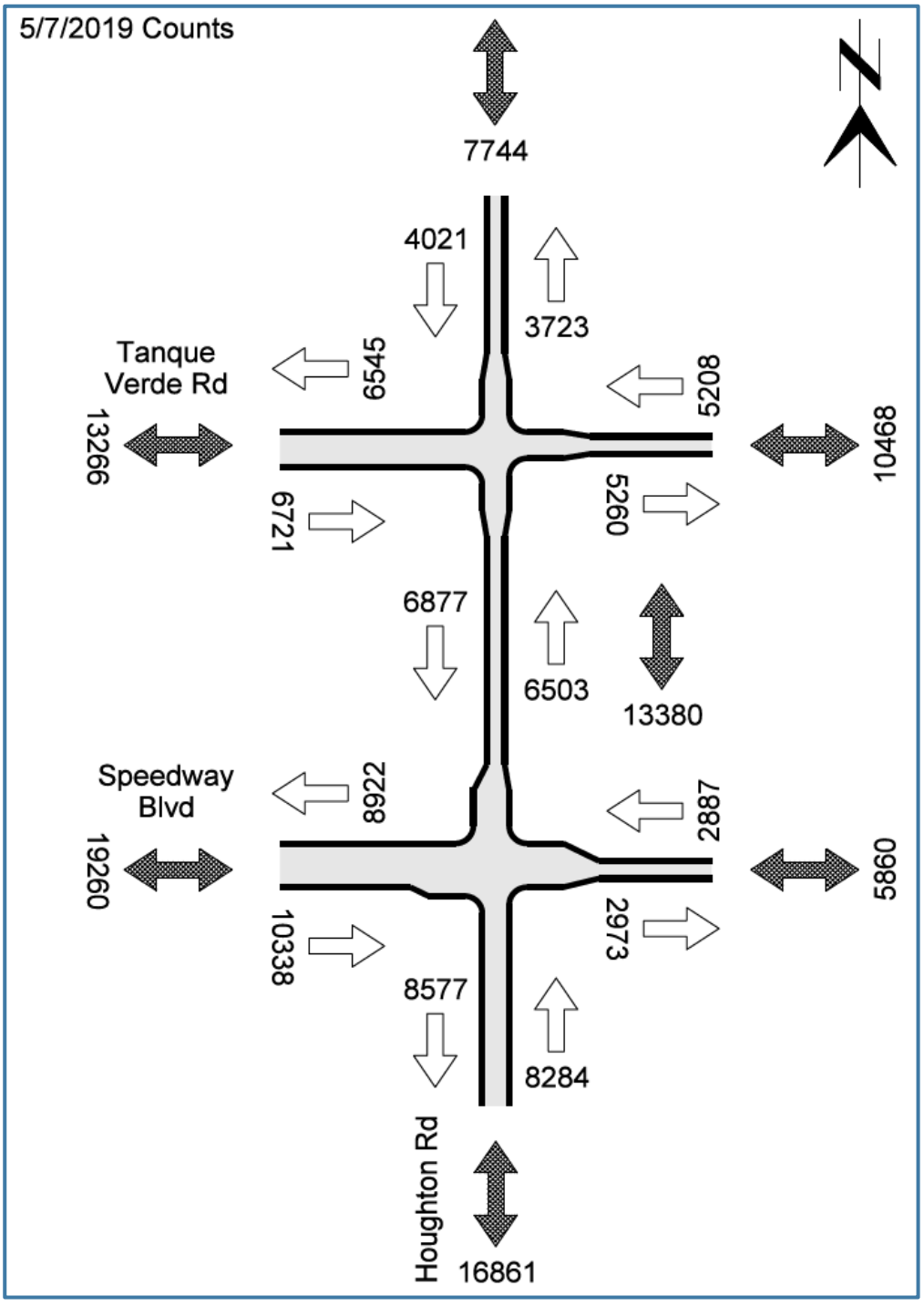


Figure 4 – Existing 2019 24-Hour Volume Counts

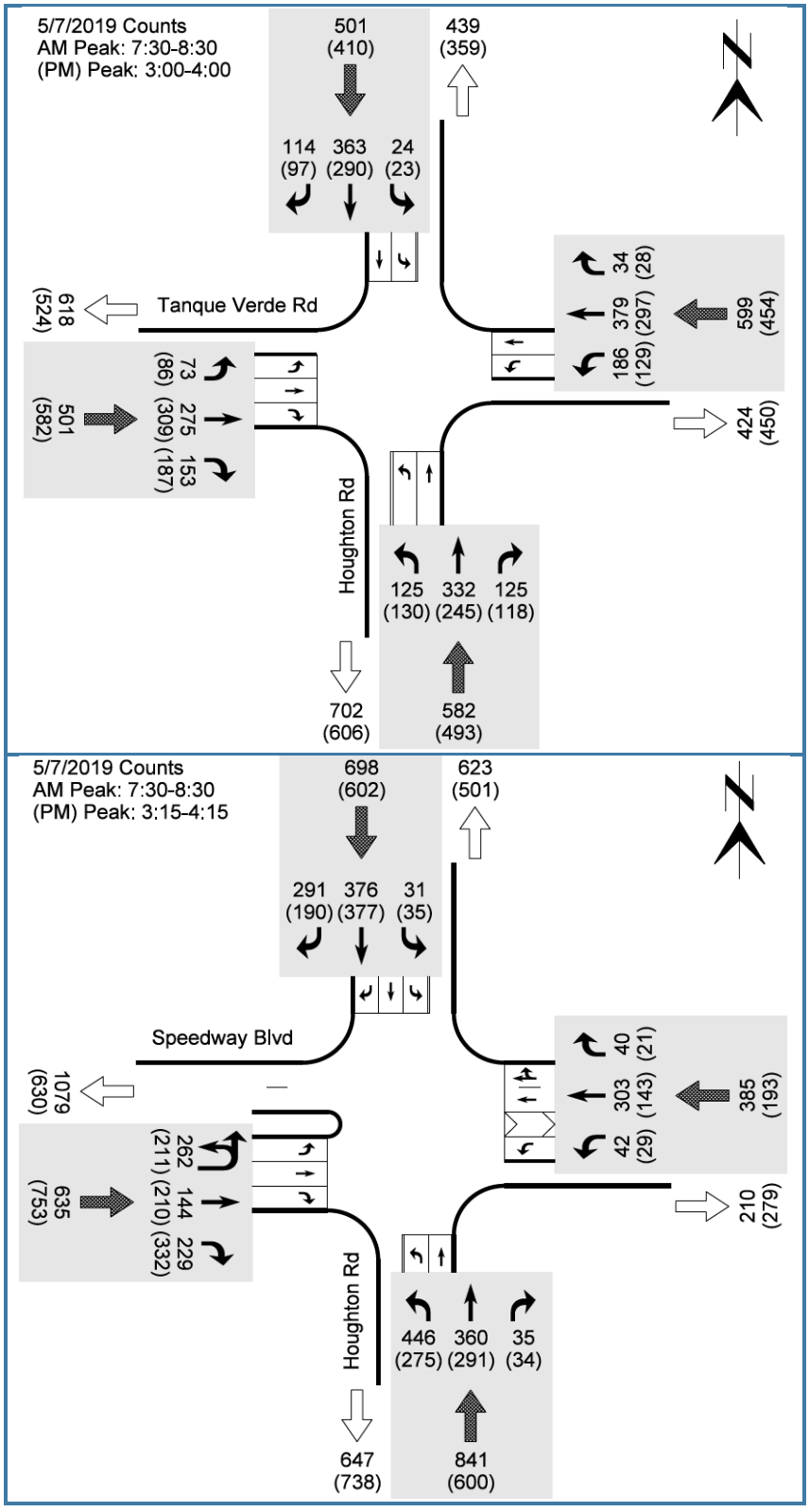


Figure 5 – Existing 2019 Turning Movement Counts

Pedestrians / Bicycle Volumes

During the six hours that intersection volume data was collected, only four pedestrians were observed at the Houghton Road/Speedway Boulevard intersection. Two pedestrians were observed at the Houghton Road/Tanque Verde Road intersection.

Peak hour bicycle movement volumes were all less than 8 bicycles per hour except for the AM EB Tanque Verde Road to SB Houghton Road and AM SB Houghton Road to EB Speedway Boulevard movements. This AM peak likely represents a group ride event and highlights the need for adequate bicycle accommodation through the study corridor despite relatively low overall bicycle volumes.

4.2 EXISTING CAPACITY ANALYSIS - 2019

Synchro traffic software was used to implement Highway Capacity Manual, 6th Edition (HCM) procedures for modeling existing traffic capacity at the two major intersections within the study area. The results of the analysis indicate that the Houghton Road/Tanque Verde Road intersection operates at LOS C in both the AM and PM peak periods. The Houghton Road/Speedway Boulevard intersection operates LOS D in the AM peak and LOS C in the PM peak.

Table 4 and Table 5 show the existing peak hour delay and LOS at the two intersections. The only movements operating at LOS E are the NB Houghton Road to WB Speedway Boulevard AM left and SB Houghton Road AM through. It should be noted that the default HCM right turn on red volume (RTOR) of 0 was used for most right turn movements, which is a conservative assumption. At the Houghton Road/Speedway Boulevard intersection, SB right and EB right RTOR volumes were estimated based on field observations. Without the RTOR estimates, delay estimates were unrealistically high. RTOR percentages of 50% and 75% were used for the two movements, respectively.

Table 4 – Houghton Road & Tanque Verde Road Existing LOS														
	SB ↓			WB ←			NB ↑			EB →				INT
	L	T/R	APR	L	T/R	APR	L	T/R	APR	L	T	R	APR	TOT
AM Delay	25.6	25.1	25.1	26.1	40.3	35.8	37.1	21.6	24.9	29.8	29.9	24.3	28.2	**28.7**
AM LOS	C	C	C	C	D	D	D	C	C	C	C	C	C	**C**
PM Delay	19.2	17.4	17.5	19.7	31.7	28.3	25.4	16.4	18.8	19.2	31.1	24.0	27.1	**23.2**
PM LOS	B	B	B	B	C	C	C	B	B	B	C	C	C	**C**

L = Left lane group T = Through lane group R = Right lane group T/R = Shared through/right lane group
APR = Approach Delay units: seconds/vehicle

Table 5 – Houghton Road & Speedway Boulevard Existing LOS															
	SB ↓				WB ←				NB ↑			EB →				INT
	L	T	R	APR	L	T	R	APR	L	T/R	APR	L	T	R	APR	TOT
AM Delay	34.6	61.9	34.5	51.7	31.4	48.4	49.4	47.0	63.8	22.0	44.2	49.8	40.5	39.4	44.6	**46.7**
AM LOS	C	E	C	D	C	D	D	D	E	C	D	D	D	D	D	**D**
PM Delay	19.9	39.8	12.4	32.0	27.6	31.2	31.3	30.7	24.8	29.8	27.5	35.0	34.3	12.8	28.2	**29.3**
PM LOS	B	D	B	C	C	C	C	C	C	C	C	D	C	B	C	**C**

L = Left lane group T = Through lane group R = Right lane group T/R = Shared through/right lane group
APR = Approach Delay units: seconds/vehicle

The existing peak hour roadway segment LOS, average travel speed (ATS), and percent time spent following (PTSF) are shown in Table 6. Roadway segment LOS was analyzed using HCM methodology for two-lane highways. The one mile spacing between traffic signals was considered sufficient for application of the HCM methodology.

Table 6 – Roadway Segment Existing LOS						
	Broadway Blvd to Speedway Blvd			Speedway Blvd to Tanque Verde Rd		
	LOS	ATS (mph)	PTSF	LOS	ATS (mph)	PTSF
AM	E	29.7	86.2%	E	31.6	78.3%
PM	E	31.1	76.2%	E	33.2	72.0%

The LOS criteria for Class I highways was used. The HCM two-lane highways capacity evaluation considered both a Class I and Class II designation for Houghton Road. These are defined as follows:

Class I: where motorists expect to travel at relatively high speed. These are major intercity routes and primary connectors of major traffic generators, serving long distance trips.

Class II: where motorists do not necessarily expect to travel at high speed. These are access routes to Class I routes, recreational routes, or routes that pass through rugged terrain, serving relatively short trips.

The HCM states that the primary determinant of a facility's classification is the motorist's expectation, which might not agree with the routes overall functional category. Houghton Road was analyzed as a Class I route but has some characteristics of a Class II route, namely that motorists do not necessarily expect to travel at high speed (speed limit 45 mph). A change in just the class of roadway can change the level of service, with no changes to the performance measures themselves. The existing roadway HCM reports for Houghton Road between Tanque Verde Road and Broadway Boulevard are included in Appendix C.

4.3 FUTURE TRAFFIC - 2030

Future traffic volumes were calculated using growth rates derived from the 2045 PAG regional transportation model. These growth rates (shown in Table 7) were applied to the 2019 turning movement counts to provide projected turning movement volumes for the 2030 design year. The 2045 PAG model showed approximately 2000 fewer vehicles on Houghton Road at Tanque Verde Road than at Speedway Boulevard. This reduction was considered unrealistic given current and expected land use, so the growth rates on this segment of Houghton Road were adjusted to produce more balanced traffic volumes between the two major intersections. The 2030 projected daily volumes are shown in Figure 6 and the 2030 projected turning movement volumes are shown in Figure 7.

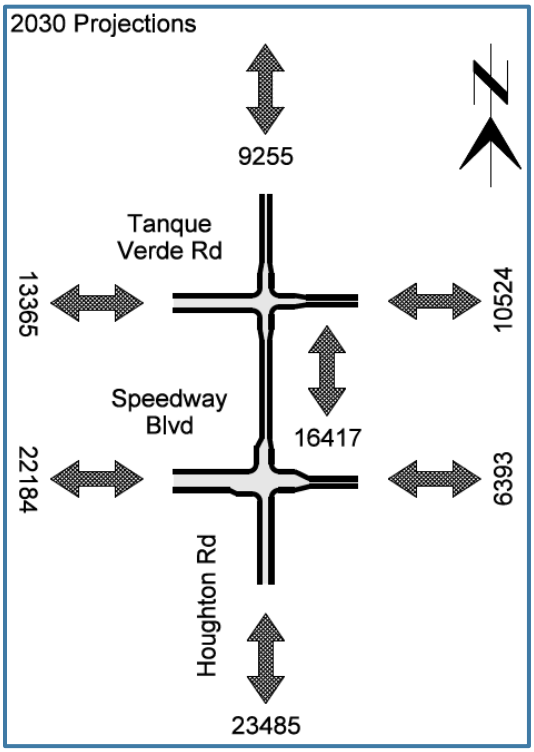


Figure 6 – 2030 Projected Daily Volumes

Compared to the 2030 traffic projections from the DCR, shown in Figure 8, the projections developed for this study are significantly lower, especially along Houghton Road. The Tanque Verde Road to Speedway Boulevard segment, for example, has a projected ADT of 16417 compared to 25600 in the DCR, approximately 36% lower. Many of the turning movement volumes are also significantly lower.

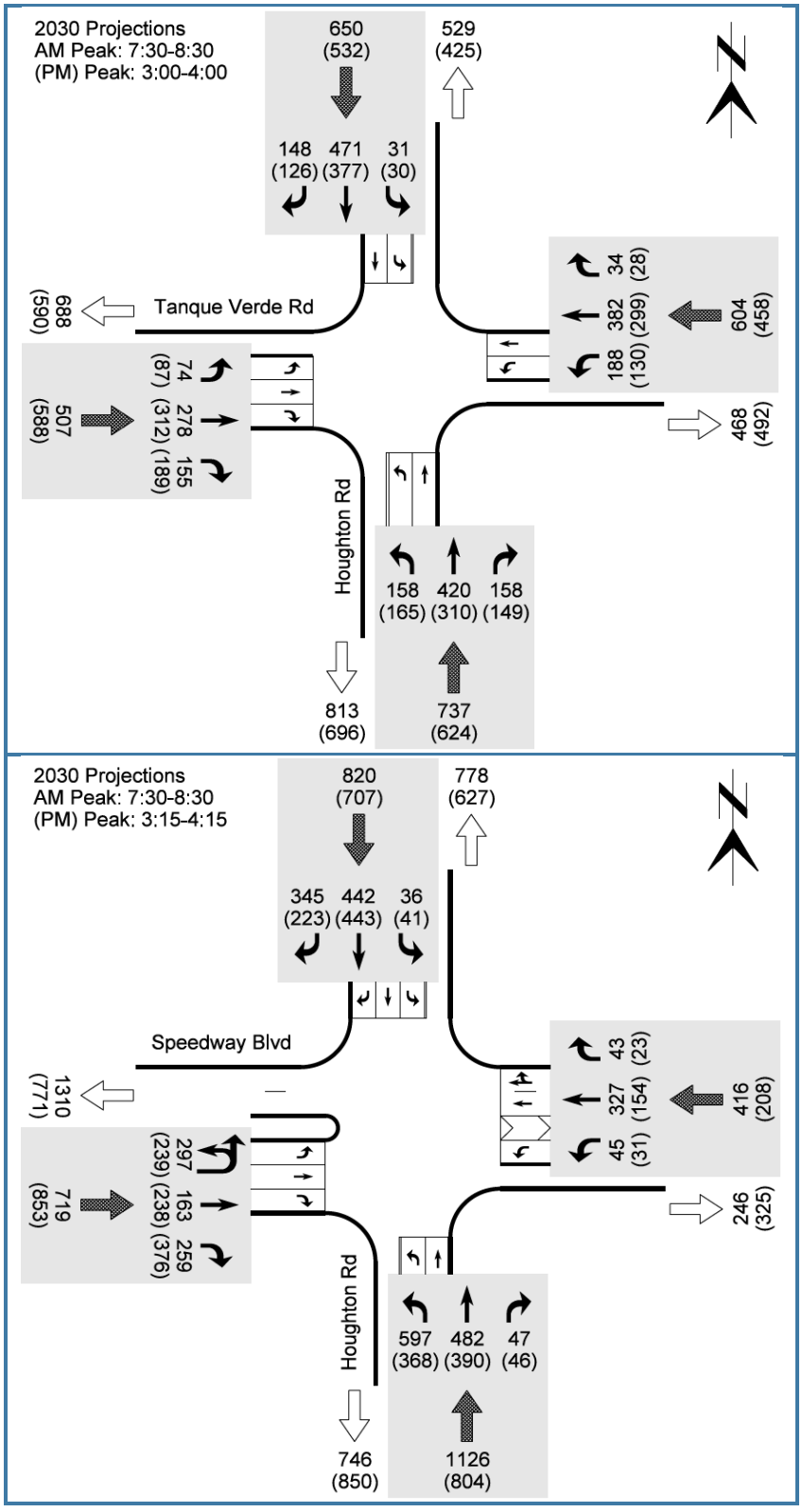


Figure 7 – 2030 Projected Turning Movement Volumes

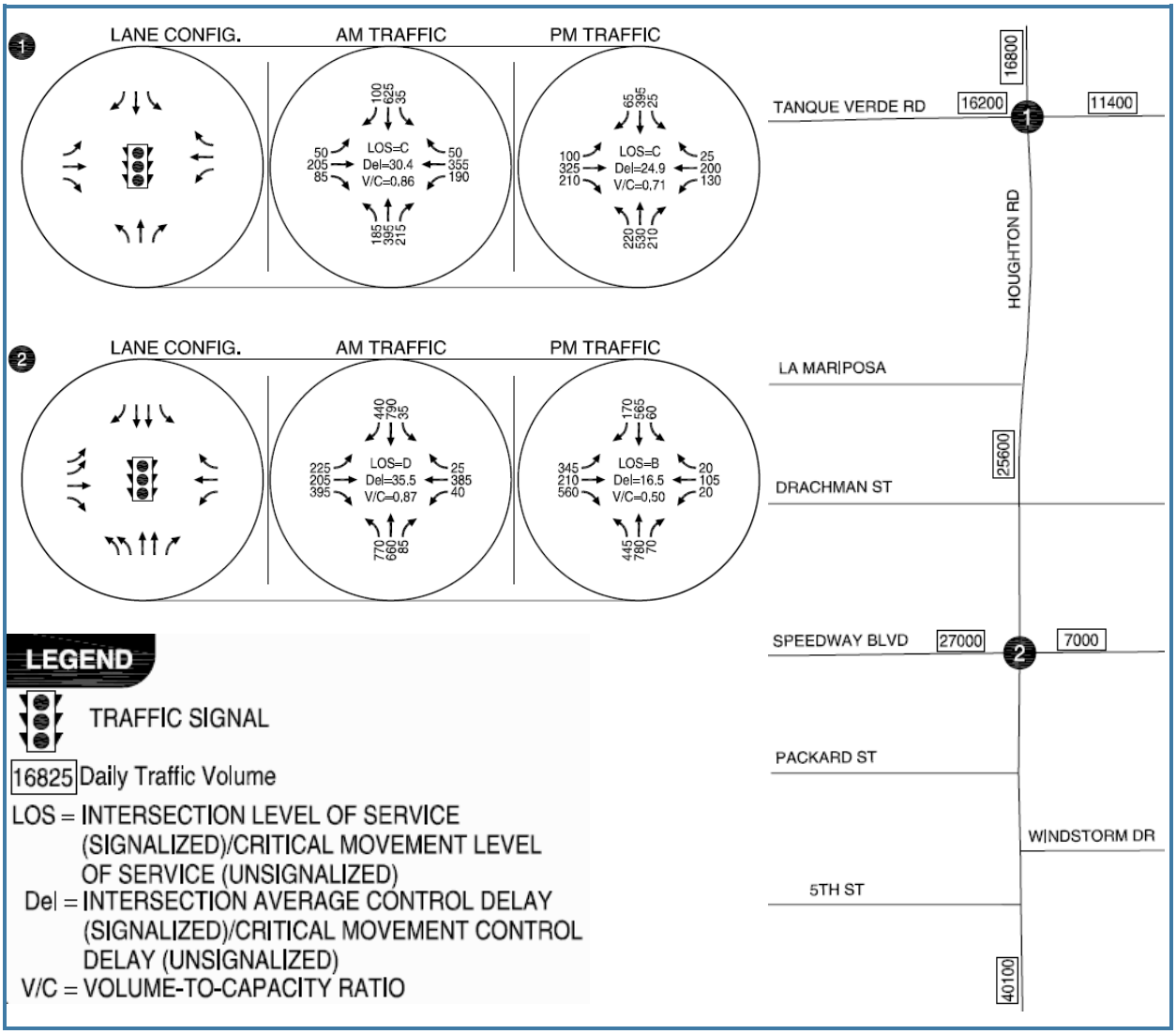


Figure 8 – DCR 2030 Projected Traffic Volumes

Table 7 – Growth Rates

Roadway	Segment	DCR Growth Rate	Used for this Study
Tanque Verde Rd	West	0.5%	0.10%
	East	0.5%	0.07%
Speedway Boulevard	West	3.4%	1.14%
	East	0.5%	0.07%
Houghton Road	North of Tanque Verde	4.0%	2.40%
	South of Tanque Verde	2.1%	2.17%
	North of Speedway		1.47%
	Speedway to Broadway	5.2%	2.69%

4.4 FUTURE CAPACITY ANALYSIS - 2030

The 2030 projected traffic volumes were used to determine LOS at the two major intersections for a no build scenario with no changes to the existing number of lanes and intersection configurations. Synchro software was used to implement HCM procedures. As with the existing traffic conditions, RTOR volumes were estimated for the SB and EB right movements at the Houghton Road/Speedway Boulevard intersection. Modeled delay and LOS for the two intersections are shown in Table 8 and Table 9.

Table 8 – Houghton Road & Tanque Verde Road 2030 No Build LOS

	SB ↓			WB ←			NB ↑			EB →				INT
	L	T/R	APR	L	T/R	APR	L	T/R	APR	L	T	R	APR	TOT
AM Delay	30.6	25.2	25.4	37.0	69.7	59.5	55.5	21.0	28.4	28.9	38.0	31.1	34.6	**36.4**
AM LOS	C	C	C	D	E	E	E	C	C	C	D	C	C	**D**
PM Delay	21.7	18.9	19.1	25.7	43.7	38.6	34.3	16.8	21.4	23.3	40.7	28.5	34.2	**27.8**
PM LOS	C	B	B	C	D	D	C	B	C	C	D	C	C	**C**

L = Left lane group T = Through lane group R = Right lane group T/R = Shared through/right lane group
APR = Approach Delay units: seconds/vehicle

Table 9 – Houghton Road & Speedway Boulevard 2030 No Build LOS

	SB ↓				WB ←				NB ↑			EB →				INT
	L	T	R	APR	L	T	R	APR	L	T/R	APR	L	T	R	APR	TOT
AM Delay	63.7	91.0	26.4	69.1	50.9	87.9	90.0	84.8	128.3	27.3	80.8	66.0	45.4	11.4	47.4	**72.0**
AM LOS	E	F	C	E	D	F	F	F	F	C	F	E	D	B	D	**E**
PM Delay	28.8	40.3	14.1	33.3	32.3	35.7	35.8	35.2	39.7	25.4	31.9	53.1	48.2	16.9	41.2	**35.2**
PM LOS	C	D	B	C	C	D	D	D	D	C	C	D	D	B	D	**D**

L = Left lane group T = Through lane group R = Right lane group T/R = Shared through/right lane group
APR = Approach Delay units: seconds/vehicle

Based on the projected volumes, the Houghton Road/Tanque Verde Road intersection will continue to operate satisfactorily with no improvements beyond signal timing maintenance, with AM LOS D and PM LOS C. Note that the analysis maintained the existing NB and SB permitted only lefts.

The Houghton Road/Speedway Boulevard intersection will begin to experience LOS F for multiple movements in the AM peak, with an overall LOS E in the AM peak. The AM NB Houghton Road to WB Speedway Boulevard left could experience average control delay exceeding two minutes and long queues. Based on these expected conditions, improvements are recommended and discussed in Section 5.

Peak hour roadway segment LOS, ATS, and PTSF are shown in Table 10. Roadway segment LOS was analyzed using HCM methodology for two-lane highways. The LOS criteria for Class I highways was used. Based on the analysis, the existing roadway will not see a decrease in LOS with the increased traffic volumes. The roadway segments will operate at LOS E between Tanque Verde Road and Broadway Boulevard during the 2030 AM and PM peak hours. PTSF values are approximately 5-10% higher than with existing traffic volumes. HCM reports are included in Appendix C.

Table 10 – Roadway Segment 2030 No Build LOS

	Broadway Blvd to Speedway Blvd			Speedway Blvd to Tanque Verde Rd		
	LOS	**ATS** (mph)	**PTSF**	**LOS**	**ATS** (mph)	**PTSF**
AM	E	26.4	92.2%	E	29.3	84.3%
PM	E	28.3	84.8%	E	31.5	78.1%

4.5 CRASH DATA

Crash data was obtained from PAG for the period from 2014-2018 including Houghton Road within the study area and the approaches on Tanque Verde Road and Speedway Boulevard. A total of 64 crashes were reported during this period, with one fatality, four incapacitating injury crashes, and 14 incapacitating injury reports. 36 of the crashes were property damage-only.

Most of the crashes were concentrated at the Houghton Road/Tanque Verde Road and Houghton Road/Speedway Boulevard intersections. Figure 9 and Figure 10 show the crash diagrams for the two intersections. The Houghton Road/Speedway Boulevard intersection saw a higher number of crashes, which would be expected given its notably higher traffic volumes. An additional eight crashes occurred away from the intersections, not shown in Figure 9 and Figure 10; these are included in Appendix D. This includes the one fatal crash, which was a single vehicle, alcohol-related crash on Speedway Boulevard approximately 500 feet east of Houghton Road.

PAG's Safety Explorer tool includes calculated level of safety service (LOSS) values, which provide an estimation of potential for safety improvement. LOSS is represented on a 1 to 4 scale, with 1 indicating the lowest potential for crash reduction, and 4 indicating the highest. The average intersection LOSS for the study area is 3.00, and the roadway weighted LOSS is 2.46. These values indicate a moderate to high potential for safety improvement, especially at the intersections.

From the crash diagrams, SB rear-ends at Speedway Boulevard are the most numerous of any approach. SB left turn crashes at Speedway Boulevard are also disproportionately represented

relative to volumes. SB drivers may have difficulty identifying NB through traffic, which could be obstructed by NB left turning vehicles. There was also a noticeable incidence of NB left turn crashes. Changes to the lane alignment and geometry at the intersection will need to be done carefully, with good visibility maintained for turning traffic.

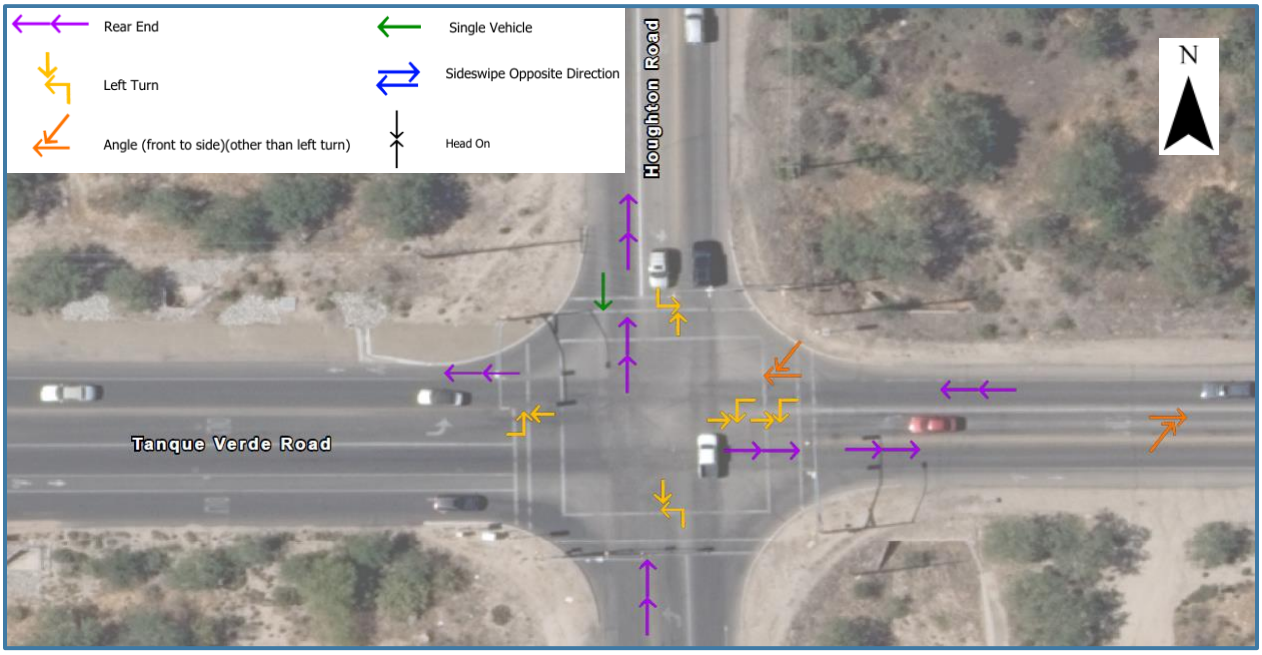


Figure 9 – Houghton Road/Tanque Verde Road Intersection Crash Diagram (2014-2018)

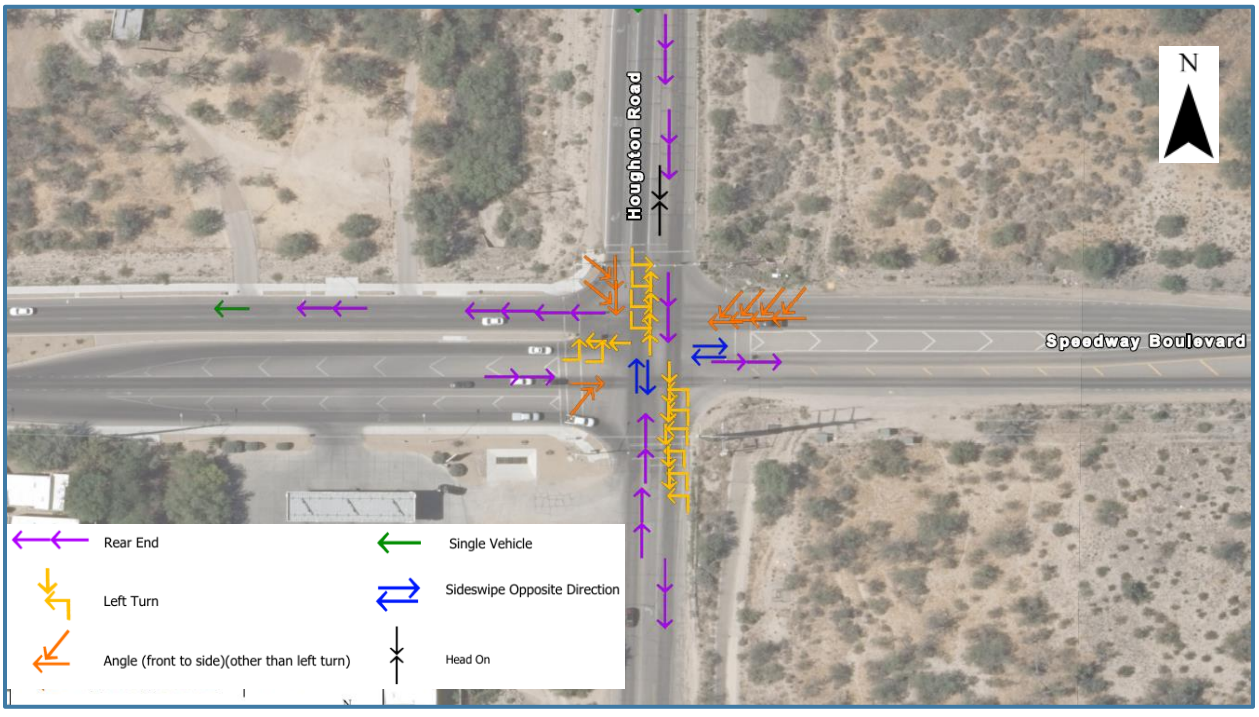


Figure 10 – Houghton Road/Speedway Boulevard Intersection Crash Diagram (2014-2018)

5 PROPOSED RECOMMENDATIONS

The proposed recommendations are based on improving the LOS along the Houghton Road corridor for projected traffic in the 2030 design year. The goal of the proposed improvements is to maintain overall LOS D or better at the intersections during the AM and PM peak hours, and minimize the number of movements experiencing LOS E. Roadway segment LOS is to be kept at LOS E or better. The proposed improvements feature widening to the south of Speedway Boulevard, and capacity improvements at the Tanque Verde Road and Speedway Boulevard intersections.

5.1 PROPOSED INTERSECTION CONFIGURATION

At the Houghton Road/Tanque Verde Road intersection, the only proposed improvement is to add a NB right turn lane. Although not required per the capacity analysis, a right turn lane is recommended for improved traffic flow and safety. The City of Tucson has received community feedback in support of a NB right turn lane at this location. Figure 12 illustrates the proposed turn lane and associated major design features, including a retaining structure (such as gabions or retaining wall) to maintain the existing drainage channel on the east side of Houghton Road. Guardrail would likely be necessary due to the retaining structure at the bottom of the expanded fill slope. Curb ramps would be installed at all four corners of the intersection to meet ADA standards.

More substantial improvements begin at the Houghton Road/Speedway Boulevard intersection, extending south to the existing six lane section. An additional NB left turn lane is necessary to handle projected traffic volumes. An additional SB departure lane is recommended to provide continuity with widening to the south. Reconstruction of the intersection will be necessary to accommodate the additional NB left turn lane and widening of the SB approach. Careful attention during design will be necessary to provide good visibility for left turning traffic. The Speedway Boulevard approaches will remain unchanged except where they tie in to the intersection.

The north Houghton Road approach to Speedway Boulevard will be a subject of special design attention. Figure 13 shows the existing and proposed lane widths. The approach is constrained by the existing Tanque Verde Wash bridge. To accommodate the proposed widening for the 45 mph posted speed limit, a lane taper of approximately 315 feet will be necessary, reducing the tangent storage length to approximately 125 feet from the existing 180 feet. This is not expected to cause any significant adverse capacity impacts, although during the design phase, options should be considered for extending the storage length. The Pima County/City of Tucson Pavement Marking Design Manual lists a minimum storage length of 150 feet for a posted speed of 45 mph. The proposed lane configuration is illustrated in Figure 11, along with the existing and DCR recommended configurations. The reduced traffic projections do not require the more extensive improvements previously recommended in the DCR.

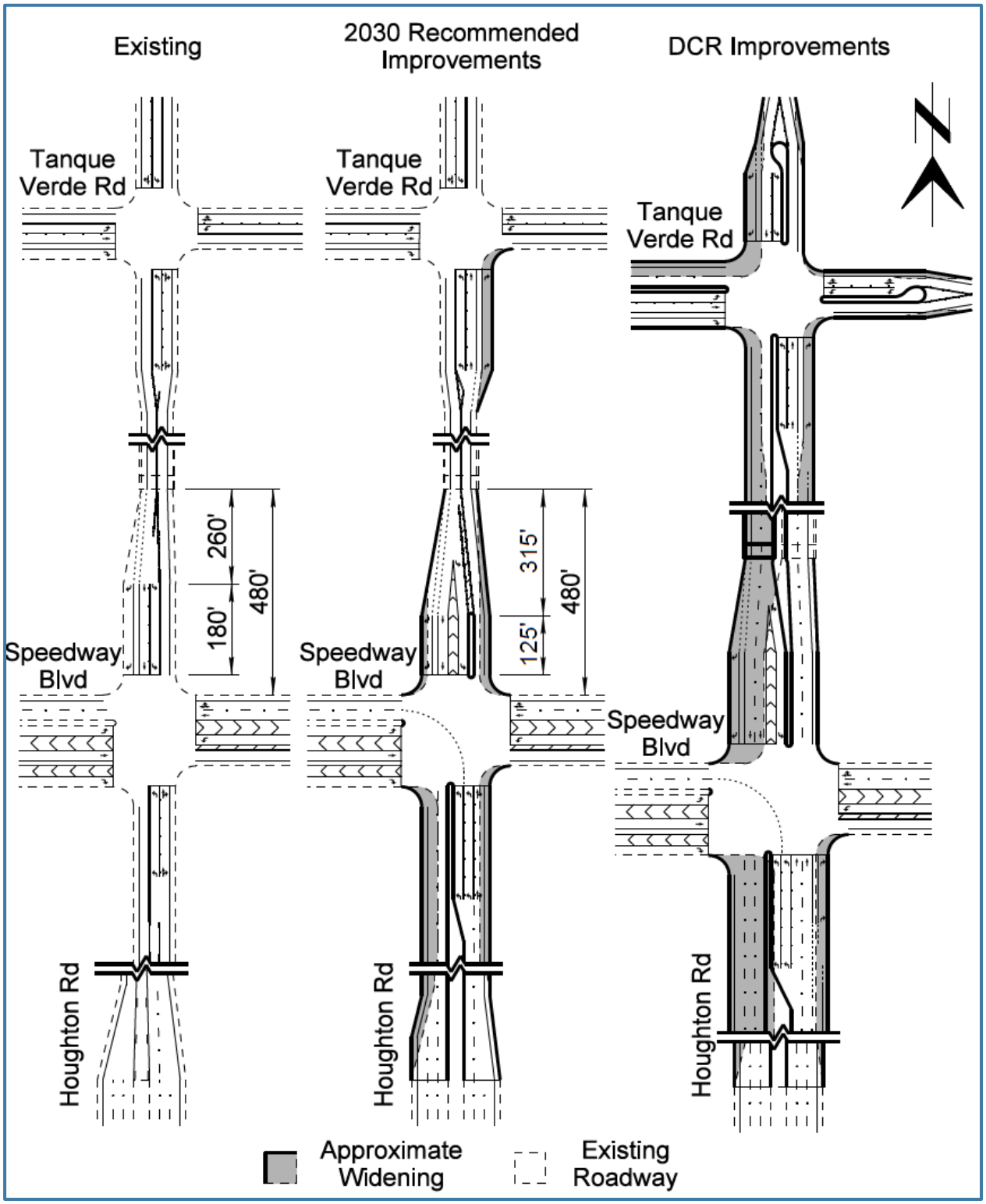


Figure 11 – Existing and Recommended Lane Configurations

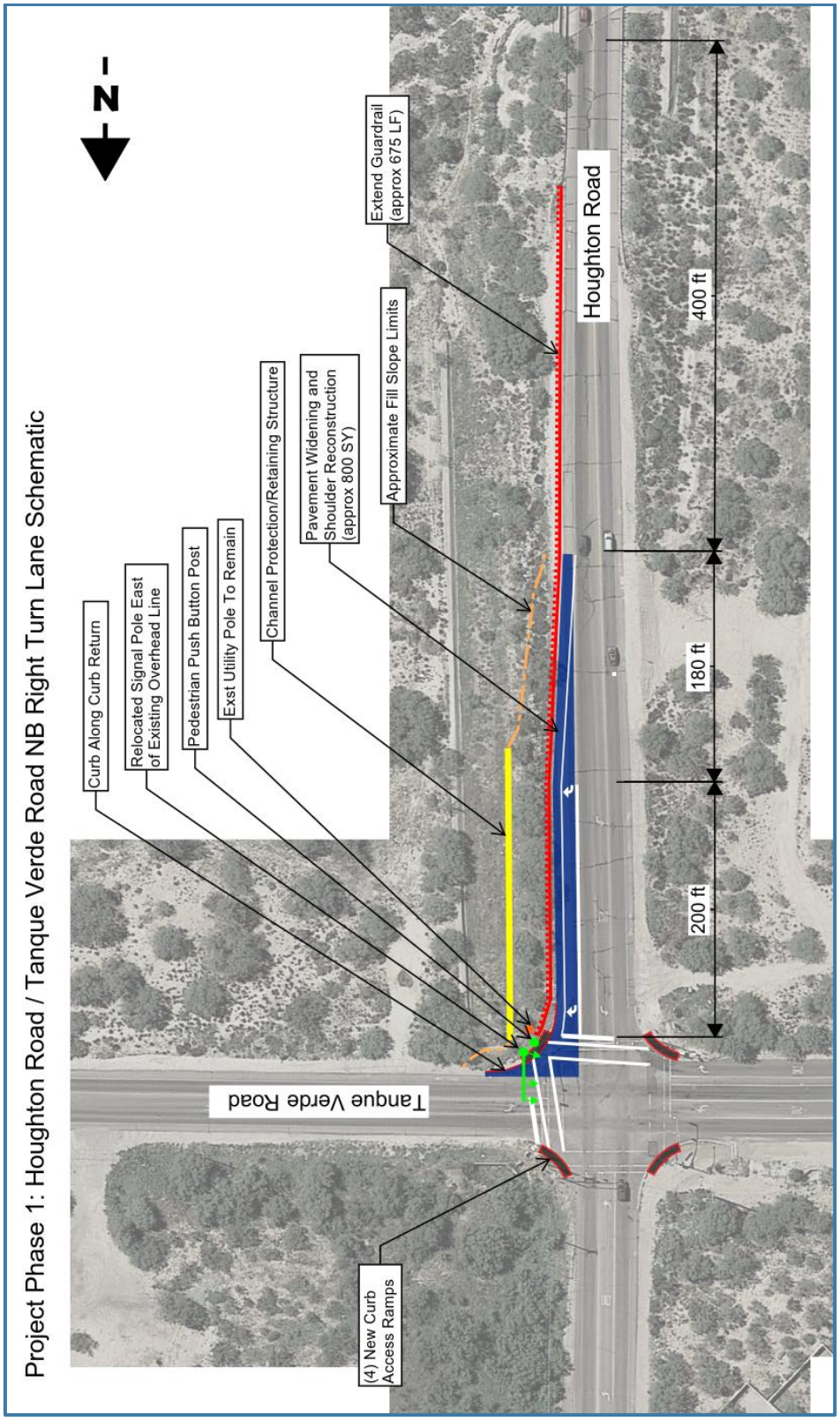


Figure 12 – NB Right Turn Lane at Tanque Verde Road

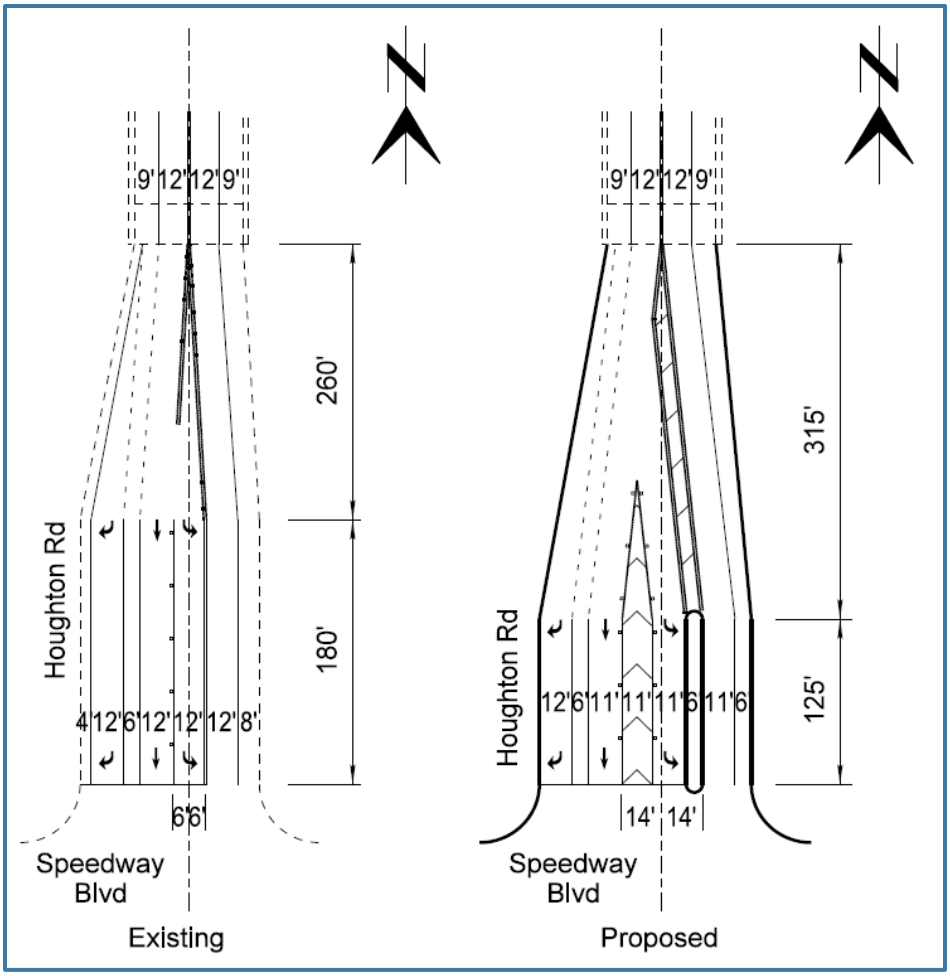


Figure 13 – North Houghton Road/Speedway Boulevard Approach

5.2 PROPOSED ROADWAY CONFIGURATIONS

The existing typical section between Tanque Verde Road and the Tanque Verde Wash bridge will remain unchanged aside from the added NB right turn lane at Houghton Road and Tanque Verde Road. With the Houghton Road/Tanque Verde Road intersection operating at an acceptable LOS with the updated 2030 traffic projections and the segment of Houghton Road between Speedway Boulevard and Tanque Verde Road maintaining its LOS, there is not supporting analysis to justify adding lanes to this segment of Houghton Road.

South of Speedway Boulevard, the proposed improvements to the Houghton Road/Speedway Boulevard intersection require widening to the south towards Broadway Boulevard. To avoid leaving an unimproved segment of Houghton Road between Speedway Boulevard and Broadway Boulevard, an additional lane in each direction is recommended on this segment in order to provide continuous improvements. The proposed typical section features two through lanes in each direction, separated by a curbed median. These improvements are expected to improve

roadway safety. The proposed widening would extend approximately ¾ mile to the existing six-lane section starting north of Broadway Boulevard.

The existing ROW should be sufficient for the proposed improvements across the entire study area except for approximately 600 feet of the east side of Houghton Road extending from Speedway Boulevard to the south. Here, the existing east ROW line is only 40 feet from the section line. Extending the ROW to the proposed limits in the DCR will provide adequate space for the proposed improvements.

Typical Section

The proposed widened typical section between the recently constructed six-lane section of Houghton Road north of Broadway Boulevard, at Vicksburg Street, and Speedway Boulevard is shown in Figure 14. No changes to the typical section north of Speedway Boulevard are proposed. Two 11-foot travel lanes are recommended in each direction, separated by a 20-foot curbed median. Each direction features a 6-foot striped multi-use lane primarily for bicycle use. A 6-foot sidewalk would be constructed along the both sides of the roadway.

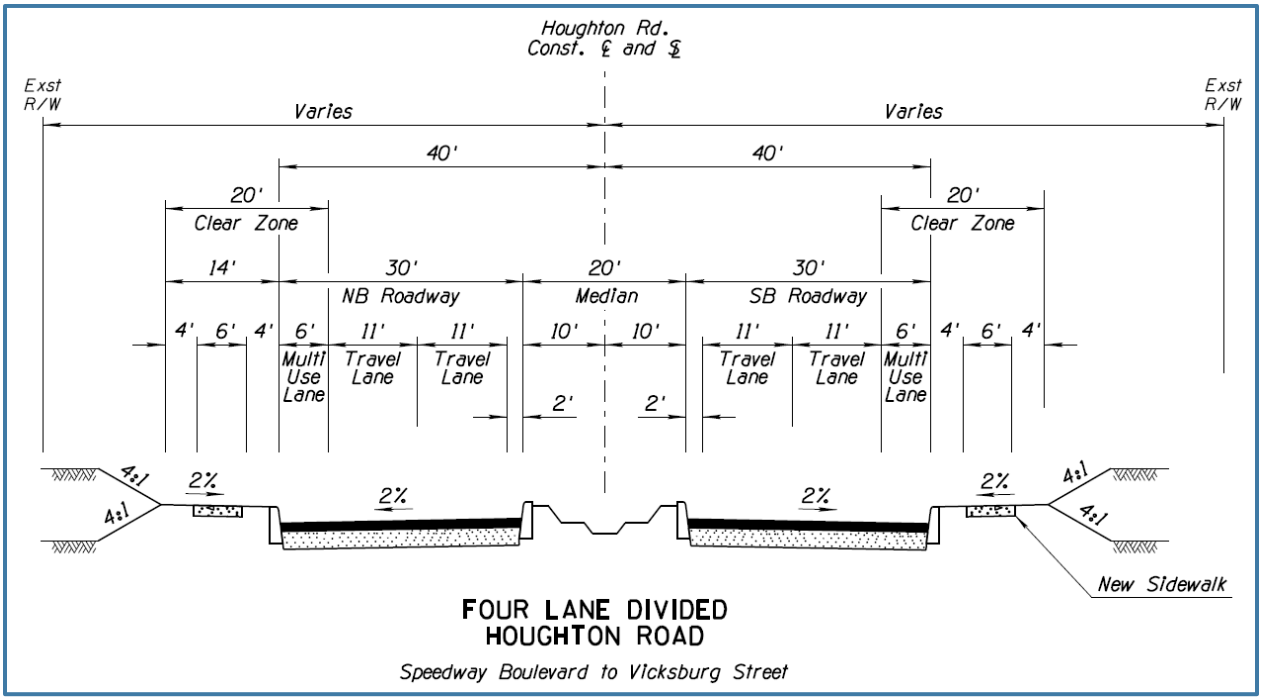


Figure 14 – Proposed Typical Section

Median Openings

Per the City of Tucson Access Management Guidelines, spacing of median openings should ideally be limited to locations of existing or potential future signalization. Typical signal spacing in Tucson is ½ mile. Based on this guideline, median openings should be provided at Speedway

Boulevard, 5th Street, and Broadway Boulevard. Minimum spacing for median openings along roadways with a 45 mph speed limit is 670 feet.

The north end of the existing six lane section features a NB left turn lane, which falls at the ¼ mile location between Broadway and Speedway Boulevard. A median opening is proposed here to allow U-turn access for NB and SB traffic, which would serve multiple driveways between Broadway and 5th Street, in addition to NB traffic heading to Vicksburg Street, which does not have a median opening. Only one residential driveway is located at this location, and a directional median opening only permitting turns from Houghton Road could be considered. This would limit potential for vehicle conflicts if future development occurs at this location.

An additional full median opening is recommended at Packard Street/Whispering Rabbit Place. This opening would serve neighborhood traffic and reduce NB U-turn volumes at Speedway Boulevard. Figure 15 shows the location of the three proposed median opening locations between Broadway Boulevard and Speedway Boulevard.

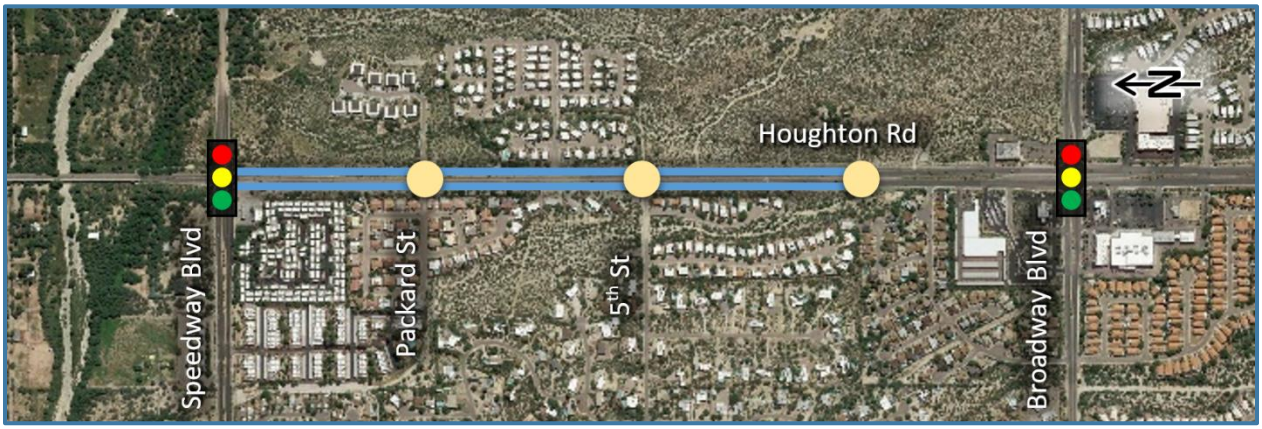


Figure 15 – Proposed Median Openings

5.3 PROPOSED CAPACITY ANALYSIS - 2030

The capacity of the proposed improvements was analyzed for the 2030 design year using the traffic projections described in Section 4.

Intersections

Modeled delay and LOS for the two major intersections are shown in Table 11 and Table 12. As with the existing traffic conditions, RTOR volumes were estimated for the SB and EB right movements at the Houghton Road/Speedway Boulevard intersection. The addition of the NB right turn lane at Houghton Road/Tanque Verde Road has negligible impact on the overall intersection performance, with a small reduction in NB through and right delay.

The proposed improvements result in a significant performance gains at the Houghton Road/Speedway Boulevard intersection, with intersection performance improving from LOS E to

LOS D in the AM peak, and delay reduction of over 25 seconds. The individual movements perform better as well, with only one LOS E in the morning peak (EB left). The PM peak performs similarly overall to the no build scenario.

Overall, the proposed improvements are expected to result in satisfactory intersection performance for the 2030 design year.

Table 11 – Houghton Road & Tanque Verde Road 2030 Proposed Improvements LOS

	SB ↓			WB ←			NB ↑				EB →				INT
	L	T/R	APR	L	T/R	APR	L	T	R	APR	L	T	R	APR	TOT
AM Delay	21.8	25.0	24.8	44.9	69.7	61.9	54.0	16.3	13.2	23.7	43.0	48.6	34.5	43.5	**37.3**
AM LOS	C	C	C	D	E	E	D	B	B	C	D	D	C	D	**D**
PM Delay	16.3	18.7	18.6	36.1	44.2	41.9	34.2	13.5	11.9	18.6	34.3	40.7	28.5	35.9	**28.0**
PM LOS	B	B	B	D	D	D	C	B	B	B	C	D	C	D	**C**

L = Left lane group T = Through lane group R = Right lane group T/R = Shared through/right lane group
APR = Approach Delay units: seconds/vehicle

Table 12 – Houghton Road & Speedway Boulevard 2030 Proposed Improvements LOS

	SB ↓				WB ←				NB ↑			EB →				INT
	L	T	R	APR	L	T	R	APR	L	T/R	APR	L	T	R	APR	TOT
AM Delay	36.5	39.0	28.4	35.4	32.4	46.2	46.9	45.0	44.1	40.9	42.6	63.8	42.8	41.8	52.3	**43.0**
AM LOS	D	D	C	D	C	D	D	D	D	D	D	E	D	D	D	**D**
PM Delay	24.4	42.0	22.7	36.2	35.7	36.4	36.7	36.4	25.9	45.9	36.8	38.3	35.4	33.5	35.8	**36.3**
PM LOS	C	D	C	D	D	D	D	D	C	D	D	D	D	C	D	**D**

L = Left lane group T = Through lane group R = Right lane group T/R = Shared through/right lane group
APR = Approach Delay units: seconds/vehicle

Roadway

Peak hour roadway segment LOS and performance measures for the 2030 design year with proposed improvements are shown in Table 13. Roadway segment LOS between Speedway Boulevard and Tanque Verde Road was analyzed using HCM methodology for two-lane

highways. Since there are no changes to the roadway section between Tanque Verde Road and Speedway Boulevard, the LOS remains the same as the existing 2030 analysis.

Table 13 – Roadway Segment 2030 Proposed Improvements LOS

	NB Broadway Blvd to Speedway Blvd			Speedway Blvd to Tanque Verde Rd		
	LOS	ATS	pc/mi/ln	LOS	ATS	PTSF
AM	B	42.1	14.6	E	29.3	84.3%
PM	A	42.1	10.5	E	31.5	78.1%

The segment between Broadway Boulevard and Speedway Boulevard was analyzed using HCM methodology for multilane highways due to the additional lanes, using density (passenger cars per mile per lane, pc/mi/ln) as a performance measure. LOS is expected to improve to LOS B in the AM peak and LOS A in the PM peak. HCM reports are included in Appendix C.

Lifespan of Proposed Improvements

The performance of the proposed improvements was analyzed beyond the 2030 design year to evaluate their useful lifespan. Table 14 summarizes the AM and PM peak intersection delay, LOS, and number of movements experiencing LOS E or F for 2030, 2035, 2040, and 2045. Note that the 2035-2045 analysis added permitted plus protected phasing for the NB left at Houghton Road/Tanque Verde Road.

Based on the results summarized below, the proposed improvements are expected to perform generally satisfactorily through 2035, with only the AM peak at Houghton Road/Tanque Verde Road experiencing an intersection LOS E. By 2040, the number of movements experiencing LOS F increases substantially, resulting in poor overall performance. By 2045, both intersections operate at LOS F in the AM peak. Therefore, the useful lifespan of the proposed improvements is expected to last until 2035-2040.

Addition of right turn lanes on the WB and SB approaches at the Houghton Road/Tanque Verde Road intersection would provide improved performance beyond the 2030 design year, providing shorter through movement queues. A second NB left turn lane and widening of the WB departure would also likely provide significant improvement.

Options for further improvement at the Houghton Road/Speedway Boulevard intersection are constrained by the Tanque Verde Wash bridge and existing large utility pole on the southeast corner of the intersection. Restriping of the bridge to fit two 11’ NB lanes, resulting in 4’-6” shoulders with an 11’ SB lane, could open options for second NB through and EB left turn lanes, which would offer some intersection performance improvement.

	Table 14 – 2030 to 2045 Performance of Proposed Improvements							
	Houghton Rd & Tanque Verde Rd				Houghton Rd & Speedway Blvd			
	2030	**2035**	**2040**	**2045**	**2030**	**2035**	**2040**	**2045**
AM Delay	37.3	61.7	70.9	87.8	43.9	54.1	67.2	84.7
AM LOS	D	E	E	F	D	D	E	F
AM # of Movements LOS E	2	5	1	1	1	4	1	2
AM # of Movements LOS F	0	1	6	6	0	1	4	7
PM Delay	28.0	41.5	50.5	61.8	42.8	49.5	64.2	76.5
PM LOS	C	D	D	E	D	D	E	E
PM # of Movements LOS E	0	0	3	2	0	0	0	1
PM # of Movements LOS F	0	0	1	3	1	1	3	2
Delay units: seconds/vehicle								

6 POTENTIAL IMPACTS

The potential utility, environmental, bridge, and ROW impacts of the proposed recommendations are described in the following sections. Due to the reduced footprint of the recommended improvements, there are fewer anticipated impacts than identified in the DCR.

6.1 EXISTING UTILITIES

The utility impact analysis was based on utility mapping conducted for the DCR. Additional mapping was not conducted for this study, and it is expected some relocations have occurred at the Tanque Verde Road and Speedway Boulevard intersections. Where the original base mapping identified Qwest telephone facilities, those facilities are now presumed to be under CenturyLink ownership and referred to as such. Utility relocation plans were reviewed for the southern segment of the study area that was impacted by the Houghton Road/ Broadway Boulevard intersection widening. Most anticipated utility impacts are located from Speedway Boulevard to the south end of the study area.

Fiber Optic – Cox Communications

The existing Cox Communications fiber optic television line that is on the east side of Houghton Road from Tanque Verde Road to south of Speedway Boulevard is not expected to be impacted. The line does pass through the southeast corner of the Houghton Road/Speedway Boulevard intersection where it should remain outside of any notable construction work.

Natural Gas – Southwest Gas

All gas line crossings along Houghton Road should be analyzed for any horizontal and vertical conflicts. These conflicts should be researched during the design phase of Houghton Road. A discussion of potential impacts in areas where there are Southwest Gas lines follows:

Tanque Verde Road: The 4” and an 8” high pressure steel gas lines north of Tanque Verde Road are outside of any impacts from the NB right turn lane addition.

Speedway Boulevard: The 8” steel and 2” PE gas line crossing Speedway Boulevard on the east side of Houghton Road will be outside the limits of work for the project and not impacted by construction. The 8” steel and a 4” PE gas lines that cross Houghton Road from the west just south of the intersection could be in conflict with potential storm drain.

Between Speedway Boulevard and 5th Street: No relocations are anticipated in this vicinity with the existing lines on the east side of Houghton Road being outside the expected slope limits.

Electric – Tucson Electric Power (TEP)

Power poles outside the existing ROW are assumed to have prior rights and are subject to reimbursement by the City for relocation and those within are assumed to not have prior rights and their relocation costs are to be covered by TEP. Final prior rights determination will need to be done during design.

Tanque Verde Road: An additional pole with lines to the northeast corner pole was added to the southeast corner of the intersection since the DCR utility mapping. This pole is outside of pavement area for the NB right turn lane, but could be impacted by the roadway slope.

Between Tanque Verde Road and Speedway Boulevard: Overhead power lines south of W. Drachman Street will likely be impacted by the construction of the new bridge over the Tanque Verde Creek. Lines over Houghton Road will need to be reviewed during final design. Overhead power lines along the west side of Houghton Road to Speedway Boulevard will be impacted by the embankment for the north Houghton Road approach to Speedway Boulevard.

Speedway Boulevard: The overhead power line along the west side of Houghton Road north of Speedway Boulevard could be impacted by embankment for the north approach widening. The tall, metal, transmission pole located on the southeast corner of the intersection will be near widening work on the south approach. Relocation costs would likely need to be paid for by the City; therefore, it is recommended that the pole be left in place with the roadway alignment designed to stay to the west of it.

Between Speedway Boulevard and 5th Street: Assuming the final alignment of Houghton Road largely follows the DCR alignment, many of the overhead power lines on the east side of Houghton Road from Speedway Boulevard southward past 5th Street will need to be relocated due to the widening. The narrower typical section from the DCR may allow a few of the poles to remain in place. Some of the poles requiring relocation likely have prior rights.

Water – Tucson Water

Since the design profile does not change dramatically, only incidental modifications or temporary shut-offs to the existing mains at drainage structures are anticipated. Coordination will need to be made with Tucson Water concerning the installation of drainage cross-structures at these water main crossings.

At Speedway Boulevard, the intersection widening that will occur as part of this project will likely not impact the 24” concrete cylinder (CC) line and 12”/16” (DI) reclaimed water (RW) line that run to the east on Speedway Boulevard, crossing Houghton Road. From Speedway Boulevard southward, however, the 12” (ACP) that continues along the west side of Houghton Road to 5th Street would likely be impacted by onsite drainage. South of 5th Street to the project limit, no existing waterlines were found.

Telephone - CenturyLink

Tanque Verde Road: Just south of the intersection, on the east side, underground telephone lines likely will not be impacting by widening for the turn lane, although traffic signal equipment will

need to placed so that it avoids the lines. There are several lines in this vicinity, but none were identified as fiber optic.

Speedway Boulevard: CenturyLink facilities at the intersection will likely not be affected by construction.

South of Speedway Boulevard: Impacts will likely be limited to relocation of a pedestal and lines on the east side of Houghton Road, adjacent to Whispering Rabbit Place. From here south to Windstorm Drive, lines along the east side of Houghton Road may be impacted by the widening with the lines running to several overhead power poles that will need to be moved due to the widening.

Sanitary Sewer – Pima County Regional Wastewater Reclamation Department

South of Speedway Boulevard at Packard Street, the lateral has manholes in the existing Houghton Road pavement that will likely need to be rebuilt and there is potential for conflict with storm drain pipes. As with the water main facilities, conflicts with the underground sewer lines will need to be examined more closely and designs modified to minimize the extent of their relocation.

Cable – Cox Communication

Between Tanque Verde Road and Speedway Boulevard, Cox lines are east of Houghton Road and outside the limits of the improvements. These lines cross Speedway Boulevard, east of Houghton Road and are not anticipated to be impacted here. South of Speedway Boulevard, these lines shift to the west and run to an overhead power pole that is approximately 300 feet south of the intersection. This pole will likely need to be relocated along with all utility lines that connect to it.

Traffic Signals – City of Tucson

Reconstruction of the signal pole and equipment at the southeast corner of the Tanque Verde Road intersection will be necessary due to the NB right turn lane widening. Reconstruction of the Speedway Boulevard intersection traffic signals will also likely be necessary due to the proposed widening. This will also provide the opportunity to replace the existing span wire signals with signal poles.

6.2 ENVIRONMENTAL STUDY UPDATES

This section provides a summary of environmental resource recommendations from the DCR, with adjustments based on the updated proposed improvements.

Vegetation

The City of Tucson Native Plant Preservation Ordinance restricts the removal of the native plant species that are on the City's list of protected native plants. As part of any potential improvements, protected native plants should be assessed, inventoried, salvaged if appropriate, and replanted in the project area.

Wildlife

The existing structures at Agua Caliente Wash and Tanque Verde Creek (both multi-span bridges) provide highly critical wildlife linkages and function as primary movement corridors between large blocks of undeveloped lands. The proposed improvements will not affect the structures, allowing them to continue to function as wildlife linkages.

Special Status Species

A native plant inventory should be conducted prior to any construction activities to locate any Tumamoc Globeberry that may be within the project area. However, the scale of improvements is not expected to cause any negative impact to the species.

A list of current candidate and listed species under the Endangered Species Act should be consulted to determine if any new species have been included since the DCR. Any new species should be evaluated to determine if they may be present within the project area. A site survey is recommended to determine if the Western Yellow-billed Cuckoo and any additional listed species are present in the project area. If any are found, the City should consult with the US Fish and Wildlife Service.

Critical Habitat

The project area does not contain any critical habitat and no special action is needed.

Cultural Resources

It is recommended that an archaeological testing plan be developed and implemented at the portions of the two previously recorded prehistoric sites likely to be affected by the proposed improvements.

For areas outside the recorded boundaries of the Tanque Verde Wash site and the Houghton Road site, it is recommended that construction be allowed to proceed with no further need for archaeological work. Additional surveys for cultural resources will be required if the ROW is extended beyond the study corridor. In addition, all work shall cease immediately when incidentally encountering cultural deposits more than 50-years old. The Director of the Arizona State Museum and the Pima County Archaeological and Historic Preservation Office shall be notified so a consultation process can begin and a course of treatment decided upon.

Air Quality

Regional air quality is discussed in the 2045 Regional Mobility and Accessibility Plan. The Tucson region is near the limit of EPA ozone standards. Prior to 2000, the Tucson region was designated in non-attainment with the carbon monoxide (CO) health standard, however, CO levels have since declined and are no longer considered a regional health concern. This project is expected to result in lower air pollutant levels due to reduced congestion.

Noise

Noise is often considered 'unwanted sound' originating from acoustic energy. Many of the noise decibels entering a subdivision comes from highway traffic. Previously, installing an asphalt rubber asphaltic concrete (ARAC) layer was a Transportation noise abatement measure. This measure was discussed in the DCR and recommended for Houghton Road. Current Transportation practice, however, is to use a terminal blend asphalt surface layer instead of ARAC. During design of the proposed recommendations, alternative noise abatement measures should be considered to reduce noise during construction and following completion.

In accordance with ADOT guidelines, a high-cost noise-abatement barrier is not warranted.

Hazardous Materials

An adjacent possible hazardous materials site was identified in the DCR at 10290 East Speedway Boulevard. ROW acquisition of this parcel is not anticipated. Any ROW acquisitions for the project will likely need a Phase I Environmental Assessment Study to determine if any mitigation measures are necessary.

Aesthetic Resources

The Houghton Road corridor is subject to landscape standards and development regulations specified in the City of Tucson Land Use Code as outlined in Article III, Division 7 Landscaping and Screening Regulations and Division 8 Native Plant Preservation. As a designated scenic route in the City of Tucson Major Streets and Routes Plan (MS&R), any potential improvements should also preserve prominent viewsheds and the natural quality of the area. Landscaping should be kept as natural as possible, to enhance natural beauty instead of replacing it with a sense of imposed design. Some methods for achieving these goals include:

- Using a palette of plants native to the immediate area of the project, including salvaged specimens of differing sizes and ages and supplemental nursery plants including cacti and succulents.
- Planting larger plants and trees with sensitivity to the location of utilities, traffic sight lines and adjacent properties to reduce future maintenance and impacts.
- Grouping plantings in an irregular way that mimics natural patterns rather than utilizing formal geometries or forms.

- Designing structural elements such as walls and channels using natural materials whenever possible or earth colored materials when man-made materials are required.
- Following best practices for plant placement and relationships within the overall context to best utilize micro-climates, exposures and clustering for the purpose of adequate irrigation.
- Wherever possible, plants should be located to make maximum use of harvest rainwater from stormwater runoff.

Neighborhood Impact

Connectivity between neighborhoods will be improved with extension of the existing sidewalk north to Speedway Boulevard. Currently, there are no continuous pedestrian facilities through the project limits.

Community Resources

Impacts to nearby community resources, including schools, churches, and fire stations, is not expected beyond normal construction activities. Construction activities should be planned so as not to impede access through the corridor, with two-way traffic maintained as much as possible and closures kept to a minimum. This is especially important given the potential for flooding to restrict access across Tanque Verde Creek to the east. Emergency access should be preserved at all times.

Recommendations for Further Study

No further study is anticipated beyond that mentioned above, including the native plant inventory, review of the endangered species list, and archaeological testing plan. However, if any potential impacts beyond those described above are discovered, they should be documented and appropriate efforts undertaken to mitigate them.

Environmental Documentation

The environmental studies for the segment of Houghton Road between Tanque Verde Road and Speedway Boulevard was undertaken by the City of Tucson in 2010 as part of the DCR. The City currently follows the environmental clearance process outlined in the COT Procedures Manual. The process is same for both federal and non-federally funded projects regarding the studies that are involved. These studies are usually summarized in a scoping document that can either be a Scoping Letter, Project Assessment (PA), or Environmental Assessment (EA). For larger projects with impacts, an Environmental Impact Statement (EIS) will need to be prepared. The segment of Houghton Road between Tanque Verde Road and Speedway Boulevard likely will need either a Scoping Letter or PA. Given that federal funds are not likely to be used, there will not be Arizona Department of Transportation (ADOT) involvement and the scoping document that summaries the environmental studies likely will not need to be prepared.

The studies that will need to be updated relate to the Arizona Antiquities Act (cultural resource evaluation), Endangered Species Act (biological evaluation), and Section 404 of the Clean Water Act (preliminary jurisdictional delineation). A work effort will need to be done to review/update the documents that were prepared at the time of the DCR and the updated reports filed with the City.

6.3 STRUCTURES

The existing bridges over Agua Caliente Wash and Tanque Verde Creek are adequate for the proposed improvements. The DCR recommended replacing the east side barrier to provide a wider pedestrian way, however, the proposed improvements do not include a sidewalk north of Speedway Boulevard. Therefore, the existing railing should be sufficient. No other improvements to existing bridges are necessary.

Based on the bridge condition assessments, several repair items should be considered. For the Tanque Verde Wash bridge, these include:

1. Fix damage to joint at north end of bridge, this should be done to prevent damage to the substructure due to corrosion.
2. Replace joint seal at Pier 6, this should be done to prevent damage to the substructure due to corrosion
3. Tree growth noted both sides of bridge; this should be trimmed during the next maintenance.
4. Spalls noted on several piers; this is not a critical repair but should be considered.
5. The deck has moderate to high hairline cracks. Consider deck sealing to prevent corrosion of deck reinforcement. This is a higher priority if the bridge is subject to deicing salts in winter.

For the Agua Caliente Wash bridge, the deck has light density hairline cracks top and bottom with efflorescence. Consider deck sealing to prevent corrosion of deck reinforcement. This is a higher priority if the bridge is subject to deicing salts in winter.

No changes to existing or new drainage structures are anticipated north of Speedway Boulevard. The existing inlet at the southwest corner of the Speedway Boulevard intersection may be impacted. A storm drain system is recommended south of Speedway Boulevard, which would replace the existing open concrete lined channels.

6.4 RIGHT OF WAY

North of Speedway Boulevard, no additional ROW is needed. South of Speedway Boulevard for approximately 600 feet, additional ROW will likely be necessary on the east side where the existing ROW extends only 40 feet east of the section line. Here, there is an existing easement

along the east side of the road that will need to be acquired. South of this area, the existing ROW is 175-200 feet wide, which is sufficient for the proposed improvements. The slope easements in the DCR will likely not be necessary due to the narrower typical section. Several temporary construction easements may be necessary for new driveway construction.

7 COST ESTIMATES

The DCR estimated cost for the project is shown in Table 15. The estimate was based off the preliminary design plans included as part of the DCR. The total estimated project cost was $21.4 million, including construction, right of way, and design fees.

The Federal Highway Administration's (FHWA) National Highway Construction Cost Index (NHCCI) was used to determine the DCR estimated cost in today's dollars. The NHCCI index 30% between June 2009 and December 2018 (the latest available NHCCI at the time of this study), from 1.4398 to 1.8727. The 2018 adjusted DCR cost is $27,842,000.

Table 15 – DCR Cost Estimate (2009 Dollars)

Item	Cost
Roadway Construction	$5,271,000
Drainage	$2,495,000
Utility Relocations and Modifications	$198,000
Signing	$38,000
Striping	$38,000
Traffic Signals	$580,000
Landscaping	$294,000
Subtotal Roadway Construction Cost	**$8,914,000**
Bridge (Agua Caliente Wash)	$1,690,000
Bridge (Tanque Verde Creek)	$5,246,000
Subtotal Bridge Construction Cost	**$6,936,000**
NPDES (Original)	$158,000
NPDES (Modifications)	$79,000
Mobilization (Est. 10%)	$892,000
Maintenance and Protection of Traffic (Est. 9%)	$803,000
Construction Survey and Layout (1%)	$90,000
Contingencies (20%)	$1,783,000
Miscellaneous Construction Subtotal	**$3,805,000**
Construction Subtotal	**$19,655,000**
Design Fee (6%)	$1,180,000
Right-of-Way (Est. $150,000 / AC)	$528,000
Easements (Est. $40,000 / AC) (not incl. TCE's)	$43,000
Total Project Cost (Rounded)	**$21,406,000**

7.1 PROPOSED RECOMMENDATIONS

Since this study does not include preliminary design plans as did the DCR, the cost estimate was developed using the DCR and similar projects on Houghton Road. The pavement area of the proposed improvements was estimated, and the cost estimated using an inflation-adjusted DCR roadway cost per square foot of pavement area. The drainage estimate was scaled from 70% of the DCR drainage estimate. The bulk of the DCR drainage improvements were located in the segment from Speedway Boulevard to the southern end of the project. The bridge costs cover all the recommended repair items discussed in Section 6.3. The utility relocation, signing, and landscaping costs were based on percentages of other items. The striping estimate was based on comparing striping length to pavement area for the Houghton Road/22nd Street improvement project.

The estimated cost for the proposed improvements is shown in Table 16 and a worksheet is included in Appendix E. The estimated cost is approximately 40% of the inflation-adjusted DCR estimate. The reduction in estimated cost is explained primarily by the elimination of new bridge construction, reduced length of roadway widening, narrower typical section, limited work to the Tanque Verde Road intersection traffic signals, and reduced new ROW needs.

Table 16 – Proposed Recommendations Cost Estimate (2019 Dollars)

Item	Cost
Roadway Construction	$2,949,000
Drainage	$2,271,000
Signing	$37,000
Striping	$61,000
Traffic Signals	$410,000
Landscaping	$208,000
Roadway Construction Subtotal	**$5,936,000**
Fix Damage to Joint at North End (Tanque Verde Wash)	$25,000
Replace Joint Seal at Pier 6 (Tanque Verde Wash)	$25,000
Pier Spall Repairs (Tanque Verde Wash)	$25,000
Deck Sealing (Tanque Verde Wash)	$550,000
Deck Sealing (Agua Caliente Wash)	$150,000
Bridge Repair Subtotal	**$775,000**
Utility Relocations and Modifications (Est. 2.5%)	$149,000
NPDES (Est. 3%)	$179,000
Mobilization (Est. 10%)	$672,000
Maintenance and Protection of Traffic (Est. 9%)	$604,000
Construction Survey and Layout (Est. 1%)	$60,000
Miscellaneous Construction Subtotal	**$1,664,000**
Construction Subtotal	**$8,375,000**
Design Fee (Est. 8%)	$637,000
Right-of-Way (Est. $200,000 / AC)	$206,000
Project Subtotal	**$9,218,000**
Contingency (20%)	$1,844,000
Total Project Cost (Rounded)	**$11,062,000**

7.2 PROJECT PHASING

The proposed recommendations do not all need to be constructed at the same time. Different components may be constructed separately as resources allow. Three main components of the project are recommended to be considered for separate phasing: the NB right turn lane at Tanque

Verde Road (Phase 1), the intersection improvements at Speedway Boulevard and widening to the south (Phase 2), and the bridge repair items (Phase 3). The phases can be constructed in any order.

The NB right turn lane at Tanque Verde Road is separate from the proposed improvements to the south, and naturally lends itself to being considered for a separate phase. The widening and intersection improvements at Speedway Boulevard would function best as a single project phase due to their relatively short length. The bridge repairs could be constructed independent of the two roadway project phases.

The costs per phase were estimated based on the subtotals shown in Table 16. The bulk of the roadway construction items are associated with Phase 2, and thus it has a significantly higher estimated cost. Miscellaneous construction costs, design fees, and contingency were estimated proportionally for each phase based on construction costs. Estimated phase costs are shown in Table 17.

Table 17 – Project Phase Cost Estimate (2019 Dollars)

Phase	Cost
Phase 1: NB Right Turn Lane at Tanque Verde Rd	$628,400
Phase 2: Speedway Blvd to Broadway Blvd Widening	$9,289,600
Phase 3: Bridge Repairs	$1,143,600
Total Project Cost	**$11,061,600**
Total Project Cost (Rounded)	**$11,062,000**

APPENDIX

A PAG TRAFFIC COUNT DATA

Peak Hour Data for Intersection

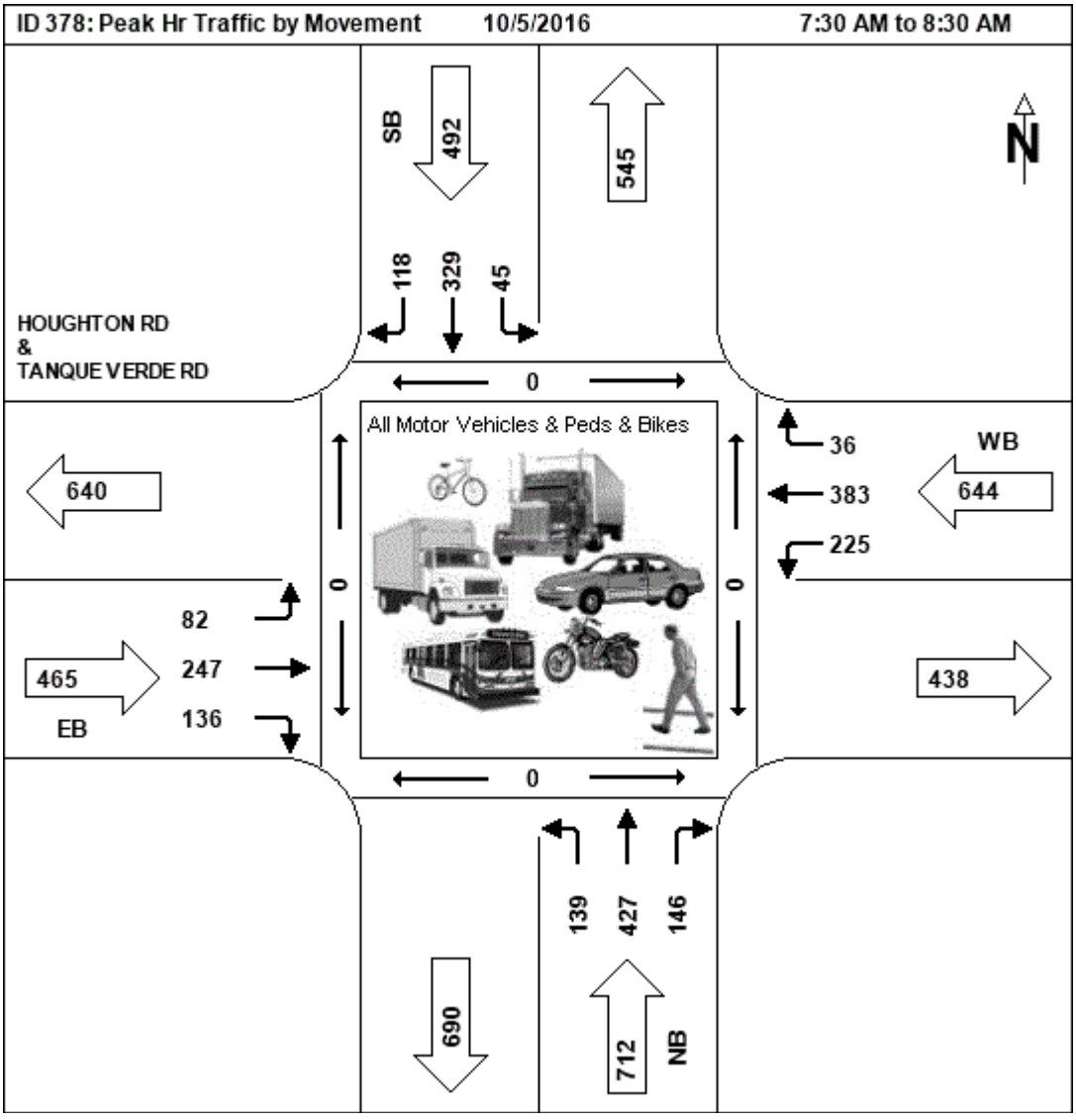
Int ID: 378
Community: -
Road 1: HOUGHTON RD
Road 2: TANQUE VERDE RD
Corridor:
Road 3:
Road 4:

|<< < > >>| 1-3 of 3

AM Peak Hour
10/05/2016

Start Time	NB Left	NB Thru	NB Right	NB Ped	NB App Total	EB Left	EB Thru	EB Right	EB Ped	EB App Total	SB Left	SB Thru	SB Right	SB Ped	SB App Total	WB Left	WB Thru	WB Right	WB Ped	WB App Total	Int Total
7:30 AM	39	130	25	0	194	21	51	30	0	102	12	72	29	0	113	40	68	7	0	115	524
7:45 AM	35	157	41	0	233	32	94	36	0	162	12	87	19	0	118	55	98	12	0	165	678
8:00 AM	31	69	51	0	151	22	54	35	0	111	16	90	41	0	147	62	90	6	0	158	567
8:15 AM	34	71	29	0	134	6	44	35	0	85	5	79	29	0	113	68	126	11	0	205	537
Total	139	427	146	0	712	81	243	136	0	460	45	328	118	0	491	225	382	36	0	643	2306
PHF	0.89	0.68	0.72		0.76	0.63	0.65	0.94		0.71	0.70	0.91	0.72		0.84	0.83	0.76	0.75		0.78	
HV %	0	0	0			0	0	0			0	0	0			0	0	0			

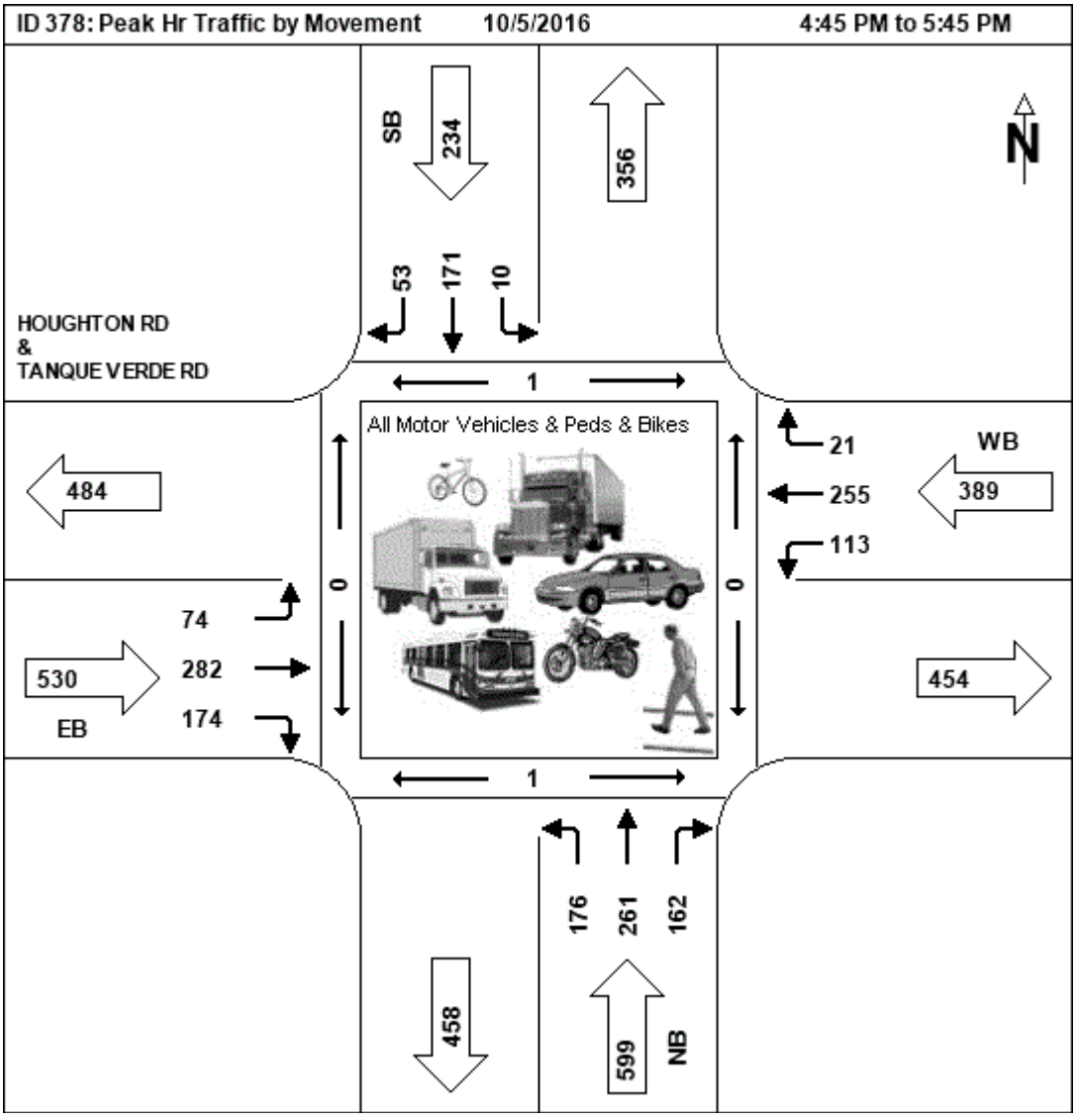
☑ Cars ☑ Trucks ☑ Pedestrians ☑ Bikes



PM Peak Hour
10/05/2016

Start Time	NB Left	NB Thru	NB Right	NB Ped	NB App Total	EB Left	EB Thru	EB Right	EB Ped	EB App Total	SB Left	SB Thru	SB Right	SB Ped	SB App Total	WB Left	WB Thru	WB Right	WB Ped	WB App Total	Int Total
4:45 PM	38	61	39	0	138	12	60	42	0	114	3	62	7	0	72	25	56	5	0	86	410
5:00 PM	37	67	45	0	149	24	80	51	0	155	3	38	13	0	54	30	60	7	1	97	455
5:15 PM	52	67	35	0	154	21	68	42	1	131	1	32	16	0	49	32	68	5	0	105	439
5:30 PM	49	66	43	0	158	17	74	39	0	130	3	39	17	0	59	26	71	4	0	101	448
Total	176	261	162	0	599	74	282	174	1	530	10	171	53	0	234	113	255	21	1	389	1752
PHF	0.85	0.97	0.90		0.95	0.77	0.88	0.85		0.85	0.83	0.69	0.78		0.81	0.88	0.90	0.75		0.93	
HV %	0	0	0			0	0	0			0	0	0			0	0	0			

☑ Cars ☑ Trucks ☑ Pedestrians ☑ Bikes



Peak Hour Data for Intersection

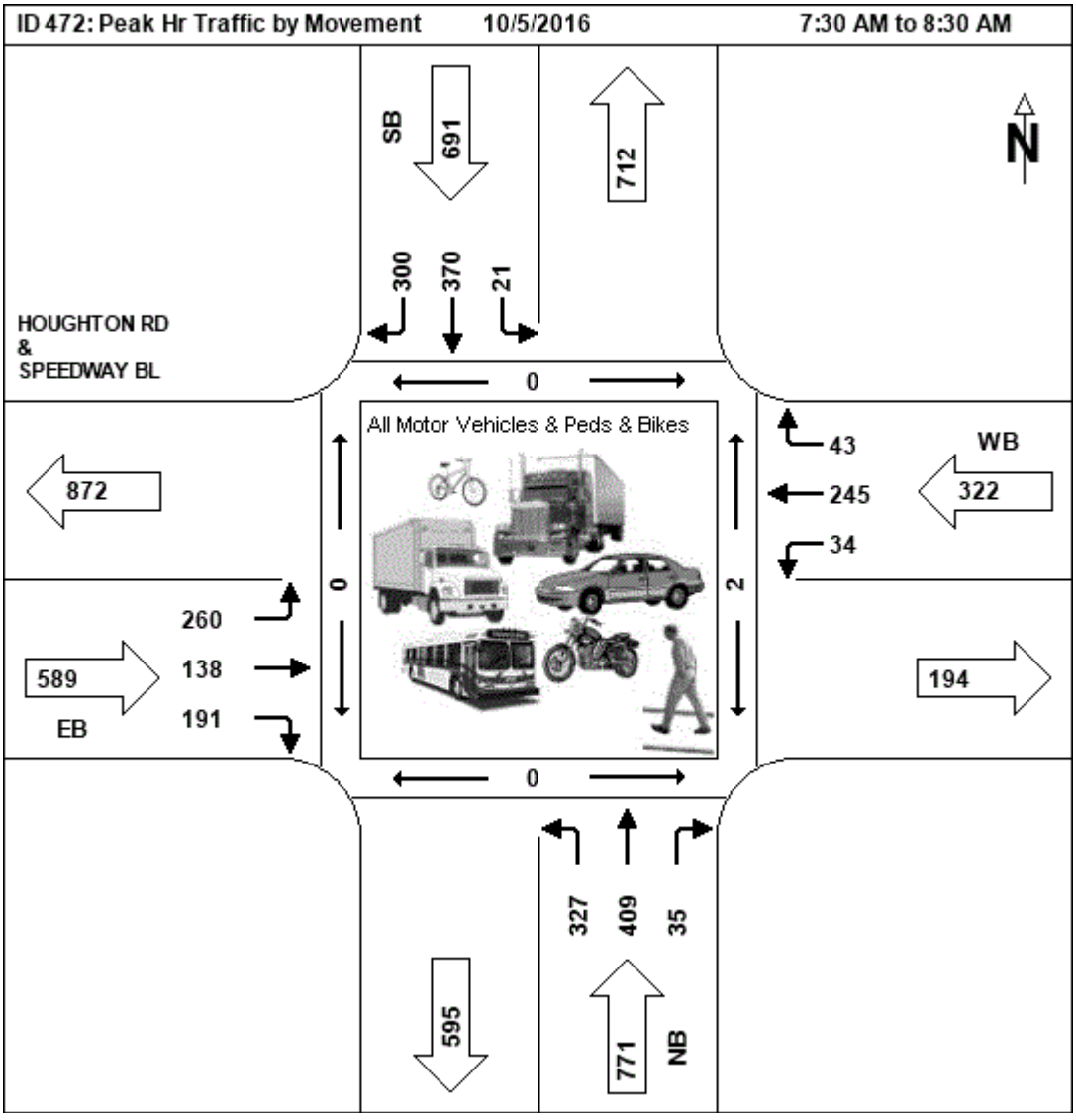
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Community: -
Road 1: HOUGHTON RD
Road 2: SPEEDWAY BL
Corridor:
Road 3:
Road 4:

|<< < > >>| 1-2 of 2

AM Peak Hour
10/05/2016

Start Time	NB Left	NB Thru	NB Right	NB Ped	NB App Total	EB Left	EB Thru	EB Right	EB Ped	EB App Total	SB Left	SB Thru	SB Right	SB Ped	SB App Total	WB Left	WB Thru	WB Right	WB Ped	WB App Total	Int Total
7:30 AM	114	104	3	0	221	62	30	46	0	138	4	77	62	0	143	7	69	12	0	88	590
7:45 AM	97	150	14	1	261	86	37	45	0	168	5	92	71	0	168	7	52	11	0	70	667
8:00 AM	55	79	13	0	147	61	35	45	0	141	6	90	89	0	185	8	75	12	0	95	568
8:15 AM	61	74	5	1	140	51	36	55	0	142	6	111	78	0	195	12	48	8	0	68	545
Total	327	407	35	2	769	260	138	191	0	589	21	370	300	0	691	34	244	43	0	321	2370
PHF	0.72	0.68	0.63		0.74	0.76	0.93	0.87		0.88	0.88	0.83	0.84		0.89	0.71	0.81	0.90		0.84	
HV %	0	0	0			0	0	0			0	0	0			0	0	0			

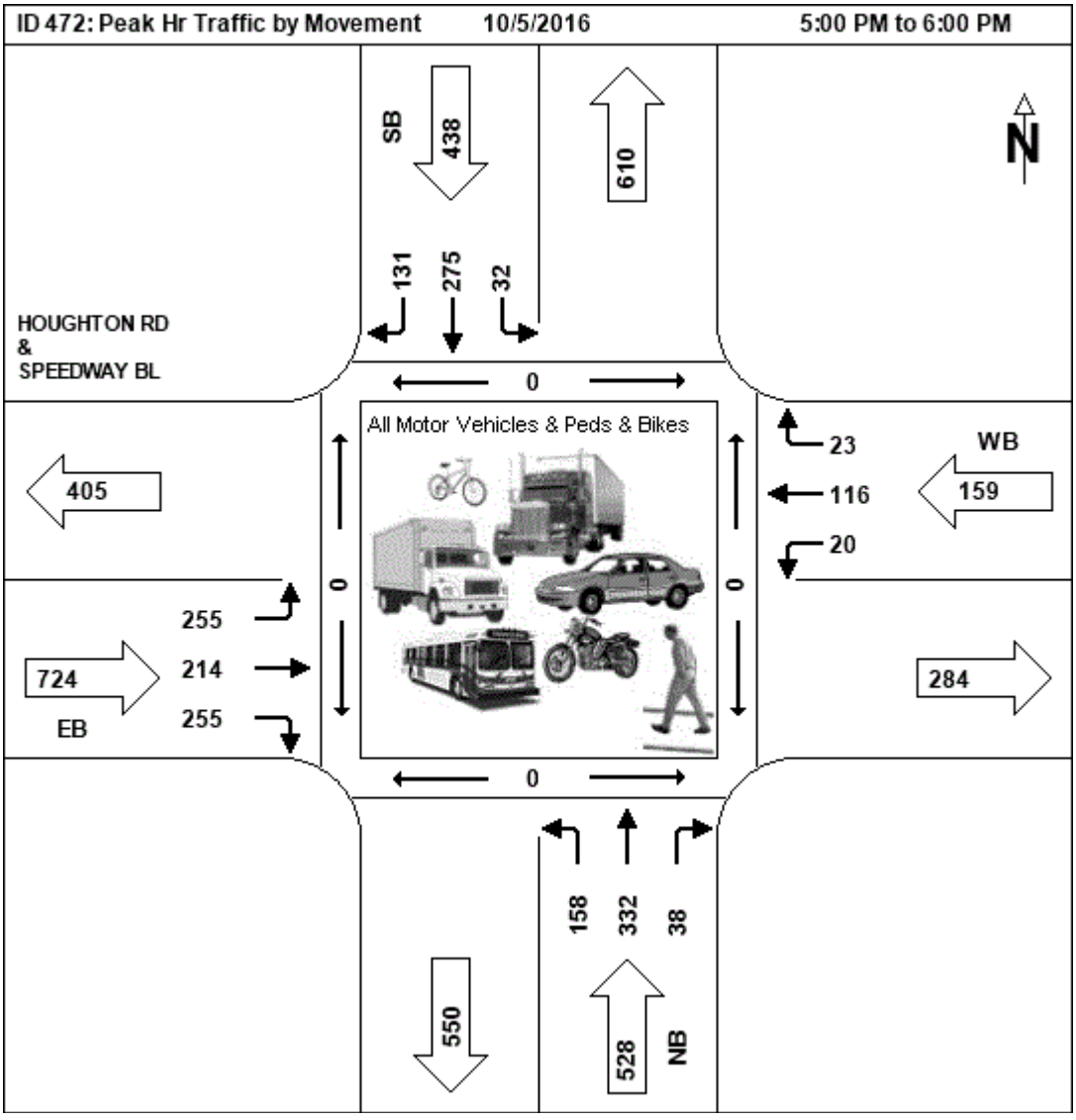
☑ Cars ☑ Trucks ☑ Pedestrians ☑ Bikes



PM Peak Hour
10/05/2016

Start Time	NB Left	NB Thru	NB Right	NB Ped	NB App Total	EB Left	EB Thru	EB Right	EB Ped	EB App Total	SB Left	SB Thru	SB Right	SB Ped	SB App Total	WB Left	WB Thru	WB Right	WB Ped	WB App Total	Int Total
5:00 PM	36	94	8	0	138	61	51	67	0	179	6	85	32	0	123	5	22	3	0	30	470
5:15 PM	40	85	10	0	135	67	52	63	0	182	8	73	33	0	114	5	35	6	0	46	477
5:30 PM	36	79	6	0	121	53	50	68	0	171	11	60	35	0	106	2	26	8	0	36	434
5:45 PM	45	74	13	0	132	74	61	56	0	191	7	57	31	0	95	8	33	6	0	47	465
Total	157	332	37	0	526	255	214	254	0	723	32	275	131	0	438	20	116	23	0	159	1846
PHF	0.87	0.88	0.71		0.95	0.86	0.88	0.93		0.95	0.73	0.81	0.94		0.89	0.63	0.83	0.72		0.85	
HV %	0	0	0			0	0	0			0	0	0			0	0	0			

☑ Cars ☑ Trucks ☑ Pedestrians ☑ Bikes



APPENDIX

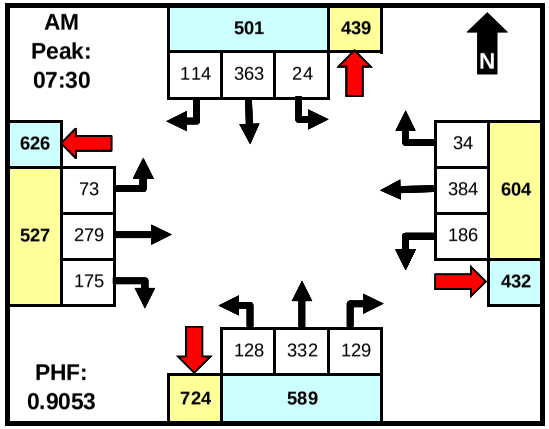
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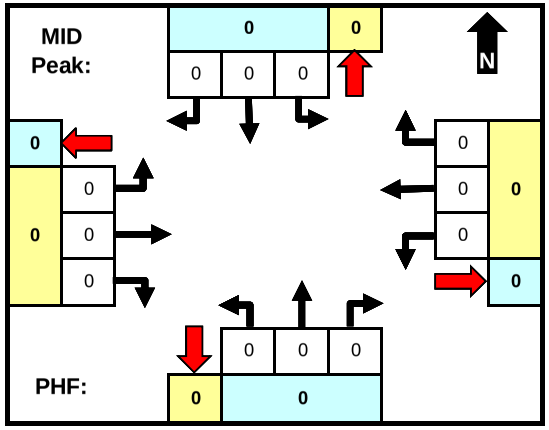
TRAFFIC RESEARCH & ANALYSIS, INC.
Specializing in Traffic Data Collection

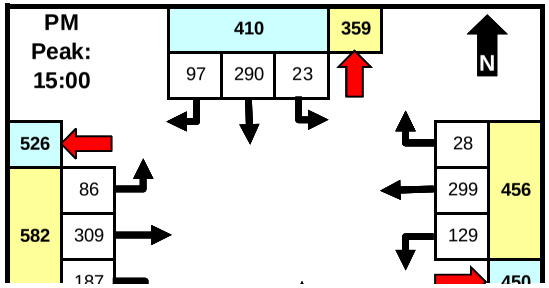
Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901567
Count Date: 5/7/2019

N HOUGHTON RD & E TANQUE VERDE RD







	From North (SB)					From East (WB)					From South (NB)					From West (EB)					INTSEC
	N HOUGHTON RD					E TANQUE VERDE RD					N HOUGHTON RD					E TANQUE VERDE RD					
Time	LT	Thru	RT	U	Cwlk	LT	Thru	RT	U	Cwlk	LT	Thru	RT	U	Cwlk	LT	Thru	RT	U	Cwlk	TOTAL
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0:15																					0
0:30																					0
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07:00	0	53	26	0	0	39	71	4	0	0	36	28	16	0	0	8	27	26	0	0	334
07:15	2	58	17	0	0	32	68	2	0	0	41	37	25	0	0	11	36	34	0	0	363
07:30	5	64	23	0	1	37	84	6	0	0	37	93	28	0	0	13	66	62	0	1	520
07:45	7	91	25	0	0	42	93	12	0	0	25	114	41	0	0	29	100	36	0	0	615
08:00	10	118	33	0	2	61	107	14	0	2	28	73	32	0	0	18	60	47	0	0	605
08:15	2	90	33	0	0	46	100	2	0	0	38	52	28	0	0	13	53	30	0	0	487
08:30	0	60	48	0	0	34	62	3	0	0	35	41	19	0	0	15	40	35	0	0	392
08:45	6	50	18	0	0	26	65	3	0	0	31	38	23	0	0	8	43	42	0	0	353
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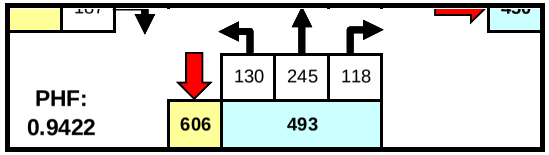
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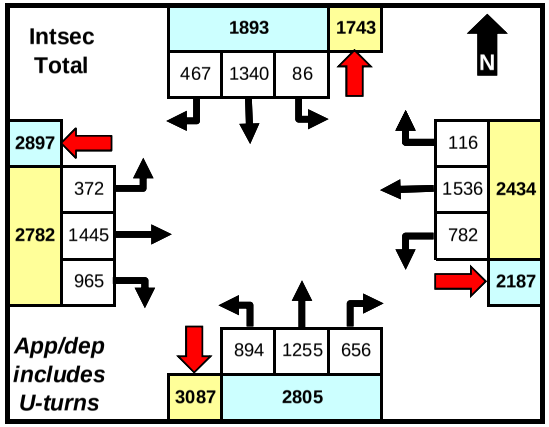
TRAFFIC RESEARCH & ANALYSIS, INC.
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Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901567
Count Date: 5/7/2019

N HOUGHTON RD & E TANQUE VERDE RD





	North		East		South		West		
	App	Dep	App	Dep	App	Dep	App	Dep	Total
AM	501	439	604	432	589	724	527	626	**2221**
MID	0	0	0	0	0	0	0	0	**0**
PM	410	359	456	450	493	606	582	526	**1941**
Total	1893	1743	2434	2187	2805	3087	2782	2897	**9914**

Comments

Unless shown otherwise, MID period defined as 10:00 AM - 2:00 PM. Peaks defined based on total intersection volume for all vehicle types. Chart totals do not include crosswalk data.

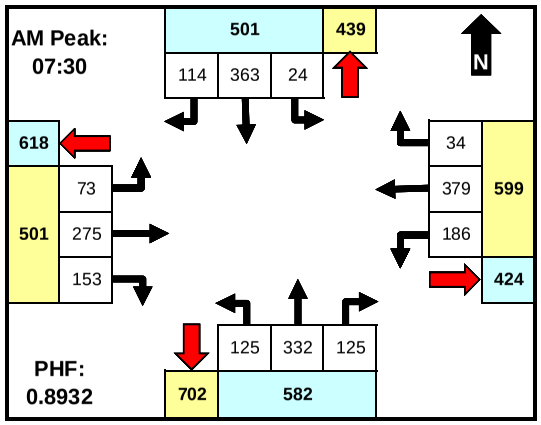
	From North (SB) N HOUGHTON RD					From East (WB) E TANQUE VERDE RD					From South (NB) N HOUGHTON RD					From West (EB) E TANQUE VERDE RD					INTSEC
13:45																					0
14:00																					0
14:15																					0
14:30																					0
14:45																					0
15:00	5	61	22	0	0	31	78	4	0	0	37	66	24	0	0	21	84	47	0	0	480
15:15	8	61	31	0	0	26	88	17	0	0	34	68	33	0	0	26	80	41	0	0	513
15:30	6	114	30	0	0	31	66	3	0	0	33	67	27	0	0	21	70	47	0	0	515
15:45	4	54	14	0	0	41	67	4	0	0	26	44	34	0	0	18	75	52	0	0	433
16:00	3	44	15	0	0	29	56	2	0	0	31	55	36	0	0	14	76	54	0	0	415
16:15	4	29	10	0	0	32	69	8	0	0	35	59	32	0	0	20	77	46	0	0	421
16:30	3	64	14	0	0	26	48	3	0	0	55	55	35	0	0	18	74	40	0	0	435
16:45	4	43	15	0	0	26	65	5	0	0	49	48	36	0	0	24	82	43	0	0	440
17:00	2	33	16	0	0	29	39	3	0	0	57	69	36	0	0	19	80	54	0	0	437
17:15	4	28	13	0	0	20	58	4	0	0	53	53	29	0	0	15	79	49	0	0	405
17:30	2	49	12	0	0	25	43	3	0	0	60	54	25	0	0	21	83	59	0	0	436
17:45	4	32	9	0	0	31	49	8	0	0	56	71	45	0	0	26	84	47	0	0	462
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22:30																					0
22:45																					0
23:00																					0
23:15																					0
23:30																					0
23:45																					0
Total	**86**	**1340**	**467**	**0**	**3**	**782**	**1536**	**116**	**0**	**2**	**894**	**1255**	**656**	**0**	**0**	**372**	**1445**	**965**	**0**	**1**	**9920**
AM Peak Hr:																					**7:30**
Pk Vol	**24**	**363**	**114**	**0**	**3**	**186**	**384**	**34**	**0**	**2**	**128**	**332**	**129**	**0**	**0**	**73**	**279**	**175**	**0**	**1**	**2227**
PHF	**0.600**	**0.769**	**0.864**	**n/a**	**0.375**	**0.762**	**0.897**	**0.607**	**n/a**	**0.250**	**0.842**	**0.728**	**0.787**	**n/a**	**n/a**	**0.629**	**0.698**	**0.706**	**n/a**	**0.250**	**0.905**
MID Peak Hr:																					
Pk Vol																					**0**
PHF																					
PM Peak Hr:																					**15:00**
Pk Vol	**23**	**290**	**97**	**0**	**0**	**129**	**299**	**28**	**0**	**0**	**130**	**245**	**118**	**0**	**0**	**86**	**309**	**187**	**0**	**0**	**1941**
PHF	**0.719**	**0.636**	**0.782**	**n/a**	**n/a**	**0.787**	**0.849**	**0.412**	**n/a**	**n/a**	**0.878**	**0.901**	**0.868**	**n/a**	**n/a**	**0.827**	**0.920**	**0.899**	**n/a**	**n/a**	**0.942**

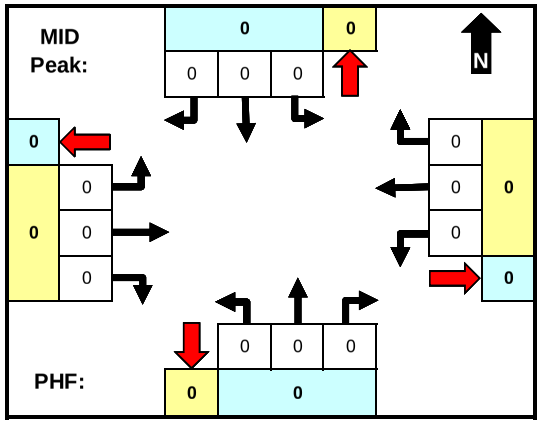
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Specializing in Traffic Data Collection

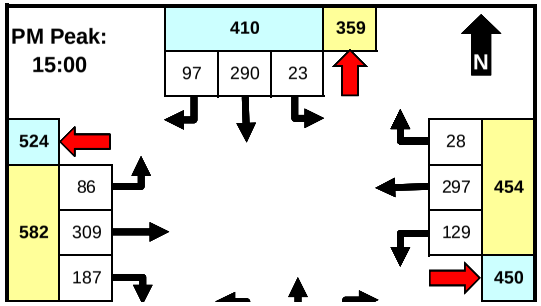
Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901567
Count Date: 5/7/2019

N HOUGHTON RD & E TANQUE VERDE RD







	From North (SB)				From East (WB)				From South (NB)				From West (EB)				INTSEC
	N HOUGHTON RD				E TANQUE VERDE RD				N HOUGHTON RD				E TANQUE VERDE RD				
Time	LT	Thru	RT	U	LT	Thru	RT	U	LT	Thru	RT	U	LT	Thru	RT	U	TOTAL
0:00																	0
0:15																	0
0:30																	0
0:45																	0
1:00																	0
1:15																	0
1:30																	0
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5:30																	0
5:45																	0
06:00	1	23	11	0	21	24	0	0	10	7	8	0	0	15	9	0	129
06:15	1	31	9	0	27	38	2	0	26	17	14	0	3	18	17	0	203
06:30	3	51	11	0	34	40	1	0	33	14	12	0	6	13	27	0	245
06:45	0	39	12	0	34	57	3	0	25	32	16	0	5	26	19	0	268
07:00	0	53	26	0	39	70	4	0	34	28	16	0	8	27	26	0	331
07:15	2	58	17	0	32	68	2	0	40	37	25	0	11	36	33	0	361
07:30	5	64	23	0	37	82	6	0	36	93	28	0	13	64	41	0	492
07:45	7	91	25	0	42	93	12	0	23	114	40	0	29	100	35	0	611
08:00	10	118	33	0	61	105	14	0	28	73	30	0	18	60	47	0	597
08:15	2	90	33	0	46	99	2	0	38	52	27	0	13	51	30	0	483
08:30	0	60	48	0	34	62	3	0	35	41	19	0	15	40	34	0	391
08:45	6	50	18	0	26	61	3	0	31	38	23	0	8	43	41	0	348
9:00																	0
9:15																	0
9:30																	0
9:45																	0
10:00																	0
10:15																	0
10:30																	0
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12:00																	0
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13:00																	0
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13:30																	0
13:45																	0

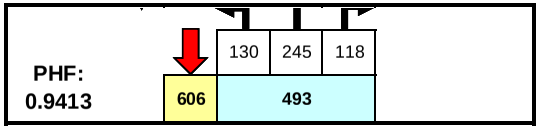
Vehicles

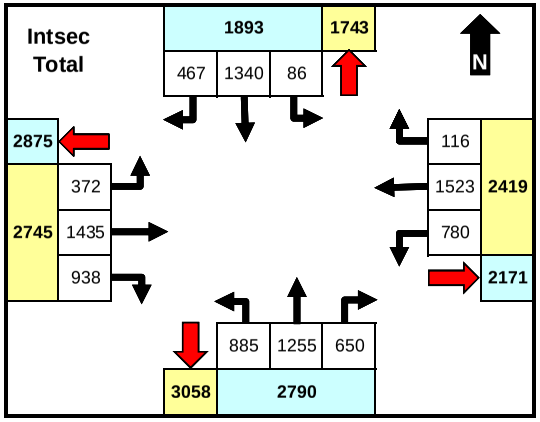
TRAFFIC RESEARCH & ANALYSIS, INC.
Specializing in Traffic Data Collection

Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901567
Count Date: 5/7/2019

N HOUGHTON RD & E TANQUE VERDE RD





	North		East		South		West		
	App	Dep	App	Dep	App	Dep	App	Dep	Total
AM	501	439	599	424	582	702	501	618	2183
MID	0	0	0	0	0	0	0	0	0
PM	410	359	454	450	493	606	582	524	1939
Total	1893	1743	2419	2171	2790	3058	2745	2875	9847

Comments

Unless shown otherwise, MID period defined as 10:00 AM - 2:00 PM. Peaks defined based on total intersection volume for all vehicle types.

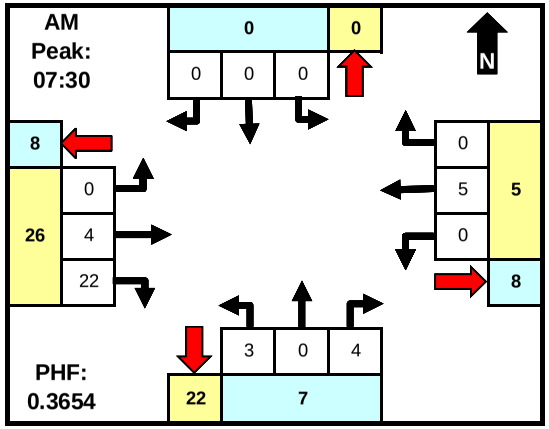
	From North (SB)				From East (WB)				From South (NB)				From West (EB)				INTSEC
	N HOUGHTON RD				E TANQUE VERDE RD				N HOUGHTON RD				E TANQUE VERDE RD				
14:00																	0
14:15																	0
14:30																	0
14:45																	0
15:00	5	61	22	0	31	78	4	0	37	66	24	0	21	84	47	0	480
15:15	8	61	31	0	26	87	17	0	34	68	33	0	26	80	41	0	512
15:30	6	114	30	0	31	66	3	0	33	67	27	0	21	70	47	0	515
15:45	4	54	14	0	41	66	4	0	26	44	34	0	18	75	52	0	432
16:00	3	44	15	0	29	56	2	0	31	55	36	0	14	76	54	0	415
16:15	4	29	10	0	32	69	8	0	35	59	32	0	20	76	46	0	420
16:30	3	64	14	0	26	48	3	0	55	55	35	0	18	74	40	0	435
16:45	4	43	15	0	26	65	5	0	49	48	36	0	24	82	43	0	440
17:00	2	33	16	0	29	39	3	0	57	69	36	0	19	79	54	0	436
17:15	4	28	13	0	20	58	4	0	53	53	29	0	15	79	49	0	405
17:30	2	49	12	0	25	43	3	0	60	54	25	0	21	83	59	0	436
17:45	4	32	9	0	31	49	8	0	56	71	45	0	26	84	47	0	462
18:00																	0
18:15																	0
18:30																	0
18:45																	0
19:00																	0
19:15																	0
19:30																	0
19:45																	0
20:00																	0
20:15																	0
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21:00																	0
21:15																	0
21:30																	0
21:45																	0
22:00																	0
22:15																	0
22:30																	0
22:45																	0
23:00																	0
23:15																	0
23:30																	0
23:45																	0
Total	86	1340	467	0	780	1523	116	0	885	1255	650	0	372	1435	938	0	9847
AM Peak Hr:																	7:30
Pk Vol	24	363	114	0	186	379	34	0	125	332	125	0	73	275	153	0	2183
PHF	0.600	0.769	0.864	n/a	0.762	0.902	0.607	n/a	0.822	0.728	0.781	n/a	0.629	0.688	0.814	n/a	0.893
MID Peak Hr:																	
Pk Vol																	0
PHF																	
PM Peak Hr:																	15:00
Pk Vol	23	290	97	0	129	297	28	0	130	245	118	0	86	309	187	0	1939
PHF	0.719	0.636	0.782	n/a	0.787	0.853	0.412	n/a	0.878	0.901	0.868	n/a	0.827	0.920	0.899	n/a	0.941

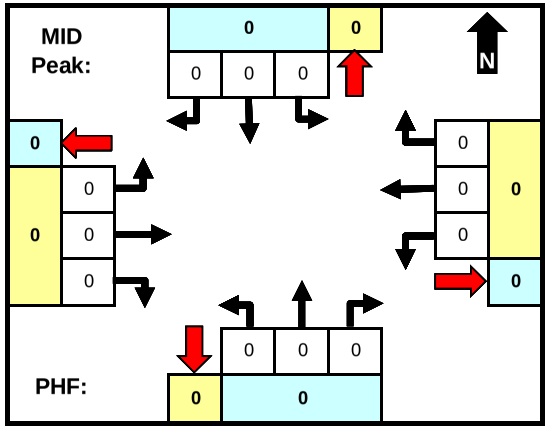
TRAFFIC RESEARCH & ANALYSIS, INC.
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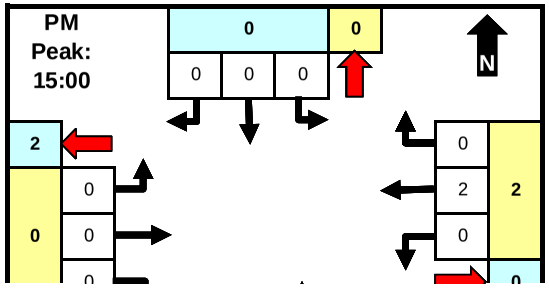
Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901567
Count Date: 5/7/2019

N HOUGHTON RD & E TANQUE VERDE RD







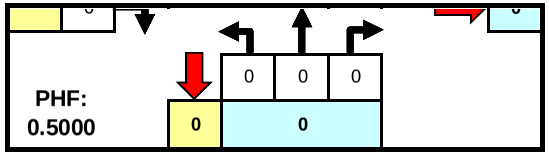
	From North (SB)				From East (WB)				From South (NB)				From West (EB)				INTSEC
	N HOUGHTON RD				E TANQUE VERDE RD				N HOUGHTON RD				E TANQUE VERDE RD				
Time	LT	Thru	RT	U	LT	Thru	RT	U	LT	Thru	RT	U	LT	Thru	RT	U	TOTAL
0:00																	0
0:15																	0
0:30																	0
0:45																	0
1:00																	0
1:15																	0
1:30																	0
1:45																	0
2:00																	0
2:15																	0
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4:30																	0
4:45																	0
5:00																	0
5:15																	0
5:30																	0
5:45																	0
06:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:15	0	0	0	0	2	1	0	0	0	0	2	0	0	2	0	0	7
06:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:45	0	0	0	0	0	0	0	0	3	0	0	0	0	2	2	0	7
07:00	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	3
07:15	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	2
07:30	0	0	0	0	0	2	0	0	1	0	0	0	0	2	21	0	26
07:45	0	0	0	0	0	0	0	0	2	0	1	0	0	0	1	0	4
08:00	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	4
08:15	0	0	0	0	0	1	0	0	0	0	1	0	0	2	0	0	4
08:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
08:45	0	0	0	0	0	4	0	0	0	0	0	0	0	0	1	0	5
9:00																	0
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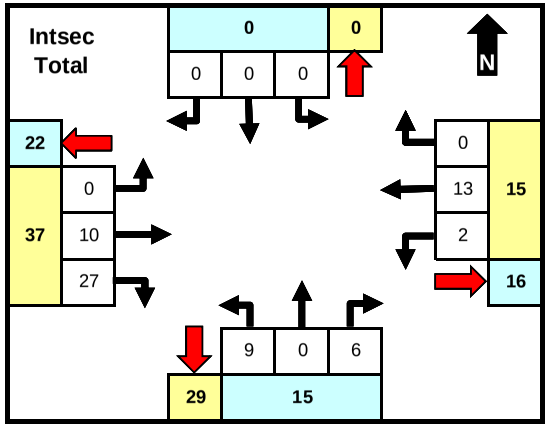
TRAFFIC RESEARCH & ANALYSIS, INC.
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Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901567
Count Date: 5/7/2019

N HOUGHTON RD & E TANQUE VERDE RD





	North		East		South		West		
	App	Dep	App	Dep	App	Dep	App	Dep	Total
AM	0	0	5	8	7	22	26	8	38
MID	0	0	0	0	0	0	0	0	0
PM	0	0	2	0	0	0	0	2	2
Total	0	0	15	16	15	29	37	22	67

Comments

Unless shown otherwise, MID period defined as 10:00 AM - 2:00 PM. Peaks defined based on total intersection volume for all vehicle types.

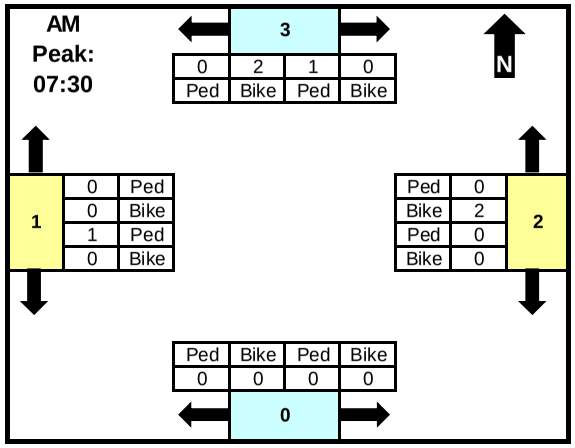
	From North (SB)				From East (WB)				From South (NB)				From West (EB)				INTSEC
	N HOUGHTON RD				E TANQUE VERDE RD				N HOUGHTON RD				E TANQUE VERDE RD				
13:45																	0
14:00																	0
14:15																	0
14:30																	0
14:45																	0
15:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:15	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
15:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:45	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
16:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:15	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
16:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
17:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18:00																	0
18:15																	0
18:30																	0
18:45																	0
19:00																	0
19:15																	0
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22:00																	0
22:15																	0
22:30																	0
22:45																	0
23:00																	0
23:15																	0
23:30																	0
23:45																	0
Total	0	0	0	0	2	13	0	0	9	0	6	0	0	10	27	0	67
AM Peak Hr:																	7:30
Pk Vol	0	0	0	0	0	5	0	0	3	0	4	0	0	4	22	0	38
PHF	n/a	n/a	n/a	n/a	n/a	0.625	n/a	n/a	0.375	n/a	0.500	n/a	n/a	0.500	0.262	n/a	0.365
MID Peak Hr:																	
Pk Vol																	0
PHF																	
PM Peak Hr:																	15:00
Pk Vol	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
PHF	n/a	n/a	n/a	n/a	n/a	0.500	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.500

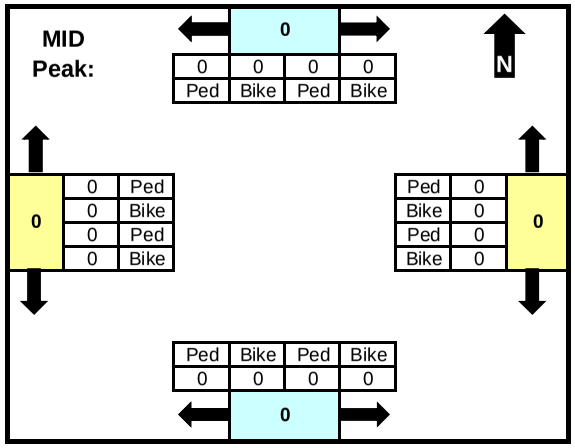
TRAFFIC RESEARCH & ANALYSIS, INC.
Specializing in Traffic Data Collection

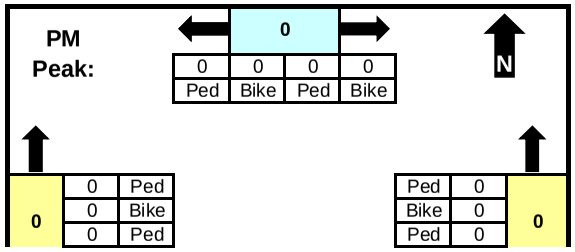
Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901567
Count Date: 5/7/2019

N HOUGHTON RD & E TANQUE VERDE RD







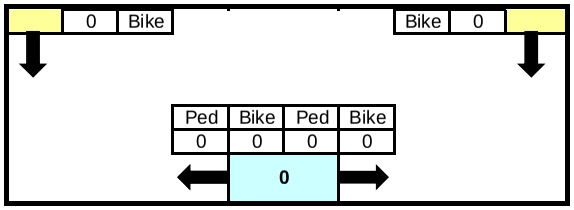
	North Leg				East Leg				South Leg				West Leg				INTSEC
	CW		CCW		CW		CCW		CW		CCW		CW		CCW		
Time	Ped	Bike	Ped	Bike	Ped	Bike	Ped	Bike	Ped	Bike	Ped	Bike	Ped	Bike	Ped	Bike	TOTAL
0:00																	0
0:15																	0
0:30																	0
0:45																	0
1:00																	0
1:15																	0
1:30																	0
1:45																	0
2:00																	0
2:15																	0
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4:30																	0
4:45																	0
5:00																	0
5:15																	0
5:30																	0
5:45																	0
06:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:30	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
07:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:00	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	4
08:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00																	0
9:15																	0
9:30																	0
9:45																	0
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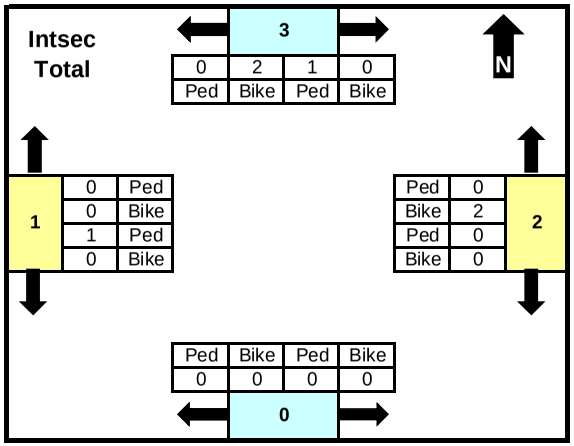
TRAFFIC RESEARCH & ANALYSIS, INC.
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Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901567
Count Date: 5/7/2019

N HOUGHTON RD & E TANQUE VERDE RD





	North		East		South		West		
	CW	CCW	CW	CCW	CW	CCW	CW	CCW	Total
AM	1	2	0	2	0	0	0	1	6
MID	0	0	0	0	0	0	0	0	0
PM	0	0	0	0	0	0	0	0	0
Total	1	2	0	2	0	0	0	1	6

CW = Clockwise
CCW = Counter-clockwise

Comments

Unless shown otherwise, MID period defined as 10:00 AM - 2:00 PM. Crosswalk peaks defined based on total intersection volume for all vehicle types.

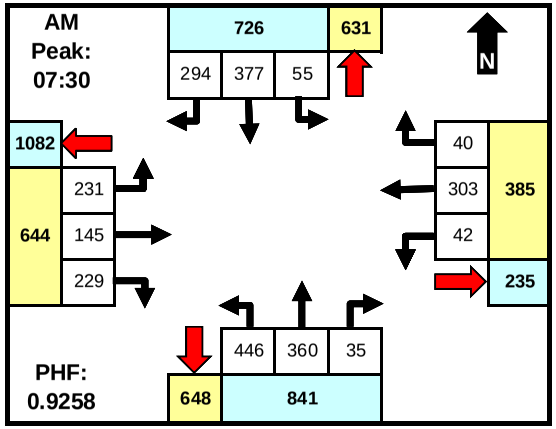
	North Leg				East Leg				South Leg				West Leg				INTSEC
	CW		CCW		CW		CCW		CW		CCW		CW		CCW		
13:15																	0
13:30																	0
13:45																	0
14:00																	0
14:15																	0
14:30																	0
14:45																	0
15:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18:00																	0
18:15																	0
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23:30																	0
23:45																	0
Total	1	0	0	2	0	0	0	2	0	0	0	0	0	0	1	0	6
AM Peak Hr:																	7:30
Pk Vol	1	0	0	2	0	0	0	2	0	0	0	0	0	0	1	0	6
MID Peak Hr:																	
Pk Vol																	0
PM Peak Hr:																	15:00
Pk Vol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

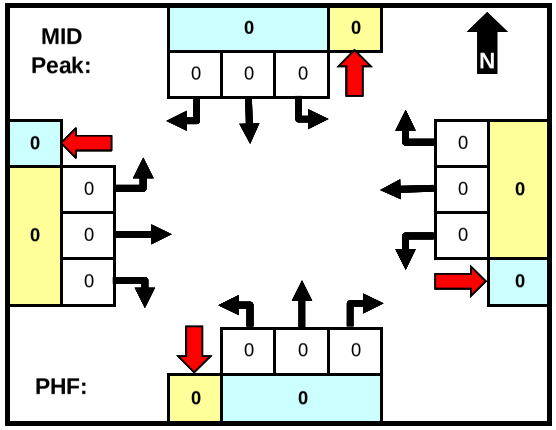
TRAFFIC RESEARCH & ANALYSIS, INC.
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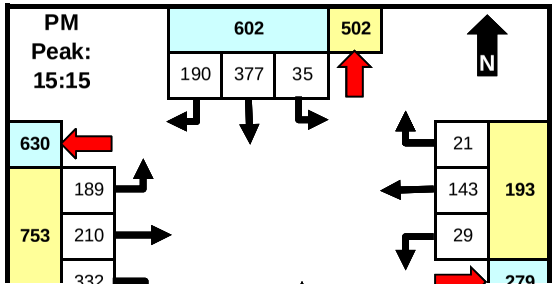
Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901566
Count Date: 5/7/2019

N HOUGHTON RD & E SPEEDWAY BLVD







	From North (SB)					From East (WB)					From South (NB)					From West (EB)					INTSEC
	N HOUGHTON RD					E SPEEDWAY BLVD					N HOUGHTON RD					E SPEEDWAY BLVD					
Time	LT	Thru	RT	U	Cwlk	LT	Thru	RT	U	Cwlk	LT	Thru	RT	U	Cwlk	LT	Thru	RT	U	Cwlk	TOTAL
0:00																					0
0:15																					0
0:30																					0
0:45																					0
1:00																					0
1:15																					0
1:30																					0
1:45																					0
2:00																					0
2:15																					0
2:30																					0
2:45																					0
3:00																					0
3:15																					0
3:30																					0
3:45																					0
4:00																					0
4:15																					0
4:30																					0
4:45																					0
5:00																					0
5:15																					0
5:30																					0
5:45																					0
06:00	4	34	15	0	0	4	21	2	0	0	38	8	3	0	0	9	10	16	4	0	168
06:15	2	49	28	0	0	3	33	7	0	0	51	39	4	0	0	20	19	36	9	0	300
06:30	2	88	29	0	0	2	38	3	0	0	62	36	4	0	0	17	21	49	6	0	357
06:45	4	58	28	0	0	5	40	3	0	0	99	47	3	0	0	29	19	44	12	0	391
07:00	2	74	39	0	0	5	53	6	0	0	98	58	6	0	0	25	16	54	5	0	441
07:15	2	77	50	0	0	11	64	9	0	0	118	69	4	0	1	30	29	53	7	0	524
07:30	6	79	47	0	0	6	83	9	0	0	140	107	10	0	0	68	41	54	12	0	662
07:45	29	85	82	0	0	7	66	14	0	0	111	113	13	0	0	65	43	63	10	0	701
08:00	11	110	90	0	0	14	74	8	0	0	109	79	8	0	0	59	31	64	8	0	665
08:15	9	103	75	0	0	15	80	9	0	0	86	61	4	0	0	39	30	48	9	0	568
08:30	2	76	42	0	0	2	68	12	0	0	89	53	2	0	0	29	27	37	7	0	446
08:45	6	83	45	0	0	5	51	13	0	0	74	52	5	0	0	36	32	42	3	0	447
9:00																					0
9:15																					0
9:30																					0
9:45																					0
10:00																					0
10:15																					0
10:30																					0
10:45																					0
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11:15																					0
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12:00																					0
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12:45																					0
13:00																					0
13:15																					0
13:30																					0

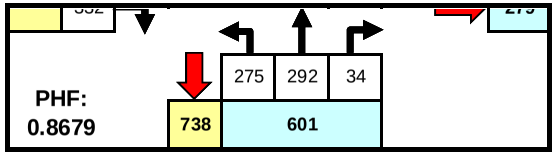
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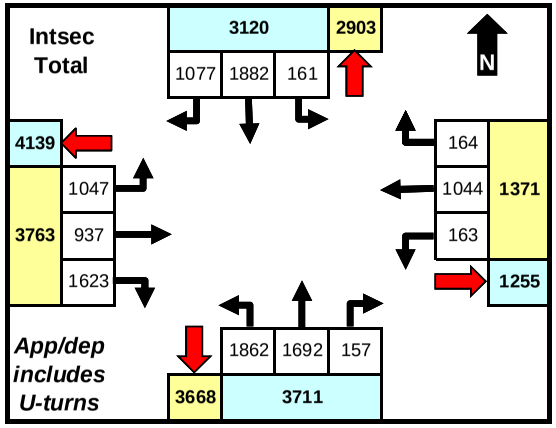
TRAFFIC RESEARCH & ANALYSIS, INC.
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Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901566
Count Date: 5/7/2019

N HOUGHTON RD & E SPEEDWAY BLVD





	North		East		South		West		
	App	Dep	App	Dep	App	Dep	App	Dep	Total
AM	726	631	385	235	841	648	644	1082	**2596**
MID	0	0	0	0	0	0	0	0	**0**
PM	602	502	193	279	601	738	753	630	**2149**
Total	3120	2903	1371	1255	3711	3668	3763	4139	**11965**

Comments

Unless shown otherwise, MID period defined as 10:00 AM - 2:00 PM. Peaks defined based on total intersection volume for all vehicle types. Chart totals do not include crosswalk data.

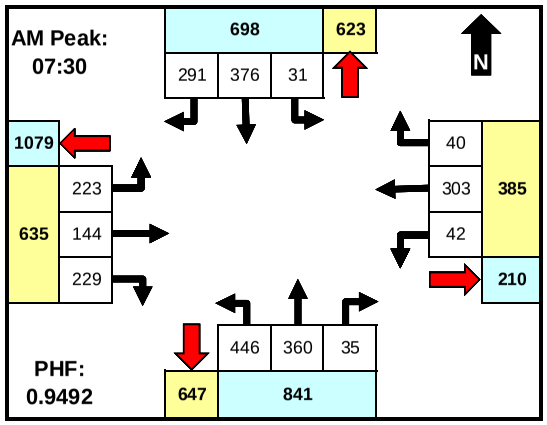
	From North (SB) N HOUGHTON RD					From East (WB) E SPEEDWAY BLVD					From South (NB) N HOUGHTON RD					From West (EB) E SPEEDWAY BLVD					INTSEC
13:45																					0
14:00																					0
14:15																					0
14:30																					0
14:45																					0
15:00	6	85	47	0	0	13	44	7	0	0	75	65	7	0	0	57	41	62	10	0	519
15:15	5	80	37	0	0	5	47	10	0	0	61	83	10	0	0	45	47	67	5	0	502
15:30	14	125	65	0	0	7	29	4	0	0	81	71	7	0	0	55	58	97	6	0	619
15:45	9	87	47	0	0	9	32	2	0	0	62	56	6	0	0	44	62	82	5	0	503
16:00	7	85	41	0	0	8	35	5	0	0	71	82	11	0	0	45	43	86	6	0	525
16:15	5	59	36	0	1	4	23	5	0	0	63	74	9	0	0	58	65	95	6	0	503
16:30	3	76	49	0	0	4	26	5	0	0	65	90	4	0	0	48	33	108	6	0	517
16:45	7	81	35	0	0	6	30	2	0	0	74	81	7	0	0	62	62	98	6	0	551
17:00	6	74	40	0	0	7	31	6	0	0	68	88	6	0	0	52	59	92	4	0	533
17:15	4	65	27	0	1	11	27	7	0	0	54	96	11	0	0	45	48	93	3	0	492
17:30	6	85	46	0	0	4	23	9	0	0	70	95	2	0	2	48	51	96	2	0	539
17:45	10	64	37	0	0	6	26	7	0	0	43	89	11	0	0	62	50	87	5	0	497
18:00																					0
18:15																					0
18:30																					0
18:45																					0
19:00																					0
19:15																					0
19:30																					0
19:45																					0
20:00																					0
20:15																					0
20:30																					0
20:45																					0
21:00																					0
21:15																					0
21:30																					0
21:45																					0
22:00																					0
22:15																					0
22:30																					0
22:45																					0
23:00																					0
23:15																					0
23:30																					0
23:45																					0
Total	**161**	**1882**	**1077**	**0**	**2**	**163**	**1044**	**164**	**0**	**0**	**1862**	**1692**	**157**	**0**	**3**	**1047**	**937**	**1623**	**156**	**0**	**11970**
AM Peak Hr:																					**7:30**
Pk Vol	**55**	**377**	**294**	**0**	**0**	**42**	**303**	**40**	**0**	**0**	**446**	**360**	**35**	**0**	**0**	**231**	**145**	**229**	**39**	**0**	**2596**
PHF	**0.474**	**0.857**	**0.817**	**n/a**	**n/a**	**0.700**	**0.913**	**0.714**	**n/a**	**n/a**	**0.796**	**0.796**	**0.673**	**n/a**	**n/a**	**0.849**	**0.843**	**0.895**	**0.813**	**n/a**	**0.926**
MID Peak Hr:																					
Pk Vol																					**0**
PHF																					
PM Peak Hr:																					**15:15**
Pk Vol	**35**	**377**	**190**	**0**	**0**	**29**	**143**	**21**	**0**	**0**	**275**	**292**	**34**	**0**	**0**	**189**	**210**	**332**	**22**	**0**	**2149**
PHF	**0.625**	**0.754**	**0.731**	**n/a**	**n/a**	**0.806**	**0.761**	**0.525**	**n/a**	**n/a**	**0.849**	**0.880**	**0.773**	**n/a**	**n/a**	**0.859**	**0.847**	**0.856**	**0.917**	**n/a**	**0.868**

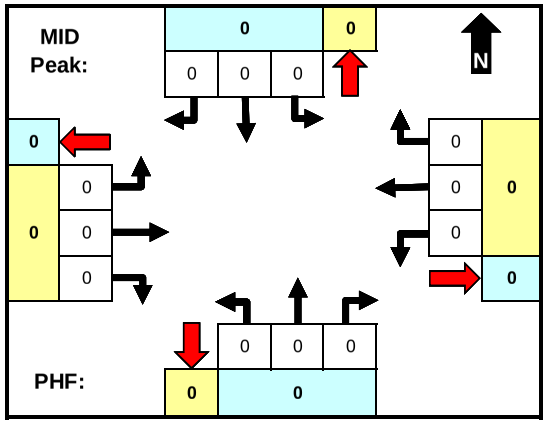
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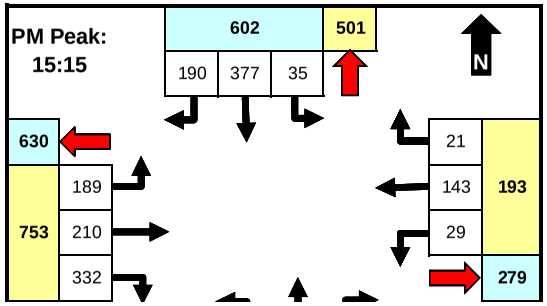
Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901566
Count Date: 5/7/2019

N HOUGHTON RD & E SPEEDWAY BLVD







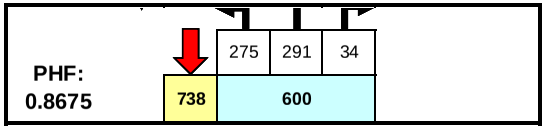
	From North (SB)				From East (WB)				From South (NB)				From West (EB)				INTSEC
	N HOUGHTON RD				E SPEEDWAY BLVD				N HOUGHTON RD				E SPEEDWAY BLVD				
Time	LT	Thru	RT	U	LT	Thru	RT	U	LT	Thru	RT	U	LT	Thru	RT	U	TOTAL
0:00																	0
0:15																	0
0:30																	0
0:45																	0
1:00																	0
1:15																	0
1:30																	0
1:45																	0
2:00																	0
2:15																	0
2:30																	0
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4:15																	0
4:30																	0
4:45																	0
5:00																	0
5:15																	0
5:30																	0
5:45																	0
06:00	4	34	15	0	4	21	2	0	38	8	3	0	9	10	16	4	168
06:15	1	49	26	0	3	33	5	0	51	39	4	0	20	19	36	8	294
06:30	2	87	29	0	2	38	3	0	62	36	4	0	17	20	49	6	355
06:45	3	58	27	0	5	40	3	0	99	47	3	0	26	19	44	12	386
07:00	2	74	39	0	5	53	5	0	98	58	5	0	23	16	54	5	437
07:15	1	77	50	0	11	64	9	0	118	69	4	0	29	29	53	7	521
07:30	4	79	47	0	6	83	9	0	140	107	10	0	65	41	54	12	657
07:45	7	84	81	0	7	66	14	0	111	113	13	0	62	43	63	10	674
08:00	11	110	89	0	14	74	8	0	109	79	8	0	58	31	64	8	663
08:15	9	103	74	0	15	80	9	0	86	61	4	0	38	29	48	9	565
08:30	2	76	41	0	2	67	12	0	89	53	2	0	29	27	37	7	444
08:45	6	83	45	0	5	51	13	0	74	52	5	0	34	32	42	3	445
9:00																	0
9:15																	0
9:30																	0
9:45																	0
10:00																	0
10:15																	0
10:30																	0
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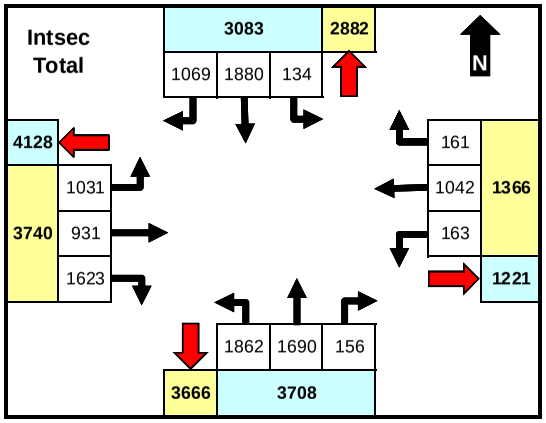
TRAFFIC RESEARCH & ANALYSIS, INC.
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Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901566
Count Date: 5/7/2019

N HOUGHTON RD & E SPEEDWAY BLVD





	North		East		South		West		
	App	Dep	App	Dep	App	Dep	App	Dep	Total
AM	698	623	385	210	841	647	635	1079	2559
MID	0	0	0	0	0	0	0	0	0
PM	602	501	193	279	600	738	753	630	2148
Total	3083	2882	1366	1221	3708	3666	3740	4128	11897

Comments

Unless shown otherwise, MID period defined as 10:00 AM - 2:00 PM. Peaks defined based on total intersection volume for all vehicle types.

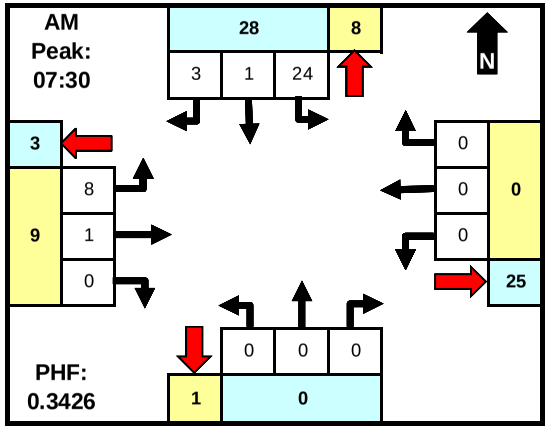
	From North (SB) N HOUGHTON RD				From East (WB) E SPEEDWAY BLVD				From South (NB) N HOUGHTON RD				From West (EB) E SPEEDWAY BLVD				INTSEC
14:00																	0
14:15																	0
14:30																	0
14:45																	0
15:00	6	85	47	0	13	44	7	0	75	65	7	0	57	40	62	10	518
15:15	5	80	37	0	5	47	10	0	61	83	10	0	45	47	67	5	502
15:30	14	125	65	0	7	29	4	0	81	71	7	0	55	58	97	6	619
15:45	9	87	47	0	9	32	2	0	62	55	6	0	44	62	82	5	502
16:00	7	85	41	0	8	35	5	0	71	82	11	0	45	43	86	6	525
16:15	5	59	36	0	4	23	5	0	63	74	9	0	58	65	95	6	502
16:30	3	76	49	0	4	26	5	0	65	90	4	0	48	33	108	6	517
16:45	7	81	35	0	6	30	2	0	74	81	7	0	62	62	98	6	551
17:00	6	74	40	0	7	31	6	0	68	88	6	0	52	56	92	4	530
17:15	4	65	27	0	11	26	7	0	54	96	11	0	45	48	93	3	490
17:30	6	85	45	0	4	23	9	0	70	94	2	0	48	51	96	2	535
17:45	10	64	37	0	6	26	7	0	43	89	11	0	62	50	87	5	497
18:00																	0
18:15																	0
18:30																	0
18:45																	0
19:00																	0
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22:15																	0
22:30																	0
22:45																	0
23:00																	0
23:15																	0
23:30																	0
23:45																	0
Total	134	1880	1069	0	163	1042	161	0	1862	1690	156	0	1031	931	1623	155	11897
AM Peak Hr:																	7:30
Pk Vol	31	376	291	0	42	303	40	0	446	360	35	0	223	144	229	39	2559
PHF	0.705	0.855	0.817	n/a	0.700	0.913	0.714	n/a	0.796	0.796	0.673	n/a	0.858	0.837	0.895	0.813	0.949
MID Peak Hr:																	
Pk Vol																	0
PHF																	
PM Peak Hr:																	15:15
Pk Vol	35	377	190	0	29	143	21	0	275	291	34	0	189	210	332	22	2148
PHF	0.625	0.754	0.731	n/a	0.806	0.761	0.525	n/a	0.849	0.877	0.773	n/a	0.859	0.847	0.856	0.917	0.868

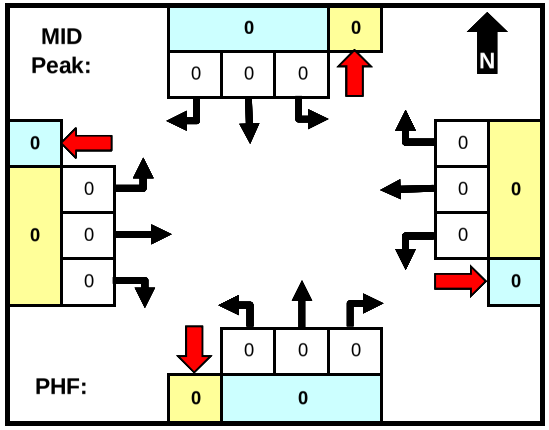
TRAFFIC RESEARCH & ANALYSIS, INC.
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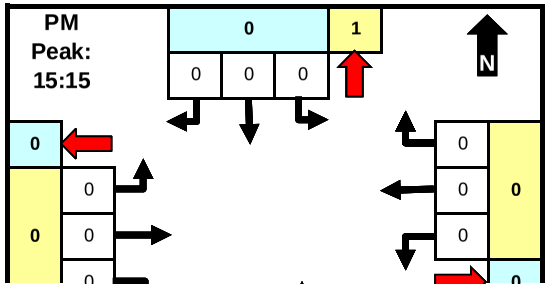
Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901566
Count Date: 5/7/2019

N HOUGHTON RD & E SPEEDWAY BLVD







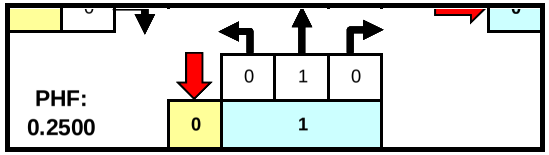
	From North (SB)				From East (WB)				From South (NB)				From West (EB)				INTSEC
	N HOUGHTON RD				E SPEEDWAY BLVD				N HOUGHTON RD				E SPEEDWAY BLVD				
Time	LT	Thru	RT	U	LT	Thru	RT	U	LT	Thru	RT	U	LT	Thru	RT	U	TOTAL
0:00																	0
0:15																	0
0:30																	0
0:45																	0
1:00																	0
1:15																	0
1:30																	0
1:45																	0
2:00																	0
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5:00																	0
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5:30																	0
5:45																	0
06:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:15	1	0	2	0	0	0	2	0	0	0	0	0	0	0	0	1	6
06:30	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
06:45	1	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0	5
07:00	0	0	0	0	0	0	1	0	0	0	1	0	2	0	0	0	4
07:15	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
07:30	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	5
07:45	22	1	1	0	0	0	0	0	0	0	0	0	3	0	0	0	27
08:00	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	2
08:15	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	3
08:30	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	2
08:45	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
9:00																	0
9:15																	0
9:30																	0
9:45																	0
10:00																	0
10:15																	0
10:30																	0
10:45																	0
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11:45																	0
12:00																	0
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12:30																	0
12:45																	0
13:00																	0
13:15																	0
13:30																	0

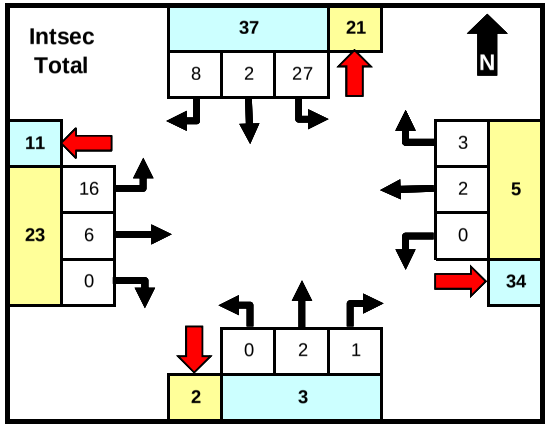
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Traffic Research & Analysis, Inc.
3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901566
Count Date: 5/7/2019

N HOUGHTON RD & E SPEEDWAY BLVD





	North		East		South		West		
	App	Dep	App	Dep	App	Dep	App	Dep	Total
AM	28	8	0	25	0	1	9	3	37
MID	0	0	0	0	0	0	0	0	0
PM	0	1	0	0	1	0	0	0	1
Total	37	21	5	34	3	2	23	11	68

Comments

Unless shown otherwise, MID period defined as 10:00 AM - 2:00 PM. Peaks defined based on total intersection volume for all vehicle types.

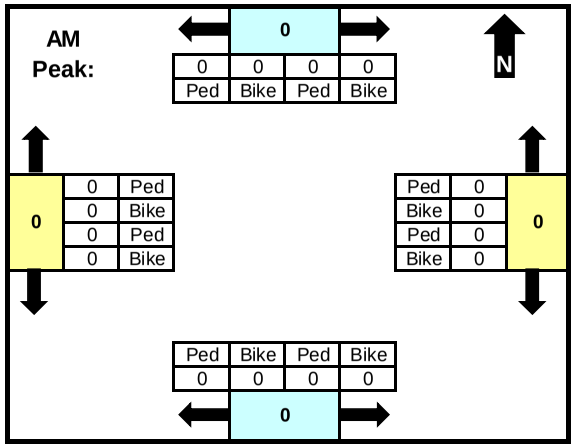
	From North (SB) N HOUGHTON RD				From East (WB) E SPEEDWAY BLVD				From South (NB) N HOUGHTON RD				From West (EB) E SPEEDWAY BLVD				INTSEC
13:45																	0
14:00																	0
14:15																	0
14:30																	0
14:45																	0
15:00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
15:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:45	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
16:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:00	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
17:15	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
17:30	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2
17:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18:00																	0
18:15																	0
18:30																	0
18:45																	0
19:00																	0
19:15																	0
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19:45																	0
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21:45																	0
22:00																	0
22:15																	0
22:30																	0
22:45																	0
23:00																	0
23:15																	0
23:30																	0
23:45																	0
Total	27	2	8	0	0	2	3	0	0	2	1	0	16	6	0	1	68
AM Peak Hr:																	7:30
Pk Vol	24	1	3	0	0	0	0	0	0	0	0	0	8	1	0	0	37
PHF	0.273	0.250	0.750	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.667	0.250	n/a	n/a	0.343
MID Peak Hr:																	
Pk Vol																	0
PHF																	
PM Peak Hr:																	15:15
Pk Vol	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
PHF	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.250	n/a	n/a	n/a	n/a	n/a	n/a	0.250

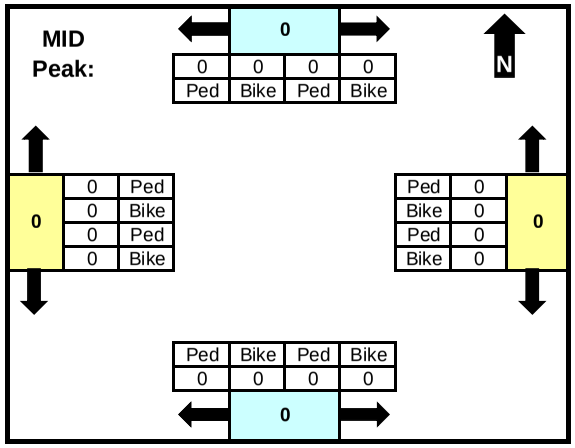
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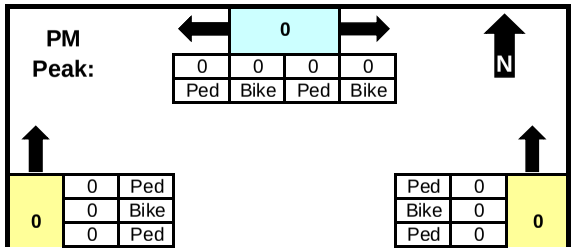
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3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901566
Count Date: 5/7/2019

N HOUGHTON RD & E SPEEDWAY BLVD







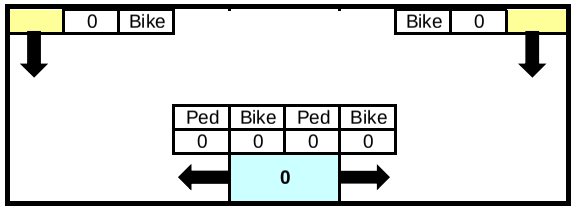
	North Leg				East Leg				South Leg				West Leg				INTSEC
	CW		CCW		CW		CCW		CW		CCW		CW		CCW		
Time	Ped	Bike	Ped	Bike	Ped	Bike	Ped	Bike	Ped	Bike	Ped	Bike	Ped	Bike	Ped	Bike	TOTAL
0:00																	0
0:15																	0
0:30																	0
0:45																	0
1:00																	0
1:15																	0
1:30																	0
1:45																	0
2:00																	0
2:15																	0
2:30																	0
2:45																	0
3:00																	0
3:15																	0
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3:45																	0
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4:15																	0
4:30																	0
4:45																	0
5:00																	0
5:15																	0
5:30																	0
5:45																	0
06:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:15	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
07:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00																	0
9:15																	0
9:30																	0
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12:30																	0
12:45																	0
13:00																	0

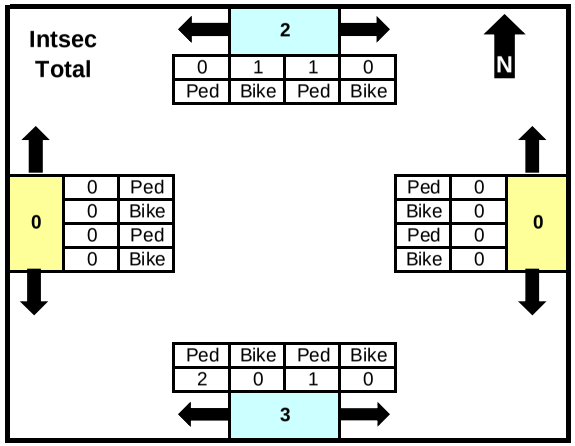
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3844 East Indian School Road
Phoenix, AZ 85018
(602) 840-1500

Intersection ID: 1901566
Count Date: 5/7/2019

N HOUGHTON RD & E SPEEDWAY BLVD





	North		East		South		West		
	CW	CCW	CW	CCW	CW	CCW	CW	CCW	Total
AM	0	0	0	0	0	0	0	0	0
MID	0	0	0	0	0	0	0	0	0
PM	0	0	0	0	0	0	0	0	0
Total	1	1	0	0	2	1	0	0	5

CW = Clockwise
CCW = Counter-clockwise

Comments

Unless shown otherwise, MID period defined as 10:00 AM - 2:00 PM. Crosswalk peaks defined based on total intersection volume for all vehicle types.

	North Leg		East Leg		South Leg		West Leg		INTSEC
	CW	CCW	CW	CCW	CW	CCW	CW	CCW	
13:15									0
13:30									0
13:45									0
14:00									0
14:15									0
14:30									0
14:45									0
15:00	0	0	0	0	0	0	0	0	0
15:15	0	0	0	0	0	0	0	0	0
15:30	0	0	0	0	0	0	0	0	0
15:45	0	0	0	0	0	0	0	0	0
16:00	0	0	0	0	0	0	0	0	0
16:15	1	0	0	0	0	0	0	0	1
16:30	0	0	0	0	0	0	0	0	0
16:45	0	0	0	0	0	0	0	0	0
17:00	0	0	0	0	0	0	0	0	0
17:15	0	0	0	1	0	0	0	0	1
17:30	0	0	0	0	0	0	0	0	2
17:45	0	0	0	0	0	0	0	0	0
18:00									0
18:15									0
18:30									0
18:45									0
19:00									0
19:15									0
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19:45									0
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20:30									0
20:45									0
21:00									0
21:15									0
21:30									0
21:45									0
22:00									0
22:15									0
22:30									0
22:45									0
23:00									0
23:15									0
23:30									0
23:45									0
Total	1	0	0	1	0	0	0	0	5
AM Peak Hr:									7:30
Pk Vol	0	0	0	0	0	0	0	0	0
MID Peak Hr:									
Pk Vol									0
PM Peak Hr:									15:15
Pk Vol	0	0	0	0	0	0	0	0	0

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Phoenix, AZ 85018
(602) 840-1500

Site ID	File Name	Route	Location	Direction	Count Type	Count Dur	Start Date	Start Time	Avg Vol	AM PkHr	AM PkVol	AM PHF	PM PkHr	PM PkVol	PM PHF	Latitude	Longitude
1	1901566	N HOUGHTON RD	At E SPEEDWAY BLVD	ALL	TMC	6	5/7/2019	6:00	11970	7:30	2596	0.9258	15:15	2149	0.8679	32.2352	-110.7732
2	1901567	N HOUGHTON RD	At E TANQUE VERDE RD	ALL	TMC	6	5/7/2019	6:00	9920	7:30	2221	0.9028	15:00	1941	0.9422	32.2508	-110.7724
3	1901568	N HOUGHTON RD	N of E TANQUE VERDE RD	NB	VOL	24	5/7/2019	0:00	3723	7:30	437	0.6744	14:45	375	0.8844	32.2525	-110.7721
3	1901569	N HOUGHTON RD	N of E TANQUE VERDE RD	SB	VOL	24	5/7/2019	0:00	4021	7:45	518	0.8520	14:45	424	0.7626	32.2526	-110.7722
4	1901571	E TANQUE VERDE RD	E of N HOUGHTON RD	ALL	VOL	24	5/7/2019	0:00	5208	7:30	592	0.8000	14:30	508	0.8699	32.2509	-110.7694
4	1901570	E TANQUE VERDE RD	E of N HOUGHTON RD	EB	VOL	24	5/7/2019	0:00	5260	7:30	431	0.7642	17:00	475	0.8543	32.2509	-110.7694
5	1901572	E TANQUE VERDE RD	W of N HOUGHTON RD	EB	VOL	24	5/7/2019	0:00	6721	7:30	516	0.7679	17:15	642	0.9386	32.2509	-110.7744
5	1901573	E TANQUE VERDE RD	W of N HOUGHTON RD	WB	VOL	24	5/7/2019	0:00	6545	7:30	641	0.9371	14:45	579	0.9104	32.2509	-110.7744
6	1901574	N HOUGHTON RD	Btwn E TANQUE VERDE RD & E SPEEDWAY BLVD	NB	VOL	24	5/7/2019	0:00	6503	7:15	594	0.7899	17:00	606	0.9127	32.2470	-110.7721
6	1901575	N HOUGHTON RD	Btwn E TANQUE VERDE RD & E SPEEDWAY BLVD	SB	VOL	24	5/7/2019	0:00	6877	7:30	703	0.7881	14:45	604	0.7989	32.2470	-110.7721
7	1901576	E SPEEDWAY BLVD	W of N HOUGHTON RD	EB	VOL	24	5/7/2019	0:00	10338	7:15	799	0.7803	16:15	1019	0.9541	32.2355	-110.7741
7	1901577	E SPEEDWAY BLVD	W of N HOUGHTON RD	WB	VOL	24	5/7/2019	0:00	8922	7:30	1062	0.9482	14:45	699	0.9102	32.2355	-110.7742
8	1901578	N HOUGHTON RD	S of E SPEEDWAY BLVD	NB	VOL	24	5/7/2019	0:00	8284	7:15	874	0.8404	16:45	647	0.9404	32.2313	-110.7728
8	1901579	N HOUGHTON RD	S of E SPEEDWAY BLVD	SB	VOL	24	5/7/2019	0:00	8577	7:30	664	0.8830	15:30	758	0.8460	32.2312	-110.7728
9	1901580	E SPEEDWAY BLVD	E of N HOUGHTON RD	EB	VOL	24	5/7/2019	0:00	2973	7:30	210	0.7955	15:30	301	0.9066	32.2354	-110.7696
9	1901581	E SPEEDWAY BLVD	E of N HOUGHTON RD	WB	VOL	24	5/7/2019	0:00	2887	7:30	383	0.9207	14:30	220	0.8871	32.2354	-110.7696

APPENDIX

C HCM REPORTS

HCM 6th Signalized Intersection Summary
1: Houghton Road & Speedway Boulevard

06/10/2019



Movement	EBU	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (veh/h)	39	223	144	229	42	303	40	446	360	35	31	376
Future Volume (veh/h)	39	223	144	229	42	303	40	446	360	35	31	376
Initial Q (Qb), veh		0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Parking Bus, Adj		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach			No			No			No			No
Adj Sat Flow, veh/h/ln		1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h		248	160	254	47	337	44	496	400	39	34	418
Peak Hour Factor		0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %		2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h		281	355	301	223	452	59	473	707	69	296	540
Arrive On Green		0.09	0.19	0.19	0.04	0.14	0.14	0.19	0.42	0.42	0.06	0.29
Sat Flow, veh/h		1781	1870	1585	1781	3164	410	1781	1677	164	1781	1870
Grp Volume(v), veh/h		248	160	254	47	188	193	496	0	439	34	418
Grp Sat Flow(s),veh/h/ln		1781	1870	1585	1781	1777	1797	1781	0	1841	1781	1870
Q Serve(g_s), s		5.4	6.3	12.8	0.0	8.4	8.6	16.0	0.0	15.1	0.0	17.0
Cycle Q Clear(g_c), s		5.4	6.3	12.8	0.0	8.4	8.6	16.0	0.0	15.1	0.0	17.0
Prop In Lane		1.00		1.00	1.00		0.23	1.00		0.09	1.00	
Lane Grp Cap(c), veh/h		281	355	301	223	254	257	473	0	776	296	540
V/C Ratio(X)		0.88	0.45	0.84	0.21	0.74	0.75	1.05	0.00	0.57	0.11	0.77
Avail Cap(c_a), veh/h		281	473	401	259	406	411	473	0	776	296	540
HCM Platoon Ratio		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh		35.5	29.8	32.5	34.8	34.1	34.2	31.1	0.0	18.3	29.8	27.0
Incr Delay (d2), s/veh		26.3	0.9	11.9	0.5	4.2	4.4	54.7	0.0	3.0	0.2	10.3
Initial Q Delay(d3),s/veh		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln		6.7	2.8	5.6	0.9	3.8	3.9	15.8	0.0	6.3	0.6	8.5
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh		61.8	30.7	44.3	35.3	38.4	38.6	85.8	0.0	21.2	30.0	37.4
LnGrp LOS		E	C	D	D	D	D	F	A	C	C	D
Approach Vol, veh/h			662			428			935			775
Approach Delay, s/veh			47.6			38.1			55.5			36.1
Approach LOS			D			D			E			D

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	11.0	41.0	9.3	21.8	22.0	30.0	13.2	17.9
Change Period (Y+Rc), s	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Max Green Setting (Gmax), s	5.0	35.0	5.0	21.0	16.0	24.0	7.0	19.0
Max Q Clear Time (g_c+I1), s	2.0	17.1	2.0	14.8	18.0	19.0	7.4	10.6
Green Ext Time (p_c), s	0.0	2.3	0.0	0.9	0.0	1.6	0.0	1.3

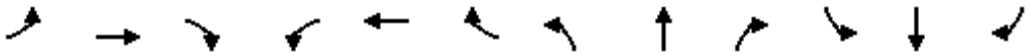
Intersection Summary	
HCM 6th Ctrl Delay	45.6
HCM 6th LOS	D

Notes

User approved ignoring U-Turning movement.



Movement	SBR
Lane Configurations	
Traffic Volume (veh/h)	291
Future Volume (veh/h)	291
Initial Q (Qb), veh	0
Ped-Bike Adj(A_pbT)	1.00
Parking Bus, Adj	1.00
Work Zone On Approach	
Adj Sat Flow, veh/h/ln	1870
Adj Flow Rate, veh/h	323
Peak Hour Factor	0.90
Percent Heavy Veh, %	2
Cap, veh/h	458
Arrive On Green	0.29
Sat Flow, veh/h	1585
Grp Volume(v), veh/h	323
Grp Sat Flow(s),veh/h/ln	1585
Q Serve(g_s), s	15.1
Cycle Q Clear(g_c), s	15.1
Prop In Lane	1.00
Lane Grp Cap(c), veh/h	458
V/C Ratio(X)	0.71
Avail Cap(c_a), veh/h	458
HCM Platoon Ratio	1.00
Upstream Filter(I)	1.00
Uniform Delay (d), s/veh	26.4
Incr Delay (d2), s/veh	8.8
Initial Q Delay(d3),s/veh	0.0
%ile BackOfQ(50%),veh/ln	6.4
Unsig. Movement Delay, s/veh	
LnGrp Delay(d),s/veh	35.2
LnGrp LOS	D
Approach Vol, veh/h	
Approach Delay, s/veh	
Approach LOS	
Timer - Assigned Phs	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	73	275	153	186	379	34	125	332	125	24	363	114
Future Volume (veh/h)	73	275	153	186	379	34	125	332	125	24	363	114
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	81	306	170	207	421	38	139	369	139	27	403	127
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	216	384	326	380	468	42	225	502	189	238	528	166
Arrive On Green	0.06	0.21	0.21	0.13	0.28	0.28	0.39	0.39	0.39	0.39	0.39	0.39
Sat Flow, veh/h	1781	1870	1585	1781	1690	153	874	1295	488	891	1363	430
Grp Volume(v), veh/h	81	306	170	207	0	459	139	0	508	27	0	530
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	0	1843	874	0	1783	891	0	1793
Q Serve(g_s), s	0.0	10.1	6.2	1.3	0.0	15.6	8.5	0.0	15.9	1.7	0.0	16.7
Cycle Q Clear(g_c), s	0.0	10.1	6.2	1.3	0.0	15.6	25.2	0.0	15.9	17.6	0.0	16.7
Prop In Lane	1.00		1.00	1.00		0.08	1.00		0.27	1.00		0.24
Lane Grp Cap(c), veh/h	216	384	326	380	0	510	225	0	691	238	0	695
V/C Ratio(X)	0.37	0.80	0.52	0.54	0.00	0.90	0.62	0.00	0.74	0.11	0.00	0.76
Avail Cap(c_a), veh/h	248	547	463	380	0	539	225	0	691	238	0	695
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	0.00	1.00	0.65	0.00	0.65	1.00	0.00	1.00
Uniform Delay (d), s/veh	28.8	24.5	23.0	24.5	0.0	22.6	29.0	0.0	17.1	24.6	0.0	17.3
Incr Delay (d2), s/veh	1.1	5.3	1.3	1.6	0.0	17.6	8.1	0.0	4.5	1.0	0.0	7.8
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.2	4.5	2.2	2.7	0.0	8.3	2.5	0.0	6.2	0.4	0.0	7.2
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	29.8	29.9	24.3	26.1	0.0	40.3	37.1	0.0	21.6	25.6	0.0	25.1
LnGrp LOS	C	C	C	C	A	D	D	A	C	C	A	C
Approach Vol, veh/h		557			666			647			557	
Approach Delay, s/veh		28.2			35.8			24.9			25.1	
Approach LOS		C			D			C			C	

Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		31.2	14.5	19.4		31.2	9.8	24.0				
Change Period (Y+Rc), s		6.0	6.0	6.0		6.0	6.0	6.0				
Max Green Setting (Gmax), s		23.0	5.0	19.0		23.0	5.0	19.0				
Max Q Clear Time (g_c+I1), s		27.2	3.3	12.1		19.6	2.0	17.6				
Green Ext Time (p_c), s		0.0	0.1	1.3		1.1	0.0	0.4				

Intersection Summary												
HCM 6th Ctrl Delay			28.7									
HCM 6th LOS			C									



Movement	EBU	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (veh/h)	21	189	210	332	29	143	21	275	291	34	35	377
Future Volume (veh/h)	21	189	210	332	29	143	21	275	291	34	35	377
Initial Q (Qb), veh		0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Parking Bus, Adj		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach			No			No			No			No
Adj Sat Flow, veh/h/ln		1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h		210	233	369	32	159	23	306	323	38	39	419
Peak Hour Factor		0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %		2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h		318	314	266	194	417	59	519	482	57	524	499
Arrive On Green		0.07	0.17	0.17	0.03	0.13	0.13	0.21	0.29	0.29	0.19	0.27
Sat Flow, veh/h		1781	1870	1585	1781	3123	444	1781	1642	193	1781	1870
Grp Volume(v), veh/h		210	233	369	32	89	93	306	0	361	39	419
Grp Sat Flow(s),veh/h/ln		1781	1870	1585	1781	1777	1790	1781	0	1836	1781	1870
Q Serve(g_s), s		5.0	8.9	6.9	1.1	3.4	3.5	5.1	0.0	13.0	0.0	15.9
Cycle Q Clear(g_c), s		5.0	8.9	6.9	1.1	3.4	3.5	5.1	0.0	13.0	0.0	15.9
Prop In Lane		1.00		1.00	1.00		0.25	1.00		0.11	1.00	
Lane Grp Cap(c), veh/h		318	314	266	194	237	239	519	0	538	524	499
V/C Ratio(X)		0.66	0.74	1.39	0.16	0.38	0.39	0.59	0.00	0.67	0.07	0.84
Avail Cap(c_a), veh/h		318	474	402	255	450	454	519	0	538	524	499
HCM Platoon Ratio		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.87	0.87
Uniform Delay (d), s/veh		28.9	29.7	9.5	26.8	29.6	29.7	23.8	0.0	23.3	20.2	26.0
Incr Delay (d2), s/veh		4.9	3.5	193.5	0.4	1.0	1.0	1.8	0.0	6.5	0.1	13.8
Initial Q Delay(d3),s/veh		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln		1.4	4.0	18.4	0.5	1.4	1.5	4.4	0.0	6.0	0.5	8.2
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh		33.8	33.1	203.0	27.2	30.6	30.7	25.5	0.0	29.8	20.3	39.8
LnGrp LOS		C	C	F	C	C	C	C	A	C	C	D
Approach Vol, veh/h			812			214			667			669
Approach Delay, s/veh			110.5			30.2			27.9			30.8
Approach LOS			F			C			C			C

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	20.0	28.0	8.4	18.6	22.0	26.0	11.0	16.0
Change Period (Y+Rc), s	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Max Green Setting (Gmax), s	5.0	22.0	5.0	19.0	7.0	20.0	5.0	19.0
Max Q Clear Time (g_c+I1), s	2.0	15.0	3.1	10.9	7.1	17.9	7.0	5.5
Green Ext Time (p_c), s	0.0	1.1	0.0	1.7	0.0	0.7	0.0	0.7

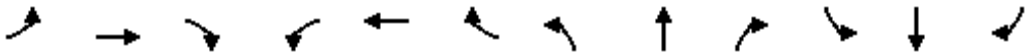
Intersection Summary	
HCM 6th Ctrl Delay	57.3
HCM 6th LOS	E

Notes

User approved ignoring U-Turning movement.



Movement	SBR
Lane Configurations	
Traffic Volume (veh/h)	190
Future Volume (veh/h)	190
Initial Q (Qb), veh	0
Ped-Bike Adj(A_pbT)	1.00
Parking Bus, Adj	1.00
Work Zone On Approach	
Adj Sat Flow, veh/h/ln	1870
Adj Flow Rate, veh/h	211
Peak Hour Factor	0.90
Percent Heavy Veh, %	2
Cap, veh/h	423
Arrive On Green	0.27
Sat Flow, veh/h	1585
Grp Volume(v), veh/h	211
Grp Sat Flow(s),veh/h/ln	1585
Q Serve(g_s), s	5.8
Cycle Q Clear(g_c), s	5.8
Prop In Lane	1.00
Lane Grp Cap(c), veh/h	423
V/C Ratio(X)	0.50
Avail Cap(c_a), veh/h	423
HCM Platoon Ratio	1.00
Upstream Filter(I)	0.87
Uniform Delay (d), s/veh	11.1
Incr Delay (d2), s/veh	3.6
Initial Q Delay(d3),s/veh	0.0
%ile BackOfQ(50%),veh/ln	3.2
Unsig. Movement Delay, s/veh	
LnGrp Delay(d),s/veh	14.7
LnGrp LOS	B
Approach Vol, veh/h	
Approach Delay, s/veh	
Approach LOS	
Timer - Assigned Phs	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	86	309	187	129	297	28	130	245	118	23	290	97
Future Volume (veh/h)	86	309	187	129	297	28	130	245	118	23	290	97
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	96	343	208	143	330	31	144	272	131	26	322	108
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	278	421	356	291	402	38	339	502	242	357	565	189
Arrive On Green	0.06	0.22	0.22	0.08	0.24	0.24	0.42	0.42	0.42	0.42	0.42	0.42
Sat Flow, veh/h	1781	1870	1585	1781	1684	158	958	1193	574	982	1340	449
Grp Volume(v), veh/h	96	343	208	143	0	361	144	0	403	26	0	430
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	0	1842	958	0	1767	982	0	1789
Q Serve(g_s), s	2.6	11.3	7.6	4.0	0.0	12.1	8.8	0.0	11.1	1.3	0.0	11.9
Cycle Q Clear(g_c), s	2.6	11.3	7.6	4.0	0.0	12.1	20.7	0.0	11.1	12.4	0.0	11.9
Prop In Lane	1.00		1.00	1.00		0.09	1.00		0.33	1.00		0.25
Lane Grp Cap(c), veh/h	278	421	356	291	0	439	339	0	744	357	0	754
V/C Ratio(X)	0.35	0.82	0.58	0.49	0.00	0.82	0.42	0.00	0.54	0.07	0.00	0.57
Avail Cap(c_a), veh/h	302	547	463	291	0	538	339	0	744	357	0	754
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	0.00	1.00	0.82	0.00	0.82	1.00	0.00	1.00
Uniform Delay (d), s/veh	18.5	23.9	22.5	18.4	0.0	23.4	22.2	0.0	14.1	18.8	0.0	14.3
Incr Delay (d2), s/veh	0.7	7.2	1.5	1.3	0.0	8.3	3.2	0.0	2.3	0.4	0.0	3.1
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.0	5.2	2.6	1.5	0.0	5.6	2.0	0.0	4.1	0.3	0.0	4.5
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	19.2	31.1	24.0	19.7	0.0	31.7	25.4	0.0	16.4	19.2	0.0	17.4
LnGrp LOS	B	C	C	B	A	C	C	A	B	B	A	B
Approach Vol, veh/h		647			504			547			456	
Approach Delay, s/veh		27.1			28.3			18.8			17.5	
Approach LOS		C			C			B			B	

Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		33.4	11.0	20.6		33.4	10.1	21.5				
Change Period (Y+Rc), s		6.0	6.0	6.0		6.0	6.0	6.0				
Max Green Setting (Gmax), s		23.0	5.0	19.0		23.0	5.0	19.0				
Max Q Clear Time (g_c+I1), s		22.7	6.0	13.3		14.4	4.6	14.1				
Green Ext Time (p_c), s		0.1	0.0	1.3		1.7	0.0	0.8				

Intersection Summary												
HCM 6th Ctrl Delay			23.2									
HCM 6th LOS			C									

HCM 6th Signalized Intersection Summary
1: Houghton Road & Speedway Boulevard

06/10/2019



Movement	EBU	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (veh/h)	44	253	163	259	45	327	43	597	482	47	36	442
Future Volume (veh/h)	44	253	163	259	45	327	43	597	482	47	36	442
Initial Q (Qb), veh		0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Parking Bus, Adj		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach			No			No			No			No
Adj Sat Flow, veh/h/ln		1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h		281	181	288	50	363	48	663	536	52	40	491
Peak Hour Factor		0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %		2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h		322	449	380	230	411	54	583	863	84	149	481
Arrive On Green		0.14	0.24	0.24	0.03	0.13	0.13	0.30	0.51	0.51	0.04	0.26
Sat Flow, veh/h		1781	1870	1585	1781	3158	414	1781	1678	163	1781	1870
Grp Volume(v), veh/h		281	181	288	50	203	208	663	0	588	40	491
Grp Sat Flow(s),veh/h/ln		1781	1870	1585	1781	1777	1796	1781	0	1841	1781	1870
Q Serve(g_s), s		18.7	11.4	11.7	3.4	15.7	16.0	41.8	0.0	31.9	0.0	36.0
Cycle Q Clear(g_c), s		18.7	11.4	11.7	3.4	15.7	16.0	41.8	0.0	31.9	0.0	36.0
Prop In Lane		1.00		1.00	1.00		0.23	1.00		0.09	1.00	
Lane Grp Cap(c), veh/h		322	449	380	230	231	233	583	0	947	149	481
V/C Ratio(X)		0.87	0.40	0.76	0.22	0.88	0.89	1.14	0.00	0.62	0.27	1.02
Avail Cap(c_a), veh/h		322	454	385	235	241	244	583	0	947	149	481
HCM Platoon Ratio		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.67	0.67
Uniform Delay (d), s/veh		43.6	44.8	12.1	50.5	59.8	59.9	47.3	0.0	24.3	63.1	52.0
Incr Delay (d2), s/veh		22.3	0.6	8.3	0.5	28.1	30.0	81.0	0.0	3.1	0.6	39.0
Initial Q Delay(d3),s/veh		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln		10.1	5.3	4.8	1.5	8.8	9.1	32.7	0.0	14.0	1.4	21.6
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh		66.0	45.4	20.4	50.9	87.9	90.0	128.3	0.0	27.3	63.7	91.0
LnGrp LOS		E	D	C	D	F	F	F	A	C	E	F
Approach Vol, veh/h			750			461			1251			914
Approach Delay, s/veh			43.5			84.8			80.8			72.1
Approach LOS			D			F			F			E

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	11.8	78.0	10.6	39.6	47.8	42.0	26.0	24.2
Change Period (Y+Rc), s	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Max Green Setting (Gmax), s	5.0	72.0	5.0	34.0	41.0	36.0	20.0	19.0
Max Q Clear Time (g_c+I1), s	2.0	33.9	5.4	13.7	43.8	38.0	20.7	18.0
Green Ext Time (p_c), s	0.0	3.9	0.0	1.9	0.0	0.0	0.0	0.2

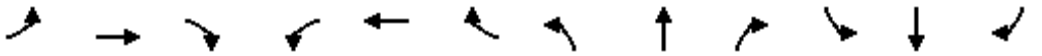
Intersection Summary	
HCM 6th Ctrl Delay	70.7
HCM 6th LOS	E

Notes

User approved ignoring U-Turning movement.



Movement	SBR
Lane Configurations	
Traffic Volume (veh/h)	345
Future Volume (veh/h)	345
Initial Q (Qb), veh	0
Ped-Bike Adj(A_pbT)	1.00
Parking Bus, Adj	1.00
Work Zone On Approach	
Adj Sat Flow, veh/h/ln	1870
Adj Flow Rate, veh/h	383
Peak Hour Factor	0.90
Percent Heavy Veh, %	2
Cap, veh/h	408
Arrive On Green	0.26
Sat Flow, veh/h	1585
Grp Volume(v), veh/h	383
Grp Sat Flow(s),veh/h/ln	1585
Q Serve(g_s), s	22.9
Cycle Q Clear(g_c), s	22.9
Prop In Lane	1.00
Lane Grp Cap(c), veh/h	408
V/C Ratio(X)	0.94
Avail Cap(c_a), veh/h	408
HCM Platoon Ratio	1.00
Upstream Filter(I)	0.67
Uniform Delay (d), s/veh	24.4
Incr Delay (d2), s/veh	24.3
Initial Q Delay(d3),s/veh	0.0
%ile BackOfQ(50%),veh/ln	11.2
Unsig. Movement Delay, s/veh	
LnGrp Delay(d),s/veh	48.7
LnGrp LOS	D
Approach Vol, veh/h	
Approach Delay, s/veh	
Approach LOS	
Timer - Assigned Phs	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	74	278	155	188	382	34	158	420	158	31	471	148
Future Volume (veh/h)	74	278	155	188	382	34	158	420	158	31	471	148
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	82	309	172	209	424	38	176	467	176	34	523	164
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	175	426	361	287	432	39	217	640	241	245	675	212
Arrive On Green	0.05	0.23	0.23	0.08	0.26	0.26	0.49	0.49	0.49	0.49	0.49	0.49
Sat Flow, veh/h	1781	1870	1585	1781	1691	152	755	1295	488	787	1365	428
Grp Volume(v), veh/h	82	309	172	209	0	462	176	0	643	34	0	687
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	0	1843	755	0	1783	787	0	1793
Q Serve(g_s), s	3.1	13.8	8.5	7.0	0.0	22.4	16.3	0.0	25.7	3.2	0.0	28.2
Cycle Q Clear(g_c), s	3.1	13.8	8.5	7.0	0.0	22.4	44.5	0.0	25.7	28.9	0.0	28.2
Prop In Lane	1.00		1.00	1.00		0.08	1.00		0.27	1.00		0.24
Lane Grp Cap(c), veh/h	175	426	361	287	0	471	217	0	882	245	0	887
V/C Ratio(X)	0.47	0.73	0.48	0.73	0.00	0.98	0.81	0.00	0.73	0.14	0.00	0.77
Avail Cap(c_a), veh/h	185	436	370	287	0	471	217	0	882	245	0	887
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	0.00	1.00	0.56	0.00	0.56	1.00	0.00	1.00
Uniform Delay (d), s/veh	26.9	32.2	30.1	28.0	0.0	33.3	38.7	0.0	18.0	29.4	0.0	18.6
Incr Delay (d2), s/veh	2.0	5.8	1.0	9.0	0.0	36.4	16.8	0.0	3.0	1.2	0.0	6.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.3	6.5	3.1	4.0	0.0	14.0	4.8	0.0	9.9	0.7	0.0	11.7
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	28.9	38.0	31.1	37.0	0.0	69.7	55.5	0.0	21.0	30.6	0.0	25.2
LnGrp LOS	C	D	C	D	A	E	E	A	C	C	A	C
Approach Vol, veh/h		563			671			819			721	
Approach Delay, s/veh		34.6			59.5			28.4			25.4	
Approach LOS		C			E			C			C	

Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		50.5	13.0	26.5		50.5	10.5	29.0				
Change Period (Y+Rc), s		6.0	6.0	6.0		6.0	6.0	6.0				
Max Green Setting (Gmax), s		44.0	7.0	21.0		44.0	5.0	23.0				
Max Q Clear Time (g_c+I1), s		46.5	9.0	15.8		30.9	5.1	24.4				
Green Ext Time (p_c), s		0.0	0.0	1.1		3.8	0.0	0.0				

Intersection Summary												
HCM 6th Ctrl Delay			36.4									
HCM 6th LOS			D									

HCM 6th Signalized Intersection Summary
1: Houghton Road & Speedway Boulevard

06/10/2019



Movement	EBU	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (veh/h)	25	214	238	376	31	154	23	368	390	46	41	443
Future Volume (veh/h)	25	214	238	376	31	154	23	368	390	46	41	443
Initial Q (Qb), veh		0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Parking Bus, Adj		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach			No			No			No			No
Adj Sat Flow, veh/h/ln		1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h		238	264	418	34	171	26	409	433	51	46	492
Peak Hour Factor		0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %		2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h		296	324	275	165	464	69	498	675	80	380	582
Arrive On Green		0.06	0.17	0.17	0.03	0.15	0.15	0.22	0.41	0.41	0.12	0.31
Sat Flow, veh/h		1781	1870	1585	1781	3100	464	1781	1642	193	1781	1870
Grp Volume(v), veh/h		238	264	418	34	97	100	409	0	484	46	492
Grp Sat Flow(s),veh/h/ln		1781	1870	1585	1781	1777	1787	1781	0	1836	1781	1870
Q Serve(g_s), s		5.0	12.2	9.0	1.4	4.4	4.5	13.7	0.0	19.0	0.0	22.1
Cycle Q Clear(g_c), s		5.0	12.2	9.0	1.4	4.4	4.5	13.7	0.0	19.0	0.0	22.1
Prop In Lane		1.00		1.00	1.00		0.26	1.00		0.11	1.00	
Lane Grp Cap(c), veh/h		296	324	275	165	266	267	498	0	755	380	582
V/C Ratio(X)		0.80	0.81	1.52	0.21	0.36	0.37	0.82	0.00	0.64	0.12	0.85
Avail Cap(c_a), veh/h		296	395	335	207	375	377	498	0	755	380	582
HCM Platoon Ratio		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.78	0.78
Uniform Delay (d), s/veh		36.2	35.8	12.3	31.3	34.4	34.5	31.0	0.0	21.2	29.0	29.0
Incr Delay (d2), s/veh		14.6	10.4	252.2	0.6	0.8	0.9	10.6	0.0	4.2	0.1	11.4
Initial Q Delay(d3),s/veh		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln		3.8	6.3	22.1	0.6	1.9	2.0	9.2	0.0	8.2	0.8	11.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh		50.8	46.2	264.6	31.9	35.3	35.3	41.6	0.0	25.4	29.1	40.3
LnGrp LOS		D	D	F	C	D	D	D	A	C	C	D
Approach Vol, veh/h			920			231			893			786
Approach Delay, s/veh			146.6			34.8			32.8			32.1
Approach LOS			F			C			C			C

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	16.5	43.0	8.9	21.6	25.5	34.0	11.0	19.5
Change Period (Y+Rc), s	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Max Green Setting (Gmax), s	5.0	37.0	5.0	19.0	14.0	28.0	5.0	19.0
Max Q Clear Time (g_c+I1), s	2.0	21.0	3.4	14.2	15.7	24.1	7.0	6.5
Green Ext Time (p_c), s	0.0	2.5	0.0	1.4	0.0	1.4	0.0	0.7

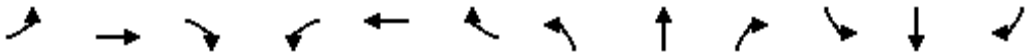
Intersection Summary	
HCM 6th Ctrl Delay	69.8
HCM 6th LOS	E

Notes

User approved ignoring U-Turning movement.



Movement	SBR
Lane Configurations	
Traffic Volume (veh/h)	223
Future Volume (veh/h)	223
Initial Q (Qb), veh	0
Ped-Bike Adj(A_pbT)	1.00
Parking Bus, Adj	1.00
Work Zone On Approach	
Adj Sat Flow, veh/h/ln	1870
Adj Flow Rate, veh/h	248
Peak Hour Factor	0.90
Percent Heavy Veh, %	2
Cap, veh/h	493
Arrive On Green	0.31
Sat Flow, veh/h	1585
Grp Volume(v), veh/h	248
Grp Sat Flow(s),veh/h/ln	1585
Q Serve(g_s), s	8.3
Cycle Q Clear(g_c), s	8.3
Prop In Lane	1.00
Lane Grp Cap(c), veh/h	493
V/C Ratio(X)	0.50
Avail Cap(c_a), veh/h	493
HCM Platoon Ratio	1.00
Upstream Filter(I)	0.78
Uniform Delay (d), s/veh	13.3
Incr Delay (d2), s/veh	2.8
Initial Q Delay(d3),s/veh	0.0
%ile BackOfQ(50%),veh/ln	3.1
Unsig. Movement Delay, s/veh	
LnGrp Delay(d),s/veh	16.2
LnGrp LOS	B
Approach Vol, veh/h	
Approach Delay, s/veh	
Approach LOS	
Timer - Assigned Phs	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	87	312	189	130	299	28	165	310	149	30	377	126
Future Volume (veh/h)	87	312	189	130	299	28	165	310	149	30	377	126
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	97	347	210	144	332	31	183	344	166	33	419	140
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	237	407	345	248	379	35	298	567	274	330	638	213
Arrive On Green	0.06	0.22	0.22	0.07	0.22	0.22	0.48	0.48	0.48	0.48	0.48	0.48
Sat Flow, veh/h	1781	1870	1585	1781	1685	157	850	1192	575	890	1341	448
Grp Volume(v), veh/h	97	347	210	144	0	363	183	0	510	33	0	559
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	0	1842	850	0	1767	890	0	1790
Q Serve(g_s), s	3.1	13.4	9.0	4.7	0.0	14.3	15.7	0.0	16.0	2.1	0.0	17.9
Cycle Q Clear(g_c), s	3.1	13.4	9.0	4.7	0.0	14.3	33.5	0.0	16.0	18.1	0.0	17.9
Prop In Lane	1.00		1.00	1.00		0.09	1.00		0.33	1.00		0.25
Lane Grp Cap(c), veh/h	237	407	345	248	0	414	298	0	841	330	0	852
V/C Ratio(X)	0.41	0.85	0.61	0.58	0.00	0.88	0.61	0.00	0.61	0.10	0.00	0.66
Avail Cap(c_a), veh/h	250	474	402	248	0	467	298	0	841	330	0	852
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	0.00	1.00	0.71	0.00	0.71	1.00	0.00	1.00
Uniform Delay (d), s/veh	22.1	28.2	26.5	22.3	0.0	28.1	27.8	0.0	14.5	21.1	0.0	15.0
Incr Delay (d2), s/veh	1.1	12.5	2.0	3.4	0.0	15.7	6.6	0.0	2.3	0.6	0.0	3.9
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.2	6.8	3.3	2.0	0.0	7.5	3.4	0.0	5.8	0.5	0.0	6.9
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	23.3	40.7	28.5	25.7	0.0	43.7	34.3	0.0	16.8	21.7	0.0	18.9
LnGrp LOS	C	D	C	C	A	D	C	A	B	C	A	B
Approach Vol, veh/h		654			507			693			592	
Approach Delay, s/veh		34.2			38.6			21.4			19.1	
Approach LOS		C			D			C			B	

Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		41.7	11.0	22.3		41.7	10.4	22.9				
Change Period (Y+Rc), s		6.0	6.0	6.0		6.0	6.0	6.0				
Max Green Setting (Gmax), s		33.0	5.0	19.0		33.0	5.0	19.0				
Max Q Clear Time (g_c+I1), s		35.5	6.7	15.4		20.1	5.1	16.3				
Green Ext Time (p_c), s		0.0	0.0	0.9		2.9	0.0	0.5				

Intersection Summary												
HCM 6th Ctrl Delay			27.8									
HCM 6th LOS			C									



Movement	EBU	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (veh/h)	44	253	163	259	45	327	43	597	482	47	36	442
Future Volume (veh/h)	44	253	163	259	45	327	43	597	482	47	36	442
Initial Q (Qb), veh		0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Parking Bus, Adj		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach			No			No			No			No
Adj Sat Flow, veh/h/ln		1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h		281	181	288	50	363	48	663	536	52	40	491
Peak Hour Factor		0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %		2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h		311	390	330	240	458	60	763	615	60	269	582
Arrive On Green		0.12	0.21	0.21	0.06	0.14	0.14	0.16	0.37	0.37	0.10	0.31
Sat Flow, veh/h		1781	1870	1585	1781	3158	414	3456	1678	163	1781	1870
Grp Volume(v), veh/h		281	181	288	50	203	208	663	0	588	40	491
Grp Sat Flow(s),veh/h/ln		1781	1870	1585	1781	1777	1796	1728	0	1841	1781	1870
Q Serve(g_s), s		9.2	7.6	15.8	0.0	9.9	10.1	10.7	0.0	26.7	0.0	22.1
Cycle Q Clear(g_c), s		9.2	7.6	15.8	0.0	9.9	10.1	10.7	0.0	26.7	0.0	22.1
Prop In Lane		1.00		1.00	1.00		0.23	1.00		0.09	1.00	
Lane Grp Cap(c), veh/h		311	390	330	240	258	260	763	0	675	269	582
V/C Ratio(X)		0.90	0.46	0.87	0.21	0.79	0.80	0.87	0.00	0.87	0.15	0.84
Avail Cap(c_a), veh/h		311	478	405	240	336	339	763	0	675	269	582
HCM Platoon Ratio		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.69	0.69
Uniform Delay (d), s/veh		37.1	31.2	34.5	36.9	37.1	37.2	34.6	0.0	26.5	36.3	29.0
Incr Delay (d2), s/veh		27.7	0.9	15.9	0.4	9.0	9.7	10.5	0.0	14.4	0.2	10.1
Initial Q Delay(d3),s/veh		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln		7.8	3.4	7.2	1.0	4.8	5.0	7.6	0.0	13.3	0.8	10.7
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh		64.9	32.1	50.3	37.4	46.2	46.9	45.1	0.0	40.9	36.5	39.0
LnGrp LOS		E	C	D	D	D	D	D	A	D	D	D
Approach Vol, veh/h			750			461			1251			914
Approach Delay, s/veh			51.4			45.6			43.2			37.8
Approach LOS			D			D			D			D

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	15.0	39.0	11.3	24.8	20.0	34.0	17.0	19.0
Change Period (Y+Rc), s	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Max Green Setting (Gmax), s	5.0	33.0	5.0	23.0	10.0	28.0	11.0	17.0
Max Q Clear Time (g_c+I1), s	2.0	28.7	2.0	17.8	12.7	24.1	11.2	12.1
Green Ext Time (p_c), s	0.0	1.4	0.0	0.9	0.0	1.6	0.0	1.0

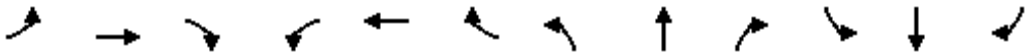
Intersection Summary	
HCM 6th Ctrl Delay	43.9
HCM 6th LOS	D

Notes

User approved pedestrian interval to be less than phase max green.
User approved ignoring U-Turning movement.



Movement	SBR
Lane Configurations	
Traffic Volume (veh/h)	345
Future Volume (veh/h)	345
Initial Q (Qb), veh	0
Ped-Bike Adj(A_pbT)	1.00
Parking Bus, Adj	1.00
Work Zone On Approach	
Adj Sat Flow, veh/h/ln	1870
Adj Flow Rate, veh/h	383
Peak Hour Factor	0.90
Percent Heavy Veh, %	2
Cap, veh/h	493
Arrive On Green	0.31
Sat Flow, veh/h	1585
Grp Volume(v), veh/h	383
Grp Sat Flow(s),veh/h/ln	1585
Q Serve(g_s), s	19.8
Cycle Q Clear(g_c), s	19.8
Prop In Lane	1.00
Lane Grp Cap(c), veh/h	493
V/C Ratio(X)	0.78
Avail Cap(c_a), veh/h	493
HCM Platoon Ratio	1.00
Upstream Filter(I)	0.69
Uniform Delay (d), s/veh	28.2
Incr Delay (d2), s/veh	8.1
Initial Q Delay(d3),s/veh	0.0
%ile BackOfQ(50%),veh/ln	8.1
Unsig. Movement Delay, s/veh	
LnGrp Delay(d),s/veh	36.3
LnGrp LOS	D
Approach Vol, veh/h	
Approach Delay, s/veh	
Approach LOS	
Timer - Assigned Phs	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	74	278	155	188	382	34	158	420	158	31	471	148
Future Volume (veh/h)	74	278	155	188	382	34	158	420	158	31	471	148
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	82	309	172	209	424	38	176	467	176	34	523	164
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	166	360	305	291	432	39	218	928	786	338	677	212
Arrive On Green	0.05	0.19	0.19	0.11	0.26	0.26	0.50	0.50	0.50	0.50	0.50	0.50
Sat Flow, veh/h	1781	1870	1585	1781	1691	152	755	1870	1585	787	1365	428
Grp Volume(v), veh/h	82	309	172	209	0	462	176	467	176	34	0	687
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	0	1843	755	1870	1585	787	0	1793
Q Serve(g_s), s	0.0	14.4	8.8	5.3	0.0	22.4	16.5	15.1	5.7	2.7	0.0	28.2
Cycle Q Clear(g_c), s	0.0	14.4	8.8	5.3	0.0	22.4	44.6	15.1	5.7	17.8	0.0	28.2
Prop In Lane	1.00		1.00	1.00		0.08	1.00		1.00	1.00		0.24
Lane Grp Cap(c), veh/h	166	360	305	291	0	471	218	928	786	338	0	890
V/C Ratio(X)	0.49	0.86	0.56	0.72	0.00	0.98	0.81	0.50	0.22	0.10	0.00	0.77
Avail Cap(c_a), veh/h	179	436	370	291	0	471	218	928	786	338	0	890
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	0.00	1.00	0.53	0.53	0.53	1.00	0.00	1.00
Uniform Delay (d), s/veh	40.7	35.1	32.9	36.7	0.0	33.3	38.5	15.2	12.9	21.2	0.0	18.5
Incr Delay (d2), s/veh	2.3	13.5	1.6	8.2	0.0	36.4	15.5	1.0	0.3	0.6	0.0	6.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.8	7.5	3.3	4.8	0.0	14.0	4.7	5.9	1.9	0.5	0.0	11.7
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	43.0	48.6	34.5	44.9	0.0	69.7	54.0	16.3	13.2	21.8	0.0	25.0
LnGrp LOS	D	D	C	D	A	E	D	B	B	C	A	C
Approach Vol, veh/h		563			671			819			721	
Approach Delay, s/veh		43.5			61.9			23.7			24.8	
Approach LOS		D			E			C			C	

Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		50.6	16.0	23.3		50.6	10.4	29.0				
Change Period (Y+Rc), s		6.0	6.0	6.0		6.0	6.0	6.0				
Max Green Setting (Gmax), s		44.0	7.0	21.0		44.0	5.0	23.0				
Max Q Clear Time (g_c+I1), s		46.6	7.3	16.4		30.2	2.0	24.4				
Green Ext Time (p_c), s		0.0	0.0	1.0		3.9	0.0	0.0				

Intersection Summary												
HCM 6th Ctrl Delay			37.3									
HCM 6th LOS			D									

HCM 6th Signalized Intersection Summary
1: Houghton Road & Speedway Boulevard

06/12/2019



Movement	EBU	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (veh/h)	25	214	238	376	31	154	23	368	390	46	41	443
Future Volume (veh/h)	25	214	238	376	31	154	23	368	390	46	41	443
Initial Q (Qb), veh		0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)		1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Parking Bus, Adj		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach			No			No			No			No
Adj Sat Flow, veh/h/ln		1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h		238	264	418	34	171	26	409	433	51	46	492
Peak Hour Factor		0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %		2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h		458	474	402	156	281	42	593	482	57	310	549
Arrive On Green		0.20	0.25	0.25	0.03	0.09	0.09	0.10	0.29	0.29	0.10	0.29
Sat Flow, veh/h		1781	1870	1585	1781	3100	464	3456	1642	193	1781	1870
Grp Volume(v), veh/h		238	264	418	34	97	100	409	0	484	46	492
Grp Sat Flow(s),veh/h/ln		1781	1870	1585	1781	1777	1787	1728	0	1836	1781	1870
Q Serve(g_s), s		4.1	9.2	19.0	0.0	3.9	4.1	2.9	0.0	19.0	0.0	18.9
Cycle Q Clear(g_c), s		4.1	9.2	19.0	0.0	3.9	4.1	2.9	0.0	19.0	0.0	18.9
Prop In Lane		1.00		1.00	1.00		0.26	1.00		0.11	1.00	
Lane Grp Cap(c), veh/h		458	474	402	156	161	162	593	0	538	310	549
V/C Ratio(X)		0.52	0.56	1.04	0.22	0.60	0.62	0.69	0.00	0.90	0.15	0.90
Avail Cap(c_a), veh/h		458	474	402	215	450	453	593	0	538	310	549
HCM Platoon Ratio		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.79	0.79
Uniform Delay (d), s/veh		24.9	24.3	28.0	35.0	32.8	32.9	30.6	0.0	25.4	29.2	25.4
Incr Delay (d2), s/veh		1.0	1.5	56.0	0.7	3.6	3.8	3.4	0.0	20.5	0.2	16.6
Initial Q Delay(d3),s/veh		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln		3.5	3.9	12.8	0.6	1.8	1.8	3.5	0.0	10.4	0.7	10.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh		25.9	25.8	84.0	35.7	36.4	36.7	34.0	0.0	45.9	29.4	42.0
LnGrp LOS		C	C	F	D	D	D	C	A	D	C	D
Approach Vol, veh/h			920			231			893			786
Approach Delay, s/veh			52.3			36.4			40.5			36.1
Approach LOS			D			D			D			D

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	13.5	28.0	8.5	25.0	13.5	28.0	20.7	12.8
Change Period (Y+Rc), s	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Max Green Setting (Gmax), s	5.0	22.0	5.0	19.0	5.0	22.0	5.0	19.0
Max Q Clear Time (g_c+I1), s	2.0	21.0	2.0	21.0	4.9	20.9	6.1	6.1
Green Ext Time (p_c), s	0.0	0.3	0.0	0.0	0.0	0.5	0.0	0.7

Intersection Summary	
HCM 6th Ctrl Delay	42.8
HCM 6th LOS	D

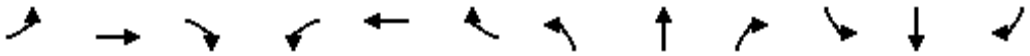
Notes

User approved pedestrian interval to be less than phase max green.

User approved ignoring U-Turning movement.



Movement	SBR
Lane Configurations	
Traffic Volume (veh/h)	223
Future Volume (veh/h)	223
Initial Q (Qb), veh	0
Ped-Bike Adj(A_pbT)	1.00
Parking Bus, Adj	1.00
Work Zone On Approach	
Adj Sat Flow, veh/h/ln	1870
Adj Flow Rate, veh/h	248
Peak Hour Factor	0.90
Percent Heavy Veh, %	2
Cap, veh/h	465
Arrive On Green	0.29
Sat Flow, veh/h	1585
Grp Volume(v), veh/h	248
Grp Sat Flow(s),veh/h/ln	1585
Q Serve(g_s), s	9.8
Cycle Q Clear(g_c), s	9.8
Prop In Lane	1.00
Lane Grp Cap(c), veh/h	465
V/C Ratio(X)	0.53
Avail Cap(c_a), veh/h	465
HCM Platoon Ratio	1.00
Upstream Filter(I)	0.79
Uniform Delay (d), s/veh	22.2
Incr Delay (d2), s/veh	3.4
Initial Q Delay(d3),s/veh	0.0
%ile BackOfQ(50%),veh/ln	3.8
Unsig. Movement Delay, s/veh	
LnGrp Delay(d),s/veh	25.6
LnGrp LOS	C
Approach Vol, veh/h	
Approach Delay, s/veh	
Approach LOS	
Timer - Assigned Phs	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	87	312	189	130	299	28	165	310	149	30	377	126
Future Volume (veh/h)	87	312	189	130	299	28	165	310	149	30	377	126
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	97	347	210	144	332	31	183	344	166	33	419	140
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	227	407	345	244	377	35	301	894	758	417	641	214
Arrive On Green	0.06	0.22	0.22	0.06	0.22	0.22	0.48	0.48	0.48	0.48	0.48	0.48
Sat Flow, veh/h	1781	1870	1585	1781	1685	157	850	1870	1585	890	1341	448
Grp Volume(v), veh/h	97	347	210	144	0	363	183	344	166	33	0	559
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	0	1842	850	1870	1585	890	0	1790
Q Serve(g_s), s	0.0	13.4	9.0	0.2	0.0	14.3	15.6	8.8	4.6	1.8	0.0	17.8
Cycle Q Clear(g_c), s	0.0	13.4	9.0	0.2	0.0	14.3	33.4	8.8	4.6	10.7	0.0	17.8
Prop In Lane	1.00		1.00	1.00		0.09	1.00		1.00	1.00		0.25
Lane Grp Cap(c), veh/h	227	407	345	244	0	413	301	894	758	417	0	856
V/C Ratio(X)	0.43	0.85	0.61	0.59	0.00	0.88	0.61	0.38	0.22	0.08	0.00	0.65
Avail Cap(c_a), veh/h	242	474	402	248	0	467	301	894	758	417	0	856
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	0.00	1.00	0.75	0.75	0.75	1.00	0.00	1.00
Uniform Delay (d), s/veh	33.0	28.2	26.5	32.5	0.0	28.1	27.5	12.5	11.4	15.9	0.0	14.8
Incr Delay (d2), s/veh	1.3	12.5	2.0	3.6	0.0	16.0	6.7	0.9	0.5	0.4	0.0	3.9
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.6	6.8	3.3	2.5	0.0	7.5	3.4	3.3	1.5	0.4	0.0	6.9
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	34.3	40.7	28.5	36.1	0.0	44.2	34.2	13.5	11.9	16.3	0.0	18.7
LnGrp LOS	C	D	C	D	A	D	C	B	B	B	A	B
Approach Vol, veh/h		654			507			693			592	
Approach Delay, s/veh		35.9			41.9			18.6			18.6	
Approach LOS		D			D			B			B	

Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		41.9	10.8	22.3		41.9	10.3	22.8				
Change Period (Y+Rc), s		6.0	6.0	6.0		6.0	6.0	6.0				
Max Green Setting (Gmax), s		33.0	5.0	19.0		33.0	5.0	19.0				
Max Q Clear Time (g_c+I1), s		35.4	2.2	15.4		19.8	2.0	16.3				
Green Ext Time (p_c), s		0.0	0.1	0.9		3.0	0.0	0.5				

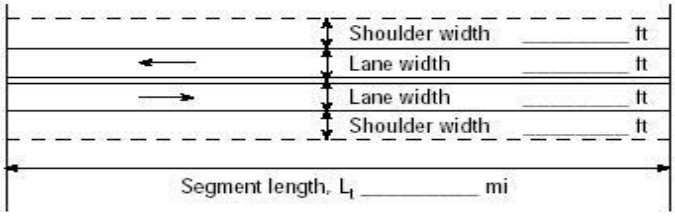
Intersection Summary												
HCM 6th Ctrl Delay			28.0									
HCM 6th LOS			C									

DIRECTIONAL TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		***Site Information***	
Analyst	*Joseph A. Vaskovic*	Highway / Direction of Travel	*Houghton Road*
Agency or Company	*WSP*	From/To	*Speedway Blvd to Tanque Verde*
Date Performed	*6/13/2019*	Jurisdiction	*City of Tucson*
Analysis Time Period	*AM Peak*	Analysis Year	*2019 Existing*

Project Description: *Houghton Road Needs Assessment*

Input Data



Show North Arrow

☑ Class I highway ☐ Class II highway ☐ Class III highway

Terrain ☑ Level ☐ Rolling

Grade Length mi Up/down

Peak-hour factor, PHF *0.88*

No-passing zone *100%*

% Trucks and Buses , P_T *2 %*

% Recreational vehicles, P_R *2%*

Access points *mi* *2*/mi

Analysis direction vol., V_d *623*veh/h

Opposing direction vol., V_o *698*veh/h

Shoulder width ft *8.0*

Lane Width ft *12.0*

Segment Length mi *1.7*

Average Travel Speed

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T (Exhibit 15-11 or 15-12)	*1.1*	*1.1*
Passenger-car equivalents for RVs, E_R (Exhibit 15-11 or 15-13)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV,ATS}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*0.998*	*0.998*
Grade adjustment factor[1], $f_{g,ATS}$ (Exhibit 15-9)	*1.00*	*1.00*
Demand flow rate[2], v_i (pc/h) $v_i=V_i/(PHF*f_{g,ATS}*f_{HV,ATS})$	*709*	*795*

Free-Flow Speed from Field Measurement		**Estimated Free-Flow Speed**	
Mean speed of sample[3], S_{FM}		Base free-flow speed[4], BFFS	*45.0 mi/h*
Total demand flow rate, both directions, *v*		Adj. for lane and shoulder width,[4] f_{LS}(Exhibit 15-7)	*0.0 mi/h*
Free-flow speed, FFS=S_{FM}+0.00776(*v*/ $f_{HV,ATS}$)		Adj. for access points[4], f_A (Exhibit 15-8)	*0.5 mi/h*
Adj. for no-passing zones, $f_{np,ATS}$ (Exhibit 15-15)	*1.2 mi/h*	Free-flow speed, FFS (FSS=BFFS-f_{LS}-f_A)	*44.5 mi/h*
		Average travel speed, ATS_d=FFS-0.00776($v_{d,ATS}$ + $v_{o,ATS}$) - $f_{np,ATS}$	*31.6 mi/h*
		Percent free flow speed, PFFS	*71.0 %*

Percent Time-Spent-Following

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T(Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Passenger-car equivalents for RVs, E_R (Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*1.000*	*1.000*
Grade adjustment factor[1], $f_{g,PTSF}$ (Exhibit 15-16 or Ex 15-17)	*1.00*	*1.00*
Directional flow rate[2], v_i(pc/h) $v_i=V_i/(PHF*f_{HV,PTSF}*f_{g,PTSF})$	*708*	*793*
Base percent time-spent-following[4], $BPTSF_d(\%)=100(1-e^{av_d^b})$	*65.8*	
Adj. for no-passing zone, $f_{np,PTSF}$ (Exhibit 15-21)	*26.6*	
Percent time-spent-following, $PTSF_d(\%)=BPTSF_d+f_{np,PTSF}*(v_{d,PTSF}/v_{d,PTSF}+v_{o,PTSF})$	*78.3*	

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 15-3)	*E*
Volume to capacity ratio, *v/c*	*0.42*

Capacity, $C_{d,ATS}$ (Equation 15-12) veh/h	*1700*
Capacity, $C_{d,PTSF}$ (Equation 15-13) veh/h	*1700*
Percent Free-Flow Speed $PFFS_d$(Equation 15-11 - Class III only)	*71.0*
Bicycle Level of Service	
Directional demand flow rate in outside lane, v_{OL} (Eq. 15-24) veh/h	*708.0*
Effective width, Wv (Eq. 15-29) ft	*28.00*
Effective speed factor, S_t (Eq. 15-30)	*4.42*
Bicycle level of service score, BLOS (Eq. 15-31)	*2.24*
Bicycle level of service (Exhibit 15-4)	*B*

Notes

1. Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.
2. If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

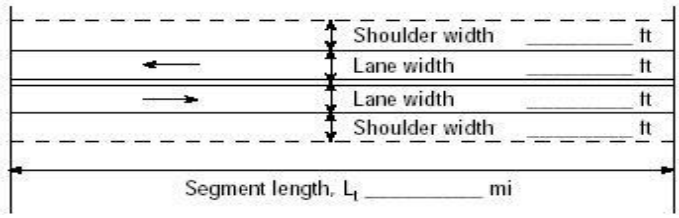
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DIRECTIONAL TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		***Site Information***	
Analyst	*Joseph A. Vaskovic*	Highway / Direction of Travel	*Houghton Road*
Agency or Company	*WSP*	From/To	*Speedway Blvd to Tanque Verde*
Date Performed	*6/13/2019*	Jurisdiction	*City of Tucson*
Analysis Time Period	*PM Peak*	Analysis Year	*2030 Existing*

Project Description: *Houghton Road Needs Assessment*

Input Data



Show North Arrow

☑ Class I highway ☐ Class II highway ☐ Class III highway

Terrain ☑ Level ☐ Rolling

Grade Length mi Up/down

Peak-hour factor, PHF *0.88*

No-passing zone *100%*

Analysis direction vol., V_d *501*veh/h

Opposing direction vol., V_o *602*veh/h

% Trucks and Buses , P_T *2* %

% Recreational vehicles, P_R *2%*

Access points *mi* *2*/mi

Shoulder width *8.0* ft

Lane Width *12.0* ft

Segment Length *1.7* mi

Average Travel Speed

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T (Exhibit 15-11 or 15-12)	*1.1*	*1.1*
Passenger-car equivalents for RVs, E_R (Exhibit 15-11 or 15-13)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV,ATS}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*0.998*	*0.998*
Grade adjustment factor[1], $f_{g,ATS}$ (Exhibit 15-9)	*1.00*	*1.00*
Demand flow rate[2], v_i (pc/h) $v_i=V_i/(PHF*f_{g,ATS}*f_{HV,ATS})$	*570*	*685*

Free-Flow Speed from Field Measurement		**Estimated Free-Flow Speed**	
Mean speed of sample[3], S_{FM}		Base free-flow speed[4], BFFS	*45.0 mi/h*
Total demand flow rate, both directions, *v*		Adj. for lane and shoulder width,[4] f_{LS}(Exhibit 15-7)	*0.0 mi/h*
Free-flow speed, $FFS=S_{FM}+0.00776(v/f_{HV,ATS})$		Adj. for access points[4], f_A (Exhibit 15-8)	*0.5 mi/h*
Adj. for no-passing zones, $f_{np,ATS}$ (Exhibit 15-15)	*1.5 mi/h*	Free-flow speed, FFS (FSS=BFFS-f_{LS}-f_A)	*44.5 mi/h*
		Average travel speed, ATS_d=FFS-0.00776($v_{d,ATS}$ + $v_{o,ATS}$) - $f_{np,ATS}$	*33.2 mi/h*
		Percent free flow speed, PFFS	*74.6 %*

Percent Time-Spent-Following

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T(Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Passenger-car equivalents for RVs, E_R (Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*1.000*	*1.000*
Grade adjustment factor[1], $f_{g,PTSF}$ (Exhibit 15-16 or Ex 15-17)	*1.00*	*1.00*
Directional flow rate[2], v_i(pc/h) $v_i=V_i/(PHF*f_{HV,PTSF}*f_{g,PTSF})$	*569*	*684*
Base percent time-spent-following[4], $BPTSF_d(\%)=100(1-e^{av_d^b})$	*57.5*	
Adj. for no-passing zone, $f_{np,PTSF}$ (Exhibit 15-21)	*32.0*	
Percent time-spent-following, $PTSF_d(\%)=BPTSF_d+f_{np,PTSF}*(v_{d,PTSF}/v_{d,PTSF}+v_{o,PTSF})$	*72.0*	

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 15-3)	*E*
Volume to capacity ratio, *v/c*	*0.33*

Capacity, $C_{d,ATS}$ (Equation 15-12) veh/h	*1700*
Capacity, $C_{d,PTSF}$ (Equation 15-13) veh/h	*1700*
Percent Free-Flow Speed $PFFS_d$(Equation 15-11 - Class III only)	*74.6*
Bicycle Level of Service	
Directional demand flow rate in outside lane, v_{OL} (Eq. 15-24) veh/h	*569.3*
Effective width, Wv (Eq. 15-29) ft	*28.00*
Effective speed factor, S_t (Eq. 15-30)	*4.42*
Bicycle level of service score, BLOS (Eq. 15-31)	*2.13*
Bicycle level of service (Exhibit 15-4)	*B*

Notes

1. Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.
2. If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

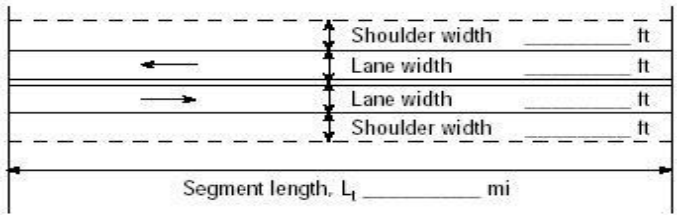
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DIRECTIONAL TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		***Site Information***	
Analyst	*Joseph A. Vaskovic*	Highway / Direction of Travel	*Houghton Road*
Agency or Company	*WSP*	From/To	*Speedway Blvd to Tanque Verde*
Date Performed	*6/13/2019*	Jurisdiction	*City of Tucson*
Analysis Time Period	*AM Peak*	Analysis Year	*2030 - Existing*

Project Description: *Houghton Road Needs Assessment*

Input Data



Analysis direction vol., V_d *778*veh/h

Opposing direction vol., V_o *820*veh/h

Shoulder width ft *8.0*

Lane Width ft *12.0*

Segment Length mi *1.7*

Show North Arrow

☑ Class I highway ☐ Class II highway ☐ Class III highway

Terrain ☑ Level ☐ Rolling

Grade Length mi Up/down

Peak-hour factor, PHF *0.88*

No-passing zone *100%*

% Trucks and Buses , P_T *2 %*

% Recreational vehicles, P_R *2%*

Access points *mi* *2*/mi

Average Travel Speed

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T (Exhibit 15-11 or 15-12)	*1.0*	*1.0*
Passenger-car equivalents for RVs, E_R (Exhibit 15-11 or 15-13)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV,ATS}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*1.000*	*1.000*
Grade adjustment factor[1], $f_{g,ATS}$ (Exhibit 15-9)	*1.00*	*1.00*
Demand flow rate[2], v_i (pc/h) $v_i=V_i/(PHF*f_{g,ATS}*f_{HV,ATS})$	*884*	*932*

Free-Flow Speed from Field Measurement		**Estimated Free-Flow Speed**	
Mean speed of sample[3], S_{FM}		Base free-flow speed[4], BFFS	*45.0 mi/h*
Total demand flow rate, both directions, *v*		Adj. for lane and shoulder width,[4] f_{LS}(Exhibit 15-7)	*0.0 mi/h*
Free-flow speed, $FFS=S_{FM}+0.00776(v/f_{HV,ATS})$		Adj. for access points[4], f_A (Exhibit 15-8)	*0.5 mi/h*
Adj. for no-passing zones, $f_{np,ATS}$ (Exhibit 15-15)	*1.1 mi/h*	Free-flow speed, FFS (FSS=BFFS-f_{LS}-f_A)	*44.5 mi/h*
		Average travel speed, $ATS_d=FFS-0.00776(v_{d,ATS}+v_{o,ATS})-f_{np,ATS}$	*29.3 mi/h*
		Percent free flow speed, PFFS	*65.8 %*

Percent Time-Spent-Following

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T(Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Passenger-car equivalents for RVs, E_R (Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*1.000*	*1.000*
Grade adjustment factor[1], $f_{g,PTSF}$ (Exhibit 15-16 or Ex 15-17)	*1.00*	*1.00*
Directional flow rate[2], v_i(pc/h) $v_i=V_i/(PHF*f_{HV,PTSF}*f_{g,PTSF})$	*884*	*932*
Base percent time-spent-following[4], $BPTSF_d(\%)=100(1-e^{av_d^b})$	*73.8*	
Adj. for no-passing zone, $f_{np,PTSF}$ (Exhibit 15-21)	*21.6*	
Percent time-spent-following, $PTSF_d(\%)=BPTSF_d+f_{np,PTSF}*(v_{d,PTSF}/v_{d,PTSF}+v_{o,PTSF})$	*84.3*	

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 15-3)	*E*
Volume to capacity ratio, *v/c*	*0.52*

Capacity, $C_{d,ATS}$ (Equation 15-12) veh/h	*1700*
Capacity, $C_{d,PTSF}$ (Equation 15-13) veh/h	*1700*
Percent Free-Flow Speed $PFFS_d$(Equation 15-11 - Class III only)	*65.8*
Bicycle Level of Service	
Directional demand flow rate in outside lane, v_{OL} (Eq. 15-24) veh/h	*884.1*
Effective width, Wv (Eq. 15-29) ft	*28.00*
Effective speed factor, S_t (Eq. 15-30)	*4.42*
Bicycle level of service score, BLOS (Eq. 15-31)	*2.35*
Bicycle level of service (Exhibit 15-4)	*B*
Notes	

1. Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.
2. If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

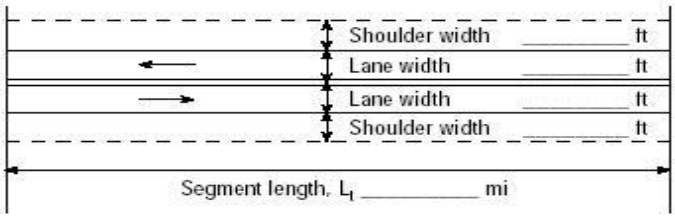
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DIRECTIONAL TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		***Site Information***	
Analyst	*Joseph A. Vaskovic*	Highway / Direction of Travel	*Houghton Road*
Agency or Company	*WSP*	From/To	*Speedway Blvd to Tanque Verde*
Date Performed	*6/13/2019*	Jurisdiction	*City of Tucson*
Analysis Time Period	*PM Peak*	Analysis Year	*2030 Existing*

Project Description: *Houghton Road Needs Assessment*

Input Data



Show North Arrow

☑ Class I highway ☐ Class II highway ☐ Class III highway

Terrain ☑ Level ☐ Rolling

Analysis direction vol., V_d	*627*veh/h	Grade Length	mi Up/down
Opposing direction vol., V_o	*707*veh/h	Peak-hour factor, PHF	*0.88*
Shoulder width ft	*8.0*	No-passing zone	*100%*
Lane Width ft	*12.0*	% Trucks and Buses , P_T	*2* %
Segment Length mi	*1.7*	% Recreational vehicles, P_R	*2%*
		Access points *mi*	*2*/mi

Average Travel Speed

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T (Exhibit 15-11 or 15-12)	*1.1*	*1.1*
Passenger-car equivalents for RVs, E_R (Exhibit 15-11 or 15-13)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV,ATS}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*0.998*	*0.998*
Grade adjustment factor[1], $f_{g,ATS}$ (Exhibit 15-9)	*1.00*	*1.00*
Demand flow rate[2], v_i (pc/h) $v_i=V_i/(PHF*f_{g,ATS}*f_{HV,ATS})$	*714*	*805*

Free-Flow Speed from Field Measurement		**Estimated Free-Flow Speed**	
Mean speed of sample[3], S_{FM}		Base free-flow speed[4], BFFS	*45.0 mi/h*
Total demand flow rate, both directions, *v*		Adj. for lane and shoulder width,[4] f_{LS}(Exhibit 15-7)	*0.0 mi/h*
Free-flow speed, FFS=$S_{FM}+0.00776(v/f_{HV,ATS})$		Adj. for access points[4], f_A (Exhibit 15-8)	*0.5 mi/h*
Adj. for no-passing zones, $f_{np,ATS}$ (Exhibit 15-15)	*1.2 mi/h*	Free-flow speed, FFS (FSS=BFFS-f_{LS}-f_A)	*44.5 mi/h*
		Average travel speed, ATS_d=FFS-0.00776($v_{d,ATS}$ + $v_{o,ATS}$) - $f_{np,ATS}$	*31.5 mi/h*
		Percent free flow speed, PFFS	*70.8 %*

Percent Time-Spent-Following

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T(Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Passenger-car equivalents for RVs, E_R (Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*1.000*	*1.000*
Grade adjustment factor[1], $f_{g,PTSF}$ (Exhibit 15-16 or Ex 15-17)	*1.00*	*1.00*
Directional flow rate[2], v_i(pc/h) $v_i=V_i/(PHF*f_{HV,PTSF}*f_{g,PTSF})$	*713*	*803*
Base percent time-spent-following[4], $BPTSF_d(\%)=100(1-e^{av_d^b})$	*65.7*	
Adj. for no-passing zone, $f_{np,PTSF}$ (Exhibit 15-21)	*26.3*	
Percent time-spent-following, $PTSF_d(\%)=BPTSF_d+f_{np,PTSF}*(v_{d,PTSF}/v_{d,PTSF}+v_{o,PTSF})$	*78.1*	

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 15-3)	*E*
Volume to capacity ratio, *v/c*	*0.42*

Capacity, $C_{d,ATS}$ (Equation 15-12) veh/h	*1700*
Capacity, $C_{d,PTSF}$ (Equation 15-13) veh/h	*1700*
Percent Free-Flow Speed $PFFS_d$(Equation 15-11 - Class III only)	*70.8*
Bicycle Level of Service	
Directional demand flow rate in outside lane, v_{OL} (Eq. 15-24) veh/h	*712.5*
Effective width, Wv (Eq. 15-29) ft	*28.00*
Effective speed factor, S_t (Eq. 15-30)	*4.42*
Bicycle level of service score, BLOS (Eq. 15-31)	*2.24*
Bicycle level of service (Exhibit 15-4)	*B*
Notes	

1. Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.
2. If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

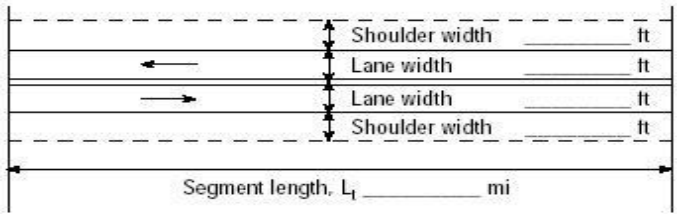
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DIRECTIONAL TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		***Site Information***	
Analyst	*Joseph A. Vaskovic*	Highway / Direction of Travel	*Houghton Road*
Agency or Company	*WSP*	From/To	*Broadway Blvd to Speedway Blvd*
Date Performed	*6/28/2019*	Jurisdiction	*City of Tucson*
Analysis Time Period	*AM Peak*	Analysis Year	*2019 Existing*

Project Description: *Houghton Road Needs Assessment*

Input Data





☑ Class I highway ☐ Class II highway ☐ Class III highway

Terrain ☐ Level ☐ Rolling

Grade Length *1.00* mi Up/down *-3.0*

Peak-hour factor, PHF *0.88*

No-passing zone *100%*

% Trucks and Buses , P_T *2 %*

% Recreational vehicles, P_R *2%*

Access points *mi* *2*/mi

Analysis direction vol., V_d *841*veh/h

Opposing direction vol., V_o *647*veh/h

Shoulder width ft *6.0*

Lane Width ft *12.0*

Segment Length mi *0.5*

Average Travel Speed

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T (Exhibit 15-11 or 15-12)	*1.1*	*4.2*
Passenger-car equivalents for RVs, E_R (Exhibit 15-11 or 15-13)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV,ATS}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*0.998*	*0.940*
Grade adjustment factor[1], $f_{g,ATS}$ (Exhibit 15-9)	*1.00*	*1.00*
Demand flow rate[2], v_i (pc/h) $v_i=V_i/(PHF*f_{g,ATS}*f_{HV,ATS})$	*958*	*782*

Free-Flow Speed from Field Measurement		**Estimated Free-Flow Speed**	
Mean speed of sample[3], S_{FM}		Base free-flow speed[4], BFFS	*45.0 mi/h*
Total demand flow rate, both directions, *v*		Adj. for lane and shoulder width,[4] f_{LS}(Exhibit 15-7)	*0.0 mi/h*
Free-flow speed, $FFS=S_{FM}+0.00776(v/f_{HV,ATS})$		Adj. for access points[4], f_A (Exhibit 15-8)	*0.5 mi/h*
Adj. for no-passing zones, $f_{np,ATS}$ (Exhibit 15-15)	*1.3 mi/h*	Free-flow speed, FFS (FSS=BFFS-f_{LS}-f_A)	*44.5 mi/h*
		Average travel speed, $ATS_d=FFS-0.00776(v_{d,ATS}+v_{o,ATS})-f_{np,ATS}$	*29.7 mi/h*
		Percent free flow speed, PFFS	*66.8 %*

Percent Time-Spent-Following

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T(Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Passenger-car equivalents for RVs, E_R (Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*1.000*	*1.000*
Grade adjustment factor[1], $f_{g,PTSF}$ (Exhibit 15-16 or Ex 15-17)	*1.00*	*0.93*
Directional flow rate[2], v_i(pc/h) $v_i=V_i/(PHF*f_{HV,PTSF}*f_{g,PTSF})$	*956*	*791*
Base percent time-spent-following[4], $BPTSF_d(\%)=100(1-e^{av_d^b})$	*74.2*	
Adj. for no-passing zone, $f_{np,PTSF}$ (Exhibit 15-21)	*22.0*	
Percent time-spent-following, $PTSF_d(\%)=BPTSF_d+f_{np,PTSF}*(v_{d,PTSF}/v_{d,PTSF}+v_{o,PTSF})$	*86.2*	

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 15-3)	*E*

Volume to capacity ratio, *v/c*	*0.56*
Capacity, $C_{d,ATS}$ (Equation 15-12) veh/h	*1700*
Capacity, $C_{d,PTSF}$ (Equation 15-13) veh/h	*1700*
Percent Free-Flow Speed $PFFS_d$(Equation 15-11 - Class III only)	*66.8*
Bicycle Level of Service	
Directional demand flow rate in outside lane, v_{OL} (Eq. 15-24) veh/h	*955.7*
Effective width, Wv (Eq. 15-29) ft	*24.00*
Effective speed factor, S_t (Eq. 15-30)	*4.42*
Bicycle level of service score, BLOS (Eq. 15-31)	*3.43*
Bicycle level of service (Exhibit 15-4)	*C*
Notes	

1. Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.
2. If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

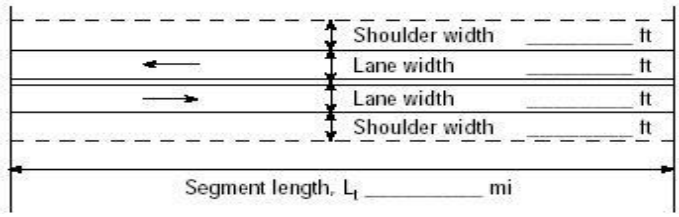
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DIRECTIONAL TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		***Site Information***	
Analyst	*Joseph A. Vaskovic*	Highway / Direction of Travel	*Houghton Road*
Agency or Company	*WSP*	From/To	*Broadway Blvd to Speedway Blvd*
Date Performed	*6/28/2019*	Jurisdiction	*City of Tucson*
Analysis Time Period	*PM Peak*	Analysis Year	*2019 Existing*

Project Description: *Houghton Road Needs Assessment*

Input Data



Analysis direction vol., V_d *600*veh/h

Opposing direction vol., V_o *738*veh/h

Shoulder width ft *6.0*

Lane Width ft *12.0*

Segment Length mi *0.5*



☑ Class I highway ☐ Class II highway ☐ Class III highway

Terrain ☐ Level ☐ Rolling

Grade Length *1.00* mi Up/down *-3.0*

Peak-hour factor, PHF *0.88*

No-passing zone *100%*

% Trucks and Buses , P_T *2 %*

% Recreational vehicles, P_R *2%*

Access points *mi* *2*/mi

Average Travel Speed

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T (Exhibit 15-11 or 15-12)	*1.1*	*4.2*
Passenger-car equivalents for RVs, E_R (Exhibit 15-11 or 15-13)	*1.1*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV,ATS}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*0.996*	*0.940*
Grade adjustment factor[1], $f_{g,ATS}$ (Exhibit 15-9)	*1.00*	*1.00*
Demand flow rate[2], v_i (pc/h) $v_i=V_i/(PHF*f_{g,ATS}*f_{HV,ATS})$	*685*	*892*

Free-Flow Speed from Field Measurement		**Estimated Free-Flow Speed**	
Mean speed of sample[3], S_{FM}		Base free-flow speed[4], BFFS	*45.0 mi/h*
Total demand flow rate, both directions, *v*		Adj. for lane and shoulder width,[4] f_{LS}(Exhibit 15-7)	*0.0 mi/h*
Free-flow speed, $FFS=S_{FM}+0.00776(v/f_{HV,ATS})$		Adj. for access points[4], f_A (Exhibit 15-8)	*0.5 mi/h*
Adj. for no-passing zones, $f_{np,ATS}$ (Exhibit 15-15)	*1.2 mi/h*	Free-flow speed, FFS (FSS=BFFS-f_{LS}-f_A)	*44.5 mi/h*
		Average travel speed, $ATS_d=FFS-0.00776(v_{d,ATS}+v_{o,ATS})-f_{np,ATS}$	*31.1 mi/h*
		Percent free flow speed, PFFS	*69.9 %*

Percent Time-Spent-Following

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T(Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Passenger-car equivalents for RVs, E_R (Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*1.000*	*1.000*
Grade adjustment factor[1], $f_{g,PTSF}$ (Exhibit 15-16 or Ex 15-17)	*1.00*	*0.93*
Directional flow rate[2], v_i(pc/h) $v_i=V_i/(PHF*f_{HV,PTSF}*f_{g,PTSF})$	*682*	*902*
Base percent time-spent-following[4], $BPTSF_d(\%)=100(1-e^{av_d^b})$	*65.5*	
Adj. for no-passing zone, $f_{np,PTSF}$ (Exhibit 15-21)	*24.9*	
Percent time-spent-following, $PTSF_d(\%)=BPTSF_d+f_{np,PTSF}*(v_{d,PTSF}/v_{d,PTSF}+v_{o,PTSF})$	*76.2*	

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 15-3)	*E*

Volume to capacity ratio, *v/c*	*0.40*
Capacity, $C_{d,ATS}$ (Equation 15-12) veh/h	*1700*
Capacity, $C_{d,PTSF}$ (Equation 15-13) veh/h	*1700*
Percent Free-Flow Speed $PFFS_d$(Equation 15-11 - Class III only)	*69.9*
Bicycle Level of Service	
Directional demand flow rate in outside lane, v_{OL} (Eq. 15-24) veh/h	*681.8*
Effective width, Wv (Eq. 15-29) ft	*24.00*
Effective speed factor, S_t (Eq. 15-30)	*4.42*
Bicycle level of service score, BLOS (Eq. 15-31)	*3.26*
Bicycle level of service (Exhibit 15-4)	*C*
Notes	

1. Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.
2. If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

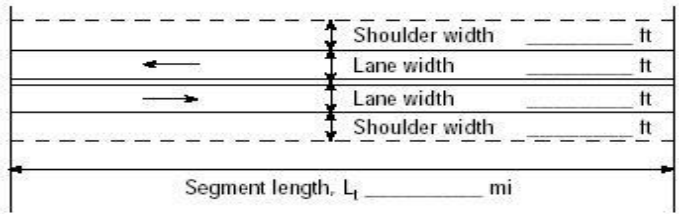
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DIRECTIONAL TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		***Site Information***	
Analyst	*Joseph A. Vaskovic*	Highway / Direction of Travel	*Houghton Road*
Agency or Company	*WSP*	From/To	*Broadway Blvd to Speedway Blvd*
Date Performed	*6/28/2019*	Jurisdiction	*City of Tucson*
Analysis Time Period	*PM Peak*	Analysis Year	*2030 Existing*

Project Description: *Houghton Road Needs Assessment*

Input Data



Analysis direction vol., V_d *1126*veh/h

Opposing direction vol., V_o *746*veh/h

Shoulder width ft *6.0*

Lane Width ft *12.0*

Segment Length mi *0.5*



☑ Class I highway ☐ Class II highway ☐ Class III highway

Terrain ☐ Level ☐ Rolling

Grade Length *1.00* mi Up/down *-3.0*

Peak-hour factor, PHF *0.88*

No-passing zone *100%*

% Trucks and Buses , P_T *2 %*

% Recreational vehicles, P_R *2%*

Access points *mi* *2*/mi

Average Travel Speed

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T (Exhibit 15-11 or 15-12)	*1.1*	*4.2*
Passenger-car equivalents for RVs, E_R (Exhibit 15-11 or 15-13)	*1.1*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV,ATS}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*0.996*	*0.940*
Grade adjustment factor[1], $f_{g,ATS}$ (Exhibit 15-9)	*1.00*	*1.00*
Demand flow rate[2], v_i (pc/h) $v_i=V_i/(PHF*f_{g,ATS}*f_{HV,ATS})$	*1285*	*902*

Free-Flow Speed from Field Measurement		**Estimated Free-Flow Speed**	
Mean speed of sample[3], S_{FM}		Base free-flow speed[4], BFFS	*45.0 mi/h*
Total demand flow rate, both directions, *v*		Adj. for lane and shoulder width,[4] f_{LS}(Exhibit 15-7)	*0.0 mi/h*
Free-flow speed, $FFS=S_{FM}+0.00776(v/f_{HV,ATS})$		Adj. for access points[4], f_A (Exhibit 15-8)	*0.5 mi/h*
Adj. for no-passing zones, $f_{np,ATS}$ (Exhibit 15-15)	*1.1 mi/h*	Free-flow speed, FFS (FSS=BFFS-f_{LS}-f_A)	*44.5 mi/h*
		Average travel speed, $ATS_d=FFS-0.00776(v_{d,ATS}+v_{o,ATS})-f_{np,ATS}$	*26.4 mi/h*
		Percent free flow speed, PFFS	*59.3 %*

Percent Time-Spent-Following

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T(Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Passenger-car equivalents for RVs, E_R (Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*1.000*	*1.000*
Grade adjustment factor[1], $f_{g,PTSF}$ (Exhibit 15-16 or Ex 15-17)	*1.00*	*0.93*
Directional flow rate[2], v_i(pc/h) $v_i=V_i/(PHF*f_{HV,PTSF}*f_{g,PTSF})$	*1280*	*912*
Base percent time-spent-following[4], $BPTSF_d(\%)=100(1-e^{av_d^b})$	*83.4*	
Adj. for no-passing zone, $f_{np,PTSF}$ (Exhibit 15-21)	*15.0*	
Percent time-spent-following, $PTSF_d(\%)=BPTSF_d+f_{np,PTSF}*(v_{d,PTSF}/v_{d,PTSF}+v_{o,PTSF})$	*92.2*	

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 15-3)	*E*

Volume to capacity ratio, *v/c*	*0.76*
Capacity, $C_{d,ATS}$ (Equation 15-12) veh/h	*1700*
Capacity, $C_{d,PTSF}$ (Equation 15-13) veh/h	*1700*
Percent Free-Flow Speed $PFFS_d$(Equation 15-11 - Class III only)	*59.3*
Bicycle Level of Service	
Directional demand flow rate in outside lane, v_{OL} (Eq. 15-24) veh/h	*1279.5*
Effective width, Wv (Eq. 15-29) ft	*24.00*
Effective speed factor, S_t (Eq. 15-30)	*4.42*
Bicycle level of service score, BLOS (Eq. 15-31)	*3.58*
Bicycle level of service (Exhibit 15-4)	*D*
Notes	

1. Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.
2. If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

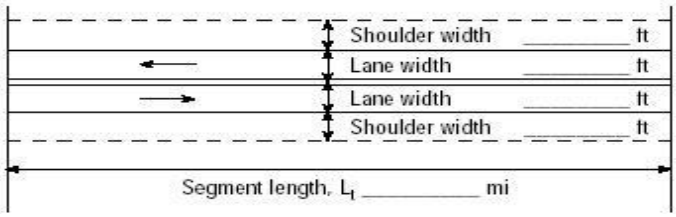
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DIRECTIONAL TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		***Site Information***	
Analyst	*Joseph A. Vaskovic*	Highway / Direction of Travel	*Houghton Road*
Agency or Company	*WSP*	From/To	*Broadway Blvd to Speedway Blvd*
Date Performed	*6/28/2019*	Jurisdiction	*City of Tucson*
Analysis Time Period	*PM Peak*	Analysis Year	*2030 Existing*

Project Description: *Houghton Road Needs Assessment*

Input Data



Show North Arrow

☑ Class I highway ☐ Class II highway ☐ Class III highway

Terrain ☐ Level ☐ Rolling

Grade Length *1.00* mi Up/down *-3.0*

Peak-hour factor, PHF *0.88*

No-passing zone *100%*

% Trucks and Buses , P_T *2 %*

% Recreational vehicles, P_R *2%*

Access points *mi* *2*/mi

Analysis direction vol., V_d	*804*veh/h
Opposing direction vol., V_o	*850*veh/h
Shoulder width ft	*6.0*
Lane Width ft	*12.0*
Segment Length mi	*0.5*

Average Travel Speed

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T (Exhibit 15-11 or 15-12)	*1.1*	*4.2*
Passenger-car equivalents for RVs, E_R (Exhibit 15-11 or 15-13)	*1.1*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV,ATS}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*0.996*	*0.940*
Grade adjustment factor[1], $f_{g,ATS}$ (Exhibit 15-9)	*1.00*	*1.00*
Demand flow rate[2], v_i (pc/h) $v_i=V_i/(PHF*f_{g,ATS}*f_{HV,ATS})$	*917*	*1028*

Free-Flow Speed from Field Measurement		**Estimated Free-Flow Speed**	
Mean speed of sample[3], S_{FM}		Base free-flow speed[4], BFFS	*45.0 mi/h*
Total demand flow rate, both directions, *v*		Adj. for lane and shoulder width,[4] f_{LS}(Exhibit 15-7)	*0.0 mi/h*
Free-flow speed, FFS=S_{FM}+0.00776(*v*/ $f_{HV,ATS}$)		Adj. for access points[4], f_A (Exhibit 15-8)	*0.5 mi/h*
Adj. for no-passing zones, $f_{np,ATS}$ (Exhibit 15-15)	*1.1 mi/h*	Free-flow speed, FFS (FSS=BFFS-f_{LS}-f_A)	*44.5 mi/h*
		Average travel speed, ATS_d=FFS-0.00776($v_{d,ATS}$ + $v_{o,ATS}$) - $f_{np,ATS}$	*28.3 mi/h*
		Percent free flow speed, PFFS	*63.6 %*

Percent Time-Spent-Following

	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T(Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Passenger-car equivalents for RVs, E_R (Exhibit 15-18 or 15-19)	*1.0*	*1.0*
Heavy-vehicle adjustment factor, $f_{HV}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	*1.000*	*1.000*
Grade adjustment factor[1], $f_{g,PTSF}$ (Exhibit 15-16 or Ex 15-17)	*1.00*	*0.93*
Directional flow rate[2], v_i(pc/h) $v_i=V_i/(PHF*f_{HV,PTSF}*f_{g,PTSF})$	*914*	*1039*
Base percent time-spent-following[4], $BPTSF_d(\%)=100(1-e^{av_d^b})$	*75.7*	
Adj. for no-passing zone, $f_{np,PTSF}$ (Exhibit 15-21)	*19.4*	
Percent time-spent-following, $PTSF_d(\%)=BPTSF_d+f_{np,PTSF}*(v_{d,PTSF}/v_{d,PTSF}+v_{o,PTSF})$	*84.8*	

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 15-3)	*E*

Volume to capacity ratio, *v/c*	*0.54*
Capacity, $C_{d,ATS}$ (Equation 15-12) veh/h	*1700*
Capacity, $C_{d,PTSF}$ (Equation 15-13) veh/h	*1700*
Percent Free-Flow Speed $PFFS_d$(Equation 15-11 - Class III only)	*63.6*
Bicycle Level of Service	
Directional demand flow rate in outside lane, v_{OL} (Eq. 15-24) veh/h	*913.6*
Effective width, Wv (Eq. 15-29) ft	*24.00*
Effective speed factor, S_t (Eq. 15-30)	*4.42*
Bicycle level of service score, BLOS (Eq. 15-31)	*3.41*
Bicycle level of service (Exhibit 15-4)	*C*
Notes	

1. Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.
2. If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

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HCS7 Multilane Highway Report

Project Information

Analyst	Joseph A. Vaskovic	Date	6/13/2019
Agency	WSP	Analysis Year	2030 - Proposed
Jurisdiction	City of Tucson	Time Period Analyzed	AM Peak Hour
Project Description	Houghton Road Needs Assessment Study		

Direction 1 Geometric Data

Direction 1	Northbound Houghton, south of Speedway		
Number of Lanes (N), ln	2	Terrain Type	Specific Grade
Segment Length (L), ft	-	Percent Grade, %	-3.00
Measured or Base Free-Flow Speed	Base	Grade Length, mi	0.00
Base Free-Flow Speed (BFFS), mi/h	45.0	Total Ramp Density (TRD), ramps/mi	0.00
Lane Width, ft	12	Left-Side Lateral Clearance (LC_R), ft	1
Median Type	Divided	Total Lateral Clearance (TLC), ft	7.00
Access Point Density, pts/mi	2.0	Free-Flow Speed (FFS), mi/h	43.2

Direction 1 Adjustment Factors

Driver Population	Mostly Familiar	Final Speed Adjustment Factor (SAF)	0.975
Driver Population SAF	0.975	Final Capacity Adjustment Factor (CAF)	0.968
Driver Population CAF	0.968		

Direction 1 Demand and Capacity

Volume(V) veh/h	1126	Heavy Vehicle Adjustment Factor (f_{HV})	0.973
Peak Hour Factor	0.94	Flow Rate (V_p), pc/h/ln	616
Total Trucks, %	2.00	Capacity (c), pc/h/ln	1900
Single-Unit Trucks (SUT), %	70	Adjusted Capacity (c_{adj}), pc/h/ln	1839
Tractor-Trailers (TT), %	30	Volume-to-Capacity Ratio (v/c)	0.33

Direction 1 Speed and Density

Lane Width Adjustment (f_{LW})	0.0	Average Speed (S), mi/h	42.1
Total Lateral Clearance Adj. (f_{LLC})	1.3	Density (D), pc/mi/ln	14.6
Median Type Adjustment (f_M)	0.0	Level of Service (LOS)	B
Access Point Density Adjustment (f_A)	0.5		

Direction 1 Bicycle LOS

Flow Rate in Outside Lane (v_{OL}),veh/h	599	Effective Speed Factor (S_t)	4.17
Effective Width of Volume (W_v), ft	18	Bicyle LOS Score (BLOS)	2.78
Average Effective Width (W_e), ft	24	Bicycle Level of Service (LOS)	C

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HCS7 Multilane Highway Report

Project Information

Analyst	Joseph A. Vaskovic	Date	6/13/2019
Agency	WSP	Analysis Year	2030 - Proposed
Jurisdiction	City of Tucson	Time Period Analyzed	PM Peak Hour
Project Description	Houghton Road Needs Assessment Study		

Direction 1 Geometric Data

Direction 1	Northbound Houghton, south of Speedway		
Number of Lanes (N), ln	2	Terrain Type	Specific Grade
Segment Length (L), ft	-	Percent Grade, %	-3.00
Measured or Base Free-Flow Speed	Base	Grade Length, mi	0.00
Base Free-Flow Speed (BFFS), mi/h	45.0	Total Ramp Density (TRD), ramps/mi	0.00
Lane Width, ft	12	Left-Side Lateral Clearance (LC_R), ft	1
Median Type	Divided	Total Lateral Clearance (TLC), ft	7.00
Access Point Density, pts/mi	2.0	Free-Flow Speed (FFS), mi/h	43.2

Direction 1 Adjustment Factors

Driver Population	Mostly Familiar	Final Speed Adjustment Factor (SAF)	0.975
Driver Population SAF	0.975	Final Capacity Adjustment Factor (CAF)	0.968
Driver Population CAF	0.968		

Direction 1 Demand and Capacity

Volume(V) veh/h	804	Heavy Vehicle Adjustment Factor (f_{HV})	0.973
Peak Hour Factor	0.94	Flow Rate (V_p), pc/h/ln	440
Total Trucks, %	2.00	Capacity (c), pc/h/ln	1900
Single-Unit Trucks (SUT), %	70	Adjusted Capacity (c_{adj}), pc/h/ln	1839
Tractor-Trailers (TT), %	30	Volume-to-Capacity Ratio (v/c)	0.24

Direction 1 Speed and Density

Lane Width Adjustment (f_{LW})	0.0	Average Speed (S), mi/h	42.1
Total Lateral Clearance Adj. (f_{LLC})	1.3	Density (D), pc/mi/ln	10.5
Median Type Adjustment (f_M)	0.0	Level of Service (LOS)	A
Access Point Density Adjustment (f_A)	0.5		

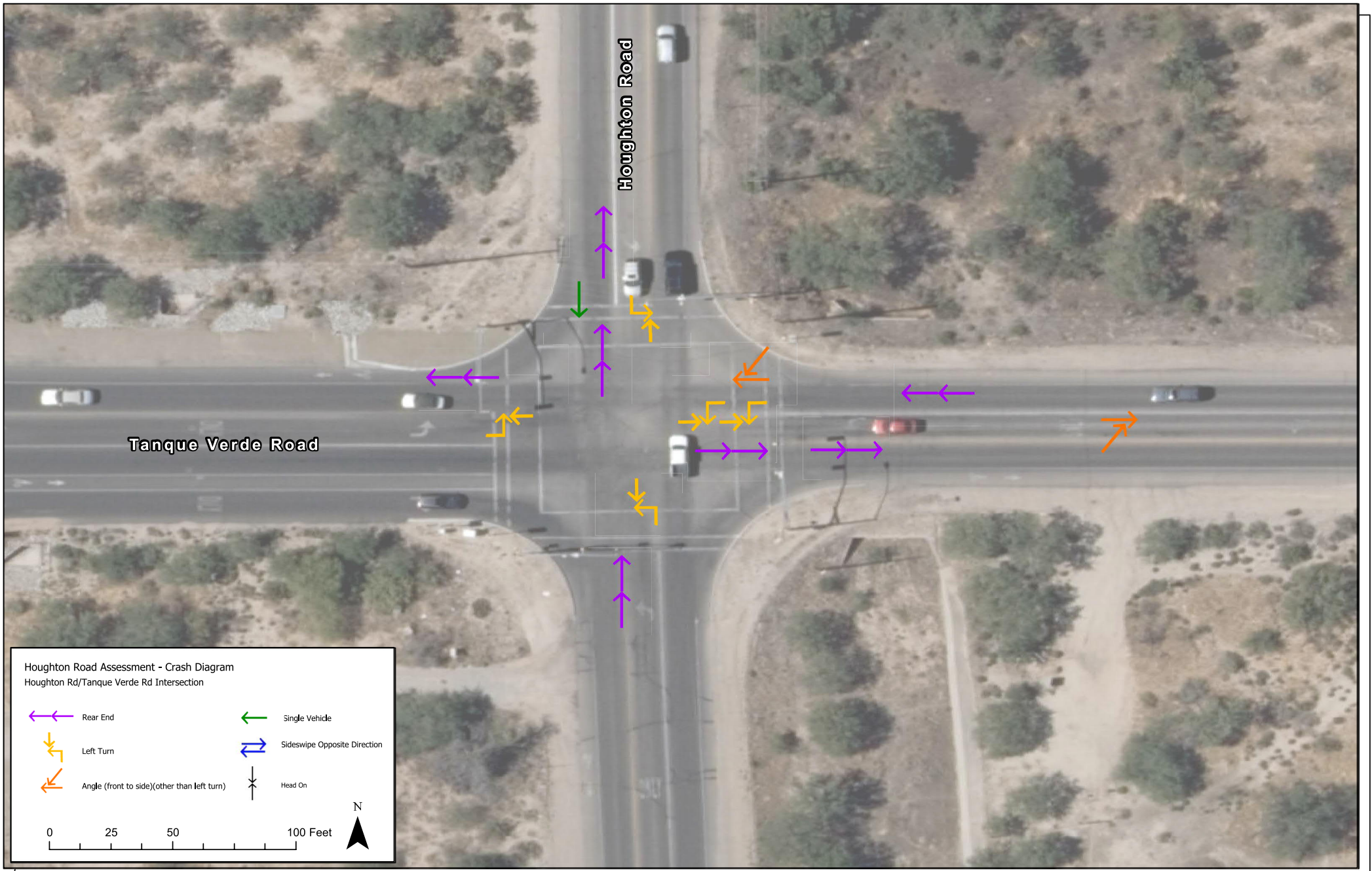
Direction 1 Bicycle LOS

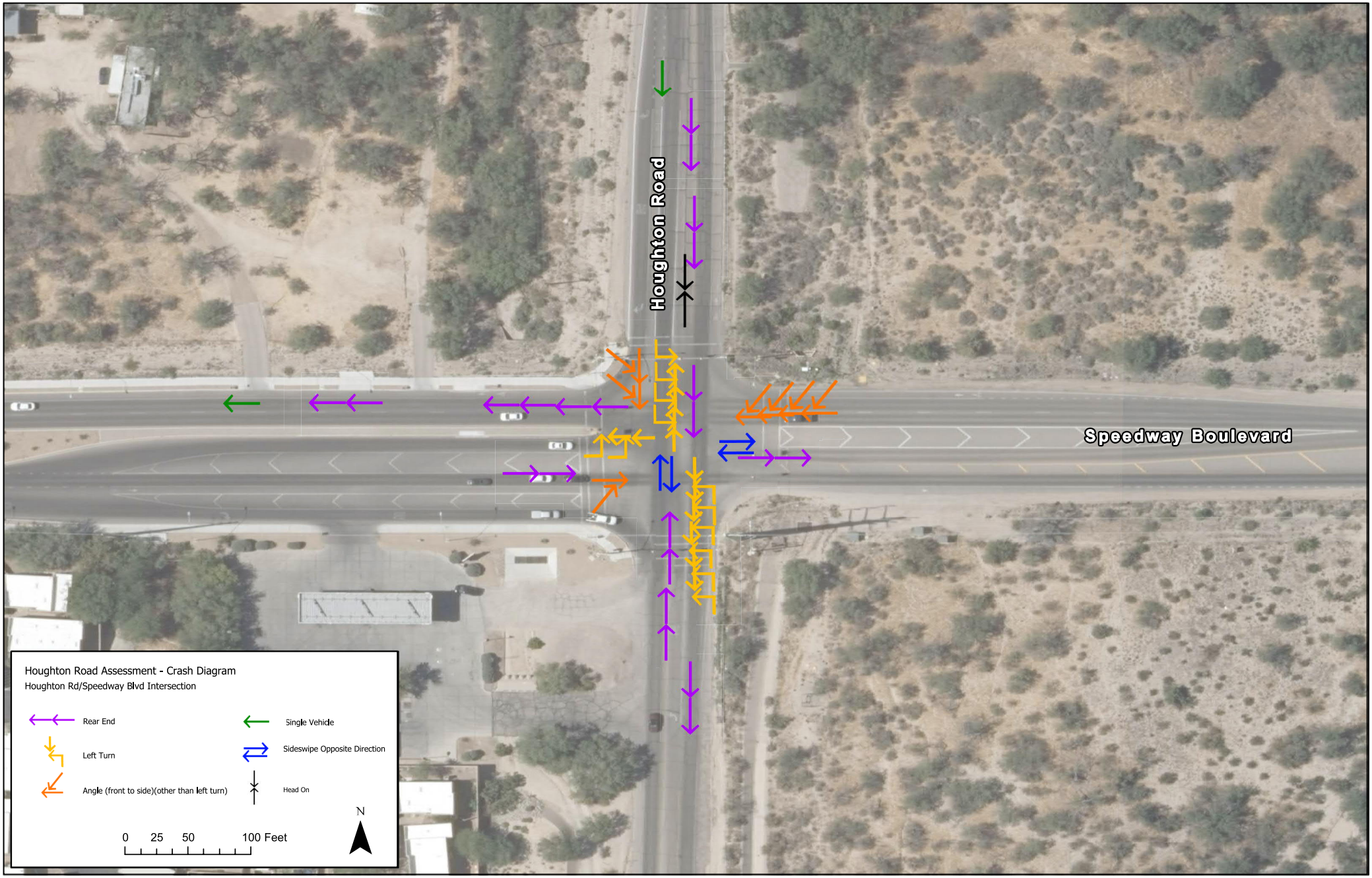
Flow Rate in Outside Lane (v_{OL}),veh/h	428	Effective Speed Factor (S_t)	4.17
Effective Width of Volume (W_v), ft	18	Bicyle LOS Score (BLOS)	2.61
Average Effective Width (W_e), ft	24	Bicycle Level of Service (LOS)	C

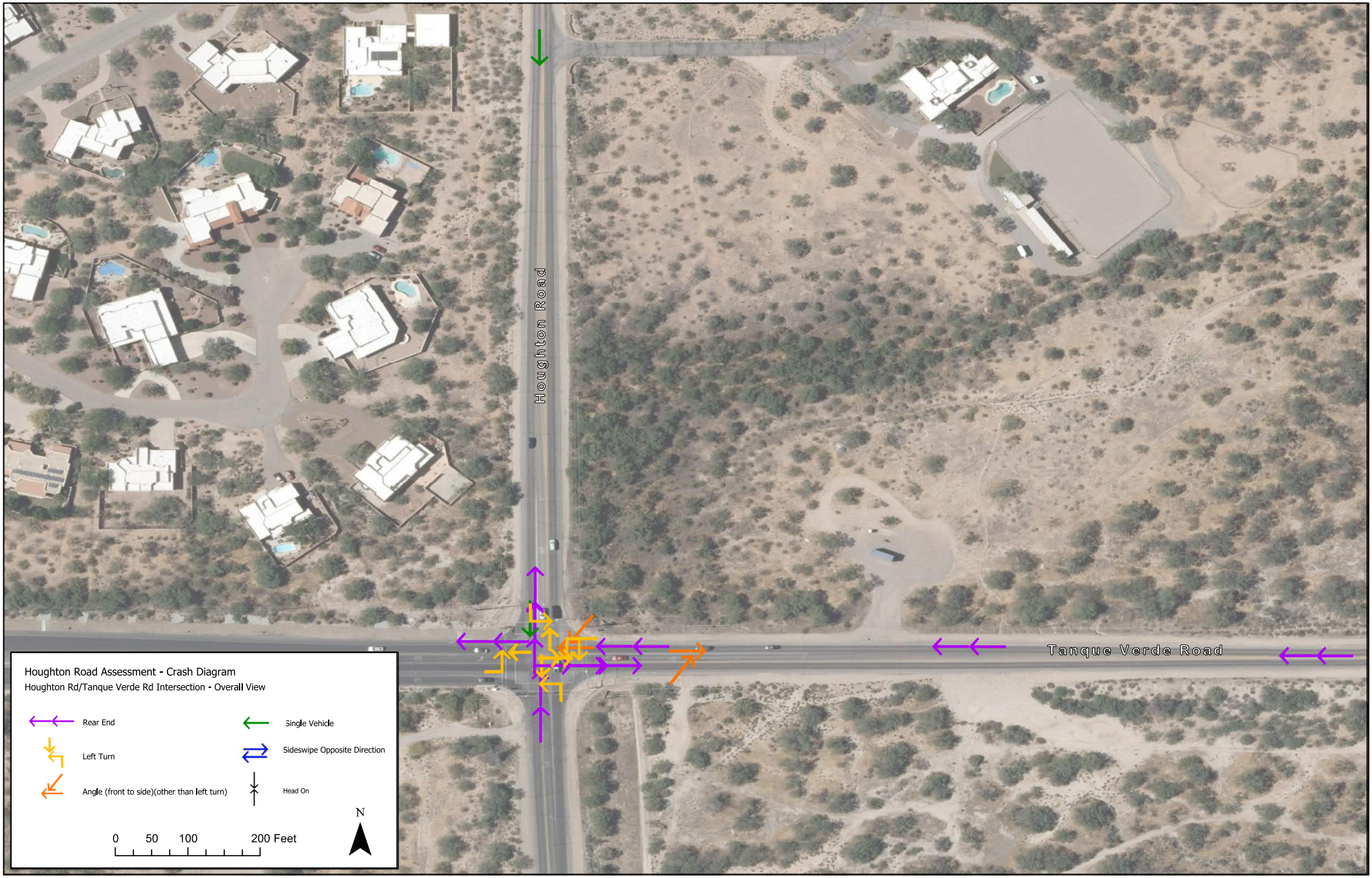
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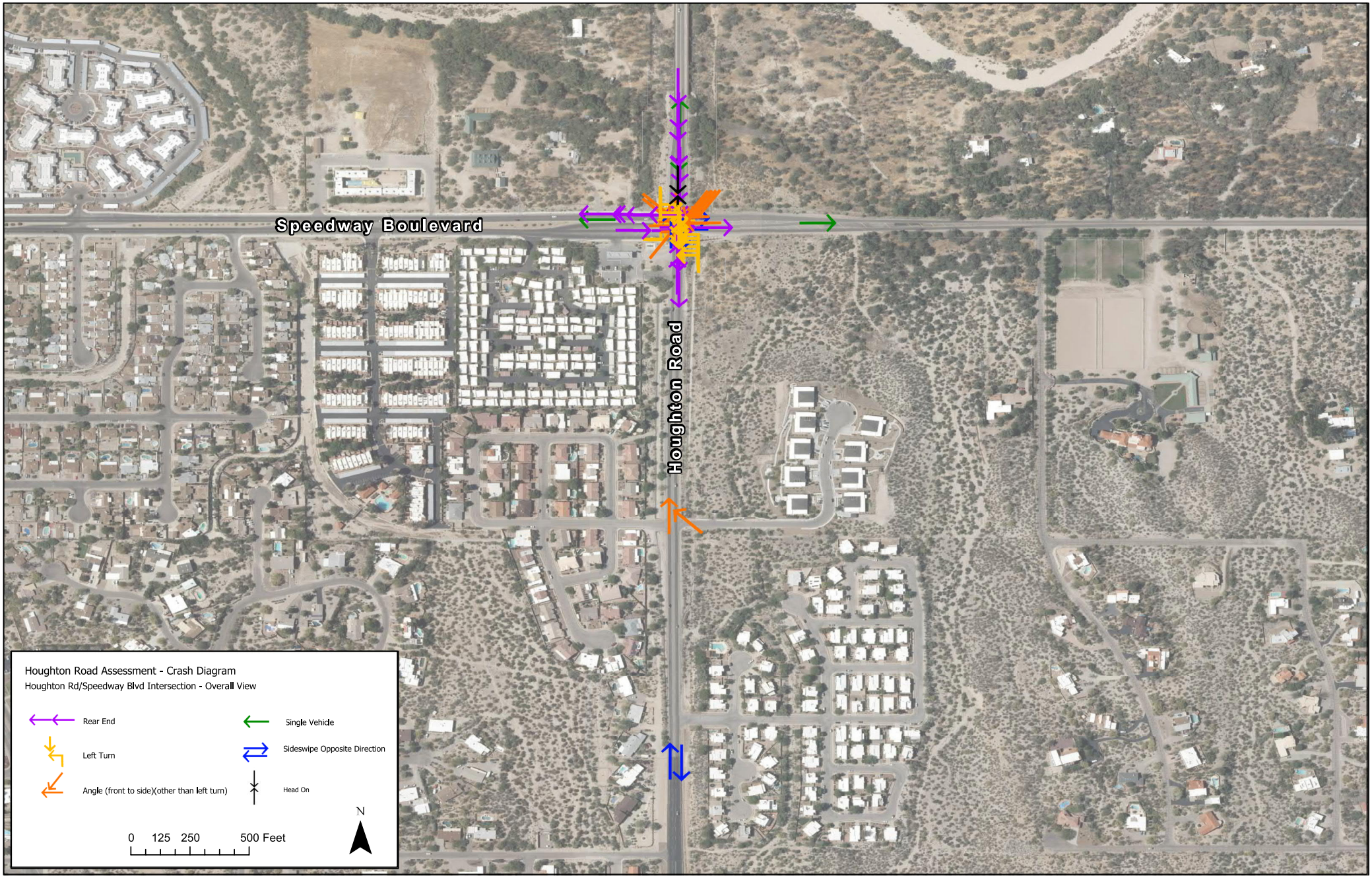
APPENDIX

D CRASH DIAGRAMS


Houghton Road
Tanque Verde Road
Houghton Road Assessment - Crash Diagram
Houghton Rd/Tanque Verde Rd Intersection
Rear End
Single Vehicle
Left Turn
Sideswipe Opposite Direction
Angle (front to side)(other than left turn)
Head On
N
0
25
50
100 Feet


Houghton Road
Speedway Boulevard
Houghton Road Assessment - Crash Diagram
Houghton Rd/Speedway Blvd Intersection
Rear End
Single Vehicle
Left Turn
Sideswipe Opposite Direction
Angle (front to side)(other than left turn)
Head On
N
0 25 50 100 Feet


Houghton Road
Tanque Verde Road
Houghton Road Assessment - Crash Diagram
Houghton Rd/Tanque Verde Rd Intersection - Overall View
Rear End
Single Vehicle
Left Turn
Sideswipe Opposite Direction
Angle (front to side)(other than left turn)
Head On
N
0
50
100
200 Feet


Speedway Boulevard
Houghton Road
Houghton Road Assessment - Crash Diagram
Houghton Rd/Speedway Blvd Intersection - Overall View
Rear End
Left Turn
Angle (front to side)(other than left turn)
Single Vehicle
Sideswipe Opposite Direction
Head On
0 125 250 500 Feet
N

APPENDIX

E COST ESTIMATE

Preliminary

CONSTRUCTION COST ESTIMATE

HOUGHTON ROAD

Tanque Verde Rd to Speedway Blvd

JOB NO.

PLAN NO.

September 11, 2019

Description	Quantity	Unit	Unit Cost	Total Cost
Roadway Construction	337,400	SF	$8.74	$2,949,000
Drainage	1	L SUM	$2,270,450.00	$2,271,000
Signing (60% of Striping)	60%	PCT	$61,000.00	$37,000
Striping	66,700	LF	$0.90	$61,000
Traffic Signals	1	L SUM	$410,000.00	$410,000
Landscaping (3.5% of Roadway Subtotal)	3.5%	PCT	$5,936,000.00	$208,000
Roadway Subtotal				**$5,936,000**
Fix Damage to Joint at North End (Tanque Verde Wash)	42	LF	$595.00	$25,000
Replace Joint Seal at Pier 6 (Tanque Verde Wash)	42	LF	$595.00	$25,000
Pier Spall Repairs (Tanque Verde Wash)	1	LS	$25,000.00	$25,000
Deck Sealing (Tanque Verde Wash)	5,500	SY	$100.00	$550,000
Deck Sealing (Agua Caliente Wash)	1,500	SY	$100.00	$150,000
Bridge Subtotal				**$775,000**
Utility Relocations and Modifications (2.5% of Roadway Subtotal)	2.5%	PCT	$5,936,000.00	$149,000
NPDES (3% of Roadway Subtotal)	3.0%	PCT	$5,936,000.00	$179,000
Mobilization (10% of Roadway and Bridge Subtotal)	10.0%	PCT	$6,711,000.00	$672,000
Maintenance and Protection of Traffic (9% of Roadway and Bridge Subtotal)	9.0%	PCT	$6,711,000.00	$604,000
Construction Survey and Layout (1% of Roadway Subtotal)	1.0%	PCT	$5,936,000.00	$60,000
Miscellaneous Construction Subtotal				**$1,664,000**
Construction Subtotal				**$8,375,000**
Design Fees (8%-10% (Construction Subtotal-(NPDES & Const Survey for Bridge) + Est. $30,000 for Bridge Repair))	1	L SUM	$637,000.00	$637,000
Right of Way (Est $200,000/AC)	1.03	ACRE	$200,000.00	$206,000
			Subtotal	$9,218,000.00
			Contingency (20%)	$1,844,000.00
			Subtotal	**$11,062,000.00**
			Project Total	**$11,062,000.00**

Preliminary

CONSTRUCTION COST ESTIMATE

HOUGHTON ROAD

Tanque Verde Rd to Speedway Blvd, Phase 1: NB Right Turn Lane at Tanque Verde Road

JOB NO.

PLAN NO.

September 11, 2019

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
	Borrow	1,300	CY	$25.00	$32,500
	Aggregate Base	180	CY	$35.00	$6,300
	Asphalt Concrete	270	TONS	$85.00	$23,000
	Signing (60% of Striping)	1	L SUM	$2,000.00	$2,000
	Striping	1,600	LF	$0.90	$1,500
	Traffic Signals	1	L SUM	$15,000.00	$15,000
	Type 1 Curb	90	LF	$15.00	$1,400
	Sidewalk	240	SF	$6.00	$1,500
	Curb Access Ramp	4	EA	$2,500.00	$10,000
	Guardrail	675	LF	$22.50	$15,200
	Concrete Channel Lining (6")	2,070	SY	$75.00	$155,300
	Reinforced Concrete Cantilever Retaining Wall (H=4')	1,600	SF	$65.00	$104,000
	Handrail	400	LF	$25.00	$10,000

Subtotal	$377,700.00
Additional Items Not Listed (0%)	$0.00
Subtotal	**$377,700.00**
Project Total	**$378,000.00**

Preliminary

CONSTRUCTION COST ESTIMATE

HOUGHTON ROAD

Tanque Verde Rd to Speedway Blvd

JOB NO.

PLAN NO.

September 11, 2019

Description	NB Rght Phase 1	Houghton/ Speedway Phase 2	Bridge Repair Phase 3	Totals
Roadway Subtotal	$378,000	$5,558,000		$5,936,000
Bridge Repair			$775,000	$775,000
Subtotals	**$378,000**	**$5,558,000**	**$775,000**	**$6,711,000**
Utility Relocation (2.5% of the Roadway Subtotal)	$9,450	$138,950		$148,400
NPDES (3% of Roadway Subtotal)	$11,400	$166,800		$178,200
Mobilization (10% of Roadway and Bridge Subtotal)	$38,000	$556,000	$78,000	$672,000
Maintenance and Protection of Traffic (9% of Roadway and Bridge Subtotal)	$35,000	$501,000	$70,000	$606,000
Construction Survey and Layout (1% of Roadway Subtotal)	$3,780	$55,580		$59,360
Miscellaneous Construction Subtotal	**$97,630**	**$1,418,330**	**$148,000**	**$1,663,960**
Construction Subtotal	**$475,630**	**$6,976,330**	**$923,000**	**$8,374,960**
Design Fees (8%-10% of Const Subtotal + Est $30,000 Bridge Repair Design)	$48,000	$559,000	$30,000	$637,000
Right of Way (Est $200,000/AC)		$206,000		$206,000
Subtotals	**$523,630**	**$7,741,330**	**$953,000**	**$9,217,960**
Contingency (20%)	$104,726	$1,548,266	$190,600	$1,843,592
Totals	$628,356	$9,289,596	$1,143,600	$11,061,552
Project Totals (Rounded)	**$628,400**	**$9,289,600**	**$1,143,600**	**$11,062,000.00**