Pines Road/BNSF Grade Separation Project

US Department of Transportation,

Office of the Secretary of Transportation

Better Utilizing Investments to Leverage Development (BUILD)

FY 2018 Grant Application

Location: Urban area of Spokane Valley, Washington

Primary Project Type: Road

Secondary Project Type: Road/Rail Crossing

BUILD Funding Request: $23,020,800

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1 Project Description

In 2017, the Pines Road crossing of the BNSF Railway Company (BNSF) railroad tracks resulted in over 27,000 vehicle hours of delay[1], at least one vehicle incident[2], and an additional 27 collisions at the adjacent Pines Road (SR 27) / Trent Avenue (SR 290) intersection. In 2018, the at-grade crossing was rated Washington State's top Tier 1 road-rail conflict.[3] The City of Spokane Valley seeks a BUILD Discretionary Grant of $23,020,800 to complete funding for the Pines Road/BNSF Grade Separation Project to create a safer, more efficient, and reliable transportation network for its users.

1.1 Project Overview

The Pines Road at-grade crossing of the BNSF Railway Company tracks is located 275 feet south of Trent Avenue in the city of Spokane Valley, WA. Pines Road and Trent Avenue are significant corridors for local travel and freight movement. Pines Road is a state highway (SR 27), and is one of Spokane Valley's primary north-south arterial roadways. It directly connects Trent Avenue, also a state highway (SR 290), with Interstate 90 to the south, and is a preferred freight route to I-90 between north Idaho and Canada. The BNSF corridor carries freight between western ports and Midwest intermodal facilities as shown in Figure 1.

Figure 1: BNSF Freight Movement in the Pacific Northwest

The BNSF corridor also hosts Amtrak, with two passenger trains per day.

The Pines Road/BNSF Grade Separation Project replaces an existing at-grade crossing with an underpass of BNSF's railroad tracks and provides a roundabout or traffic signal at the intersection of Pines Road and Trent Avenue. These improvements will reduce the risk of

[1] 60 trains/day (freight and passenger) with an average crossing time of 3.55 minutes/train, creating 3.6 hours of roadway blockage due to freight and passenger trains/day (14.8% of the day); with 16,925 vehicles/day (2016 City ADT records projected into 2017), 14.8% of vehicles will be affected for an average of 1.78 minutes (including lead/lag time for gate operations), resulting in 74.3 vehicle hours/day of delay, or 27,100 vehicle hours/year.
[2] Analysis of Washington Department of Transportation (WSDOT) Vehicle Crash Data, 2015-2017
[3] DRAFT Prioritization of Prominent Road-Rail Conflicts Phase 2 Study, May 22, 2018

collisions between the existing 16,400 vehicles/day[4] and 60 trains/day[5] at the crossing and help prevent unintended releases of hazardous materials. The existing crossing is shown in Figure 2.

Figure 2: View of Existing Pines Road/BNSF Crossing

Train horns through Spokane Valley will be reduced, as will the community severance effects created by the railroad tracks.

Replacement of the existing signalized intersection with a roundabout at the Pines/Trent intersection is predicted to reduce all collisions by 19%, and fatal and injury collisions by 71%.[6]

Afternoon peak hour intersection delays are anticipated to drop nearly 40 seconds with a roundabout or about 10 seconds for a traffic signal.[7] Pedestrians and cyclists will be able to cross Trent Avenue more safety and comfortably. The improvements support freight movement and regional mobility goals as articulated in various plans such as Horizon 2040, the Metropolitan Planning Organization's (MPO) regional transportation plan and the Inland Pacific Hub Transportation Study, a partnership of public and private agencies dedicated to creating a freight gateway in the region.

The City's preliminary alternative analysis to be conducted in 2018 will evaluate the benefits of a signalized intersection versus a roundabout. The potential project configurations may result in

[4] Most recent traffic volume count performed by the City.
[5] WSDOT. Washington State Rail Plan, March 2014. http://www.wsdot.wa.gov/NR/rdonlyres/F67D73E5-2F2D-40F2-9795-736131D98106/0/StateRailPlan-Final201403.pdf, Figures 4.2 and 4.3 showing 48 freight trains in 2010 and 114 freight trains in 2035, or 66 added trains over 25 years (2.64 trains/year). Growth assumes double track capacity, but as of 2018 only a single track exists, providing growth from 2010 equal to 50%, or 1.32 trains/year.
[6] NCHRP Report 705, Evaluation of Safety Strategies at Signalized Intersections, 2011 (https://www.nap.edu/login.php?action=guest&record_id=14573)
[7] Appendix D - DRAFT Pines Road/BNSF Grade Separation – Consolidated Traffic and Safety Analysis, March 27, 2018 – Table 8.

either a roundabout or a new traffic signal, either of which can be applied to various alignment configurations. Two alignment options are illustrated in Figures 3 and 4, assuming a roundabout is implemented over a traffic signal. The analysis is a coordinated effort with Washington State Department of Transportation (WSDOT) and BNSF and considers a variety of project elements specific to the rail corridor and highway design requirements. Final design configuration must accommodate BNSF's planned mainline track expansion project and highway alignments will be subject to WSDOT approval.

Figure 3: Alternate 1 with Roundabout

Figure 4: Alternate 2 with Roundabout

1.2 Transportation Challenges the Project Aims to Address

1.2.1 Safety Risks at and Near the Crossings

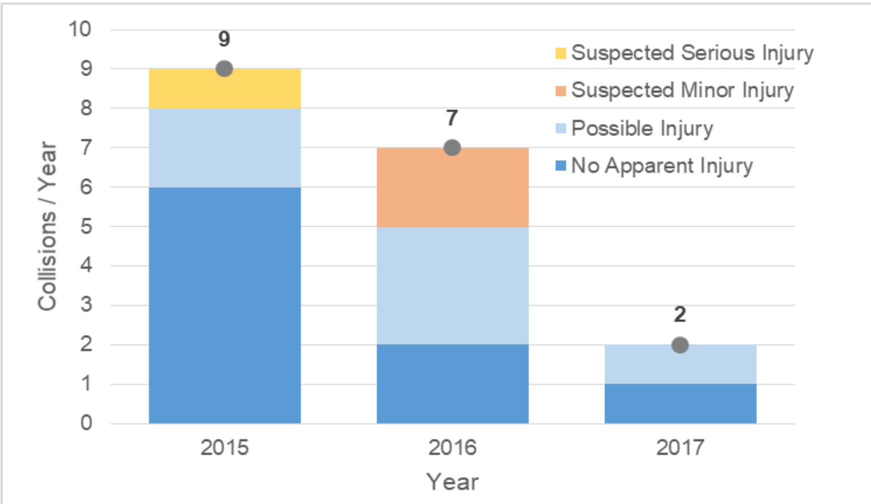
All at-grade railroad crossings have the potential for fatalities, serious injuries, and hazardous material spills (e.g. Bakken oil), particularly when there are high volumes of rail traffic and roadway traffic, such as at the Pines Road/BNSF at-grade crossing. Incidents at road intersections and at-grade rail crossings could result in fatalities or serious injuries, particularly when there are high volumes of vehicle or rail traffic, as is the case in this project. The conflicts and risks associated with this project's existing at-grade crossing will continue to grow over time, as both train and vehicle volumes grow. It is projected the number of freight trains on this corridor will increase from 60 trains per day to 114 trains per day by 2035.[8]

The collision history at the Pines Road / Trent Avenue intersection for 2015 to 2017 inclusive is summarized in Figure 5. Replacement of the existing signalized intersection with a roundabout

[8] WSDOT. Washington State Rail Plan, March 2014. http://www.wsdot.wa.gov/NR/rdonlyres/F67D73E5-2F2D-40F2-9795-736131D98106/0/StateRailPlan-Final201403.pdf, Figures 4.2 and 4.3 showing 48 freight trains in 2010 and 114 freight trains in 2035, or 66 added trains over 25 years (2.64 trains/year). Growth assumes double track capacity but as of 2018 only a single track exists, providing growth from 2010 equal to 50%, or 1.32 trains/year.

will reduce collisions, should a roundabout be the selected configuration. Since all traffic moves through the roundabout in the same direction, the highest severity collisions associated with left turn movements will be virtually eliminated.

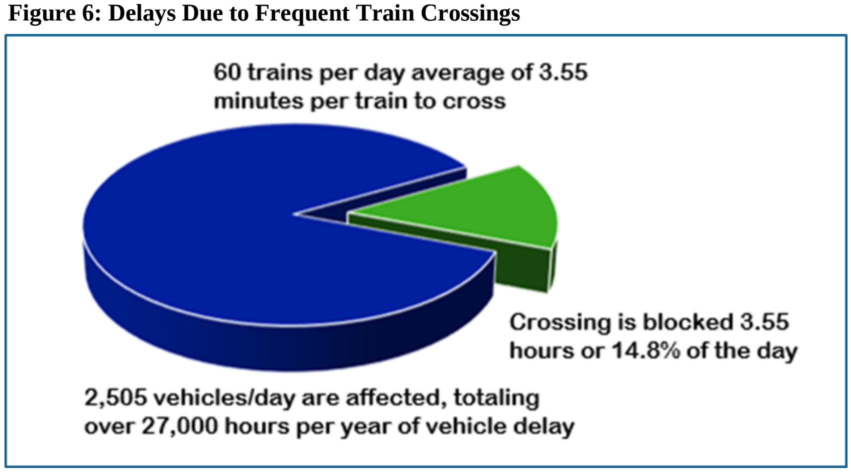
Figure 5: Collision History, Pines Rd (SR 27) / Trent Ave (SR290) Intersection, 2015-2017



1.2.2 Long Delays at the Crossings and Adjacent Intersections

The current daily freight and passenger train volume is estimated to be 60 trains/day, which means that on average, people and freight are delayed 60 times per day at each roadway-railway crossing.[9] A recent City survey recorded an average of 3.55 minutes of delay for each train crossing. Per Footnote 1, this average time over 60 crossings per day results in 74 vehicle hours of crossing delays to traffic on Pines Road daily. Delays are further compounded by the time required for the vehicle queues created by the train crossing to dissipate. In addition, queued vehicles may block adjacent intersections, most importantly the Pines/Trent intersection causing delays to through traffic on Trent Avenue. Figure 6 illustrates the delays due to train crossings.

Figure 6: Delays Due to Frequent Train Crossings



The existing Pines / Trent intersection operates at level of service (LOS) D in the afternoon peak hour. The Trent Avenue approaches operate at LOS E with average delays per vehicle of approximately 60 seconds. By 2040 the PM peak hour delays will further increase

[9] Washington Department of Transportation (WSDOT). Washington State Rail Plan. Technical Note 3a: Freight Rail Demand, Commodity Flows and Volumes. Dec. 2013.

to over two minutes per vehicle (LOS F) if no improvements are implemented. Conversion of this intersection to a roundabout results in significant reduction in delay. With 2040 volumes, the average delay per vehicle is forecast to be 8-9 seconds in the PM peak, with the intersection's roundabout operating at LOS A. If a traffic signal is provided, the average delay per vehicle is forecast to be 30-40 seconds in the PM peak, with the signalized intersection operating at an LOS C-D. The results of the LOS analysis consider the project's two alternate design options for the 2040 horizon year.[10]

1.2.3 Inefficient Emergency Services Access

Key emergency services (fire, police, medical) are located south of the railway. Of particular importance is the Valley Hospital located 1.5 miles south of the project location near the intersection of Pines Road and Mission Ave. The long and frequent delays at the rail crossings may cause delays for providing emergency services to the north. The grade-separated crossing removes this barrier to emergency vehicles, creating more reliable access to both sides of the railroad tracks.

1.2.4 Constrained Access to Future Developable Land

Close to 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS 'E' operating conditions at the Pines Road /Trent Avenue intersection. In particular, the Pinecroft Business Park, located immediately southeast of the project site, has capacity to double its employee population from 2,000 to over 4,000 employees, and nearly double its 500,000 square feet of existing buildings space to upwards of 900,000 square feet.[11] These parcels, along with several hundred more acres beyond the city limits, are some of the last undeveloped parcels available for industrial use in the area.

1.2.5 Lack of Community Connectivity

The rail corridor bisects the northern parts of Spokane Valley from the main city south of the railway. On Pines Road, the rail corridor provides a barrier between neighborhoods, recreation areas, commercial retail sites, and schools located on both sides of the railway. The new grade-separated crossing and roundabout or traffic signal will provide sidewalks along Pines Road, making the route more appealing to pedestrians and more reliable for all users and modes. In addition to a grade separated crossing of the railroad tracks, the roundabout or traffic signal will create a safer and more comfortable crossing of Trent Avenue.

1.2.6 Noise Pollution from Train Horns

Spokane Valley residents have long complained about the noise pollution of the train horns. Federal law requires locomotives to sound their horns at 96 to 110 decibels as they approach at-

[10] Appendix D - DRAFT Pines Road/BNSF Grade Separation – Consolidated Traffic and Safety Analysis, March 27, 2018

[11] Letter to City of Spokane Valley Council, J. Traeger, JMA Commercial Real Estate, LLC for Pinecroft, LLC (http://www.spokanevalley.org/filestorage/6862/6927/8180/11735/Pinecroft_Business_Park.pdf)

grade crossings and continue blowing the horn until the lead locomotive fully occupies the crossing. Train horns are a source of significant public concern in Spokane Valley.[12]

1.2.7 Project Benefits Specific to Rural Areas

Rural Areas will directly benefit from the project even though it is located in a designated Urban Area. As identified in Section 2, the project is located less than a half mile from the U.S. Census Bureau's Urban Area limits. The project's two highways are main thoroughfares for rural traffic connecting to interstate rail, freeway routes, and urban economic activity centers.

1.3 Project History and Relationship to Other Plans

The following summarizes some of the other plans that provide context to the Pines Road/BNSF grade-separation project.

1.3.1 Horizon 2040 https://www.srtc.org/horizon-2040/

Horizon 2040 is the Spokane Regional Transportation Council's (SRTC) long-range transportation plan for the Spokane region through 2040. Horizon 2040 identifies the following projects along the BNSF railroad as regionally significant:

- Pines Road (SR 27/SR 290) underpass;
- Barker Road overpass; and
- Sullivan Road Bridge improvements at BNSF and Trent Avenue overpass

The Pines Road underpass was identified in the regionally significant projects with a recommended implementation horizon of 2021-2030.

1.3.2 Bridging the Valley https://www.srtc.org/bridging-the-valley/#

Bridging the Valley was completed in 2006 and presented a plan to separate vehicle traffic from train traffic in the 42-mile corridor between Spokane, Washington, and Athol, Idaho. This stretch included 75 at-grade rail crossings, 11 of which were to be grade separated. The Pines Road/BNSF project was one of these 11 projects and had a 2001 estimated total project cost of $23 million.

Bridging the Valley included project objectives to:

- Improve public safety by reducing rail/vehicle collisions
- Improve emergency services access to residents and businesses along the corridor
- Eliminate waiting times and improve traffic flow for all travel modes at rail crossings
- Reduce noise levels, particularly related to train whistles at crossings
- Enhance economic opportunities for a rail corridor served by a key regional railroad

[12] "Spokane Valley, Cheney residents want to silence train whistles." The Spokesman-Review, March 6, 2016. See attachment.

The original Bridging the Valley concept included grade-separation of Pines Road under the BNSF railway and realignment of the existing intersection at Pines Road and Trent Avenue. The original project addressed the road/rail grade-separation objective, but had significant property access issues and resulted high delays at the signalized intersection. The current concept has been proposed as a result of a coordinated review of the project with the Washington State Department of Transportation (WSDOT) that focused on providing the most important benefits, satisfying WSDOT requirements for state highway design and meeting the objectives of Horizon 2040.

1.3.3 Washington State Joint Transportation Committee

The Joint Transportation Committee (JTC) was created in 2005 and its purpose is to review and research transportation programs and issues to better inform state and local government policymakers, including legislators. The JTC conducted an evaluation of prominent road/rail conflicts and developed a prioritization process to address the impacts on a statewide level based on mobility, safety and community criteria. Using this process, Pines Road was ranked number 12 in the state out of over 300 crossings reviewed and out of nearly 4,200 crossings statewide. [13]

1.3.3.1 Washington State Freight Mobility Strategic Investment Board

In spring 2018, the Washington State Freight Mobility Strategic Investment Board (FMSIB) partnered with the State's MPOs to refine the JTC's prioritization of prominent road/rail conflicts. In its first draft release, the Pines/BNSF Grade Separation Project was identified as Washington State's #1 priority (Tier 1) road-rail conflict.[14]

1.3.4 Great Northern Corridor Coalition http://greatnortherncorridor.org/coalition

The Great Northern Corridor Coalition is a multi-state cooperative of eight northern tier states, several MPOs, numerous ports, BNSF Railway and other interested parties. The Coalition's mission is to promote a premier multi-state corridor by acting collectively to promote public policy, research and multi-modal infrastructure development that expands commerce and enhances safety on the corridor. The BNSF railroad through Spokane Valley is identified as a part of the Great Northern Corridor.

1.3.5 Inland Pacific Hub https://www.srtc.org/inland-pacific-hub/

The Inland Pacific Hub (IPH) is a partnership of public and private sector representatives from northern Idaho and eastern Washington working together to create a multi-modal global gateway to foster increased domestic and international commerce. Phase 2 of the IHP initiative identified priority projects to support the IPH vision, including the Horizon 2040 and Bridging the Valley programs.[15]

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[13] Prioritization of Prominent Road-Rail Conflict in Washington State, Washington State Joint Transportation Committee, January 2017

[14] DRAFT Prioritization of Prominent Road-Rail Conflicts – MP/RTPO/WSDOT Coordinating Committee, May 22, 2018.

[15] Inland Pacific Hub Transportation Investment and Project Priority Blueprint, 2012

1.4 Project Parties

The City of Spokane Valley is the applicant for this project and will manage any grant funding awarded and all design and construction activities associated with the project. The City will work closely with the WSDOT and BNSF Railway Company to deliver the project. See 4.7.1 for letters of support from WSDOT, BNSF and other stakeholders.

The **City of Spokane Valley** is located near the eastern border of Washington and is the ninth largest city in Washington with a population of 94,890.[16]

WSDOT is responsible for building, maintaining, and operating the state highway system and state ferry system. They are responsible for 26 miles of highway within Spokane Valley, including Pines Road and Trent Avenue.

BNSF Railway Company operates the east-west Class I railway at the heart of this project. This railway connects Seattle and Portland in the west to Chicago and Minneapolis-St. Paul in the east with many service points in between. This railway also connects customers with the global marketplace. The Spokane region is a convergence of several rail lines on the northern tier of BNSF's network.

The project partners will coordinate closely and support project delivery as follows:

Project Activity:	Spokane Valley	WSDOT	BNSF Railway
Manage Funding Allocations	✓		
Procurement	✓		
Project Reviews/Approvals	✓	✓	✓
Public Involvement	✓	✓	

1.5 Summary of Project Benefits

Construction of this project has both national and regional significance. At the national level, this project reduces risk for freight trains, passenger trains, and freight trucks by eliminating road/rail conflicts. The BNSF rail corridor carries freight and passenger trains between western ports and Midwest intermodal facilities. The elimination of the project's at-grade crossing reduces train/vehicle incident risks at the crossing. At a regional level, the elimination of delays at the rail crossing will enhance the mobility of freight trucks traveling to/from Interstate 90 just south of the project.

[16] Washington State Office of Financial Management. http://www.ofm.wa.gov/pop/april1/default.asp. April 1, 2017.

Additional regional benefits include:

- Unlocking the economic potential to develop prime vacant land zoned for industrial, mixed-use, and commercial uses
- Re-connecting communities and recreation areas
- Improving the quality of life through noise and emissions reductions

The overall project supports regional commerce within the Inland Pacific Hub and achieves regional planning goals that have been in place for more than a decade.

Expected system users that will benefit from this project include:

- Travelers (automobile drivers/passengers, pedestrians, bicyclists)
- Trucking companies and the companies that use their services for freight transport
- BNSF Railway and companies that use the railway for freight transport
- Amtrak and their passengers
- Property owners near the project (businesses, vacant land owners)
- Local residents that cross the railroad for a variety of purposes

Table 1 provides a summary of the conditions at the Pines Road/BNSF railroad crossing with and without the project.

Table 1: Before and After Conditions at Pines Road BNSF Railway Crossings

Conditions	No Project	With Project
At-grade crossings	1	0
Longest segment with no at-grade crossings* (miles)	1.0	2.1
Daily Train Horns at Pines/BNSF Crossing	60	0
Predicted annual collisions** – Pines/Trent intersection	27	18***
Predicted annual incidents (Fatal and Injury) - Pines/Trent intersection	8	6
Predicted annual incidents** - Pines Road/BNSF crossing	1	0
Annual vehicle hours of peak hour intersection delay** - Pines/Trent intersection	13,432	3,454
Annual vehicle hours of railroad crossing delay** - Pines Road/BNSF crossing	27,100	0

** Between Evergreen Road and Vista Road*
*** Based on 2017 volumes and a roundabout at Pines & Trent; number of predicted collisions and delays will increase as volumes increase*
**** The total number of collisions at the Pines/Trent intersection is predicted to drop 5 collisions/year, but the number of high severity collisions (fatal+injury) is predicted to decrease by 6 collisions/year, indicating that the number of low-severity collisions will increase. The BCA model does not distinguish between different severity levels.*

This project will generate key long-term benefits that leverage federal investment by enhancing the mobility and safety of people and freight in the region, while also providing economic opportunities and enhancing the environment and surrounding communities. The project outcomes are summarized in Table 2.

Table 2: Expected Project Outcomes

Safety Outcomes	• Eliminates the risk of conflict between roadway users and trains by separating uses • Eliminates potential queuing of vehicles stopped for train crossings • Reduces the potential for high severity collisions at the intersection • Adds ADA-accessible active transportation features to increase safety
State of Good Repair	• Improves infrastructure resilience through new construction of the underpass, intersection improvement via roundabout or improved signalization, and approaches to current standards • The City of Spokane Valley's various street-related funds have sufficient funding to cover operations and maintenance; there is a Capital Reserve available as a contingency • The City has successfully implemented similar projects, including most recently the Sullivan Road West Bridge replacement at the Spokane River and is currently underway with a very similar grade separation project at the intersection of Barker Road and Trent Avenue.
Economic Competitiveness	• Decrease transportation costs and improve long-term efficiency, reliability, and costs in the movement of workers and goods • When combined with other Horizon 2040 regionally significant projects, creates an 3.6-mile section with only one remaining at-grade BNSF crossing • Contributes to reliable movement of regional freight by road and rail • Enhance the access and reliability to close to 170 acres of prime, buildable industrial-zoned land and 56 acres of residential-zoned land
Environmental Sustainability	• Reduces fuel consumption and tailpipe emissions for idling vehicles • Eliminates the need for train horns for a 2.1-mile section
Quality of Life	• Improves community connectedness between neighborhoods, industrial jobs, and nearby recreational areas • Eliminates train horn noise at Pines Road and improves the health and well-being of surrounding residents and businesses[17] • Reduces delay for all modes of travel and improve traffic circulation • Greatly enhance accessibility for active modes by eliminating infrastructure gaps and reducing delay
Partnership and Innovation	• Helps fulfill the vision of the MPO's Horizon 2040 Metropolitan Transportation Plan • Addresses one of Washington State's highest priority road-rail conflicts. • Supports the Great Northern Corridor Coalition's vision for safe, efficient, and environmentally sound transportation services

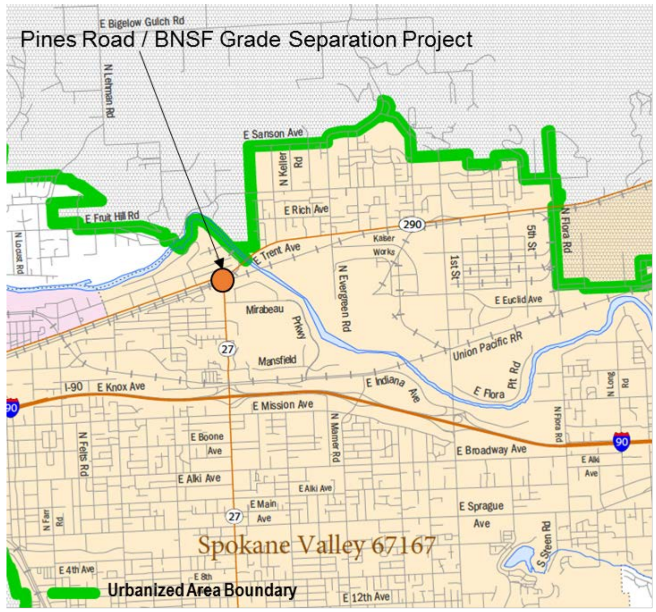
[17] "Spokane Valley, Cheney residents want to silence train whistles." The Spokesman-Review, March 6, 2016.

2 Project Location

The project is located in the City of Spokane Valley, WA, in the northeast corner of the state, approximately 9 miles from the Idaho border and 90 miles south of the Canadian border. It is within the urbanized area (UA) of Spokane Valley (67167) as shown on Figure 7.

The geographic location is 47°41'21" N, 117°14'22" W. Figure 8 shows the proposed project location and surrounding area. Key features shown include:

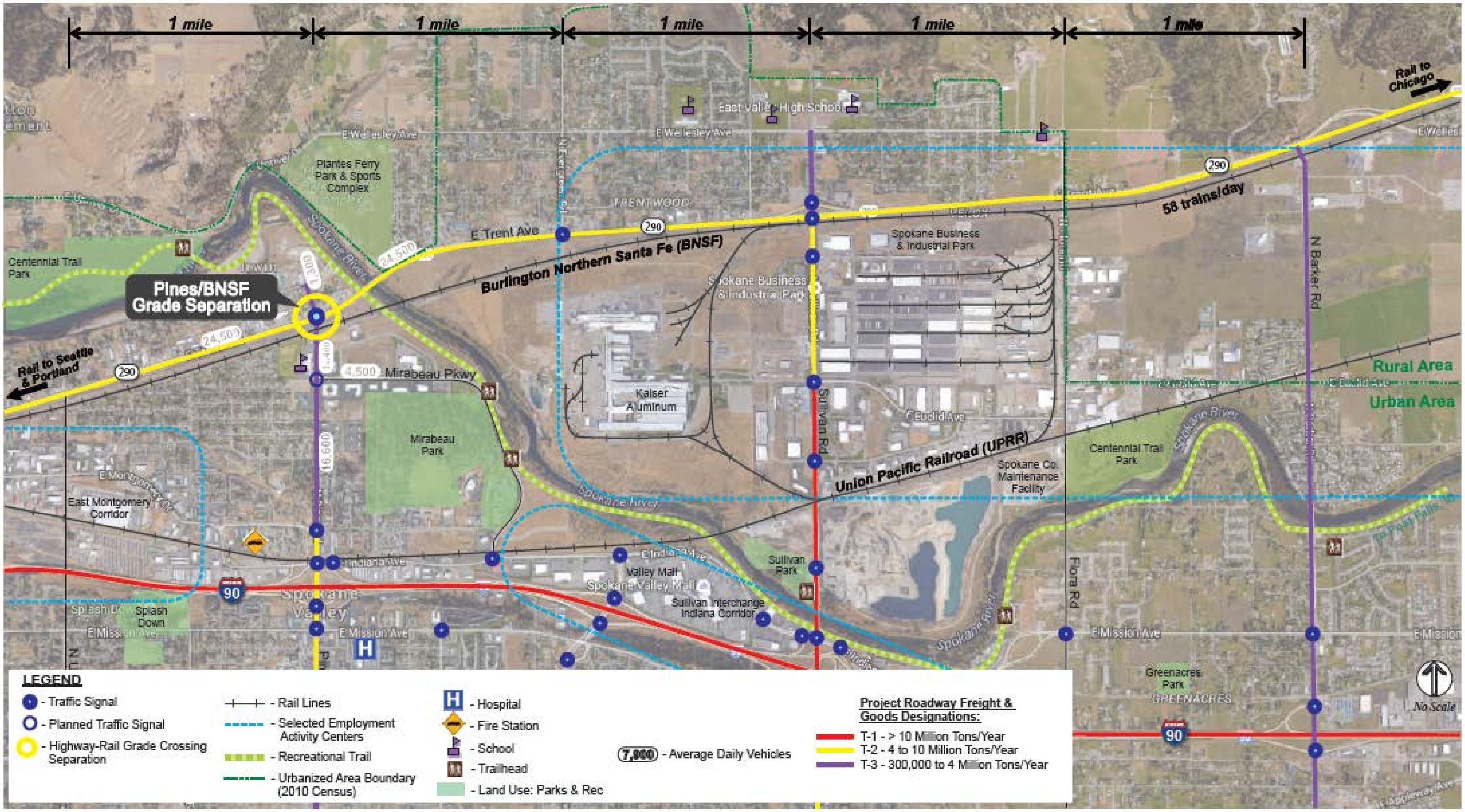
Figure 7: Urbanized Area Boundary



- Project: highway-rail crossing improvements on the BNSF rail line: grade separation at Pines Road
- Freight Rail Routes: BNSF and UPRR lines
- Land Use: key industrial areas, parks and recreation areas, schools, and vacant land
- Traffic Data: BNSF train volumes (Freight 58 per day, Amtrak 2 per day) and average daily traffic on project roadways (up to 35,000 vehicles/day[18]).

[18] Based on a 60/40 split of the most recent City ADT volumes at the intersection of Pines Road and Trent Avenue.

Figure 8: Project Locations and Connections to Existing Transportation Infrastructure



3 Grant Funds, Sources and Uses of Project Funds

The City of Spokane Valley is requesting **$23,020,800** in BUILD grant funds, which is **80.0%** of the **$28,776,000** total future project cost (estimate in year of expenditure dollars). This section provides discussion on the cost, committed and expected funding, federal funding overview, project budget, BUILD funding allocation, and the City's financial condition and grant management capabilities.

3.1 Project Costs

Not included in the project's estimate, previously incurred project costs include:

- $394,385 for planning (done in 2004), preliminary engineering (done in 2004), which included 30% design plans and cost estimates for the previous concept, and environmental documentation (initial NEPA approval in 2006).
- Through June 2018, $184,000 for preliminary engineering & alternative analysis/selection (2017-2018). The City is completing a preliminary alternative analysis for the project in order to clearly identify the project's requirements and costs. At the time of this submittal to the BUILD program, the analysis was coordinating with BNSF's future rail expansion project.
- The City secured $510,000 for early property acquisition (completed in 2017). This acquisition's final cost was approximately $494,000. Without this acquisition, the parcel was at risk of development and would restrict the configuration of the proposed project.

The future costs will be incurred for the following activities:

- Pre-construction activities:
  - Preliminary and final engineering of the updated concept
  - Additional acquisition of real property
- Construction, including construction engineering and management

The total estimated future cost in 2017 dollars is $24,040,536. This cost has been escalated at 3.5% annually to reflect the year costs are to be incurred as summarized in Table 3. The total future costs including inflation is $28,776,000.

Table 3: Annual Inflated Project Costs

Phase	2017 Cost	Year of Expenditure	Inflated Cost (3.5% annually)
Construction (2022-2024)	$ 14,536,000	2023	$ 17,869,000
Design Engineering (2019-2020)			
Preliminary Engineering	2,326,400	2019	2,493,000
Final Engineering	581,600	2020	645,000
Right-of-Way (2020-2021)	4,200,000	2021	4,820,000
Construction Engineering (2022-2024)	2,399,000	2023	2,949,000
Total Project Cost	**$ 24,043,000**		**$ 28,776,000**

3.2 Committed and Expected Funding

With exception to the 2004 regional planning and preliminary engineering efforts, the project has not secured any outside funding. Including the City's previously incurred project costs, Spokane Valley has secured $2,421,321 of local agency funds. As of June 2018, the City had expended approximately $678,000, resulting in an available project fund balance of **$1,743,000**, or **6.1%** of the **$28,776,000** total future project costs.

Parallel to BUILD, the City continues to pursue all available funding sources. Two other federal requests submitted in 2018 would be used to reduce the total award amount from the BUILD program. For this BUILD submittal, the project funding assumes all Federal dollars will be from the BUILD program and ignores the potential contributions from STBG or CRISI. Award of any of these programs would not reduce the 20% non-Federal match requirement.

- **Program:** Consolidated Rail Infrastructure & Safety Improvements (CRISI)
  Funding Request: $1,246,500 (50%)
  City Match Amount: $1,246,500 (50%)
  Funding Obligation Window: Estimated 2019-2020 (TBD at award – Fall 2018)
  Description: The City's application to the 2018 CRISI program request is for "Track 2" funding to complete the preliminary engineering and environmental review tasks.

- **Program:** Surface Transportation Block Grant (STBG) or Congestion Mitigation & Air Quality (CMAQ)
  Funding Request: $3,795,000 (80.6%)
  City Match Amount: $405,000 + $510,000 of previously incurred ROW costs (19.6%)
  Funding Obligation Window: 2020-2023 (funds available as early as 2020)
  Description: To streamline the City's efforts with CRISI funds, the City requested RW phase only funds from the STBG program. If awarded, the timing of RW funding would align with the completion of the CRISI-funded phases of the project.

There is opportunity to receive additional non-Federal matching funds through various programs such as Washington State Transportation Improvement Board (TIB), Washington State Freight Mobility Strategic Investment Board (FMSIB), Washington State Legislative Direct Appropriation (LDA), or City contributions. Table 4 provides a detailed breakdown of the committed and expected funding for both federal and non-federal sources.

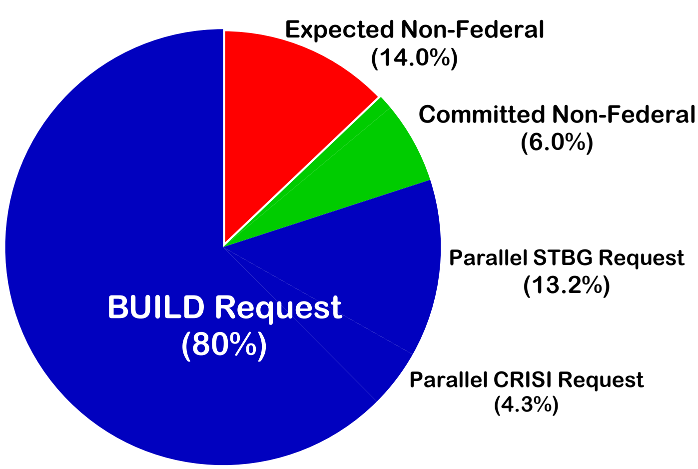
Table 4: Funding Sources

		Total ($)	Total (%)
Federal Funding			
Requested	BUILD	$23,020,800	80%
	Parallel CRISI Request (not quantified herein) = $1,246,500		
	Parallel STBG Request (not quantified herein) = $3,795,000		
	Subtotal	**$23,020,800**	**80%**
Non-Federal Funding			
Committed	City of Spokane Valley	$1,743,000	6%
Expected	BNSF*	$300,000	1%
	Other (TIB, FMSIB, LDA, Additional City Funds)	$3,712,200	13%
	Subtotal	**$5,755,200**	**20%**
	Total	**$28,776,000**	**100%**

** Per 23CFR 646.210, BNSF will determine their funding commitment once the 30% design plans and cost estimates have been brought up to current standards.*

The share of the anticipated funding sources is summarized in Figure 10. Expected funding from BNSF will be determined once the design has reached 30%. Conservatively, the project has assumed a BNSF contribution of $300,000.

Figure 9: Funding Sources



3.3 Project Budget

The City remains committed to this project even though it has yet to receive outside funding support. The committed funds are from the City of Spokane Valley's Capital Reserve and Grade Separation Project funds. See Appendix A for the City's endorsement and commitment of funding for this project. In lieu of any grant funds, the City will fund engineering design through 2018 as the alternative analysis nears completion, leading to the detailed engineering design. Table 5 summarizes the Project Budget and allocation of costs.

Table 5: Allocation of Project Funding

Project Phase	BUILD	Other Federal	Non Federal	Total
Right-of-Way Acquisition *(% by Phase)*	$ 2,202,800 *46%*	$ -	$ 2,617,200 *54%*	$4,820,000 *100%*
Engineering *(% by Phase)*	$ -	$ -	$ 3,138,000 *100%*	$3,138,000 *100%*
Construction *(% by Phase)*	$ 20,818,000 *100%*	$ -	$ - *0%*	$20,818,000 *100%*
TOTAL	**$ 23,020,800**	**$0**	**$5,755,200**	**$28,776,000**

3.4 BUILD Funding Allocation

If awarded BUILD funding, the City will allocate most funding to construction of the project elements (90% of BUILD funds), and the remainder to right-of-way acquisition (10% of BUILD funds). All of the funding will be spent on railway-highway grade separation and associated intersection improvements.

4 Merit Criteria

This section provides a summary of how the project meets the merit selection criteria for outcomes related to safety, state of good repair, economic competitiveness, environmental protection, quality of life, innovation, partnership, and non-Federal revenue for transportation infrastructure investment.

4.1 Safety

The BNSF mainline and Trent Avenue are high volume train and vehicle corridors respectively. As such, there is potential for significant safety hazards for vehicle, pedestrian, and bicyclist cross- traffic. There is currently an average of 58 freight trains per day using the BNSF line at the Pines Road crossing and the corridor has the capacity for train volumes to increase to 114 daily trains in the future, or five trains every hour on average. This is of particular concern to the community because the BNSF rail corridor is the route for commodity travel from the North American interior through Spokane Valley on its way to west coast terminals. As discussed in Section 1.3.3.1, the Pines Road/BNSF grade separation project is ranked the state's number one unfunded, road-rail conflict priority. To illustrate the magnitude of shipments, the Washington State Department of Ecology estimates that over 2 billion gallons of Bakken oil travels through

Spokane Valley annually.[19] This project eliminates the risk of fatalities, serious injuries, and commodity spills that can happen at a road/rail at-grade crossings.

In addition to the positive outcomes of the roadway-railway grade separation, the project offers additional safety benefits by replacing the existing at-grade intersection of Pines Road at Trent Avenue with a roundabout or traffic signal. As discussed in Section 1.1, it is expected that a roundabout will result in a 19% reduction in collisions, and a 71% reduction in fatal and injury collisions. Table 6 summarizes the expected collision reduction for the railroad crossing and Pines/Trent intersection in 2040 horizon year (the 2040 horizon year matches the MPO regional travel demand model future forecast horizon).

Table 6: Annual Collision Reduction, 2040 Horizon Year

Location	All Collisions	Fatal and Injury Collisions
Pines / BNSF RR Crossing	1.1	0.5
Pines / Trent Intersection	14.6	4.5
Total	15.7	5.0

The grade separation project also improves emergency access and provides enhanced detour/evacuation routes to residents, businesses, and schools by eliminating the delay impact resulting from crossing trains or incidents on the tracks. Additionally, improved access to Trent Avenue enhances the highway's role as a good alternate route to I-90 and Highway 95 in Idaho.

The safety of active modes will be enhanced with the addition of ADA-accessible sidewalks on the Pines Road underpass. Further, all ADA-related project improvements will be completed to satisfy current standards.

4.2 State of Good Repair

The project will address current roadway condition issues as the project will require full reconstruction of the affected portions of those roadways. All design will be to current design standards to provide a robust finished product that will have long term resilience greater than the current infrastructure. WSDOT has responsibility for maintenance of Pines Road and Trent Avenue, including the intersection being completed as part of this project. WSDOT has the resources to implement and properly maintain the asset for the design life of all elements.

The financial condition of the City of Spokane Valley is reported in their comprehensive annual budget and monthly financial reports[20]. The City employs staff with experience in grant management, project management and asset management.

[19] As of April 2018, 42 gallons per barrel x 680 barrels per car x 19,604 cars per quarter x 4 quarters = 2.24 billion gallons:https://fortress.wa.gov/ecy/coastalatlas/storymaps/spills/spills_sm.html
[20] Spokane Valley Budget & Financial Reports: http://www.spokanevalley.org/content/6836/6902/7156/default.aspx

The City successfully manages approximately five to eight million dollars in grants (federal and non-federal) on an annual basis and documents these figures in the annual budget. The primary source of the City capital funding for transportation projects comes from the City's Real Estate Excise Tax (REET) Revenue. Transportation operations funding comes from state gas tax revenue and a utility tax on telephones. The City's Street Fund has sufficient funding to cover operations and maintenance of the project. The City has a Capital Reserve Fund as a contingency for capital projects, and the General Fund may be used as a contingency for operating costs. Independent Audit Opinions are performed annually for the City of Spokane Valley under the U.S. Office of Management and Budget (OMB) Circular A-133. The two most recent, for fiscal years 2015 and 2016, reported no Significant Deficiencies or Material Weaknesses.

The project creates opportunities to provide access to currently undeveloped land by creating excess capacity within the Pines/Trent intersection. Further economic activity in the area creates opportunities for direct developer contribution to future upgrading, and adds to the City's tax base, both of which can further support long-term management of the infrastructure.

The City has recently demonstrated its ability to implement a comparable project. The $15 million Sullivan Road West Bridge Replacement Project combined four funding sources: one federal, two state, and a local city match. The City hired a consultant for the project's design using a RFQ process. The design was completed, the right-of-way was obtained, the project was bid, and construction began in the summer of 2014. The project was administered and inspected by the City. Construction was substantially completed in late 2016.

Also underway is the City's Barker Road/BNSF Grade Separation Project, recipient of a $9 million TIGER IX award offered by the USDOT. The project is federally funded at 64% and non-federally funded at 36%. It includes two federal funding sources, two state funding sources, and a local city match. The project is currently progressing with the engineering phase and scheduled to begin construction in 2020.

4.3 Economic Competitiveness

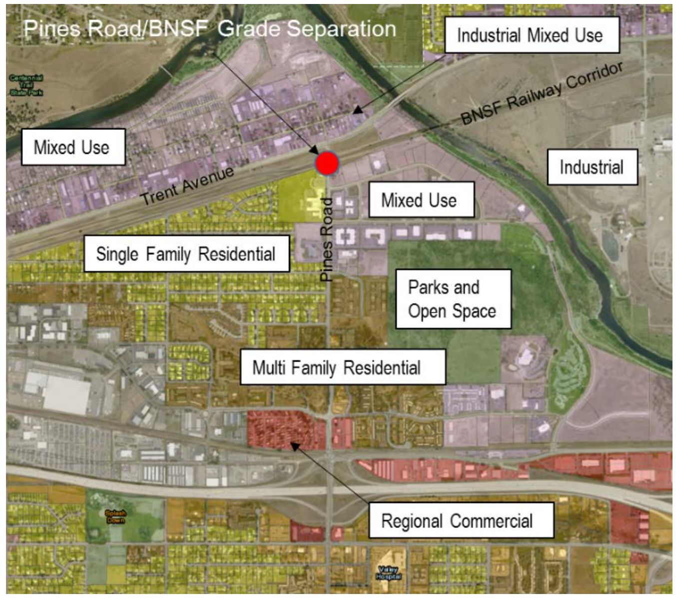
The smooth flow of trade, vital to U.S. economic competitiveness, is facilitated by addressing key deficiencies across the system. The Pines Road grade separation of the BNSF mainline provides an opportunity to target a local deficiency that effectively ripples benefit through the rest of the transportation system. The BNSF mainline that travels through the City of Spokane Valley is part of a broad rail network that moves freight between international marine ports and terminals on the west coast, and points across the western half of the U.S. Almost 94% of Washington's east-west bulk cargo rail traffic travels through this corridor.[21] The BNSF railway also serves interstate passenger rail service via Amtrak's Empire Builder route between Seattle and Chicago. Currently, the BNSF line carries an average of 58 freight and two passenger trains

[21] Washington Department of Transportation (WSDOT). Washington State Rail Plan. Technical Note 3a: Freight Rail Demand, Commodity Flows and Volumes. Dec. 2013.

daily, and usage on the line is estimated to grow 143 percent by 2035.[22] Upon completion, there will be 2.1 miles of rail corridor that will be unencumbered by at-grade crossings. When combined with the other Horizon 2040 regionally significant projects (Barker Road/BNSF Grade-Separation and Sullivan Road Bridge Reconstruction), the only remaining at-grade crossings between Harvard Road and Vista Road would be at Evergreen and University Roads.

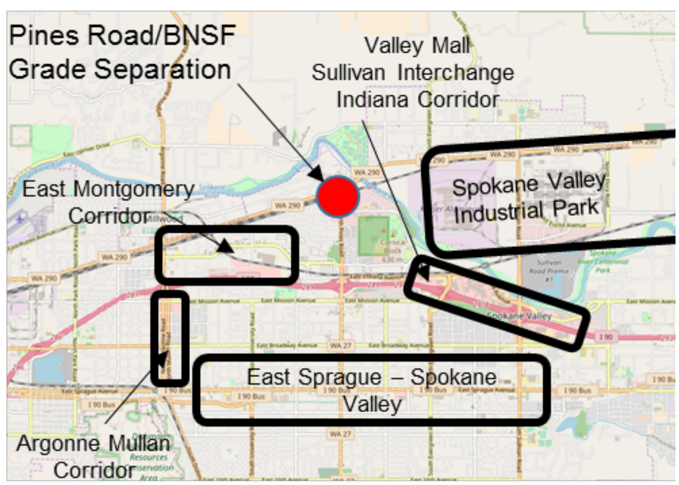
The Pines Road grade separation also has a significant benefit to trade facilitated by trucking. Pines Road serves as a primary arterial roadway directly connecting a State Highway at the project site with Interstate 90 to the south. The project promotes improved interstate freight movement to/from Canada and Idaho through Spokane County/Kootenai County by reducing vehicle-train conflicts as envisioned in the 2006 Bridging the Valley Plan.

Figure 10: Current Zoning



The project improves regional economic vitality by significantly improving reliability and accessibility to close to 170 acres of mixed-use or commercially-zoned and 56 acres of prime industrially-zoned parcels shown in Figure 10. With the City expected to accommodate an additional 20,000 residents and 18,000 employees, the Pines/Trent/BNSF/I-90 area will remain as a centralized corridor for growth (Figure 11). This project contributes significantly to supporting and managing this economic growth by building transportation infrastructure necessary to attract, retain, and expand businesses.

Figure 11: Selected 2040 Employment Activity Centres



The investment to expand the capacity of the transportation network will allow the land to support economic development at a much higher intensity. The economic and tax impacts of that higher level of development stemming from the construction and occupation of industrial developments are estimated as follows[23]:

[22] Ibid.
[23] Fiscal and Economic Benefits of the Pines Road Underpass Project, ECONorthwest 2016; http://www.spokanevalley.org/PinesBNSF

- $1.3 billion in total economic output in Spokane County ($686 million in direct spending)
- 8,719 new jobs supported in the county (4,312 direct jobs)
- $8.2 million in new general fund taxes to the city (25 year present value at 4%)
- $101.9 million in new general fund taxes to Washington State (25 year present value at 4%)

4.4 Environmental Protection

Grade separation of the BNSF rail line generates environmental benefits in reduced noise and air pollution. For Spokane Valley residents this represents a seemingly continuous sounding of horns along the railway corridor from Barker to Pines Road. The required sounding of train horns is significantly reduced with the grade separation of Pines Road.

The project supports air quality improvements and fuel efficiency. No longer will vehicle traffic be idling waiting for the crossings to be cleared by freight and passenger trains blocking Pines Road. Crossings are occupied for an average of approximately three and a half minutes for each train to pass plus the time to dissipate queues. Further reductions in idling will result from reductions in peak hour intersection delays at the Pines/Trent intersection. Afternoon peak hour intersection delays are anticipated to drop nearly 40 seconds per vehicle with a roundabout or about 10 seconds per vehicle for a traffic signal.[24] These savings equate to nearly 40 hours and 10 hours of daily time savings for a roundabout or traffic signal, respectively.[25] Idling vehicles consume fuel and emit harmful air pollutants. Spokane Valley and the rest of the region are identified by the U.S. Environmental Protection Agency (EPA) as maintenance areas for Particulate Matter (PM10) and Carbon Monoxide (CO), providing a significant annual reduction in CO, particulate matter, and greenhouse gas as compared with the current configuration.

4.5 Quality of Life

The Pines Road/BNSF Grade Separation project will substantially contribute to the improved livability for residents in the region by enhancing community connectivity while reducing the negative effects of train horn noise and decreasing transportation delays.

The BNSF rail corridor bisects the community. The area north of Trent Avenue is largely residential. Plantes Ferry Park and Sports Complex are also located to the north, while Trent Elementary School is located immediately south of the Pines Road/BNSF crossing. The majority of the City’s commercial, employment, and residential uses lie south of the BNSF corridor and Trent Avenue. This project will help knit together the northern and southern sectors of the community by eliminating barriers that impede mobility.

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[24] Appendix D - DRAFT Pines Road/BNSF Grade Separation – Consolidated Traffic and Safety Analysis, March 27, 2018 – Table 8.

[25] PM Peak Hour assumes 10% of intersection ADT of 35,000 vehicles (based on most recent City volume counts).
Roundabout: 40 seconds/vehicle x 10% x 35,000 vehicles / 3600 seconds/hour = 38.9 hours.
Traffic Signal: 10 seconds/vehicle x 10% x 35,000 vehicles / 3600 seconds/hour = 9.7 hours.

The project will complete key gaps in the City's pedestrian and bicycle networks that provide transportation and recreational options. Sidewalks are proposed for Pines Road, which will support travel by active modes along Pines Road. Given the location of the project and its proximity to schools, commercial centers, employment areas, parks, and the Spokane River, safe and comfortable pedestrian connections are very important and will provide a great benefit for the community.

This project enhances the unique characteristics of Spokane Valley and significantly improves connections to many community amenities. The 37.5-mile paved, mixed-use Centennial Trail runs along the Spokane River between Spokane, Washington and Coeur d'Alene, Idaho. It connects several local amenities, and includes a crossing of the Spokane River. Pines Road is a gateway to the Trail, and the project will provide a safer and more convenient route to it. South of Trent Avenue, Mirabeau Parkway provides access to Mirabeau Point Park from Pines Road, with river and Centennial Trail access. Plantes Ferry Park and Sports Complex is a 95-acre regional sports complex, located north of Trent Avenue, with sporting fields, trails, picnic areas, and playgrounds. Pines Road and Trent Avenue are important routes to this facility.

The project greatly benefits travel time reliability for all modes, and provides redundancy in the network to improve speed and reliability for emergency response vehicles where delay can have tragic outcomes; for school buses where delay means tardiness; and for commercial vehicles where the delay has negative economic impact.

The positive outcome for freight and passenger rail travel achieved by removing two at-grade crossings of the BNSF line supports the continued implementation of Horizon 2040 and the previous Bridging the Valley Plan. The project will also accommodate the planned additional mainline tracks for the rail corridor.

The ability to safely walk or bike across Trent Avenue between the residential communities, schools, commercial centers, and employment areas is hampered by gaps in the active transportation networks on Pines Road and the nature of traffic on Trent Avenue. The project enhances mobility for active modes by constructing Americans with Disabilities Act (ADA)-compliant sidewalks that connect the land uses to the north and south of the project area, and improve the comfort and safety of crossing Trent Avenue with a roundabout.

4.6 Innovation

The City of Spokane Valley will evaluate innovative bridge construction techniques to reduce the impact on the community and the existing traffic. This may include constructing the structures off-site before staging for construction. The project will also take advantage of the Spokane Regional Transportation Management Center (SRTMC) Intelligent Transportation Systems (ITS) infrastructure to communicate traveler information about construction activities and expected delays throughout the project using SRTMC's website and 511 telephone system.

Other ITS technologies, such as work zone queue management and speed management systems, will be evaluated for applicability during project engineering.

4.7 Partnership

This project demonstrates support from numerous public and private partners across the region. Two states, several regional public entities, multiple cities, and local business organization, as well as two Class I railroads actively participated in the Horizon 2040 planning document, and in the previous Bridging the Valley plan and other workshops, stakeholder outreach, and funding initiatives to further this effort. Table 7 summarizes the key partners associated with the Pines Road/BNSF grade-separation project and other related projects.

Table 7: Partners in the Project Development

State and Local Agencies	
• Idaho Transportation Department • Washington State Department of Transportation • Washington Freight Mobility Strategic Investment Board • Washington Utility and Transportation Commission • State and Federal Legislators	
Regional Agencies	
• Spokane Regional Transportation Council • Spokane Transit Authority • Kootenai Metropolitan Planning Organization	
Railroads	
• BNSF Railway Company	• Union Pacific Railroad
Local Agencies and Districts	
• Kootenai County • Spokane County • City of Athol • Town of Millwood • City of Rathdrum	• City of Spokane • City of Spokane Valley • Area Fire Districts/Emergency Response Systems • Area School Districts
Chambers of Commerce	
• Spokane Valley	• Greater Spokane Incorporated

The City of Spokane Valley has an excellent working relationship with WSDOT, and collaborate on roughly 10 to 20 projects per year. WSDOT maintains and operates 26 miles of state roadways within Spokane Valley. The City and WSDOT are both members of the SRTMC and work together to provide active regional transportation systems management and operations (e.g. incident management, traveler information). WSDOT and the City have delivered several ITS projects together, and WSDOT operates and maintains City traffic signals and ITS infrastructure on the state highways within the City through a long-standing Interlocal Agreement. The City and WSDOT collaboratively review traffic impact studies and permits for properties on Trent Avenue and Pines Road.

Other recent joint projects include planning efforts for three interchange justification reports (IJRs), paving projects, and bridge projects. The City worked closely with WSDOT on the evaluation process which selected the project's preferred design alternative that is submitted with this application.

The City coordinates with BNSF regarding the roadway crossings (at-grade and grade-separated) throughout the city. The two entities have worked together to complete several crossing diagnostic reviews in the past few years and coordinate all regularly scheduled and unplanned maintenance activities. In recent years, the City and BNSF have worked together to implement structural improvements at an overpass, enhance safety at at-grade crossings, and minor road upgrades at other crossings. The City is actively engaged with BNSF on the fully-funded Barker Road/BNSF Grade Separation Project and also the evaluation of the Pines/BNSF preferred design alternative that is included with this application. As required by CFR 646.210, the project will benefit from BNSF funding support once the project completes the 30% design drawings.

4.7.1 Letters of Support

Spokane Valley gathers letters of support from local and regional stakeholders. Further, the City has requested support through its website and at local gatherings like public meetings and presentations to groups like Washington State Congressmen or the Spokane Valley Chamber of Commerce. Letters of support are posted to the City's website: http://www.spokanevalley.org/PinesBNSF

5 Project Readiness

With the help of BUILD funding, the Pines Road/BNSF Grade Separation Project is expected to begin construction by 2022.

This project readiness section provides a summary of the technical feasibility, project schedule, required approvals needed, and mitigations for anticipated scope, schedule, and budget risks. The City is ready to advance the design of the project, and in fact will complete the preferred design alternative for the project this year. At the time of this submittal, the proposed roundabout is the most accurate, up to date configuration and represents the City's preferred alternative, however, the project's full traffic analysis is ongoing and may require revisions to the project and alter the intersection design. In 2018, both federal and city funds will be used to begin the engineering and right-of-way acquisition phases of the project.

5.1 Technical Feasibility

The technical feasibility of the proposed improvements has been thoroughly established through previous planning and preliminary engineering efforts.

5.1.1 Statement of Work

The Pines Road/BNSF Grade Separation Project replaces an existing at-grade crossing with an underpass of BNSF's railroad tracks and provides a roundabout or traffic signal at the intersection of Pines Road and Trent Avenue. The typical section for Pines Road consists of four travel lanes with a shared center turn lane. A 6 foot wide sidewalk is on the west side of the road and a 12 foot wode shared path is on the east. The sidewalk and shared use path are separated from the roadway by a swale when necessary for drainage. The Trent alignment and typical section stay the same.

Challenges exist with the final alignment of the intersecting highways because of the potential conflict with BNSF's additional mainline track project planned for the rail corridor. As part of the design engineering, the City, WSDOT, and BNSF will identify an acceptable layout in order for all partners to proceed with their respective projects. Table 8 provides the detailed project scope of work pertaining to how the design and construction will be achieved for the project.

5.1.2 Design Criteria and Basis of Design

Oversight of the project design and construction will be led by the City of Spokane Valley, in partnership with WSDOT and BNSF. Project roles for each stakeholder are described in Section 1.4. Design criteria was identified in the Bridging the Valley preliminary engineering effort and includes national, City, AASHTO, WSDOT, and BNSF standards. The process will follow WSDOT's project development and delivery procedures and standards supplemented with City procedures and standards as applicable to the project. Procedures and design criteria from the *Union Pacific Railroad and BNSF Railway Guidelines for Railroad Grade Separation Projects* and the AREMA *Manual for Railway Engineering* will also guide the project.

Table 8: Project Scope of Work

Engineering	Bid Letting & Construction
Procurement of Engineering Services Task 1: Surveying & Mapping Task 2: Utility Coordination Task 3: 30% Plans and Estimate Update* Task 4: 60% PS&E Task 5: 90% PS&E Task 6: Final PS&E Task 7: Local Agency Permits Task 8: Public Involvement Task 9: Project Management Task 10: Quality Management Task 11: Project Team Meetings Tasks 1 through 6 will be completed in the order shown, while Tasks 7 through 11 will be ongoing throughout the course of the engineering.	Final PS&E Review by FHWA, WSDOT, Spokane Valley, and BNSF Advertisement and Bid Letting Procurement of Contractor Notice to Proceed Shop Drawings and Submittal Reviews Fabrication of Structural Supports Mobilization and Erosion Control Temporary Traffic Control Utility Demarcation Bridge Structure Construction Roadway and Rail Construction Site Visits and Inspection Record ("As Constructed") Drawings Meetings

*Although 30% plans and costs were developed in 2004, they will need to be updated to current standards (including all required railroad clearances) and to account for current conditions and unit prices. This update may include geotechnical updates if needed.

5.1.3 Basis of Cost Estimate and Contingency Levels

As the scope of the project continues to develop, the cost estimate has been established from the project's most conservative design alternative, Alternative 1, as of June 2018 (Figures 3 & 4). The final design of BNSF's planned mainline track expansion will impact the project's final configuration. Costs were developed in 2017 dollars, and inflated at 3.5% annually to the start of each respective phase. A 20% contingency has been used for construction costs. The detailed cost estimate in 2017 dollars is included in Appendix B.

5.2 Scope, Schedule, and Budget Risk Mitigation Measures

The project has been the subject of several reviews and continues to develop through coordination with WSDOT and BNSF. Both the City of Spokane Valley and WSDOT have proven design standards and project delivery procedures in place. The lack of funding presents risks associated with schedule, which in turn can create scope and budget risks as time passes. For example, the eastward realignment of Pines Road protected access to several businesses on Trent Avenue. If new businesses are developed on Trent Avenue between Pines Road and Spokane River, the advantages of shifting Pines Road will be lost (Figure 4). Due to BNSF's possible mainline track expansion project, it's unclear as to what highway alignment will satisfactorily accommodate the improved rail corridor. Continued coordination with BNSF is critical to the progression of the proposed grade separation project.

5.2.1 Project Schedule

The project schedule shown in Table 9 includes the major project milestones for right-of-way acquisition, engineering, and construction and demonstrates that the project can meet the funding obligation and construction deadlines required by the BUILD grant program. Environmental approval was obtained through NEPA in 2006 as part of the Bridging the Valley environmental documentation process. Project-specific NEPA documentation will be developed as part of the engineering effort and approval is anticipated with this project. The schedule takes into account procurement and review timelines. The timelines for right-of-way acquisition and construction are dependent on funding.

Table 9: Project Schedule

PHASE	BEGIN	END
Preliminary Engineering (Incl. RW Plans & Prep)	09/2017	12/2019
Final Engineering Design	01/2020	12/2020
Environmental Documents (NEPA)	01/2019	12/2019
Right - of - Way	01/2020	12/2021
CN Ad/Bid/Award	06/2022	09/2022
Construction*	09/2022	12/2024

*Substantial Completion Date. Construction contract finalization by 09/2025.

5.3 Required Approvals

This section provides a summary of all required approvals related to environmental permits and reviews, state and local approvals, and state and local planning.

5.3.1.1 Environmental Permits and Reviews

The project has completed the environmental process as follows:

Environmental Process & Completed Efforts
National Environmental Policy Act (NEPA) and State EPA (SEPA) Status The Bridging the Valley project has already received NEPA Class II Categorical Exclusion and SEPA Categorical Exemption per WAC 197-11- 800 on August 22, 2006. The approval documentation is posted on the City's website. Project-specific NEPA documentation will be developed as part of the engineering effort and approval is anticipated by end of 2018.
Reviews, Approvals, and Permits by other Agencies The NEPA approval documentation provides a full list of all required permits and reviews. The Bridging the Valley stakeholders listed in Section 9 participated in reviews. This included reviews by the City of Spokane Valley, WSDOT, and BNSF.
Environmental Studies and other Documents Full environmental documentation in hard copy is on file at the Spokane Regional Transportation Council (SRTC). Copies are available upon request. The project was found to have no effect for most environmental components. Where there are small environmental impacts, mitigation measures have been identified and include procedures for hazmat disposal, erosion control, and stormwater treatment facilities.
WDOT Discussions on NEPA Compliance As part of the Bridging the Valley study, the project team coordinated with WSDOT to obtain SEPA approval concurrently with the NEPA approval.
Public Engagement Extensive public engagement has been an on-going effort as part of the Horizon 2040 and the previous Bridging the Valley planning and engineering efforts, as well as public engagement to solicit the public's preference for their preferred alternative. Efforts included public open houses, alternatives workshops, site visits with neighborhoods at each crossing in Washington and Idaho, mailings, and outreach. Public support has been overwhelmingly positive. Public engagement will continue through the right-of-way, engineering, and construction of this project.

5.3.1.2 State and Local Approvals

The Pines Road/ BNSF Grade Separation project is included in the Statewide Transportation Improvement Program (STIP), Horizon 2040 Metropolitan Transportation Plan, and the Spokane Valley TIP. A STIP amendment was obtained in May 2017 (STIP ID WA-10613) to proceed with the full engineering phase of the project. Additional right-of-way, engineering, and construction approvals will be obtained from the City, WSDOT, and BNSF at key milestones throughout the project.

5.3.1.3 Federal transportation Requirements Affecting State and Local Planning

Significant planning and preliminary engineering for this project have been completed. These efforts show that the proposed project is not only feasible but has the support of all project partners, the community, the region, and beyond:

Planning or Design Effort with Supporting Project Elements
Bridging the Valley Planning Study • Grade Separation Analysis: development, evaluation, refinement, and documentation of grade separation alternatives to support transportation needs and BNSF operations • Traffic Analysis: evaluation of traffic impacts associated with each alternative for 2001 and 2020 • Economic Analysis: benefit-cost analysis of all alternatives
Bridging the Valley 30% Preliminary Engineering • Right-of-Way needs were determined for this project • Design reports (including criteria), 30% plans, cost estimate, and environmental documentation were performed for these projects
Inland Pacific Hub Transportation Investment and Project Priority Blueprint • Lists the Bridging the Valley grade separation projects as priority rail improvement projects with significant project synergy economic benefits • Demonstrates support from local partners and identifies a midterm construction period of 2016-2021
Washington State Freight Mobility Plan 2014 • Identifies project for future implementation
Horizon 2040 Metropolitan Transportation Plan • Identifies this project and other Bridging the Valley grade separation projects
Spokane Valley Comprehensive Plan (2014) • Goal to support and encourage the continued viability of passenger and freight rail system in the region; Policy to support Bridging the Valley grade separation projects
City of Spokane Valley TIP • Includes project funding for early pre-construction activities
Fiscal and Economic Analysis of Project Analysis of incremental development, tax revenue benefits, economic output, jobs, and wages showing the significant benefit of implementing this project.[26]
Joint Transportation Committee Prioritization of Rail-Rail Conflicts in Washington State (*DRAFT* May 2018) • Rate the State's overall top priority grade separation project requiring funding support.

[26] Fiscal and Economic Benefits of the Pines Road Underpass Project, ECONorthwest 2016; http://www.spokanevalley.org/PinesBNSF

5.4 Assessment of Project Risks and Mitigation Strategies

The City has identified the following potential project risks and the associated mitigation measures:

Potential Risks	Mitigation Measures
Design Coordination	BNSF's mainline track expansion at the project location will impact the proposed grade separation and highway alignment. BNSF's proposed track location has yet to be identified and continued coordination between the City and WSDOT is critical to ensure the timely progression of both the City and BNSF's projects.
Project Funding	The City has multiple options for meeting the project's remaining financing needs. The City plans to pursue other funding opportunities including TIB, STBG, CMAQ, or FMSIB. The schedule also allows some leeway to obtain funding for the construction phase.
Environmental Approvals	The project has already received NEPA approval for a categorical exclusion, and minor mitigation measures (e.g. erosion control, stormwater treatment) have been identified. This information will be used to complete project-specific NEPA documentation.
Water Table at Pines Road	The project is near the Spokane River. Sometimes the water table is low near rivers. The nearby Argonne Road/BNSF Grade Separation project constructed an underpass of the rail line and did not run into any water table issues. Similar construction techniques will be used for excavation.
Utility Conflicts	Potential utility issues were identified during the 15% preliminary engineering, and on earlier designs, which means utility coordination can start early.
Right-of-Way Acquisition	On-going engagement with the public has built positive support for development potential. These efforts will be continued.

5.4.1 Benefit-Cost Assessment Summary

Table 10 summarizes the BCA findings identified in Appendix C. Annual costs and benefits are computed over the lifecycle of the project (estimated at 33 years). As stated earlier, construction is expected to be completed by 2024 with 2025 being the project opening year. Benefits accrue during the full operation of the project.

Table 10: Overall Results of the Benefit Cost Analysis, 2016 Dollars

Project Evaluation Metric	7% Discount Rate		3% Discount Rate
Total Discounted Benefits	$39,240,984		$88,679,091
Total Discounted Costs	$18,240,557		$21,784,430
Net Present Value	$21,000,428		$66,894,661
Benefit / Cost Ratio	2.15		4.07
Internal Rate of Return (%)		13.1%	
Payback Period (years)		6.43	

Values in 2017 Dollars Unless Specified Otherwise

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 13.1%. With a 7% real discount rate, the $18.2 million investment would result in $39.2 million in total benefits for a Net Present Value of $21.0 million and a Benefit/Cost ratio of approximately 2.15.

5.4.2 Cost Share

A community the size of Spokane Valley is greatly challenged to fund a project of this magnitude on its own. With many competing needs for city funds, the financial wherewithal to locally shoulder the entire burden of this project is not possible. With such geographically dispersed benefits generated by this project, federal assistance is not only a necessity but also a wise investment for the broader multi-modal transportation system.

Private funding in the project by BNSF will reduce the reliance on Federal funding. BNSF is expected to contribute funding to the project in partnership with the City of Spokane Valley. The City of Spokane Valley has already spent approximately $678,000 on right of way acquisition and preliminary design analysis. Further, the City has committed an additional $1,743,000 of its own funds toward the project and will continue to pursue additional non-Federal funding sources such as TIB, FMSIB, and LDA. City funds will be allocated to the project annually.

The City of Spokane Valley is sufficiently positioned to financially deliver this project with the assistance of the BUILD funding. The City is able to undertake all necessary long-term maintenance and rehabilitation through funds available from several street funds.

Appendix A

Local Agency Endorsement Form

CITY OF Spokane Valley

10210 E Sprague Avenue ♦ Spokane Valley WA 99206
Phone: (509) 720-5000 ♦ Fax: (509) 720-5075 ♦ www.spokanevalley.org

U.S. Department of Transportation

Better Utilizing Investments to Leverage Development (BUILD) Transportation Discretionary Grants Program

Call for Projects
Local Agency Project Endorsement

Project: Pines Road/BNSF Grade Separation Project

The attached project application reflects established local funding priorities consistent with the adopted local plans and programs.

The project described is financially feasible; local match revenue identified in the project application is available and committed to the project. If awarded Federal funds, the City is committed to securing all remaining unsecured non-Federal funds in order to satisfy BUILD program requirements. Costs identified in the application represent accurate planning level estimates needed to accomplish the work described herein.

This project has the full endorsement of the governing body/leadership of this agency or organization. This document must be signed by a person in a position or a representative of a governing body that has the authority to make decisions for the entire organization.

Mark Calhoun, City Manager
Name and Title of Designated Representative

[signature]
Signature of Designated Representative
FOR MARK CALHOUN

7-12-18
Date

Appendix B

Detailed Cost Estimate

City of Spokane Valley, WA
Pines Road/BNSF Grade Separation Project
Opinion of Probable Construction Cost
Alternative 1

Formatted By: Adam Jackson
Date: June 28, 2018

Contingency Code (%) or Unit	ITEM	UNIT	TRENT QUANTITY	PINES QUANTITY	TOTAL QUANTITY	UNIT PRICE (YEAR 2017)	ITEM COST (YEAR 2017)
%	CLEARING AND GRUBBING	LS			1	$50,000.00	$50,000.00
%	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	LS			1	$10,000.00	$10,000.00
U	REMOVING ASPHALT CONC. PAVEMENT	SY	11274	4500	15774	$4.00	$63,097.78
%	CONSTRUCTION SURVEYING	LS			1	$15,000.00	$15,000.00
%	SPCC PLAN	LS			1	$4,000.00	$4,000.00
%	TRAFFIC CONTROL	LS			1	$510,000.00	$510,000.00
%	SURVEYING	LS			1	$150,000.00	$150,000.00
%	RECORD DRAWING (MIN BID $10,000 LS)	LS			1	$10,000.00	$10,000.00
%	MINOR CHANGE, UNEXPECTED SITE CONDITIONS	LS			1	$50,000.00	$50,000.00
%	CONTRACTING AGENCY FIELD OFFICE	LS			1	$10,000.00	$10,000.00
%	PROPERTY RESTORATION	LS			1	$10,000.00	$10,000.00
%	UTILITY POTHOLING	LS			1	$10,000.00	$10,000.00
U	ROADWAY EXCAVATION INLC. HAUL	CY	49149	147587	196736	$10.00	$1,967,359.00
U	CATCH BASIN	EACH	8		8	$2,500.00	$20,000.00
U	STORM SEWER PIPE 18 IN. DIAM.	LF	1200	400	1600	$60.00	$96,000.00
U	SEWER MANHOLE	EACH	6		6	$3,000.00	$18,000.00
U	WORK ACCESS	LS		1	1	$25,000.00	$25,000.00
U	TEMPORARY SHORING	LS		1	1	$50,000.00	$50,000.00
U	STRUCTURE EXCAVATION CLASS A INCL. HAUL	CY		1272	1272	$25.00	$31,800.00
U	GRAVEL BACKFILL FOR GRAVITY BLOCK RETAINING WALL	CY		23	23	$50.00	$1,150.00
U	FURNISHING AND DRIVING STEEL TEST PILE	EACH		4	4	$17,000.00	$68,000.00
U	FURNISHING ST. PILING	LF		4600	4600	$100.00	$460,000.00
U	DRIVING ST. PILE	EACH		46	46	$4,500.00	$207,000.00
U	FURNISHING STEEL PILE TIP OR SHOE	EACH		50	50	$500.00	$25,000.00
U	PILE SPLICES	EACH		50	50	$500.00	$25,000.00
U	CONTROLLED DENSITY FILL	CY		66	66	$150.00	$9,900.00
U	CONC. CLASS 4000 FOR BRIDGE (ENCASEMENT)	CY		142	142	$650.00	$92,300.00
U	ST. REINF. BAR FOR BRIDGE (ENCASEMENT)	LB		18800	18800	$1.25	$23,500.00
U	PRECAST REINFORCED CONCRETE	LS		1	1	$178,000.00	$178,000.00
U	PRESTRESS 42" CONC. DOUBLE CELL BEAM W/ CURB & W/	LF		686	686	$800.00	$548,800.00
U	ELASTOMERIC PAD - SUPERSTR.	EACH		32	32	$1,500.00	$48,000.00
U	ERECTION OF SUPERSTRUCTURE	LS		1	1	$100,000.00	$100,000.00
U	RR BRIDGE SAFETY RAILING	LF		689	689	$200.00	$137,800.00
U	STRUCTURAL CARBON STEEL	LS		1	1	$8,931.00	$8,931.00
U	BRIDGE DECK WATERPROOFING	SY		660	660	$160.00	$105,600.00
U	PRECAST GRAVITY BLOCK RETAINING WALL	SF		500	500	$85.00	$42,500.00
U	CANTILEVER SOLDIER PILE WALL	SF	2572		2572	$120.00	$308,640.00
U	CRUSHED SURFACING BASE COURSE (CSBC)	CY		573	573	$20.00	$11,460.00
U	CRUSHED SURFACING TOP COURSE (CSTC)	CY	1454	912	2366	$60.00	$141,960.00
U	CEMENT CONC. PAVEMENT (PCC)	CY	3540	1995	5535	$300.00	$1,660,500.00
U	HMA Plantmix Pavement	TON		1740	1740	$110.00	$191,400.00
%	IRRIGATION SYSTEM	LS			1	$20,000.00	$20,000.00
%	EROSION/WATER POLLUTION CONTROL	LS			1	$150,000.00	$150,000.00
U	SEEDING, FERTILIZING, AND MULCHING	ACRE	1.10	1.75	3	$5,000.00	$14,250.00
%	LANDSCAPING	LS			1	$100,000.00	$100,000.00
U	CEMENT CONC. TRAFFIC CURB	LF	2394	3120	5514	$33.00	$181,962.00
U	PRECAST CONCRETE BARRIER	LF	1197	200	1397	$50.00	$69,850.00
U	PAINT LINE	LF	9095	8500	17595	$0.25	$4,398.63
%	MISC PLASTIC STRIPING	LS			1	$5,000.00	$5,000.00
%	PERMANENT SIGNING	LS			1	$20,000.00	$20,000.00
%	ILLUMINATION SYSTEM COMPLETE	LS			1	$100,000.00	$100,000.00
%	TRAFFIC SIGNAL SYSTEM	LS			1	$300,000.00	$300,000.00
%	ITS SYSTEM COMPLETE	LS			1	$50,000.00	$50,000.00
U	UTILITIES - GAS MAIN RELOCATION	LF			0	$200.00	$0.00
U	UTILITIES - WATER LINE RELOCATION	LF	800	1560	2360	$100.00	$236,000.00
U	UTILITIES - FIBER OPTIC RELOCATION Centrury Link	LF	1425	575	2000	$200.00	$400,000.00
U	UTILITIES - TELECOMMUNICATION RELOCATION	LF			0	$150.00	$0.00
U	UTILITIES - SEWER	LF	1500		1500	$200.00	$300,000.00
U	CEMENT CONCRETE SIDEWALK	SY	1945	2900	4845	$50.00	$242,250.00
	UTILITIES - YELLOWSTONE PIPELINE RELOCATION						
%	Shoofly				1	$860,000.00	$860,000.00
U	Railroad Flagging	Day			400	$1,000.00	$400,000.00
U	Temporary Shoring for Construction Staging - Roadway	SF	2100		2100	$30.00	$63,000.00

1	Construction Subtotal			$11,012,408
2	Mobilization		10%	$1,101,241
3	**Subtotal**			**$12,113,649**
4	Unit Price Contingencies	$8,578,408	20%	$1,715,682
5	Percentage Item Contingencies	$2,434,000	29%	$705,860
7	**Contingencies**		**20.0%**	**$2,421,542**
8	**Subtotal**			**$14,535,191**
9	Sales Tax (N/A included in unit costs)			$0
10	**Subtotal**			**$14,535,191**
11	Total Construction Subtotal			$14,535,191
12	Design Engineering (PE + FE)		20%	$2,907,038
13	RIGHT-OF-WAY			$4,200,000
14	Construction Engineer and Inspection		16.5%	$2,398,307
15	**TOTAL PROJECT COST (DESIGN, CONSTRUCTION, CONSTRUCTION ENGINEERING)**			**$24,040,536**

YEAR 2017 CONCEPTUAL ESTIMATE TOTAL ALTERNATIVE 1 **$24,040,536**

Phase	2017 Cost ($1,000)	Year of Expenditure	Inflated Cost (@3.5%)
Construction (2022-2024)	**$14,536,000**	**2023**	**$17,869,000**
Design Engineering (2019-2020)			
Preliminary Engineering	**$2,326,400**	**2019**	**$2,493,000**
Final Engineering	**$581,600**	**2020**	**$645,000**
Right of Way (2020-2021)	**$4,200,000**	**2021**	**$4,820,000**
Construction Engineering (2022-2024)	**$2,399,000**	**2023**	**$2,949,000**
Total	**$24,043,000**		**$28,776,000**

Appendix C

Benefit Cost Analysis

Pines Road Grade Separation

Benefit Cost Analysis Supplementary Documentation

BUILD Grants Program

City of Spokane Valley

July 3, 2018

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1 Executive Summary

With increasing growth in freight train traffic, the Pines Road grade crossing is becoming increasingly difficult for motorists, pedestrians, and other users. In 2018, the at-grade crossing was rated Washington State's top Tier 1 road-rail conflict.[1] Extended delays at the project location result in inefficient emergency services access, noise pollution from train whistles, inefficient freight truck movements along a preferred long-haul freight route, and a worsening Level of Service (LOS) projected to reach 'F' in future years due to high traffic volumes. The Pines Road/BNSF Grade Separation Project replaces an existing at-grade crossing with an underpass of BNSF's railroad tracks and provides a roundabout or traffic signal at the intersection of Pines Road and Trent Avenue. This will allow pedestrians and cyclists to be able to cross Trent Avenue more safely and comfortably. The improvements support freight movement and regional mobility goals as articulated in various plans such as Horizon 2040, the MPO's regional transportation plan, and the Inland Pacific Hub Transportation Study, a partnership of public and private agencies dedicated to creating a freight gateway in the region.

The City of Spokane Valley seeks a BUILD Discretionary Grant of $23,020,800[2] to complete funding for the Pines Road/BNSF Grade Separation Project to create a safer, more efficient, and reliable transportation network for its users.

The proposed concept is illustrated in Figure 1.

Figure 1: Pines Road/BNSF Grade Separation Project

[1] DRAFT Prioritization of Prominent Road-Rail Conflicts Phase 2 Study, May 22, 2018

[2] $23,020,800 is the total, rounded estimated project cost. $23,016,863 is the sum of the project phases without rounding of the individual phase costs. See Table 8 for a summary of funding sources.

Table ES-1 summarizes the impacts and associated monetary benefits expected from the project.

Table ES-1: Summary of Infrastructure Improvements and Associated Benefits

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternative	Type of Impacts	Population Affected by Impacts	Economic Benefits	Summary of Results ($2017, Discounted at 7%)
With increasing growth in freight train traffic, the Pines Road grade crossing is becoming increasingly difficult for motorists, pedestrians, and other users. Extended delays at the project location result in inefficient emergency services access, noise pollution from train whistles, inefficient freight truck movements along a preferred long-haul freight route, and a lack of industrial development potential due to a current Level of Service (LOS) 'E' operating condition, with an LOS 'F' condition expected due to worsening conditions.	The project replaces an existing at-grade crossing with an underpass of BNSF's railroad tracks and provides a roundabout or improved signalized controls at the intersection of Pines Road and Trent Avenue. The improvements support freight movement and regional mobility goals as articulated in various plans such as Horizon 2040, the MPO's regional transportation plan, and the Inland Pacific Hub Transportation Study, a partnership of public and private agencies dedicated to creating a freight gateway in the region. The elimination of delays at the rail crossings will improve the mobility of freight trucks traveling from Canada to Interstate 90, unlock the economic potential to develop prime vacant commercial and industrial land, support active pedestrian and bicycle lifestyles, and improving the quality of life through noise and emissions reductions.	Reduced Travel Time Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Motorists, shippers, local businesses and residents	Reduced Travel Time Costs	**$18,401,917**
		Improved Safety and Avoided Accident Costs from Eliminated Pines Road Grade Crossing	Motorists, shippers, local businesses and residents	Improved Safety and Avoided Accident Costs	**$19,015,787**
		Avoided Emission Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Local residents and residents across the country	Avoided Emissions Costs	**$34,342**
		Reduced Vehicle Operating Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Motorists, shippers, local businesses and residents	Reduced Vehicle Operating Costs	**$883,590**
		Residual Value of Infrastructure Asset	Local, state, and federal governments	Residual Value of Infrastructure Asset	**$820,344**
		Reduced Ongoing Infrastructure Maintenance Cost	Motorists, shippers, local businesses and residents	Operations & Maintenance Cost Savings	**$85,005**

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternative	Type of Impacts	Population Affected by Impacts	Economic Benefits	Summary of Results ($2017, Discounted at 7%)
		Fewer rail crossing blockages will improve travel time reliability as there will be a significantly lower chance for drivers to be delayed thus reducing the unpredictability of trips in the area. This also allows both short and long-haul trucks to experience improved delivery timeliness.	Motorists, shippers, local businesses and residents	Improved Travel Time Reliability	**n/a**
		Close to 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS 'E' operating conditions at the Pines Road /Trent Avenue intersection. These parcels, and several hundred more acres beyond the city limits, are some of the last undeveloped parcels available for industrial use in the area.	Motorists, shippers, local businesses and residents, local/state/federal governments	Unlock Future Development Potential	**n/a**

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternative	Type of Impacts	Population Affected by Impacts	Economic Benefits	Summary of Results ($2017, Discounted at 7%)
		Grade separation will provide pedestrian and cycling facilities allowing for greater connectivity and promotion of active lifestyles, in addition to improved access to nearby businesses and other public facilities.	Pedestrians, cyclists, local businesses and residents.	Improved Connectivity	**n/a**
		Grade separation will reduce noise pollution from train whistles.	Pedestrians, cyclists, local businesses and residents.	Reduced Noise Pollution	**n/a**
		Fewer rail crossing blockages will improve travel time and reliability for emergency responders that may otherwise not be able to pass or be forced to take a longer route.	Motorists, shippers, local businesses and residents	Improved Emergency Vehicle Access	**n/a**

The period of analysis used in the estimation of benefits and costs is 38 years, including 8 years of construction and planning and 30 years of operation. The total project costs include $24.0 million dollars in future capital costs as shown in Table ES-2. These costs shown below solely capture future capital costs and do not include previously incurred costs ($1,028,385). Values shown below include both rounded and non-rounded values to allow for comparison with the application narrative. The benefit cost analysis used non-rounded and constant project costs for accuracy and to not overstate project costs through rounding.

Table ES-2: Summary of Future Project Costs, Constant and Year of Expenditure Dollars*

Cost Component	Non-Rounded Values		Rounded Values	
	2017$	YOE$	2017$	YOE$
Construction	$14,535,191	$17,867,461	$14,536,000	$17,869,000
Right of Way	$4,200,000	$4,819,597	$4,200,000	$4,820,000
Construction Engineering	$2,398,307	$2,948,131	$2,399,000	$2,949,000
Preliminary Engineering	$2,325,631	$2,491,274	$2,326,400	$2,493,000
Final Engineering	$581,408	$644,617	$581,600	$645,000
Total Project Costs	**$24,040,536**	**$28,771,079**	**$24,043,000**	**$28,776,000**

**This table does not include previously incurred costs of $1,028,385*

Tables ES-3, ES-4 and ES-5 provide various summaries of the relevant data and calculations used to derive the benefits and costs of the project. Based on the analysis presented in the rest of this document, the project is expected to generate $39.2 million in discounted benefits and $18.2 in discounted costs, using a 7 percent real discount rate. Therefore, the project is expected to generate a Net Present Value of $21.0 million and a Benefit/Cost Ratio of 2.15.

Table ES-3: Summary of Total Project Benefits and Costs

Calendar Year	Project Year	Direct Beneficiaries	Total Benefits ($2017)	Total Costs* ($2017)	Undiscounted Net Benefits ($2017)	Discounted Total Benefits at 7% ($2017)	Discounted Total Costs at 7% ($2017)	Discounted Net Benefits at 7% ($2017)
2017	1	Workers otherwise unemployed (shadow wage benefit); not quantified	$0	-$945,718	-$945,718	$0	-$945,718	-$945,718
2018	2		$0	-$41,333	-$41,333	$0	-$38,629	-$38,629
2019	3		$0	-$41,333	-$41,333	$0	-$36,102	-$36,102
2020	4		$0	-$5,007,038	-$5,007,038	$0	-$4,087,235	-$4,087,235
2021	5		$0	-$2,100,000	-$2,100,000	$0	-$1,602,080	-$1,602,080
2022	6		$0	-$8,466,749	-$8,466,749	$0	-$6,036,675	-$6,036,675
2023	7		$0	-$5,080,049	-$5,080,049	$0	-$3,385,051	-$3,385,051
2024	8		$0	-$3,386,699	-$3,386,699	$0	-$2,109,066	-$2,109,066
2025	9	Federal and State governments, pedestrians, cyclists, motorists, local residents and businesses, trucking companies, AMTRAK and their passengers, property owners along the project corridor, and other residents across the country.	$3,555,960	$0	$3,555,960	$2,069,601	$0	$2,069,601
2026	10		$3,671,533	$0	$3,671,533	$1,997,070	$0	$1,997,070
2027	11		$3,793,051	$0	$3,793,051	$1,928,195	$0	$1,928,195
2028	12		$3,920,889	$0	$3,920,889	$1,862,786	$0	$1,862,786
2029	13		$4,056,471	$0	$4,056,471	$1,801,122	$0	$1,801,122
2030	14		$4,200,124	$0	$4,200,124	$1,742,902	$0	$1,742,902
2031	15		$4,351,808	$0	$4,351,808	$1,687,706	$0	$1,687,706
2032	16		$4,512,185	$0	$4,512,185	$1,635,423	$0	$1,635,423
2033	17		$4,680,314	$0	$4,680,314	$1,585,384	$0	$1,585,384
2034	18		$4,859,047	$0	$4,859,047	$1,538,250	$0	$1,538,250
2035	19		$5,047,551	$0	$5,047,551	$1,493,388	$0	$1,493,388
2036	20		$5,237,457	$0	$5,237,457	$1,448,201	$0	$1,448,201
2037	21		$5,435,670	$0	$5,435,670	$1,404,680	$0	$1,404,680
2038	22		$5,619,836	$0	$5,619,836	$1,357,264	$0	$1,357,264
2039	23		$5,733,837	$0	$5,733,837	$1,294,202	$0	$1,294,202
2040	24		$5,849,933	$0	$5,849,933	$1,234,025	$0	$1,234,025
2041	25		$5,968,601	$0	$5,968,601	$1,176,689	$0	$1,176,689
2042	26		$6,089,634	$0	$6,089,634	$1,122,010	$0	$1,122,010
2043	27		$6,213,957	$0	$6,213,957	$1,070,015	$0	$1,070,015
2044	28		$6,341,431	$0	$6,341,431	$1,020,529	$0	$1,020,529
2045	29		$6,472,186	$0	$6,472,186	$973,431	$0	$973,431
2046	30		$6,606,221	$0	$6,606,221	$928,589	$0	$928,589
2047	31		$6,743,960	$0	$6,743,960	$885,935	$0	$885,935

Calendar Year	Project Year	Direct Beneficiaries	Total Benefits ($2017)	Total Costs* ($2017)	Undiscounted Net Benefits ($2017)	Discounted Total Benefits at 7% ($2017)	Discounted Total Costs at 7% ($2017)	Discounted Net Benefits at 7% ($2017)
2048	32		$6,883,520	$0	$6,883,520	$845,110	$0	$845,110
2049	33		$7,027,861	$0	$7,027,861	$806,385	$0	$806,385
2050	34		$7,176,876	$0	$7,176,876	$769,610	$0	$769,610
2051	35		$7,327,463	$0	$7,327,463	$734,354	$0	$734,354
2052	36		$7,481,760	$0	$7,481,760	$700,764	$0	$700,764
2053	37		$7,639,860	$0	$7,639,860	$668,759	$0	$668,759
2054	38		$17,829,424	$0	$17,829,424	$1,458,604	$0	$1,458,604
Total			**$180,328,417**	**-$25,068,921**	**$155,259,497**	**$39,240,984**	**-$18,240,557**	**$21,000,428**

**Total costs used within the benefit cost analysis considered previously incurred costs of $1,028,385*

Table ES-4: Summary of Project Benefits by Benefit Type

Calendar Year	Project Year	Reduced Travel Time Costs	Improved Safety and Avoided Accident Costs	Avoided Emissions Costs	Reduced Vehicle Operating Costs	Residual Value of Infrastructure Asset	Operations and Maintenance Cost Savings
2017	1	$0	$0	$0	$0	$0	$0
2018	2	$0	$0	$0	$0	$0	$0
2019	3	$0	$0	$0	$0	$0	$0
2020	4	$0	$0	$0	$0	$0	$0
2021	5	$0	$0	$0	$0	$0	$0
2022	6	$0	$0	$0	$0	$0	$0
2023	7	$0	$0	$0	$0	$0	$0
2024	8	$0	$0	$0	$0	$0	$0
2025	9	$1,328,352	$2,155,081	$3,225	$58,302	$0	$11,000
2026	10	$1,413,335	$2,181,221	$3,229	$62,748	$0	$11,000
2027	11	$1,503,758	$2,207,959	$3,242	$67,092	$0	$11,000
2028	12	$1,599,970	$2,235,311	$3,265	$71,343	$0	$11,000
2029	13	$1,702,342	$2,263,291	$3,286	$76,552	$0	$11,000
2030	14	$1,811,269	$2,291,913	$3,371	$82,571	$0	$11,000
2031	15	$1,927,170	$2,321,193	$3,478	$88,967	$0	$11,000
2032	16	$2,050,492	$2,351,146	$3,606	$95,941	$0	$11,000
2033	17	$2,181,711	$2,381,786	$3,765	$102,052	$0	$11,000
2034	18	$2,321,332	$2,413,130	$3,964	$109,621	$0	$11,000
2035	19	$2,469,893	$2,445,194	$4,192	$117,272	$0	$11,000

Calendar Year	Project Year	Reduced Travel Time Costs	Improved Safety and Avoided Accident Costs	Avoided Emissions Costs	Reduced Vehicle Operating Costs	Residual Value of Infrastructure Asset	Operations and Maintenance Cost Savings
2036	20	$2,617,606	$2,477,994	$4,433	$126,424	$0	$11,000
2037	21	$2,774,156	$2,511,546	$4,695	$134,273	$0	$11,000
2038	22	$2,916,256	$2,545,868	$4,974	$141,739	$0	$11,000
2039	23	$2,989,724	$2,580,978	$5,144	$146,992	$0	$11,000
2040	24	$3,065,050	$2,616,895	$5,327	$151,661	$0	$11,000
2041	25	$3,142,284	$2,653,636	$5,524	$156,157	$0	$11,000
2042	26	$3,221,472	$2,691,222	$5,664	$160,277	$0	$11,000
2043	27	$3,302,665	$2,729,671	$5,873	$164,748	$0	$11,000
2044	28	$3,385,915	$2,769,003	$6,088	$169,425	$0	$11,000
2045	29	$3,471,273	$2,809,238	$6,312	$174,363	$0	$11,000
2046	30	$3,558,794	$2,850,398	$6,542	$179,487	$0	$11,000
2047	31	$3,648,533	$2,892,502	$6,780	$185,144	$0	$11,000
2048	32	$3,740,546	$2,935,574	$7,026	$189,373	$0	$11,000
2049	33	$3,834,893	$2,979,635	$7,280	$195,053	$0	$11,000
2050	34	$3,931,631	$3,024,708	$7,543	$201,993	$0	$11,000
2051	35	$4,030,824	$3,070,817	$7,733	$207,089	$0	$11,000
2052	36	$4,132,533	$3,117,984	$7,928	$212,315	$0	$11,000
2053	37	$4,236,823	$3,166,235	$8,128	$217,673	$0	$11,000
2054	38	$4,343,761	$3,215,594	$8,334	$223,167	$10,027,568	$11,000
Total		**$86,654,365**	**$78,886,723**	**$159,950**	**$4,269,812**	**$10,027,568**	**$330,000**

Table ES-5: Summary of Pertinent Quantifiable Data

Calendar Year	Project Year	Avoided Person Hours of Delay at Crossing	Avoided Gasoline Consumption (Gallons)	Avoided Diesel Consumption (Gallons)	Avoided Motor Oil Consumption (Quarts)	Avoided Fatalities	Avoided Injuries
2017	1	0	0	0	0	0	0
2018	2	0	0	0	0	0	0
2019	3	0	0	0	0	0	0
2020	4	0	0	0	0	0	0
2021	5	0	0	0	0	0	0
2022	6	0	0	0	0	0	0
2023	7	0	0	0	0	0	0
2024	8	0	0	0	0	0	0
2025	9	84,435	13,542	2,982	1,502	0	4
2026	10	89,837	14,408	3,173	1,598	0	4
2027	11	95,584	15,330	3,376	1,700	0	4
2028	12	101,700	16,311	3,592	1,809	0	4
2029	13	108,207	17,354	3,822	1,925	0	5
2030	14	115,131	18,465	4,067	2,048	0	5
2031	15	122,498	19,646	4,327	2,179	0	5
2032	16	130,336	20,903	4,604	2,319	0	5
2033	17	138,677	22,241	4,898	2,467	0	5
2034	18	147,552	23,664	5,212	2,625	0	5
2035	19	156,995	25,179	5,545	2,793	0	5
2036	20	166,384	26,685	5,877	2,960	0	5
2037	21	176,335	28,281	6,229	3,137	0	5
2038	22	185,367	29,729	6,548	3,298	0	5
2039	23	190,037	30,478	6,713	3,381	0	6
2040	24	194,825	31,246	6,882	3,466	0	6
2041	25	199,735	32,033	7,055	3,553	0	6
2042	26	204,768	32,841	7,233	3,643	0	6
2043	27	209,929	33,668	7,415	3,735	0	6
2044	28	215,221	34,517	7,602	3,829	0	6
2045	29	220,646	35,387	7,794	3,925	0	6
2046	30	226,209	36,279	7,990	4,024	0	6
2047	31	231,914	37,194	8,192	4,126	0	7
2048	32	237,762	38,132	8,398	4,230	0	7

Calendar Year	Project Year	Avoided Person Hours of Delay at Crossing	Avoided Gasoline Consumption (Gallons)	Avoided Diesel Consumption (Gallons)	Avoided Motor Oil Consumption (Quarts)	Avoided Fatalities	Avoided Injuries
2049	33	243,759	39,094	8,610	4,336	0	7
2050	34	249,908	40,080	8,827	4,446	0	7
2051	35	256,213	41,092	9,050	4,558	0	7
2052	36	262,678	42,128	9,278	4,673	0	7
2053	37	269,307	43,192	9,512	4,791	0	8
2054	38	276,105	44,282	9,753	4,912	0	8
Total		**5,508,056**	**883,382**	**194,556**	**97,988**	**5.08**	**173**

In addition to the monetized benefits presented in Tables ES-3 to ES-5, the project would generate benefits that are difficult to monetize. A brief description of those benefits is provided below.

Economic Competitiveness

- ***Improved Travel Time Reliability***

  On average, motorists are delayed 60 times per day at each roadway-railway crossing. With some trains nearly one and a half miles in length, crossings are closed for approximately three to five minutes for each train to pass. Delays are further compounded by the time required for the vehicle queues created by the train crossing to dissipate. Furthermore, the current Pines Road and Trent Avenue intersection operates at a LOS of 'E' which is projected to reach LOS 'F' due to worsening conditions. The project would transform the intersection to a LOS 'A' for a roundabout or LOS 'D' for a traffic signal, which will improve travel time reliability as there will be a significantly lower chance for drivers to be delayed thus reducing the unpredictability of trips in the area.

- ***Improved Access to Future Development Potential***

  Close to 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS 'E' operating conditions at the Pines Road /Trent Avenue intersection. These parcels, and several hundred more acres beyond the city limits, are some of the last undeveloped parcels available for industrial use in the area.

Quality of Life

- ***Improved Connectivity***

  Grade separation will provide pedestrian and cycling facilities allowing for greater connectivity and promotion of active lifestyles, in addition to improved access to nearby businesses and other public facilities. The BNSF Railway bisects the northern parts of Spokane Valley from the main city south of the railway. The project will connect a diverse neighborhoods surrounding the Study area including residential, commercial, mixed-use and industrial areas. The new grade-separated crossing and roundabout will provide sidewalks, making the route more appealing to pedestrians and bicyclists. In addition to an improved crossing of the railroad tracks, the roundabout will create a safer and more comfortable crossing of Trent Avenue.

- ***Improved Emergency Vehicle Access***

  Key emergency services (fire, police, and EMS) are located south of the railway crossing. The long and frequent delays at the rail crossings causes delays for providing emergency services to the north. Eliminating the Pines Road grade crossing will improve travel time and reliability for emergency responders that may otherwise not be able to pass or be forced to take a longer route.

- ***Reduced Noise Pollution***

  Spokane Valley residents have long complained about the noise pollution of the train whistles. Federal law requires locomotives to sound their horns at 96 to 100 decibels as they approach at-grade crossings and continue blowing the horn until the train clears the crossing. Not only do the horns disturb the peacefulness of the surrounding area, medical studies have linked loud noises, such as train whistles, to stress-related health problems.[3] As part of the broader Bridging the

[3] "Spokane Valley, Cheney residents want to silence train whistles." The Spokesman-Review, March 6, 2016.

Valley plan, all existing at-grade crossings will be eliminated, which will allow noise from train horns and whistles to be severely reduced. The Pines Road project alone will significantly reduce the amount of train horn and whistle noise and serves as an incremental improvement toward the overall goal of removing all at-grade crossings.

2 Introduction

This document provides detailed technical information on the economic analyses conducted in support of the Grant Application for the Pines Road/BNSF Grade Separation project.

- Section 1 – Executive Summary
- Section 2 – Introduction: Outlines the BCA document layout and structure to assist USDOT reviewers.
- Section 3 - Methodological Framework: Introduces the conceptual framework used in the Benefit-Cost Analysis (BCA).
- Section 4 - Project Overview: Provides an overview of the project, including a brief description of existing conditions and proposed alternatives; a summary of cost estimates and schedule; and a description of the types of effects that the Pines Road/BNSF Grade Separation is expected to generate.
- Section 5 - General Assumptions: Discusses the general assumptions used in the estimation of project costs and benefits.
- Section 6 – Demand Projections: Estimates of travel demand and traffic volumes.
- Section 7 – Benefits Measurement, Data and Assumptions: Details the specific data elements and assumptions used to address the goals of the project and to comply with program requirements.
- Section 8 – Summary of Findings and Benefit-Cost Outcomes: Estimates the project's Net Present Value (NPV), its Benefit/Cost Ratio (BCR), and other project evaluation metrics.
- Section 9 – Benefit Cost Sensitivity Analysis: Provides the outcomes of the sensitivity analysis that evaluates the different assumptions made by the City and the impact that the variability of those assumptions may have on the overall project.
- Section 10 - Supplementary Data Tables: Includes a breakdown of all benefits associated with the merit criteria outcomes for the project, including annual estimates of benefits and costs, as well as intermediate values to assist DOT in its review of the application.

3 Methodological Framework

The specific methodology developed for this application was developed using the above BCA principles and is consistent with the USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Applications (June 2018). In particular, the methodology involves:

- Establishing existing and future conditions under the Build and No Build scenarios;
- Assessing benefits with respect to each of the eight merit criteria identified in the notice of funding opportunity (NOFO);

- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement;
- Using USDOT guidance for the valuation of travel time savings, safety benefits and reductions in air emissions, while relying on industry best practice for the valuation of other effects
- Discounting future benefits and costs with the real discount rates recommended by USDOT (7 percent, and 3 percent for sensitivity analysis); and
- Conducting a sensitivity analysis to assess the impacts of changes in key estimating assumptions.

4 Project Overview

With increasing growth in freight train traffic, the Pines Road grade crossing is becoming increasingly difficult for motorists, pedestrians, and other users. Extended delays at the project location result in inefficient emergency services access, noise pollution from train whistles, inefficient freight truck movements along a preferred long-haul freight route, and a worsening Level of Service (LOS) projected to reach 'F' in future years due to high traffic volumes. The Pines Road/BNSF Grade Separation Project replaces an existing at-grade crossing with an underpass of BNSF's railroad tracks and provides a roundabout or traffic signal at the intersection of Pines Road and Trent Avenue. This will allow pedestrians and cyclists to be able to cross Trent Avenue more safely and comfortably. The improvements support freight movement and regional mobility goals as articulated in various plans such as Horizon 2040, the MPO's regional transportation plan, and the Inland Pacific Hub Transportation Study, a partnership of public and private agencies dedicated to creating a freight gateway in the region. In 2018, the at-grade crossing was rated Washington State's top Tier 1 road-rail conflict.[4]

The project will improve the current conditions in the area and in nearby neighborhoods by:

- ***Creating*** an underpass which will foster increased connectivity for all road users, pedestrians, and cyclists by installing new sidewalks and shared-use lanes
- ***Convert*** an existing intersection into an improved roundabout allowing a greater flow of traffic
- ***Improving*** public safety by eliminating rail/vehicle encounters at the Pines Road/BNSF crossing
- ***Improving*** travel time reliability through the elimination of rail crossing blockages, allowing for greater predictability in travel times
- ***Improving*** emergency services access along the Project corridor
- ***Eliminating*** wait times and prolonged queuing both at the crossing and along the Project corridor
- ***Eliminating*** vehicle queuing along Trent Avenue as a result of train crossings
- ***Reducing*** noise pollution arising from train whistles at the Pines Road/BNSF crossing
- ***Unlocking*** the economic development potential of prime industrial, commercial, and mixed-use land near the Project location
- ***Linking*** a large residential neighborhood to the north with the City's commercial and employment hub to the south
- ***Unlocking*** the economic development potential of approximately 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS 'E' operating conditions at the Pines Road /Trent Avenue intersection.

[4] DRAFT Prioritization of Prominent Road-Rail Conflicts Phase 2 Study, May 22, 2018

4.1 Base Case and Alternative Case

4.1.1 Base Case

The Base Case for the Pines Road Grade Separation project is defined as the No Build scenario. In the Base Case, the lack of grade separation and continued freight train growth continues to delay road users and maintains the LOS 'E' designation. Vehicle queuing along Trent Avenue continues to pose severe safety concerns.

The key assumptions used to define the Base Case (No Build Scenario) are as follows:

- Average Annual Daily Traffic (AADT) on Trent Avenue (East of Pines Road) of **27,393** (2017), growing at a rate of **2.5% per year** which is the historical 10-year annual average growth rate (AAGR) based upon City of Spokane Valley traffic counts. Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate (AAGR) to be most suitable.
- AADT on Trent Avenue (West of Pines Road) of **22,825** (2017), growing at a rate of **1.1% per year** which is the historical 10-year annual average growth rate based upon City of Spokane Valley traffic counts. Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate (AAGR) to be most suitable.
- AADT at the Pines Road crossing of **16,925** (2017), growing at a rate of **2.3% per year** derived using the historical 10-year annual average growth rate. Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate (AAGR) to be most suitable. AADT is broken down by the following modes:
  - **87%** passenger vehicles
  - **12%** trucks, and
  - **1%** transit
- **58** daily freight trains (2017) growing at a rate of **3.8% per year** until 2035, in line with WSDOT projections, and **3.4% per year** thereafter taking into account anticipated freight growth
- Average freight train speed of **25 miles per hour**
- Average freight train length of **6,500 feet**
- **2** daily passenger trains (2017) growing at rate of **2.0% per year**
- Average passenger train speed of **35 miles per hour**
- Average passenger train length of **1,000 feet**
- Average lead and lag time for gate closure of **0.6 minutes**

4.1.2 Alternative Case

The Alternative Case is defined as the Build scenario. In the Alternative Case, grade separation will eliminate train/vehicle encounters and eliminate wait times at the Pines Road crossing. The existing signalized intersection is converted to a roundabout allowing for greater flow of traffic and reduced collision severity. Traffic congestion and related safety concerns along Trent Avenue [due to train crossings] are eliminated. Specifically, the new infrastructure and improved process described in the project overview section above will result in the following changes to some key inputs and assumptions:

- AADT on Trent Avenue (East of Pines Road) of **27,393** (2017), growing at a rate of **2.3% per year** based on the historical 10-year annual average growth rate informed by the City of Spokane

Valley's traffic counts**.** Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate (AAGR) to be most suitable.

- AADT on Trent Avenue (West of Pines Road) of **22,825** (2017), growing at a rate of **1.1% per year** which is the historical 10-year annual average growth rate based upon City of Spokane Valley traffic counts. Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate (AAGR) to be most suitable.
- AADT at the Pines Road crossing of **16,925** (2017), growing at a rate of **2.5% per year** derived using historical 10-year annual average growth rates. Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate (AAGR) to be most suitable.
    - **87%** passenger vehicles (same as Base Case)
    - **12%** trucks (same as Base Case), and
    - **1%** transit (same as Base Case)
- **58** daily freight trains (2017, same as Base Case) growing at a rate of **3.8% per year** until 2035, in line with WSDOT projections, and **3.4% per year** thereafter taking into account anticipated freight growth.
- Average freight train speed of **25 miles per hour** (same as Base Case)
- Average freight train length of **6,500 feet** (same as Base Case)
- **2** daily passenger trains (same as Base Case) growing at a rate of **2.0% per year** (same as Base Case)
- Average passenger train speed of **35 miles per hour** (same as Base Case)
- Average passenger train length of **1,000 feet** (same as Base Case)
- Average lead and lag time of **0.6 minutes** (same as Base Case)

4.2 Project Cost and Schedule

Table 6 summarizes the project's capital cost components with design engineering and right-of-way acquisition beginning in 2020 and substantial completion expected at the end of 2024. Costs shown in Table 6 and Table 7 below exclude costs already incurred and solely capture future project capital costs in constant (2017$) and year of expenditure (YOE$) dollars.

It should be noted that Table 6 values may differ slightly from costs reporting in Table 3 of the application narrative due to the phasing of costs. The narrative estimated that costs are fully incurred in a specific year while the BCA sought to phase costs over the activity duration to allow for more accurate discounting.

Table 6: Future Capital Cost Summary Table

Year	2017$	YOE$
2020	$5,007,038	$5,590,359
2021	$2,100,000	$2,426,713
2022	$8,466,749	$10,126,425
2023	$5,080,049	$6,288,510
2024	$3,386,699	$4,339,072
Total	**$24,040,536**	**$28,771,079**

Costs are shown both rounded and non-rounded in the tables below to allow for comparison with the costs presented within the project narrative.

Table 7: Capital Cost Components

Component	Non-Rounded Values		Rounded Values	
	2017$	YOE$	2017$	YOE$
Construction	$14,535,191	$17,867,461	$14,536,000	$17,869,000
Right of Way	$4,200,000	$4,819,597	$4,200,000	$4,820,000
Construction Engineering	$2,398,307	$2,948,131	$2,399,000	$2,949,000
Preliminary Engineering	$2,325,631	$2,491,274	$2,326,400	$2,493,000
Final Engineering	$581,408	$644,617	$581,600	$645,000
Total Project Cost	**$24,040,536**	**$28,771,079**	**$24,043,000**	**$28,776,000**

Table 8 summarizes the anticipated funding sources for the project with Table 9 below shows the allocation of project funding. Table 10 summarizes project costs including previously incurred costs ($1,028,385) to ensure transparency.

Table 8: Summary of Anticipated Funding Sources

Funding Source	Capital YOE$, Non-Rounded	Capital YOE$, Rounded	Percent of Total Capital Cost Financed
Non-Federal Sources			
City of Spokane Valley Allocation	$1,742,016	$1,743,000	6.1%
BNSF Estimated Contribution	$300,000	$300,000	1.0%
Other: TIB, FMSIB, LDA, Additional City Funds)	$3,712,200	$3,712,200	12.9%
Total Non-Federal Sources	**$5,754,216**	**$5,755,200**	**20%**
BUILD	$23,016,863	$23,020,800	80.0%
Total Project Costs	**$28,771,079**	**$28,776,000**	

Table 9: Allocation of Project Funding

Project Phase	BUILD	Non-Federal	Total (YOE$, Non-Rounded)	Total (YOE$, Rounded)
Right-of-way Acquisition	$2,202,423	$2,616,752	$4,819,176	$4,820,000
Engineering	-	$3,137,463	$3,137,463	$3,138,000
Construction	$20,814,440	-	$20,814,440	$20,818,000
Total	**$23,016,863**	**$5,754,216**	**$28,771,079**	**$28,776,000**

Table 10: Capital Cost Components Including Previously Incurred Costs

Component	Non-Rounded Values		Rounded Values	
	2017$	YOE$	2017$	YOE$
Previously Incurred Costs	$1,028,385	$1,028,385	$1,029,000	$1,029,000
Construction	$14,535,191	$17,867,461	$14,536,000	$17,869,000
Right of Way	$4,200,000	$4,819,597	$4,200,000	$4,820,000
Construction Engineering	$2,398,307	$2,948,131	$2,399,000	$2,949,000
Preliminary Engineering	$2,325,631	$2,491,274	$2,326,400	$2,493,000
Final Engineering	$581,408	$644,617	$581,600	$645,000
Total Project Cost	**$25,068,921**	**$29,799,464**	**$25,072,000**	**$29,805,000**

Lastly, Table 11 summarizes the anticipated project schedule including preliminary engineering and necessary right-of-way acquisitions.

Table 11: Project Schedule

Phase	Begin	End
Prelim. Engineering (Incl. RW Plans & Prep)	Sep-17	Dec-19
Engineering Design	Jan-20	Dec-20
Environmental Documents (NEPA)	Jan-19	Dec-19
Right of Way Acquisition	Jan-20	Dec-21
CN Ad/Bid/Award	Jun-22	Sep-22
Construction*	Sep-22	Dec-24

4.3 Effects on Selection

The main benefit categories associated with the project are mapped into the eight merit criteria set forth by USDOT in the table below.

Table 12: Expected Effects on Merit Criteria Outcomes and Benefit Categories

Merit Criteria	Impact Categories	Description	Monetized	Qualitative
Safety	Improved Safety and Avoided Accident Costs	Improved Safety and Avoided Accident Costs from Eliminated Pines Road Grade Crossing	Yes	-
State of Good Repair	Residual Value of Infrastructure Asset	Residual Value of Infrastructure Asset	Yes	-
	Operations & Maintenance Cost Savings	Reduction in maintenance costs for the existing at-grade crossing	Yes	-
Economic Competitiveness	Reduced Travel Time Costs	Reduced Travel Time Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Yes	-
	Reduced Vehicle Operating Costs	Reduced Vehicle Operating Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Yes	-
	Improved Travel Time Reliability	Fewer rail crossing blockages will improve travel time reliability as there will be a significantly lower chance for drivers to be delayed thus reducing the unpredictability of trips in the area. This also allows both short and long-haul trucks to experience increase in delivery timeliness	-	Yes

Merit Criteria	Impact Categories	Description	Monetized	Qualitative
	Improved Access to Economic Development Potential	Close to 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS ‘E’ operating conditions at the Pines Road /Trent Avenue intersection. These parcels, and several hundred more acres beyond the city limits, are some of the last undeveloped parcels available for industrial use in the area.	-	Yes
Environmental Protection	Avoided Emissions Costs	Avoided Emission Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Yes	-
Quality of Life	Improved Connectivity	Grade separation will provide pedestrian and cycling facilities allowing for greater connectivity and promotion of active lifestyles, in addition to improved access to nearby businesses and other public facilities	-	Yes
	Improved Emergency Vehicle Access	Fewer rail crossing blockages will improve travel time reliability as there will be a significantly lower chance for drivers to be delayed thus reducing the unpredictability of trips in the area.	-	Yes
	Reduced Noise Pollution	Grade separation will reduce noise pollution from train whistles.	-	Yes

Merit Criteria	Impact Categories	Description	Monetized	Qualitative
Innovation	Innovative Bridge Construction	The City of Spokane Valley will evaluate innovative bridge construction techniques to reduce the impact on the community and the existing traffic. This may include constructing the structures off-site before staging for construction.	-	Yes
	Intelligent Transportation Systems	The project will take advantage of the Spokane Regional Transportation Management Center (SRTMC) Intelligent Transportation Systems (ITS) infrastructure to communicate traveler information about construction activities and expected delays throughout the project using SRTMC's website and 511 telephone system.	-	Yes
Partnership	Support from Public and Private Partners	This project demonstrates support from numerous public and private partners across the region. Two states, several regional public entities, multiple cities, and local business organization, as well as two Class I railroads actively participated in the Horizon 2040, and in the previous Bridging the Valley plan and other workshops, stakeholder outreach, and funding initiatives to further this effort.	-	Yes

5 General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of construction and including 30 years of operations.

The monetized benefits and costs are estimated in 2017 dollars with future dollars discounted in compliance with BUILD requirements using a 7 percent real rate, and sensitivity testing at 3 percent.

The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- Input prices are expressed in 2017 Dollars;
- The period of analysis begins in 2017 and ends in 2054. It includes project development and construction years (8) and full years of operations (30).
- A constant 7 percent real discount rate is assumed throughout the period of analysis. A 3 percent real discount rate is used for sensitivity analysis.

6 Demand Projections

Accurate demand projections are important to ensure the reasonable BCA output results. The magnitudes of the long-term benefits accruing over the Pines Road Grade Separation project study period are a function of vehicle traffic at the Pines Road Crossing and Pines Road / Trent Avenue intersection, and freight and passenger train growth.

6.1 Methodology

Recent and historical traffic counts supplied by the City of Spokane Valley were used to inform and provide historical 10-year annual average growth rates. Moreover, although motorists may choose to take longer detours to avoid the congested and unreliable crossings which could be avoided in the Alternative Case, the additional benefits of avoided detours were not estimated due to a lack of reliable data.

6.2 Assumptions

All assumptions used in the estimation of demand inputs for the Pines Road Grade Separation project are provided in Table 13.

Table 13: Assumptions used in the Estimation of Demand

Variable Name	Unit	Value	Source
Pines Road Crossing			
AADT (2017)	vehicles/day	16,512	2016 actual traffic count data grown by validated historical AAGR. Share of vehicle counts based upon engineering estimates.
Passenger Vehicles	%	87.0%	
Trucks	%	12.0%	
Buses	%	1.00%	
AADT Growth Rate	%	2.51%	Historical 10-year average annual growth rate at crossing validated through comparison with Spokane Regional Transportation Council (SRTC) Travel Demand Model (TDM) outputs

Variable Name	Unit	Value	Source
Maximum Trains at Crossing	trains/day	125	WSDOT State Rail Plan *http://www.wsdot.wa.gov/NR/rdonlyres/F67D73E5-2F2D-40F2-9795-736131D98106/0/StateRailPlanFinal201403.pdf*
Freight Train Traffic Growth (2017-2035)	%	3.81%	
Freight Train Traffic Growth (2036-2054)	%	3.40%	HDR assumption. Growth is capped at 125 trains per day.
Passenger Train Traffic Growth	%	2.00%	HDR assumption based on long term population growth
Freight Trains at Crossing (2017)	trains/day	58.1	WSDOT State Rail Plan http://www.wsdot.wa.gov/NR/rdonlyres/F67D73E5-2F2D-40F2-9795-736131D98106/0/StateRailPlanFinal201403.pdf
Passenger Trains at Crossing (2017)	trains/day	2.04	Amtrak
Avg. Freight Train Speed	miles/hour	25.0	BNSF
Avg. Passenger Train Speed	miles/hour	30.0	HDR assumption
Avg. Freight Train Length	feet	6,500	BNSF
Avg. Passenger Train Length	feet	1,000	HDR assumption
Lead and Lag Time	minutes	0.60	HDR based upon industry standard
Trent Avenue Intersection			
AADT, East of Pines Road (2017)	vehicles/day	27,393	Traffic counts conducted in 2015 and 2016. Data grown by validated historical AAGR.
AADT, West of Pines Road (2017)	vehicles/day	22,825	
AADT Growth Rate East of Pines Road	%	2.30%	Historical 10-year average annual growth rate validated through comparison with SRTC Travel Demand Model outputs
AADT Growth Rate West of Pines Road	%	1.12%	

6.3 Demand Projections

The resulting projections for average traffic volumes at the Pines Road crossing and Trent Avenue intersection, as well as train volumes and expected hours of vehicle delay (Base Case) are presented in the table below.

Table 14: Demand Projections

Category	2025	2034	2044	2054
Total Annual Traffic at Pines Road Crossing	7,530,081	9,408,480	12,049,969	15,433,073
Total Annual Traffic at Trent Ave. Intersection	11,990,442	14,709,550	18,459,769	23,166,112
Annual Freight Trains at Pines Road Crossing	28,623	40,082	45,625	45,625
Annual Passenger Trains at Pines Road Crossing	872	1,043	1,271	1,549
Total Vehicle Hours of Delay - Passenger Vehicles	13,825,737	24,160,853	35,241,231	45,210,666

Category	2025	2034	2044	2054
Total Vehicle Hours of Delay - Trucks	1,906,998	3,332,531	4,860,859	6,235,954
Total Vehicle Hours of Delay - Bus Driver and Passenger	158,917	277,711	405,072	519,663

7 Benefits Measurement, Data and Assumptions

This section describes the measurement approach used for each benefit or impact category identified in Table ES-1 and provides an overview of the associated methodology, assumptions, and estimates.

7.1 Safety Outcomes

The proposed project would contribute to promoting merit outcomes through accident reductions due to eliminated train/vehicle encounters at the Pines Road grade crossing.

7.1.1 Methodology

Accident costs, and impacts on life, limb and property, are a significant component of road user costs. Road safety is a key economic factor in the planning of roads, as well as an important indicator of transportation efficiency, while outside of the economic context, highway safety is often the object of public concern and a leading social issue. Estimating safety benefits requires data on the frequency and severity of accidents for the type of road and area under consideration; in addition, the costs of injuries and fatalities must be monetized. Base Case collisions at the Pines Road crossing were derived using the FRA's collision prediction formulae. Collisions at the Pines Road and Trent Avenue were calculated using crash data actuals provided by the City of Spokane Valley and crash modification factors (CMF) obtained from the US DOT Crash Modification Factor Clearinghouse. While PDO (property damage only) accidents occur, only benefits realized from mitigated injury accidents and fatalities were monetized.

7.1.2 Assumptions

The assumptions used in the estimation of safety benefits are summarized in the table below.

Table 15: Assumptions used in the Estimation of Safety Benefits

Variable Name	Unit	Value	Source
Value of a Statistical Life	2017$/fatality	$9,600,000	US DOT, Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses. 2017.
Average Cost per Accident Injury	2017$/injury	$174,000	US DOT, Based on MAIS Injury Severity Scale and KACBO-AIS Conversion if Injury Unknown. Department of Transportation Analyses. 2017.
2017 Expected Accident Rate	accidents/year	1.0868	HDR Calculations Using FRA Collision Prediction Formulae. See: https://www.ite.org/marketplace/gradecrossing/sec03.htm
2026 Expected Accident Rate	accidents/year	1.0869	
2036 Expected Accident Rate	accidents/year	1.0869	
2046 Expected Accident Rate	accidents/year	1.0869	

Variable Name	Unit	Value	Source
Fatalities as Share of Total Accidents	%	9.09%	HDR calculation using FRA GX Tool. See: https://www.fra.dot.gov/Page/P1056
Injuries as Share of Total Accidents	%	36.4%	
Crash Modification Factor	factor	0.68	US DOT Crash Modification Factor Clearinghouse. "Convert Intersection With Minor-Road Stop Control to Modern Roundabout
Expected Intersection Fatalities - No Build	fatalities	0.13	Washington Department of Transportation
Expected Intersection Injuries - No Build	injuries	9.87	
Expected Intersection Fatalities - Build	fatalities	0.09	Washington Department of Transportation
Expected Intersection Injuries - Build	injuries	6.71	
Growth in Intersection Accidents	%/year	2.30%	Historical 10-year Average Annual Growth Rate at Crossing

7.1.3 Benefit Estimates

The table below shows the benefit estimates of eliminated train/vehicle encounters. With a 7 percent discount rate applied to the benefits, the estimated present value is $19.0 million. See Section 10.3 and 10.4 for additional information.

Table 16: Estimates of Safety Benefits, 2017 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Improved Safety and Avoided Accident Costs	$2,155,081	$78,886,723	$19,015,787
Total	**$2,155,081**	**$78,886,723**	**$19,015,787**

7.2 State of Good Repair Outcomes

7.2.1 Methodology

The proposed project would contribute to the state of good repair by converting an existing intersection into an improved roundabout. Due to the time period considered for the analysis, the remaining (or residual) value of the new infrastructure asset is not fully captured. As a result, the residual value of the new grade separation underpass is monetized. The estimated underpass lifespan was deducted from the benefit cost analysis benefit period to obtain the service life outside the study period. The remaining life as a factor of the estimated asset service life was multiplied by the project capital costs to derive the estimate.

7.2.2 Assumptions

The assumptions used in the estimation of State of Good Repair benefits are summarized in the table below.

Table 17: Assumptions used in the Estimation of State of Good Repair Benefits

Variable Name	Unit	Date	Value	Source
Estimated Asset Service Life	years	2017-2054	50.0	Transportation for America, Bridges Overview. "Expected Lifespan of 50 years."
BCA Benefit Period	years	2017-2054	30.0	HDR Calculations with City of Spokane Valley Consultation
Service Life Remaining	years	2017-2054	20.0	
Project Capital Costs	2017$	2017-2054	$25,068,921	
Annual Maintenance Cost Savings	2017$	2017-2054	$11,000	Estimate based upon long term maintenance of at-grade crossing infrastructure

7.2.3 Benefit Estimates

The table below shows the estimated residual value of the new infrastructure asset. With a 7 percent discount rate, the estimated present value is $0.83 million. See Section 10.5 for more information.

Table 18: Estimates of State of Good Repair Benefits, 2017 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Residual Value of Infrastructure Asset	$0	$7,818,570	$732,310
Operations and Maintenance Cost Savings	$11,000	$330,000	$97,322
Total	**$11,000**	**$8,148,570**	**$829,632**

7.3 Economic Competitiveness

To quantify the benefits associated with economic outcomes, multiple impacts were considered primarily in relevance to motorists. Specifically, these impacts included travel time costs, vehicle operating costs, and pavement maintenance costs – all of which were monetized.

7.3.1 Methodology

Travel time savings will be generated for motorists (automobiles, trucks, and transit buses) at the Pines Road crossing. Reduced crossing blockage times will lead to decreased vehicle travel time costs which are monetized using DOT guidance for value of time of automobile drivers and passengers, bus passengers, as well as heavy vehicle truck drivers and bus drivers. Out-of-pocket vehicle operating cost savings will accrue from decreased vehicle wait times and idling as a result of the new underpass across Trent Avenue. The out-of-pocket cost savings were monetized based on the change in delay time and associated fuel and oil used while idling.

Travel time savings in hours between the Base and the Alternative Cases were estimated based on AADT forecasts derived on the City of Spokane's historical traffic counts and the Federal Rail Administration (FRA) database regarding daily train counts, speeds, and lengths. The expected crossing time delay was then derived by applying the probability of delay which is a function of train frequency, speed, length, and lead and lag time.

Value of time for vehicle type, as well as occupancy assumptions for both automobiles and trucks are available in the Benefit-Cost Analysis Guidance for Discretionary Grant Applications published by US DOT. The average transit bus occupancy was derived from consultation with the City of Spokane Valley. The estimate for travel time savings is simply the product of hours of delay, vehicle occupancy, and respective value of time.

The reduction in vehicle idling time at Pines Road crossing will translate into lower vehicle operating costs from reduced fuel and motor oil consumption in the Alternative. The change in vehicle delay time (by vehicle type and by year) is multiplied by the associated vehicle fuel consumption rate to obtain annual estimates of fuel consumption from idling. This multiplied by the cost per unit of fuel provides an estimate of the change in fuel costs. The same methodology is applied to track the change in motor oil consumption and costs. The sum of the two costs produces an estimate for the overall vehicle operating cost impacts due to vehicle delay time at the crossing.

7.3.2 Assumptions

The assumptions used in the estimation of economic outcomes and benefits are summarized in the table below.

Table 19: Assumptions used in the Estimation of Economic Outcomes

Variable Name	Unit	Date	Value	Source
Average Passenger Vehicle Occupancy	persons	2017-2054	1.39	Federal Highway Administration Highway Statistics 2016, Table VM1
Average Truck Occupancy	persons	2017-2054	1.00	
Average Transit Bus Occupancy	persons	2017-2054	60.0	City of Spokane Valley
Value of Time for Automobile Driver and Passenger	2017$/hour	2017-2054	$14.8	**Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis** https://www.transportation.gov/office-policy/transportation-policy/revised-departmental-guidance-valuation-travel-time-economic
Value of Time for Truck Driver	2017$/hour	2017-2054	$28.6	
Value of Time for Bus Driver	2017$/hour	2017-2054	$30.0	
Value of Time for Bus Passenger	2017$/hour	2017-2054	$14.8	
Vehicle Fuel Burned at Idle - Automobile	gal/hr	2017-2054	0.36	US DOE: Alternative Fuels Data Center and Argonne National Laboratory, "Idle Reduction Savings Worksheet" (2014) - Average of gasoline passenger vehicles
Vehicle Diesel Burned at Idle - Truck	gal/hr	2017-2054	0.49	US DOE: Alternative Fuels Data Center and Argonne National Laboratory, "Idle Reduction Savings Worksheet" (2014) - Combination Trucks
Vehicle Diesel Burned at Idle - Transit Bus	gal/hr	2017-2054	0.97	US DOE: Alternative Fuels Data Center and Argonne National Laboratory, "Idle Reduction Savings Worksheet" (2014) - Transit Bus
Average Consumption of Motor Oil per Hour	quarts/hr	2017-2054	0.03	Based on US DOT: HERS-ST Highway Economic Requirements System (2002) oil consumption of 1.38qt/1000miles and assuming that "One hour of idle time is equal to approximately 25 miles of driving" (Ford Motor Company, 2011)

Variable Name	Unit	Date	Value	Source
Cost of Motor Oil - Automobile	2017$/hour	2017-2054	$10.16	Average oil price sourced from HERS model and inflated to 2017$ by Motor Oil CPI (BLS CUUR0000SS47021)
Cost of Motor Oil - Truck	2017$/hour	2017-2054	$4.06	
Cost of Motor Oil - Bus	2017$/hour	2017-2054	$4.06	
		2017	$1.92	Gasoline and Diesel Source: US EIA Annual Energy Outlook 2016. Converted to 2017$, net of Federal & State Taxes
		2018	$1.89	
		2019	$2.10	
		2020	$2.23	
		2021	$2.35	
		2022	$2.47	
		2023	$2.50	
		2024	$2.53	
		2025	$2.57	
		2026	$2.61	
		2027	$2.62	
		2028	$2.62	
		2029	$2.64	
		2030	$2.69	
		2031	$2.73	
		2032	$2.78	
		2033	$2.78	
		2034	$2.81	
		2035	$2.83	
		2036	$2.90	
		2037	$2.90	
		2038	$2.92	
		2039	$2.96	
		2040	$2.99	
		2041	$3.01	
		2042	$3.02	
		2043	$3.03	
		2044	$3.04	
		2045	$3.06	
		2046	$3.07	
		2047	$3.09	
		2048	$3.08	
		2049	$3.09	
		2050	$3.14	
		2051	$3.14	
		2052	$3.14	
		2053	$3.14	
		2054	$3.14	
		2017	$2.18	Gasoline and Diesel Source: US EIA Annual Energy Outlook 2016. Converted to 2017$, net of Federal & State Taxes
		2018	$2.46	
		2019	$2.65	
		2020	$2.77	
		2021	$2.86	
		2022	$2.96	
		2023	$3.01	
		2024	$3.06	

Variable Name	Unit	Date	Value	Source
		2025	$3.14	
		2026	$3.20	
		2027	$3.24	
		2028	$3.26	
		2029	$3.30	
		2030	$3.37	
		2031	$3.43	
		2032	$3.50	
		2033	$3.50	
		2034	$3.55	
		2035	$3.58	
		2036	$3.65	
		2037	$3.66	
		2038	$3.67	
		2039	$3.72	
		2040	$3.74	
		2041	$3.75	
		2042	$3.75	
		2043	$3.75	
		2044	$3.76	
		2045	$3.78	
		2046	$3.80	
		2047	$3.85	
		2048	$3.85	
		2049	$3.89	
		2050	$3.93	
		2051	$3.93	
		2052	$3.93	
		2053	$3.93	
		2054	$3.93	

7.3.3 Benefit Estimates

The complete set of economic outcomes is shown in the table below. With a 7 percent discount rate, the estimated present value of benefits over the project life cycle is over $19.2 million. These benefits accrue to many users including motorists, local residents and businesses, and shippers. See Section 10.6 and 10.7 for additional information.

Table 20: Estimates of Economic Benefits, 2017 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Reduced Travel Time Costs	$1,328,352	$86,654,365	$18,401,917
Reduced Vehicle Operating Costs	$58,302	$4,269,812	$883,590
Total	**$1,386,654**	**$90,924,177**	**$19,285,507**

Improved Travel Time Reliability

On average, motorists are delayed 60 times per day at each roadway-railway crossing. With some trains nearly one and a half miles in length, crossings are closed for approximately three to five minutes for each train to pass. Delays are further compounded by the time required for the vehicle queues created by the train crossing to dissipate. Furthermore, the current Pines Road and Trent Avenue intersection operates at a LOS of 'E' which is projected to reach LOS 'F' due to worsening conditions. The project would transform the intersection to a LOS 'A' for a roundabout and LOS 'D' for a traffic signal, which will improve travel time reliability as there will be a significantly lower chance for drivers to be delayed thus reducing the unpredictability of trips in the area.

Improved Access to Future Development Potential

Close to 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS 'E' operating conditions at the Pines Road /Trent Avenue intersection. These parcels, and several hundred more acres beyond the city limits, are some of the last undeveloped parcels available for industrial use in the area.

7.4 Environmental Protection Outcomes

The proposed project would contribute to environmental sustainability benefits through a net reduction in emissions due to reduced vehicle delay time at the Pines Road Crossing. Environmental costs are increasingly considered as an important component in the evaluation of transportation projects and the main environmental impacts of vehicle use and exhaust emissions can impose wide-ranging social costs on people, material, and vegetation. The negative effects of pollution depend not only on the quantity of pollution produced, but also on the types of pollutants emitted and the conditions into which the pollution is released.

7.4.1 Methodology

The change in vehicle delay time at the Pines Road crossing is used to estimate the total fuel consumption while idling by vehicle type. The total estimated vehicle delay times are multiplied by the appropriate emission factors for tons of for CO_2, NO_x VOC, PM, and SO_2 per hour of vehicle idling. Each pollutant is then multiplied by its monetary value to get the total emission cost impact due to vehicle delay time.

7.4.2 Assumptions

The assumptions used in the estimation of environmental sustainability benefits are summarized in the table below.

Table 21: Assumptions used in the Estimation Environmental Sustainability Benefits

Variable Name	Unit	Year	Value	Source
Highway Emissions Inputs				
CO_2 per Gallon of Fuel Burned - Highway Vehicles (Idling)	grams/hour	2017	3,079	MOVES Average Annual Emissions Factors for Idling, Using US National Default Fleet Mix of Highway Vehicles
		2018	3,017	
		2019	2,955	
		2020	2,892	
		2021	2,828	
		2022	2,764	
		2023	2,699	
		2024	2,633	
		2025	2,567	
		2026	2,506	
		2027	2,449	
		2028	2,396	
		2029	2,350	

Variable Name	Unit	Year	Value	Source
		2030	2,310	
		2031	2,275	
		2032	2,243	
		2033	2,216	
		2034	2,196	
		2035	2,179	
		2036	2,165	
		2037	2,155	
		2038	2,146	
		2039	2,140	
		2040	2,137	
		2041	2,137	
		2042	2,137	
		2043	2,137	
		2044	2,137	
		2045	2,137	
		2046	2,137	
		2047	2,137	
		2048	2,137	
		2049	2,137	
		2050	2,137	
		2051	2,137	
		2052	2,137	
		2053	2,137	
		2054	2,137	
NOx per Gallon of Fuel Burned - Highway Vehicles (Idling)	grams/hour	2017	3.48	MOVES Average Annual Emissions Factors for Idling, Using US National Default Fleet Mix of Highway Vehicles
		2018	3.07	
		2019	2.71	
		2020	2.40	
		2021	2.13	
		2022	1.91	
		2023	1.72	
		2024	1.55	
		2025	1.40	
		2026	1.28	
		2027	1.16	
		2028	1.06	
		2029	0.98	
		2030	0.91	
		2031	0.86	
		2032	0.81	
		2033	0.78	
		2034	0.75	
		2035	0.74	
		2036	0.72	
		2037	0.71	
		2038	0.71	
		2039	0.70	
		2040	0.70	
		2041	0.70	
		2042	0.70	
		2043	0.70	
		2044	0.70	
		2045	0.70	
		2046	0.70	
		2047	0.70	
		2048	0.70	
		2049	0.70	
		2050	0.70	

Variable Name	Unit	Year	Value	Source
		2051	0.70	
		2052	0.70	
		2053	0.70	
		2054	0.70	
VOC per Gallon of Fuel Burned - Highway Vehicles (Idling)	grams/hour	2017	0.81	MOVES Average Annual Emissions Factors for Idling, Using US National Default Fleet Mix of Highway Vehicles
		2018	0.68	
		2019	0.57	
		2020	0.48	
		2021	0.41	
		2022	0.35	
		2023	0.31	
		2024	0.27	
		2025	0.23	
		2026	0.21	
		2027	0.19	
		2028	0.17	
		2029	0.15	
		2030	0.14	
		2031	0.13	
		2032	0.12	
		2033	0.12	
		2034	0.11	
		2035	0.11	
		2036	0.11	
		2037	0.11	
		2038	0.11	
		2039	0.10	
		2040	0.10	
		2041	0.10	
		2042	0.10	
		2043	0.10	
		2044	0.10	
		2045	0.10	
		2046	0.10	
		2047	0.10	
		2048	0.10	
		2049	0.10	
		2050	0.10	
		2051	0.10	
		2052	0.10	
		2053	0.10	
		2054	0.10	
PM per Gallon of Fuel Burned - Highway Vehicles (Idling)	grams/hour	2017	0.19	MOVES Average Annual Emissions Factors for Idling, Using US National Default Fleet Mix of Highway Vehicles
		2018	0.17	
		2019	0.15	
		2020	0.13	
		2021	0.11	
		2022	0.10	
		2023	0.09	
		2024	0.08	
		2025	0.07	
		2026	0.06	
		2027	0.06	
		2028	0.05	
		2029	0.04	
		2030	0.04	
		2031	0.04	
		2032	0.03	
		2033	0.03	

Variable Name	Unit	Year	Value	Source
		2034	0.03	
		2035	0.03	
		2036	0.03	
		2037	0.03	
		2038	0.03	
		2039	0.03	
		2040	0.03	
		2041	0.03	
		2042	0.03	
		2043	0.03	
		2044	0.03	
		2045	0.03	
		2046	0.03	
		2047	0.03	
		2048	0.03	
		2049	0.03	
		2050	0.03	
		2051	0.03	
		2052	0.03	
		2053	0.03	
		2054	0.03	
SO_2 per Gallon of Fuel Burned - Highway Vehicles (Idling)	grams/hour	2017	0.02	MOVES Average Annual Emissions Factors for Idling, Using US National Default Fleet Mix of Highway Vehicles
		2018	0.02	
		2019	0.02	
		2020	0.02	
		2021	0.02	
		2022	0.02	
		2023	0.02	
		2024	0.02	
		2025	0.02	
		2026	0.02	
		2027	0.02	
		2028	0.02	
		2029	0.02	
		2030	0.02	
		2031	0.02	
		2032	0.02	
		2033	0.02	
		2034	0.02	
		2035	0.02	
		2036	0.02	
		2037	0.02	
		2038	0.02	
		2039	0.02	
		2040	0.02	
		2041	0.02	
		2042	0.02	
		2043	0.02	
		2044	0.02	
		2045	0.02	
		2046	0.02	
		2047	0.02	
		2048	0.02	
		2049	0.02	
		2050	0.02	
		2051	0.02	
		2052	0.02	
		2053	0.02	
		2054	0.02	

Variable Name	Unit	Year	Value	Source
Emission Value Inputs				
CO_2 cost per short ton	2017$/short ton	2017	$10.13	Interagency Working Group on Social Cost of Carbon, United States Government. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (May 2013; revised July 2015). Adjusted global C02 values to domestic based upon 2016 current GDP (24.58%). It's assumed the fraction of GDP lost due to climate change is similar across countries and thus the domestic benefit would be proportional to the U.S. share of global GDP.
		2018	$10.39	
		2019	$10.65	
		2020	$10.91	
		2021	$10.91	
		2022	$11.17	
		2023	$11.43	
		2024	$11.69	
		2025	$11.95	
		2026	$12.21	
		2027	$12.47	
		2028	$12.73	
		2029	$12.73	
		2030	$12.99	
		2031	$13.25	
		2032	$13.51	
		2033	$13.77	
		2034	$14.03	
		2035	$14.29	
		2036	$14.55	
		2037	$14.81	
		2038	$15.07	
		2039	$15.33	
		2040	$15.59	
		2041	$15.85	
		2042	$15.85	
		2043	$16.11	
		2044	$16.37	
		2045	$16.63	
		2046	$16.89	
		2047	$17.15	
		2048	$17.41	
		2049	$17.67	
		2050	$17.93	
		2051	$17.93	
		2052	$17.93	
		2053	$17.93	
		2054	$17.93	
Domestic CO_2 Adjustment	US GDP/World GDP	2017-2054	24.58%	Adjusted to US GDP (2016) as a percentage of World GDP (2016).
NOx cost per short ton	2017$/short ton	2017-2054	$7,508	Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks (August 2012), page 922, Table VIII-16, "Economic Values Used for Benefits Computations (2010 dollars)". Inflated to 2017$.
VOC cost per short ton	2017$/short ton	2017-2054	$1,905	
PM cost per short ton	2017$/short ton	2017-2054	$343,442	
SO_2 cost per short ton	2017$/short ton	2017-2054	$44,373	

7.4.3 Benefit Estimates

The table below shows the benefit estimates of reducing vehicle delay times. With a 7 percent discount rate, the estimated present value of benefits over the project life cycle is $0.15 million dollars. See Section 10.8, 10.9, and 10.10 for additional information.

Table 22: Estimates of Community and Environmental Benefits, 2017 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Avoided Emissions Costs	$3,225	$159,950	$34,342
Total	**$3,225**	**$159,950**	**$34,342**

7.5 Quality of Life Outcomes

Improved Connectivity

Grade separation will provide pedestrian and cycling facilities allowing for greater connectivity and promotion of active lifestyles, in addition to improved access to nearby businesses and other public facilities. The BNSF Railway bisects the northern parts of Spokane Valley from the main city south of the railway. The project will connect a diverse neighborhoods surrounding the Study area including residential, commercial, mixed-use and industrial areas. The new grade-separated crossing and roundabout will provide sidewalks, making the route more appealing to pedestrians and bicyclists. In addition to an improved crossing of the railroad tracks, the roundabout will create a safer and more comfortable crossing of Trent Avenue.

Improved Emergency Vehicle Access

Key emergency services (fire, police, and EMS) are located south of the railway crossing. The long and frequent delays at the rail crossings causes delays for providing emergency services to the north. Eliminating the Pines Road grade crossing blockage will improve travel time and reliability for emergency responders that may otherwise not be able to pass or be forced to take a longer route.

Reduced Noise Pollution

Spokane Valley residents have long complained about the noise pollution of the train whistles. Federal law requires locomotives to sound their horns at 96 to 100 decibels as they approach at-grade crossings and continue blowing the horn until the train clears the crossing. Not only do the horns disturb the peacefulness of the surrounding area, medical studies have linked loud noises, such as train whistles, to stress-related health problems.[5] As part of the broader Bridging the Valley plan, all existing at-grade crossings will be eliminated, which will allow noise from train horns and whistles to be severely reduced. The Pines Road project alone will significantly reduce the amount of train horn and whistle noise and serves as an incremental improvement toward the overall goal of removing all at-grade crossings.

7.6 Innovation

The City of Spokane Valley will evaluate innovative bridge construction techniques to reduce the impact on the community and the existing traffic. This may include constructing the structures off-site before staging for construction. The project will also take advantage of the Spokane Regional Transportation Management Center (SRTMC) Intelligent Transportation Systems (ITS) infrastructure to communicate traveler information about construction activities and expected delays throughout the project using SRTMC's website and 511 telephone system. Other ITS technologies, such as work zone queue management and speed management systems, will be evaluated for applicability during project engineering.

[5] Spokane Valley, Cheney residents want to silence train whistles." The Spokesman-Review, March 6, 2016.

7.7 Partnership

This project demonstrates support from numerous public and private partners across the region. Two states, several regional public entities, multiple cities, and local business organization, as well as two Class I railroads actively participated in the Horizon 2040, and in the previous Bridging the Valley plan and other workshops, stakeholder outreach, and funding initiatives to further this effort. Table 23 summarizes the key partners associated with the Pines Road/BNSF grade-separation project and other related projects.

Table 23: Partners in Project Development

State and Local Agencies	
• Idaho Transportation Department • Washington State Department of Transportation • Washington Freight Mobility Strategic Investment Board • Washington Utility and Transportation Commission • State and Federal Legislators	
Regional Agencies	
• Spokane Regional Transportation Council • Spokane Transit Authority • Kootenai Metropolitan Planning Organization	
Railroads	
• BNSF Railway Company	• Union Pacific Railroad
Local Agencies and Districts	
• Kootenai County • Spokane County • City of Athol • Town of Millwood • City of Rathdrum	• City of Spokane • City of Spokane Valley • Area Fire Districts/Emergency Response Systems • Area School Districts
Chambers of Commerce	
• Spokane Valley	• Greater Spokane Incorporated

8 Summary of Findings and Benefit-Cost Outcomes

The tables below summarizes the BCA findings. Annual costs and benefits are computed over the lifecycle of the project (38 years). As stated earlier, construction is expected to be completed by 2024 with 2025 being the project opening year. Benefits accrue during the full operation of the project.

Table 24: Overall Results of the Benefit Cost Analysis, 2017 Dollars

Project Evaluation Metric	7% Discount Rate	3% Discount Rate
Total Discounted Benefits	$39,240,984	$88,679,091
Total Discounted Costs	$18,240,557	$21,784,430
Net Present Value	$21,000,428	$66,894,661
Benefit / Cost Ratio	2.15	4.07
Internal Rate of Return (%)	13.1%	
Payback Period (years)	6.43	

Values in 2017 Dollars Unless Specified Otherwise

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 13.1 percent. With a 7 percent real discount rate, the $18.2 million investment would result in $39.2 million in total benefits for a Net Present Value of $21.0 million and a Benefit/Cost ratio of approximately 2.15.

With a 3 percent real discount rate, the Net Present Value of the project would increase to $66.9 million, for a Benefit/Cost ratio of 4.07

Table 25: Benefit Estimates by Merit Criteria Outcome for the Full Build Alternative

Merit Criteria	Impact Categories	7% Discount Rate	3% Discount Rate
Safety	Improved Safety and Avoided Accident Costs	$19,015,787	$40,653,882
State of Good Repair	Residual Value of Infrastructure Asset	$820,344	$3,359,064
	Operations & Maintenance Cost Savings	$85,005	$175,306
Economic Competitiveness	Reduced Travel Time Costs	$18,401,917	$42,348,159
	Reduced Vehicle Operating Costs	$883,590	$2,064,343
	Improved Travel Time Reliability	n/a	n/a
	Unlock Future Development Potential	n/a	n/a
Environmental Protection	Avoided Emissions Costs	$34,342	$78,337
Quality of Life	Improved Connectivity	n/a	n/a
	Improved Emergency Vehicle Access	n/a	n/a
	Reduced Noise Pollution	n/a	n/a
Innovation	Innovative Bridge Construction	n/a	n/a
	Intelligent Transportation Systems		
Partnership	Support from Public and Private Partners	n/a	n/a
Total Benefit Estimates		**$39,240,984**	**$88,679,091**

9 Benefit Cost Sensitivity Analysis

9.1 Variation in Key Inputs and Assumptions

The BCA outcomes presented in the previous sections rely on a large number of assumptions and long-term projections; both of which are subject to considerable uncertainty.

The primary purpose of the sensitivity analysis is to help identify the variables and model parameters whose variations have the greatest impact on the BCA outcomes: the "critical variables."

The sensitivity analysis can also be used to:

- Evaluate the impact of changes in individual critical variables – how much the final results would vary with reasonable departures from the "preferred" or most likely value for the variable; and
- Assess the robustness of the BCA and evaluate, in particular, whether the conclusions reached under the "preferred" set of input values are significantly altered by reasonable departures from those values.

The outcomes of the quantitative analysis for the Pines Road Grade Separation project using a 7 percent discount rate are summarized in the table below. The table provides the percentage changes in project NPV associated with variations in variables or parameters, as indicated in the column headers.

Table 26: Quantitative Assessment of Sensitivity, Summary (Discounted at 7%)

Original NPV (discounted at 7%)	Parameters	Change in Parameter Value	New NPV (discounted at 7%)	Change in NPV	New B/C Ratio
$23,380,256	Capital Expenditures	+25% Growth	$16,440,288	-21.7%	1.72
		-25% Growth	$25,560,567	21.7%	2.87
	AADT Growth Rate	+2% Growth	$36,619,394	74.4%	3.01
		-2% Growth	$11,049,229	-47.4%	1.61
	Freight Train Growth Rate	+2% Growth	$23,343,373	11.2%	2.28
		-2% Growth	$19,079,854	-9.1%	2.05

As to be expected, lowering the growth rates for both traffic and freight train growth reduce the net present value of the projects. However, freight train growth does not significantly alter the results of the project due to the capacity constraints of the rail network, resulting in the benefit cost changing by no more than 5%. Traffic growth provides significant variation, with a 2% increase or decrease resulting in the net present value to range between increasing $2.3 million to decreasing $9.9 million. Decreasing or increasing capital costs by 25% results in the BCR ranging between 1.72 and 2.87. The sensitivity analysis indicates that the Pines Road Grade Separation project is robust across the changes, with the benefit cost ratio exceeding 1.5 in each of the cases examined, resulting in beneficial impacts to stakeholders and society.

10 Supplementary Data Tables

This section breaks down all benefits associated with the merit criteria outcomes (State of Good Repair, Economic Competitiveness, Quality of Life, Safety, and Environmental Sustainability) in annual form for the Pines Road Grade Separation project. Supplementary data tables are also provided for some specific benefit categories.

10.1 Annual Estimates of Total Project Benefits and Costs

Calendar Year	Project Year	Total Benefits ($2017)	Total Costs ($2017)	Undiscounted Net Benefits ($2017)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2017	1	$0	-$945,718	-$945,718	-$945,718	-$945,718
2018	2	$0	-$41,333	-$41,333	-$38,629	-$40,129
2019	3	$0	-$41,333	-$41,333	-$36,102	-$38,961
2020	4	$0	-$5,007,038	-$5,007,038	-$4,087,235	-$4,582,149
2021	5	$0	-$2,100,000	-$2,100,000	-$1,602,080	-$1,865,823
2022	6	$0	-$8,466,749	-$8,466,749	-$6,036,675	-$7,303,492
2023	7	$0	-$5,080,049	-$5,080,049	-$3,385,051	-$4,254,461
2024	8	$0	-$3,386,699	-$3,386,699	-$2,109,066	-$2,753,697
2025	9	$3,555,960	$0	$3,555,960	$2,069,601	$2,807,108
2026	10	$3,671,533	$0	$3,671,533	$1,997,070	$2,813,924
2027	11	$3,793,051	$0	$3,793,051	$1,928,195	$2,822,386
2028	12	$3,920,889	$0	$3,920,889	$1,862,786	$2,832,534
2029	13	$4,056,471	$0	$4,056,471	$1,801,122	$2,845,127
2030	14	$4,200,124	$0	$4,200,124	$1,742,902	$2,860,080
2031	15	$4,351,808	$0	$4,351,808	$1,687,706	$2,877,058
2032	16	$4,512,185	$0	$4,512,185	$1,635,423	$2,896,200
2033	17	$4,680,314	$0	$4,680,314	$1,585,384	$2,916,617
2034	18	$4,859,047	$0	$4,859,047	$1,538,250	$2,939,803
2035	19	$5,047,551	$0	$5,047,551	$1,493,388	$2,964,904
2036	20	$5,237,457	$0	$5,237,457	$1,448,201	$2,986,849
2037	21	$5,435,670	$0	$5,435,670	$1,404,680	$3,009,599
2038	22	$5,619,836	$0	$5,619,836	$1,357,264	$3,020,939
2039	23	$5,733,837	$0	$5,733,837	$1,294,202	$2,992,446
2040	24	$5,849,933	$0	$5,849,933	$1,234,025	$2,964,113
2041	25	$5,968,601	$0	$5,968,601	$1,176,689	$2,936,156
2042	26	$6,089,634	$0	$6,089,634	$1,122,010	$2,908,443
2043	27	$6,213,957	$0	$6,213,957	$1,070,015	$2,881,379
2044	28	$6,341,431	$0	$6,341,431	$1,020,529	$2,854,843
2045	29	$6,472,186	$0	$6,472,186	$973,431	$2,828,842
2046	30	$6,606,221	$0	$6,606,221	$928,589	$2,803,326
2047	31	$6,743,960	$0	$6,743,960	$885,935	$2,778,422
2048	32	$6,883,520	$0	$6,883,520	$845,110	$2,753,319

Calendar Year	Project Year	Total Benefits ($2017)	Total Costs ($2017)	Undiscounted Net Benefits ($2017)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2049	33	$7,027,861	$0	$7,027,861	$806,385	$2,729,179
2050	34	$7,176,876	$0	$7,176,876	$769,610	$2,705,871
2051	35	$7,327,463	$0	$7,327,463	$734,354	$2,682,181
2052	36	$7,481,760	$0	$7,481,760	$700,764	$2,658,893
2053	37	$7,639,860	$0	$7,639,860	$668,759	$2,635,999
2054	38	$17,829,424	$0	$17,829,424	$1,458,604	$5,972,553

10.2 Annual Demand Projections

Calendar Year	Project Year	Total Annual Traffic at Pines Road Crossing	Total Annual Traffic at Trent Ave. Intersection	Annual Freight Trains at Pines Road Crossing	Annual Passenger Trains at Pines Road Crossing	Total Vehicle Hours of Delay - Passenger Vehicles	Total Vehicle Hours of Delay - Trucks	Total Vehicle Hours of Delay - Bus Driver and Passenger
2017	1	16,925	27,393	58.1	2.04	0	0	0
2018	2	17,349	28,022	60.4	2.08	0	0	0
2019	3	17,784	28,666	62.7	2.12	0	0	0
2020	4	18,229	29,324	65.0	2.16	0	0	0
2021	5	18,686	29,998	67.5	2.21	0	0	0
2022	6	19,154	30,687	70.1	2.25	0	0	0
2023	7	19,634	31,392	72.8	2.30	0	0	0
2024	8	20,126	32,113	75.5	2.34	0	0	0
2025	9	20,630	32,851	78.4	2.39	37,879	5,225	435
2026	10	21,147	33,605	81.4	2.44	40,302	5,559	463
2027	11	21,677	34,377	84.5	2.49	42,881	5,915	493
2028	12	22,220	35,167	87.7	2.54	45,624	6,293	524
2029	13	22,777	35,974	91.1	2.59	48,543	6,696	558
2030	14	23,347	36,801	94.6	2.64	51,649	7,124	594
2031	15	23,932	37,646	98.2	2.69	54,954	7,580	632
2032	16	24,532	38,511	101.9	2.75	58,471	8,065	672
2033	17	25,147	39,395	105.8	2.80	62,213	8,581	715
2034	18	25,777	40,300	109.8	2.86	66,194	9,130	761
2035	19	26,422	41,226	114.0	2.91	70,430	9,715	810
2036	20	27,084	42,173	117.9	2.97	74,643	10,296	858
2037	21	27,763	43,141	121.9	3.03	79,107	10,911	909

Calendar Year	Project Year	Total Annual Traffic at Pines Road Crossing	Total Annual Traffic at Trent Ave. Intersection	Annual Freight Trains at Pines Road Crossing	Annual Passenger Trains at Pines Road Crossing	Total Vehicle Hours of Delay - Passenger Vehicles	Total Vehicle Hours of Delay - Trucks	Total Vehicle Hours of Delay - Bus Driver and Passenger
2038	22	28,459	44,132	125.0	3.09	83,159	11,470	956
2039	23	29,172	45,146	125.0	3.15	85,254	11,759	980
2040	24	29,902	46,183	125.0	3.22	87,402	12,055	1,005
2041	25	30,652	47,244	125.0	3.28	89,604	12,359	1,030
2042	26	31,420	48,329	125.0	3.35	91,862	12,671	1,056
2043	27	32,207	49,439	125.0	3.41	94,177	12,990	1,082
2044	28	33,014	50,575	125.0	3.48	96,551	13,317	1,110
2045	29	33,841	51,736	125.0	3.55	98,985	13,653	1,138
2046	30	34,689	52,925	125.0	3.62	101,481	13,997	1,166
2047	31	35,558	54,140	125.0	3.70	104,040	14,350	1,196
2048	32	36,449	55,384	125.0	3.77	106,664	14,712	1,226
2049	33	37,362	56,656	125.0	3.84	109,354	15,083	1,257
2050	34	38,298	57,957	125.0	3.92	112,113	15,464	1,289
2051	35	39,257	59,289	125.0	4.00	114,941	15,854	1,321
2052	36	40,241	60,651	125.0	4.08	117,842	16,254	1,355
2053	37	41,249	62,044	125.0	4.16	120,815	16,664	1,389
2054	38	42,282	63,469	125.0	4.24	123,865	17,085	1,424
Total		**1,054,394**	**1,634,061**	**3,944**	**114**	**2,470,999**	**340,827**	**28,402**

10.3 Safety Outcomes: Pertinent Quantifiable Impacts

Calendar Year	Project Year	Fatalities Avoided	Injuries Avoided
2017	1	0.00	0.00
2018	2	0.00	0.00
2019	3	0.00	0.00
2020	4	0.00	0.00
2021	5	0.00	0.00
2022	6	0.00	0.00
2023	7	0.00	0.00
2024	8	0.00	0.00
2025	9	0.15	4.18
2026	10	0.15	4.27

Calendar Year	Project Year	Fatalities Avoided	Injuries Avoided
2027	11	0.15	4.36
2028	12	0.15	4.45
2029	13	0.15	4.54
2030	14	0.15	4.64
2031	15	0.16	4.74
2032	16	0.16	4.83
2033	17	0.16	4.94
2034	18	0.16	5.04
2035	19	0.16	5.15
2036	20	0.16	5.26
2037	21	0.16	5.37
2038	22	0.17	5.48
2039	23	0.17	5.60
2040	24	0.17	5.72
2041	25	0.17	5.84
2042	26	0.17	5.97
2043	27	0.17	6.09
2044	28	0.18	6.23
2045	29	0.18	6.36
2046	30	0.18	6.50
2047	31	0.18	6.64
2048	32	0.18	6.78
2049	33	0.18	6.93
2050	34	0.19	7.08
2051	35	0.19	7.23
2052	36	0.19	7.39
2053	37	0.19	7.55
2054	38	0.20	7.71
Total		**5.08**	**172.84**

10.4 Safety Outcomes: Annual Benefit Estimates

Calendar Year	Project Year	Improved Safety and Avoided Accident Costs	Total Safety Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2017	1	$0	$0	$0	$0
2018	2	$0	$0	$0	$0
2019	3	$0	$0	$0	$0
2020	4	$0	$0	$0	$0
2021	5	$0	$0	$0	$0
2022	6	$0	$0	$0	$0
2023	7	$0	$0	$0	$0
2024	8	$0	$0	$0	$0
2025	9	$2,155,081	$2,155,081	$1,254,277	$1,701,241
2026	10	$2,181,221	$2,181,221	$1,186,440	$1,671,724
2027	11	$2,207,959	$2,207,959	$1,122,414	$1,642,929
2028	12	$2,235,311	$2,235,311	$1,061,980	$1,614,836
2029	13	$2,263,291	$2,263,291	$1,004,928	$1,587,427
2030	14	$2,291,913	$2,291,913	$951,063	$1,560,681
2031	15	$2,321,193	$2,321,193	$900,199	$1,534,582
2032	16	$2,351,146	$2,351,146	$852,163	$1,509,111
2033	17	$2,381,786	$2,381,786	$806,793	$1,484,250
2034	18	$2,413,130	$2,413,130	$763,935	$1,459,983
2035	19	$2,445,194	$2,445,194	$723,445	$1,436,294
2036	20	$2,477,994	$2,477,994	$685,186	$1,413,165
2037	21	$2,511,546	$2,511,546	$649,031	$1,390,582
2038	22	$2,545,868	$2,545,868	$614,860	$1,368,529
2039	23	$2,580,978	$2,580,978	$582,561	$1,346,993
2040	24	$2,616,895	$2,616,895	$552,026	$1,325,959
2041	25	$2,653,636	$2,653,636	$523,155	$1,305,413
2042	26	$2,691,222	$2,691,222	$495,855	$1,285,343
2043	27	$2,729,671	$2,729,671	$470,037	$1,265,734
2044	28	$2,769,003	$2,769,003	$445,617	$1,246,575
2045	29	$2,809,238	$2,809,238	$422,516	$1,227,853
2046	30	$2,850,398	$2,850,398	$400,660	$1,209,556
2047	31	$2,892,502	$2,892,502	$379,980	$1,191,673
2048	32	$2,935,574	$2,935,574	$360,409	$1,174,192

Calendar Year	Project Year	Improved Safety and Avoided Accident Costs	Total Safety Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2049	33	$2,979,635	$2,979,635	$341,887	$1,157,103
2050	34	$3,024,708	$3,024,708	$324,354	$1,140,394
2051	35	$3,070,817	$3,070,817	$307,755	$1,124,057
2052	36	$3,117,984	$3,117,984	$292,040	$1,108,080
2053	37	$3,166,235	$3,166,235	$277,158	$1,092,454
2054	38	$3,215,594	$3,215,594	$263,064	$1,077,169
Total		**$78,886,723**	**$78,886,723**	**$19,015,787**	**$40,653,882**

10.5 State of Good Repair: Annual Benefits Estimates

Calendar Year	Project Year	Residual Value of Infrastructure Asset	Operations and Maintenance Cost Savings	Total State of Good Repair Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2017	1	$0	$0	$0	$0	$0
2018	2	$0	$0	$0	$0	$0
2019	3	$0	$0	$0	$0	$0
2020	4	$0	$0	$0	$0	$0
2021	5	$0	$0	$0	$0	$0
2022	6	$0	$0	$0	$0	$0
2023	7	$0	$0	$0	$0	$0
2024	8	$0	$0	$0	$0	$0
2025	9	$0	$11,000	$11,000	$6,402	$8,684
2026	10	$0	$11,000	$11,000	$5,983	$8,431
2027	11	$0	$11,000	$11,000	$5,592	$8,185
2028	12	$0	$11,000	$11,000	$5,226	$7,947
2029	13	$0	$11,000	$11,000	$4,884	$7,715
2030	14	$0	$11,000	$11,000	$4,565	$7,490
2031	15	$0	$11,000	$11,000	$4,266	$7,272
2032	16	$0	$11,000	$11,000	$3,987	$7,060
2033	17	$0	$11,000	$11,000	$3,726	$6,855
2034	18	$0	$11,000	$11,000	$3,482	$6,655
2035	19	$0	$11,000	$11,000	$3,255	$6,461
2036	20	$0	$11,000	$11,000	$3,042	$6,273

Calendar Year	Project Year	Residual Value of Infrastructure Asset	Operations and Maintenance Cost Savings	Total State of Good Repair Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2037	21	$0	$11,000	$11,000	$2,843	$6,090
2038	22	$0	$11,000	$11,000	$2,657	$5,913
2039	23	$0	$11,000	$11,000	$2,483	$5,741
2040	24	$0	$11,000	$11,000	$2,320	$5,574
2041	25	$0	$11,000	$11,000	$2,169	$5,411
2042	26	$0	$11,000	$11,000	$2,027	$5,254
2043	27	$0	$11,000	$11,000	$1,894	$5,101
2044	28	$0	$11,000	$11,000	$1,770	$4,952
2045	29	$0	$11,000	$11,000	$1,654	$4,808
2046	30	$0	$11,000	$11,000	$1,546	$4,668
2047	31	$0	$11,000	$11,000	$1,445	$4,532
2048	32	$0	$11,000	$11,000	$1,351	$4,400
2049	33	$0	$11,000	$11,000	$1,262	$4,272
2050	34	$0	$11,000	$11,000	$1,180	$4,147
2051	35	$0	$11,000	$11,000	$1,102	$4,026
2052	36	$0	$11,000	$11,000	$1,030	$3,909
2053	37	$0	$11,000	$11,000	$963	$3,795
2054	38	$10,027,568	$11,000	$10,038,568	$821,244	$3,362,749
Total		**$10,027,568**	**$330,000**	**$10,357,568**	**$905,349**	**$3,534,371**

10.6 Economic Competitiveness: Pertinent Quantifiable Impacts

Calendar Year	Project Year	Avoided Person Hours of Delay at Rail Crossings	Avoided Gasoline Consumption (Gallons)	Avoided Diesel Consumption (Gallons)	Avoided Motor Oil Consumption (Quarts)
2017	1	0	0	0	0
2018	2	0	0	0	0
2019	3	0	0	0	0
2020	4	0	0	0	0
2021	5	0	0	0	0
2022	6	0	0	0	0
2023	7	0	0	0	0
2024	8	0	0	0	0
2025	9	84,435	13,542	2,982	1,502
2026	10	89,837	14,408	3,173	1,598
2027	11	95,584	15,330	3,376	1,700
2028	12	101,700	16,311	3,592	1,809
2029	13	108,207	17,354	3,822	1,925
2030	14	115,131	18,465	4,067	2,048
2031	15	122,498	19,646	4,327	2,179
2032	16	130,336	20,903	4,604	2,319
2033	17	138,677	22,241	4,898	2,467
2034	18	147,552	23,664	5,212	2,625
2035	19	156,995	25,179	5,545	2,793
2036	20	166,384	26,685	5,877	2,960
2037	21	176,335	28,281	6,229	3,137
2038	22	185,367	29,729	6,548	3,298
2039	23	190,037	30,478	6,713	3,381
2040	24	194,825	31,246	6,882	3,466
2041	25	199,735	32,033	7,055	3,553
2042	26	204,768	32,841	7,233	3,643
2043	27	209,929	33,668	7,415	3,735
2044	28	215,221	34,517	7,602	3,829
2045	29	220,646	35,387	7,794	3,925
2046	30	226,209	36,279	7,990	4,024
2047	31	231,914	37,194	8,192	4,126
2048	32	237,762	38,132	8,398	4,230

Calendar Year	Project Year	Avoided Person Hours of Delay at Rail Crossings	Avoided Gasoline Consumption (Gallons)	Avoided Diesel Consumption (Gallons)	Avoided Motor Oil Consumption (Quarts)
2049	33	243,759	39,094	8,610	4,336
2050	34	249,908	40,080	8,827	4,446
2051	35	256,213	41,092	9,050	4,558
2052	36	262,678	42,128	9,278	4,673
2053	37	269,307	43,192	9,512	4,791
2054	38	276,105	44,282	9,753	4,912
Total		**5,508,056**	**883,382**	**194,556**	**97,988**

10.7 Economic Competitiveness: Annual Benefit Estimates

Calendar Year	Project Year	Reduced Travel Time Costs	Reduced Vehicle Operating Costs	Total Economic Competitiveness Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2017	1	$0	$0	$0	$0	$0
2018	2	$0	$0	$0	$0	$0
2019	3	$0	$0	$0	$0	$0
2020	4	$0	$0	$0	$0	$0
2021	5	$0	$0	$0	$0	$0
2022	6	$0	$0	$0	$0	$0
2023	7	$0	$0	$0	$0	$0
2024	8	$0	$0	$0	$0	$0
2025	9	$1,328,352	$58,302	$1,386,654	$807,045	$1,094,637
2026	10	$1,413,335	$62,748	$1,476,083	$802,891	$1,131,294
2027	11	$1,503,758	$67,092	$1,570,850	$798,541	$1,168,860
2028	12	$1,599,970	$71,343	$1,671,313	$794,029	$1,207,392
2029	13	$1,702,342	$76,552	$1,778,894	$789,850	$1,247,681
2030	14	$1,811,269	$82,571	$1,893,840	$785,876	$1,289,613
2031	15	$1,927,170	$88,967	$2,016,137	$781,893	$1,332,904
2032	16	$2,050,492	$95,941	$2,146,433	$777,966	$1,377,714
2033	17	$2,181,711	$102,052	$2,283,763	$773,590	$1,423,166
2034	18	$2,321,332	$109,621	$2,430,953	$769,577	$1,470,766
2035	19	$2,469,893	$117,272	$2,587,165	$765,449	$1,519,687
2036	20	$2,617,606	$126,424	$2,744,030	$758,747	$1,564,882

Calendar Year	Project Year	Reduced Travel Time Costs	Reduced Vehicle Operating Costs	Total Economic Competitiveness Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2037	21	$2,774,156	$134,273	$2,908,429	$751,593	$1,610,327
2038	22	$2,916,256	$141,739	$3,057,995	$738,546	$1,643,823
2039	23	$2,989,724	$146,992	$3,136,715	$707,998	$1,637,028
2040	24	$3,065,050	$151,661	$3,216,712	$678,555	$1,629,881
2041	25	$3,142,284	$156,157	$3,298,440	$650,276	$1,622,614
2042	26	$3,221,472	$160,277	$3,381,749	$623,084	$1,615,142
2043	27	$3,302,665	$164,748	$3,467,413	$597,073	$1,607,821
2044	28	$3,385,915	$169,425	$3,555,339	$572,162	$1,600,575
2045	29	$3,471,273	$174,363	$3,645,636	$548,312	$1,593,423
2046	30	$3,558,794	$179,487	$3,738,281	$525,463	$1,586,326
2047	31	$3,648,533	$185,144	$3,833,677	$503,619	$1,579,424
2048	32	$3,740,546	$189,373	$3,929,919	$482,488	$1,571,917
2049	33	$3,834,893	$195,053	$4,029,945	$462,400	$1,564,977
2050	34	$3,931,631	$201,993	$4,133,625	$443,268	$1,558,485
2051	35	$4,030,824	$207,089	$4,237,913	$424,721	$1,551,267
2052	36	$4,132,533	$212,315	$4,344,848	$406,951	$1,544,087
2053	37	$4,236,823	$217,673	$4,454,496	$389,926	$1,536,946
2054	38	$4,343,761	$223,167	$4,566,928	$373,615	$1,529,843
Total		**$86,654,365**	**$4,269,812**	**$90,924,177**	**$19,285,507**	**$44,412,502**

10.8 Environmental Sustainability: Pertinent Quantifiable Impacts (1 of 2)

Calendar Year	Project Year	Annual Emissions Avoided - CO_2 (tons)	Annual Emissions Avoided - NOx (tons)	Annual Emissions Avoided - VOC (tons)	Annual Emissions Avoided - PM (tons)	Annual Emissions Avoided - SO_2 (tons)
2017	1	0.0	0.000	0.000	0.000	0.000
2018	2	0.0	0.000	0.000	0.000	0.000
2019	3	0.0	0.000	0.000	0.000	0.000
2020	4	0.0	0.000	0.000	0.000	0.000
2021	5	0.0	0.000	0.000	0.000	0.000
2022	6	0.0	0.000	0.000	0.000	0.000
2023	7	0.0	0.000	0.000	0.000	0.000
2024	8	0.0	0.000	0.000	0.000	0.000
2025	9	123.2	0.067	0.011	0.003	0.001

Calendar Year	Project Year	Annual Emissions Avoided - CO_2 (tons)	Annual Emissions Avoided - NOx (tons)	Annual Emissions Avoided - VOC (tons)	Annual Emissions Avoided - PM (tons)	Annual Emissions Avoided - SO_2 (tons)
2026	10	127.9	0.065	0.011	0.003	0.001
2027	11	133.0	0.063	0.010	0.003	0.001
2028	12	138.5	0.061	0.010	0.003	0.001
2029	13	144.5	0.060	0.009	0.003	0.001
2030	14	151.2	0.060	0.009	0.003	0.001
2031	15	158.4	0.060	0.009	0.003	0.001
2032	16	166.1	0.060	0.009	0.002	0.001
2033	17	174.7	0.061	0.009	0.002	0.001
2034	18	184.2	0.063	0.010	0.002	0.001
2035	19	194.4	0.066	0.010	0.002	0.001
2036	20	204.8	0.068	0.010	0.002	0.001
2037	21	216.0	0.071	0.011	0.003	0.002
2038	22	226.2	0.074	0.011	0.003	0.002
2039	23	231.2	0.076	0.011	0.003	0.002
2040	24	236.6	0.078	0.012	0.003	0.002
2041	25	242.6	0.080	0.012	0.003	0.002
2042	26	248.7	0.082	0.012	0.003	0.002
2043	27	254.9	0.084	0.012	0.003	0.002
2044	28	261.4	0.086	0.013	0.003	0.002
2045	29	268.0	0.088	0.013	0.003	0.002
2046	30	274.7	0.090	0.013	0.003	0.002
2047	31	281.6	0.093	0.014	0.003	0.002
2048	32	288.7	0.095	0.014	0.003	0.002
2049	33	296.0	0.097	0.014	0.003	0.002
2050	34	303.5	0.100	0.015	0.004	0.002
2051	35	311.1	0.102	0.015	0.004	0.002
2052	36	319.0	0.105	0.016	0.004	0.002
2053	37	327.0	0.108	0.016	0.004	0.002
2054	38	335.3	0.110	0.016	0.004	0.002
Total		**6,823**	**2.38**	**0.36**	**0.09**	**0.05**

10.9 Environmental Sustainability: Pertinent Quantifiable Impacts (2 of 2)

Calendar Year	Project Year	Avoided Vehicle-hours of Delay Time
2017	1	0
2018	2	0
2019	3	0
2020	4	0
2021	5	0
2022	6	0
2023	7	0
2024	8	0
2025	9	43,539
2026	10	46,324
2027	11	49,288
2028	12	52,441
2029	13	55,797
2030	14	59,367
2031	15	63,166
2032	16	67,208
2033	17	71,509
2034	18	76,085
2035	19	80,955
2036	20	85,796
2037	21	90,927
2038	22	95,585
2039	23	97,993
2040	24	100,462
2041	25	102,993
2042	26	105,589
2043	27	108,250
2044	28	110,979
2045	29	113,776
2046	30	116,645
2047	31	119,586
2048	32	122,602
2049	33	125,694

Calendar Year	Project Year	Avoided Vehicle-hours of Delay Time
2050	34	128,865
2051	35	132,116
2052	36	135,450
2053	37	138,868
2054	38	142,373
Total		**2,840,229**

10.10 Environmental Sustainability: Annual Benefit Estimates (1 of 2)

Calendar Year	Project Year	Avoided Emissions Costs	Total Environmental Sustainability Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2017	1	$0	$0	$0	$0
2018	2	$0	$0	$0	$0
2019	3	$0	$0	$0	$0
2020	4	$0	$0	$0	$0
2021	5	$0	$0	$0	$0
2022	6	$0	$0	$0	$0
2023	7	$0	$0	$0	$0
2024	8	$0	$0	$0	$0
2025	9	$3,225	$3,225	$1,877	$2,546
2026	10	$3,229	$3,229	$1,756	$2,475
2027	11	$3,242	$3,242	$1,648	$2,412
2028	12	$3,265	$3,265	$1,551	$2,359
2029	13	$3,286	$3,286	$1,459	$2,305
2030	14	$3,371	$3,371	$1,399	$2,295
2031	15	$3,478	$3,478	$1,349	$2,299
2032	16	$3,606	$3,606	$1,307	$2,314
2033	17	$3,765	$3,765	$1,275	$2,346
2034	18	$3,964	$3,964	$1,255	$2,398
2035	19	$4,192	$4,192	$1,240	$2,462
2036	20	$4,433	$4,433	$1,226	$2,528
2037	21	$4,695	$4,695	$1,213	$2,600
2038	22	$4,974	$4,974	$1,201	$2,674

Calendar Year	Project Year	Avoided Emissions Costs	Total Environmental Sustainability Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2039	23	$5,144	$5,144	$1,161	$2,685
2040	24	$5,327	$5,327	$1,124	$2,699
2041	25	$5,524	$5,524	$1,089	$2,718
2042	26	$5,664	$5,664	$1,043	$2,705
2043	27	$5,873	$5,873	$1,011	$2,723
2044	28	$6,088	$6,088	$980	$2,741
2045	29	$6,312	$6,312	$949	$2,759
2046	30	$6,542	$6,542	$920	$2,776
2047	31	$6,780	$6,780	$891	$2,793
2048	32	$7,026	$7,026	$863	$2,810
2049	33	$7,280	$7,280	$835	$2,827
2050	34	$7,543	$7,543	$809	$2,844
2051	35	$7,733	$7,733	$775	$2,831
2052	36	$7,928	$7,928	$743	$2,818
2053	37	$8,128	$8,128	$712	$2,805
2054	38	$8,334	$8,334	$682	$2,792
Total		**$159,950**	**$159,950**	**$34,342**	**$78,337**

Appendix D

Draft Pines Road/BNSF Grade Separation - Consolidated Traffic and Safety Analysis

FEHR & PEERS

DRAFT MEMORANDUM

Date: March 27, 2018

To: Erica Amsden, City of Spokane Valley

From: Chris Breiland, and Nathan Chan, Fehr & Peers

Subject: Pines Road/BNSF Grade Separation – Consolidated Traffic and Safety Analysis

SE17-0560

INTRODUCTION

As part of a larger effort to remove at-grade rail crossings in the Spokane region, Spokane Valley is working to grade separate the Pines Road/BNSF crossing and also improve traffic and freight operations at the Pines Road/Trent Avenue intersection. In support of this project, Fehr & Peers prepared an existing conditions analysis, developed travel demand forecasts, traffic operations and safety analyses under year 2020 and 2040 conditions for multiple alternatives at the Pines Road / Trent Avenue intersection, as well as analysis under the scenario that closes the at-grade railroad crossing at University Road. This memo presents a summary of findings for four conceptual alternatives studied as part of the Pines Road/BNSF Grade Separation project.

Project Context

This project is part of a larger effort known as Bridging the Valley, which is a regional program to separate vehicle traffic from major train crossings between Spokane, WA and Athol, ID. Through these projects, Spokane Valley seeks to improve safety, provide reliable traffic and freight routes, and spur economic development and job creation.

The City of Spokane Valley is leading the effort to secure funding and study alternatives for the Pines Road/BNSF Grade Separation project, which is included in the City's 2018 Six-Year Transportation Improvement Program (TIP). The goals of this project include:

- Improving emergency vehicle access
- Improving safety and reduce delay caused by train/vehicle conflict
- Reducing noise from train horns at crossings
- Improving access to Trent Elementary and the neighborhood to the north of Trent Avenue

- Enhancing development capabilities of almost 230 acres of mixed use commercial property

EXISTING CONDITIONS ANALYSIS

The existing conditions analysis includes an analysis of existing traffic operations and collision history in the area. Traffic analysis was performed for the following intersections:

1. Pines Road / Trent Avenue
2. University Road / Trent Avenue
3. Argonne Road / Trent Avenue
4. Argonne Road / Montgomery Avenue

Collision history was documented at the Pines Road/BNSF rail crossing and the Pines Road / Trent Avenue intersection.

Turning Movement Count Collection

Intersection turning movement counts were collected at the four study intersections mentioned previously during the AM (7-9 AM) and PM (4-6 PM) peak hours on Wednesday August 30, 2017.

BNSF Rail Operations

The Burlington Northern Santa Fe (BNSF) Railroad crosses Barker Road and Flora Road just south of Trent Avenue. The BNSF route is one of the company's main transcontinental lines between west coast ports and the interior of the country and hosts Amtrak's twice-daily Empire Builder between Chicago and Seattle/Portland. **Table 1** illustrates some basic operating characteristics for each of these at-grade crossings. Federal Railroad Administration (FRA) data indicates that the BNSF line hosts about 56 trains per day, mostly long-haul freight trains passing quickly through the area.

Historic collision data indicates that the grade crossings at University Road have operated safely over the last 40 years. However, a fatal vehicle collision occurred with a train at the Pines Road / BNSF crossing in 2001.

TABLE 1. OPERATING CHARACTERISTICS

Street Crossing	Average Trains per Day	Typical Train Frequency	Gates Down Average/Max (minutes)	Typical Train Speed	List of Collisions (1975-2016)
Pines Road	56	10-90 mins[1]	3/4.5 mins[1]	1 - 79 mph	2001 - fatality

Source: Federal Railroad Administration, 2017
1. Data was not collected at the BNSF and Pines Road railroad crossing. Results are from a similar study at the BNSF/Barker Road crossing prepared by Fehr & Peers in 2017.

Level of Service Standards

Level of service (LOS) is used to describe and evaluate traffic operations along major arterial corridors and intersections within a city. Levels range from LOS A to LOS F, which encompass a range of congestion types from uninterrupted traffic (LOS A) to highly-congested conditions (LOS F). The description and intersection delay thresholds of each LOS category are described in **Table 2.** These are based on the Highway Capacity Manual, which is the methodology used by Spokane Valley. The LOS for signalized intersections is measured by the average delay per vehicle entering the intersection from all approaches, while the LOS for unsignalized intersections is measured by the average delay per vehicle on the approach with the highest average delay.

TABLE 2. LEVEL OF SERVICE DESCRIPTION AND DELAY THRESHOLDS AT INTERSECTIONS

Level of Service	Description	Signalized Intersection Delay (seconds)	Unsignalized Intersection Delay (seconds)
A	Free-flowing conditions.	0-10	0-10
B	Stable operating conditions.	10-20	10-15
C	Stable operating conditions, but individual motorists are affected by the interaction with other motorists.	20-35	15-25
D	High density of motorists, but stable flow.	35-55	25-35
E	Near-capacity operations, with speeds reduced to a low but uniform speed.	55-80	35-50
F	Over-capacity conditions with long delays.	> 80	>50

Source: Highway Capacity Manual 2016, Transportation Research Board

The LOS standards for Spokane Valley defined in their Comprehensive Plan as follows:

- LOS D for major arterial corridors:
  - Argonne / Mullan between Trent Avenue and Appleway Boulevard.
  - Pines Road between Trent Avenue and 8th Avenue.
  - Evergreen Road between Indiana Avenue and 8th Avenue.
  - Sullivan Road between Wellesley Avenue and 8th Avenue.
  - Sprague Avenue / Appleway Boulevard between Fancher Road and Park Road.
- LOS D for signalized intersections not on major arterial corridors.
- LOS E for unsignalized intersections (LOS F is acceptable if the peak hour traffic signal warrant is not met).

WSDOT also uses LOS thresholds for State Highways and given that Trent Avenue is also State Route 290 (SR 290), intersections with Trent Avenue would need to operate at LOS D or better to meet WSDOT LOS standards for state routes in urban areas.

Existing Intersection Traffic Operations

Existing traffic conditions, including average vehicle delay and LOS, at the study area intersections are shown in **Table 3**. Detailed calculations are provided in **Attachment A**. These results were calculated with the following assumptions:

- Intersection peak hour factors (PHF) were consistent with 2017 counts
- Truck percentages consistent with 2017 counts (6% AM and 2% PM)
- Signal timing between AM and PM peak hours were consistent

TABLE 3. 2017 EXISTING PEAK HOUR INTERSECTION OPERATIONS

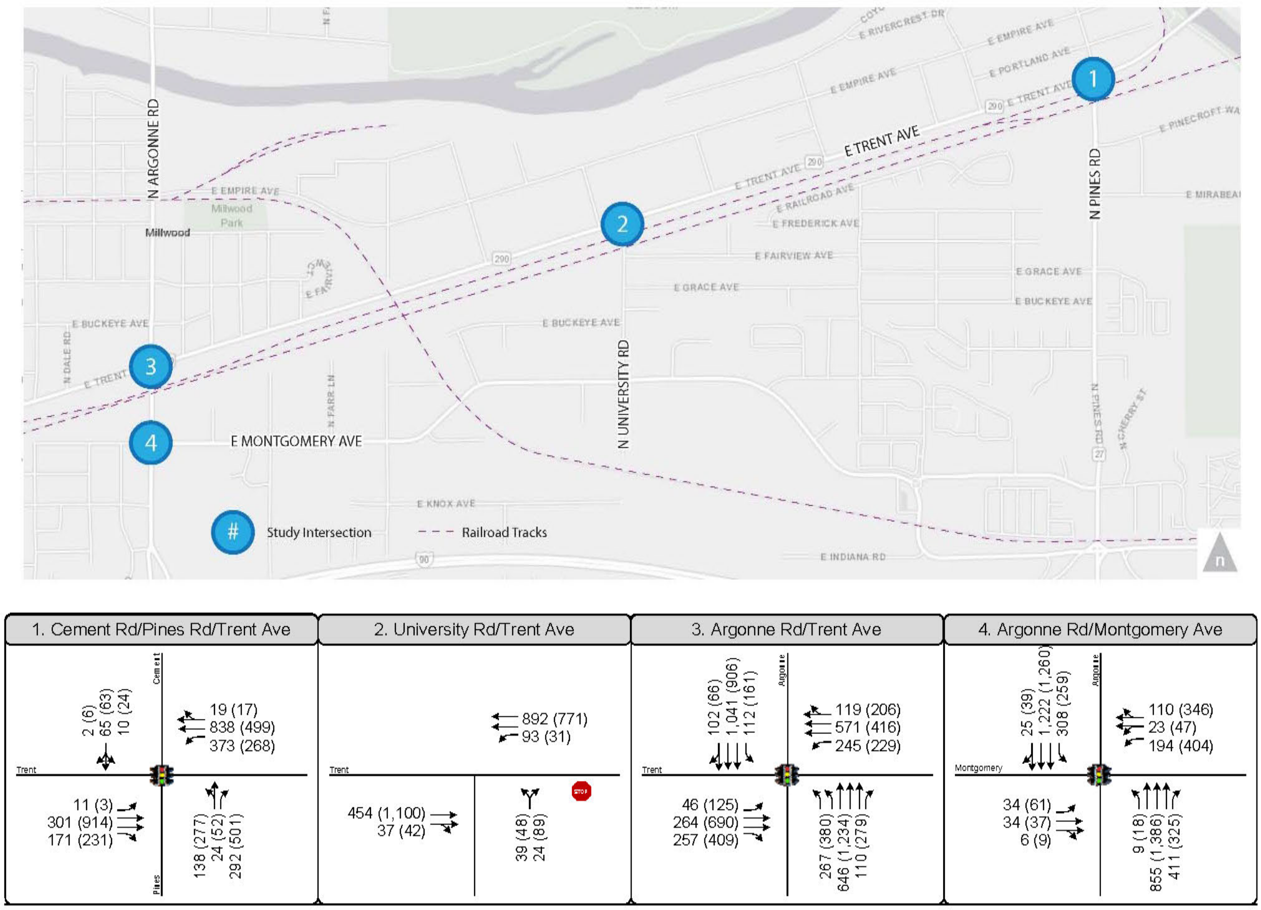
ID	Intersection	Control / Approach	AM Peak Hour		PM Peak Hour	
			Delay	LOS	Delay	LOS
1	Pines Road / Trent Avenue	Signal	26	C	47	D
2	University Road / Trent Avenue	TWSC / NB	17	C	29	D
3	Argonne Road / Trent Avenue	Signal	47	D	50	D
4	Argonne Road / Montgomery Avenue	Signal	33	C	39	D

Source: Fehr & Peers, 2017

Under existing conditions, all four intersections currently meet WSDOT and Spokane Valley LOS standards during the AM and PM peak hours.

The existing lane configurations for each study intersection and peak hour turn movement counts are shown in **Figure 1.**

Figure 1. 2017 Existing Lane Configurations and AM (PM) Peak Hour Turning Movements



Pines Road / Trent Avenue Intersection Collision History

Vehicle collision history was analyzed over a five-year period from January 2012 to December 2016 at the Pines Road / Trent Avenue intersection. **Table 4** provides a summary of the collision history at the intersection by severity and whether the cause was related to the intersection. There were 59 collisions reported at or near the Pines Road / Trent Avenue intersection where 22 resulted in an injury while zero resulted in a fatality. 45 of the 59 collisions were found to be at the intersection or the cause was found to be related to the intersection. Of the 22 injury collisions, 18 were from collisions where the cause was related to the intersection.

TABLE 4. 2012-2016 COLLISION SUMMARY BY SEVERITY AT THE PINES ROAD / TRENT AVENUE INTERSECTION

Summary	All Collisions	Fatal Collisions	Injury Collisions	Intersection Related
5 year total	59	0	22	45
Average per year	11.8	0	4.4	9.0

Source: WSDOT, 2017

Table 5 provides a summary of crashes from 2012 to 2016 at the Pines Road / Trent Avenue intersection by crash type. Of the 59 total crashes over this period, about 46% resulted in a rear-end collision at the traffic light while about 31% were caused by an improper left-turn or failure to yield. While the remaining collisions had a variety of causes.

TABLE 5. 2012-2016 COLLISIONS BY TYPE AT THE PINES ROAD / TRENT AVENUE INTERSECTION

Severity	Total	Improper turn/failure to yield	Rear-end at traffic light	Railway Crossing Gate	Speeding	Pedestrian	Other
All crashes	59	18	27	3	2	1	8
Injury crashes	22	6	10	0	1	1	4

Source: WSDOT, 2017

Based on the analysis of recent collisions at this location, it is likely that a roundabout at this location would reduce the "improper left turn" and "rear-end at traffic light" collisions. The reduction in these types of collisions is based on a low-speed approach to the roundabouts, which make it easier to judge gaps in traffic and safely enter the traffic stream. The likelihood of injury crashes is also much lower at a roundabout. While roundabouts are generally shown to have lower injury/fatality collision rates, there can be more sideswipe and low-speed failure to yield collisions. Additionally, the grade separation would eliminate the issue of railway crossing gate collisions (although the railway grade crossing collisions are rare).

TRAVEL DEMAND FORECASTING

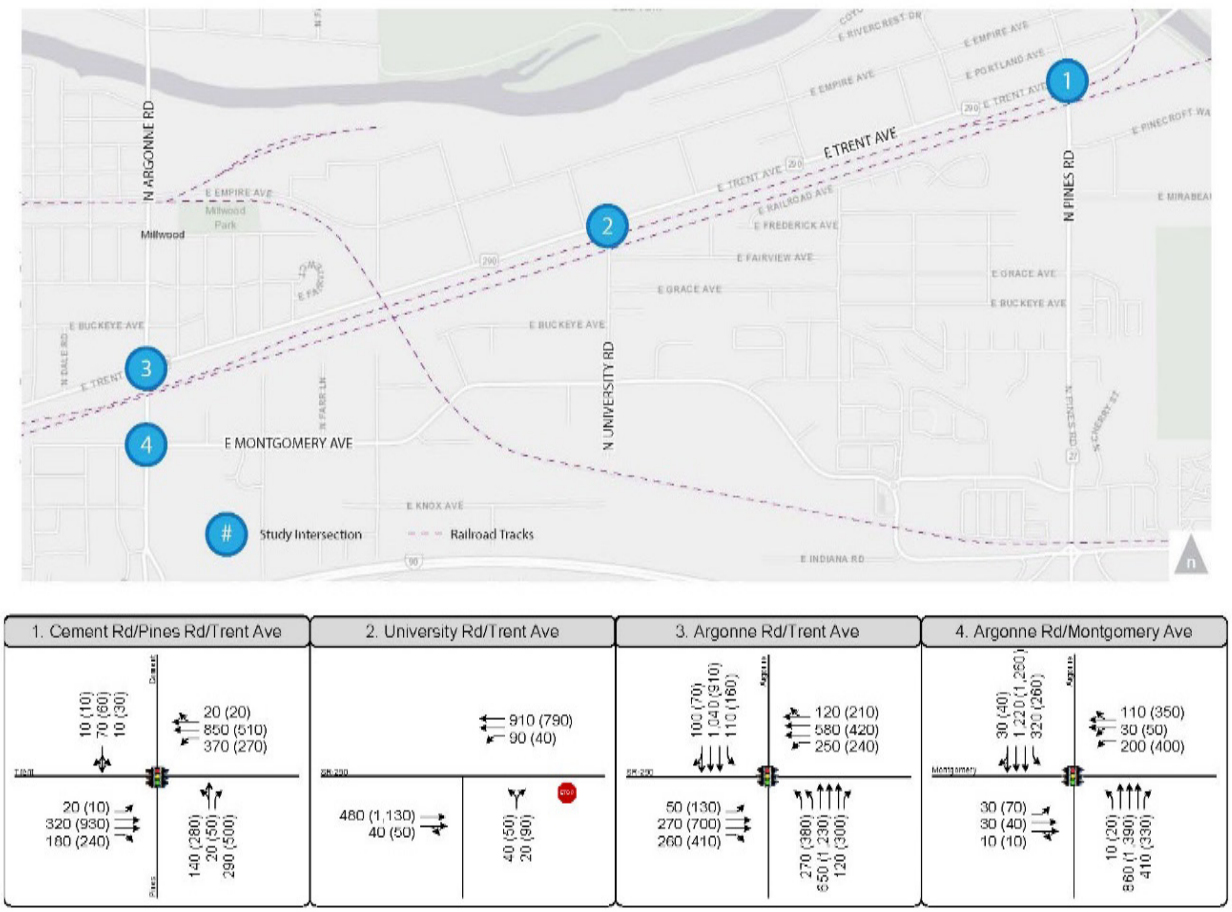
AM and PM traffic volumes at each of the study intersections were developed for 2020 and 2040 conditions.

2020 Forecasts

Volumes were forecast to year 2020 using an annual growth rate calculated using the 2017 counts and the 2040 forecasted volumes from the SRTC regional travel demand model (see next section). This growth rate was then then applied to the 2017 counts to develop the 2020 forecasts. The forecasting process for the 2040 volumes is explained in the following section.

The 2020 forecasted volumes and intersection lane configurations are shown in **Figure 2.**

Figure 2. 2020 No Build Lane Configurations and AM (PM) Peak Hour Turning Movement Forecasts



2040 Forecasts

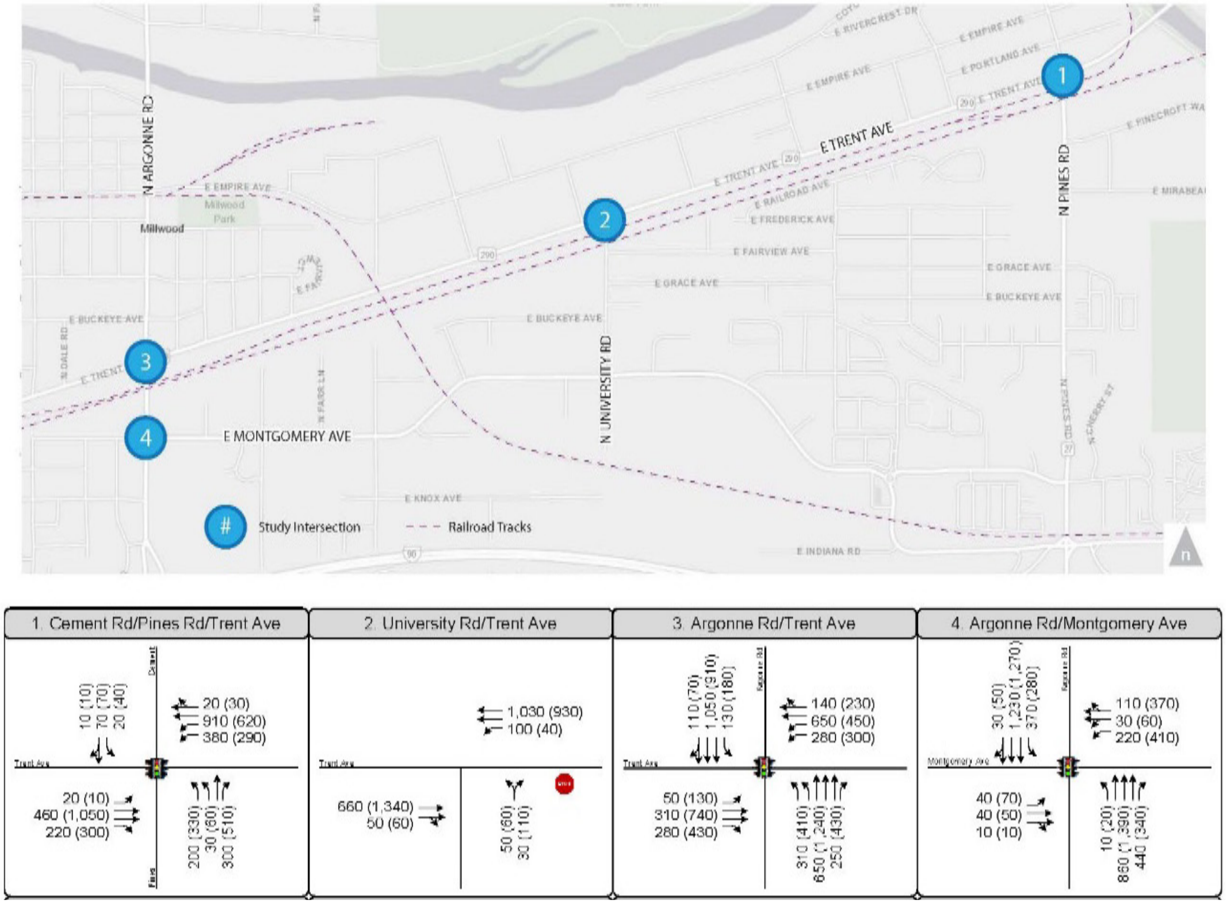
The 2040 AM and PM peak forecasts were forecasted using the SRTC regional travel demand model developed for the Horizon 2040 Regional Transportation Plan. This model was recently updated in December 2017 and it includes the regional growth forecast for Spokane Valley, Spokane County and all the surrounding jurisdictions. In addition to land use growth, there were several key transportation projects assumed in the SRTC 2040 model:

- The Barker Road/I-90 interchange would be reconfigured to a standard diamond interchange with two-lane roundabouts plus slip ramps for right-turn movements at both ramps (as reflected in I-90/Barker Rd the Interchange Justification Report)
- Barker Road between I-90 and Appleway Avenue would be widened to five lanes
- Bigelow Gulch Road would be widened to four lanes and connected to Sullivan Road

Instead of using the traffic forecasts directly from the 2040 travel demand model, 2040 AM and PM peak volumes were estimated using an industry standard approach known as the difference method. Under the difference method, the difference in traffic volumes between the 2015 and 2040 models were added to the observed counts at each of the study intersections to arrive at a 2040 forecast traffic volume. This method reduces model error by relying as much as possible on observed data rather than model output data.

The 2040 forecasted volumes and lane configurations are shown in **Figure 3**.

Figure 3. 2040 No Build Lane Configurations and AM (PM) Peak Hour Intersection Turning Movement Forecasts



2020 AND 2040 ALTERNATIVES ANALYSIS

AM and PM peak hour vehicle delay and level of service (LOS) were analyzed for 2020 and 2040. There are four conceptual alternatives being studied for the Pines Road / BNSF Grade Separation Project. These four alternatives only affect the lane configuration and intersection control of the Pines Road / Trent Avenue intersection. So, the following intersections were analyzed in 2020 and 2040 under each alternative:

- No Build:
  - Pines Road / Trent Avenue
  - University Road / Trent Avenue
  - Argonne Road / Trent Avenue
  - Argonne Road / Montgomery Avenue
- Alternative 1:
  - Pines Road / Trent Avenue
- Alternative 1a (roundabout):
  - Pines Road / Trent Avenue

- Alternative 2:
  - Pines Road / Trent Avenue
- Alternative 2a (roundabout):
  - Pines Road / Trent Avenue

No Build Results

All four study intersections were analyzed under the No Build alternative which includes the following assumptions:

- 2020 intersection lane configurations and signal timings were consistent with the 2017 existing analysis
- 2040 analysis assumes consistency with the Spokane Valley Comprehensive Plan:
  - Improvements at the Pines Road / Trent Avenue intersection were assumed to be consistent with the Spokane Valley Comprehensive Plan which includes:
    - North/south split phasing changed to standard protected left turn phasing
    - Addition of a second westbound left turn pocket
    - Addition of a dedicated southbound left turn pocket
    - Reconfigured northbound approach with two left turn pockets, one through lane, and one right turn lane
  - Improvements at the Argonne Road / Trent Avenue intersection were assumed to be consistent with the Spokane Valley Comprehensive Plan which includes:
    - Restriping one westbound through lane as a dedicated left turn lane

Tables 6 and 7 show the intersection operation results for 2020 and 2040 under the No Build conditions respectively. Detailed Synchro results can be found in **Attachment B.**

TABLE 6. 2020 NO BUILD PEAK HOUR INTERSECTION OPERATIONS

ID	Intersection	Control / Approach	AM Peak Hour		PM Peak Hour	
			Delay	LOS	Delay	LOS
1	Pines Road / Trent Avenue	Signal	28	C	50	D
2	University Road / Trent Avenue	TWSC / NB	18	C	32	D
3	Argonne Road / Trent Avenue	Signal	48	D	51	D
4	Argonne Road / Montgomery Avenue	Signal	33	C	40	D

Source: Fehr & Peers, 2018

TABLE 7. 2040 NO BUILD PEAK HOUR INTERSECTION OPERATIONS

ID	Intersection	Control / Approach	AM Peak Hour		PM Peak Hour	
			Delay	LOS	Delay	LOS
1	Pines Road / Trent Avenue	Signal	23	C	28	C
2	University Road / Trent Avenue	TWSC / NB	24	C	**69**	**F**
3	Argonne Road / Trent Avenue	Signal	52	D	52	D
4	Argonne Road / Montgomery Avenue	Signal	37	D	43	D

Source: Fehr & Peers, 2018

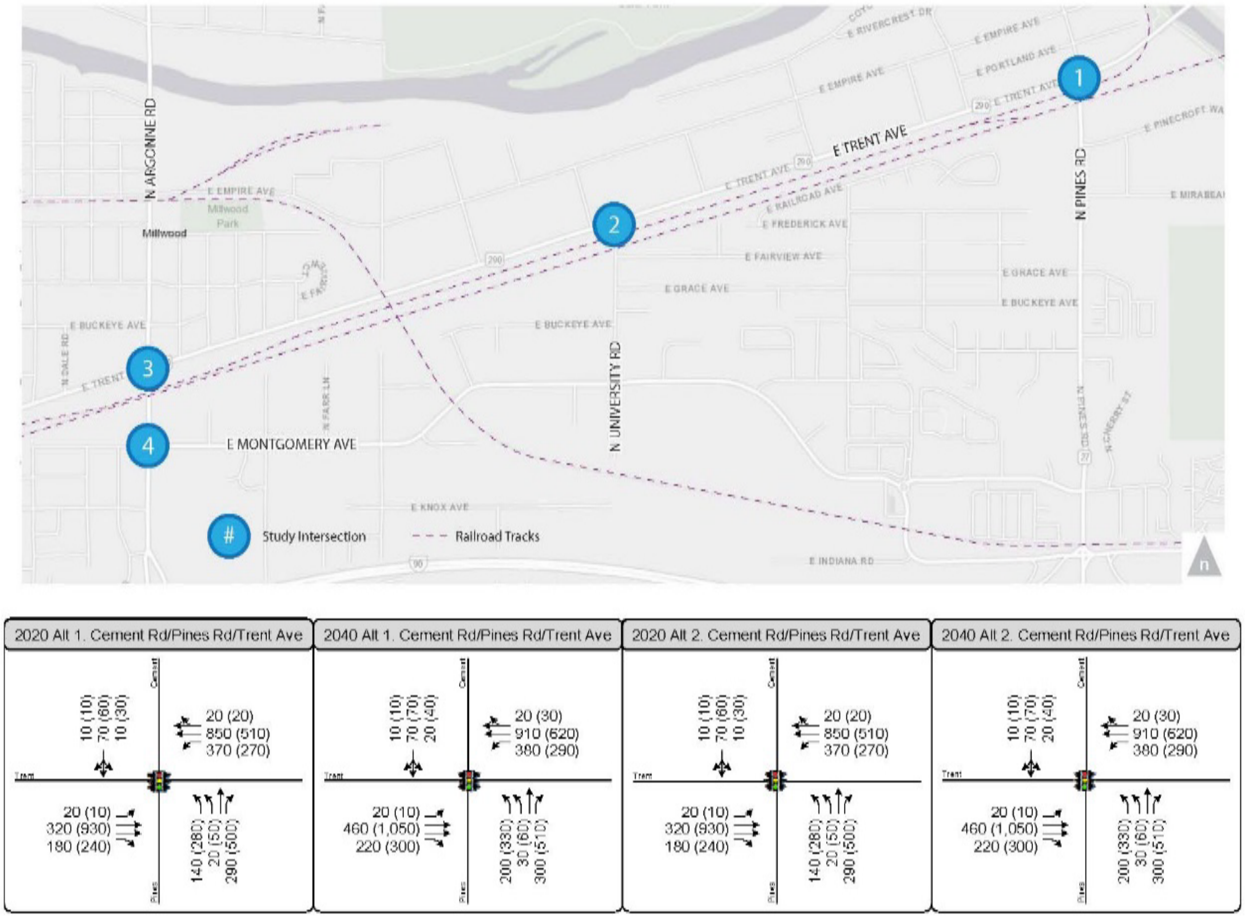
The analysis shows that under the No Build Condition, all intersections would operate at an acceptable LOS during the AM and PM peak hour in both 2020 and 2040 conditions, with the exception of the University Road / Trent Avenue intersection. By 2040, the University Road / Trent Avenue intersection fails both the City's and WSDOT's standards during the PM peak hour.

While intersection LOS standards are generally met under the No Build alternative, the delays and at-grade rail safety issues at the Pines Road / BNSF crossing are not addressed. Additionally, the queues caused by the Pines Road / Trent Avenue signal are expected to grow in the future as regional traffic volumes increase. The northbound queues at this intersection will extend back across the railroad tracks, increasing the potential for vehicle/train conflicts.

Grade Separation Alternative Results

The Pines Road / Trent Avenue intersection was evaluated under the following four BNSF grade separation alternatives. Note that a reconstruction of the Pines Road / Trent Avenue intersection is required for the grade separation in order to be able to depress the roadway under the railroad tracks. For roundabout alternatives (1a and 2a), forecasted traffic volumes in 2040 two eastbound and westbound lanes for the roundabouts. Conceptual drawings of the alternatives are provided in **Attachment C.** 2020 and 2040 lane configurations and turning movement forecasts are provided in **Figure 4.**

Figure 4. 2020 and 2040 Alternatives Lane Configuration and AM (PM) Peak Hour Turning Movement Forecasts



Alternative 1:

The analysis included the following additional assumptions not clearly shown in the conceptual drawings:

- There is one eastbound and westbound left-turn lane (same geometry as the No Build conditions)
- The eastbound right-turn has the same geometry as the No Build conditions
- The northbound movement has two left-turn lanes with one pocket of 150 feet and one trap lane
- The southbound approach is a single shared lane

Alternative 1a (roundabout):

This alternative was analyzed using the Sidra software (version 6.1) using the settings consistent with WSDOT's Sidra Policy Settings published in November 2015. The lane configurations were assumed to follow those in the conceptual drawings. In this case, the assumed speed on Pines Road approaching the intersection is 35 miles per hour and 25 miles per hour on Cement Road approaching the intersection. The circulating speed within the roundabout is assumed to be 15-20 miles per hour.

Alternative 2:

This analysis for this alternative includes the following assumptions in conjunction with the conceptual drawings:

- There is one eastbound left-turn lane with the same geometry as the No Build conditions
- The eastbound right-turn has the same geometry as the No Build Scenario
- There are two westbound left-turn pockets with a storage length of 175 feet
- The northbound movement has two left-turn lanes with one pocket of 150 feet and one trap lane
- The northbound movement also has one right-turn pocket of approximately 150 feet
- The southbound approach is a single shared lane

Alternative 2a (roundabout):

The lane configuration is the same as that of Alternative 1a; however, given the additional curvature of the northbound approach, the assumed speed on Pines Road approaching the intersection was decreased to 15 miles per hour.

Tables 8 and 9 show the operation analysis results for the Pines Road / Trent Avenue intersection under each alternative including the No Build for 2020 and 2040 respectively. Detailed operation results can be found in **Attachment D.**

TABLE 8. 2020 NO BUILD AND ALTERNATIVES PEAK HOUR INTERSECTION OPERATIONS

Pines Rd / Trent Ave	Control	AM Peak Hour	PM Peak Hour
		Delay / LOS	Delay / LOS
No Build	Signal	28 / C	47 / D
Alternative 1	Signal	27 / C	42 / D
Alternative 1a	Roundabout	8 / A	9 / A
Alternative 2	Signal	24 / C	32 / C
Alternative 2a	Roundabout	7 / A	7 / A

Source: Fehr & Peers, 2018

TABLE 9. 2040 NO BUILD AND ALTERNATIVES PEAK HOUR INTERSECTION OPERATIONS

Pines Rd / Trent Ave	Control	AM Peak Hour	PM Peak Hour
		Delay / LOS	Delay / LOS
No Build	Signal	23 / C	28 / C
Alternative 1	Signal	28 / C	41 / D
Alternative 1a	Roundabout	9 / A	9 / A
Alternative 2	Signal	26 / C	32 / C
Alternative 2a	Roundabout	8 / A	8 / A

Source: Fehr & Peers, 2018

In the 2020 and 2040 scenarios, both alternatives meet the City and WSDOT LOS standard. In both the AM and PM peak hour, Alternative 2 performs better than Alternative 1 in terms of delay and LOS. Similarly, the roundabout alternative (Alternative 2a) operates at an even better LOS than Alternative 2.

It is worth noting that while the intersection operations for Alternatives 2 and 2a might be slightly better than 1 and 1a, the sharp curve south of the Pines Road / Trent Avenue intersection is unusual for an arterial road and the lower speed required to negotiate this curve will negate much of the intersection operations improvements, particularly for the roundabout alternative. Additional discussion about the disadvantages of this sharp curve are included in the conclusions section.

These results show slightly more delay for Alternative 1 and 2 when compared with the No Build due to the difference in lane geometry at the southbound approach. In all of the Alternatives, the southbound approach consists of a shared right, through, and left movement whereas the No Build includes a separate left turn pocket. If the Alternatives included this separate left turn pocket, the operations are anticipated to be similar to the No Build alternative. For example the Alternative 2 PM peak hour would improve to have a delay of 32 seconds with an LOS C.

In addition to improving the operations at the intersection, roundabouts also help manage queuing in the system. Alternative 1 experiences long queuing for vehicles traveling in the eastbound and westbound directions in the 2020 PM and 2040 PM peak hours. In the eastbound direction, queues are anticipated to spill back to the previous intersection and in the westbound directions queues are anticipated to spill back onto the bridge over the Spokane River. Alternative 2 experiences long queuing in the eastbound directions during the 2020 PM and 2040 PM peak hours and in the westbound direction in the 2040 AM and PM peak hours. In the 2040 PM peak hour, both Alternative 1 and 2 experience long queuing for vehicles traveling in the northbound direction where queues are expected to spill back to the bridge under railroad tracks.

2020 AND 2040 SAFETY ANALYSIS

A safety analysis was conducted to predict average intersection collision frequency in 2020 and 2040 at the Pines Road / Trent Avenue intersection under each Alternative along based on the Highway Safety Manual (HSM) predictive method. The following scenarios were analyzed:

- No Build scenario
- Alternative 1 with a signal
- Alternative 1 with a roundabout
- Alternative 2 with a signal
- Alternative 2 with a roundabout

Methodology

We used WSDOT's spreadsheet tool for urban and suburban arterials to automate the HSM Predictive analysis[1] (see http://www.wsdot.wa.gov/Design/Support.htm). The WSDOT disclaimer should be noted as it relates to the results when using this tool.[2] The tool, which is based on the HSM predictive method, includes several inputs to predict average annual crashes by type, including:

- Intersection control type (signal or stop)
- Number of legs on intersection
- Average Annual Daily Traffic entering intersection
- Presence of lighting
- Calibration factor
- Number of approaches with left-turn and right-turn lanes
- Left-turn signal phasing (permissive, protected or permissive/protected)
- Pedestrian crossing volume
- Lanes crossed by a pedestrian
- Collision history (not applicable to multiyear forecasts)

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[1] Safety Analysis Guide. Washington State Department of Transportation, September 2017. Pg 16.

[2] Under 23 U.S. Code § 148 and 23 U.S. Code § 409, safety data, reports, surveys, schedules, lists compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential crash sites, hazardous roadway conditions, or railway-highway crossings are not subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

- Presence of red light cameras
- Right-turn on red restrictions
- Number of bus stops within 1,000 feet of the intersection
- Schools within 1,000 feet of the intersection
- Alcohol sales establishments within 1,000 feet of the intersection

For the above inputs, many variables were assumed to be consistent under all 2020 and 2040 scenarios, including:

- Lighting would be present;
- The calibration factor was set to 1 (default);
- No red light cameras would be present;
- Right-turn on red would be allowed (under scenarios that assume signals);
- No public transit bus stops would be within 1,000 feet of the intersection;
- The Trent Elementary school would be within 1,000 feet of the intersection;
- Two alcohol establishments would be within 1,000 feet of the intersection (Dos Amigos and Valley Bar and Grill)

Intersection Type

The spreadsheet tool includes a stop control and signal control option, but does not include a roundabout option. Therefore a signal was assumed for all intersections and predicted collisions for intersections with a roundabout were adjusted from the predictions with a signal based on research provided by WSDOT and other sources (see description below).

Reduction in Collisions from Roundabouts

WSDOT references studies by the Institute for Highway Safety and Federal Highway Administration that have shown that roundabouts are safer than signals.[3] Based on those studies as compared to other control types, roundabouts typically achieve:

- A 37 percent reduction in overall collisions
- A 75 percent reduction in injury collisions
- A 90 percent reduction in fatality collisions
- A 40 percent reduction in pedestrian collisions

The reduction in collisions can be attributed to lower travel speeds (typically 15-20 mph) through the intersection, eliminating the temptation to "beat the light" (all drivers must slow down), and the one-way travel pattern which reduces the likelihood of T-bone and head-on collisions.

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[3] https://www.wsdot.wa.gov/Safety/roundabouts/benefits.htm

To be consistent with WSDOT data sources, the methodology used to predict collisions with a roundabout is based on a 75% reduction in injury collisions and 37% reduction in all collisions from what would be predicted with a signal.

Average Annual Daily Traffic Forecasts

Average annual daily traffic (AADT) was forecast for the year 2020 for each approach to the each intersection by applying an annual growth rate to the most recent observed daily count. The annual growth rate was calculated from the most recent observed count and the 2040 forecasted AADT from the SRTC model. Traffic volumes in 2020 were assumed to be the same under both alternatives as well as the No Build Scenario. Under Alternative 2, the north leg would tie into E Portland Avenue instead of Cement Road. Given that these are both low volume streets that provide local access to the same general area, the volumes were assumed to be the same as Alternative 1 and the No Build Scenario.

Average annual daily traffic (AADT) was forecast for the year 2040 for each approach to the each intersection using the SRTC travel demand model developed to support the Horizon 2040 plan. One model run was used for 2040 forecasts under both alternatives, including the No Build Scenario. In order to develop forecasts, the difference method was used whereby the growth in daily traffic for each segment between the 2015 model and 2040 model was added to the existing (most recent) observed daily traffic counts as reported by City of Spokane Valley[4]. This method reduces the likelihood of model error. The 2020 and 2040 AADT outcomes using the methodologies described here are summarized in **Table 10**.

TABLE 10: 2020 AND 2040 AADT BY APPROACH FOR EACH ALTERNATIVE

Alternative	Intersection	EB	WB	NB	SB
2020 AADT					
No Build / Alternative 1 / Alternative 2	Pines Road / Trent Avenue	11,500	13,600	8,100	800
2040 AADT					
No Build / Alternative 1 / Alternative 2	Pines Road / Trent Avenue	13,500	15,200	8,400	840

Source: WSDOT, 2018

[4] http://www.spokanevalley.org/Traffic (see "Most Recent ADT")

Lane Configurations

The number of turn lanes at each intersection under each alternative as well as the maximum number of lanes a pedestrian would have to cross was based on the conceptual drawings provided in **Attachment C** and were shown previously in **Figure 4**.

Under both alternatives and the No Build Scenario, right-turn only lanes are included in the eastbound and northbound approaches, as well as two northbound left-turn lanes and one eastbound left-turn lane. Under Alternative 1 there would be one westbound left-turn lane, while under Alternative 2 and the No Build Scenario there would be two westbound left-turn lanes. Under the No Build Scenario there would be a southbound left-turn pocket, which is not assumed in Alternative 1 and 2.

Left-Turn Signal Phasing

Under Alternative 1 and 2 all left-turns would have a protected signal phasing, with the exception of the southbound left, which would be permissive. The southbound approach is a low-volume movement that primarily provides access to the adjacent businesses. Under the No Build Scenario all left-turns would have a protected signal phase.

Pedestrian Crossing Volumes

Two-hour pedestrian counts across all four legs of the existing Pines Road / Trent Avenue intersection were collected on a weekday in August, 2017 in both the AM peak period (7 AM – 9 AM) and the PM peak period (4 PM – 6 PM). The combined total pedestrian crossings during these four hours was 22. Using calibration factors from the National Bicycle and Pedestrian Documentation Project (which estimates about 20% of daily pedestrian activity occurs during these four hours), it was estimated that there are about 110 daily pedestrian crossings at the Pines Road / Trent Avenue intersection.

A 2% annual growth rate was assumed for pedestrian volumes crossing the Pines Road/Trent Avenue intersection. Therefore, it was assumed that by 2020 there would be about 120 daily pedestrian crossings at this intersection.

Data from the SRTC travel demand model shows that within the three transportation analysis zones surrounding this intersection the number of households will grow by about 125% and the number of employees will grow by about 260% between 2015 and 2040. Based on these localized growth forecasts it was assumed that pedestrian volumes would increase by about 200% between now and 2040. Therefore, it was estimated that by 2040 there would be about 330 daily pedestrian crossings of the Pines Road / Trent Avenue intersection.

Safety Analysis Findings

Using the methodology described in the previous section, Table **11** shows the average predicted crashes per year by 2040 at the Pines Road / Cement Road / Trent Avenue intersection under Alternative 1, both with a signal and with a roundabout. The findings illustrates that the Pines Road intersection is predicted to have a higher average number of injury crashes per year with a signal than with a roundabout. The results would be predicted to be similarly higher if a signal as opposed to a roundabout were assumed under the other alternatives.

TABLE 11. PREDICTED AVERAGE COLLISIONS PER YEAR BY ALTERNATIVE AT PINES ROAD / TRENT AVENUE

Intersection	Intersection Control	Predicted average collisions per year	Fatal & injury collisions per year	PDO crashes per year
Year 2020				
Alternative 1	Signal	3.9	1.4	2.5
Alternative 1a	Roundabout	2.4	0.4	2.2
Alternative 2	Signal	3.9	1.4	2.5
Alternative 2a	Roundabout	2.4	0.4	2.2
No Build	Signal	3.3	1.2	2.1
Year 2040				
Alternative 1	Signal	4.5	1.6	2.9
Alternative 1a	Roundabout	2.8	0.4	2.5
Alternative 2	Signal	4.5	1.6	2.9
Alternative 2a	Roundabout	2.8	0.4	2.5
No Build	Signal	3.9	1.4	2.5

Source: Fehr & Peers, 2017

The No Build Scenario is predicted to have slightly fewer injury crashes per year (in both 2020 and 2040) than both Alternatives 1 and 2 with a signal. This finding is primarily due to the fact that the No Build Scenario assumes a separate left-turn pocket with protected left-turn signal phasing for southbound movements, while Alternative 1 and 2 do not. However, the No Build scenario is predicted to have about one more injury crash per year on average (in both 2020 and 2040) than Alternatives 1 and 2 with a roundabout.

UNIVERSITY ROAD CLOSURE SCENARIO

When evaluating the grade separation of Pines Road at the BNSF mainline, Spokane Valley, SRTC, and BNSF have also considered the benefits and consequences of closing the University Road crossing of the tracks. As part of this study, Fehr & Peers analyzed the effects of closing the at-grade railroad crossing at University Road and examined rerouted travel demand as well as intersection operations at the remaining three study intersections for the 2020 and 2040 AM and PM peak hour.

Using the SRTC regional travel demand model, traffic volumes were rerouted from the University Road / Trent Avenue intersection to adjacent intersections based on model travel patterns. **Figures 5 and 6** present the trip distribution results of closing University Road. Approximately 200 vehicles were rerouted in the 2020 scenarios and approximately 300 were rerouted in the 2040 scenarios.

Figure 5. University Road Closure – Trip Distribution (In)

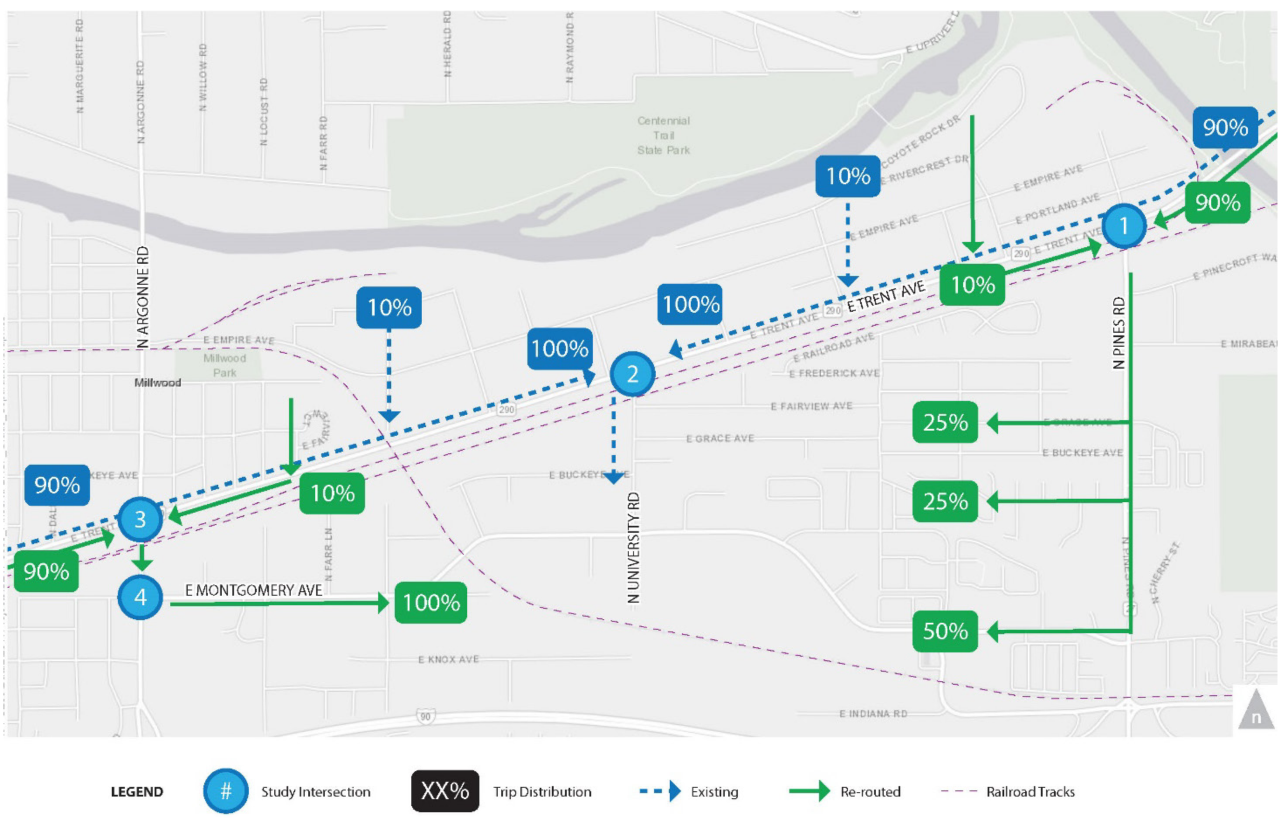


Figure 6. University Road Closure – Trip Distribution (Out)

Approximately 90% of trips turning onto Trent Avenue from University Road were assumed to travel either eastbound or westbound along Trent Avenue past the adjacent study intersections.

For vehicles heading in the eastbound direction, it is assumed that approximately 50% of those vehicles are expected to reroute to Pines Road via Montgomery Avenue. The remaining 50% are expected to use other residential streets to reach Pines Road.

The rerouted vehicles were assigned to the volume forecasts at the three remaining study intersections and the intersection operations were analyzed for the 2020 and 2040 scenarios. At the Argonne Road / Trent Avenue intersection in 2040, the westbound approach is only assumed to have two through lanes (as opposed to three in the 2020 scenario).

Figures 7 and 8 show the updated traffic volume forecasts for 2020 and 2040 after the University Road closure.

Figure 7. 2020 University Road Closure Lane Configuration and AM (PM) Peak Hour Turning Movement Forecasts

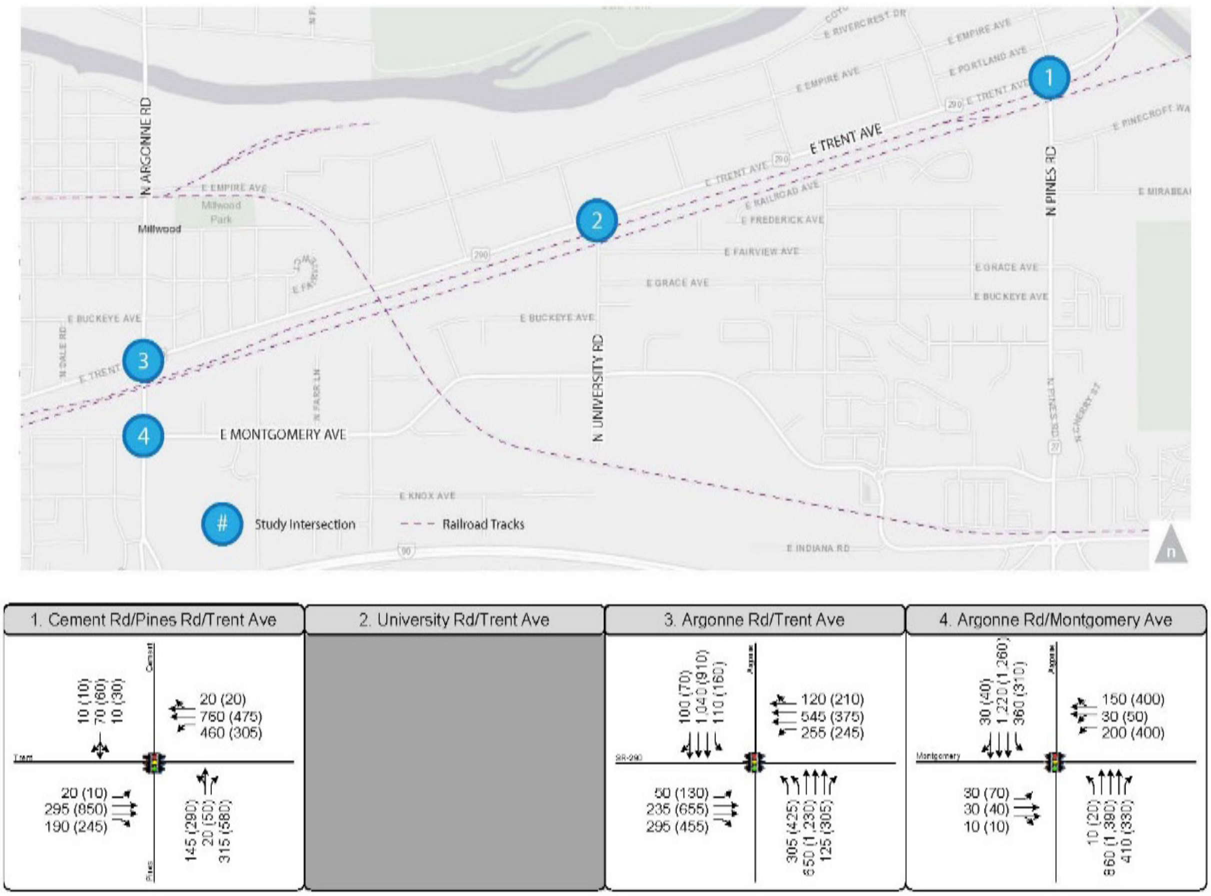
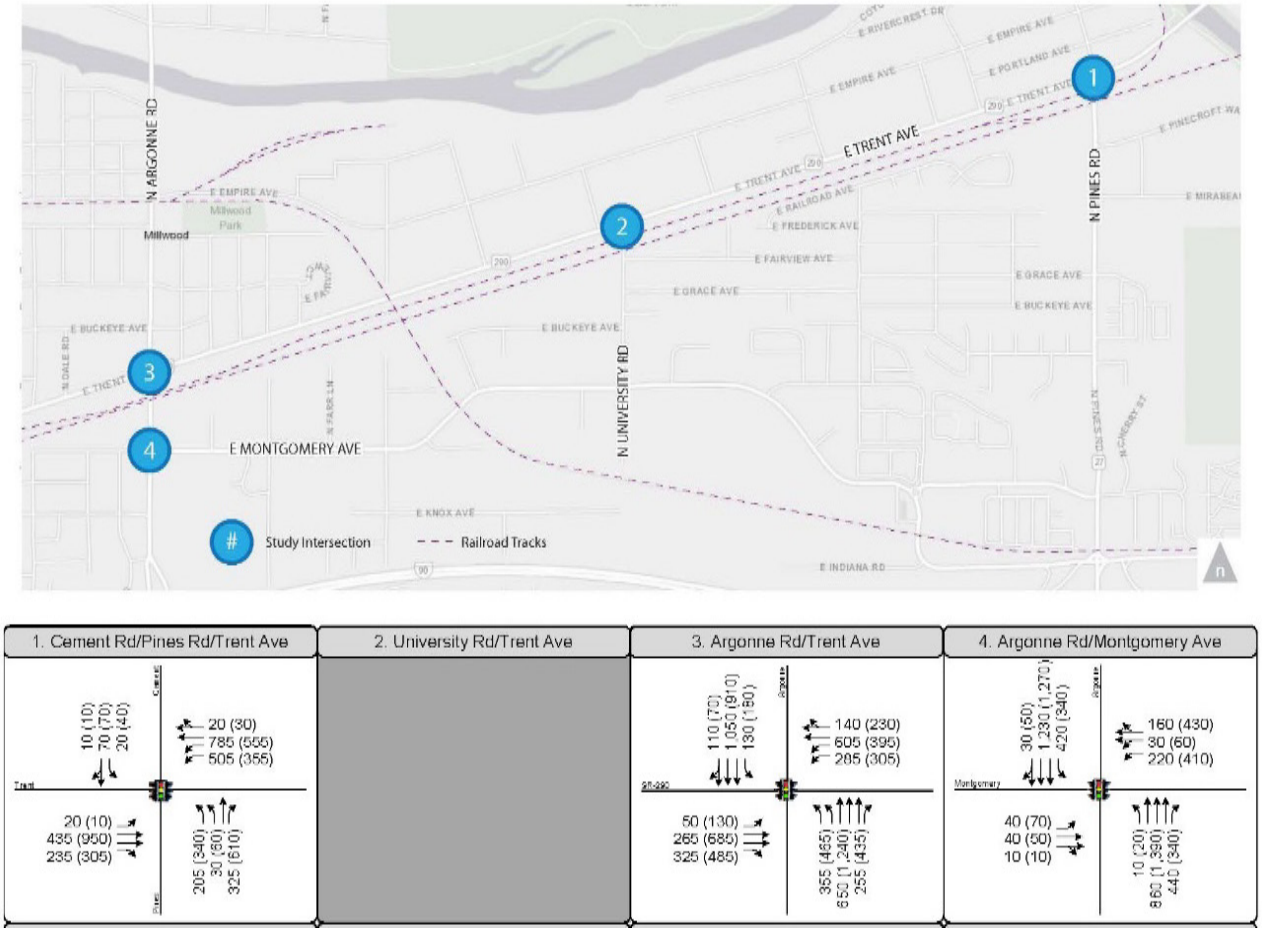


Figure 8. 2040 University Road Closure Lane Configuration and AM (PM) Peak Hour Turning Movement Forecasts



The delay and LOS results for the 2020 and 2040 University Road closure scenario are shown in **Tables 12 and 13** below and can also be found in **Attachment E**:

TABLE 12. 2020 NO BUILD AND UNIVERSITY CLOSURE PEAK HOUR INTERSECTION OPERATIONS

ID	Intersection	Control / Approach	AM Peak Hour		PM Peak Hour	
			No Build Delay / LOS	Closure Delay / LOS	No Build Delay / LOS	Closure Delay / LOS
1	Pines Road / Trent Avenue	Signal	28 / C	33 / C	50 / D	53 / D
2	University Road / Trent Avenue	TWSC / NB	18 / C		32 / D	
3	Argonne Road / Trent Avenue	Signal	48 / D	48 / D	51 / D	51 / D
4	Argonne Road / Montgomery Avenue	Signal	33 / C	34 / C	40 / D	44 / D

Source: Fehr & Peers, 2017

TABLE 13. 2040 COMPREHENSIVE PLAN AND UNIVERSITY CLOSURE PEAK HOUR INTERSECTION OPERATIONS

ID	Intersection	Control / Approach	AM Peak Hour		PM Peak Hour	
			No Build Delay / LOS	Closure Delay / LOS	No Build Delay / LOS	Closure Delay / LOS
1	Pines Road / Trent Avenue	Signal	23 / C	24 / C	28 / C	31 / C
2	University Road / Trent Avenue	TWSC / NB	24 / C		**69 / F**	
3	Argonne Road / Trent Avenue	Signal	52 / D	52 / D	52 / D	52 / D
4	Argonne Road / Montgomery Avenue	Signal	37 / D	39 / D	43 / D	51 / D

Source: Fehr & Peers, 2017

In 2020 and 2040, all intersections meet the City and WSDOT LOS standards with the closure of the University Road / BNSF crossing.

While the results indicate that the University Road / BNSF crossing could be closed without resulting in any LOS impacts, and would in fact eliminate the LOS F condition at University Road/Trent Avenue,[5]

[5] There are other options available to improve the LOS at this intersection including widening to include separate left and right northbound turn lanes or restricting access to be right in/out only. Additional study would be required to determine the best course of action to improve LOS.

consideration must be given to the drivers that would need to reroute to find an alternative route to Trent Avenue. Unlike some other areas in Spokane Valley, the residential area around the University Road/BNSF crossing is not well connected to the surrounding street grid. The UPRR tracks significantly limit access to the west and south and hilly terrain limits access to the west. It is worth noting that the University Road /BNSF crossing is one of the few quiet zone crossings in the Valley. Quiet zones have enhanced safety systems at the grade crossings, which allow trains to pass without blowing their whistles.

Given the factors described above, the fact that there has not been a train/vehicle collision at this crossing in more than 40 years, and the low current and forecasted volumes (Pines Road has nearly six times the PM peak hour volume as University Road), we recommend that the University Road/BNSF crossing be maintained.

SUMMARY OF FINDINGS

Based on the analysis of the different alternatives, each concept offers different advantages and disadvantages as they relate to mobility, traffic flow, delay and safety. Under Alternatives 1 and 2, traffic operations at the redesigned Pines Road / Trent Avenue intersection show similar traffic operations and safety results when comparing the two alternatives. Overall, the roundabout alternatives perform better than the signals with respect to LOS, queuing, and safety, although the traffic signal options would still meet LOS thresholds and perform similarly to many other signalized arterial intersections in Spokane Valley and around the state.

Alternatives 2 and 2a include an intersection geometry that consists of a sharp 90 degree turn in the northbound approach to enter the intersection. This configuration can cause potential issues with truck and freight operations entering the intersection from the south as trucks may be slow in navigating the sharp turn and oversize loads may track into adjacent lanes. This configuration also presents a potential safety issue given the sharp curve as drivers would enter the curve and have limited visibility of the rest of the intersection and of the vehicles queued at the intersection. These potential visibility issues could be addressed with signage/flashing beacons/variable message signs, but these elements add cost and complexity to the project and are unnecessary for Alternatives 1 and 1a. Overall, the configuration for Alternatives 2 and 2a is unusual, which may catch unfamiliar drivers off-guard.

Since all four Alternatives only affect the Pines Road / Trent Avenue intersection, no operational issues other than those shown under the No Build condition are expected for the other study intersections.

Given that the Pines Road / Trent Avenue intersection would have the capacity to serve increased demand due to the University Road closure, the Alternatives are also expected to operate similarly in 2020 and 2040 even if University Road was closed. However, given the limited connectivity to the neighborhood around the University Road / BNSF crossing, along with the relatively low volumes of traffic and existing safety enhancements at this crossing, we recommend that the University Road grade crossing remain open.

FEHR PEERS

ATTACHMENT A: 2017 EXISTING CONDITIONS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑	↱	↰	↑↑↱			↰↑	↱		✥	
Traffic Volume (veh/h)	11	301	171	373	838	19	138	24	292	10	65	2
Future Volume (veh/h)	11	301	171	373	838	19	138	24	292	10	65	2
Number	1	6	16	5	2	12	7	4	14	3	8	18
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
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1700	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	12	342	0	424	952	22	157	27	162	11	74	2
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	22	593	265	475	1495	35	206	35	214	14	94	3
Arrive On Green	0.01	0.19	0.00	0.31	0.49	0.49	0.16	0.16	0.16	0.07	0.07	0.07
Sat Flow, veh/h	1527	3047	1363	1527	3045	70	1312	226	1363	201	1350	36
Grp Volume(v), veh/h	12	342	0	424	476	498	184	0	162	87	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1527	1524	1591	1538	0	1363	1587	0	0
Q Serve(g_s), s	0.6	8.2	0.0	21.3	18.6	18.6	9.2	0.0	9.1	4.3	0.0	0.0
Cycle Q Clear(g_c), s	0.6	8.2	0.0	21.3	18.6	18.6	9.2	0.0	9.1	4.3	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.04	0.85		1.00	0.13		0.02
Lane Grp Cap(c), veh/h	22	593	265	475	748	781	241	0	214	111	0	0
V/C Ratio(X)	0.54	0.58	0.00	0.89	0.64	0.64	0.76	0.00	0.76	0.78	0.00	0.00
Avail Cap(c_a), veh/h	114	1176	526	1331	1802	1882	651	0	577	464	0	0
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	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	39.3	29.4	0.0	26.4	15.1	15.1	32.4	0.0	32.4	36.8	0.0	0.0
Incr Delay (d2), s/veh	18.6	0.9	0.0	6.0	0.9	0.9	5.0	0.0	5.4	11.4	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.4	3.5	0.0	9.7	8.0	8.3	4.2	0.0	3.7	2.2	0.0	0.0
LnGrp Delay(d),s/veh	57.9	30.2	0.0	32.4	16.0	16.0	37.4	0.0	37.8	48.1	0.0	0.0
LnGrp LOS	E	C		C	B	B	D		D	D		
Approach Vol, veh/h		354			1398			346			87	
Approach Delay, s/veh		31.2			21.0			37.6			48.1	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.2	45.4		17.6	31.0	21.6		10.1
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	6.0	95.0		34.0	70.0	31.0		23.5
Max Q Clear Time (g_c+I1), s	2.6	20.6		11.2	23.3	10.2		6.3
Green Ext Time (p_c), s	0.0	6.1		1.4	1.7	5.4		0.2

Intersection Summary	
HCM 2010 Ctrl Delay	26.4
HCM 2010 LOS	C

Intersection	
Int Delay, s/veh	1.3

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	454	37	93	892	39	24
Future Vol, veh/h	454	37	93	892	39	24
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	91	91	91	91	91	91
Heavy Vehicles, %	6	6	6	6	6	6
Mvmt Flow	499	41	102	980	43	26

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	540	0	1214	270
Stage 1	-	-	-	-	519	-
Stage 2	-	-	-	-	695	-
Critical Hdwy	-	-	4.22	-	6.92	7.02
Critical Hdwy Stg 1	-	-	-	-	5.92	-
Critical Hdwy Stg 2	-	-	-	-	5.92	-
Follow-up Hdwy	-	-	2.26	-	3.56	3.36
Pot Cap-1 Maneuver	-	-	997	-	168	716
Stage 1	-	-	-	-	551	-
Stage 2	-	-	-	-	446	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	997	-	151	716
Mov Cap-2 Maneuver	-	-	-	-	278	-
Stage 1	-	-	-	-	551	-
Stage 2	-	-	-	-	400	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.9	17.3
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	362	-	-	997	-
HCM Lane V/C Ratio	0.191	-	-	0.103	-
HCM Control Delay (s)	17.3	-	-	9	-
HCM Lane LOS	C	-	-	A	-
HCM 95th %tile Q(veh)	0.7	-	-	0.3	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	46	264	257	245	571	119	267	646	110	112	1041	102
Future Volume (vph)	46	264	257	245	571	119	267	646	110	112	1041	102
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.97		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2913	1303	1456	4077		2825	4185	1303	1456	4129	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2913	1303	1456	4077		2825	4185	1303	1456	4129	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	50	287	279	266	621	129	290	702	120	122	1132	111
RTOR Reduction (vph)	0	0	67	0	21	0	0	0	39	0	7	0
Lane Group Flow (vph)	50	287	212	266	729	0	290	702	81	122	1236	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	8.0	15.8	37.3	28.4	36.2		21.5	68.1	96.5	16.7	58.3	
Effective Green, g (s)	10.5	18.3	44.8	30.9	38.7		25.5	70.1	101.5	18.7	60.3	
Actuated g/C Ratio	0.07	0.12	0.30	0.21	0.26		0.17	0.47	0.68	0.12	0.40	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	101	355	389	299	1051		480	1955	881	181	1659	
v/s Ratio Prot	0.03	c0.10	0.10	c0.18	0.18		c0.10	0.17	0.02	c0.08	c0.30	
v/s Ratio Perm			0.07						0.04			
v/c Ratio	0.50	0.81	0.55	0.89	0.69		0.60	0.36	0.09	0.67	0.74	
Uniform Delay, d1	67.2	64.1	44.1	57.9	50.3		57.6	25.6	8.4	62.7	38.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.90	0.20	0.19	1.00	1.00	
Incremental Delay, d2	3.8	12.7	1.6	25.8	2.0		1.5	0.4	0.0	9.5	1.9	
Delay (s)	71.0	76.8	45.6	83.7	52.3		111.0	5.5	1.7	72.2	40.1	
Level of Service	E	E	D	F	D		F	A	A	E	D	
Approach Delay (s)		62.2			60.5			32.6			43.0	
Approach LOS		E			E			C			D	

Intersection Summary			
HCM 2000 Control Delay	47.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	72.8%	ICU Level of Service	C
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	34	34	6	194	23	110	9	855	411	308	1222	25
Future Volume (vph)	34	34	6	194	23	110	9	855	411	308	1222	25
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.98		1.00	0.92		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2845		1325	2528		1456	4185	1303	1456	4173	
Flt Permitted	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2845		1325	2528		1456	4185	1303	1456	4173	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	38	38	7	218	26	124	10	961	462	346	1373	28
RTOR Reduction (vph)	0	7	0	0	103	0	0	0	271	0	1	0
Lane Group Flow (vph)	38	38	0	126	139	0	10	961	191	346	1400	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	7.5	7.5		23.1	23.1		1.2	45.0	45.0	54.4	98.2	
Effective Green, g (s)	10.0	10.0		25.6	25.6		2.2	47.0	46.0	55.4	100.2	
Actuated g/C Ratio	0.07	0.07		0.17	0.17		0.01	0.31	0.31	0.37	0.67	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	97	189		226	431		21	1311	399	537	2787	
v/s Ratio Prot	c0.03	0.01		c0.10	0.06		0.01	c0.23		c0.24	0.34	
v/s Ratio Perm									0.15			
v/c Ratio	0.39	0.20		0.56	0.32		0.48	0.73	0.48	0.64	0.50	
Uniform Delay, d1	67.1	66.2		57.0	54.6		73.3	45.9	42.3	39.1	12.4	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.75	0.63	
Incremental Delay, d2	2.6	0.5		9.6	2.0		16.0	3.7	4.1	4.3	0.5	
Delay (s)	69.7	66.8		66.6	56.6		89.4	49.6	46.3	33.7	8.3	
Level of Service	E	E		E	E		F	D	D	C	A	
Approach Delay (s)		68.1			60.0			48.8			13.4	
Approach LOS		E			E			D			B	

Intersection Summary			
HCM 2000 Control Delay	33.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.6%	ICU Level of Service	B
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	3	914	231	268	499	17	277	52	501	24	63	6
Future Volume (veh/h)	3	914	231	268	499	17	277	52	501	24	63	6
Number	1	6	16	5	2	12	7	4	14	3	8	18
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
Adj Sat Flow, veh/h/ln	1667	1635	1667	1667	1636	1700	1700	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	3	933	0	273	509	17	283	53	256	24	64	6
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	4	2	2	4	4	2	2	2	2	2	2
Cap, veh/h	6	1034	471	302	1592	53	314	59	330	30	80	8
Arrive On Green	0.00	0.33	0.00	0.19	0.52	0.52	0.23	0.23	0.23	0.07	0.07	0.07
Sat Flow, veh/h	1587	3106	1417	1587	3069	102	1347	252	1417	416	1108	104
Grp Volume(v), veh/h	3	933	0	273	257	269	336	0	256	94	0	0
Grp Sat Flow(s),veh/h/ln	1587	1553	1417	1587	1554	1618	1599	0	1417	1628	0	0
Q Serve(g_s), s	0.2	35.9	0.0	21.1	12.0	12.0	25.5	0.0	21.2	7.1	0.0	0.0
Cycle Q Clear(g_c), s	0.2	35.9	0.0	21.1	12.0	12.0	25.5	0.0	21.2	7.1	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.06	0.84		1.00	0.26		0.06
Lane Grp Cap(c), veh/h	6	1034	471	302	806	839	373	0	330	118	0	0
V/C Ratio(X)	0.48	0.90	0.00	0.91	0.32	0.32	0.90	0.00	0.78	0.80	0.00	0.00
Avail Cap(c_a), veh/h	431	1340	611	431	806	839	447	0	396	462	0	0
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	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	62.2	39.8	0.0	49.6	17.4	17.4	46.6	0.0	44.9	57.1	0.0	0.0
Incr Delay (d2), s/veh	47.1	7.3	0.0	17.3	0.2	0.2	19.0	0.0	7.8	11.5	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.2	16.3	0.0	10.7	5.2	5.4	13.3	0.0	9.0	3.6	0.0	0.0
LnGrp Delay(d),s/veh	109.3	47.1	0.0	66.8	17.6	17.6	65.6	0.0	52.7	68.6	0.0	0.0
LnGrp LOS	F	D		E	B	B	E		D	E		
Approach Vol, veh/h		936			799			592			94	
Approach Delay, s/veh		47.3			34.4			60.0			68.6	
Approach LOS		D			C			E			E	
Timer	1	2	3	4	5	6	7	8				
Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	6.5	70.9		34.1	29.8	47.6		13.6				
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5				
Max Green Setting (Gmax), s	34.0	54.0		35.0	34.0	54.0		35.5				
Max Q Clear Time (g_c+I1), s	2.2	14.0		27.5	23.1	37.9		9.1				
Green Ext Time (p_c), s	0.0	7.4		1.6	0.7	3.8		0.3				
Intersection Summary												
HCM 2010 Ctrl Delay			47.0									
HCM 2010 LOS			D									

Intersection	
Int Delay, s/veh	2.1

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	1100	42	31	771	48	89
Future Vol, veh/h	1100	42	31	771	48	89
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	93	93	93	93	93	93
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	1183	45	33	829	52	96

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	1228	0	1686	614
Stage 1	-	-	-	-	1205	-
Stage 2	-	-	-	-	481	-
Critical Hdwy	-	-	4.14	-	6.84	6.94
Critical Hdwy Stg 1	-	-	-	-	5.84	-
Critical Hdwy Stg 2	-	-	-	-	5.84	-
Follow-up Hdwy	-	-	2.22	-	3.52	3.32
Pot Cap-1 Maneuver	-	-	563	-	85	435
Stage 1	-	-	-	-	247	-
Stage 2	-	-	-	-	588	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	563	-	80	435
Mov Cap-2 Maneuver	-	-	-	-	186	-
Stage 1	-	-	-	-	247	-
Stage 2	-	-	-	-	554	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.5	28.6
HCM LOS			D

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	296	-	-	563	-
HCM Lane V/C Ratio	0.498	-	-	0.059	-
HCM Control Delay (s)	28.6	-	-	11.8	-
HCM Lane LOS	D	-	-	B	-
HCM 95th %tile Q(veh)	2.6	-	-	0.2	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	125	690	409	229	416	206	380	1234	279	161	906	66
Future Volume (vph)	125	690	409	229	416	206	380	1234	279	161	906	66
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	3027	1354	1513	4133		2936	4349	1354	1513	4305	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	3027	1354	1513	4133		2936	4349	1354	1513	4305	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	128	704	417	234	424	210	388	1259	285	164	924	67
RTOR Reduction (vph)	0	0	32	0	59	0	0	0	64	0	5	0
Lane Group Flow (vph)	128	704	385	234	575	0	388	1259	221	164	986	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	16.8	35.8	60.8	20.5	39.5		25.0	52.9	73.4	19.8	42.7	
Effective Green, g (s)	19.3	38.3	68.3	23.0	42.0		29.0	54.9	78.4	21.8	44.7	
Actuated g/C Ratio	0.13	0.26	0.46	0.15	0.28		0.19	0.37	0.52	0.15	0.30	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	194	772	616	231	1157		567	1591	707	219	1282	
v/s Ratio Prot	0.08	c0.23	0.12	c0.15	0.14		0.13	c0.29	0.05	c0.11	c0.23	
v/s Ratio Perm			0.16						0.12			
v/c Ratio	0.66	0.91	0.62	1.01	0.50		0.68	0.79	0.31	0.75	0.77	
Uniform Delay, d1	62.2	54.2	31.1	63.5	45.2		56.2	42.4	20.4	61.5	48.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.83	0.38	0.18	1.00	1.00	
Incremental Delay, d2	7.9	15.0	2.0	62.6	0.3		2.3	2.8	0.2	13.1	2.8	
Delay (s)	70.1	69.2	33.1	126.1	45.5		105.1	19.0	3.9	74.6	50.8	
Level of Service	E	E	C	F	D		F	B	A	E	D	
Approach Delay (s)		57.2			67.2			34.1			54.2	
Approach LOS		E			E			C			D	

Intersection Summary			
HCM 2000 Control Delay	49.6	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	88.8%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2015 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	61	37	9	404	47	346	18	1386	325	259	1260	39
Future Volume (vph)	61	37	9	404	47	346	18	1386	325	259	1260	39
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.97		1.00	0.90		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	2940		1377	2578		1513	4349	1354	1513	4330	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	2940		1377	2578		1513	4349	1354	1513	4330	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	62	38	9	412	48	353	18	1414	332	264	1286	40
RTOR Reduction (vph)	0	9	0	0	242	0	0	0	132	0	2	0
Lane Group Flow (vph)	62	38	0	284	287	0	18	1414	200	264	1324	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	5.5	5.5		39.5	39.5		3.0	58.0	58.0	27.0	82.0	
Effective Green, g (s)	8.0	8.0		42.0	42.0		4.0	60.0	59.0	28.0	84.0	
Actuated g/C Ratio	0.05	0.05		0.28	0.28		0.03	0.40	0.39	0.19	0.56	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	80	156		385	721		40	1739	532	282	2424	
v/s Ratio Prot	c0.04	0.01		c0.21	0.11		0.01	c0.33		c0.17	0.31	
v/s Ratio Perm									0.15			
v/c Ratio	0.78	0.25		0.74	0.40		0.45	0.81	0.38	0.94	0.55	
Uniform Delay, d1	70.1	68.1		49.0	43.8		71.9	40.0	32.4	60.1	20.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.81	0.67	
Incremental Delay, d2	36.4	0.8		11.9	1.6		7.9	4.3	2.0	30.1	0.6	
Delay (s)	106.5	68.9		60.9	45.4		79.8	44.3	34.4	78.8	14.6	
Level of Service	F	E		E	D		E	D	C	E	B	
Approach Delay (s)		90.3			50.8			42.8			25.2	
Approach LOS		F			D			D			C	

Intersection Summary			
HCM 2000 Control Delay	39.0	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	84.2%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

FEHR PEERS

ATTACHMENT B: 2020 AND 2040 NO BUILD CONDITIONS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Future Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
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
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1700	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	364	0	420	966	23	159	23	160	11	80	11
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	38	607	271	469	1465	35	207	30	210	14	101	14
Arrive On Green	0.02	0.20	0.00	0.31	0.48	0.48	0.15	0.15	0.15	0.08	0.08	0.08
Sat Flow, veh/h	1527	3047	1363	1527	3042	72	1342	194	1363	169	1228	169
Grp Volume(v), veh/h	23	364	0	420	484	505	182	0	160	102	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1527	1524	1591	1537	0	1363	1566	0	0
Q Serve(g_s), s	1.2	9.1	0.0	22.0	20.2	20.2	9.5	0.0	9.4	5.3	0.0	0.0
Cycle Q Clear(g_c), s	1.2	9.1	0.0	22.0	20.2	20.2	9.5	0.0	9.4	5.3	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.05	0.87		1.00	0.11		0.11
Lane Grp Cap(c), veh/h	38	607	271	469	734	766	237	0	210	129	0	0
V/C Ratio(X)	0.61	0.60	0.00	0.90	0.66	0.66	0.77	0.00	0.76	0.79	0.00	0.00
Avail Cap(c_a), veh/h	110	1130	505	1279	1731	1808	625	0	554	440	0	0
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	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	40.4	30.4	0.0	27.7	16.5	16.5	33.9	0.0	33.9	37.6	0.0	0.0
Incr Delay (d2), s/veh	14.7	1.0	0.0	6.3	1.0	1.0	5.2	0.0	5.6	10.1	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.7	3.9	0.0	10.0	8.7	9.0	4.4	0.0	3.9	2.7	0.0	0.0
LnGrp Delay(d),s/veh	55.1	31.4	0.0	33.9	17.5	17.4	39.2	0.0	39.5	47.8	0.0	0.0
LnGrp LOS	E	C		C	B	B	D		D	D		
Approach Vol, veh/h		387			1409			342			102	
Approach Delay, s/veh		32.8			22.4			39.3			47.8	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	8.1	46.3		17.9	31.7	22.6		11.4
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	6.0	95.0		34.0	70.0	31.0		23.5
Max Q Clear Time (g_c+I1), s	3.2	22.2		11.5	24.0	11.1		7.3
Green Ext Time (p_c), s	0.0	6.4		1.4	1.7	5.6		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	27.9
HCM 2010 LOS	C

Intersection	
Int Delay, s/veh	1.2

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	480	40	90	910	40	20
Future Vol, veh/h	480	40	90	910	40	20
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	91	91	91	91	91	91
Heavy Vehicles, %	6	6	6	6	6	6
Mvmt Flow	527	44	99	1000	44	22

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	571	0	1247	286
Stage 1	-	-	-	-	549	-
Stage 2	-	-	-	-	698	-
Critical Hdwy	-	-	4.22	-	6.92	7.02
Critical Hdwy Stg 1	-	-	-	-	5.92	-
Critical Hdwy Stg 2	-	-	-	-	5.92	-
Follow-up Hdwy	-	-	2.26	-	3.56	3.36
Pot Cap-1 Maneuver	-	-	971	-	160	699
Stage 1	-	-	-	-	531	-
Stage 2	-	-	-	-	444	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	971	-	144	699
Mov Cap-2 Maneuver	-	-	-	-	272	-
Stage 1	-	-	-	-	531	-
Stage 2	-	-	-	-	399	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.8	18
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	342	-	-	971	-
HCM Lane V/C Ratio	0.193	-	-	0.102	-
HCM Control Delay (s)	18	-	-	9.1	-
HCM Lane LOS	C	-	-	A	-
HCM 95th %tile Q(veh)	0.7	-	-	0.3	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	50	270	260	250	580	120	270	650	120	110	1040	100
Future Volume (vph)	50	270	260	250	580	120	270	650	120	110	1040	100
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.97		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2913	1303	1456	4078		2825	4185	1303	1456	4130	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2913	1303	1456	4078		2825	4185	1303	1456	4130	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	293	283	272	630	130	293	707	130	120	1130	109
RTOR Reduction (vph)	0	0	66	0	21	0	0	0	42	0	7	0
Lane Group Flow (vph)	54	293	217	272	739	0	293	707	88	120	1232	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	8.0	16.1	37.9	28.0	36.1		21.8	68.0	96.0	16.9	58.1	
Effective Green, g (s)	10.5	18.6	45.4	30.5	38.6		25.8	70.0	101.0	18.9	60.1	
Actuated g/C Ratio	0.07	0.12	0.30	0.20	0.26		0.17	0.47	0.67	0.13	0.40	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	101	361	394	296	1049		485	1953	877	183	1654	
v/s Ratio Prot	0.04	c0.10	0.10	c0.19	0.18		c0.10	0.17	0.02	c0.08	c0.30	
v/s Ratio Perm			0.07						0.05			
v/c Ratio	0.53	0.81	0.55	0.92	0.70		0.60	0.36	0.10	0.66	0.75	
Uniform Delay, d1	67.4	64.0	43.8	58.5	50.5		57.4	25.7	8.6	62.5	38.4	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.89	0.19	0.17	1.00	1.00	
Incremental Delay, d2	5.4	13.0	1.7	31.6	2.2		1.6	0.4	0.0	8.2	1.9	
Delay (s)	72.7	77.0	45.4	90.1	52.7		109.8	5.4	1.5	70.6	40.3	
Level of Service	E	E	D	F	D		F	A	A	E	D	
Approach Delay (s)		62.4			62.6			32.0			43.0	
Approach LOS		E			E			C			D	

Intersection Summary			
HCM 2000 Control Delay	47.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	73.4%	ICU Level of Service	D
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	30	30	10	200	30	110	10	860	410	320	1220	30
Future Volume (vph)	30	30	10	200	30	110	10	860	410	320	1220	30
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.96		1.00	0.93		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2806		1325	2536		1456	4185	1303	1456	4170	
Flt Permitted	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2806		1325	2536		1456	4185	1303	1456	4170	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	34	34	11	225	34	124	11	966	461	360	1371	34
RTOR Reduction (vph)	0	10	0	0	102	0	0	0	268	0	2	0
Lane Group Flow (vph)	34	35	0	133	148	0	11	966	193	360	1403	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	7.1	7.1		23.9	23.9		1.2	46.0	46.0	53.0	97.8	
Effective Green, g (s)	9.6	9.6		26.4	26.4		2.2	48.0	47.0	54.0	99.8	
Actuated g/C Ratio	0.06	0.06		0.18	0.18		0.01	0.32	0.31	0.36	0.67	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	93	179		233	446		21	1339	408	524	2774	
v/s Ratio Prot	c0.02	0.01		c0.10	0.06		0.01	c0.23		c0.25	0.34	
v/s Ratio Perm									0.15			
v/c Ratio	0.37	0.19		0.57	0.33		0.52	0.72	0.47	0.69	0.51	
Uniform Delay, d1	67.3	66.5		56.6	54.1		73.4	45.1	41.5	40.8	12.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.78	0.64	
Incremental Delay, d2	2.4	0.5		9.8	2.0		21.6	3.4	3.9	5.2	0.5	
Delay (s)	69.7	67.1		66.4	56.1		95.0	48.5	45.4	37.1	8.6	
Level of Service	E	E		E	E		F	D	D	D	A	
Approach Delay (s)		68.2			59.7			47.8			14.4	
Approach LOS		E			E			D			B	

Intersection Summary			
HCM 2000 Control Delay	33.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	64.8%	ICU Level of Service	C
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Future Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
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
Adj Sat Flow, veh/h/ln	1667	1635	1667	1667	1636	1700	1700	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	949	0	276	520	20	286	51	255	31	61	10
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	4	2	2	4	4	2	2	2	2	2	2
Cap, veh/h	18	1041	475	303	1570	60	314	56	328	38	75	12
Arrive On Green	0.01	0.34	0.00	0.19	0.51	0.51	0.23	0.23	0.23	0.08	0.08	0.08
Sat Flow, veh/h	1587	3106	1417	1587	3052	117	1357	242	1417	491	965	158
Grp Volume(v), veh/h	10	949	0	276	264	276	337	0	255	102	0	0
Grp Sat Flow(s),veh/h/ln	1587	1553	1417	1587	1554	1615	1599	0	1417	1614	0	0
Q Serve(g_s), s	0.8	38.3	0.0	22.3	13.0	13.1	26.9	0.0	22.1	8.1	0.0	0.0
Cycle Q Clear(g_c), s	0.8	38.3	0.0	22.3	13.0	13.1	26.9	0.0	22.1	8.1	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.07	0.85		1.00	0.30		0.10
Lane Grp Cap(c), veh/h	18	1041	475	303	799	831	370	0	328	126	0	0
V/C Ratio(X)	0.54	0.91	0.00	0.91	0.33	0.33	0.91	0.00	0.78	0.81	0.00	0.00
Avail Cap(c_a), veh/h	413	1282	585	413	799	831	428	0	379	438	0	0
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	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	64.3	41.6	0.0	51.8	18.6	18.6	49.0	0.0	47.1	59.3	0.0	0.0
Incr Delay (d2), s/veh	22.4	8.7	0.0	19.7	0.2	0.2	21.5	0.0	8.6	11.5	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.5	17.6	0.0	11.4	5.6	5.9	14.1	0.0	9.4	4.0	0.0	0.0
LnGrp Delay(d),s/veh	86.7	50.3	0.0	71.5	18.8	18.8	70.5	0.0	55.7	70.8	0.0	0.0
LnGrp LOS	F	D		E	B	B	E		E	E		
Approach Vol, veh/h		959			816			592			102	
Approach Delay, s/veh		50.7			36.6			64.1			70.8	
Approach LOS		D			D			E			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.5	73.3		35.3	31.0	49.9		14.7
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	34.0	54.0		35.0	34.0	54.0		35.5
Max Q Clear Time (g_c+I1), s	2.8	15.1		28.9	24.3	40.3		10.1
Green Ext Time (p_c), s	0.0	7.6		1.4	0.7	3.6		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	50.1
HCM 2010 LOS	D

Intersection	
Int Delay, s/veh	2.3

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	1130	50	40	790	50	90
Future Vol, veh/h	1130	50	40	790	50	90
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	93	93	93	93	93	93
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	1215	54	43	849	54	97

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	1269	0	1753	634
Stage 1	-	-	-	-	1242	-
Stage 2	-	-	-	-	511	-
Critical Hdwy	-	-	4.14	-	6.84	6.94
Critical Hdwy Stg 1	-	-	-	-	5.84	-
Critical Hdwy Stg 2	-	-	-	-	5.84	-
Follow-up Hdwy	-	-	2.22	-	3.52	3.32
Pot Cap-1 Maneuver	-	-	543	-	76	422
Stage 1	-	-	-	-	236	-
Stage 2	-	-	-	-	567	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	543	-	70	422
Mov Cap-2 Maneuver	-	-	-	-	175	-
Stage 1	-	-	-	-	236	-
Stage 2	-	-	-	-	522	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.6	31.7
HCM LOS			D

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	281	-	-	543	-
HCM Lane V/C Ratio	0.536	-	-	0.079	-
HCM Control Delay (s)	31.7	-	-	12.2	-
HCM Lane LOS	D	-	-	B	-
HCM 95th %tile Q(veh)	2.9	-	-	0.3	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	130	700	410	240	420	210	380	1230	300	160	910	70
Future Volume (vph)	130	700	410	240	420	210	380	1230	300	160	910	70
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	3027	1354	1513	4132		2936	4349	1354	1513	4303	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	3027	1354	1513	4132		2936	4349	1354	1513	4303	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	133	714	418	245	429	214	388	1255	306	163	929	71
RTOR Reduction (vph)	0	0	30	0	59	0	0	0	65	0	5	0
Lane Group Flow (vph)	133	714	388	245	584	0	388	1255	241	163	995	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	17.0	35.9	61.0	20.5	39.4		25.1	52.8	73.3	19.8	42.5	
Effective Green, g (s)	19.5	38.4	68.5	23.0	41.9		29.1	54.8	78.3	21.8	44.5	
Actuated g/C Ratio	0.13	0.26	0.46	0.15	0.28		0.19	0.37	0.52	0.15	0.30	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	196	774	618	231	1154		569	1588	706	219	1276	
v/s Ratio Prot	0.09	c0.24	0.13	c0.16	0.14		0.13	c0.29	0.05	c0.11	c0.23	
v/s Ratio Perm			0.16						0.13			
v/c Ratio	0.68	0.92	0.63	1.06	0.51		0.68	0.79	0.34	0.74	0.78	
Uniform Delay, d1	62.3	54.4	31.0	63.5	45.4		56.2	42.5	20.9	61.4	48.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.82	0.39	0.21	1.00	1.00	
Incremental Delay, d2	9.0	16.4	2.0	76.1	0.4		2.3	2.8	0.2	12.8	3.1	
Delay (s)	71.2	70.8	33.0	139.6	45.7		104.7	19.2	4.6	74.3	51.4	
Level of Service	E	E	C	F	D		F	B	A	E	D	
Approach Delay (s)		58.3			71.6			33.9			54.6	
Approach LOS		E			E			C			D	

Intersection Summary			
HCM 2000 Control Delay	50.7	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	89.7%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2015 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	70	40	10	400	50	350	20	1390	330	260	1260	40
Future Volume (vph)	70	40	10	400	50	350	20	1390	330	260	1260	40
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.97		1.00	0.90		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	2938		1377	2577		1513	4349	1354	1513	4329	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	2938		1377	2577		1513	4349	1354	1513	4329	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	71	41	10	408	51	357	20	1418	337	265	1286	41
RTOR Reduction (vph)	0	9	0	0	251	0	0	0	134	0	2	0
Lane Group Flow (vph)	71	42	0	286	279	0	20	1418	203	265	1325	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	5.5	5.5		39.5	39.5		3.0	58.0	58.0	27.0	82.0	
Effective Green, g (s)	8.0	8.0		42.0	42.0		4.0	60.0	59.0	28.0	84.0	
Actuated g/C Ratio	0.05	0.05		0.28	0.28		0.03	0.40	0.39	0.19	0.56	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	80	156		385	721		40	1739	532	282	2424	
v/s Ratio Prot	c0.05	0.01		c0.21	0.11		0.01	c0.33		c0.18	0.31	
v/s Ratio Perm									0.15			
v/c Ratio	0.89	0.27		0.74	0.39		0.50	0.82	0.38	0.94	0.55	
Uniform Delay, d1	70.6	68.2		49.1	43.6		72.0	40.1	32.5	60.2	20.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.81	0.68	
Incremental Delay, d2	63.6	0.9		12.2	1.6		9.5	4.3	2.1	29.8	0.6	
Delay (s)	134.1	69.1		61.3	45.2		81.5	44.4	34.5	78.8	14.8	
Level of Service	F	E		E	D		F	D	C	E	B	
Approach Delay (s)		106.9			50.8			43.0			25.4	
Approach LOS		F			D			D			C	

Intersection Summary			
HCM 2000 Control Delay	39.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	85.0%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Future Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
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
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1604	1604	1700
Adj Flow Rate, veh/h	23	523	0	432	1034	23	227	34	136	23	80	11
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	1	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	40	802	508	570	1310	29	325	328	541	40	137	19
Arrive On Green	0.03	0.26	0.00	0.19	0.43	0.43	0.11	0.20	0.20	0.03	0.10	0.10
Sat Flow, veh/h	1527	3047	1363	2963	3048	68	2963	1604	1363	1527	1380	190
Grp Volume(v), veh/h	23	523	0	432	517	540	227	34	136	23	0	91
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1482	1524	1592	1482	1604	1363	1527	0	1570
Q Serve(g_s), s	1.0	10.5	0.0	9.4	20.1	20.1	5.1	1.2	4.6	1.0	0.0	3.8
Cycle Q Clear(g_c), s	1.0	10.5	0.0	9.4	20.1	20.1	5.1	1.2	4.6	1.0	0.0	3.8
Prop In Lane	1.00		1.00	1.00		0.04	1.00		1.00	1.00		0.12
Lane Grp Cap(c), veh/h	40	802	508	570	655	684	325	328	541	40	0	156
V/C Ratio(X)	0.58	0.65	0.00	0.76	0.79	0.79	0.70	0.10	0.25	0.58	0.00	0.58
Avail Cap(c_a), veh/h	111	1023	607	1298	1079	1127	779	550	730	513	0	596
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	33.0	22.5	0.0	26.1	16.9	16.9	29.4	22.1	13.8	33.0	0.0	29.5
Incr Delay (d2), s/veh	12.8	1.0	0.0	2.1	2.2	2.1	2.7	0.1	0.2	12.8	0.0	3.5
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	0.6	4.5	0.0	4.0	8.7	9.1	2.2	0.5	1.7	0.6	0.0	1.8
LnGrp Delay(d),s/veh	45.8	23.4	0.0	28.2	19.0	18.9	32.1	22.3	14.1	45.8	0.0	33.0
LnGrp LOS	D	C		C	B	B	C	C	B	D		C
Approach Vol, veh/h		546			1489			397			114	
Approach Delay, s/veh		24.4			21.7			25.1			35.6	
Approach LOS		C			C			C			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	6.3	20.0	19.2	23.0	13.5	12.8	7.8	34.4
Change Period (Y+Rc), s	4.5	* 6	6.0	5.0	6.0	6.0	6.0	* 5
Max Green Setting (Gmax), s	23.0	* 24	30.0	23.0	18.0	26.0	5.0	* 49
Max Q Clear Time (g_c+I1), s	3.0	6.6	11.4	12.5	7.1	5.8	3.0	22.1
Green Ext Time (p_c), s	0.0	0.9	1.7	5.0	0.5	1.0	0.0	7.4

Intersection Summary	
HCM 2010 Ctrl Delay	23.4
HCM 2010 LOS	C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

Intersection						
Int Delay, s/veh	1.5					

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	660	50	100	1030	50	30
Future Vol, veh/h	660	50	100	1030	50	30
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	91	91	91	91	91	91
Heavy Vehicles, %	6	6	6	6	6	6
Mvmt Flow	725	55	110	1132	55	33

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	780	0	1539	390
Stage 1	-	-	-	-	753	-
Stage 2	-	-	-	-	786	-
Critical Hdwy	-	-	4.22	-	6.92	7.02
Critical Hdwy Stg 1	-	-	-	-	5.92	-
Critical Hdwy Stg 2	-	-	-	-	5.92	-
Follow-up Hdwy	-	-	2.26	-	3.56	3.36
Pot Cap-1 Maneuver	-	-	807	-	102	597
Stage 1	-	-	-	-	416	-
Stage 2	-	-	-	-	399	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	807	-	88	597
Mov Cap-2 Maneuver	-	-	-	-	212	-
Stage 1	-	-	-	-	416	-
Stage 2	-	-	-	-	345	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.9	23.6
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	280	-	-	807	-
HCM Lane V/C Ratio	0.314	-	-	0.136	-
HCM Control Delay (s)	23.6	-	-	10.2	-
HCM Lane LOS	C	-	-	B	-
HCM 95th %tile Q(veh)	1.3	-	-	0.5	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	50	310	280	280	650	140	310	650	250	130	1050	110
Future Volume (vph)	50	310	280	280	650	140	310	650	250	130	1050	110
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.97		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2913	1303	2825	2835		2825	4185	1303	1456	4125	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2913	1303	2825	2835		2825	4185	1303	1456	4125	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	337	304	304	707	152	337	707	272	141	1141	120
RTOR Reduction (vph)	0	0	56	0	12	0	0	0	102	0	8	0
Lane Group Flow (vph)	54	337	248	304	847	0	337	707	170	141	1253	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	8.2	31.5	53.3	20.4	43.7		21.8	58.3	78.7	18.8	50.3	
Effective Green, g (s)	10.7	34.0	60.8	22.9	46.2		25.8	60.3	83.7	20.8	52.3	
Actuated g/C Ratio	0.07	0.23	0.41	0.15	0.31		0.17	0.40	0.56	0.14	0.35	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	103	660	528	431	873		485	1682	727	201	1438	
v/s Ratio Prot	0.04	0.12	0.08	c0.11	c0.30		c0.12	0.17	0.04	c0.10	c0.30	
v/s Ratio Perm			0.11						0.09			
v/c Ratio	0.52	0.51	0.47	0.71	0.97		0.69	0.42	0.23	0.70	0.87	
Uniform Delay, d1	67.2	50.7	32.7	60.3	51.2		58.4	32.3	16.9	61.6	45.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.56	0.46	1.17	1.00	1.00	
Incremental Delay, d2	4.7	0.7	0.7	5.2	23.4		3.2	0.6	0.1	10.5	6.1	
Delay (s)	71.9	51.4	33.4	65.5	74.6		94.4	15.3	19.9	72.2	51.8	
Level of Service	E	D	C	E	E		F	B	B	E	D	
Approach Delay (s)		45.1			72.2			36.5			53.8	
Approach LOS		D			E			D			D	

Intersection Summary			
HCM 2000 Control Delay	52.2	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	84.8%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	40	40	10	220	30	110	10	860	440	370	1230	30
Future Volume (vph)	40	40	10	220	30	110	10	860	440	370	1230	30
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.97		1.00	0.93		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2827		1325	2544		1456	4185	1303	1456	4170	
Flt Permitted	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2827		1325	2544		1456	4185	1303	1456	4170	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	45	45	11	247	34	124	11	966	494	416	1382	34
RTOR Reduction (vph)	0	10	0	0	102	0	0	0	288	0	2	0
Lane Group Flow (vph)	45	46	0	138	165	0	11	966	206	416	1414	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	7.2	7.2		23.8	23.8		1.2	40.0	40.0	59.0	97.8	
Effective Green, g (s)	9.7	9.7		26.3	26.3		2.2	42.0	41.0	60.0	99.8	
Actuated g/C Ratio	0.06	0.06		0.18	0.18		0.01	0.28	0.27	0.40	0.67	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	94	182		232	446		21	1171	356	582	2774	
v/s Ratio Prot	c0.03	0.02		c0.10	0.06		0.01	c0.23		c0.29	0.34	
v/s Ratio Perm									0.16			
v/c Ratio	0.48	0.25		0.59	0.37		0.52	0.82	0.58	0.71	0.51	
Uniform Delay, d1	67.7	66.7		56.9	54.5		73.4	50.6	47.1	37.8	12.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.69	0.80	
Incremental Delay, d2	3.8	0.7		10.8	2.3		21.6	6.7	6.7	5.1	0.5	
Delay (s)	71.5	67.4		67.7	56.9		95.0	57.2	53.8	31.1	10.6	
Level of Service	E	E		E	E		F	E	D	C	B	
Approach Delay (s)		69.2			60.6			56.4			15.2	
Approach LOS		E			E			E			B	

Intersection Summary			
HCM 2000 Control Delay	37.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.2%	ICU Level of Service	C
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Future Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
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
Adj Sat Flow, veh/h/ln	1667	1667	1667	1667	1667	1700	1667	1667	1667	1667	1667	1700
Adj Flow Rate, veh/h	10	1071	0	296	633	31	337	61	214	41	71	10
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	1	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	20	1304	779	388	1615	79	425	275	412	57	90	13
Arrive On Green	0.01	0.41	0.00	0.13	0.53	0.53	0.14	0.17	0.17	0.04	0.06	0.06
Sat Flow, veh/h	1587	3167	1417	3079	3073	150	3079	1667	1417	1587	1430	201
Grp Volume(v), veh/h	10	1071	0	296	326	338	337	61	214	41	0	81
Grp Sat Flow(s),veh/h/ln	1587	1583	1417	1540	1583	1640	1540	1667	1417	1587	0	1631
Q Serve(g_s), s	0.6	26.5	0.0	8.2	10.8	10.9	9.3	2.8	11.1	2.3	0.0	4.3
Cycle Q Clear(g_c), s	0.6	26.5	0.0	8.2	10.8	10.9	9.3	2.8	11.1	2.3	0.0	4.3
Prop In Lane	1.00		1.00	1.00		0.09	1.00		1.00	1.00		0.12
Lane Grp Cap(c), veh/h	20	1304	779	388	832	862	425	275	412	57	0	103
V/C Ratio(X)	0.51	0.82	0.00	0.76	0.39	0.39	0.79	0.22	0.52	0.72	0.00	0.79
Avail Cap(c_a), veh/h	90	1725	967	769	1150	1192	734	435	549	90	0	130
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	43.2	23.0	0.0	37.2	12.5	12.5	36.7	31.9	26.1	42.0	0.0	40.7
Incr Delay (d2), s/veh	19.1	2.5	0.0	3.1	0.3	0.3	3.4	0.4	1.0	15.5	0.0	22.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.3	11.9	0.0	3.7	4.8	5.0	4.2	1.3	4.4	1.2	0.0	2.6
LnGrp Delay(d),s/veh	62.4	25.5	0.0	40.3	12.8	12.8	40.1	32.3	27.1	57.5	0.0	62.7
LnGrp LOS	E	C		D	B	B	D	C	C	E		E
Approach Vol, veh/h		1081			960			612			122	
Approach Delay, s/veh		25.9			21.3			34.8			60.9	
Approach LOS		C			C			C			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	9.2	19.5	17.1	42.3	18.2	10.5	7.1	52.3
Change Period (Y+Rc), s	6.0	5.0	6.0	* 6	6.0	5.0	6.0	6.0
Max Green Setting (Gmax), s	5.0	23.0	22.0	* 48	21.0	7.0	5.0	64.0
Max Q Clear Time (g_c+I1), s	4.3	13.1	10.2	28.5	11.3	6.3	2.6	12.9
Green Ext Time (p_c), s	0.0	1.1	0.9	7.8	0.8	0.1	0.0	9.8

Intersection Summary		
HCM 2010 Ctrl Delay		27.8
HCM 2010 LOS		C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

Intersection	
Int Delay, s/veh	4.8

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	1340	60	40	930	60	110
Future Vol, veh/h	1340	60	40	930	60	110
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	93	93	93	93	93	93
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	1441	65	43	1000	65	118

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	1505	0	2059	753
Stage 1	-	-	-	-	1473	-
Stage 2	-	-	-	-	586	-
Critical Hdwy	-	-	4.14	-	6.84	6.94
Critical Hdwy Stg 1	-	-	-	-	5.84	-
Critical Hdwy Stg 2	-	-	-	-	5.84	-
Follow-up Hdwy	-	-	2.22	-	3.52	3.32
Pot Cap-1 Maneuver	-	-	441	-	~ 48	352
Stage 1	-	-	-	-	177	-
Stage 2	-	-	-	-	519	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	441	-	~ 43	352
Mov Cap-2 Maneuver	-	-	-	-	132	-
Stage 1	-	-	-	-	177	-
Stage 2	-	-	-	-	468	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.6	68.6
HCM LOS			F

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	222	-	-	441	-
HCM Lane V/C Ratio	0.823	-	-	0.098	-
HCM Control Delay (s)	68.6	-	-	14	-
HCM Lane LOS	F	-	-	B	-
HCM 95th %tile Q(veh)	6.2	-	-	0.3	-

Notes			
~: Volume exceeds capacity	$: Delay exceeds 300s	+: Computation Not Defined	*: All major volume in platoon

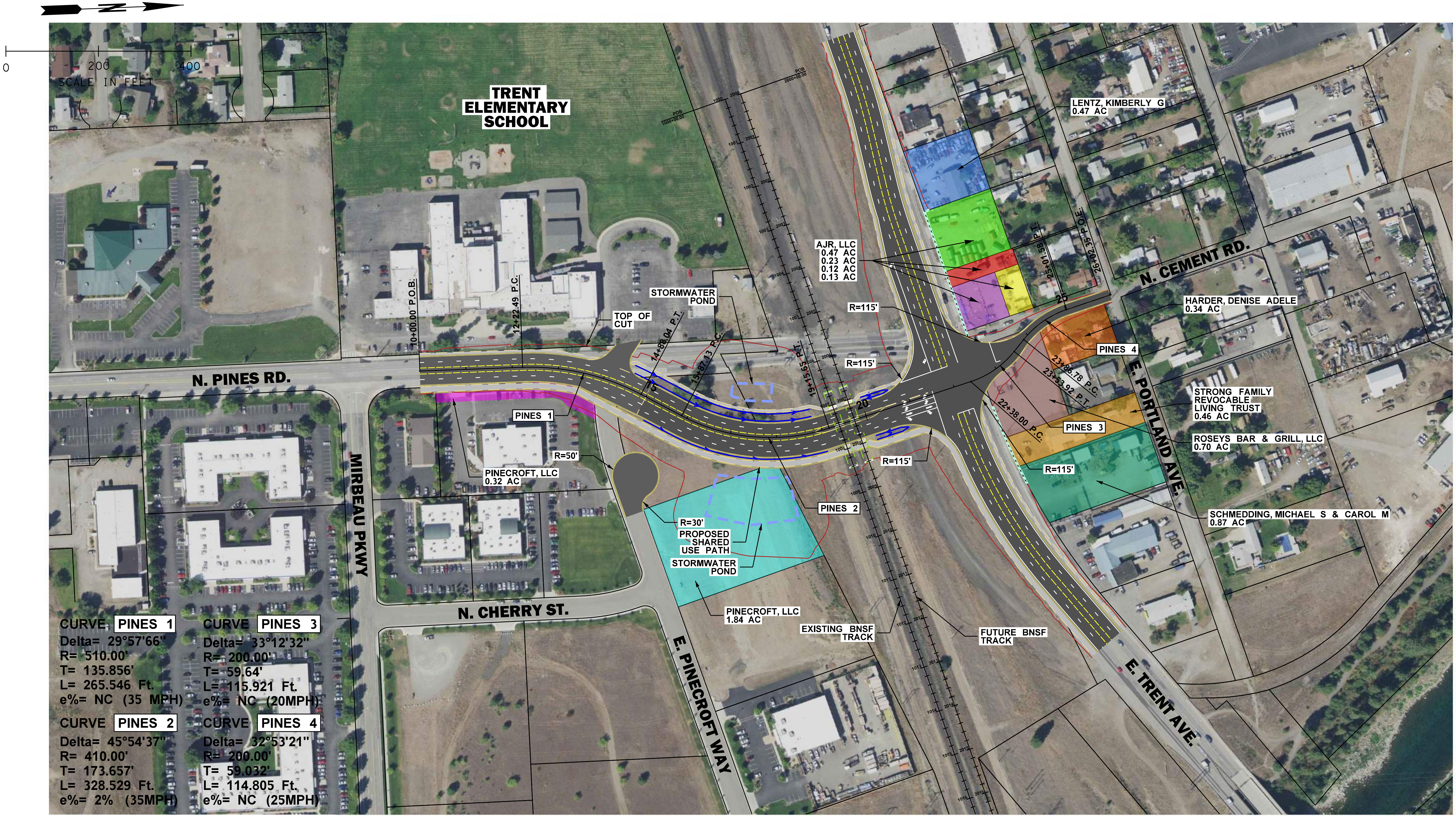
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	130	740	430	300	450	230	410	1240	430	180	910	70
Future Volume (vph)	130	740	430	300	450	230	410	1240	430	180	910	70
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	3027	1354	2936	2873		2936	4349	1354	1513	4303	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	3027	1354	2936	2873		2936	4349	1354	1513	4303	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	133	755	439	306	459	235	418	1265	439	184	929	71
RTOR Reduction (vph)	0	0	27	0	42	0	0	0	68	0	5	0
Lane Group Flow (vph)	133	755	412	306	652	0	418	1265	371	184	995	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	17.6	40.5	67.6	11.5	34.4		27.1	55.6	67.1	21.4	44.9	
Effective Green, g (s)	20.1	43.0	75.1	14.0	36.9		31.1	57.6	72.1	23.4	46.9	
Actuated g/C Ratio	0.13	0.29	0.50	0.09	0.25		0.21	0.38	0.48	0.16	0.31	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	202	867	677	274	706		608	1670	650	236	1345	
v/s Ratio Prot	c0.09	c0.25	0.13	c0.10	0.23		0.14	c0.29	0.05	c0.12	0.23	
v/s Ratio Perm			0.17						0.22			
v/c Ratio	0.66	0.87	0.61	1.12	0.92		0.69	0.76	0.57	0.78	0.74	
Uniform Delay, d1	61.7	50.9	26.9	68.0	55.2		55.0	40.1	27.9	60.8	46.1	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.59	0.40	0.27	1.00	1.00	
Incremental Delay, d2	7.5	9.5	1.6	89.5	17.7		2.4	2.4	0.9	15.0	2.2	
Delay (s)	69.2	60.4	28.4	157.5	72.8		89.6	18.6	8.3	75.8	48.3	
Level of Service	E	E	C	F	E		F	B	A	E	D	
Approach Delay (s)		50.7			98.7			30.5			52.5	
Approach LOS		D			F			C			D	

Intersection Summary			
HCM 2000 Control Delay	52.0	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	86.9%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	70	50	10	410	60	370	20	1390	340	280	1270	50
Future Volume (vph)	70	50	10	410	60	370	20	1390	340	280	1270	50
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.98		1.00	0.90		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	2953		1377	2577		1513	4349	1354	1513	4325	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	2953		1377	2577		1513	4349	1354	1513	4325	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	71	51	10	418	61	378	20	1418	347	286	1296	51
RTOR Reduction (vph)	0	9	0	0	251	0	0	0	138	0	3	0
Lane Group Flow (vph)	71	52	0	301	305	0	20	1418	209	286	1344	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	5.5	5.5		39.5	39.5		3.0	58.0	58.0	27.0	82.0	
Effective Green, g (s)	8.0	8.0		42.0	42.0		4.0	60.0	59.0	28.0	84.0	
Actuated g/C Ratio	0.05	0.05		0.28	0.28		0.03	0.40	0.39	0.19	0.56	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	80	157		385	721		40	1739	532	282	2422	
v/s Ratio Prot	c0.05	0.02		c0.22	0.12		0.01	c0.33		c0.19	0.31	
v/s Ratio Perm									0.15			
v/c Ratio	0.89	0.33		0.78	0.42		0.50	0.82	0.39	1.01	0.56	
Uniform Delay, d1	70.6	68.4		49.8	44.1		72.0	40.1	32.7	61.0	21.1	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.91	0.87	
Incremental Delay, d2	63.6	1.2		14.6	1.8		9.5	4.3	2.2	46.2	0.6	
Delay (s)	134.1	69.6		64.4	45.9		81.5	44.4	34.8	101.7	18.9	
Level of Service	F	E		E	D		F	D	C	F	B	
Approach Delay (s)		104.3			52.4			43.0			33.4	
Approach LOS		F			D			D			C	

Intersection Summary			
HCM 2000 Control Delay	43.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.85		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	87.3%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2040 forecast			
c Critical Lane Group			

ATTACHMENT C: CONCEPTUAL DESIGNS



CURVE PINES 1	CURVE PINES 3
Delta= 29°57'66"	Delta= 33°12'32"
R= 510.00'	R= 200.00'
T= 135.856'	T= 59.64'
L= 265.546 Ft.	L= 115.921 Ft.
e%= NC (35 MPH)	e%= NC (20MPH)

CURVE PINES 2	CURVE PINES 4
Delta= 45°54'37"	Delta= 32°53'21"
R= 410.00'	R= 200.00'
T= 173.657'	T= 59.032'
L= 328.529 Ft.	L= 114.805 Ft.
e%= 2% (35MPH)	e%= NC (25MPH)

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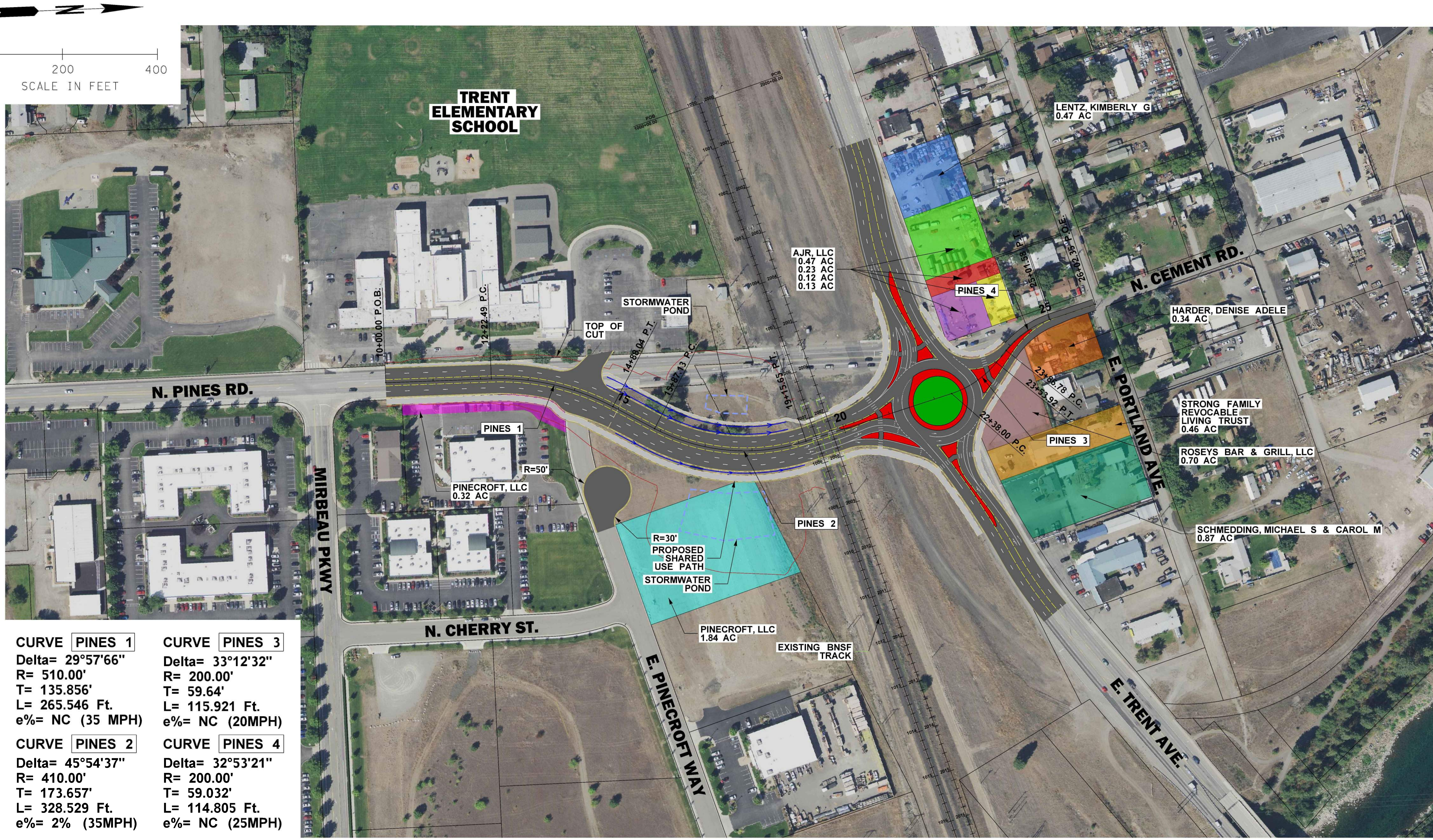
City of Spokane Valley

PINES & TRENT ALTERNATIVE 1

DAVID EVANS AND ASSOCIATES INC.

HDR



CURVE PINES 1	CURVE PINES 3
Delta= 29°57'66"	Delta= 33°12'32"
R= 510.00'	R= 200.00'
T= 135.856'	T= 59.64'
L= 265.546 Ft.	L= 115.921 Ft.
e%= NC (35 MPH)	e%= NC (20MPH)

CURVE PINES 2	CURVE PINES 4
Delta= 45°54'37"	Delta= 32°53'21"
R= 410.00'	R= 200.00'
T= 173.657'	T= 59.032'
L= 328.529 Ft.	L= 114.805 Ft.
e%= 2% (35MPH)	e%= NC (25MPH)

City of Spokane Valley

PINES & TRENT ALTERNATIVE 1 - ROUNDABOUT

DAVID EVANS AND ASSOCIATES INC.

HDR

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CURVE PINES 1
Delta= 26°55'55"
R= 510.00'
T= 122.12'
L= 239.73 Ft.
e%= NC (35 MPH)

CURVE PINES 2
Delta= 13°35'13"
R= 510.00'
T= 60.75'
L= 120.94 Ft.
e%= NC (35MPH)

CURVE PINES 3
Delta= 60°24'24"
R= 250.00'
T= 145.52'
L= 263.57 Ft.
e%= 4.0% (30MPH)

CURVE PINES 4
Delta= 108°48'07"
R= 110.00'
T= 153.65'
L= 208.88 Ft.
e%= NC (20MPH)

CURVE PINES 5
Delta= 70°58'40"
R= 200.00'
T= 142.60'
L= 247.76 Ft.
e%= NC (25MPH)

c:\pwworking\west01\d0536309\002_ALT 2_Plan.dgn
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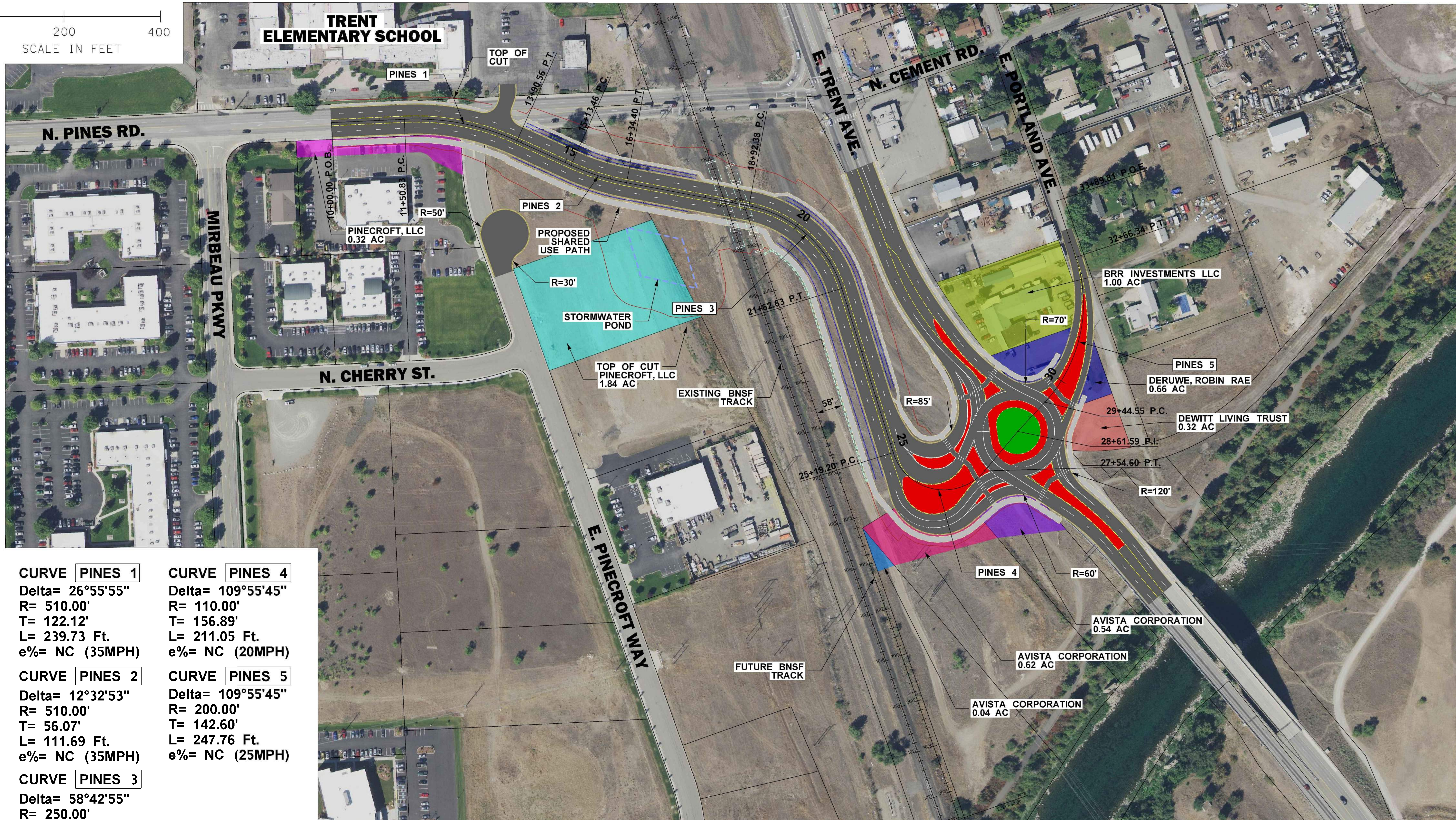
City of Spokane Valley

PINES & TRENT ALTERNATIVE 2

DAVID EVANS AND ASSOCIATES INC.

HDR



CURVE PINES 1
Delta= 26°55'55"
R= 510.00'
T= 122.12'
L= 239.73 Ft.
e%= NC (35MPH)

CURVE PINES 2
Delta= 12°32'53"
R= 510.00'
T= 56.07'
L= 111.69 Ft.
e%= NC (35MPH)

CURVE PINES 3
Delta= 58°42'55"
R= 250.00'
T= 140.60'
L= 256.16 Ft.
e%= 4.0% (30MPH)

CURVE PINES 4
Delta= 109°55'45"
R= 110.00'
T= 156.89'
L= 211.05 Ft.
e%= NC (20MPH)

CURVE PINES 5
Delta= 109°55'45"
R= 200.00'
T= 142.60'
L= 247.76 Ft.
e%= NC (25MPH)

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City of Spokane Valley

PINES & TRENT ALTERNATIVE 2 - ROUNDABOUT

DAVID EVANS AND ASSOCIATES INC.

HDR

FEHR PEERS

ATTACHMENT D: 2020 AND 2040 ALTERNATIVES ANALYSIS

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	23	364	205	420	989	159	23	330	102
v/c Ratio	0.26	0.64	0.49	0.79	0.61	0.44	0.12	0.72	0.51
Control Delay	68.0	48.6	10.6	45.0	20.4	52.4	51.7	15.7	58.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	68.0	48.6	10.6	45.0	20.4	52.4	51.7	15.7	58.0
Queue Length 50th (ft)	15	115	0	241	248	50	14	0	61
Queue Length 95th (ft)	57	233	68	485	406	113	50	91	156
Internal Link Dist (ft)		5246			2649		2504		831
Turn Bay Length (ft)	220		260	285		150		1000	
Base Capacity (vph)	91	947	564	1070	2635	1008	547	682	372
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.25	0.38	0.36	0.39	0.38	0.16	0.04	0.48	0.27

Intersection Summary
Description: 2017 counts

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Future Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
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
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	364	0	420	966	23	159	23	160	11	80	11
Adj No. of Lanes	1	2	1	1	2	0	2	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	38	608	272	469	1466	35	451	244	208	14	101	14
Arrive On Green	0.02	0.20	0.00	0.31	0.48	0.48	0.15	0.15	0.15	0.08	0.08	0.08
Sat Flow, veh/h	1527	3047	1363	1527	3042	72	2963	1604	1363	169	1228	169
Grp Volume(v), veh/h	23	364	0	420	484	505	159	23	160	102	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1527	1524	1591	1482	1604	1363	1566	0	0
Q Serve(g_s), s	1.2	9.0	0.0	21.9	20.1	20.1	4.0	1.0	9.4	5.3	0.0	0.0
Cycle Q Clear(g_c), s	1.2	9.0	0.0	21.9	20.1	20.1	4.0	1.0	9.4	5.3	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.05	1.00		1.00	0.11		0.11
Lane Grp Cap(c), veh/h	38	608	272	469	734	767	451	244	208	129	0	0
V/C Ratio(X)	0.61	0.60	0.00	0.89	0.66	0.66	0.35	0.09	0.77	0.79	0.00	0.00
Avail Cap(c_a), veh/h	110	1135	508	1284	1739	1816	1210	655	557	442	0	0
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	40.2	30.3	0.0	27.5	16.4	16.4	31.6	30.3	33.9	37.5	0.0	0.0
Incr Delay (d2), s/veh	14.7	0.9	0.0	6.2	1.0	1.0	0.5	0.2	6.0	10.1	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.7	3.9	0.0	10.0	8.5	8.9	1.7	0.5	3.9	2.7	0.0	0.0
LnGrp Delay(d),s/veh	54.9	31.2	0.0	33.8	17.4	17.3	32.1	30.5	39.8	47.6	0.0	0.0
LnGrp LOS	D	C		C	B	B	C	C	D	D		
Approach Vol, veh/h		387			1409			342			102	
Approach Delay, s/veh		32.6			22.3			35.6			47.6	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	8.1	46.1		17.7	31.6	22.6		11.4
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	6.0	95.0		34.0	70.0	31.0		23.5
Max Q Clear Time (g_c+I1), s	3.2	22.1		11.4	23.9	11.0		7.3
Green Ext Time (p_c), s	0.0	6.4		1.3	1.7	5.6		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	27.2
HCM 2010 LOS	C

MOVEMENT SUMMARY

Site: Pines / Trent AM - Alt1a

Pines / Trent
2020 AM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	152	3.0	0.072	9.0	LOS A	0.3	7.5	0.39	0.65	33.7
8	T1	22	3.0	0.072	4.5	LOS A	0.3	7.5	0.38	0.63	27.2
18	R2	315	3.0	0.238	4.7	LOS A	1.1	28.4	0.42	0.59	35.0
Approach		489	3.0	0.238	6.1	LOS A	1.1	28.4	0.41	0.61	34.1
East: Trent Ave											
1	L2	420	3.0	0.596	11.9	LOS B	4.0	101.4	0.50	0.69	34.9
6	T1	966	3.0	0.596	7.5	LOS A	4.0	102.0	0.49	0.63	39.6
16	R2	23	3.0	0.596	7.2	LOS A	4.0	102.0	0.49	0.61	29.8
Approach		1409	3.0	0.596	8.8	LOS A	4.0	102.0	0.49	0.65	37.9
North: Cement Rd											
7	L2	11	3.0	0.187	10.2	LOS B	0.8	19.4	0.71	0.78	29.1
4	T1	76	3.0	0.187	6.1	LOS A	0.8	19.4	0.71	0.78	27.0
14	R2	11	3.0	0.187	6.5	LOS A	0.8	19.4	0.71	0.78	28.7
Approach		98	3.0	0.187	6.6	LOS A	0.8	19.4	0.71	0.78	27.4
West: Trent Ave											
5	L2	22	3.0	0.184	13.4	LOS B	1.1	27.1	0.62	0.71	30.5
2	T1	348	3.0	0.184	8.8	LOS A	1.1	28.9	0.61	0.69	39.3
12	R2	196	3.0	0.120	5.7	LOS A	0.0	0.0	0.00	0.58	41.4
Approach		565	3.0	0.184	7.9	LOS A	1.1	28.9	0.40	0.65	39.6
All Vehicles		2561	3.0	0.596	8.0	LOS A	4.0	102.0	0.46	0.65	36.9

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Organisation: FEHR AND PEERS | Processed: Thursday, March 01, 2018 3:40:37 PM
Project: \\FPSE03\Data2\2017Projects\SE17-0556_PinesRd-BNSF_Grade_Separation\Analysis\Trent_Roundabouts\Trent_2020_updatedModel.sip6

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	23	364	205	420	989	159	23	330	102
v/c Ratio	0.21	0.54	0.44	0.61	0.67	0.39	0.11	0.70	0.46
Control Delay	51.6	33.7	8.0	35.6	21.3	40.3	39.6	13.7	44.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	51.6	33.7	8.0	35.6	21.3	40.3	39.6	13.7	44.7
Queue Length 50th (ft)	11	87	0	94	171	38	10	0	46
Queue Length 95th (ft)	46	168	54	199	383	89	40	82	125
Internal Link Dist (ft)		5246			2649		2504		831
Turn Bay Length (ft)	220		260	175		150		150	
Base Capacity (vph)	113	1179	653	2472	2898	1247	677	766	460
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.20	0.31	0.31	0.17	0.34	0.13	0.03	0.43	0.22

Intersection Summary
Description: 2017 counts

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Future Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
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
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	364	0	420	966	23	159	23	160	11	80	11
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	40	724	324	571	1229	29	478	259	220	14	102	14
Arrive On Green	0.03	0.24	0.00	0.19	0.40	0.40	0.16	0.16	0.16	0.08	0.08	0.08
Sat Flow, veh/h	1527	3047	1363	2963	3042	72	2963	1604	1363	169	1228	169
Grp Volume(v), veh/h	23	364	0	420	484	505	159	23	160	102	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1482	1524	1591	1482	1604	1363	1566	0	0
Q Serve(g_s), s	1.0	6.8	0.0	8.8	18.3	18.3	3.1	0.8	7.4	4.2	0.0	0.0
Cycle Q Clear(g_c), s	1.0	6.8	0.0	8.8	18.3	18.3	3.1	0.8	7.4	4.2	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.05	1.00		1.00	0.11		0.11
Lane Grp Cap(c), veh/h	40	724	324	571	616	643	478	259	220	130	0	0
V/C Ratio(X)	0.58	0.50	0.00	0.74	0.79	0.79	0.33	0.09	0.73	0.78	0.00	0.00
Avail Cap(c_a), veh/h	139	1429	639	3137	2189	2286	1524	825	701	556	0	0
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	31.8	21.8	0.0	25.1	17.2	17.2	24.6	23.6	26.3	29.7	0.0	0.0
Incr Delay (d2), s/veh	12.6	0.5	0.0	1.9	2.3	2.2	0.4	0.1	4.5	9.7	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.6	2.9	0.0	3.8	8.0	8.4	1.3	0.4	3.1	2.2	0.0	0.0
LnGrp Delay(d),s/veh	44.4	22.4	0.0	27.0	19.5	19.4	25.0	23.7	30.9	39.4	0.0	0.0
LnGrp LOS	D	C		C	B	B	C	C	C	D		
Approach Vol, veh/h		387			1409			342			102	
Approach Delay, s/veh		23.7			21.7			27.7			39.4	
Approach LOS		C			C			C			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.7	32.7		15.7	18.7	21.7		10.0
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	6.0	95.0		34.0	70.0	31.0		23.5
Max Q Clear Time (g_c+I1), s	3.0	20.3		9.4	10.8	8.8		6.2
Green Ext Time (p_c), s	0.0	6.4		1.3	1.9	5.7		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	23.7
HCM 2010 LOS	C

MOVEMENT SUMMARY

Site: Pines / Trent - Alt2a

Pines / Trent
2020 AM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	152	3.0	0.072	1.9	LOS A	0.3	7.5	0.39	0.33	21.4
8	T1	22	3.0	0.072	0.7	LOS A	0.3	7.5	0.38	0.29	18.5
18	R2	315	3.0	0.238	0.8	LOS A	1.1	28.4	0.42	0.20	21.6
Approach		489	3.0	0.238	1.1	LOS A	1.1	28.4	0.41	0.25	21.4
East: Trent Ave											
1	L2	420	3.0	0.596	11.9	LOS B	4.0	101.4	0.50	0.69	34.9
6	T1	966	3.0	0.596	7.5	LOS A	4.0	102.0	0.49	0.63	39.6
16	R2	23	3.0	0.596	7.2	LOS A	4.0	102.0	0.49	0.61	29.8
Approach		1409	3.0	0.596	8.8	LOS A	4.0	102.0	0.49	0.65	37.9
North: Cement Rd											
7	L2	11	3.0	0.187	10.2	LOS B	0.8	19.4	0.71	0.78	29.1
4	T1	76	3.0	0.187	6.1	LOS A	0.8	19.4	0.71	0.78	27.0
14	R2	11	3.0	0.187	6.5	LOS A	0.8	19.4	0.71	0.78	28.7
Approach		98	3.0	0.187	6.6	LOS A	0.8	19.4	0.71	0.78	27.4
West: Trent Ave											
5	L2	22	3.0	0.184	13.4	LOS B	1.1	27.1	0.62	0.71	30.5
2	T1	348	3.0	0.184	8.8	LOS A	1.1	28.9	0.61	0.69	39.3
12	R2	196	3.0	0.120	5.7	LOS A	0.0	0.0	0.00	0.58	41.4
Approach		565	3.0	0.184	7.9	LOS A	1.1	28.9	0.40	0.65	39.6
All Vehicles		2561	3.0	0.596	7.1	LOS A	4.0	102.0	0.46	0.58	32.9

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	10	949	245	276	540	286	51	510	102
v/c Ratio	0.14	0.80	0.38	0.80	0.28	0.65	0.21	0.80	0.62
Control Delay	74.3	46.3	14.3	71.7	14.4	64.9	57.1	14.6	77.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	74.3	46.3	14.3	71.7	14.4	64.9	57.1	14.6	77.3
Queue Length 50th (ft)	9	414	52	239	102	132	43	0	90
Queue Length 95th (ft)	33	#631	147	#432	225	191	88	127	165
Internal Link Dist (ft)		5246			2649		2504		831
Turn Bay Length (ft)	220		260	285		150		1000	
Base Capacity (vph)	386	1202	646	386	1936	771	418	737	414
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.79	0.38	0.72	0.28	0.37	0.12	0.69	0.25

Intersection Summary

Description: 2017 counts

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Future Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
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
Adj Sat Flow, veh/h/ln	1667	1635	1667	1667	1636	1700	1667	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	949	0	276	520	20	286	51	255	31	61	10
Adj No. of Lanes	1	2	1	1	2	0	2	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	4	2	2	4	4	2	2	2	2	2	2
Cap, veh/h	19	1057	482	306	1592	61	638	345	294	39	76	13
Arrive On Green	0.01	0.34	0.00	0.19	0.52	0.52	0.21	0.21	0.21	0.08	0.08	0.08
Sat Flow, veh/h	1587	3106	1417	1587	3052	117	3079	1667	1417	491	965	158
Grp Volume(v), veh/h	10	949	0	276	264	276	286	51	255	102	0	0
Grp Sat Flow(s),veh/h/ln	1587	1553	1417	1587	1554	1615	1540	1667	1417	1614	0	0
Q Serve(g_s), s	0.7	34.6	0.0	20.3	11.7	11.7	9.7	3.0	20.8	7.4	0.0	0.0
Cycle Q Clear(g_c), s	0.7	34.6	0.0	20.3	11.7	11.7	9.7	3.0	20.8	7.4	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.07	1.00		1.00	0.30		0.10
Lane Grp Cap(c), veh/h	19	1057	482	306	811	842	638	345	294	128	0	0
V/C Ratio(X)	0.53	0.90	0.00	0.90	0.33	0.33	0.45	0.15	0.87	0.80	0.00	0.00
Avail Cap(c_a), veh/h	453	1406	641	453	811	842	904	489	416	480	0	0
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	58.6	37.4	0.0	47.0	16.4	16.5	41.3	38.7	45.7	54.0	0.0	0.0
Incr Delay (d2), s/veh	21.4	6.4	0.0	15.4	0.2	0.2	0.5	0.2	13.1	10.8	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.4	15.7	0.0	10.2	5.0	5.3	4.2	1.4	9.2	3.7	0.0	0.0
LnGrp Delay(d),s/veh	80.0	43.8	0.0	62.5	16.7	16.7	41.8	38.9	58.8	64.8	0.0	0.0
LnGrp LOS	F	D		E	B	B	D	D	E	E		
Approach Vol, veh/h		959			816			592			102	
Approach Delay, s/veh		44.1			32.2			48.9			64.8	
Approach LOS		D			C			D			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.4	68.2		29.7	29.0	46.6		13.9
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	34.0	54.0		35.0	34.0	54.0		35.5
Max Q Clear Time (g_c+I1), s	2.7	13.7		22.8	22.3	36.6		9.4
Green Ext Time (p_c), s	0.0	7.6		2.0	0.8	4.0		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	42.2
HCM 2010 LOS	D

MOVEMENT SUMMARY

Site: Pines / Trent PM - Alt1a

Pines / Trent
2020 PM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	304	3.0	0.209	10.4	LOS B	1.0	26.4	0.66	0.82	33.1
8	T1	54	3.0	0.209	5.6	LOS A	1.0	26.4	0.66	0.78	26.9
18	R2	543	3.0	0.549	7.1	LOS A	3.7	93.9	0.78	0.94	34.2
Approach		902	3.0	0.549	8.1	LOS A	3.7	93.9	0.73	0.89	33.3
East: Trent Ave											
1	L2	307	3.0	0.437	12.3	LOS B	2.3	59.3	0.55	0.76	22.6
6	T1	580	3.0	0.437	7.8	LOS A	2.4	60.2	0.54	0.67	39.5
16	R2	23	3.0	0.437	7.5	LOS A	2.4	60.2	0.54	0.64	29.7
Approach		909	3.0	0.437	9.3	LOS A	2.4	60.2	0.54	0.70	31.2
North: Cement Rd											
7	L2	33	3.0	0.174	9.1	LOS A	0.7	17.3	0.64	0.81	28.7
4	T1	65	3.0	0.174	7.1	LOS A	0.7	17.3	0.64	0.81	17.8
14	R2	11	3.0	0.174	5.4	LOS A	0.7	17.3	0.64	0.81	28.4
Approach		109	3.0	0.174	7.5	LOS A	0.7	17.3	0.64	0.81	21.0
West: Trent Ave											
5	L2	11	3.0	0.469	13.4	LOS B	3.3	83.3	0.68	0.74	30.5
2	T1	1011	3.0	0.469	8.8	LOS A	3.4	88.1	0.67	0.72	39.2
12	R2	261	3.0	0.160	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		1283	3.0	0.469	8.3	LOS A	3.4	88.1	0.53	0.69	39.4
All Vehicles		3203	3.0	0.549	8.5	LOS A	3.7	93.9	0.60	0.75	34.1

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	10	949	245	276	540	286	51	510	102
v/c Ratio	0.12	0.73	0.36	0.65	0.30	0.60	0.20	0.79	0.57
Control Delay	65.7	35.8	11.7	59.5	15.2	55.3	49.6	13.7	65.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	65.7	35.8	11.7	59.5	15.2	55.3	49.6	13.7	65.8
Queue Length 50th (ft)	8	318	40	107	97	110	36	0	75
Queue Length 95th (ft)	30	534	132	178	220	176	82	122	154
Internal Link Dist (ft)		5246			2649		2504		831
Turn Bay Length (ft)	220		260	285		150		150	
Base Capacity (vph)	445	1387	721	863	1822	889	482	772	477
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.68	0.34	0.32	0.30	0.32	0.11	0.66	0.21

Intersection Summary
Description: 2017 counts

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Future Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
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
Adj Sat Flow, veh/h/ln	1667	1635	1667	1667	1636	1700	1667	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	949	0	276	520	20	286	51	255	31	61	10
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	4	2	2	4	4	2	2	2	2	2	2
Cap, veh/h	19	1145	522	364	1449	56	661	358	304	40	78	13
Arrive On Green	0.01	0.37	0.00	0.12	0.47	0.47	0.21	0.21	0.21	0.08	0.08	0.08
Sat Flow, veh/h	1587	3106	1417	3079	3052	117	3079	1667	1417	491	965	158
Grp Volume(v), veh/h	10	949	0	276	264	276	286	51	255	102	0	0
Grp Sat Flow(s),veh/h/ln	1587	1553	1417	1540	1554	1615	1540	1667	1417	1614	0	0
Q Serve(g_s), s	0.6	27.4	0.0	8.6	10.6	10.7	7.9	2.4	17.0	6.1	0.0	0.0
Cycle Q Clear(g_c), s	0.6	27.4	0.0	8.6	10.6	10.7	7.9	2.4	17.0	6.1	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.07	1.00		1.00	0.30		0.10
Lane Grp Cap(c), veh/h	19	1145	522	364	738	767	661	358	304	130	0	0
V/C Ratio(X)	0.52	0.83	0.00	0.76	0.36	0.36	0.43	0.14	0.84	0.78	0.00	0.00
Avail Cap(c_a), veh/h	547	1699	775	1061	850	884	1092	591	502	581	0	0
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	48.5	28.3	0.0	42.1	16.4	16.4	33.6	31.4	37.1	44.5	0.0	0.0
Incr Delay (d2), s/veh	19.9	2.3	0.0	3.2	0.3	0.3	0.4	0.2	6.4	9.8	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.4	12.1	0.0	3.8	4.6	4.8	3.4	1.2	7.2	3.1	0.0	0.0
LnGrp Delay(d),s/veh	68.4	30.6	0.0	45.4	16.7	16.7	34.0	31.6	43.6	54.4	0.0	0.0
LnGrp LOS	E	C		D	B	B	C	C	D	D		
Approach Vol, veh/h		959			816			592			102	
Approach Delay, s/veh		31.0			26.4			37.9			54.4	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.2	52.9		26.2	17.7	42.4		12.5
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	34.0	54.0		35.0	34.0	54.0		35.5
Max Q Clear Time (g_c+I1), s	2.6	12.7		19.0	10.6	29.4		8.1
Green Ext Time (p_c), s	0.0	7.6		2.2	1.1	7.0		0.4

Intersection Summary	
HCM 2010 Ctrl Delay	32.1
HCM 2010 LOS	C

MOVEMENT SUMMARY

Site: Pines / Trent PM - Alt2a

Pines / Trent
2020 PM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	304	3.0	0.209	3.3	LOS A	1.0	26.4	0.66	0.60	21.2
8	T1	54	3.0	0.209	1.9	LOS A	1.0	26.4	0.66	0.51	18.3
18	R2	543	3.0	0.549	3.2	LOS A	3.7	93.9	0.78	0.89	21.3
Approach		902	3.0	0.549	3.2	LOS A	3.7	93.9	0.73	0.77	21.1
East: Trent Ave											
1	L2	307	3.0	0.437	12.3	LOS B	2.3	59.3	0.55	0.76	22.6
6	T1	580	3.0	0.437	7.8	LOS A	2.4	60.2	0.54	0.67	39.5
16	R2	23	3.0	0.437	7.5	LOS A	2.4	60.2	0.54	0.64	29.7
Approach		909	3.0	0.437	9.3	LOS A	2.4	60.2	0.54	0.70	31.2
North: Cement Rd											
7	L2	33	3.0	0.174	9.1	LOS A	0.7	17.3	0.64	0.81	28.7
4	T1	65	3.0	0.174	7.1	LOS A	0.7	17.3	0.64	0.81	17.8
14	R2	11	3.0	0.174	5.4	LOS A	0.7	17.3	0.64	0.81	28.4
Approach		109	3.0	0.174	7.5	LOS A	0.7	17.3	0.64	0.81	21.0
West: Trent Ave											
5	L2	11	3.0	0.469	13.4	LOS B	3.3	83.3	0.68	0.74	30.5
2	T1	1011	3.0	0.469	8.8	LOS A	3.4	88.1	0.67	0.72	39.2
12	R2	261	3.0	0.160	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		1283	3.0	0.469	8.3	LOS A	3.4	88.1	0.53	0.69	39.4
All Vehicles		3203	3.0	0.549	7.1	LOS A	3.7	93.9	0.60	0.72	29.2

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	23	523	250	432	1057	227	34	341	114
v/c Ratio	0.28	0.80	0.36	0.85	0.63	0.58	0.16	0.42	0.62
Control Delay	70.0	54.7	4.8	53.0	21.2	55.8	51.1	2.6	66.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	70.0	54.7	4.8	53.0	21.2	55.8	51.1	2.6	66.8
Queue Length 50th (ft)	17	197	0	299	297	85	24	0	81
Queue Length 95th (ft)	51	303	49	483	426	138	59	24	161
Internal Link Dist (ft)		5151			2649		2154		831
Turn Bay Length (ft)	220		260	285		150		1000	
Base Capacity (vph)	84	810	775	685	2022	624	338	925	246
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.27	0.65	0.32	0.63	0.52	0.36	0.10	0.37	0.46

Intersection Summary
Description: 2040 forecast

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Future Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
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
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	523	0	432	1034	23	227	34	136	23	80	11
Adj No. of Lanes	1	2	1	1	2	0	2	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	37	733	478	476	1609	36	326	177	575	30	105	14
Arrive On Green	0.02	0.24	0.00	0.31	0.53	0.53	0.11	0.11	0.11	0.10	0.10	0.10
Sat Flow, veh/h	1527	3047	1363	1527	3048	68	2963	1604	1363	315	1096	151
Grp Volume(v), veh/h	23	523	0	432	517	540	227	34	136	114	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1527	1524	1592	1482	1604	1363	1561	0	0
Q Serve(g_s), s	1.4	14.3	0.0	24.7	22.0	22.0	6.7	1.8	5.8	6.5	0.0	0.0
Cycle Q Clear(g_c), s	1.4	14.3	0.0	24.7	22.0	22.0	6.7	1.8	5.8	6.5	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.04	1.00		1.00	0.20		0.10
Lane Grp Cap(c), veh/h	37	733	478	476	804	840	326	177	575	149	0	0
V/C Ratio(X)	0.62	0.71	0.00	0.91	0.64	0.64	0.70	0.19	0.24	0.76	0.00	0.00
Avail Cap(c_a), veh/h	101	973	585	824	1216	1271	750	406	770	292	0	0
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	43.9	31.6	0.0	30.0	15.3	15.3	38.9	36.7	16.9	40.1	0.0	0.0
Incr Delay (d2), s/veh	15.8	1.7	0.0	7.9	0.9	0.8	2.7	0.5	0.2	7.8	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.7	6.2	0.0	11.4	9.4	9.8	2.9	0.8	2.2	3.1	0.0	0.0
LnGrp Delay(d),s/veh	59.7	33.3	0.0	37.9	16.2	16.2	41.6	37.3	17.1	47.9	0.0	0.0
LnGrp LOS	E	C		D	B	B	D	D	B	D		
Approach Vol, veh/h		546			1489			397			114	
Approach Delay, s/veh		34.4			22.5			32.8			47.9	
Approach LOS		C			C			C			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		15.0	34.3	26.8		14.7	8.2	52.9
Change Period (Y+Rc), s		5.0	6.0	5.0		6.0	6.0	* 5
Max Green Setting (Gmax), s		23.0	49.0	29.0		17.0	6.0	* 73
Max Q Clear Time (g_c+I1), s		8.7	26.7	16.3		8.5	3.4	24.0
Green Ext Time (p_c), s		1.3	1.7	5.5		0.2	0.0	8.0

Intersection Summary	
HCM 2010 Ctrl Delay	27.8
HCM 2010 LOS	C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

MOVEMENT SUMMARY

Site: Pines / Trent AM - Alt1

Pines / Trent
2040 AM
Roundabout

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
Movement Performance - Vehicles											
South: Pines Rd											
3	L2	217	3.0	0.113	9.4	LOS A	0.5	12.4	0.47	0.70	33.5
8	T1	33	3.0	0.113	4.8	LOS A	0.5	12.4	0.47	0.67	27.1
18	R2	326	3.0	0.265	5.1	LOS A	1.3	32.3	0.51	0.63	34.8
Approach		576	3.0	0.265	6.7	LOS A	1.3	32.3	0.49	0.66	33.7
East: Trent Ave											
1	L2	432	3.0	0.664	13.1	LOS B	5.3	136.9	0.62	0.78	22.5
6	T1	1034	3.0	0.664	8.6	LOS A	5.3	136.9	0.61	0.73	39.1
16	R2	23	3.0	0.664	8.2	LOS A	5.3	136.7	0.61	0.71	29.6
Approach		1489	3.0	0.664	9.9	LOS A	5.3	136.9	0.61	0.74	32.1
North: Cement Rd											
7	L2	22	3.0	0.235	10.9	LOS B	1.0	25.7	0.75	0.86	28.2
4	T1	76	3.0	0.235	8.9	LOS A	1.0	25.7	0.75	0.86	17.6
14	R2	11	3.0	0.235	7.2	LOS A	1.0	25.7	0.75	0.86	27.8
Approach		109	3.0	0.235	9.1	LOS A	1.0	25.7	0.75	0.86	19.8
West: Trent Ave											
5	L2	22	3.0	0.270	13.7	LOS B	1.7	42.7	0.68	0.75	30.4
2	T1	500	3.0	0.270	9.1	LOS A	1.8	45.9	0.67	0.72	39.1
12	R2	239	3.0	0.147	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		761	3.0	0.270	8.3	LOS A	1.8	45.9	0.46	0.69	39.3
All Vehicles		2934	3.0	0.664	8.8	LOS A	5.3	136.9	0.55	0.72	33.2

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	23	523	250	432	1057	227	34	341	114
v/c Ratio	0.24	0.75	0.33	0.76	0.76	0.48	0.13	0.50	0.52
Control Delay	47.6	37.3	3.1	43.8	26.2	35.0	31.7	3.9	41.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	47.6	37.3	3.1	43.8	26.2	35.0	31.7	3.9	41.6
Queue Length 50th (ft)	11	123	0	103	189	53	15	0	50
Queue Length 95th (ft)	40	218	35	#233	#496	94	42	25	114
Internal Link Dist (ft)		5151			2649		2154		831
Turn Bay Length (ft)	220		260	175		150		150	
Base Capacity (vph)	97	894	903	565	1388	867	470	687	343
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.24	0.59	0.28	0.76	0.76	0.26	0.07	0.50	0.33

Intersection Summary

Description: 2040 forecast

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Future Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
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
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	523	0	432	1034	23	227	34	136	23	80	11
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	40	790	526	534	1259	28	376	204	418	33	114	16
Arrive On Green	0.03	0.26	0.00	0.18	0.41	0.41	0.13	0.13	0.13	0.10	0.10	0.10
Sat Flow, veh/h	1527	3047	1363	2963	3048	68	2963	1604	1363	315	1096	151
Grp Volume(v), veh/h	23	523	0	432	517	540	227	34	136	114	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1482	1524	1592	1482	1604	1363	1561	0	0
Q Serve(g_s), s	1.0	10.2	0.0	9.3	20.1	20.1	4.8	1.3	5.1	4.7	0.0	0.0
Cycle Q Clear(g_c), s	1.0	10.2	0.0	9.3	20.1	20.1	4.8	1.3	5.1	4.7	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.04	1.00		1.00	0.20		0.10
Lane Grp Cap(c), veh/h	40	790	526	534	630	658	376	204	418	163	0	0
V/C Ratio(X)	0.58	0.66	0.00	0.81	0.82	0.82	0.60	0.17	0.32	0.70	0.00	0.00
Avail Cap(c_a), veh/h	114	1050	643	666	765	799	1022	553	715	398	0	0
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	32.1	22.1	0.0	26.3	17.4	17.4	27.5	26.0	17.8	28.9	0.0	0.0
Incr Delay (d2), s/veh	12.6	1.0	0.0	6.0	6.0	5.8	1.6	0.4	0.4	5.4	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.6	4.4	0.0	4.2	9.4	9.8	2.1	0.6	2.0	2.3	0.0	0.0
LnGrp Delay(d),s/veh	44.8	23.1	0.0	32.3	23.4	23.2	29.1	26.4	18.2	34.3	0.0	0.0
LnGrp LOS	D	C		C	C	C	C	C	B	C		
Approach Vol, veh/h		546			1489			397			114	
Approach Delay, s/veh		24.0			25.9			25.1			34.3	
Approach LOS		C			C			C			C	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		13.5	18.0	22.3		13.0	7.7	32.6
Change Period (Y+Rc), s		5.0	6.0	5.0		6.0	6.0	* 5
Max Green Setting (Gmax), s		23.0	15.0	23.0		17.0	5.0	* 34
Max Q Clear Time (g_c+I1), s		7.1	11.3	12.2		6.7	3.0	22.1
Green Ext Time (p_c), s		1.3	0.7	5.0		0.2	0.0	5.2

Intersection Summary	
HCM 2010 Ctrl Delay	25.7
HCM 2010 LOS	C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

MOVEMENT SUMMARY

Site: Pines / Trent AM - Alt2

Pines / Trent
2040 AM
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	217	3.0	0.113	2.2	LOS A	0.5	12.4	0.47	0.40	21.4
8	T1	33	3.0	0.113	1.0	LOS A	0.5	12.4	0.47	0.35	18.4
18	R2	326	3.0	0.265	1.1	LOS A	1.3	32.3	0.51	0.28	21.6
Approach		576	3.0	0.265	1.5	LOS A	1.3	32.3	0.49	0.33	21.3
East: Trent Ave											
1	L2	432	3.0	0.664	13.1	LOS B	5.3	136.9	0.62	0.78	22.5
6	T1	1034	3.0	0.664	8.6	LOS A	5.3	136.9	0.61	0.73	39.1
16	R2	23	3.0	0.664	8.2	LOS A	5.3	136.7	0.61	0.71	29.6
Approach		1489	3.0	0.664	9.9	LOS A	5.3	136.9	0.61	0.74	32.1
North: Cement Rd											
7	L2	22	3.0	0.235	10.9	LOS B	1.0	25.7	0.75	0.86	28.2
4	T1	76	3.0	0.235	8.9	LOS A	1.0	25.7	0.75	0.86	17.6
14	R2	11	3.0	0.235	7.2	LOS A	1.0	25.7	0.75	0.86	27.8
Approach		109	3.0	0.235	9.1	LOS A	1.0	25.7	0.75	0.86	19.8
West: Trent Ave											
5	L2	22	3.0	0.270	13.7	LOS B	1.7	42.7	0.68	0.75	30.4
2	T1	500	3.0	0.270	9.1	LOS A	1.8	45.9	0.67	0.72	39.1
12	R2	239	3.0	0.147	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		761	3.0	0.270	8.3	LOS A	1.8	45.9	0.46	0.69	39.3
All Vehicles		2934	3.0	0.664	7.8	LOS A	5.3	136.9	0.55	0.65	29.8

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	10	1071	306	296	664	337	61	520	122
v/c Ratio	0.17	0.94	0.33	0.88	0.35	0.73	0.24	0.77	0.65
Control Delay	72.3	56.9	2.8	77.2	15.7	64.1	53.4	19.3	71.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	72.3	56.9	2.8	77.2	15.7	64.1	53.4	19.3	71.7
Queue Length 50th (ft)	9	478	0	247	139	145	47	129	101
Queue Length 95th (ft)	30	#710	46	#447	257	209	96	224	173
Internal Link Dist (ft)		5151			2649		2154		831
Turn Bay Length (ft)	220		260	285		150		1000	
Base Capacity (vph)	60	1143	959	364	1881	578	313	693	282
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.17	0.94	0.32	0.81	0.35	0.58	0.19	0.75	0.43

Intersection Summary

Description: 2040 forecasts

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Future Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
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
Adj Sat Flow, veh/h/ln	1667	1667	1667	1667	1667	1700	1667	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	1071	0	296	633	31	337	61	214	41	71	10
Adj No. of Lanes	1	2	1	1	2	0	2	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	19	1180	735	324	1735	85	451	244	497	50	86	12
Arrive On Green	0.01	0.37	0.00	0.20	0.56	0.56	0.15	0.15	0.15	0.09	0.09	0.09
Sat Flow, veh/h	1587	3167	1417	1587	3073	150	3079	1667	1417	543	941	132
Grp Volume(v), veh/h	10	1071	0	296	326	338	337	61	214	122	0	0
Grp Sat Flow(s),veh/h/ln	1587	1583	1417	1587	1583	1640	1540	1667	1417	1616	0	0
Q Serve(g_s), s	0.7	38.1	0.0	21.7	13.4	13.4	12.5	3.9	13.7	8.8	0.0	0.0
Cycle Q Clear(g_c), s	0.7	38.1	0.0	21.7	13.4	13.4	12.5	3.9	13.7	8.8	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.09	1.00		1.00	0.34		0.08
Lane Grp Cap(c), veh/h	19	1180	735	324	894	926	451	244	497	148	0	0
V/C Ratio(X)	0.53	0.91	0.00	0.91	0.36	0.37	0.75	0.25	0.43	0.82	0.00	0.00
Avail Cap(c_a), veh/h	67	1252	768	401	946	980	635	344	581	306	0	0
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	58.4	35.4	0.0	46.3	14.2	14.2	48.6	44.9	29.5	53.0	0.0	0.0
Incr Delay (d2), s/veh	21.4	9.5	0.0	22.2	0.2	0.2	3.0	0.5	0.6	10.7	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.4	18.2	0.0	11.5	5.9	6.1	5.5	1.8	5.4	4.4	0.0	0.0
LnGrp Delay(d),s/veh	79.8	44.8	0.0	68.4	14.4	14.4	51.6	45.5	30.1	63.8	0.0	0.0
LnGrp LOS	E	D		E	B	B	D	D	C	E		
Approach Vol, veh/h		1081			960			612			122	
Approach Delay, s/veh		45.2			31.1			43.5			63.7	
Approach LOS		D			C			D			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		22.4	30.3	50.3		15.9	7.4	73.1
Change Period (Y+Rc), s		5.0	6.0	* 6		5.0	6.0	6.0
Max Green Setting (Gmax), s		24.5	30.0	* 47		22.5	5.0	71.0
Max Q Clear Time (g_c+I1), s		15.7	23.7	40.1		10.8	2.7	15.4
Green Ext Time (p_c), s		1.7	0.6	4.2		0.3	0.0	9.8

Intersection Summary	
HCM 2010 Ctrl Delay	40.7
HCM 2010 LOS	D

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

MOVEMENT SUMMARY

Site: Pines / Trent PM - Alt1

Pines / Trent
2040 PM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	359	3.0	0.275	10.8	LOS B	1.5	37.6	0.73	0.85	33.0
8	T1	65	3.0	0.275	6.0	LOS A	1.5	37.6	0.74	0.81	26.8
18	R2	554	3.0	0.617	8.1	LOS A	4.5	116.3	0.85	1.00	33.7
Approach		978	3.0	0.617	8.9	LOS A	4.5	116.3	0.80	0.94	32.9
East: Trent Ave											
1	L2	330	3.0	0.538	13.2	LOS B	3.4	87.7	0.64	0.83	22.5
6	T1	705	3.0	0.538	8.6	LOS A	3.5	88.6	0.63	0.75	39.1
16	R2	34	3.0	0.538	8.2	LOS A	3.5	88.6	0.63	0.72	29.5
Approach		1068	3.0	0.538	10.0	LOS B	3.5	88.6	0.63	0.78	31.5
North: Cement Rd											
7	L2	43	3.0	0.236	9.8	LOS A	1.0	24.9	0.70	0.84	28.4
4	T1	76	3.0	0.236	7.8	LOS A	1.0	24.9	0.70	0.84	17.7
14	R2	11	3.0	0.236	6.1	LOS A	1.0	24.9	0.70	0.84	28.1
Approach		130	3.0	0.236	8.3	LOS A	1.0	24.9	0.70	0.84	21.0
West: Trent Ave											
5	L2	11	3.0	0.552	14.7	LOS B	4.6	118.8	0.76	0.82	30.3
2	T1	1141	3.0	0.552	9.9	LOS A	4.8	121.9	0.75	0.79	38.9
12	R2	326	3.0	0.201	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		1478	3.0	0.552	9.1	LOS A	4.8	121.9	0.59	0.75	39.2
All Vehicles		3655	3.0	0.617	9.3	LOS A	4.8	121.9	0.66	0.81	33.9

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	10	1071	306	296	664	337	61	520	122
v/c Ratio	0.14	0.88	0.32	0.71	0.38	0.68	0.23	0.84	0.61
Control Delay	59.0	42.0	2.2	56.8	16.7	51.2	43.3	22.2	58.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	59.0	42.0	2.2	56.8	16.7	51.2	43.3	22.2	58.4
Queue Length 50th (ft)	7	371	0	104	127	117	38	95	81
Queue Length 95th (ft)	27	#591	38	#169	252	175	82	#194	150
Internal Link Dist (ft)		5151			2649		2154		831
Turn Bay Length (ft)	220		260	175		150		150	
Base Capacity (vph)	73	1230	1028	454	1731	668	362	633	339
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.14	0.87	0.30	0.65	0.38	0.50	0.17	0.82	0.36

Intersection Summary

Description: 2040 forecasts

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Future Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
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
Adj Sat Flow, veh/h/ln	1667	1667	1667	1667	1667	1700	1667	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	1071	0	296	633	31	337	61	214	41	71	10
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	19	1234	788	370	1529	75	512	277	405	51	89	12
Arrive On Green	0.01	0.39	0.00	0.12	0.50	0.50	0.17	0.17	0.17	0.09	0.09	0.09
Sat Flow, veh/h	1587	3167	1417	3079	3073	150	3079	1667	1417	543	941	132
Grp Volume(v), veh/h	10	1071	0	296	326	338	337	61	214	122	0	0
Grp Sat Flow(s),veh/h/ln	1587	1583	1417	1540	1583	1640	1540	1667	1417	1616	0	0
Q Serve(g_s), s	0.6	29.9	0.0	9.0	12.5	12.5	9.8	3.0	12.2	7.1	0.0	0.0
Cycle Q Clear(g_c), s	0.6	29.9	0.0	9.0	12.5	12.5	9.8	3.0	12.2	7.1	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.09	1.00		1.00	0.34		0.08
Lane Grp Cap(c), veh/h	19	1234	788	370	788	816	512	277	405	152	0	0
V/C Ratio(X)	0.52	0.87	0.00	0.80	0.41	0.41	0.66	0.22	0.53	0.80	0.00	0.00
Avail Cap(c_a), veh/h	83	1389	857	514	860	891	756	409	518	380	0	0
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	47.0	26.9	0.0	41.0	15.2	15.2	37.4	34.6	28.7	42.5	0.0	0.0
Incr Delay (d2), s/veh	19.7	5.6	0.0	6.1	0.3	0.3	1.5	0.4	1.1	9.3	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.4	13.9	0.0	4.1	5.5	5.7	4.3	1.4	4.8	3.5	0.0	0.0
LnGrp Delay(d),s/veh	66.7	32.6	0.0	47.1	15.6	15.6	38.8	35.0	29.8	51.8	0.0	0.0
LnGrp LOS	E	C		D	B	B	D	C	C	D		
Approach Vol, veh/h		1081			960			612			122	
Approach Delay, s/veh		32.9			25.3			35.3			51.8	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		20.9	17.5	43.3		14.0	7.2	53.7
Change Period (Y+Rc), s		5.0	6.0	* 6		5.0	6.0	6.0
Max Green Setting (Gmax), s		23.5	16.0	* 42		22.5	5.0	52.0
Max Q Clear Time (g_c+I1), s		14.2	11.0	31.9		9.1	2.6	14.5
Green Ext Time (p_c), s		1.8	0.5	5.5		0.3	0.0	9.4

Intersection Summary	
HCM 2010 Ctrl Delay	31.6
HCM 2010 LOS	C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

MOVEMENT SUMMARY

Site: Pines / Trent PM - Alt2

Pines / Trent
2040 PM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	359	3.0	0.275	3.7	LOS A	1.5	37.6	0.73	0.67	21.1
8	T1	65	3.0	0.275	2.2	LOS A	1.5	37.6	0.74	0.57	18.3
18	R2	554	3.0	0.617	4.1	LOS A	4.5	116.3	0.85	1.01	21.1
Approach		978	3.0	0.617	3.8	LOS A	4.5	116.3	0.80	0.86	20.9
East: Trent Ave											
1	L2	330	3.0	0.538	13.2	LOS B	3.4	87.7	0.64	0.83	22.5
6	T1	705	3.0	0.538	8.6	LOS A	3.5	88.6	0.63	0.75	39.1
16	R2	34	3.0	0.538	8.2	LOS A	3.5	88.6	0.63	0.72	29.5
Approach		1068	3.0	0.538	10.0	LOS B	3.5	88.6	0.63	0.78	31.5
North: Cement Rd											
7	L2	43	3.0	0.236	9.8	LOS A	1.0	24.9	0.70	0.84	28.4
4	T1	76	3.0	0.236	7.8	LOS A	1.0	24.9	0.70	0.84	17.7
14	R2	11	3.0	0.236	6.1	LOS A	1.0	24.9	0.70	0.84	28.1
Approach		130	3.0	0.236	8.3	LOS A	1.0	24.9	0.70	0.84	21.0
West: Trent Ave											
5	L2	11	3.0	0.552	14.7	LOS B	4.6	118.8	0.76	0.82	30.3
2	T1	1141	3.0	0.552	9.9	LOS A	4.8	121.9	0.75	0.79	38.9
12	R2	326	3.0	0.201	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		1478	3.0	0.552	9.1	LOS A	4.8	121.9	0.59	0.75	39.2
All Vehicles		3655	3.0	0.617	7.9	LOS A	4.8	121.9	0.66	0.79	29.3

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

FEHR & PEERS

ATTACHMENT E: 2020 AND 2040 UNIVERSITY ROAD CLOSURE ANALYSIS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	295	190	460	760	20	145	20	315	10	70	10
Future Volume (veh/h)	20	295	190	460	760	20	145	20	315	10	70	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
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
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1700	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	335	0	523	864	23	165	23	188	11	80	11
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	36	517	231	565	1564	42	226	31	228	14	100	14
Arrive On Green	0.02	0.17	0.00	0.37	0.52	0.52	0.17	0.17	0.17	0.08	0.08	0.08
Sat Flow, veh/h	1527	3047	1363	1527	3032	81	1348	188	1363	169	1228	169
Grp Volume(v), veh/h	23	335	0	523	434	453	188	0	188	102	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1527	1524	1590	1536	0	1363	1566	0	0
Q Serve(g_s), s	1.5	10.4	0.0	33.3	19.6	19.6	11.8	0.0	13.5	6.5	0.0	0.0
Cycle Q Clear(g_c), s	1.5	10.4	0.0	33.3	19.6	19.6	11.8	0.0	13.5	6.5	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.05	0.88		1.00	0.11		0.11
Lane Grp Cap(c), veh/h	36	517	231	565	786	820	257	0	228	128	0	0
V/C Ratio(X)	0.64	0.65	0.00	0.93	0.55	0.55	0.73	0.00	0.82	0.80	0.00	0.00
Avail Cap(c_a), veh/h	90	931	417	1054	1427	1488	515	0	457	363	0	0
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	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	49.1	39.3	0.0	30.6	16.6	16.6	40.1	0.0	40.8	45.8	0.0	0.0
Incr Delay (d2), s/veh	17.4	1.4	0.0	7.1	0.6	0.6	4.0	0.0	7.3	10.9	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.8	4.5	0.0	15.1	8.3	8.7	5.3	0.0	5.6	3.2	0.0	0.0
LnGrp Delay(d),s/veh	66.5	40.7	0.0	37.7	17.2	17.2	44.1	0.0	48.1	56.6	0.0	0.0
LnGrp LOS	E	D		D	B	B	D		D	E		
Approach Vol, veh/h		358			1410			376			102	
Approach Delay, s/veh		42.3			24.8			46.1			56.6	
Approach LOS		D			C			D			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	8.4	58.3		22.0	43.5	23.2		12.8
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	6.0	95.0		34.0	70.0	31.0		23.5
Max Q Clear Time (g_c+I1), s	3.5	21.6		15.5	35.3	12.4		8.5
Green Ext Time (p_c), s	0.0	5.5		1.5	2.2	4.8		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	32.6
HCM 2010 LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	50	235	295	255	545	120	305	650	125	110	1040	100
Future Volume (vph)	50	235	295	255	545	120	305	650	125	110	1040	100
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.97		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2913	1303	1456	4072		2825	4185	1303	1456	4130	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2913	1303	1456	4072		2825	4185	1303	1456	4130	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	255	321	277	592	130	332	707	136	120	1130	109
RTOR Reduction (vph)	0	0	65	0	23	0	0	0	44	0	7	0
Lane Group Flow (vph)	54	255	256	277	699	0	332	707	92	120	1232	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	8.0	15.5	39.1	28.3	35.8		23.6	68.3	96.6	16.9	56.6	
Effective Green, g (s)	10.5	18.0	46.6	30.8	38.3		27.6	70.3	101.6	18.9	58.6	
Actuated g/C Ratio	0.07	0.12	0.31	0.21	0.26		0.18	0.47	0.68	0.13	0.39	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	101	349	404	298	1039		519	1961	882	183	1613	
v/s Ratio Prot	0.04	0.09	c0.12	c0.19	c0.17		c0.12	0.17	0.02	0.08	c0.30	
v/s Ratio Perm			0.08						0.05			
v/c Ratio	0.53	0.73	0.63	0.93	0.67		0.64	0.36	0.10	0.66	0.76	
Uniform Delay, d1	67.4	63.7	44.4	58.5	50.2		56.6	25.5	8.4	62.5	39.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.83	0.23	0.21	1.00	1.00	
Incremental Delay, d2	5.4	7.7	3.2	33.7	1.7		1.9	0.4	0.0	8.2	2.2	
Delay (s)	72.7	71.3	47.6	92.2	51.9		105.4	6.2	1.8	70.6	41.9	
Level of Service	E	E	D	F	D		F	A	A	E	D	
Approach Delay (s)		59.3			63.1			33.7			44.4	
Approach LOS		E			E			C			D	

Intersection Summary			
HCM 2000 Control Delay	48.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	74.5%	ICU Level of Service	D
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	30	30	10	200	30	150	10	860	410	360	1220	30
Future Volume (vph)	30	30	10	200	30	150	10	860	410	360	1220	30
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.96		1.00	0.91		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2806		1325	2503		1456	4185	1303	1456	4170	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2806		1325	2503		1456	4185	1303	1456	4170	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	34	34	11	225	34	169	11	966	461	404	1371	34
RTOR Reduction (vph)	0	10	0	0	139	0	0	0	268	0	2	0
Lane Group Flow (vph)	34	35	0	148	141	0	11	966	193	404	1403	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	7.1	7.1		23.9	23.9		1.2	46.0	46.0	53.0	97.8	
Effective Green, g (s)	9.6	9.6		26.4	26.4		2.2	48.0	47.0	54.0	99.8	
Actuated g/C Ratio	0.06	0.06		0.18	0.18		0.01	0.32	0.31	0.36	0.67	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	93	179		233	440		21	1339	408	524	2774	
v/s Ratio Prot	c0.02	0.01		c0.11	0.06		0.01	c0.23		c0.28	0.34	
v/s Ratio Perm									0.15			
v/c Ratio	0.37	0.19		0.64	0.32		0.52	0.72	0.47	0.77	0.51	
Uniform Delay, d1	67.3	66.5		57.3	54.0		73.4	45.1	41.5	42.5	12.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.78	0.65	
Incremental Delay, d2	2.4	0.5		12.5	1.9		21.6	3.4	3.9	7.5	0.5	
Delay (s)	69.7	67.1		69.8	55.9		95.0	48.5	45.4	40.8	8.6	
Level of Service	E	E		E	E		F	D	D	D	A	
Approach Delay (s)		68.2			60.7			47.8			15.8	
Approach LOS		E			E			D			B	

Intersection Summary			
HCM 2000 Control Delay	34.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	68.4%	ICU Level of Service	C
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	850	245	305	475	20	290	50	580	30	60	10
Future Volume (veh/h)	10	850	245	305	475	20	290	50	580	30	60	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
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
Adj Sat Flow, veh/h/ln	1667	1635	1667	1667	1636	1700	1700	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	867	0	311	485	20	296	51	286	31	61	10
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	4	2	2	4	4	2	2	2	2	2	2
Cap, veh/h	18	961	438	337	1551	64	323	56	336	38	75	12
Arrive On Green	0.01	0.31	0.00	0.21	0.51	0.51	0.24	0.24	0.24	0.08	0.08	0.08
Sat Flow, veh/h	1587	3106	1417	1587	3043	125	1364	235	1417	491	965	158
Grp Volume(v), veh/h	10	867	0	311	247	258	347	0	286	102	0	0
Grp Sat Flow(s),veh/h/ln	1587	1553	1417	1587	1554	1614	1598	0	1417	1614	0	0
Q Serve(g_s), s	0.8	35.2	0.0	25.3	12.2	12.3	27.8	0.0	25.4	8.2	0.0	0.0
Cycle Q Clear(g_c), s	0.8	35.2	0.0	25.3	12.2	12.3	27.8	0.0	25.4	8.2	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.08	0.85		1.00	0.30		0.10
Lane Grp Cap(c), veh/h	18	961	438	337	792	823	379	0	336	126	0	0
V/C Ratio(X)	0.54	0.90	0.00	0.92	0.31	0.31	0.92	0.00	0.85	0.81	0.00	0.00
Avail Cap(c_a), veh/h	410	1274	581	410	792	823	425	0	377	435	0	0
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	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	64.7	43.5	0.0	50.8	18.8	18.8	48.9	0.0	48.0	59.7	0.0	0.0
Incr Delay (d2), s/veh	22.4	7.4	0.0	23.8	0.2	0.2	22.9	0.0	15.5	11.5	0.0	0.0
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	0.0
%ile BackOfQ(50%),veh/ln	0.5	16.0	0.0	13.3	5.3	5.5	14.7	0.0	11.4	4.1	0.0	0.0
LnGrp Delay(d),s/veh	87.1	50.9	0.0	74.7	19.0	19.0	71.8	0.0	63.5	71.3	0.0	0.0
LnGrp LOS	F	D		E	B	B	E		E	E		
Approach Vol, veh/h		877			816			633			102	
Approach Delay, s/veh		51.3			40.2			68.1			71.3	
Approach LOS		D			D			E			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.5	73.1		36.2	33.9	46.7		14.8
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	34.0	54.0		35.0	34.0	54.0		35.5
Max Q Clear Time (g_c+I1), s	2.8	14.3		29.8	27.3	37.2		10.2
Green Ext Time (p_c), s	0.0	6.7		1.4	0.6	3.5		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	52.8
HCM 2010 LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	130	655	455	245	375	210	425	1230	305	160	910	70
Future Volume (vph)	130	655	455	245	375	210	425	1230	305	160	910	70
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	3027	1354	1513	4115		2936	4349	1354	1513	4303	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	3027	1354	1513	4115		2936	4349	1354	1513	4303	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	133	668	464	250	383	214	434	1255	311	163	929	71
RTOR Reduction (vph)	0	0	29	0	67	0	0	0	66	0	5	0
Lane Group Flow (vph)	133	668	435	250	530	0	434	1255	245	163	995	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	17.0	35.1	62.3	20.5	38.6		27.2	53.6	74.1	19.8	41.2	
Effective Green, g (s)	19.5	37.6	69.8	23.0	41.1		31.2	55.6	79.1	21.8	43.2	
Actuated g/C Ratio	0.13	0.25	0.47	0.15	0.27		0.21	0.37	0.53	0.15	0.29	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	196	758	630	231	1127		610	1612	714	219	1239	
v/s Ratio Prot	0.09	c0.22	0.15	c0.17	0.13		0.15	c0.29	0.05	c0.11	c0.23	
v/s Ratio Perm			0.17						0.13			
v/c Ratio	0.68	0.88	0.69	1.08	0.47		0.71	0.78	0.34	0.74	0.80	
Uniform Delay, d1	62.3	54.1	31.6	63.5	45.4		55.2	41.8	20.5	61.4	49.5	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.83	0.40	0.26	1.00	1.00	
Incremental Delay, d2	9.0	11.7	3.2	82.8	0.3		2.6	2.6	0.2	12.8	3.9	
Delay (s)	71.2	65.7	34.7	146.3	45.7		103.7	19.4	5.4	74.3	53.3	
Level of Service	E	E	C	F	D		F	B	A	E	D	
Approach Delay (s)		54.9			75.4			35.5			56.3	
Approach LOS		D			E			D			E	

Intersection Summary			
HCM 2000 Control Delay	51.2	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	88.5%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2015 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	70	40	10	400	50	400	20	1390	330	310	1260	40
Future Volume (vph)	70	40	10	400	50	400	20	1390	330	310	1260	40
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.97		1.00	0.89		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	2938		1377	2560		1513	4349	1354	1513	4329	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	2938		1377	2560		1513	4349	1354	1513	4329	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	71	41	10	408	51	408	20	1418	337	316	1286	41
RTOR Reduction (vph)	0	9	0	0	251	0	0	0	134	0	2	0
Lane Group Flow (vph)	71	42	0	306	310	0	20	1418	203	316	1325	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	5.5	5.5		39.5	39.5		3.0	58.0	58.0	27.0	82.0	
Effective Green, g (s)	8.0	8.0		42.0	42.0		4.0	60.0	59.0	28.0	84.0	
Actuated g/C Ratio	0.05	0.05		0.28	0.28		0.03	0.40	0.39	0.19	0.56	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	80	156		385	716		40	1739	532	282	2424	
v/s Ratio Prot	c0.05	0.01		c0.22	0.12		0.01	c0.33		c0.21	0.31	
v/s Ratio Perm									0.15			
v/c Ratio	0.89	0.27		0.79	0.43		0.50	0.82	0.38	1.12	0.55	
Uniform Delay, d1	70.6	68.2		50.0	44.2		72.0	40.1	32.5	61.0	20.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.82	0.69	
Incremental Delay, d2	63.6	0.9		15.5	1.9		9.5	4.3	2.1	78.4	0.5	
Delay (s)	134.1	69.1		65.5	46.1		81.5	44.4	34.5	128.7	15.0	
Level of Service	F	E		E	D		F	D	C	F	B	
Approach Delay (s)		106.9			53.0			43.0			36.9	
Approach LOS		F			D			D			D	

Intersection Summary			
HCM 2000 Control Delay	44.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	89.5%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑	↱	↰↰	↑↱		↰↰	↑	↱	↰	↱	
Traffic Volume (veh/h)	20	435	235	505	785	20	205	30	325	20	70	10
Future Volume (veh/h)	20	435	235	505	785	20	205	30	325	20	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
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
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1604	1604	1700
Adj Flow Rate, veh/h	23	494	0	574	892	23	233	34	164	23	80	11
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	1	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	39	716	470	714	1367	35	326	326	605	39	136	19
Arrive On Green	0.03	0.24	0.00	0.24	0.45	0.45	0.11	0.20	0.20	0.03	0.10	0.10
Sat Flow, veh/h	1527	3047	1363	2963	3035	78	2963	1604	1363	1527	1380	190
Grp Volume(v), veh/h	23	494	0	574	448	467	233	34	164	23	0	91
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1482	1524	1590	1482	1604	1363	1527	0	1570
Q Serve(g_s), s	1.1	10.8	0.0	13.3	16.7	16.7	5.5	1.3	5.5	1.1	0.0	4.0
Cycle Q Clear(g_c), s	1.1	10.8	0.0	13.3	16.7	16.7	5.5	1.3	5.5	1.1	0.0	4.0
Prop In Lane	1.00		1.00	1.00		0.05	1.00		1.00	1.00		0.12
Lane Grp Cap(c), veh/h	39	716	470	714	686	716	326	326	605	39	0	154
V/C Ratio(X)	0.59	0.69	0.00	0.80	0.65	0.65	0.71	0.10	0.27	0.59	0.00	0.59
Avail Cap(c_a), veh/h	105	962	581	1221	1015	1059	732	518	768	482	0	561
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	35.1	25.4	0.0	26.0	15.6	15.6	31.3	23.6	12.8	35.1	0.0	31.4
Incr Delay (d2), s/veh	13.4	1.3	0.0	2.2	1.1	1.0	2.9	0.1	0.2	13.4	0.0	3.6
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	0.0
%ile BackOfQ(50%),veh/ln	0.6	4.7	0.0	5.6	7.2	7.5	2.4	0.6	2.1	0.6	0.0	1.9
LnGrp Delay(d),s/veh	48.5	26.7	0.0	28.2	16.6	16.6	34.2	23.7	13.0	48.5	0.0	35.0
LnGrp LOS	D	C		C	B	B	C	C	B	D		C
Approach Vol, veh/h		517			1489			431			114	
Approach Delay, s/veh		27.7			21.1			25.3			37.7	
Approach LOS		C			C			C			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	6.4	20.8	23.5	22.1	14.0	13.2	7.9	37.8
Change Period (Y+Rc), s	4.5	* 6	6.0	5.0	6.0	6.0	6.0	* 5
Max Green Setting (Gmax), s	23.0	* 24	30.0	23.0	18.0	26.0	5.0	* 49
Max Q Clear Time (g_c+I1), s	3.1	7.5	15.3	12.8	7.5	6.0	3.1	18.7
Green Ext Time (p_c), s	0.0	1.0	2.3	4.3	0.6	1.1	0.0	6.4

Intersection Summary	
HCM 2010 Ctrl Delay	23.9
HCM 2010 LOS	C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	50	265	325	285	605	140	355	650	255	130	1050	110
Future Volume (vph)	50	265	325	285	605	140	355	650	255	130	1050	110
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.97		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2913	1303	2825	2831		2825	4185	1303	1456	4125	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2913	1303	2825	2831		2825	4185	1303	1456	4125	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	288	353	310	658	152	386	707	277	141	1141	120
RTOR Reduction (vph)	0	0	56	0	13	0	0	0	109	0	8	0
Lane Group Flow (vph)	54	288	297	310	797	0	386	707	168	141	1253	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	8.2	28.8	53.3	20.6	41.2		24.5	60.8	81.4	18.8	50.1	
Effective Green, g (s)	10.7	31.3	60.8	23.1	43.7		28.5	62.8	86.4	20.8	52.1	
Actuated g/C Ratio	0.07	0.21	0.41	0.15	0.29		0.19	0.42	0.58	0.14	0.35	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	103	607	528	435	824		536	1752	750	201	1432	
v/s Ratio Prot	0.04	0.10	c0.11	c0.11	c0.28		c0.14	0.17	0.03	0.10	c0.30	
v/s Ratio Perm			0.12						0.09			
v/c Ratio	0.52	0.47	0.56	0.71	0.97		0.72	0.40	0.22	0.70	0.88	
Uniform Delay, d1	67.2	52.1	34.3	60.3	52.4		57.0	30.5	15.5	61.6	45.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.37	0.48	1.39	1.00	1.00	
Incremental Delay, d2	4.7	0.6	1.4	5.5	23.3		3.5	0.5	0.1	10.5	6.3	
Delay (s)	71.9	52.7	35.7	65.8	75.7		81.9	15.1	21.7	72.2	52.2	
Level of Service	E	D	D	E	E		F	B	C	E	D	
Approach Delay (s)		45.6			72.9			35.3			54.2	
Approach LOS		D			E			D			D	

Intersection Summary			
HCM 2000 Control Delay	51.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	84.9%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	40	40	10	220	30	160	10	860	440	420	1230	30
Future Volume (vph)	40	40	10	220	30	160	10	860	440	420	1230	30
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.97		1.00	0.91		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2827		1325	2503		1456	4185	1303	1456	4170	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2827		1325	2503		1456	4185	1303	1456	4170	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	45	45	11	247	34	180	11	966	494	472	1382	34
RTOR Reduction (vph)	0	10	0	0	148	0	0	0	288	0	2	0
Lane Group Flow (vph)	45	46	0	161	152	0	11	966	206	472	1414	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	7.2	7.2		23.8	23.8		1.2	40.0	40.0	59.0	97.8	
Effective Green, g (s)	9.7	9.7		26.3	26.3		2.2	42.0	41.0	60.0	99.8	
Actuated g/C Ratio	0.06	0.06		0.18	0.18		0.01	0.28	0.27	0.40	0.67	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	94	182		232	438		21	1171	356	582	2774	
v/s Ratio Prot	c0.03	0.02		c0.12	0.06		0.01	c0.23		c0.32	0.34	
v/s Ratio Perm									0.16			
v/c Ratio	0.48	0.25		0.69	0.35		0.52	0.82	0.58	0.81	0.51	
Uniform Delay, d1	67.7	66.7		58.1	54.3		73.4	50.6	47.1	40.0	12.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.73	0.81	
Incremental Delay, d2	3.8	0.7		15.8	2.2		21.6	6.7	6.7	8.2	0.5	
Delay (s)	71.5	67.4		73.9	56.5		95.0	57.2	53.8	37.2	10.8	
Level of Service	E	E		E	E		F	E	D	D	B	
Approach Delay (s)		69.2			62.5			56.4			17.4	
Approach LOS		E			E			E			B	

Intersection Summary			
HCM 2000 Control Delay	38.6	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	72.9%	ICU Level of Service	C
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	950	305	355	555	30	340	60	610	40	70	10
Future Volume (veh/h)	10	950	305	355	555	30	340	60	610	40	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
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
Adj Sat Flow, veh/h/ln	1667	1667	1667	1667	1667	1700	1667	1667	1667	1667	1667	1700
Adj Flow Rate, veh/h	10	969	0	362	566	31	347	61	316	41	71	10
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	1	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	19	1171	720	448	1535	84	427	352	505	55	153	22
Arrive On Green	0.01	0.37	0.00	0.15	0.50	0.50	0.14	0.21	0.21	0.03	0.11	0.11
Sat Flow, veh/h	1587	3167	1417	3079	3054	167	3079	1667	1417	1587	1430	201
Grp Volume(v), veh/h	10	969	0	362	293	304	347	61	316	41	0	81
Grp Sat Flow(s),veh/h/ln	1587	1583	1417	1540	1583	1637	1540	1667	1417	1587	0	1631
Q Serve(g_s), s	0.6	26.7	0.0	11.0	10.9	10.9	10.5	2.9	17.8	2.5	0.0	4.5
Cycle Q Clear(g_c), s	0.6	26.7	0.0	11.0	10.9	10.9	10.5	2.9	17.8	2.5	0.0	4.5
Prop In Lane	1.00		1.00	1.00		0.10	1.00		1.00	1.00		0.12
Lane Grp Cap(c), veh/h	19	1171	720	448	796	823	427	352	505	55	0	175
V/C Ratio(X)	0.52	0.83	0.00	0.81	0.37	0.37	0.81	0.17	0.63	0.75	0.00	0.46
Avail Cap(c_a), veh/h	83	1580	903	704	1053	1089	672	399	545	83	0	175
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	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	47.2	27.5	0.0	39.8	14.6	14.6	40.2	31.1	25.6	46.0	0.0	40.3
Incr Delay (d2), s/veh	19.7	2.8	0.0	3.9	0.3	0.3	4.2	0.2	2.0	18.0	0.0	1.9
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	0.4	12.2	0.0	4.9	4.8	5.0	4.7	1.3	7.2	1.4	0.0	2.1
LnGrp Delay(d),s/veh	66.9	30.3	0.0	43.7	14.9	14.9	44.5	31.3	27.6	64.0	0.0	42.2
LnGrp LOS	E	C		D	B	B	D	C	C	E		D
Approach Vol, veh/h		979			959			724			122	
Approach Delay, s/veh		30.7			25.7			36.0			49.6	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	9.3	25.3	20.0	41.6	19.3	15.3	7.2	54.4
Change Period (Y+Rc), s	6.0	5.0	6.0	* 6	6.0	5.0	6.0	6.0
Max Green Setting (Gmax), s	5.0	23.0	22.0	* 48	21.0	7.0	5.0	64.0
Max Q Clear Time (g_c+I1), s	4.5	19.8	13.0	28.7	12.5	6.5	2.6	12.9
Green Ext Time (p_c), s	0.0	0.6	1.0	6.8	0.8	0.1	0.0	8.3

Intersection Summary	
HCM 2010 Ctrl Delay	31.2
HCM 2010 LOS	C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	130	685	485	305	395	230	465	1240	435	180	910	70
Future Volume (vph)	130	685	485	305	395	230	465	1240	435	180	910	70
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.94		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	3027	1354	2936	2860		2936	4349	1354	1513	4303	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	3027	1354	2936	2860		2936	4349	1354	1513	4303	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	133	699	495	311	403	235	474	1265	444	184	929	71
RTOR Reduction (vph)	0	0	27	0	55	0	0	0	69	0	6	0
Lane Group Flow (vph)	133	699	468	311	583	0	474	1265	375	184	994	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	17.6	38.3	67.9	11.5	32.2		29.6	57.8	69.3	21.4	44.6	
Effective Green, g (s)	20.1	40.8	75.4	14.0	34.7		33.6	59.8	74.3	23.4	46.6	
Actuated g/C Ratio	0.13	0.27	0.50	0.09	0.23		0.22	0.40	0.50	0.16	0.31	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	202	823	680	274	661		657	1733	670	236	1336	
v/s Ratio Prot	c0.09	c0.23	0.16	c0.11	0.20		0.16	c0.29	0.05	c0.12	0.23	
v/s Ratio Perm			0.19						0.22			
v/c Ratio	0.66	0.85	0.69	1.14	0.88		0.72	0.73	0.56	0.78	0.74	
Uniform Delay, d1	61.7	51.7	28.4	68.0	55.7		53.9	38.3	26.4	60.8	46.4	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.52	0.42	0.31	1.00	1.00	
Incremental Delay, d2	7.5	8.2	2.9	95.8	13.1		2.8	2.0	0.8	15.0	2.3	
Delay (s)	69.2	59.9	31.3	163.8	68.8		85.0	18.2	8.9	75.8	48.7	
Level of Service	E	E	C	F	E		F	B	A	E	D	
Approach Delay (s)		50.1			99.9			30.8			52.9	
Approach LOS		D			F			C			D	

Intersection Summary			
HCM 2000 Control Delay	51.6	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.84		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	85.3%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	70	50	10	410	60	430	20	1390	340	340	1270	50
Future Volume (vph)	70	50	10	410	60	430	20	1390	340	340	1270	50
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.98		1.00	0.89		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	2953		1377	2559		1513	4349	1354	1513	4325	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	2953		1377	2559		1513	4349	1354	1513	4325	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	71	51	10	418	61	439	20	1418	347	347	1296	51
RTOR Reduction (vph)	0	9	0	0	251	0	0	0	138	0	3	0
Lane Group Flow (vph)	71	52	0	322	345	0	20	1418	209	347	1344	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	5.5	5.5		39.5	39.5		3.0	58.0	58.0	27.0	82.0	
Effective Green, g (s)	8.0	8.0		42.0	42.0		4.0	60.0	59.0	28.0	84.0	
Actuated g/C Ratio	0.05	0.05		0.28	0.28		0.03	0.40	0.39	0.19	0.56	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	80	157		385	716		40	1739	532	282	2422	
v/s Ratio Prot	c0.05	0.02		c0.23	0.13		0.01	c0.33		c0.23	0.31	
v/s Ratio Perm									0.15			
v/c Ratio	0.89	0.33		0.84	0.48		0.50	0.82	0.39	1.23	0.56	
Uniform Delay, d1	70.6	68.4		50.8	44.9		72.0	40.1	32.7	61.0	21.1	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.93	0.89	
Incremental Delay, d2	63.6	1.2		19.0	2.3		9.5	4.3	2.2	121.2	0.6	
Delay (s)	134.1	69.6		69.8	47.2		81.5	44.4	34.8	177.6	19.2	
Level of Service	F	E		E	D		F	D	C	F	B	
Approach Delay (s)		104.3			55.1			43.0			51.7	
Approach LOS		F			E			D			D	

Intersection Summary			
HCM 2000 Control Delay	50.5	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	92.7%	ICU Level of Service	F
Analysis Period (min)	15		
Description: 2040 forecast			
c Critical Lane Group			