WASHINGTON AND OLD DOMINION TRAIL

SIX INTERSECTION STUDY

RECOMMENDATIONS REPORT

MAY 2012

PREPARED BY:

TOOLE DESIGN GROUP
FOR:

NORTHERN VIRGINIA REGIONAL PARK AUTHORITY

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EXECUTIVE SUMMARY

The Northern Virginia Regional Park Authority (NVRPA) commissioned an evaluation of the physical and operational conditions at six roadway crossings along the Washington and Old Dominion (W&OD) Trail. The purpose of this report is to complement the Existing Conditions Report (February 2012) with specific recommendations for short term improvements at each location to mitigate safety and operational deficiencies. For a few locations, we discuss potential considerations for long-term consideration.

RECOMMENDATION APPROACH

Based on field inventory and observations, sight-distance assessments, trail-user intercept surveys, spot speed counts, and video counts and analysis, specific recommendations were developed for each trail crossing location with a goal of improving the safety, comfort, and priority of trail users at each crossing. The trail-user intercept surveys allowed trail users to provide their ideas for improvement. A summary of trail-user opinions is included for each location along with representative suggestions which were considered in the development of short term and long term improvement recommendations.

The majority of recommendations have potential for short term implementation (6 months to 2 years). They are generally in conformance with MUTCD, AASHTO, NVRPA, and VDOT guidelines with a few exceptions which are noted as requiring potential FHWA/VDOT experimentation. Experimental recommendations are limited to treatments which have demonstrated potentially promising safety or operational benefits in similar environments. These recommendations include estimates of probable cost and will likely require coordination and support of VDOT and/or other local jurisdictions to implement.

Potential long term improvements are noted where appropriate and an opinion of grade separation is offered. Cost estimates are not developed for these long term alternatives. Additionally, grade separation analysis requires additional engineering analyses to provide accurate cost/benefit assessment.

Recommendations are noted as short-term (S1, S2, etc.), mid-term (M1, M2, etc.), or long-term (L1, L2, etc.). These recommendations are unique to each location. General recommendations (G1, G2, etc.) are intended for uniform application at each of the study locations.

GENERAL RECOMMENDATIONS

The following general recommendations are recommended for uniform adoption throughout the trail system and for these six intersections in particular.

G1. Maintain minimum required sight triangles for the stop/signal controlled condition.
Not providing the sight triangles may contribute to poor yielding behavior, increase trail-user discomfort, or be a contributing factor in a crash. The trail sight line triangle is determined along the trail by the stop line on the trail (typically 6-10 feet from the roadway edge) and varies along the roadway (based on the approach speed of motorists and roadway grade). The required sight triangles

are included in Appendix I of the Existing Conditions Report. This does not mean trees or buildings need to be removed. It is recommended vegetation be cleared between 2 feet and 10 feet from ground level.

These minimum sight lines are recommended by AASHTO and VDOT guidelines.

G2. Clear vegetation to the maximum extent feasible approaching roadways.
Any additional clearing of vegetation vertically (between 2 and 10 feet from the ground) outside of the minimum sight triangles will open views towards the roadway and improve the safety of those trail users who will continue to approach intersections and not stop completely.

G3. Maintain minimum sight triangles between intersecting sidewalks/shoulders.
Providing 15 foot by 25 foot clear triangular areas on the approaches to pedestrian sidewalks and shoulders will improve pedestrian and trail user safety by ensuring both users have sufficient space to see each other and stop prior to colliding. The forthcoming AASHTO Bike Guide will recommend the minimum sight line shown in the figure below.

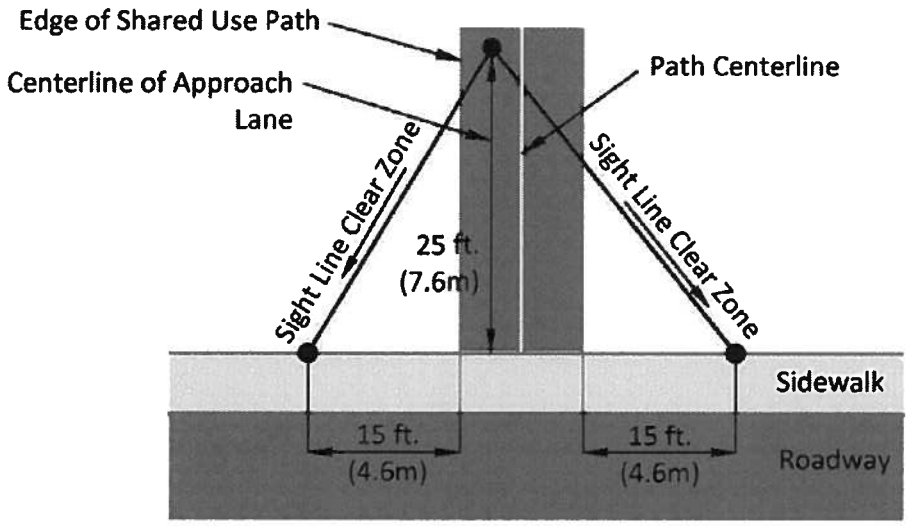


Figure 1 - AASHTO 2012 recommended sight lines between trails and sidewalks

G4. Improve or provide lighting of trail crossings.
Trail lighting was assessed as part of a separate analysis by NVRPA and TDG. Based upon the findings of this study documenting inconsistent yielding and high volume so users, it is recommended that the following intersections where vehicles turn across the trail be prioritized for lighting - Lee Highway {11th}, Columbia Pike {3rd}, Wiehle {1st}. At Sterling Boulevard, should the installation of rapid flashing beacons not be determined to be feasible or produce the intended results if installed, the installation of improved lighting should be considered a higher priority at this location given the low yielding rate, the multiple threat condition, and the surrounding higher density land use.

G5. Widen curb ramps, trail approaches, and crosswalks to 14-20 feet.
The existing 10 foot trail and crossing requires users to cross essentially in single file. Widening the trail approach and crosswalk to 14-20 feet will allow larger platoons of users to cross in less time without conflicting with crossing users. The width of the widening and curb ramp will be contingent upon the approach geometry of each intersection. It is recommended that the curb ramps be designed to match the full width of the trail with flares located outside of the trail width where it is determined they are necessary. During reconstruction projects, the trail approach could be split into two segments to promote the separation of crossing trail traffic (minimizing conflicts between opposing directions of traffic) and to prevent motorists from thinking it is a roadway into which they can turn.

Figure 2 - Example split trail crossing, Interurban Trail, Seattle

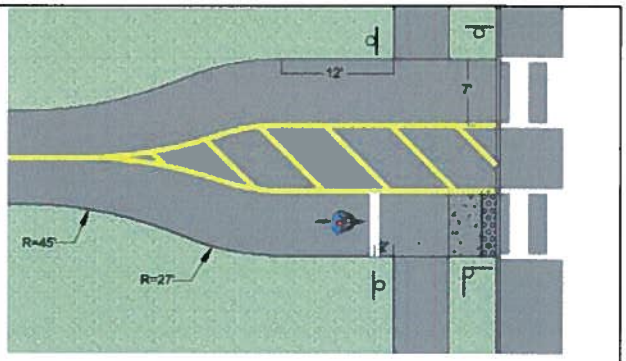


Figure 3 - Example split trail crossing with flush median and split crosswalk

G6. Pave approximately 25 feet of the bridle trail approach to the W&OD.
There were numerous requests to keep stones from the bridle trail off from the paved W&OD portion of the trail as they potentially create slipping hazards for trail users. To reduce the workload of maintenance crews, it is recommended that the first 25 feet of the bridle trail be paved. This should create sufficient space for the stones and debris to clear from feet and wheels before the user enters the mainline of the W&OD trail.

With the exception of lighting, the probable cost of these improvements is incorporated into each specific location described in the remainder of this memorandum.

Discussion of Installation of Traffic Signal or Active Warning Devices for Uncontrolled Crossings at Belmont Ridge Road, Sterling Boulevard, and Hunter Mill Road.

Each of the trail crossings were identified by trail users as being the most uncomfortable crossings of the six intersections evaluated. The existing conditions analysis verified each location had generally low motorists yielding rates, high motorist speeds, and poor sight lines which are likely to contribute to the trail user safety concerns. For each trail crossing, the following MUTCD warrants were reviewed to test potential need for a traffic signal:

- Warrant 3, Peak Hour (Figure 4C-3)
- Warrant 4, Pedestrian Volume – Peak Hour (Figure 4C-8)

For purposes of the warrant analysis, bicyclists were considered vehicles for Warrant 3; bicyclists were considered pedestrians to evaluate the Warrant 4.The motor vehicle and trail volumes were quantified during the behavior and compliance observations portion of the project and not separately established. Due to the methodology of the existing conditions assessment, evaluations of the 4-hour warrants were not feasible (two hours of counts on two days instead of 4 hours of counts on one day); therefore, the peak hour warrants were evaluated. The following hours were evaluated - on a weekday between 1 and 2 pm and 4-5pm; on a weekend between 11am and 12pm and 4-5pm. With the exception of 1 – 2pm, these hours correspond with typical peak periods of trail and motorists traffic volumes at these locations. Due to the higher speeds of vehicles documented at each crossing, Warrant 4 was evaluated with the 70% reduction factor chart (Figure 4C-8).

Each location met signal warrants for the installation of a traffic signal (Warrant 3) or a pedestrian signal (warrant 4) due to high peak hour volumes on the trail in conjunction with high roadway volumes and speeds. The maximum delay experienced by trail users who had to wait was assessed and found to vary from a low of 36 seconds at Hunter Mill to 43 seconds at Belmont Ridge and a high of 69 seconds at Sterling Boulevard. As discussed in the existing conditions report, delays in excess of 30 seconds can result in risky crossing behaviors resulting from the poor level of service. However, when all trail users are considered at these locations, the mean delay varied from 3 to 9 seconds. This suggests a combination of motorist yielding along with sufficient gaps in traffic provides a high level of service for a majority of trail users.

Installation of a traffic signal would benefit the smaller group of trail users who have to wait up to a minute to cross the roadway by creating gaps in traffic (if the signal is set for a relatively quick or a "hot" response). However, the installation of a traffic signal would likely require it be coordinated with adjacent traffic signals which would require trail users to stop at the trail signal, even when gaps in traffic are available. This will increase trail user delay and degrade their level of service similar to the conditions at Columbia Road or Lee Highway. Unfortunately, experience has shown signals installed at locations with short crossings in conjunction with frequent gaps in traffic have resulted in trail users crossing against the signals which are not set for a "hot" response. This frustrates motorists who appear to be stopping for no one and it breeds disrespect for the signal by trail users who feel it doesn't work it they have to wait 30 seconds or more regardless of traffic flow.

It is important to note the MUTCD does not require installation of a signal if warrants are met and suggests a series of alternative solutions (Section 4B.04) including the following:

- Addition of additional signs or markings
- Improving sight distances
- Reducing approach speeds
- Add a pedestrian refuge
- Installing a flashing beacon
- Installing a pedestrian hybrid beacon

Attempts have been made to enhance signs and markings at all three locations. A median would be beneficial at Hunter Mill Road and Belmont Ridge Road but it will require a larger roadway project to implement. A standard non-actuated flashing beacon is present at Hunter Mill Road. The device and/or pavement markings are contributing positively to yielding behavior which was found to be the highest of the uncontrolled locations at 52% which is significantly higher than the more typical 30% for these passive style warning systems. The 52% yielding rate is consistent with other research studies and may be the maximum rate feasible for this device.

Given the frequency of gaps it is recommended that an active traffic control device be installed in lieu of a traffic signal or passive warning beacon at these locations. Based on recent research indicating a high effectiveness at relatively low installation cost, it is recommended the rapid flashing beacon be installed and evaluated for effectiveness for trail and motorists safety at Belmont Ridge Road and Sterling Boulevard. Consideration should also be given to retrofitting the Hunter Mill Crossing Warning Sign to be actuated by trail users or to replace it with a rapid flashing beacon.

Rapid flashing beacons have been issued interim approval by the Federal Highway Administration for use with pedestrian and trail crossings. Test results have shown they can increase yielding rates to a sustained 70-90% from baselines as low as 5%. The beacons can be wirelessly interconnected and solar powered. This device will require VDOT support but does not require FHWA experimentation as it is approved for use at trail crossings. It may be desirable to experiment with passive detection strategies (microwave, video, etc.) as numerous studies have found fewer than 50% of pedestrians (trail users) will actuate the device.

Should it be determined that a rapid flashing beacon not provide sufficient yielding rates or result in a degradation of safety for trail users or motorists, a pedestrian hybrid beacon may be warranted. Each location meets the criteria for the installation of a pedestrian hybrid beacon.

SITE SPECIFIC RECOMMENDATIONS

BELMONT RIDGE ROAD

PUBLIC FEEDBACK

When asked what improvements they would recommend to improve safety at this crossing, 36% suggested a traffic signal and 27% suggested an underpass or overpass. Ten percent (10%) recommended a stop sign for motorists on Belmont Ridge Road and 9% suggested flashing lights to warn motorists of the trail. These percentages are based on the total number of survey respondents. Approximately one fifth of the survey respondents did not give a recommendation and one quarter offered more than one recommendation. Figure 1 visualizes these recommendations. Appendix B contains detailed survey data.

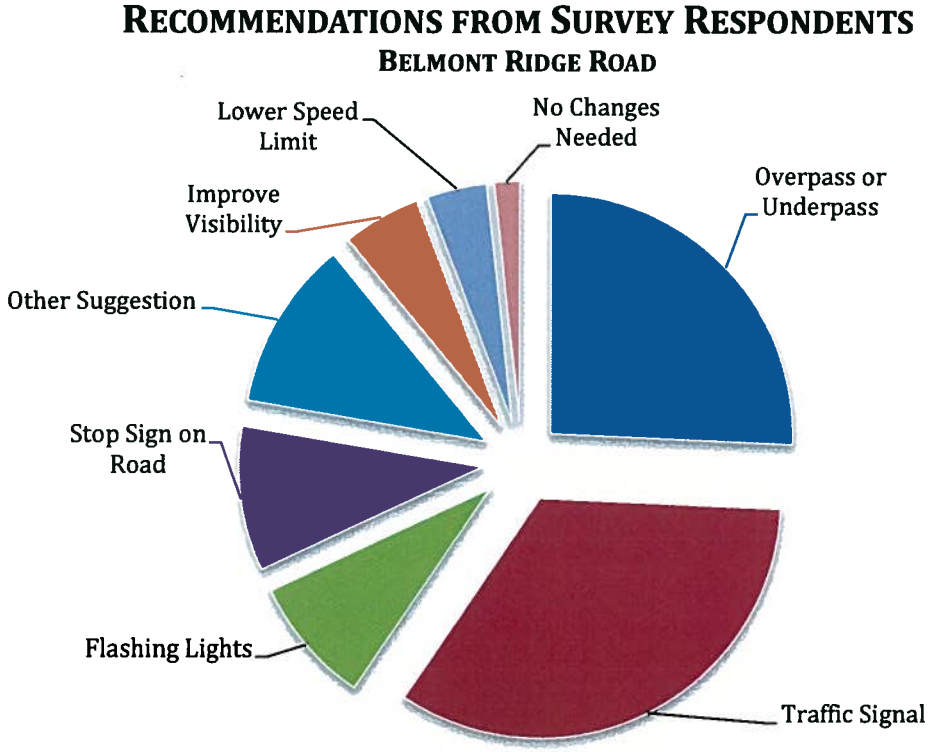


Figure 4: Safety Improvement Recommendations from Survey Respondents at Belmont Ridge Road

Select Trail User Comments

SELECTED TRAIL USER COMMENTS

The following are representative examples of the types of improvements trail users provided to the project team during the in-person trail-user intercept survey in the summer of 2011.

"Signal or Overpass"

"blinking yellow or red"

"either an overpass or a stop light"

"overgrown bushes on east side"

"more notice to the auto, cut down bushes"

"slower speed limits for cars. more enforcement to slow cars & make them stop for trail users. more measures to make cars observe the crosswalk to yield to bikes/peds"
"this is one of the scariest crossings on the W&OD trail due to high speed of the cars - stop light or lowered road speed limit"

"fly over or speed limit reduction to 30-35 mph"

"limit parking west side of road since parked cars restrict visibility to cars driving south on Belmont"

"put in traffic light w/ crosswalk signal--also at hunter mill crossing"

"better signs, educate motorists regarding right of ways"

"stop light when the pedestrian wants to cross"
"a bridge is excessive"

"cut grass for sight distance crossing and to see runners/bikes"
"flashing lights"

"Clean the gravel from trail"

"overpass- too many rear end collisions when drivers unexpectedly & unnecessarily stop trim/remove the shrubbery so its easier for drivers to see, maybe flashing lights on the road as drivers approach"

RECOMMENDATIONS

Long term this crossing is slated for grade separation. This is the preferred solution considering the vehicle speeds, sight lines, and low yielding rates. This crossing was determined to be the most hazardous and uncomfortable of the six locations studied. The trail crossing met signal warrants for the installation of a traffic signal (warrant 3), pedestrian signal (warrant 4), and a pedestrian hybrid signal due to high peak hour volumes on the trail in conjunction with high roadway volumes and speeds.

VDOT has not identified funding for the Belmont Ridge Road Widening and Bridge project. It is therefore recommended that shorter term improvements be incorporated as soon as possible to improve safety at this location.

S1. Relocate or eliminate parking area on the northwest corner at Belmont Ridge Road.
This parking presents a safety hazard to trail users and motorists by limiting sight lines, introducing unexpected parking maneuvers within the roadway, and creating unexpected street crossings. Consideration should be given to expanding the parking area on the northeast side (old Judith Road)

or to relocating both parking areas to a trail head on Jackpit Lane. This could create an opportunity to create a welcoming trail head.

Figure 5: The existing parking and portions of the vegetation are limiting sight lines between trail users and motorists below the clearance areas recommended by AASHTO

S2. Replace Trail Crossing Signs with Actuated Rectangular Rapid Flash Beacons.
This crossing was determined to be the most hazardous and uncomfortable of the six locations studied. The trail crossing met signal warrants for the installation of a traffic signal (warrant 2), pedestrian signal (warrant 4), and a pedestrian hybrid signal. It is recommended that this location include an advance flashing beacon (to replace the existing advance W11-1 sign) and a beacon at the crossing (replacing the existing W11-1 sign) due to the high vehicle speeds. The beacons can be wirelessly interconnected and solar powered. The beacons should be pedestrian actuated or provide passive detection.

S3. Provide an advance yield line along with a modified R1-5 sign.
It is recommended a yield line be located 20 feet in advance of the crossing to improve the comfort of the trail users crossing the roadway.

Figure 6: Example of an advanced yield line utilized in conjunction with a Rapid Flashing Beacon installation in Boulder, CO

M1. Mid Term Crossing Island

Should it begin to look like it may be infeasible or unlikely that Belmont Ridge Road would be widened by VDOT, it is recommended that consideration be given to a spot roadway widening project which would allow the construction of a 12 foot wide crossing island to create a refuge and to traffic calm the crossing.

L1. Long Term Grade Separation

It is understood that VDOT has preliminary design completed for a widening of Belmont Ridge Road which would include a bridge over the W&OD Trail. Due to the high vehicle speeds and low yielding rates, this grade separation project should be a high priority for installation to ensure the safety of trail users from potentially fatal crashes and motorists from potentially severe rear end crashes. The preliminary design plans depict the provision of 10 foot shared use paths on both sides of Belmont Ridge Road with two connections to the trail provided. It is recommended the proposed plan be modified to provide four connections to the trail to limit the need for trail users to cross Belmont Ridge Road (two new connections shown with cyan colored arrows).

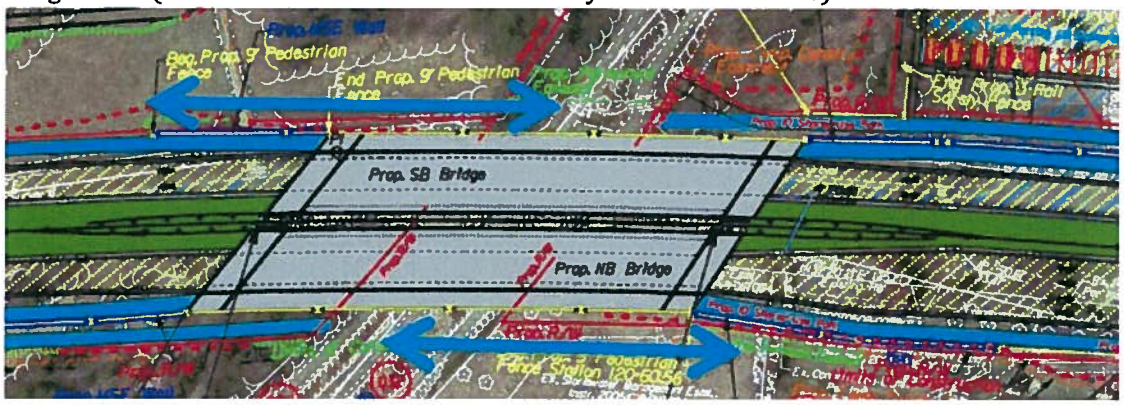


Figure 7: VDOT preliminary engineering plan with TDG recommendation for completing sidewalk network on both sides of the roadway

ESTIMATE OF PROBABLE COST

It is estimated that the development of construction drawings and the actual construction of the short term improvements will cost approximately $65,200. This estimate does not include paving a portion of the bridal trail, the addition of street lighting, clearing of shrubbery and trees obstructing sight lines, or the removal of the parking area. Mid-term and long term concept drawings and cost estimates were not developed. The largest cost item for this location is the rapid flashing beacons. The concept design for the short term improvements can be found in Appendix A. The backup details for the cost estimate calculation can be found in Appendix B.

OPINION OF GRADE SEPARATION

It appears realistic to consider grade separation at this location to improve the comfort, safety, and convenience of the W&OD trail users and to reduce delays to traffic on the Belmont Ridge Road. Due to the low yielding rate and higher motorist operating speeds, this would be the highest priority grade separation location as well given the fact this has completed preliminary engineering work completed by VDOT.

STERLING BOULEVARD

PUBLIC FEEDBACK

When asked what improvements they would recommend to improve safety at this crossing, 30% suggested a traffic signal and 24% suggested an underpass or overpass. Twelve percent (12%) recommended flashing warning lights for motorists on Sterling Boulevard and 9% felt that increased warning signage could increase safety. These percentages are based on the total number of survey respondents. Approximately one third of the survey respondents did not give a recommendation and one fifth offered more than one recommendation. Figure 5 visualizes these recommendations. Appendix B contains detailed survey data.

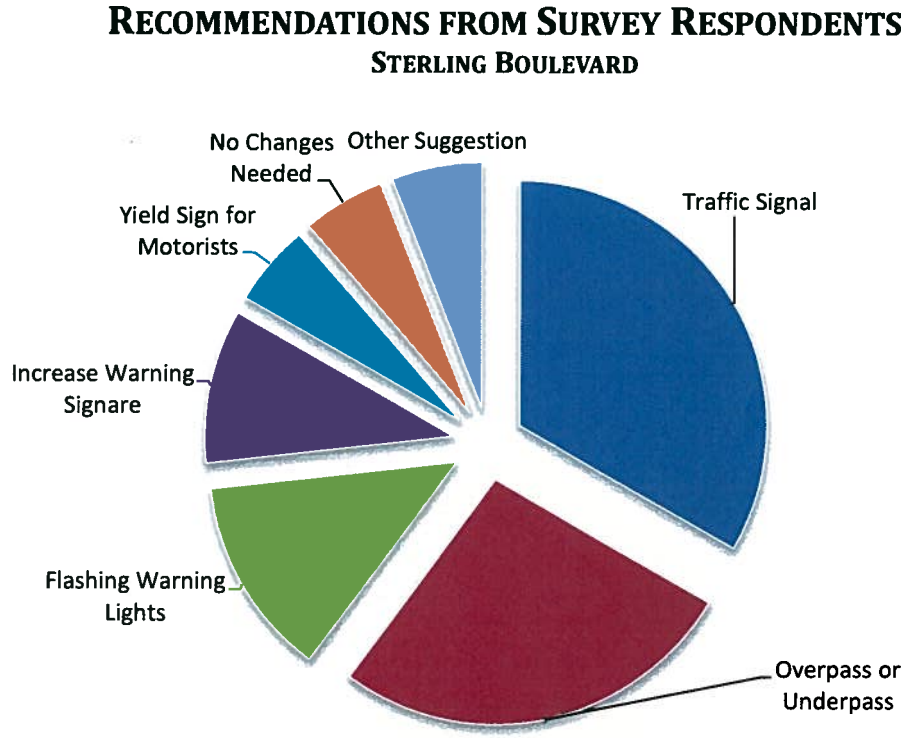


Figure 8: Safety Improvement Recommendations from Survey-Takers at Sterling Boulevard

SELECTED TRAIL USER COMMENTS

The following are representative examples of the types of improvements trail users provided to the project team during the in-person trail-user intercept survey in the summer of 2011.

> *"at least a traffic light. the best solution would be a bridge over the traffic lanes"*
>
> *"flashing yellow lights for cars"*
>
> *"find some way to slow auto traffic"*

"a blinking yellow light on sterling blvd. please remind the bikers to slow down a bit. some of them are riding too fast in congested areas"

"flashing warning lights on road. a bridge"

RECOMMENDATIONS

S4. Widen median curb curt to match widened trail and crosswalk.
A wider crossing will allow more trail users to stage within the median.

S5. Replace Trail Crossing Signs with Actuated Rectangular Rapid Flash Beacons.
Given the low motorists yielding compliance and the high operating speeds at this location, it is recommended the rapid flashing beacon be installed. The trail crossing met signal warrants for the installation of a traffic signal (warrant 3), pedestrian signal (warrant 4), and a pedestrian hybrid signal. To address the multiple threat condition at this crossing, the posting of a rapid flashing beacon on the right hand side of the road and on the left hand side (median) side of the roadway should be considered. The beacons can be wirelessly interconnected and solar powered. The beacons should be pedestrian actuated or provide passive detection.

S6. Provide an advance yield line along with a modified R1-5 sign.
It is recommended a yield line be located 20 feet in advance of the crossing to improve the comfort of the trail users crossing the roadway.

S7. Reduce the length of the northbound deceleration/left turn lane on Sterling Boulevard to expand median refuge.
The extension of the travel lane through the median refuge and crosswalk requires trail users to cross an additional lane of traffic increasing the chances of a multiple threat crash. This would require the lane be shortened approximately 60 feet.

S8. Complete sidewalk network along Sterling Boulevard.
Sidewalks end unexpectedly on the approach to the trail from the adjacent sidewalk network. It is recommended the sidewalk system be completed on both sides of Sterling Boulevard between the trail and the adjacent intersections.

Figure 9: It is recommended to trim existing vegetation and complete the sidewalk connection to the trail in addition to providing advanced yield line and rapid flashing beacons

ESTIMATE OF PROBABLE COST

It is estimated that the development of construction drawings and the actual construction of the short term improvements will cost approximately $101,750. This estimate does not include paving a portion of the bridal trail, the addition of street lighting, clearing of shrubbery and trees obstructing sight lines, or the construction of additional sidewalks along Sterling Boulevard. Mid-term and long term concept drawings and cost estimates were not developed. The largest cost item for this location is the rapid flashing beacons. The concept design for the short term improvements can be found in Appendix A. The backup details for the cost estimate calculation can be found in Appendix B.

OPINION OF GRADE SEPARATION

It appears realistic to consider grade separation at this location to improve the comfort, safety, and convenience of the W&OD trail users and to reduce delays to traffic on the Sterling Boulevard. Due to the low yielding rate and higher motorist operating speeds, this could be a higher priority grade separation location should the short term improvements not prove to be effective at improving yielding rates by motorists to trail users.

The trail alignment and adjacent land uses appear to provide sufficient space for required ADA accessible ramps without major obstructions or conflicts with adjacent utilities. To access the viability of grade separation and to determine potential construction and engineering cost, further study is required. Should grade separation be pursued, it is recommended all four connections be made between Sterling Boulevard and the W&OD Trail.

WIEHLE AVENUE

PUBLIC FEEDBACK

When asked what improvements they would recommend to improve safety at this crossing, 22% suggested an underpass or overpass and 18% suggested a traffic signal. Twelve percent (12%) recommended flashing warning lights for motorists on Wiehle Avenue. These percentages are based on the total number of survey respondents. Approximately one third of the survey respondents did not give a recommendation and one tenth offered more than one recommendation. Figure 7 visualizes these recommendations. Appendix B contains detailed survey data.

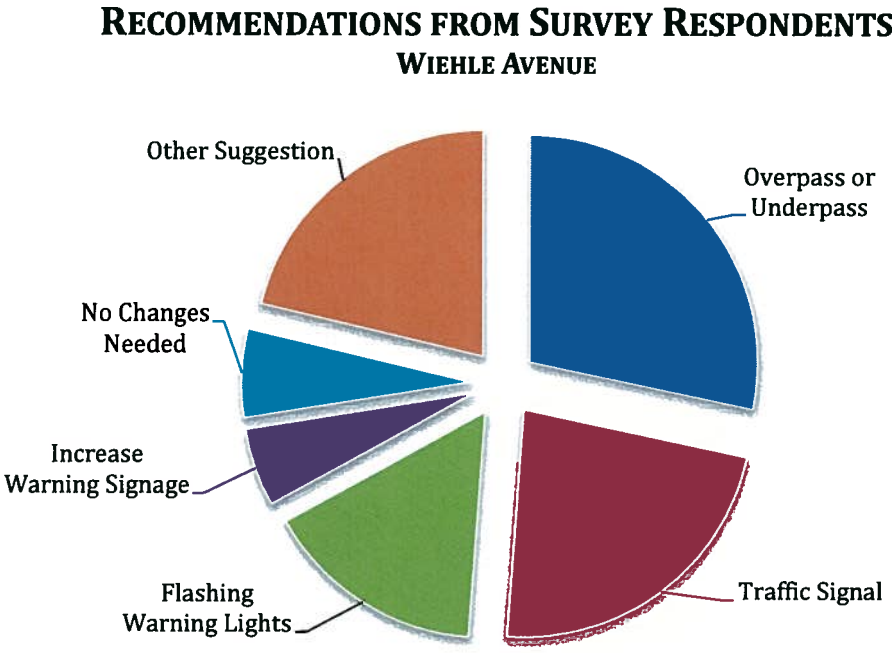


Figure 10: Safety Improvement Recommendations from Survey Respondants at Wiehle Avenue

SELECT TRAIL USER COMMENTS

The following are representative examples of the types of improvements trail users provided to the project team during the in-person trail-user intercept survey in the summer of 2011.

> *"add a bike signal synced with traffic light. or make bike crosswalk at light crosswalk"*
>
> *"traffic taking a right from sunset hills toward trail should be on green only to make crossing more predictable"*
>
> *"bridge or coordinated lights with cross walk light for path"*
>
> *"right turn signal on sunset hills does not alert drivers to crosswalk/trail - they turn, gun the gas, and don't see you until too late"*

"center median not wide enough for bikes, often have to cross in 2 segments (stop in middle) so this is unsafe, westbound approach is too steep, makes stopping more difficult"

"pedestrian activated flashing yellow or red, like a "hawk" or similar, problem is proximity to the left and right turns"

"southbound traffic on Wiehle Ave should be required to stop before trail when light is red at sunset hills. traffic turning right from westbound sunset hills should be required to stop at trail and proceed only when northbound traffic on Wiehle Ave has a green light at sunset hills"

"move the cross walk down the road away from the intersection"

"better enforcement of crosswalk"

"red light beyond the crosswalk to hold traffic short of the trail until green"

RECOMMENDATIONS

S9. Widen median curb curt to match widened trail and crosswalk.

A wider crossing will allow more trail users to stage within the median. Given the narrowness of the existing a median, the wider opening will allow users to angle themselves within the median so trailers and longer bikes will not be exposed to cross traffic should they be waiting in the median. The median should also be designed to contrast with the roadway to help trail users visualize the "protected" area where they can wait without being exposed within an adjacent travel lane.

Figure 11: Example of widened median with full width curb cut and differentiating surface treatment

S10. Add an additional traffic signal for the southbound Sunset Hills Road approach to Wiehle Avenue prior to the crosswalk with a stop line.

Due to the proximity of the crossing to the signal at Wiehle Avenue, motorists are blocking the crosswalk at a high percentage. The presence of motorists within the crosswalk creates a potentially

hazardous situation as trail users are moving between vehicles, have difficulty accessing the curb cut to the median, and have limited sight lines with motorists turning northbound onto Sunset Hills Road from Wiehle Avenue. The signal timing should be set to stop motorists closest to the fire station with a few seconds of green time at the signal at Wiehle Avenue to clear cars from the crosswalk.

It is recommended NVRPA convene a working meeting with VDOT staff to discuss how best to add this signal mast arm. The design will require an assessment of the visual impact and operation of the adjacent fire station emergency signal and existing signal at Sunset Hills Road. A new signal may require an additional mast arm be installed with a stop line to indicate where motorists should stop prior to the crosswalk.

S11. Provide an advance yield line along with a modified R1-5 sign for the northbound Sunset Hills Road approach to the trail crossing.
Advanced yield lines have been documented to reduce the multiple threat crash as it improves the sight line for crossing trail users to the second lane of traffic.

S12. Discuss with VDOT the narrowing of travel lanes and/or the widening of Sunset Hills Road to widen the median to 14 feet.
The existing 7 foot six inch median could be widened by narrowing the existing travel lanes to 10 feet (existing lanes vary from 11 to 13 feet). This could potentially add up to 6 additional feet of width to the median. An alternative which might be more palatable to VDOT would be to standardize the lanes at 11 feet, and to widen the roadway approximately 6 feet towards the west which would also improve the travel lane alignment through the intersection.

S13. Provide advance trail crossing warning signs (W11-15) for eastbound left turning traffic and westbound right turning traffic from Sunset Hills Road.

S14. Provide turning traffic yield to pedestrians and bicycles signs (modified W10-15) notifying motorist to yield to pedestrians and bicyclists in crosswalk adjacent to traffic signal on the signal span wire.

ESTIMATE OF PROBABLE COST
It is estimated that the development of construction drawings and the actual construction of the short term improvements will cost approximately $110,375. This estimate does not include paving a portion of the bridal trail, the addition of street lighting, or clearing of shrubbery and trees obstructing sight lines. Mid-term and long term concept drawings and cost estimates were not developed. The largest cost item for this location is the installation of a new traffic pole mast arm with signals and the installation of pedestrian and bicycle signals. The concept design for the short term improvements can be found in Appendix A. The backup details for the cost estimate calculation can be found in Appendix B.

OPINION OF GRADE SEPARATION
It appears possible to consider grade separation at this location to improve the comfort, safety, and convenience of the W&OD trail users and to reduce delays to traffic on the Wiehle Avenue. This location does not appear to be in need of grade separation if the short term recommendations resolve the conflicts with motorists blocking the crosswalk and turning motorists increase rates of yielding.

The trail alignment and adjacent land uses appear to provide sufficient space for required ADA accessible ramps but there may be severe challenges with a bridge due to the overhead powerline wire locations. It may be more realistic to focus on a tunnel, but that too may have serious conflicts with buried utilities. To access the viability of grade separation and to determine potential construction and engineering cost, further study is required. Should grade separation be pursued, it is recommended all four connections be made between Wiehle Avenue and the W&OD Trail.

HUNTER MILL ROAD

PUBLIC FEEDBACK

When asked what improvements they would recommend to improve safety at this crossing, 17% suggested an underpass or overpass and 14 % recommended flashing warning lights for motorists on Hunter Mill Road. Eighteen percent (18%) suggested a traffic signal and 9% recommended a stop sign for motorists. These percentages are based on the total number of survey respondents. Approximately one third of the survey respondents did not give a recommendation and one tenth offered more than one recommendation. Figure 9 visualizes these suggestions. Appendix B contains detailed survey data.

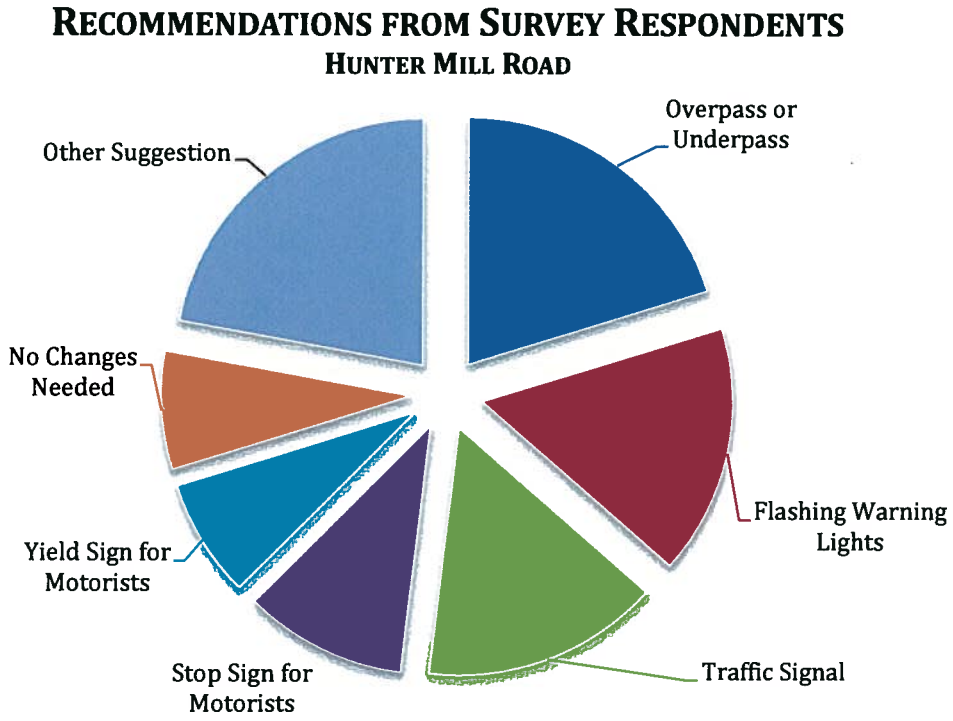


Figure 12: Safety Improvement Recommendations from Survey Respondents at Hunter Mill Road

SELECT TRAIL USER COMMENTS

The following are representative examples of the types of improvements trail users provided to the project team during the in-person trail-user intercept survey in the summer of 2011.

> *"lower the speed limit within two miles of intersection either direction by 5 miles"*
>
> *"flashing yield signs"*
>
> *"1) a bridge over Hunter Mill 2) until a bridge is installed, a traffic signal for mandatory motor vehicle stop when trail users are present. need detector sensor for trail users or maybe a light switch/button that works within 5-10 seconds"*

"put up clear signs like in arlington or at zebra crossings in some mall parking areas. "Stop. State law. Stop for pedestrians or cyclists at crosswalk""

"cut down some of the trees/shrubbery that block views of the road coming from south, cars have to come up a hill, harder to see"

"it is a blind curve in both directions. do something about the road or build a bridge"

"Please DO NOT suggest a traffic signal at the intersection. We would be forced to wait too long. A bridge is the only other option that would be acceptable. The intersection works as is 99% of the time."

"Removing more of the brush at all intersections to give trail & road users more visibility"

"Build a bridge over the road before more people diUntil you do that, clear out brush on the right side coming from Tamarack so you can see when you can cross and so that cars can see you."

RECOMMENDATIONS

S15. Replace Advanced Trail Crossing Flashing Beacon and Trail Crossing Signs with Actuated Rectangular Rapid Flash Beacons.

Flashing beacons which flash continuously have not demonstrated an ability to provide consistent yielding from motorists. This is likely due to the fact the beacon flashes continuously and the light does not command attention. Given the low motorists yielding compliance and the poor sight lines at this location, it is recommended the rapid flashing beacon be installed.

Rapid flashing beacons have been issued interim approval by the Federal Highway Administration for use with pedestrian crossings. Test results have shown they can increase yielding rates to a sustained 70-90% from baselines as low as 5%. Thus far they have been utilized in urbanized locations strictly as pedestrian crossings. Their use at trail crossing has potential but would be considered experimental for a trail context. It is recommended that this location include an advance flashing beacon (to replace the existing advance W11-1 sign) and a beacon at the crossing (replacing the existing W11-1 sign) due to the high vehicle speeds. The beacons can be wirelessly interconnected and solar powered. The beacons should be pedestrian actuated.

This device will require VDOT support and would require FHWA experimentation as it is not explicitly approved for use at trail crossings presently.

S16. Provide an advance yield line along with a modified R1-5 sign.
It is recommended a yield line be located 20 feet in advance of the crossing to improve the comfort of the trail users crossing the roadway.

ESTIMATE OF PROBABLE COST
It is estimated that the development of construction drawings and the actual construction of the short term improvements will cost approximately $55,950. This estimate does not include paving a portion of the bridal trail, the addition of street lighting, or clearing of shrubbery and trees obstructing sight lines. Mid-term and long term concept drawings and cost estimates were not developed. The largest cost item for this location is the installation of rapid flashing beacons. The concept design for the short term improvements can be found in Appendix A. The backup details for the cost estimate calculation can be found in Appendix B.

OPINION OF GRADE SEPARATION
It appears possible to consider grade separation at this location to improve the comfort, safety, and convenience of the W&OD trail users and to reduce delays to traffic on the Hunter Mill Road. However, given the higher rates of yielding and relatively low delay experienced by trail users, the location does not appear to be a high priority for grade separation.

The trail alignment and adjacent land uses appear to provide sufficient space for required ADA accessible ramps but there may be severe challenges with a bridge due to the overhead powerline wire locations. It may be more realistic to focus on a tunnel, but that too may have serious conflicts with buried utilities. To access the viability of grade separation and to determine potential construction and engineering cost, further study is required. Should grade separation be pursued, it is recommended all four connections be made between Hunter Mill Road and the W&OD Trail.

LEE HIGHWAY

PUBLIC FEEDBACK

When asked what improvements they would recommend to improve safety at this crossing, 14% suggested an underpass or overpass and 15% recommended adjusting the signal timings to better serve trail users at the signalized crossing with Lee Highway. Sixteen percent (16%) suggested ways of resolving conflicts between southbound right-turning motorists. These percentages are based on the total number of survey respondents. Just under one third of the survey respondents did not give a recommendation and less than one tenth offered more than one recommendation. Figure 11 visualizes these suggestions. Appendix B contains detailed survey data.

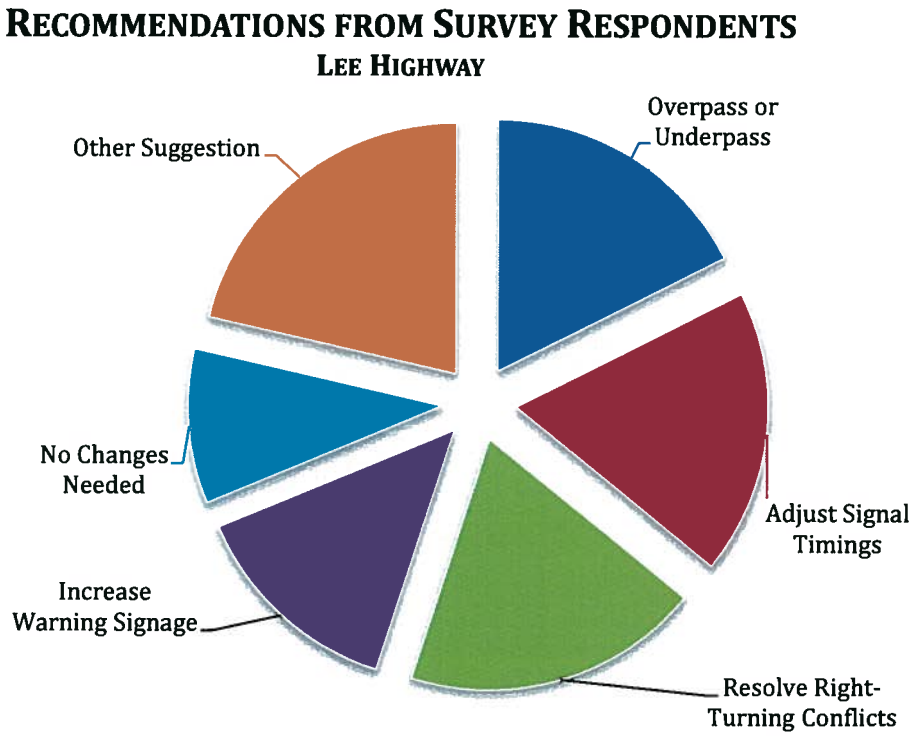


Figure 13: Safety Improvement Recommendations from Survey Respondents at Lee Highway

SELECT TRAIL USER COMMENTS

The following are representative examples of the types of improvements trail users provided to the project team during the in-person trail-user intercept survey in the summer of 2011.

> *"There is an awkward gap at this intersection where all lights are red and all signals say don't walk. Cyclists/peds are often confused."*

> *"Status of signal should be altered so that right turn on red for autos coming off I-66 east should be prohibited. Also, right-most lane on that off ramp, approaching signal, should be clearly designated as either a bike lane or a car lane."*

"Have a big sign saying 'yield to people in crosswalk'."

"Cross walk light could come on 30 seconds earlier - traffic gets a red light well before cross walk turns on"

"A separate trail crossing light?"

"No turn on red sign for cars heading east on Fairfax Dr."

"One of the phases of the light needs to be trail only (no right turning cars)"

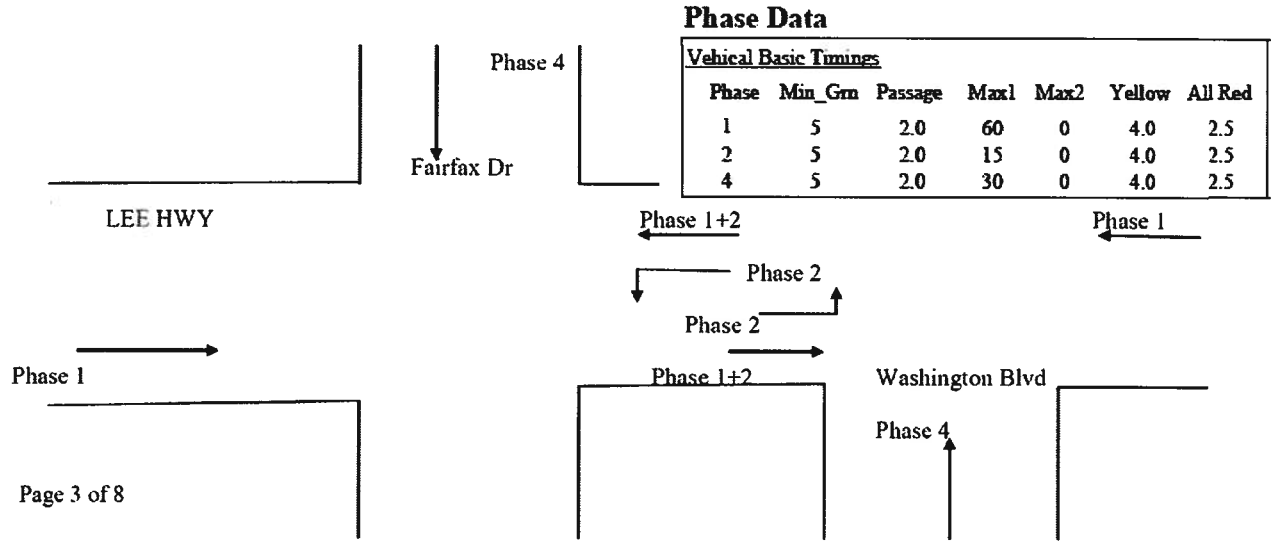
"longer bike crossing signal"

"maybe signage telling cars making right turn (from fairfax dr) that cyclists have right of way if they're in crosswalk"

RECOMMENDATIONS

S17. Signal Timing Study of Crossing of Lee Highway

It is recommended a study be conducted to assess optimization of the traffic signal to reduce delay, minimize confusion, and improve safety. The existing phases with timing are shown below:



Phase Data

Vehical Basic Timings

Phase	Min_Grn	Passage	Max1	Max2	Yellow	All Red
1	5	2.0	60	0	4.0	2.5
2	5	2.0	15	0	4.0	2.5
4	5	2.0	30	0	4.0	2.5

Figure 14: Signal Timing Diagram with Timing Information Provided by Arlington County

S17a. Evaluate need for push buttons. At actuated intersections, push buttons are typically provided to call the crossing phase within the signal. This phase can be set up to be in recall mode whereupon it is not required to be actuated and the crossing phase is provided each cycle. Due to generally low actuation rates by pedestrians, highway agencies may opt to set the crossing phase in recall during peak periods to avoid pedestrians being trapped in the roadway. Given the high volumes of trail users, their regular presence at the crossing, and the proximity to the Metro Station and commercial activity, it is recommended the crossing be set in recall mode and the pushbuttons be removed.

Should it be determined that setting the crossing in recall for all times of day is not possible, the existing pushbuttons should be relocated per current MUTCD and ADAAG requirements.

S17b. Reallocate Portion of Phase 2 Time to Provide Protected Trail Crossing Phase

- It may be possible to create a protected crossing phase by stopping southbound motorists at Fairfax Drive (during phase 2 timing) which will allow 14-25 seconds of time to be reallocated to the trail crossing. This time leads into phase 4 which is presently where the trail crosses in conjunction with eastbound Fairfax right turns. Trail users would continue to be allowed to cross during phase 4, but the initial queue of trail users would clear without interference from turning motorists during phase 2. Southbound motorists would be allowed to turn left onto I-66.

S17c. Reallocate Portion of Phase 2 or 4 Time to Provide Protected Eastbound Right Turn Motorist Phase

- Consider installation of right turn lane and right turn signal for eastbound Fairfax Drive to provide a clearer message to motorists to not turn and to allow potential to separate trail crossing from right turning motorists (with either an LPI or protected phase)
- Implement leading pedestrian interval (LPI) of 7 seconds corresponding to the "WALK" portion of the signal timing prior to onset of eastbound green
- Add turning traffic yield to pedestrians and bicycles sign if a separate crossing phase is not implemented (modified R10-15 shown at right)

R10-15

S18. Implement Permanent No Turn On Red

- eastbound Fairfax to prevent violation of right-turn only arrow (if implemented) and to maintain integrity of protected or leading trail crossing phases (if implemented)
- northbound Washington to keep crosswalk clear of motor vehicles

S19. Remove Stop Signs and Install Bicycle Signals

Install bicycle signals to signify additional "legal" time for bicyclists to enter the intersection (technically they can only enter during the solid walk portion of the phase). Recent research completed on the Mount Vernon Trail in Alexandria (approved by FHWA) along with other locations in the United States indicates a bicycle signal may improve compliance and safety at trail crossings.

Figure 15: Bike Signal, NYC

Note a bicycle signal would require FHWA experimentation.

S19. Add W&OD Trail sign panel to overhead span wire over crosswalk

S20. Improve Lee Highway to Westmoreland Route to Van Buren Trailhead

A large number of W&OD trail bicyclists are utilizing Lee Highway, Westmoreland Street, and Van Buren Street to access the W&OD trailhead on Van Buren. This route bypasses the congested sections of the trail leading to the East Falls Church Metro Station, avoids the hill, and minimizes conflicts with motorists driving to the Metro Station. This route could be improved by implementing the following:

- Add wayfinding signs include wayfinding to curb ramps and push buttons to cross Lee Highway at Westmoreland
- Relocate pushbuttons at Westmoreland to be in proper location
- Add bicycle lanes to Lee Highway to provide connection between W&OD and Westmoreland/Van Buren connection
- Add bicycle box for northbound approach to 66 to allow left turn transitions across lanes from bike lane – also to discourage right turn on red and improve stop line compliance

S21. Improve Sightlines for Eastbound Motorists Approach from Fairfax Drive

- Add advance warning sign for right turning traffic of W&OD trail – after driveway closest to Lee Highway for westbound approach
- Relocate eastbound NTOR signs to improve sightline to trail by locating signs near traffic light or on traffic island

Figure 16: Location of Existing Signs Block View of Trail

S22. Realign trail approaches to Lee Highway

It is recommended the existing trail approaches be defined more clearly approaching Lee Highway. An interim measure would be to add pavement markings to define the edges of the trail and to add a centerline leading up to the crosswalk.

L2: Long term, the approaches should be reconstructed to improve the approach geometry of the trail and to widen the trail. Consideration should be given to the purchase of land from Cars USA to remove the driveway.

Figure 17: The existing approaches to Lee Highway do not clearly define the primary trail alignment to the user. The driveway should be subservient to the trail at this location with some wayfinding signs provided to guide the user towards the crosswalk for the trail/Metro Station or alternatively to Lee Highway via the driveway.

ESTIMATE OF PROBABLE COST

It is estimated that the development of construction drawings and the actual construction of the short term improvements will cost approximately $19,500. This estimate does not include the addition of street lighting or clearing of shrubbery and trees obstructing sight lines. Mid-term and long term concept drawings and cost estimates were not developed. The largest cost item for this location is the installation of bicycle signals. It is anticipated that a traffic signal timing study of this intersections would cost approximately $15,000. The concept design for the short term improvements can be found in Appendix A. The backup details for the cost estimate calculation can be found in Appendix B.

OPINION OF GRADE SEPARATION

It does not appear realistic to consider grade separation at this location. The trail alignment and adjacent land uses appear to limit the available space for required ADA accessible ramps. There may be severe challenges with a bridge and a tunnel due to the overhead powerline wire locations and likley conflicts with buried utilities. To access the viability of grade separation and to determine potential construction and engineering cost, further study is required. Should grade separation be pursued, it is recommended all four connections be made between Lee Highway and the W&OD Trail.

COLUMBIA PIKE

PUBLIC FEEDBACK

When asked what improvements they would recommend to improve safety at this crossing, 22% suggested adjusting the signal timings to better serve trail users and 8% recommended an overpass or underpass at Columbia Pike. Other suggestions included increasing warning signage, adding flashing warning lights, resolving the conflicts with eastbound right-turning vehicles and repainting the patched crosswalk lines. Percentages are based on the total number of survey respondents. One third of the survey respondents did not give a recommendation and less than one tenth offered more than one recommendation. Figure 13 visualizes these suggestions. Appendix B contains detailed survey data.

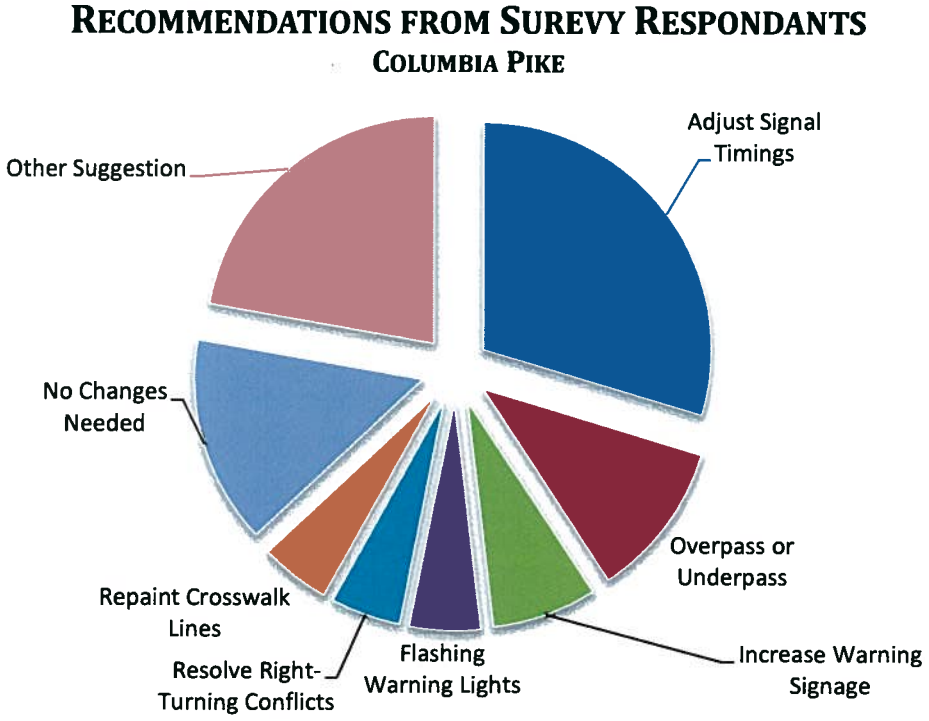


Figure 18: Safety Improvement Recommendations from Survey Respondents at Columbia Pike

SELECT TRAIL USER COMMENTS

The following are representative examples of the types of improvements trail users provided to the project team during the in-person trail-user intercept survey in the summer of 2011.

"Longer cross time, no turn on red sign"

"Better defined crosswalk lines on road"

"Better located/more buttons"

"Longer crossing signal; turns red quickly"

"Perhaps a delayed crossing for cars so trail users can get a start."

"Change light sooner when button is pushed"

"Not having a green light for left turn signal at the same time as walk signal crossing needs to be aligned with curb cuts, coming from west to east you need to have a light for cyclists to show red/greens"

RECOMMENDATIONS

It is recommended the NVRPA work with Arlington County and VDOT to implement the recommendations developed by TDG for the TLC Case Study of this intersection as part of the reconstruction of Columbia Pike. The following recommendations are from the case study:

S23. Remove pushbuttons and call trail crossing phase during each cycle or relocate pushbuttons with stub poles to the required ADAAG location.

S24. Remove Stop Signs and Install bicycle signals

To signify additional "legal" time for bicyclists to enter the intersection (technically they can only enter during the solid walk portion of the phase).

S25. Implement leading pedestrian interval (LPI) of 7 seconds.

Corresponding to the "WALK" portion of the signal timing prior to onset of northbound green from Four Mile Run. Numerous complaints and observations of conflicts were registered for both crosswalks so this should be applied to both crosswalks.

S26. Realign Trail approach to Columbia Pike.

A trail realignment will reduce approach speeds to the intersection and clarify which crossing should be utilized for crossing the roadway. The existing trail leads to an ambiguous area which does not align with a crosswalk (southbound approach).

S27. Add right turn traffic yield to pedestrians and bicycles sign (modified R10-15).

For traffic turning from northbound Four Mile Run onto eastbound Columbia Pike.

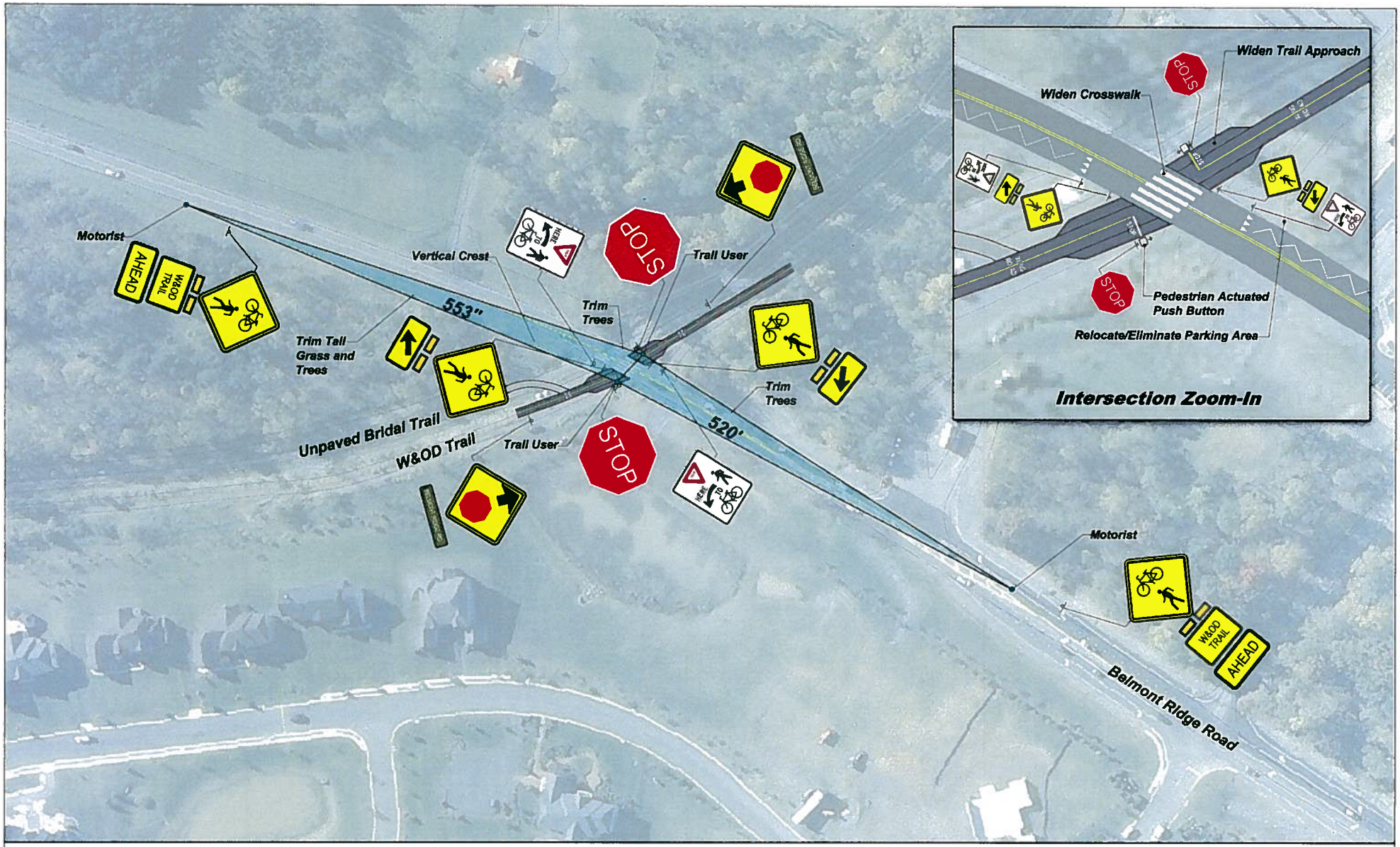
ESTIMATE OF PROBABLE COST

An estimate was not developed as this project is currently under design.

OPINION OF GRADE SEPARATION

It does not appear necessary to consider grade separation at this location given the proximity to the Four Mile Run Trail underpass nearby. It may be desirable to work with Arlington County to focus on improvements to the Four Mile Run Trail tunnel and improve connections between it and the W&OD Trail, including wayfinding.

APPENDIX A – SHORT TERM RECOMMENDED CONCEPT DESIGNS



Toole Design Group

Northern Virginia Regional Park Authority

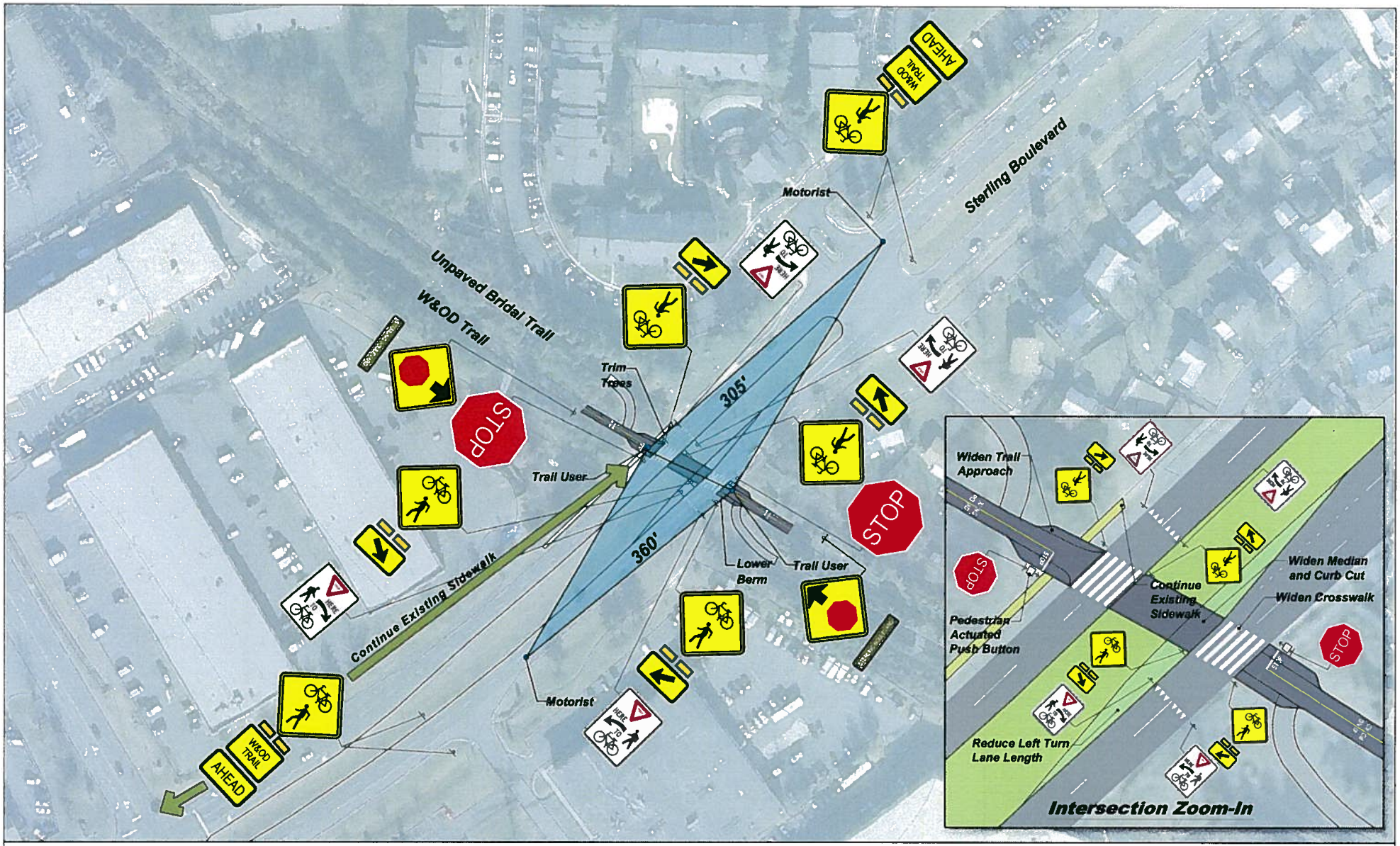
W&OD TRAIL INTERSECTION STUDY

Belmont Ridge Road

SIGHT TRIANGLES & RECOMMENDATIONS

PLAN SHEET 1

FEBRUARY, 2012



TooleDesignGroup

Northern Virginia Regional Park Authority

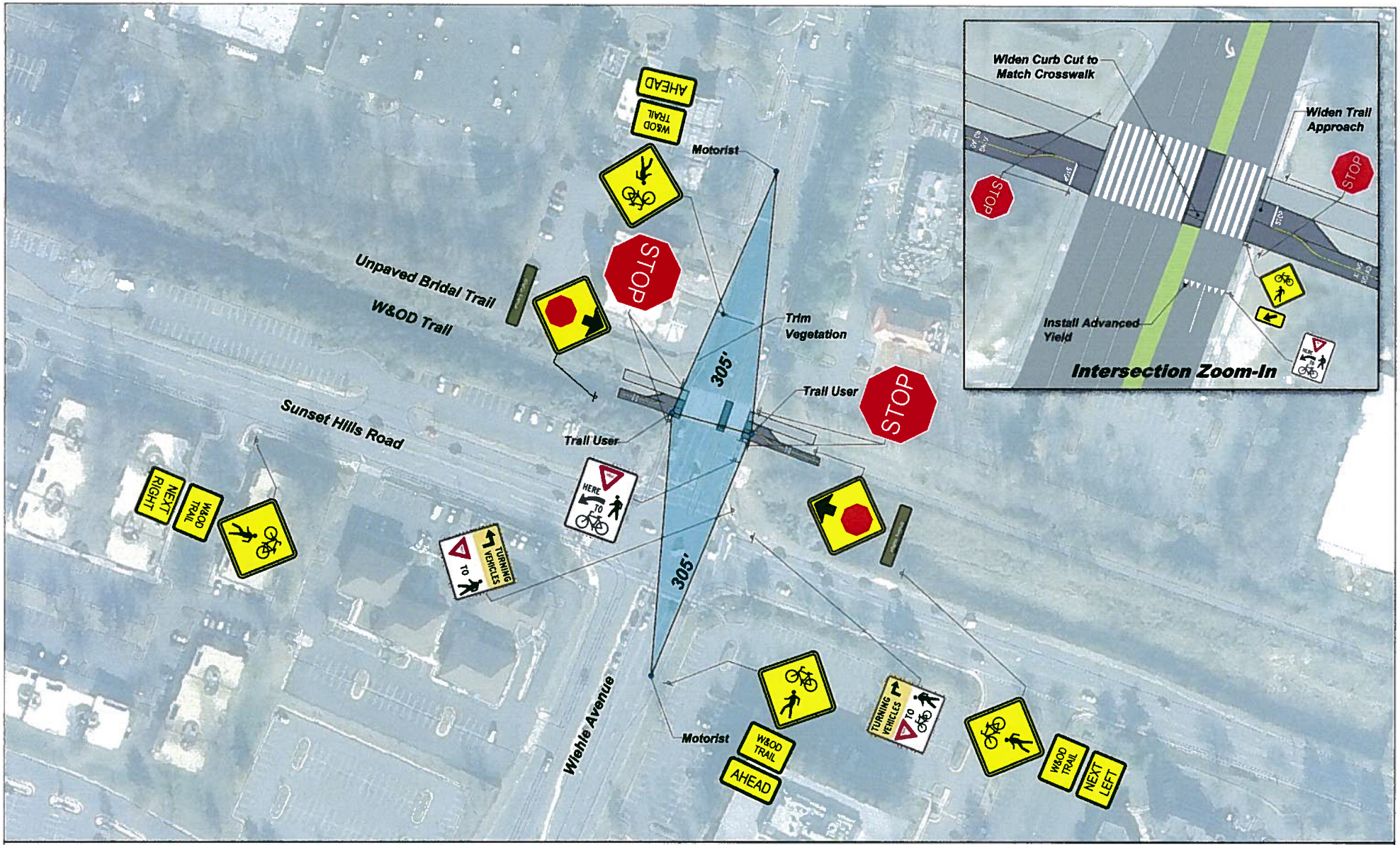
W&OD TRAIL INTERSECTION STUDY

Sterling Boulevard

SIGHT TRIANGLES & RECOMMENDATIONS

PLAN SHEET 2

FEBRUARY, 2012



ToolDesignGroup

Northern Virginia Regional Park Authority

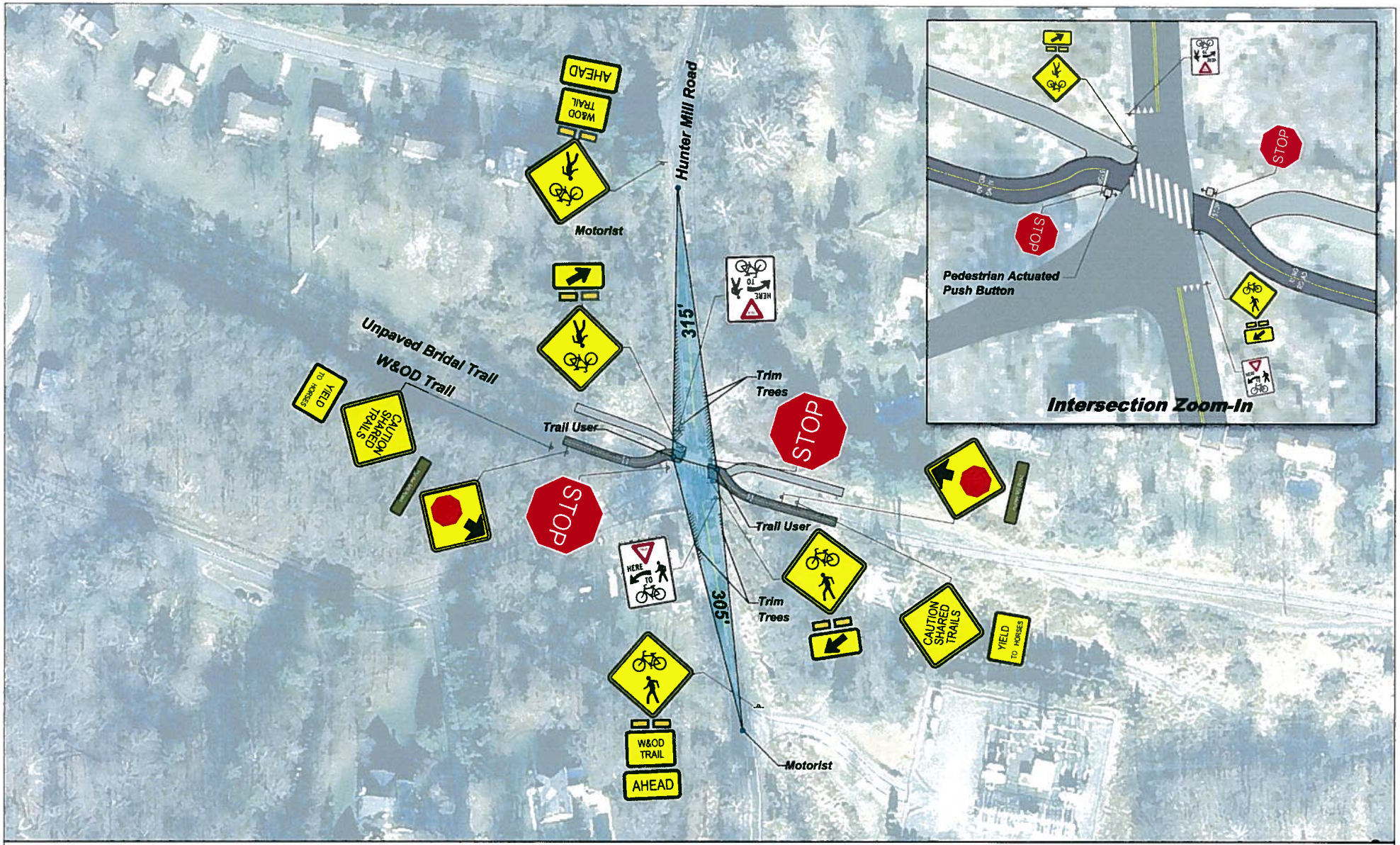
W&OD TRAIL INTERSECTION STUDY

Wiehle Avenue

SIGHT TRIANGLES & RECOMMENDATIONS

PLAN SHEET 3

FEBRUARY, 2012



Toole Design Group

Northern Virginia Regional Park Authority

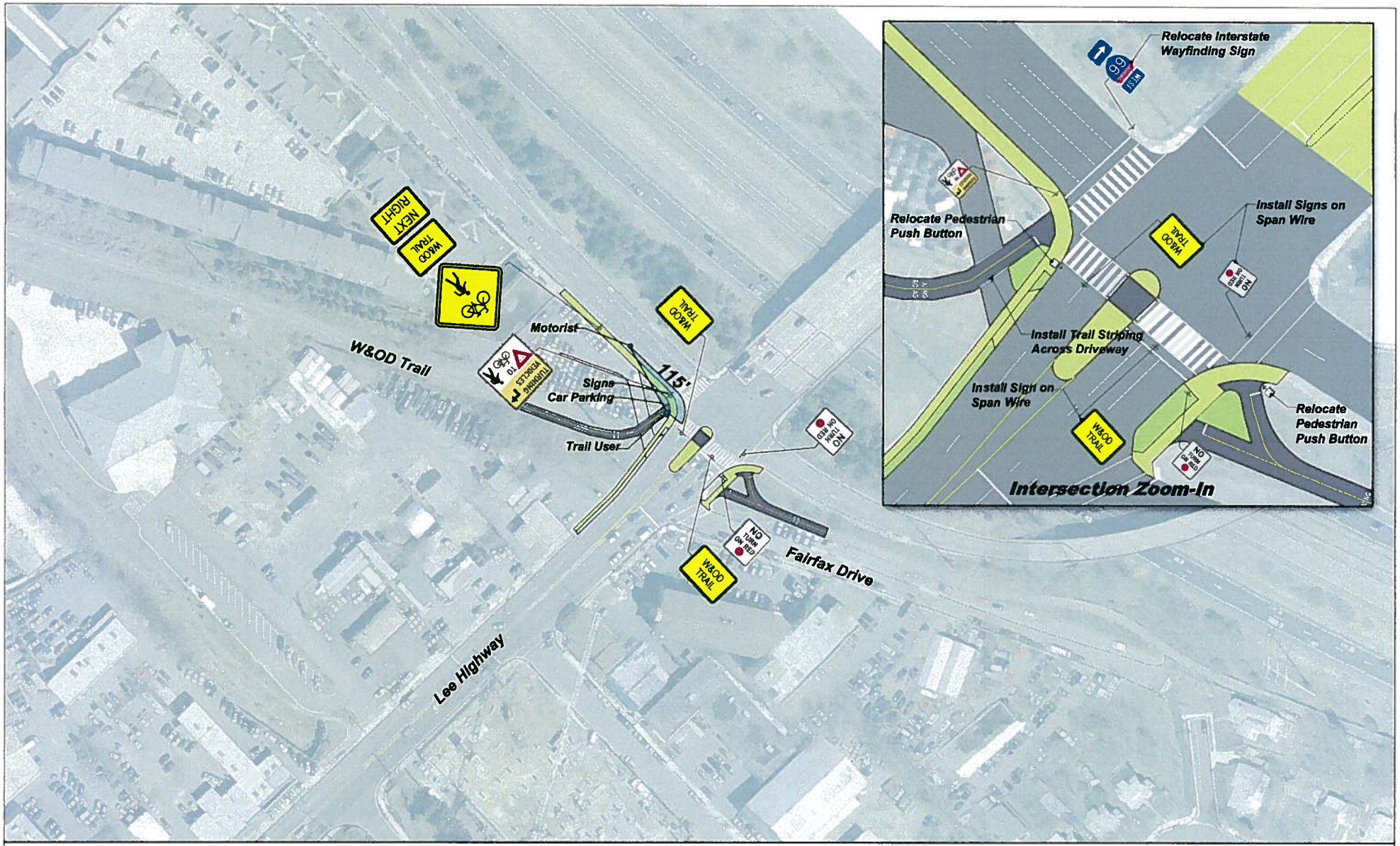
W&OD TRAIL INTERSECTION STUDY

Hunter Mill Road

SIGHT TRIANGLES & RECOMMENDATIONS

PLAN SHEET 4

FEBRUARY, 2012



Toole Design Group

Northern Virginia Regional Park Authority

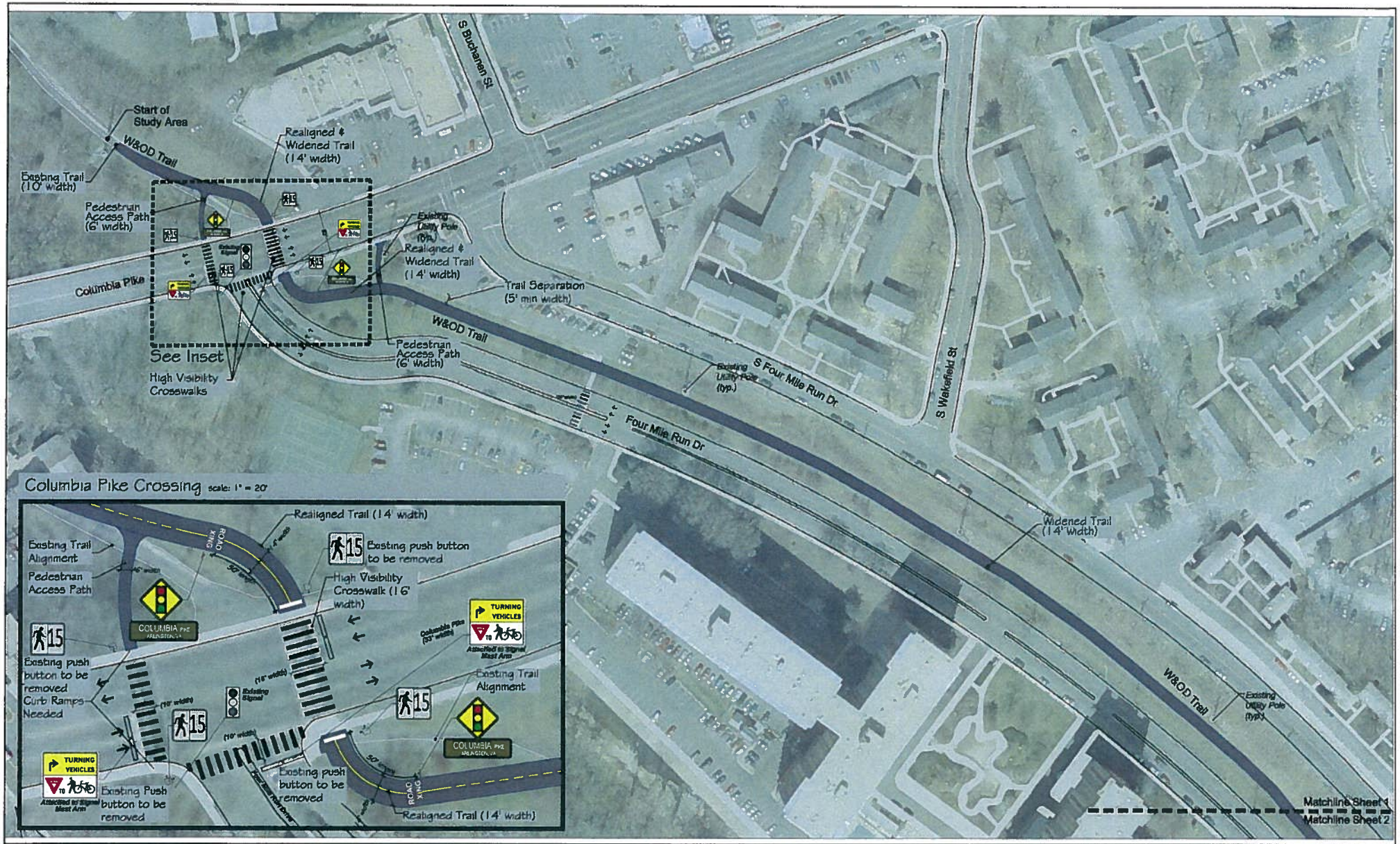
W&OD TRAIL INTERSECTION STUDY

Lee Highway

SIGHT TRIANGLES & RECOMMENDATIONS

PLAN SHEET 5

FEBRUARY, 2012

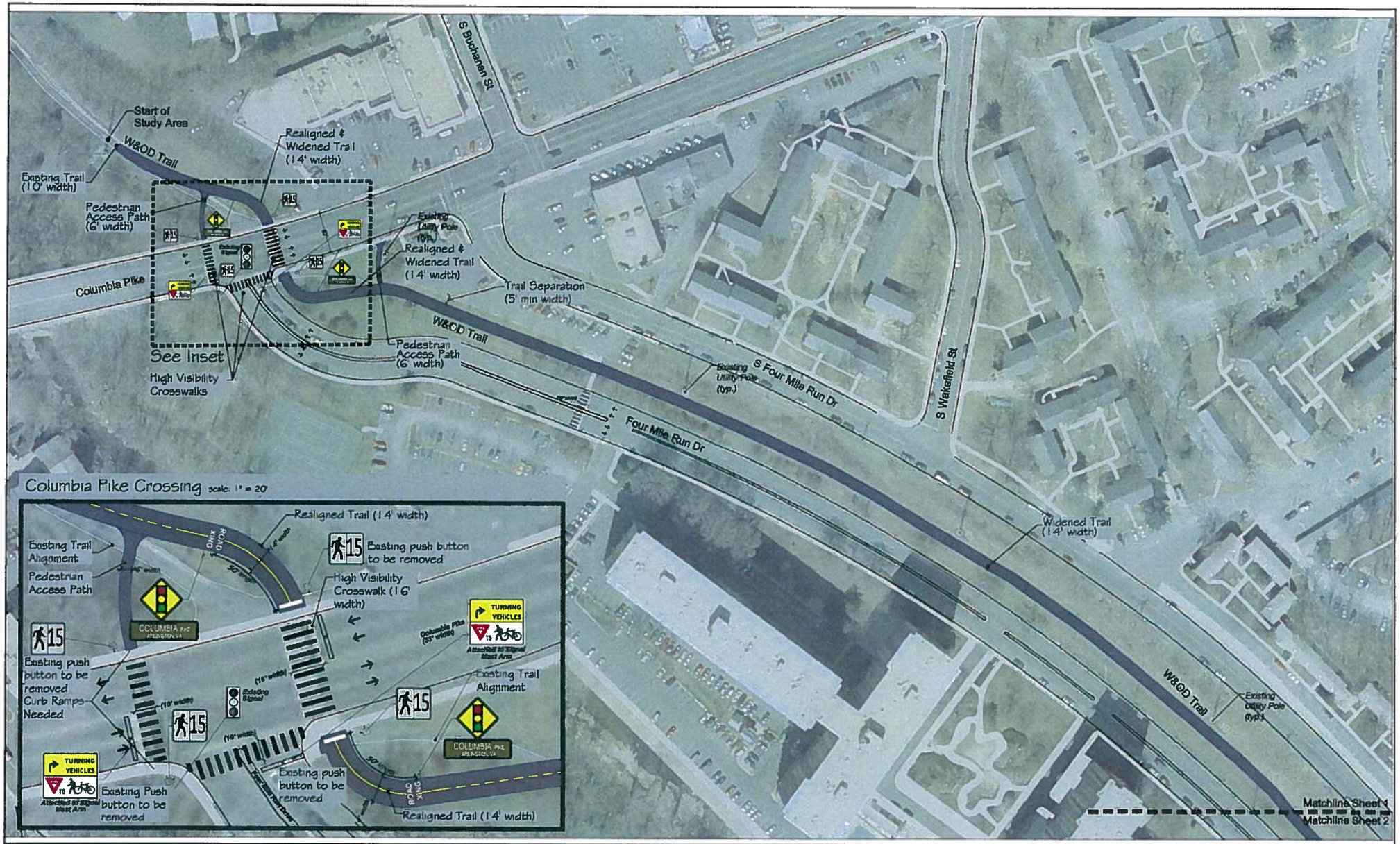


ARLINGTON SHARED USE TRAIL STUDY
Washington & Old Dominion Trail

From: Columbia Pike
To: West of S. George Mason Dr.

NOT FOR CONSTRUCTION

SCALE: 1" = 50'
PLAN SHEET 1
July 30, 2010 2 of 7



Toole Design Group

ARLINGTON VIRGINIA

TC

ARLINGTON SHARED USE TRAIL STUDY

Washington & Old Dominion Trail

From: Columbia Pike
To: West of S. George Mason Dr.

NOT FOR CONSTRUCTION

0' 50' 100'
SCALE: 1" = 50'
PLAN SHEET 1
July 30, 2010 2 of 7

APPENDIX B – ESTIMATE BACKUP CALCULATIONS

BELMONT RIDGE ROAD ESTIMATE BACKUP

Item	Quantity	Unit	2010 Unit Cost	Total Cost
Remove Pavement & Excavation (2' Depth)	55	CY	$20.00	$1,100
Remove Curb & Gutter	0	LF	$10.00	$0
Fill	32	CY	$20.00	$640
Seed & Mulch	0	SY	$3.00	$0
Milling	236	SY	$6.00	$1,413
Asphalt (6" Depth)	24	TON	$60.00	$1,457
Aggregate Base (6" Depth)	14	CY	$50.00	$685.19
Thermoplastic Pavement Marking (all widths up to 24")	90	LF	$3.00	$270
24" Thermoplastic Pavement Marking	110	LF	$10.00	$1,100
Thermoplastic Pavement Marking (Symbol or Text)	6	EA	$250.00	$1,500
Manufacture & Install Sign	2	EA	$250.00	$500
Remove Sign	4	EA	$50.00	$200
Relocate Existing Sign	2	EA	$200.00	$400
Rapid Flashing Beacon Assembly (set of 4)	1	EA	$25,000.00	$25,000
New Signal Head	0	EA	$5,000.00	$0
Bicycle Signal	0	EA	$5,000.00	$0
Pedestrian Countdown Signal	0	EA	$5,000.00	$0
Remove Pedestrian Push Button	0	EA	$500.00	$0
Lump Sum Items				
Engineering (15%)	1.00	LS	$5,140.00	$5,140
Survey	1.00	LS	$5,000.00	$5,000
E&S (5%)	1.00	LS	$1,713.00	$1,713
Maintenance of Traffic (10%)	1.00	LS	$3,427.00	$3,427
Utility Adjustments (10%)	0.00	LS	$3,427.00	$0
			Subtotal	**$49,546**
Mobilizaton (10%)	1.00	LS	$4,781.00	$4,781
			Subtotal	**$54,327**

20% Contingency	$10,865
Total Estimated Cost	**$65,192**

Note: This cost estimate is a planning level estimate only.

STERLING BOULEVARD ESTIMATE BACKUP

Item	Quantity	Unit	2010 Unit Cost	Total Cost
Remove Pavement & Excavation (2' Depth)	126	CY	$20.00	$2,520
Remove Curb & Gutter	0	LF	$10.00	$0
Fill	109	CY	$20.00	$2,180
Seed & Mulch	126	SY	$3.00	$378
Milling	669	SY	$6.00	$4,013
Asphalt (6" Depth)	32	TON	$60.00	$1,918
Aggregate Base (6" Depth)	11	CY	$50.00	$527.78
Thermoplastic Pavement Marking (all widths up to 24")	160	LF	$3.00	$480
24" Thermoplastic Pavement Marking	220	LF	$10.00	$2,200
Thermoplastic Pavement Marking (Symbol or Text)	6	EA	$250.00	$1,500
Manufacture & Install Sign	2	EA	$250.00	$500
Remove Sign	4	EA	$50.00	$200
Relocate Existing Sign	2	EA	$200.00	$400
Rapid Flashing Beacon Assembly (set of 6)	1	EA	$35,000.00	$35,000
New Signal Head	0	EA	$5,000.00	$0
Bicycle Signal	0	EA	$5,000.00	$0
Pedestrian Countdown Signal	0	EA	$5,000.00	$0
Remove Pedestrian Push Button	0	EA	$500.00	$0
Lump Sum Items				
Engineering (15%)	1.00	LS	$7,773.00	$7,773
Survey	1.00	LS	$5,000.00	$5,000
E&S (5%)	1.00	LS	$2,591.00	$2,591
Maintenance of Traffic (10%)	1.00	LS	$5,182.00	$5,182
Utility Adjustments (10%)	1.00	LS	$5,182.00	$5,182
			Subtotal	**$77,545**
Mobilizaton (10%)	1.00	LS	$7,247.00	$7,247
			Subtotal	**$84,792**

20% Contingency	$16,958
Total Estimated Cost	**$101,750**

Note: This cost estimate is a planning level estimate only.

WIEHLE AVENUE ESTIMATE BACKUP

Item	Quantity	Unit	2010 Unit Cost	Total Cost
Remove Pavement & Excavation (2' Depth)	77	CY	$20.00	$1,540
Remove Curb & Gutter	70	LF	$10.00	$700
Fill	45	CY	$20.00	$900
Seed & Mulch	0	SY	$3.00	$0
Milling	334	SY	$6.00	$2,007
Asphalt (6" Depth)	34	TON	$60.00	$2,039
Aggregate Base (6" Depth)	19	CY	$50.00	$953.70
Thermoplastic Pavement Marking (all widths up to 24")	140	LF	$3.00	$420
24" Thermoplastic Pavement Marking	0	LF	$10.00	$0
Thermoplastic Pavement Marking (Symbol or Text)	4	EA	$250.00	$1,000
Manufacture & Install Sign	6	EA	$250.00	$1,500
Remove Sign	6	EA	$50.00	$300
Relocate Existing Sign	0	EA	$200.00	$0
Rapid Flashing Beacon Assembly (set of 4)	0	EA	$25,000.00	$0
New Traffic Signal Head and Mast Arm	1	EA	$25,000.00	$25,000
Bicycle Signal	2	EA	$5,000.00	$10,000
Pedestrian Countdown Signal	2	EA	$5,000.00	$10,000
Remove Pedestrian Push Button	0	EA	$500.00	$0
Lump Sum Items				
Engineering (15%)	1.00	LS	$8,454.00	$8,454
Survey	1.00	LS	$5,000.00	$5,000
E&S (5%)	1.00	LS	$2,818.00	$2,818
Maintenance of Traffic (10%)	1.00	LS	$5,636.00	$5,636
Utility Adjustments (10%)	1.00	LS	$5,636.00	$5,636
			Subtotal	**$83,903**
Mobilizaton (10%)	1.00	LS	$8,076.00	$8,076
			Subtotal	**$91,979**

20% Contingency	$18,396
Total Estimated Cost	**$110,375**

Note: This cost estimate is a planning level estimate only.

HUNTER MILL ROAD ESTIMATE BACKUP

Item	Quantity	Unit	2010 Unit Cost	Total Cost
Remove Pavement & Excavation (2' Depth)	0	CY	$20.00	$0
Remove Curb & Gutter	0	LF	$10.00	$0
Fill	0	CY	$20.00	$0
Seed & Mulch	0	SY	$3.00	$0
Milling	0	SY	$6.00	$0
Asphalt (6" Depth)	0	TON	$60.00	$0
Aggregate Base (6" Depth)	0	CY	$50.00	$0.00
Thermoplastic Pavement Marking (all widths up to 24")	0	LF	$3.00	$0
24" Thermoplastic Pavement Marking	0	LF	$10.00	$0
Thermoplastic Pavement Marking (Symbol or Text)	2	EA	$250.00	$500
Manufacture & Install Sign	4	EA	$250.00	$1,000
Remove Sign	4	EA	$50.00	$200
Relocate Existing Sign	0	EA	$200.00	$0
Rapid Flashing Beacon Assembly (set of 4)	1	EA	$25,000.00	$25,000
New Signal Head	0	EA	$5,000.00	$0
Bicycle Signal	0	EA	$5,000.00	$0
Pedestrian Countdown Signal	0	EA	$5,000.00	$0
Remove Pedestrian Push Button	0	EA	$500.00	$0
Lump Sum Items				
Engineering (15%)	1.00	LS	$4,005.00	$4,005
Survey	1.00	LS	$5,000.00	$5,000
E&S (5%)	1.00	LS	$1,335.00	$1,335
Maintenance of Traffic (10%)	1.00	LS	$2,670.00	$2,670
Utility Adjustments (10%)	1.00	LS	$2,670.00	$2,670
			Subtotal	**$42,380**
Mobilizaton (10%)	1.00	LS	$4,238.00	$4,238
			Subtotal	**$46,618**

20% Contingency	$9,324
Total Estimated Cost	**$55,942**

Note: This cost estimate is a planning level estimate only.

LEE HIGHWAY ESTIMATE BACKUP

Item	Quantity	Unit	2010 Unit Cost	Total Cost
Remove Pavement & Excavation (2' Depth)	0	CY	$20.00	$0
Remove Curb & Gutter	0	LF	$10.00	$0
Fill	0	CY	$20.00	$0
Seed & Mulch	0	SY	$3.00	$0
Milling	0	SY	$6.00	$0
Asphalt (6" Depth)	0	TON	$60.00	$0
Aggregate Base (6" Depth)	0	CY	$50.00	$0.00
Thermoplastic Pavement Marking (all widths up to 24")	100	LF	$3.00	$300
24" Thermoplastic Pavement Marking	0	LF	$10.00	$0
Thermoplastic Pavement Marking (Symbol or Text)	0	EA	$250.00	$0
Manufacture & Install Sign	4	EA	$250.00	$1,000
Remove Sign	3	EA	$50.00	$150
Relocate Existing Sign	2	EA	$200.00	$400
Rapid Flashing Beacon Assembly (set of 4)	0	EA	$25,000.00	$0
New Signal Head	0	EA	$5,000.00	$0
Bicycle Signal	2	EA	$5,000.00	$10,000
Pedestrian Countdown Signal	0	EA	$5,000.00	$0
Remove Pedestrian Push Button	2	EA	$500.00	$1,000
Lump Sum Items				
Engineering (15%)	1.00	LS	$1,928.00	$1,928
Survey	0.00	LS	$5,000.00	$0
E&S (5%)	0.00	LS	$643.00	$0
Maintenance of Traffic (10%)	0.00	LS	$1,285.00	$0
Utility Adjustments (10%)	0.00	LS	$1,285.00	$0
			Subtotal	**$14,778**
Mobilizaton (10%)	1.00	LS	$1,478.00	$1,478
			Subtotal	**$16,256**

20% Contingency	$3,251
Total Estimated Cost	**$19,507**

Note: This cost estimate is a planning level estimate only.

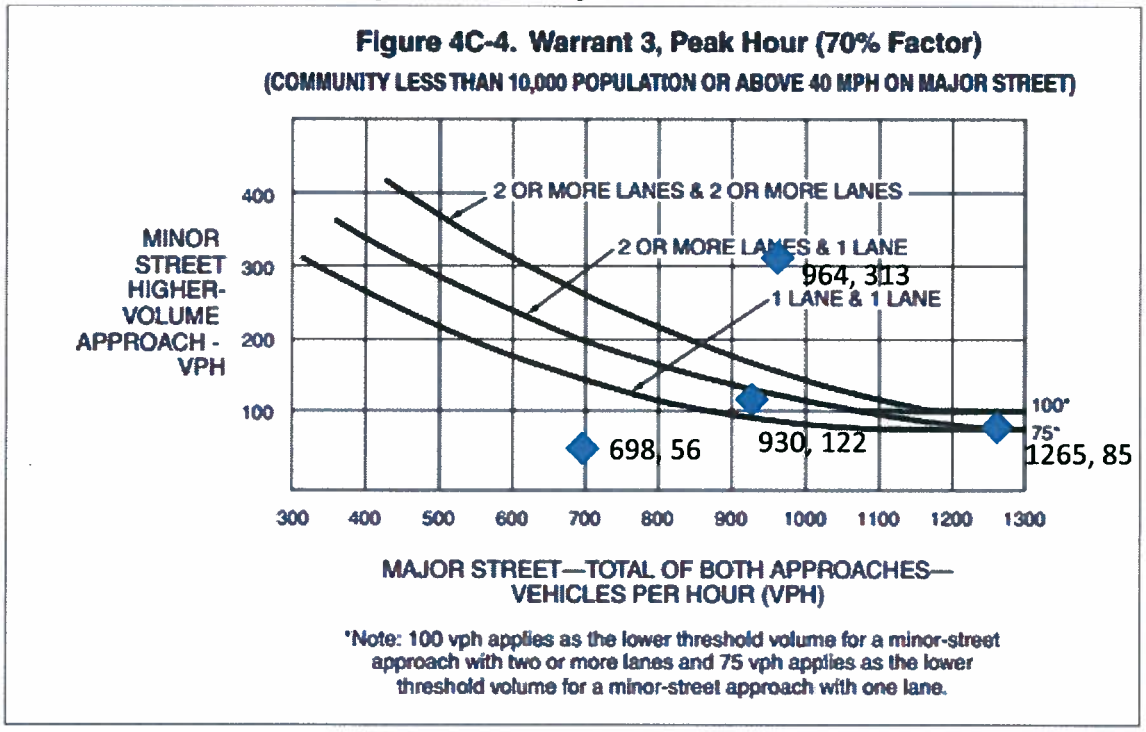
COLUMBIA PIKE

An estimate was not developed as this project is currently under design.

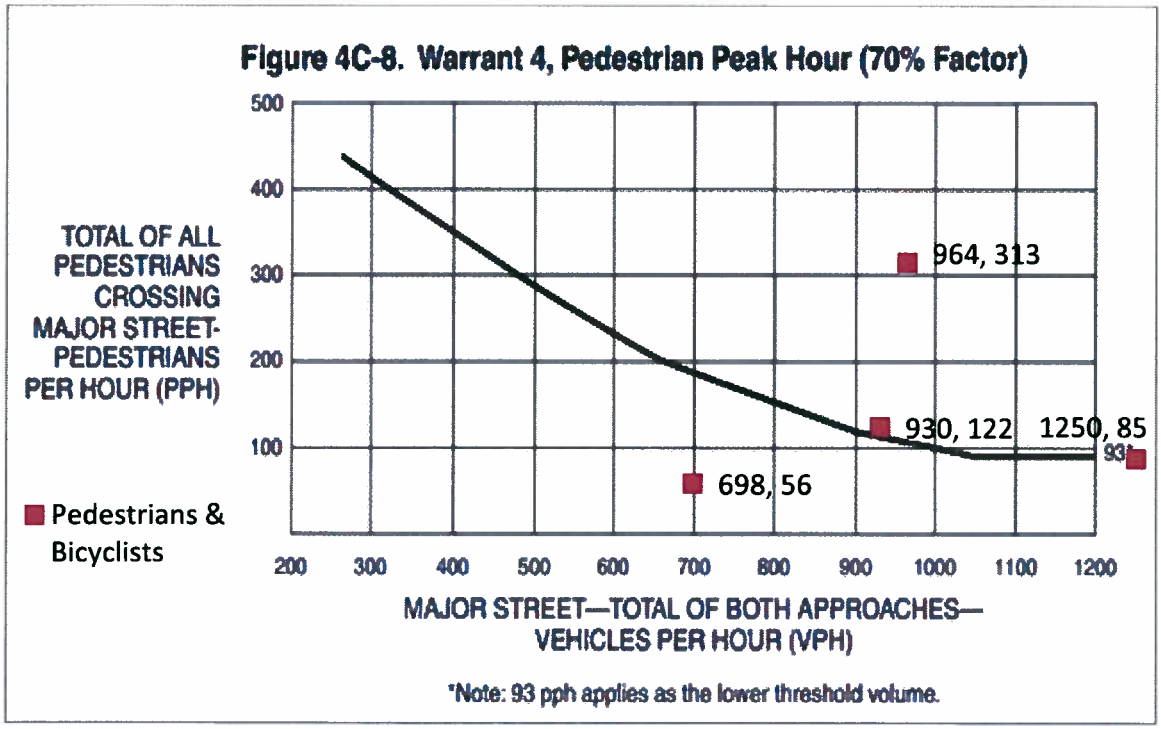
APPENDIX C – MUTCD SIGNAL WARRANT ANALYSES

BELMONT RIDGE MUTCD SIGNAL WARRANT ASSESSMENTS

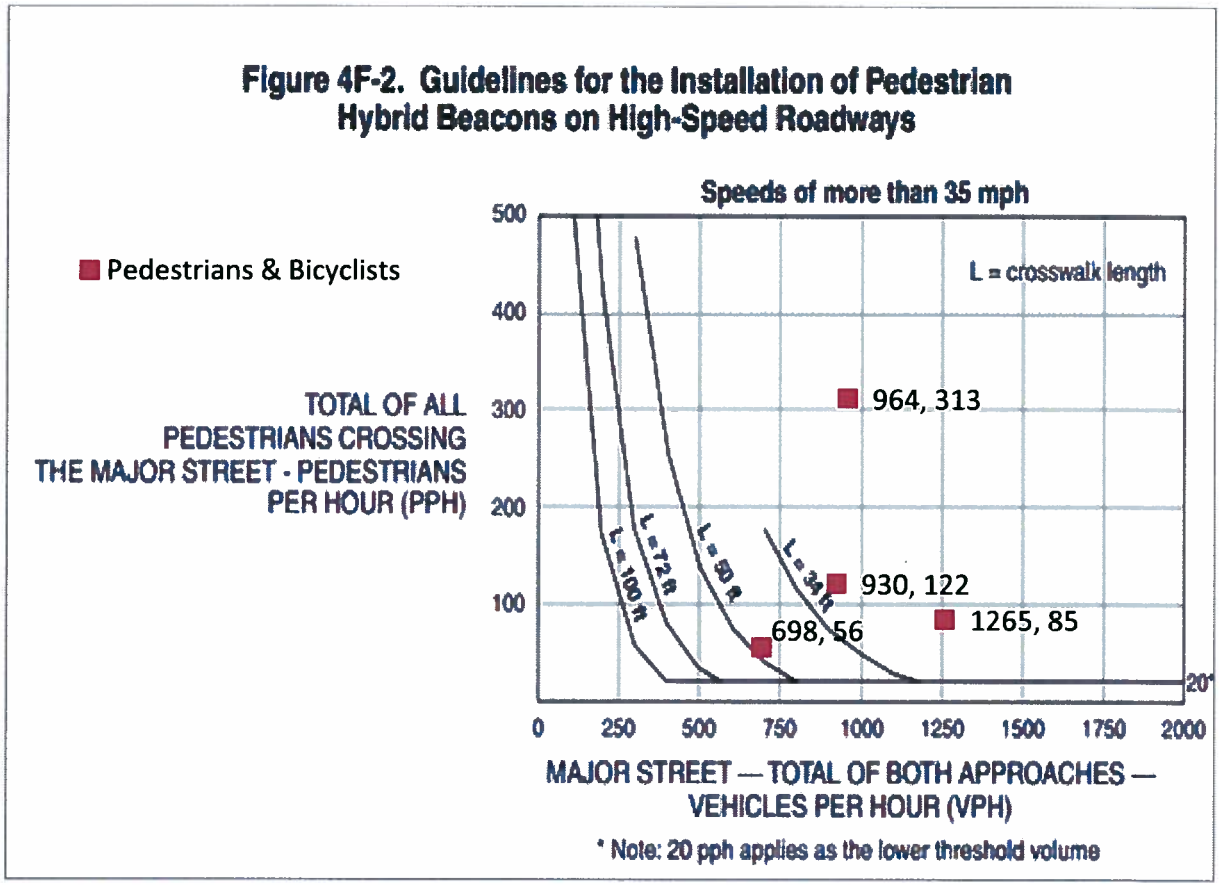
WARRANT 3, PEAK HOUR (70% FACTOR)



WARRANT 4, PEDESTRIAN PEAK HOUR (70% FACTOR)



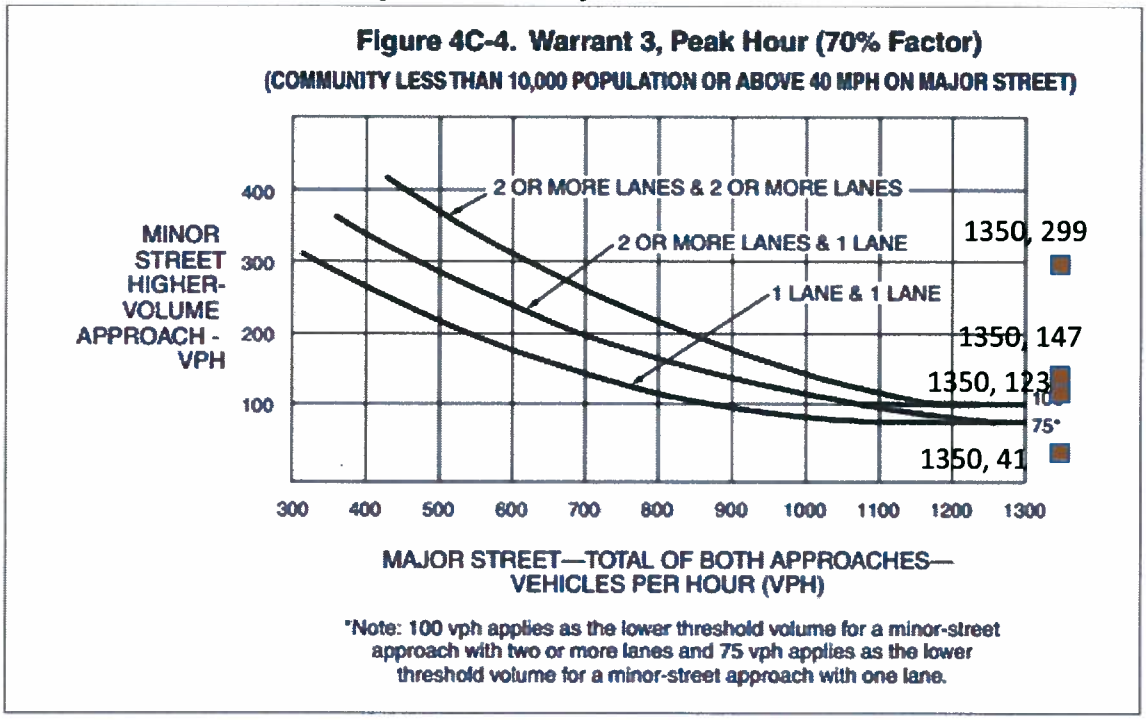
PEDESTRIAN HYBRID BEACON



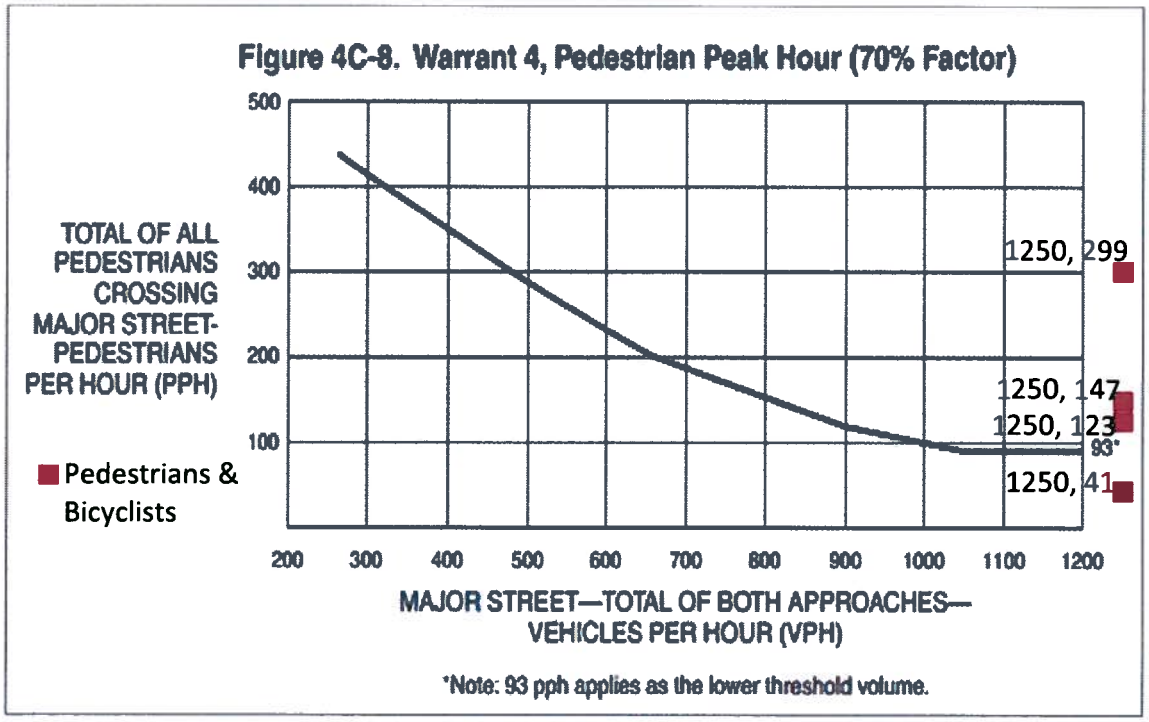
The W&OD Trail crossing at Belmont Ridge Road meets the hybrid signal warrants at three of the four hours studied when bicyclists are included in pedestrian counts. Crosswalk length is assumed to be 34 feet for the purposes of this warrant.

STERLING BLVD MUTCD SIGNAL WARRANT ASSESSMENTS

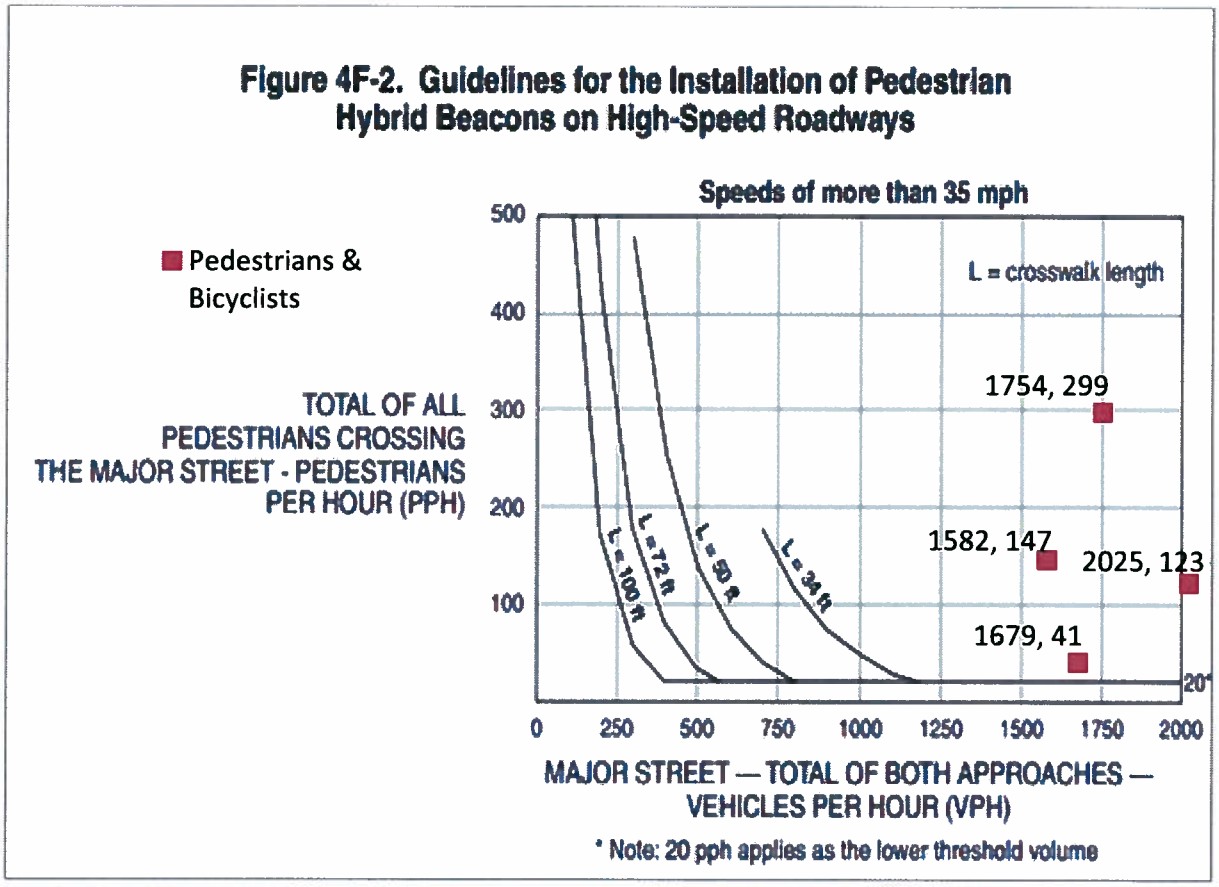
WARRANT 3, PEAK HOUR (70% FACTOR)



Warrant 4, Pedestrian Peak Hour (70% Factor)



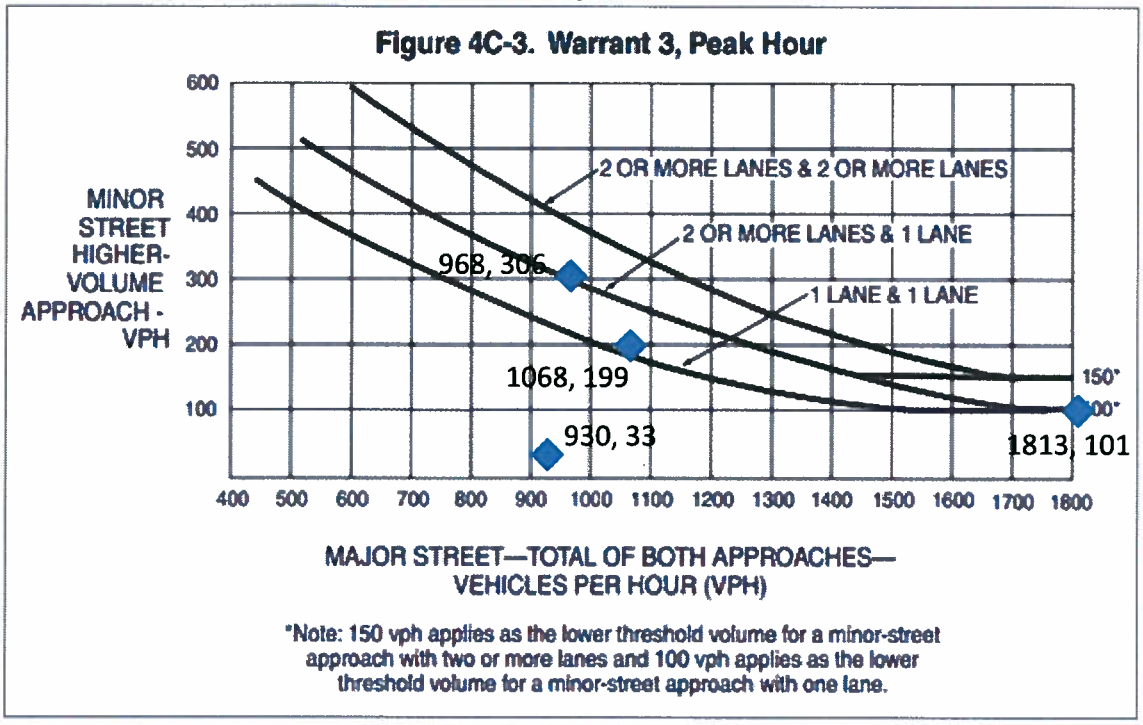
PEDESTRIAN HYBRID BEACON



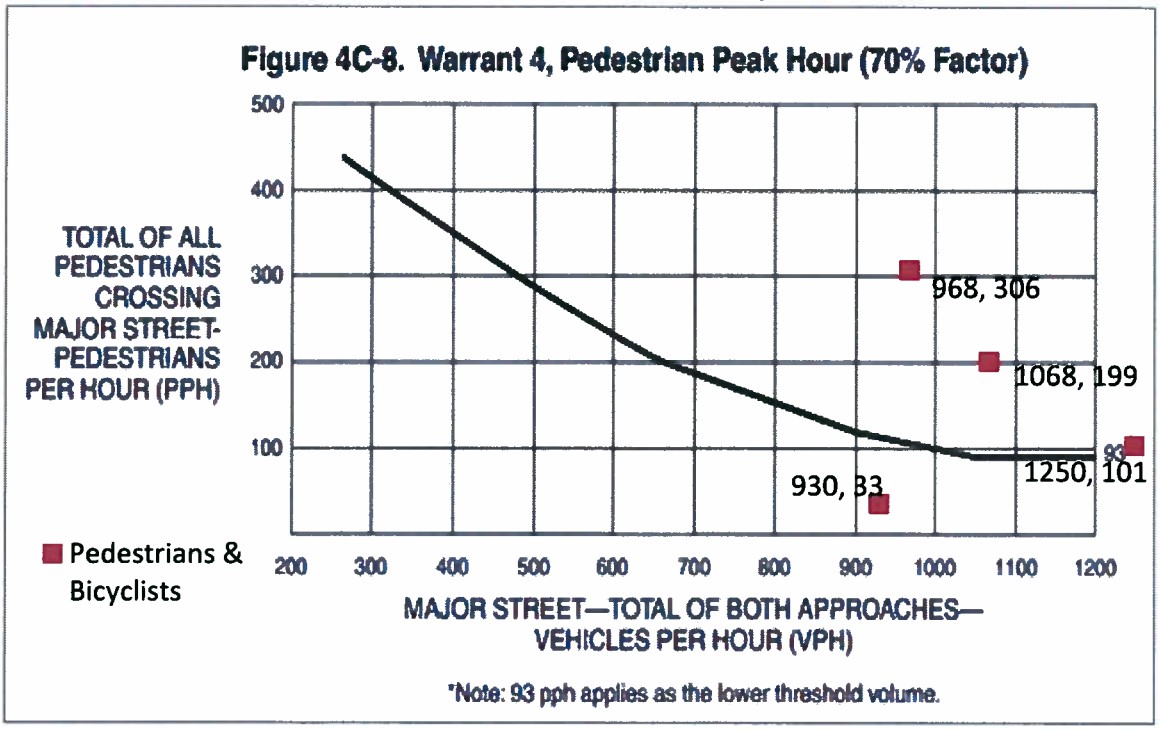
The W&OD Trail crossing at Sterling Blvd meets the hybrid signal warrants at all four hours studied when bicyclists are included in pedestrian counts. The Crosswalk length is assumed to be 34 feet for the purposes of this warrant as trail users can cross to the median (maximum 3 lane crossing on the east side).

HUNTER MILL MUTCD SIGNAL WARRANT ASSESSMENTS

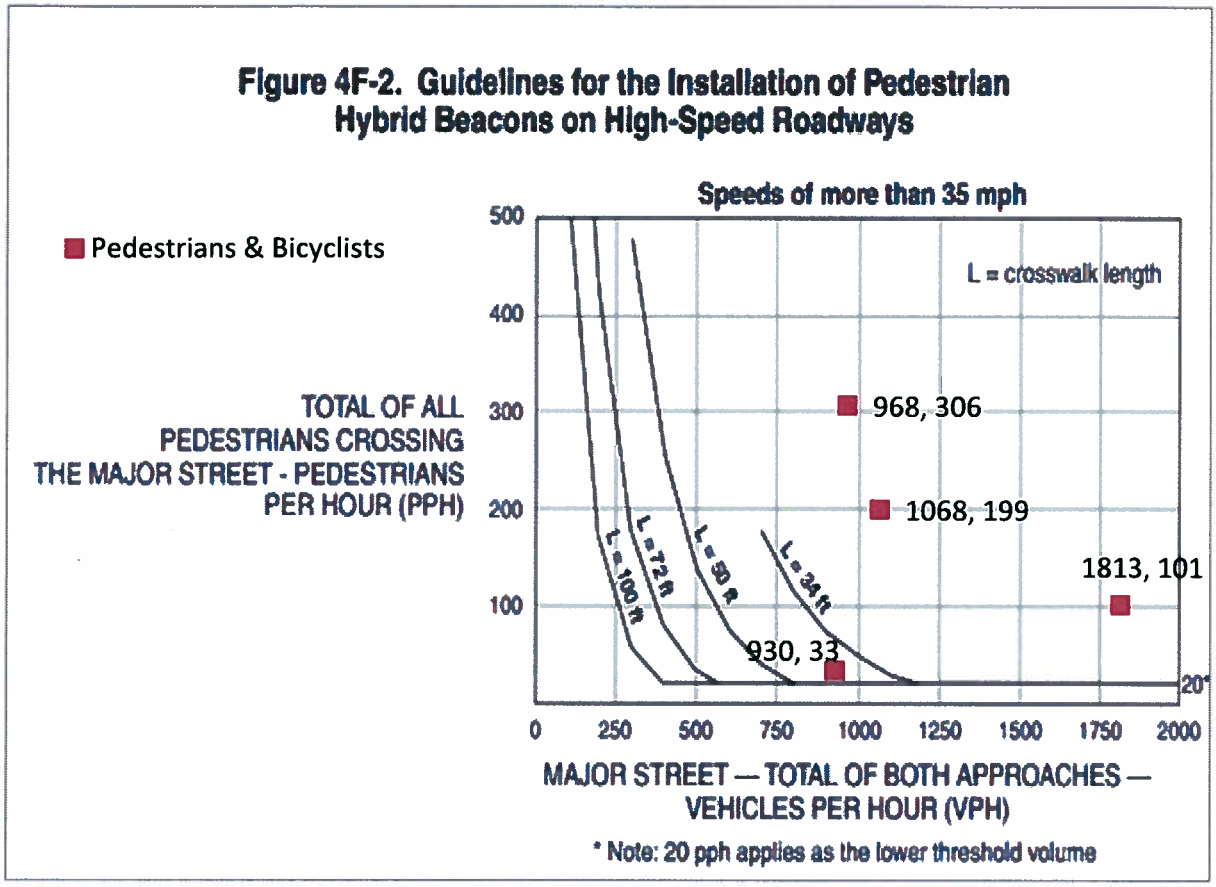
WARRANT 3, PEAK HOUR (70% FACTOR)



WARRANT 4, PEDESTRIAN PEAK HOUR (70% FACTOR)



PEDESTRIAN HYBRID BEACON



The W&OD Trail crossing at Hunter Mill Road meets the hybrid signal warrants at three of the four hours studied when bicyclists are included in pedestrian counts. Crosswalk length is assumed to be 34 feet for the purposes of this warrant.