Study of an Experimental Bike Signal on the Mount Vernon Trail in Alexandria, Virginia

Final Report

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1.0 Background & Introduction

With over one million visitors every year, the Mount Vernon Trail is one of the Washington, D.C. region's most popular multi-use trails. The trail follows the Potomac River's Virginia shoreline and transitions to on-street facilities approximately one half mile north of the experiment location. The location is also less than one mile from the Woodrow Wilson Memorial Bridge, which connects trail users to park spaces and trails on the east bank of the Potomac River, as well as cultural destinations such as the National Harbor. The Mount Vernon Trail is a critical link in the regional bicycle network.

This experiment was located at the Mount Vernon Trail crossing of the Porto Vecchio Condominium driveway, adjacent to the intersection of South Washington Street, also known as the Mt. Vernon Memorial Parkway and the George Washington Memorial Parkway, and South Alfred Street/Porto Vecchio driveway, shown in Figure 1.

Figure 1 - Intersection of the Porte Vecchio Driveway & Mount Vernon Trail, immediately adjacent to the intersection of South Washington Street & South Alfred Street/Porto Vecchio Driveway

This intersection was chosen for evaluation and traffic control experimentation in response to safety concerns reported by Porto Vecchio Condominium residents and Mount Vernon Trail users. At the onset of the experiment, the intersection was signalized for motorists and pedestrians and stop-controlled for bicyclists. The stop sign for bicyclists at the signalized intersection resulted in confusion and low compliance, generating frustrations and safety concerns from both residents and trail users. A major safety concern reported were bicyclists who disregarded the stop sign, at times resulting in conflicts with motorists using the Porto Vecchio driveway. Additionally, this intersection is considered a sidepath crossing because it is within the functional area of the adjacent intersection. Sidepath crossings have been documented to be potentially hazardous for trail users when motorists, especially those turning, who do not expect a trail crossing in such close proximity to the intersection, fail to

notice approaching trail users as they cross the trail. Secondarily, queued motorists may block the trail crossing, especially during right-turn-on red movements.

This experiment consisted of a phased assessment of various traffic control treatments to determine the effectiveness for each treatment to mitigate the safety concerns. The phases were:

- Phase I - baseline condition with stop signs on the trail for cyclists
- Phase II - condition without stop signs when the pedestrian signal applied to all trail users
- Phase IIIA - condition with the bicycle signal (four to six weeks following installation)
- Phase IIIB - condition with the bicycle signal (11 months following installation)

This report documents the changes in compliance, conflict, and behavior associated with each phase of intersection traffic control treatment adjustments. The bicycle control and signal timings (including fixing the pedestrian signal) were the only factors changed in the experiment to effectively study the bicycle signal.

The remainder of this report includes sections covering Intersection Traffic-Control Descriptions, Experimental Design and Project Timeline, Experimental Analyses Results, Conclusions and Next Steps. Observations and final conclusions are based upon research completed through all phases.

2.0 Intersection Traffic-Control Descriptions

This section provides details on the traffic control for each of the three phases of the experiment: Phase I – Stop Sign, Phase II –Pedestrian Signal and Phase IIIA/IIIB - Bicycle Signal.

2.1 Phase I – Stop Sign

Traffic Controls, July 2010

- South Washington Street, the Porto Vecchio Driveway, and South Alfred Street were controlled by a traffic signal.
- Westbound right turns from the Porto Vecchio Driveway were posted with NO TURN ON RED WHEN PEDESTRIANS ARE PRESENT and DO NOT BLOCK BIKE PATH signs.
- Northbound right turns from South Washington Street into the Porto Vecchio Driveway were posted with NO TURN ON RED WHEN PEDESTRIANS ARE PRESENT.
- Southbound left turns from South Washington Street into Porto Vecchio driveway were controlled by an actuated left-turn signal operating with protected/permitted phasing.
- Both approaches of the Mount Vernon Trail crossing at the Porto Vecchio driveway were posted with a stop sign (intended for bicyclists)
    - The southbound approach was also posted with a BICYCLIST MUST DISMOUNT sign.
    - The northbound approach was also posted with a BIKE ROUTE sign.
- Mount Vernon Trail crossing of the Porto Vecchio driveway had pedestrian signals with pushbuttons (intended for all non-bicyclists). However, the crosswalk signal rested in “don’t walk” at all times.

- The cycle length was 120 seconds.
- There was video detection for vehicles in the driveway and on South Alfred Street to actuate the signal to enter South Washington Street.
- South Washington Street set for maximum recall at all times of day

Observations

The placement of a stop sign for trail users at a signalized intersection is not consistent with MUTCD practice or AASHTO Guidelines which discourage the posting of stop signs at signalized intersections[1,2]. Historically, posting stop signs at signalized intersections was intended to "protect" bicyclists operating on sidepaths from conflicts with left- and right-turning motorists from the parallel roadway; however, experience has shown this treatment degrades bicyclists' respect for the stop sign and decreases compliance. A fundamental flaw with this combination of a stop sign at a traffic signal is it is not clear to motorists, bicyclists, or pedestrians the stop sign applies only to bicyclists. It is also problematic that the stop sign implies bicyclists have the right to proceed after stopping, even if they are crossing against the intersection's red traffic signal thereby violating crossing traffic's right-of-way.

Figure 2 – Southbound Mt. Vernon Trail, July 2010

Figure 3 – Northbound Mt. Vernon Trail, July 2010

Field observations found the southbound stop sign was partially obscured by traffic signal pole for the majority of the approach (Figure 2) and the northbound stop sign was partially obscured by vegetation (Figure 3).

The locations of the pedestrian pushbuttons do not meet 2009 MUTCD guidance. Specifically, the traffic signal poles and pushbuttons are located on the left side of the trail relative to the through moving bicyclist who is riding on the right (figures 3 through 6). This layout requires bicyclists to

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[1] 2009 MUTCD Section 2B.04 States: "Standard: Because the potential for conflicting commands could create driver confusion, YIELD or STOP signs shall not be used in conjunction with any traffic control signal operation, except…If a minor street or driveway is located within or adjacent to the area controlled by the traffic control signal, but does not require separate traffic signal control because an extremely low potential for conflict exists."

[2] 1999 AASHTO Bike Guide, pg 34 States: "…shared use paths should be given the same priority through intersections as the parallel highway…efforts to require or encourage bicyclists to yield or stop at each cross-street and driveway are inappropriate and frequently ignored by bicyclists."

obstruct the opposite flow of trail traffic or to potentially have to dismount to actuate the signal. Additionally, the pedestrian crosswalk signal rested in the Don't Walk display at all times which indicates that the push buttons may not have been functional. These push buttons also do not meet American with Disabilities guidelines.

The decorative walls and vegetation on either side of the driveway restrict the sight distance between Porto Vecchio traffic and the trail. Convex mirrors are installed at the crossing in an attempt to allow trail users and driveway users to see around the sightline obstructions (figures 4 and 5).

With the South Washington Street movement set for maximum recall with a signal cycle length of 120 seconds, it is possible for Porto Vecchio driveway vehicles to wait up to 105 seconds for a green signal.

Figure 4 - Porto Vecchio driveway looking south, Aug 2010

Figure 5 –Porto Vecchio driveway looking north, Aug 2010

Figure 6 – Southbound view from South Washington Street, August 2010

2.2 Phase II – Pedestrian Signal

Traffic Control Adjustment, August 24th, 2010

On August 24th, 2010, the following changes were made to the traffic controls at the intersection:

- The stop signs were removed from the Mt Vernon Trail crossing of the Porto Vecchio driveway. The BICYCLIST MUST DISMOUNT sign (southbound) and BIKE ROUTE sign (northbound) remained.
- The pedestrian signals for the Mount Vernon Trail crossing of the Porto Vecchio driveway were reprogrammed to operate in pedestrian recall mode at all times of the day. The walk time was maximized with the parallel South Washington Street vehicular movement. The pedestrian push buttons were left in place.
- The cycle length for the intersection was reduced from 120 seconds to 100 seconds.
- All other traffic controls remained the same as in Phase I.

2.3 Phase IIIA/IIIB – Bicycle Signal

Phase IIIA is the analyses the bicycle signal condition two to four weeks after the installation of the bicycle signal. Phase IIIB is the analyses of the bicycle signal condition 11 months (August/ September 2011) after the installation of the bicycle signal.

Traffic Control Adjustment, October 18, 2010

On October 18th, 2010, the following changes were made to the traffic operations at the intersection:

- Bicycle signals were added to the south and north approaches of the Mount Vernon Trail crossing of the Porto Vecchio driveway. The bicycle signals were mounted adjacent to the pedestrian signals (Figure7). The bicycle signal timing matches the parallel South Washington Street vehicular movement, maximizing green time for bicyclists on the trail.
- The pedestrian signals for the Mount Vernon Trail crossing of the Porto Vecchio driveway continued to operate in pedestrian recall mode at all times of the day.
- All other traffic controls remained the same as in Phase II.

Figure 7 - Phase III Bicycle Signal Operation

3.0 Experiment Design and Project Timeline

3.1 Experiment Design

This evaluation is a three-phase observation of traffic-control compliance and behavior at the Mount Vernon trail crossing at the Porto Vecchio Driveway. The experimental approach includes video analysis, speed analysis, crash analysis, and online & intercept surveys.

Video Analysis

The experiment team recorded up to 12 hours of video to capture typical midweek and weekend operations. Video was recorded in August 2010 for Phase I, September 2010 for Phase II, November 2010 for Phase IIIA, and August/ September 2011 for Phase IIIB as detailed in the table in the following section. The video was utilized to determine traffic-control compliance, to monitor for conflicts between various users, and to count

Figure 8 - Example Video from Phase II

movements across the trail by mode and direction. Video analyses results are in sections 4.1 Traffic Compliance Analyses and 4.2 Conflict Analyses.

The comparative evaluations between all phases of the experiment were limited to the weekend days. Comparisons between weekday and weekend riders are included in Phase IIIA and IIIB only. Historical counts and national trends indicate trail use is considerably higher on Saturdays and Sundays than other days of the week. Additionally, weekend trail users typically represent a wider cross section of people who bicycle for utilitarian and recreational purposes. It is hypothesized the lower volume mid-week users are primarily experienced utilitarian or commute-oriented bicyclists and that this sub-group of riders may not exhibit the same behaviors as the recreation-oriented bicyclists.

Speed Analysis

Bicyclist operating speeds are important for safety at this location because they determine sight lines and stopping distances and to assess whether changes to traffic control affect the operating speed of bicyclists. Speed studies were conducted during Phase I in July 2010 and during Phase IIIB in November 2011. The results of these studies can be found in section 4.3 Trail Speed Analysis.

Crash Analysis

Reported crashes between January 2000 and December 2011 were collected from the City of Alexandria crash database. All crashes located within 100 feet of the intersection are included, not just crashes at the trail crossing. The results of the crash analysis can be found in section 4.4 Crash Analysis.

Online and Intercept Surveys

Online surveys for Porto Vecchio residents and Intercept Surveys for trail users were conducted to determine user understanding and perception of traffic controls at the trail crossing. Initial and follow-up online surveys for Porto Vecchio residents were distributed in July/August 2010 to determine baseline perceptions and September/October 2011 to assess impact of traffic control changes to perceptions of residents. Intercept surveys were collected from trail users in July 2010 for Phase I, September 2010 for Phase II, and September 2011 for Phase IIIB. The results of the online and intercept surveys analyses can be found in section 4.4 Online and Intercept Surveys.

3.2 Project Timeline

The project timeline is shown in the following table.

Table 1: Project Timeline

Request to Experiment Submitted to FHWA	June 18, 2010
FHWA Approval of Request to Experiment	July 21, 2010
Phase I – Stop Sign	
City Briefing to Porto Vecchio Condo Board	July 28, 2010
Porto Vecchio Online Survey #1	July 29 – August 25, 2010
Trail User Intercept Survey #1	July 31, 2010
Trail User Speed Study #1	July 31, 2010
Video Analyses #1, Weekend 7am – 7pm	August 14, 2010 (Saturday)
Phase II – Pedestrian Signal	**August 24, 2010**
Trail User Intercept Survey, #2	September 18, 2010 (Saturday)
Video Analyses #2, Weekend 5am – 5pm	September 18, 2010 (Saturday)
Phase IIIA – Bicycle Signal, 1 month follow up	**October 18, 2010 (Monday)**
News and Blog Stories	October 18 – October 29, 2010
Video Analyses #3 , Weekday 7am – 7pm	November 3, 2010 (Wednesday)
Video Analyses #4, Weekend 9am – 5pm	November 13, 2010 (Saturday)
Progress Report #1	May 30, 2011
Phase IIIB – Bicycle Signal , 11 month follow up	
Porto Vecchio Online Survey #2	September 26 – October 13, 2011
Trail User Intercept Survey #3	September 17, 2011 (Saturday)
Video Analyses #5, Weekday 6am – 6pm	August 23, 2011 (Tuesday)
Video Analyses #6, Weekend 6am – 6pm	September 3, 2011 (Saturday)
Trail User Speed Study #2	November 20, 2011 (Sunday)
Final Report	January 2012

Due to scheduling conflicts, weekday video analysis was not performed during Phase I and Phase II. Additionally, during Phase II, weekend video for analysis was recorded on the same day as the trail users intercept surveys were conducted. These issues and their relevance will be discussed further in the report.

4.0 Experimental Analysis Results

The experimental analysis includes five elements: Traffic Compliance Analyses, Conflict Analyses, Trail Speed Analyses, Crash Analyses and Online & Intercept Survey Results. The following sections describe each element and summarize the observational results.

4.1 Traffic Compliance Analysis

This section provides a summary of bicycle and pedestrian traffic-control compliance during Phase I – Stop Sign, Phase II – Pedestrian Signal, and Phase IIIA/Phase IIIB – Bicycle Signal conditions. Cyclists at the greatest risk are those who do not stop while South Washington Street has a red signal because of

potential for conflicts with motorists exiting or entering the Porto Vecchio driveway. The tables below tabulate the behavior in relation to both the vehicle signal (red, yellow, green) and the pedestrian signal phases (solid "don't walk," flashing "don't walk," "walk") in order to compare bicyclist violation rates between experiment phases and determine cyclists exposure to potential conflicts.

Phase I - Stop Sign

During Phase I, the trail was controlled by a pedestrian signal with a countdown timer for pedestrians and stop signs for cyclists. Pedestrians were considered compliant when they entered the intersection during the pedestrian "walk" indication. The pedestrian push button and pedestrian signal were not functioning on August 14, 2010, so all pedestrians were technically non-compliant. Thus, pedestrian compliance data could not be captured in this phase of analysis. It was unclear how long the push button and pedestrian signal had been broken. There were very few observations of pedestrians pushing the button. Bicyclists were considered compliant when they stopped fully at the stop sign and proceeded into the intersection only when it was clear of conflicting traffic, regardless of signal phase.

The following table summarizes cyclist behavior at the crossing. Though signal phase did not determine cyclist compliance, it was noted in order to compare behaviors across phases and to determine cyclists' exposure to potential conflicts. Grey shading signifies compliant behavior.

Table 2: Phase I Weekend Stop Sign Compliance

		Compliant Bicyclists	
S Washington Signal	**Cyclist Action**	**Count**	**% of Total**
Green/Yellow	Stops	33	1.7%
Green/Yellow	Does Not Stop	1,732	88.7%
Red	Stops	30	1.5%
Red	Does Not Stop	158	8.1%
	Total Compliant	**63**	**3.2%**
	Total Non-Compliant	**1,890**	**96.8%**
	Total	*1,953*	

Though 96.8% of cyclists don't stop at the stop sign, only 9.6% crossed during the South Washington Street red interval, when traffic entering or exiting the Porto Vecchio driveway has the green indication. Therefore, while the cyclists rarely heeded the stop sign, the vast majority proceeded through the intersection during portions of the signal cycle when they were least likely to conflict with a motorist.

Phase II - Pedestrian Signal

During this phase, both bicyclists and pedestrians were controlled by the pedestrian signal with countdown timer. The cycle length for the intersection was reduced from 120 seconds to 100 seconds.

Thus, both were considered compliant when they entered the intersection during the pedestrian "walk" indication. The purpose of this analysis is to determine bicyclist compliance with the pedestrian signal after the removal of the stop sign and to develop a baseline of pedestrian compliance since this data could not be captured during Phase I. The following table summarizes trail user behavior. Grey shading signifies compliant behavior.

Table 3: Phase II Weekend Pedestrian Signal Compliance

When Trail User Entered Crossing…		Bicyclists		Pedestrians	
S Washington Signal Indication	**Pedestrian Indication**	**Count**	**% of Cyclists**	**Count**	**% of Pedestrians**
Green	"Walk"	1,426	82.2%	720	77.4%
Green	Flashing "Don't Walk"	181	10.4%	78	8.4%
Yellow	Solid "Don't Walk"	36	2.1%	18	1.9%
Red	Solid "Don't Walk"	91	5.3%	114	12.3%
	Total Compliant	**1,426**	**82.2%**	**720**	**77.4%**
	Total Non-Compliant	**308**	**17.8%**	**210**	**22.6%**
	Total	*1,734*		*930*	

During Phase II, 82.2% of all bicyclists operated in compliance with the pedestrian signal. Compared to Phase I, cyclists who entered the crossing during the South Washington St. red indication decreased from 9.6% to 5.3%. The pedestrian baseline compliance was established at 77.4%, with 12.3% of pedestrians crossing with the highest risk for conflict, during the South Washington Street red indication.

Phase IIIA - Bicycle Signal

During this phase of the experiment, the bicycle signal operated with the same phasing as the parallel roadway vehicular signal. The pedestrian signal phasing and cycle length were not changed. Cyclists were considered compliant if they crossed only when the bicycle signal was green or yellow. Pedestrians were considered compliant if they entered when they had the "walk" indication, as in Phase II. This phase was conducted 4-6 weeks after phase II.

The purpose of this analysis is to determine the rate of bicyclist compliance compared to the previous phase and the effect the bicycle signal may have had on pedestrian compliance. To allow comparison between experiment phases, the table below tabulates the behavior in relation to the vehicle signal, the bicycle signal, and the pedestrian signal phases. Grey shading signifies compliant behavior.

Table 4: Phase IIIA Weekend Bicycle and Pedestrian Signal Compliance

When Trail User Entered Crossing…			Bicyclists		Pedestrians	
S Washington Signal Indication	**Bike Signal Indication**	**Pedestrian Indication**	**Count**	**% of Cyclists**	**Count**	**% of Pedestrians**
Green	Green	"Walk"	778	73.5%	336	69.0%
Green	Green	Flashing "Don't Walk"	117	11.0%	64	13.1%
Yellow	Yellow	Solid "Don't Walk"	30	2.8%	17	3.5%
Red	Red	Solid "Don't Walk"	134	12.7%	70	14.4%
		Total Compliant	**925**	**87.3%**	**336**	**69.0%**
		Total Non-Compliant	**134**	**12.7%**	**151**	**31.0%**
		Grand Total	*1,059*		*487*	

Cyclist compliance increased from 82.2% in Phase II to 87.3% in Phase IIIA. Compared to Phase II, bicyclists who entered the crossing during the red phase increased from 5.3% to 12.7%. Pedestrians were less compliant with the pedestrian signal than in Phase II.

During Phase IIIA, video was also analyzed on a weekday to determine whether day of the week affects trail-user behavior. The following table summarizes the weekday results in Phase IIIA. Grey shading signifies compliant behavior.

Table 5: Phase IIIA Weekday Bicycle and Pedestrian Signal Compliance

When Trail User Entered Crossing…			Bicyclists		Pedestrians	
S Washington Signal Indication	**Bike Signal Indication**	**Pedestrian Indication**	**Count**	**% of Cyclists**	**Count**	**% of Pedestrians**
Green	Green	" Walk"	233	80.1%	124	75.2%
Green	Green	Flashing "Don't Walk"	22	7.6%	15	9.1%
Yellow	Yellow	Solid "Don't Walk"	8	2.7%	2	1.2%
Red	Red	Solid "Don't Walk"	28	9.6%	24	14.5%
		Total Compliant	**263**	**90.4%**	**124**	**75.2%**
		Total Non-Compliant	**28**	**9.6%**	**41**	**24.8%**
		Grand Total	*291*		*165*	

The weekday and weekend behaviors for Phase IIIA were very similar and differences in compliance overall could not be deemed statistically significant based on comparison of data for this phase. This differed from the hypothesis that trail user purpose and behavior differ on weekdays and weekends. Weekday and weekend conditions from different phases are not compared in this study due to insufficient data from earlier phases of the experiment.

Phase IIIB - Bicycle Signal

This phase was conducted 11 months after the bicycle signal installation with no changes to the crossing traffic control from Phase IIIA. Cyclist and pedestrian compliance were considered the same as in Phase IIIA.

The purpose of this analysis is to determine the effect of the bicycle signal after several months, once regular users have adjusted to the change. To allow comparison between experiment phases, the following table tabulates trail user behavior in relation to the vehicle signal, bicycle signal, and pedestrian signal indications. Grey shading signifies compliant behavior.

Table 6: Phase IIIB Weekend Bicycle and Pedestrian Signal Compliance

When Trail User Entered Crossing…			Bicyclists		Pedestrians	
S Washington Signal Indication	**Bike Signal Indication**	**Pedestrian Indication**	**Count**	**% of Cyclists**	**Count**	**% of Pedestrians**
Green	Green	" Walk"	1,109	83.6%	686	81.0%
Green	Green	Flashing "Don't Walk"	74	5.6%	53	6.3%
Yellow	Yellow	Solid "Don't Walk"	26	2.0%	31	3.7%
Red	Red	Solid "Don't Walk"	117	8.8%	77	9.1%
		Total Compliant	**1209**	**91.2%**	**686**	**81.0%**
		Total Non-Compliant	**117**	**8.8%**	**161**	**19.0%**
		Grand Total	*1,326*		*847*	

Cyclist compliance increased from 87.3% in Phase IIIA to 91.2% in Phase IIIB. Bicyclists who entered the crossing during the red phase on South Washington St decreased from 12.7% in Phase IIIA to 8.8% in Phase IIIB; however, there is no statistically significant difference in the proportion of cyclists crossing during the red indication on South Washington St from Phase I.

During Phase IIIB, video was also analyzed on a weekday to determine whether day of the week affects trail-user behavior. The following table summarizes the weekday results in Phase IIIB. Grey shading signifies compliant behavior.

Table 7: Phase IIIB Weekday Bicycle and Pedestrian Signal Compliance

When Trail User Entered Crossing…			Bicyclists		Pedestrians	
S Washington Signal Indication	**Bike Signal Indication**	**Pedestrian Indication**	**Count**	**% of Cyclists**	**Count**	**% of Pedestrians**
Green	Green	" Walk"	631	82.9%	229	80.6%
Green	Green	Flashing "Don't Walk"	46	6.0%	23	8.1%
Yellow	Yellow	Solid "Don't Walk"	16	2.1%	5	1.8%
Red	Red	Solid "Don't Walk"	68	8.9%	27	9.5%
		Total Compliant	**693**	**91.1%**	**229**	**80.6%**
		Total Non-Compliant	**68**	**8.9%**	**55**	**19.4%**
		Grand Total	*761*		*284*	

The weekday and weekend behaviors for Phase IIIB were very similar; differences in compliance overall could not be deemed statistically significant. This differed from the hypothesis that trail user purpose and behavior differ on weekdays and weekends for this phase. This differed from the hypothesis that trail user purpose and behavior differ on weekdays and weekends. Weekday and weekend conditions from different phases are not compared in this study due to insufficient data from earlier phases of the experiment.

Discussion of Compliance Analysis

The following table shows a comparison of trail-user behavior for Phases I, II, IIIA, and IIIB as percentages of total bicyclists and pedestrians. Data from the weekdays studied in Phase IIIA and IIIB are not included in the table because there is not statistical evidence to confirm that these rates are different from the weekend rates.

Table 8: Trail-User Compliance by Phase

		Phase I	Phase II	Phase IIIA	Phase IIIB
Bikes	% Compliant	3.2%	82.2%	87.3%	91.2%
	% Non-Compliant	96.8%	17.8%	12.7%	8.8%
	% cross on S Washington red	9.6%	5.3%	12.7%	8.8%
Peds	% Compliant	N/A	77.4%	69.0%	81.0%
	% Non-Compliant	N/A	22.6%	31.0%	19.0%
	% cross on S Washington red	N/A	12.3%	14.4%	9.1%

The compliance data validates complaints that bicyclists were not obeying the stop sign in Phase I; however, as mentioned earlier, expecting bicyclists to stop at the stop sign when the signal indication is green is confusing, counter to transportation engineering principals, and unreasonable. Throughout the experiment, bicyclist compliance continually increased. Even after a one-year adjustment period to the bicycle signal, bicyclist compliance continued to increase. Since the pedestrian push button was not functioning during Phase I, few pedestrians were technically considered compliant during this phase, however they had no ability to be compliant due to the faulty equipment. It is possible this trained pedestrians to believe it made no difference to push the button which resulted in our observations that few pedestrians attempted o press the button. It is also possible that due to the short crossing, the low traffic volume and the long adjacent parallel green pedestrians viewed the push button as an unreasonable device.

The decrease in pedestrian compliance from Phase II to IIIA and increase from IIIA to IIIB are statistically significant; however, the change between Phase II and IIIB is not statistically significant. The data does not indicate the bicycle signal affected pedestrian compliance. A review of the video tape indicates the pedestrians typically crossed where gaps became available. It is possible that the combination of pedestrian arrivals and availability of additional gaps (due to relatively low volume of traffic into and out of the driveway) led to the decrease in pedestrian compliance from Phase II to IIIA; however this was not evaluated specifically between phases.

Pedestrian phasing and timing does not adequately suit cyclists since it required a lengthy period of flashing “don’t walk” timed to allow the slowest-moving pedestrian to finish crossing.” At the Porto Vecchio driveway, the pedestrian indicator has a countdown timer which enables trail users to judge

whether or not they can finish crossing before the solid "don't walk" indication appears. An ITE study[3] of 600 to 900 crossings in San Francisco before and after installation of countdown timers found that fewer pedestrians were still in the crosswalk during the red signal indication with countdown timers than without, but did not study the effect on cyclists. The countdown timer at the Mt Vernon Trail crossing counts down the final 12 seconds prior to the solid "don't walk" indication, accommodating a crossing speed of 2.3 feet per second, which is lower than the MUTCD-recommended maximum of 3.5 feet per second for pedestrians. Cyclists traveling 8 mph (the mean speed of uphill cyclists in Phase I) only require 2.4 seconds to cross. This could be a reason for only moderate cyclist-compliance rates during Phase II when 10.4% of cyclists enter during the flashing "don't walk "indication. With the bicycle signal, cyclists crossing during the flashing "don't walk" (while the bicycle signal indicated green) were considered compliant. Given the fact the countdown timer is present for all phases, it is not possible to determine the effect it may have had on the compliance of pedestrians and bicyclists from a pre-timer condition.

During the red indication on South Washington Street, traffic on the Porto Vecchio driveway has the right of way at the trail crossing. Thus, this is the most dangerous crossing time for non-compliant trail users. The difference in this crossing rate between Phases I and IIIB did not change considerably. Cyclists risked this potential conflict most during Phase I and least during Phase II. One reason for the decrease in cyclists who crossed during the red indication on South Washington Street during Phase II may be that for a few hours during the video, intercept survey collectors were on site. Cyclists may have behaved differently because they were being observed by the survey team, or because they were reminded of the importance of safety at the crossing.

On weekdays in Phases IIIA and IIIB, cyclist and pedestrian compliance increased between phases, further supporting that compliance increased after adjustment to the bicycle signal.

4.2 Conflict Analysis for All Phases of Experiment

Through video observations, conflicts between motorists and pedestrians/bicyclists within the crosswalk were recorded. The following conflict analysis establishes potential safety issues not indicated in the crash data in section 4.4 Crash Analysis. Conflicts were defined as any interaction between users that required a user to stop, required a user to suddenly change speed or direction, or a resulted in a collision. The signal phase at the time of the conflict was also recorded. Based on observations of the crossing, most conflicts during the red indication on South Washington Street were the fault of a cyclist or pedestrian who should have stopped for either the red bicycle indication or the "don't walk" pedestrian indication. Most conflicts during the green indication on South Washington Street were the fault of a motorist who failed to properly yield to trail users in the

[3] Markowitz, Sciortino, Fleck and Yee. "Pedestrian Countdown Signals: Experience with an Extensive Pilot Installation." ITE Journal. January 2006.

crossing. The most common conflict type was a motorist turning right-on-red from the Porto Vechhio driveway across the trail, blocking the trail users while they waited for a gap in traffic.

In rare cases, trail users were at fault during the green on South Washington Street for not yielding to vehicles already in the driveway. The following table shows conflicts across the experiment phases.

Table 9: Conflicts by Signal Phase and Experiment Phase on Weekends

	Phase I	Phase II	Phase IIIA	Phase IIIB
Conflicts During Washington RED	27	11	12	11
Conflicts During Washington GREEN	58	52	32	23
Total Conflicts	85	63	44	34
% Trail Users in a Conflict	4.4%	2.4%	2.8%	1.6%
% Motorists in a Conflict*	25.6%	18.5%	13.9%	11.5%
% of Trail Users in a Conflict on Washington RED	1.4%	0.4%	0.8%	0.5%
% of Trail Users in a Conflict on Washington GREEN	3.0%	2.0%	2.1%	1.1%
% of Motorists in a Conflict on Washington RED	8.1%	3.2%	3.8%	3.7%
% of Motorists in a Conflict on Washington GREEN	17.5%	15.3%	10.1%	7.8%
Total # of Trail Users	1953	2664	1546	2173
Total # of Motorists Entering S Washington St	141	179	173	136
Total # of Motorists Exiting S Washington St	191	161	143	159

*% Motorists includes only motorists crossing the trail (through Washington Street traffic is not included)

The following table compares conflicts from the weekday video analysis in Phases IIIA and IIIB. This data should not be directly compared to data from weekends of other phases since multiple factors could affect behavioral shifts other than phase and adjustments should be made to compensate for different trail and motorists volumes to compare to weekend rates.

Table 10: Conflicts by Signal Phase and Experiment Phase on Weekdays

	Phase IIIA Weekday	Phase IIIB Weekday
Conflicts During Washington RED	6	18
Conflicts During Washington GREEN	14	13
Total Conflicts	20	31
% Trail Users in a Conflict	4.4%	3.0%
% Motorists in a Conflict	5.1%	7.7%
% of Trail Users in a Conflict on Washington RED	1.3%	1.7%
% of Trail Users in a Conflict on Washington GREEN	3.1%	1.2%
% of Motorists in a Conflict on Washington RED	1.5%	4.5%
% of Motorists in a Conflict on Washington GREEN	3.6%	3.2%
Total # of Trail Users	456	1045
Total # of Motorists Entering S Washington St	181	193
Total # of Motorists Exiting S Washington St	213	211

On the weekend days studied, the proportions of trail users and motorists involved in conflicts steadily decreased.

The most prevalent conflict observed in the video analysis, is generated by the westbound motorists turning right-on-red from the Porto Vecchio property. Between 52% and 79% of all conflicts during the green indication on South Washington Street resulted from a motorist making a right turn on red from the Porto Vecchio driveway or blocking the crosswalk before making the right turn onto South Washington Street. These motorists are violating the NO TURN ON RED WHEN PEDESTRIANS ARE PRESENT and DO NOT BLOCK BIKE PATH signs. Of particular concern is the consistently high percentage of motorists who pull into the crosswalk without first stopping at the stop line. The decorative wall and vegetation limits sight lines of motorists to approaching trail users. The survey results from Porto Vecchio indicated few of them utilize the mirror at the driveway so this behavior is particularly risky as a crash could result. Numerous interactions were noted in the video where trail users appeared to make angry gestures to motorists who pulled into the crosswalk in this manner. The table below demonstrates the larger percentages of conflicts which result where the motorist fails to first stop at the stop line. The table provides the total number of motorists turning right, the number resulting conflicts with trail users, and the percentage of right turning motorists involved in a conflict. It also compares identifies the percentages and behavior of right turn-on-red motorists.

Table 11: Motorists Conflicts With Trail Users While Turning Right on Red from Porto Vecchio by Experiment Phase on Weekends

	Phase I			Phase II			Phase IIIA			Phase IIIB		
	Total Obs.	Conflicts	%	Total Obs.	Conflicts	%	Total Obs.	Conflicts	%	Total Obs.	Conflicts	%
stops at stop line - proceeds into xwalk	55	19	33%	37	5	14%	39	1	3%	50	2	4%
rolls through stop line - proceeds into xwalk	50	14	28%	69	22	32%	47	13	28%	42	12	29%
	105	**33**	**31%**	**106**	**27**	**26%**	**86**	**14**	**16%**	**92**	**15**	**15%**
Percent of RTOR vs [All Right Turns]	[132]		80%	[122]		86.9 %	[101]		85%	[118]		78%
% of Motorists Who Fail to Stop First	50		37.9 %	69		56.6 %	47		46.5 %	42		35.6 %

Table 12: S. Washington Street Motorists Conflicts With Trail Users While Turning on Green into Porto Vecchio by Experiment Phase on Weekends

	Phase I			Phase II			Phase IIIA			Phase IIIB		
	Total Obs.	Conflicts	%	Total Obs.	Conflicts	%	Total Obs.	Conflicts	%	Total Obs.	Conflicts	%
Southbound left turn on green motorists	95	17	17.9%	134	11	8.2%	119	4	3.4%	103	7	6.7%
Northhbound left turn on green motorists	45	8	17.8%	41	4	9.8%	51	3	5.9%	33	0	0%

The treatments produced a consistent decline in conflict rates at each stage of the experiment with the exception of the Phase III left turn conflict. Observations of these conflicts indicate the conflicts are a generally balanced mixture of motorists failing to potentially see or yield to the approaching bicyclists prior to their turn and trail users failing to observe the red or DON'T WALK signal.

Discussion of Conflict Analysis

Prior sidepath safety research indicates that the southbound left-turn on green, northbound right-turn on green, and Porto Vecchio right-turn on red movements are likely to have higher crash rates. This experiment showed decreases for each of these conflict types (i.e. conflicts during the Washington green) through each phase of the experiment. This experiment documented approximately 25% of all motorists crossing the trail during phase I experienced a conflict with a trail user. Proportionate to the traffic volume, this is a high percentage and is likely a major contributing factor to the negative perceptions of trail users the residents of Porto Vecchio conveyed during the survey and their perception the crossing was unsafe. Based upon the survey data and the letter submitted by the Porto Vecchio Condominium Association, it appears the high percentage of residents experiencing conflict as a semi-regular occurrence during the baseline continues to affect their perception of the trail crossing safety as their concerns do not seem to recognize the decreasing conflicts measured in this experiment over a period of a year.

The proportion of weekend motorists in a conflict during the Washington green indication decreased across the phases from 17.5% during Phase I to 7.8% during Phase IIIB. This may have resulted from the 20-second cycle-length reduction in Phase II, which may have increased motorists' incentive to wait for a protected turning opportunity by shortening their wait times or . Significant conflict reductions were not observed immediately in Phase II, possibly due to the gradual realization of shorter wait times. Increased trail-user compliance also likely contributed to lower conflict rates.

This conflict data indicates that bicyclists have responded positively to the changes in timing by increasing their compliance with the traffic control. Additionally, the removal of the stop sign seems to have particularly decreased conflicts during the South Washington Street red indication. The experiment seems to also demonstrate the traffic control treatments utilized at each stage of the experiment are increasingly effective at mitigating the most prevalent conflicts associated with sidepaths.

The highest relative conflict rate which the traffic control treatment adjustments did not resolve is the Porto Vecchio right turn on red. Conflicts involving this movement decreased with changes in traffic control, but this may be more attributable to other factors such as the traffic-signal cycle-length reduction as the reduction is limited to those motorists who first stop at the line. Despite the reduction in cycle length (and necessary wait time) high percentages of motorists are turning right-on-red. The 35% to 56% of motorists who approach and enter the crosswalk without first stopping was found to be the most significant cause of conflict in the crosswalk.

The proportion of motorists involved in conflicts on weekdays in Phases IIIA and IIIB were lower than on weekdays in the same phases. Since the proportion of trail users in a conflict did not vary considerably, the shift in motorist conflict rates is likely due to the decrease in trail users on the trail on weekdays.

4.3 Trail Speed Analysis

The purpose of this speed analysis is to evaluate whether there is a significant change in trail user speeds under the stop sign operation in Phase I and after the bicycle signal was installed, in Phase IIIB.

Speed data was collected with a laser gun directed at bicyclists and pedestrians as they entered the crossing to determine the typical operating speed of cyclists in Phase I and IIIB. A platoon, or group of cyclists traveling together, was counted only once.

In Phase I, 164 bicyclist speeds were collected on July 31st between 10:30 and 11:45 AM. Separate observations were taken for the north and south approach to determine the effect of the southbound downhill grade with a good view of the signal and the northbound chicane in the trail alignment with a poor view of the signal. The data showed that the downhill grade may contribute to slightly elevated approach speeds since the mean southbound speed was 9.0 mph while the mean northbound speed was 6.6 mph. No cyclists were observed traveling faster 16 mph southbound or 13 mph northbound.

Pedestrian speeds were also collected in Phase I. Pedestrians averaged 3.3 mph and never traveled faster than 10 mph. There were only 22 observations per approach, which is an extremely small sample size, indicating that this data may not be reliable.

In Phase IIIB, 109 bicyclist speeds were collected on November 20, 2011 between 10:00 and 11:50 AM. Pedestrians were not tallied in this phase. Only one cyclist was observed going faster than 16 mph, at 19 mph.

The following table summarizes the data collected in Phases I and IIIB:

Table 13: Observed Trail-User Speeds at Porto Vecchio Driveway Crossing

	User Type	Mean (mph)	85th Percentile (mph)
Phase I	Cyclist	8.3	12.0
Phase I	Pedestrian	3.3	5.0
Phase IIIB	Cyclist	10.3	13.8

Discussion of Speed Analysis

The National Park Service website states that the trail speed limit is 15 mph, though no signs were observed surrounding the intersection. The current AASHTO Bike Guide[4] recommends a minimum shared-use path design speed of 20 mph, advising a design speed of 30 mph or more when a downhill grade exceeds 4 percent. The 85th percentile operating speed of cyclists was 12.0 mph in Phase I and 13.8 mph in Phase IIIB, well below both the speed limit and recommended design speed.

There is a statistically significant difference between the cyclist speeds in Phase I and in Phase IIIB. There are several factors that could influence this change in observed speeds. One factor that might affect speeds is the volume of trail users on the trail. Another factor may be that the trail was much more congested on the warm July day when Phase I speeds were collected compared to the brisk November day when Phase IIIB speeds were tallied. Finally, a third factor could be that the removal of the stop sign and addition of the bicycle signal gives the right of way to the cyclists during a green indication and reduces their need to slow at the approach.

4.4 Crash Analysis

There were no reported crashes between bicyclists or pedestrians with vehicles entering and exiting the Porto Vecchio Condominium driveway or between bicyclists and pedestrians within the crossing between 2000 and 2010. There are relatively few crashes at this intersection year by year. The predominant crashes are rear end along the South Washington Street which can be a typical crash type for a signalized intersection on higher-volume, higher-speed roadways. Side swipes may have resulted from vehicles attempting to pass stopped, right-turning vehicles yielding to trail users or slower moving through vehicles. The angle crashes are primarily due to red light running or motorists turning onto the South Washington Street on red, possibly due to poor visibility from the Porto Vecchio driveway.

The following table summarizes crashes at the intersection between June 2000 and January 2011.

[4] Page 36, 1999 AASHTO Guide for the Development of Bicycle Facilities

Table 14: Crash Data from S Washington St and St Alfred St/Porto Vecchio driveway

Date	Rear End	Angle	Sideswipe	Run Off Road	Total	Phase
2000		1			1	I
2001					0	I
2002		1			1	I
2003	1				1	I
2004	1	1	1	1	4	I
2005	1	1			2	I
2006	1	1		1	3	I
2007		2			2	I
2008	1		1		2	I
2009					0	I
1/1/2009 - 8/24/2010					0	I
8/25/2009 - 9/18/2010	1				1	II
2011					0	III

Discussion of Crash Analysis

Given the high volume of motorists and trail users, there appears to be no unusual trends for crashes. It appears from the video observations that conflicts are avoided primarily due to the fact the relative speed differential between motorists and trail users is low within the crosswalk. The surveys indicate regular users are familiar with the conditions and the typical operating behaviors at the crossing which may result in faster response times and heightened awareness of potential conflict at this location. There were a number of near misses and evasive maneuvers observed in the video but none resulted in an actual crash. There have been no reported crashes during the time period of the experiment.

4.5 Online and Intercept Survey Results

Public Outreach and Porto Vecchio Resident Surveys

On July 28, 2010, Yon Lambert[5] met with the Porto Vecchio Condo Board to describe the planned experiment on the trail. He presented the project goals and described the overall project timeline. He requested that the residents, staff, and guests of the property participate in an online survey to register their opinions on safety and operations of the trail crossing at the Porto Vecchio driveway.

The initial survey was hosted online for approximately four weeks through the end of August 2010 on the Survey Monkey website. Notification of the residents and staff was achieved through an email invitation from the Condo Board. A total of 23 responses were recorded. A follow-up survey was

[5] Yon Lambert was the City of Alexandria Bicycle and Pedestrian Coordinator at this time.

conducted for approximately four weeks during September and October 2011, which received 41 responses. Both surveys asked residents about their opinions of safety and operations at the crossing.

Trail Intercept Survey

Trail intercept surveys were collected on Saturdays during Phases I (114 respondents), Phase II (49 respondents), and Phase IIIB (102 respondents). Trail users were offered cold water and a snack in exchange for taking the survey which asked questions about their opinions of safety and operations at the crossing. The surveys also asked users their purpose on the trail, mode of travel, and frequency of visits.

Summary of Responses

The following tables summarize responses from the Porto Vecchio online survey for motorists and the trail intercept survey.

Table 15: Responses to "How safe do you feel at the crossing?"

		Safe	Moderately Safe	Moderately Unsafe	Unsafe
Phase I	Motorists	4%	44%	44%	4%
	Cyclists	43%	15%	28%	14%
	Pedestrians	52%	27%	15%	6%
Phase II	Motorists	–	–	–	–
	Cyclists	57%	13%	30%	0%
	Pedestrians	44%	12%	40%	4%
Phase IIIB	Motorists	5%	30%	30%	36%
	Cyclists	48%	39%	13%	0%
	Pedestrians	36%	48%	10%	7%

Generally, motorists felt less safe than trail users and their feeling of safety worsened between Phases I and IIIB. More cyclists felt safe (indicating either "safe" or "moderately safe") with each phase of the study. Additionally, no cyclists felt unsafe during Phase II or IIIB, an improvement from the 14% in Phase I. About two-thirds (66%) of pedestrians felt either safe or moderately safe in Phase I. During Phase II, 56% felt safe or moderately safe, but by Phase IIIB, 84% felt safe or moderately safe. The proportion of pedestrians that felt unsafe remained steady for all phases, at 4-7%.

Table 16: Responses to "Who do you feel has the most priority at this crossing?"

		All Trail Users	Cyclists	Pedestrians	Drivers	Unsure
Phase I	Motorists	9%	9%	22%	30%	30%
	Cyclists	25%	11%	16%	38%	10%
	Pedestrians	44%	6%	34%	13%	3%
Phase II	Motorists	–	–	–	–	–
	Cyclists	27%	3%	40%	30%	0%
	Pedestrians	36%	4%	36%	20%	4%
Phase IIIB	Motorists	26%	9%	19%	30%	16%
	Cyclists	38%	9%	26%	20%	7%
	Pedestrians	37%	10%	27%	20%	7%

A consistent 30% of motorists thought that motorists had the most priority at the crossing for each survey. The major change for motorists was the decrease of those who were "unsure" from 30% percent in Phase I to 16% in Phase IIIB. The majority of the shift went toward "all trail users". The percentage of cyclists that thought driver had the most priority at crossing decreased steadily from 38% in Phase I to 30% in Phase II to 20% in Phase IIIB. Pedestrians regularly felt that pedestrians or all trail users had the most priority at the crossing.

Table 17: Responses to "Which best represents your opinion of traffic regulations at the driveway?"

The traffic regulations…		are confusing and unclear	do not apply to trail	are reasonable	are unreasonable
Phase I	Cyclists	20%	8%	61%	11%
	Pedestrians	26%	3%	61%	10%
Phase II	Cyclists	4%	–	92%	4%
	Pedestrians	9%	–	90%	0%
Phase IIIB	Cyclists	11%	4%	78%	7%
	Pedestrians	10%	8%	83%	0%

Most pedestrians and cyclists felt that traffic regulations were reasonable during Phase II – Pedestrian Signal (90-92%), a significant increase from Phase I – Stop Sign. Cyclist confusion decreased considerably with the removal of the stop sign from 20% to 4%. Though pedestrian confusion decreases also between Phases I and II/IIIB, this change is not statistically significant. Changes in responses between Phases II and IIIB could not be deemed statistically significant.

Table 18: Responses to "How often do you conflict with a trail user/motorist at the crossing?"

		Never	Rarely	Some of the time	Most of the time
Phase I	Motorists	9%	17%	61%	9%
	Cyclists	27%	25%	31%	5%
	Pedestrians	18%	39%	33%	6%
Phase II	Motorists	–	–	–	–
	Cyclists	50%	33%	17%	0%
	Pedestrians	48%	28%	24%	0%
Phase IIIB	Motorists	2%	14%	61%	21%
	Cyclists	13%	51%	30%	6%
	Pedestrians	18%	46%	32%	7%

Motorists felt they had more conflicts with trail users in Phase IIIB than in Phase I. This is in contrast to the observations from the video analysis which showed they actually had fewer conflicts, as shown in 4.1 Traffic Compliance Analysis. Trail users felt that they had fewer conflicts in Phase II than in Phase I or IIIB, when actually their conflicts constantly decreased.

Table 19: Responses to "Do you use the mirrors at this location?"

		I did not know they were there	No, they are not helpful	Yes, they are helpful
Phase I	Motorists	9%	39%	48%
	Cyclists	30%	27%	43%
	Pedestrians	48%	23%	29%
Phase II	Motorists	–	–	–
	Cyclists	21%	21%	57%
	Pedestrians	26%	26%	48%
Phase IIIB	Motorists	5%	57%	39%
	Cyclists	40%	20%	40%
	Pedestrians	32%	23%	46%

Most motorists surveyed in Phase I found the mirrors helpful, but most in Phase IIIB did not. Most cyclists and pedestrians who knew about the mirrors found them helpful. The mirrors were not modified or adjusted for any phase of this experiment.

Table 20: Responses to "Which best represents your opinion of the traffic signal at the driveway?"

Phase I Motorists	I wait a reasonable amount of time for a green light	27.3%
	I wait too long for a green light, but I only turn when the light is green	4.5%
	I wait too long for a green light, so I turn right on red frequently	63.6%
Phase IIIB Motorists	I wait a reasonable amount of time for a green light	15.9%
	I wait too long for a green light, but I only turn when the light is green	2.3%
	I wait too long for a green light, so I turn right on red frequently	72.7%

Fewer motorists in Phase IIIB (16%) felt that they wait a reasonable amount of time for a green light than in Phase I (27%). This result is counter than what was expected because the cycle length was

reduced from 120 seconds in Phase I to 100 seconds in Phases II-IIIB. More motorists in Phase IIIB stated that they turn right on red more frequently due to their feeling of a long wait time.

Table 21: Responses to "How do you feel about safety at the crossing with the addition of the bicycle signal?" (Phase IIIB only)

The bicycle signal…	improves safety	worsens safety	does not affect safety
Motorists	27%	39%	48%
Cyclists	81%	2%	14%
Pedestrians	51%	2%	46%

Most pedestrians and, especially, cyclists agree that the bicycle signal improves safety at the crossing; however, motorists believe that it does not affect or even worsens safety.

Sample of Citizen Concerns July/August 2010 – Phase I

"As usual, numerous bikes rode in front of me without slowing or stopping. When the light turned green, I pulled out. A young lady on a bike slammed on her brakes, flew over her handlebars and the bike went over. No one was visibly hurt." *–Motorist*

"As a cyclist who rides this path and crosses this driveway I am appalled at the idea that cyclists must currently stop, press a button then wait to cross. At the same time the whole concept that cyclist should always yield way to this driveway is nothing but attempting to bully cyclists and other trail users." *–Cyclist*

"The stop sign is NEVER heeded." *–Motorist*

"A yield sign for cyclists and a stop sign for cars exiting Porto Vecchio would have made more sense. A private driveway shouldn't have the right of way over the Mount Vernon Trail." *–Local Blog*

"As for the intersection of our driveway with the bike path, we agree that it's dangerous and needs attention" *–Motorist*

"From my experience as both a biker and a driver at PV, I think a major part of the safety concern at the intersection is the problem of visibility for drivers exiting PV and the problem of the activation of the traffic light allowing PV drivers to exit onto S. Washington St" *–Motorist/Cyclist*

"We should stop trying to insist that cyclists stop (and sometimes even dismount) at stop signs. It doesn't work. Instead, we should require cyclists to treat stop signs as yield signs." *–Motorist/Cyclist*

Sample of Citizen Concerns September/October 2011 – Phases IIIA and IIIB

"I believe the current system favors cyclists and establishes for them a right of way that can be exploited by them if an accident occurs." *–Motorist*

"I do not think the bicyclists take responsibility for their own safety. If they see a green light, they go full speed ahead." –*Motorist*

"I am very concerned that as I make a left into the building, even with the green arrow, that the cyclists will ignore the red light for bicycles, which they appear to do pretty routinely. It is difficult to see oncoming bicycles from the left when turning into the building when heading south." –*Motorist*

"[The bicycle signal] is useless and has created more hazard for the older folk walking." –*Motorist/Pedestrian*

"My sense is that testing the light must be accompanied with some degree of enforcement, otherwise repeated violations carry no consequence and the light will become effectively invisible." –*Motorist*

"[The bicycle signal] has been an improvement. Unfortunately it is too often ignored or not noticed." –*Motorist*

"I find it [the bicycle signal] to be more helpful" – *Cyclist*

"[The bicycle signal] makes me feel that cyclists are a priority to the city" –*Cyclist*

"The old system of "dismount before crossing" (as at many other crossings on trail) made it clear that 1) diligence was needed at all times and that 2) cars had priority. Now most cyclists go through whether the light is red or green." –*Pedestrian*

"I like them [bicycle signals], better for safety" – *Cyclist*

"I feel that the measures employed are adequate." –*Pedestrian*

Letter Submitted to City of Alexandria from Porto Vecchio Homeowners Association Board Regarding Signal Experiment – December 2011

The board canvassed some of the residents to express their views on the operations of the intersection, safety, and suggested some potential strategies for improvement. The letter is attached in Appendix D. The following summarizes the main points raised:

- The board feels the intersection is "dangerous," primarily due to a combination of the restricted sight lines (from the Porto Vecchio decorative wall) and the high volumes of trail users
- Crossing the trail as a motorist is "stressful"
- Crossing the driveway is "hazardous" for trail users
- The green signal encourages bicyclists to "speed through the intersection without being mindful that cars may be exiting or entering the parking lot with limited visibility of them."
- It is recommended the green signal be set to a flashing red to encourage bicyclists to "exercise caution" as they approach the driveway

- It is recommended additional signs be added to the trail to warn of the driveway approach and the limited sight lines which are likely to be of particular benefit to new users of the trail.

Discussion of Survey Results

Generally, motorists surveyed were less satisfied in Phase IIIB, with 39% stating that the bicycle signal worsens safety at the crossing. Only 4% of the 23 motorist survey respondents during Phase I – Stop Sign described themselves as feeling unsafe, compared to 36% of the 41 respondents in Phase IIIB – Bicycle Signal. Many motorists were perceived increased cyclist speeds (reducing safety) under the bicycle signal operation and several emphasized the need for enforcement of traffic laws at the crossing.

While other motorist responses shifted, very few could be determined statistically significant due to the small sample size of survey respondents. Changes in the feeling of priority at the crossing, frequency of conflicts, and opinion of the traffic signal all cannot be deemed statistically significant. The survey was available to all Porto Vecchio residents, visitors, and employees, but that only a few chose to respond, which likely took time and effort, may have biased the results.

When the stop sign was removed, bicyclists' perception of safety increased and confusion decreased. Cyclists felt that both the pedestrian signal and the bicycle signal operations were more reasonable and less confusing than the stop sign; however, differences between their opinions of traffic operations in Phases II and IIIB were not statistically significant. Eighty-one percent (81%) of cyclists felt that the bicycle signal improves safety. Overall, this indicates that the cyclists did not like the stop sign, which is appropriate considering that a stop sign provides unclear messaging at a signalized crossing and conflicts with state laws establishing right-of-way in the crossing. Bicyclists preferred the bicycle signal operation, though not statistically significantly more than the pedestrian signal operation. In written responses, some cyclists indicated that the behavior of other cyclists, as well as that of the vehicles, concerns them. Like the motorist survey results, the trail intercept survey results may have been biased because only those trail users willing to stop and provide feedback could be considered.

Generally, the addition of the bicycle signal did not affect pedestrians' opinions of the crossing. Nearly half of pedestrians in Phase IIIB felt that the bicycle signal did not affect safety, while the other half felt that the bicycle signal improved safety. In both phases with an operating pedestrian signal (II and IIIB), no pedestrians felt that the crossing was unreasonable. As with the motorist survey, the trail intercept survey had small sample sizes of 33 to 44 respondents and may have been biased because only those pedestrians willing to stop and provide feedback could be considered.

The letter submitted by the Porto Vecchio Homeowners Association Board tracks the comments received in the online surveys and provide helpful insights for moving forward to the evaluation of potential improvements.

5.0 Conclusion

5.1 Stop Sign Condition

The observational analysis and intercept surveys indicate the bicyclists were treating the stop sign as a yield condition. The majority of intercept survey responses indicate the bicyclists viewed the stop sign as unreasonable. The placement of a stop sign for trail users at a signalized intersection is not consistent with MUTCD practice or AASHTO Guidelines which discourage the posting of stop signs at signalized intersections. The stop sign posting also confused normal right-of-way law and created a situation where it would be unclear who would be at fault should a bicyclist be involved in a crash with a motorists crossing the trail on a green signal. The stop sign may have been intended to control conflicts between bicyclist and motorists, but the data indicates that the stop sign was frequently ignored and potentially decreased safety. More cyclists entered the crossing during the conflicting signal phase (South Washington Red) compared to later experiment phases.

The survey data clearly indicates that bicyclists were confused by the stop sign which led them to feel less safe operating in the intersection. Motorists were also clearly displeased with the low stop-sign compliance, increasing tension with trail users and creating discomfort at the crossing. The use of stop signs to control bicyclists at sidepath crossings of signalized intersections should be discontinued.

5.2 Pedestrian Signal Condition

Removing the stop sign and pedestrian push button and changing the signal timing to provide a pedestrian indication automatically with each cycle increased cyclist and pedestrian compliance and reduced ambiguity with regard to establishment of a bicyclist's right-of-way. Cyclists were also less likely to cross during the red indication on South Washington Street - the time when there is conflicting traffic on the driveway.

The MUTCD states pedestrian signal heads are "exclusively intended for controlling pedestrian traffic." These signals were not developed to control bicyclists thus pedestrian phasing does not adequately suit cyclists since it is timed to allow the slowest-moving pedestrian to finish crossing during the flashing "don't walk" indication. Cyclists entering the crossing during the flashing don't walk" indication is technically behaving illegally even though they may have a reasonable amount of time to cross.

5.3 Bicycle Signal Condition

The bicycle signal allows bicyclists to legally enter the crossing during the flashing "don't walk" portion of the cycle. While the proportion of cyclists making the potentially risky maneuver of crossing during the red on South Washington Street does not decrease greatly with the bicycle signal, the proportion involved in a conflict does decrease. Fewer conflicts indicate that while bicyclist behavior is still not entirely compliant, it is less risky than in experiment phases with the stop sign or pedestrian signal. Generally, public opinion on the bicycle signal is divided. Most cyclists believe the bicycle signal

improves safety and most motorists believe it has no effect on safety. The Porto Vecchio residents indicated they believe the bicycle signal is increasing bicycle operating speeds. This was found to be true to a limited degree as the mean and 85th percentile speeds did increase from phase I to Phase III. The bicyclist 85th percentile speed (13.8 mph) does remain lower than the posted speed (15 mph). It is possible this speed difference is due to other factors such as trail volume and weather.

Regardless of their opinion of the bicycle signal, most motorists felt that further efforts are needed to improve safety and operations at the crossing with an emphasis on motorists' comfort and bicyclists' safety.

6.0 Recommendations

The conflict and compliance data indicates that the use of a pedestrian signal or a bicycle signal is highly preferable to the use of a stop sign for sidepath control at signalized intersections. The bicycle signal experiment changed one aspect of the crossing, the traffic control for cyclists, in order to determine the effect of the bicycle signal on safety and operations at the trail crossing. Further changes could help supplement the bicycle signal and potentially further improve compliance and reduce conflicts.

It is recommended that the following be considered for implementation:

- Repaint the stop bar at the Porto Vecchio driveway and add a high-visibility crosswalk. This will increase the visibility of the crossing and may increase awareness of potential conflicts. It may also increase motorist compliance with first stopping at the stop line prior to entering the crosswalk should turns-on-red continue to be permitted.
- Add warning signs for right- and left- turning motorists on South Washington Street, notifying them of the trail crossing ahead for northbound and southbound South Washington Street, respectively. This may increase awareness of the trail crossing.
- Add warning signs for trail users notifying them of the approaching crossing for northbound (prior to the curves) and southbound trail users.
- Increase enforcement of the bicycle and pedestrian signals for trail users and the NO TURN ON RED sign for motorists. This may further encourage compliance for all users and lead to reductions in conflicts.
- Remove the BIKE ROUTE and BICYCLIST MUST DISMOUNT signs. This may reduce confusion at the approach and increase compliance with the bicycle signal.
- Provide additional outreach to all user groups to inform them of the results of this experiment. It is particularly important to correct false perceptions of the behaviors, conflicts, compliance, and laws that this study uncovered to decrease the hostility noted in survey responses and observed in video and on-site to create a safer crossing for all users.
- Provide additional outreach to educate residents of the Porto Vecchio condominium that the trail is a major regional transportation link and, as such, it has priority over the driveway

(priority established by transportation network and relative volume). Place an emphasis on stopping at the stop line prior to entering the crosswalk and use of the mirrors to determine when “no pedestrians or bicyclists are present”.

- It is also important to educate all modes on safe and courteous operating behaviors at this location.

Prohibition of Right Turn-On-Red

Given the fact the highest percentages of conflicts are generated by Porto Vecchio motorists turning right-on-red, it is recommended that the City consider a full time prohibition of this movement. This is likely to be concerning to the residents so it may be advisable to attempt to first work with them to improve their behavior approaching the crosswalk while the City simultaneously works to shorten the cycle length to the minimum necessary to reduce Porto Vecchio wait time at the driveway. The video analysis and the ability of motorists to find gaps to turn right-on-red indicates there may be an ability to change the signal timing to be more responsive to waiting vehicles in the driveway which will reduce the desire and need to turn right-on-red.

- Ensure that the camera detector which actuates the light for the Porto Vecchio driveway is accurately detecting motorists behind the stop bar.
- Replace the existing NO TURN ON RED WHEN PEDESTRIANS ARE PRESENT sign for right-turning motorists from the Porto Vecchio driveway with a full time NO TURN ON RED posting. This will reduce the majority of conflicts between motorists and trail users contingent on motorist compliance. This is particularly necessary given the inadequate sight distance resulting from the decorative walls and vegetation at the driveway entrance. It is not possible for motorists to see approaching trail users without pulling onto the trail crossing. While this measure will increase the wait time for some motorists (a maximum of one minute) it will decrease their stress level and significantly eliminate conflicts.
- Utilize shorter cycle lengths during non-peak hours to increase opportunities for Porto Vecchio traffic to exit the property on a green signal. This should help improve NO TURN ON RED compliance and decrease the frustration of the motorists making this movement.

Other Potential Adjustments

- Change the signal timing to provide protected left turns into the Porto Vecchio property from South Washington and display a red indication to cyclists. This will decrease motorists stress and improve trail user safety. It will be important to educated Porto Vecchio residents that this will likely require them to wait additional time for the left turn signal compared to existing operations. An alternative would be to utilize a flashing yellow arrow during times of permissive operation to remind motorists to yield to oncoming vehicle traffic and crossing trail traffic.
- It is not recommended to provide a flashing red bicycle operation as this is legally equivalent to the stop sign condition which has been documented to create unsafe conditions at the site. It may be desirable however to consider replacing the green bicycle signal portion of the phase to a flashing yellow bicycle signal operation.