Appendix D: Bicycle and Pedestrian Counting Plan

City of Davis

Bicycle and Pedestrian Counting Plan

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1 Introduction

In recognition of the myriad benefits of shifting drivers to walking and bicycling (e.g. increased public health, decreased congestion, lower user costs) and a federal transportation bill focused heavily on performance measurement, cities, states, and the Federal Highways Administration are increasingly interested in measuring rates of walking and bicycling (United States Department of Transportation Federal Highways Adminstration, 2013). This data has traditionally been collected via manual counts in the field. However, various emerging technologies designed to automate the counting process can serve as a highly cost-effective supplement to manual counts, providing a far richer set of data. As a widely renowned bicycling community, the City of Davis would like to join this growing trend of transportation data collection and to establish a world class bicycle and pedestrian data collection program.

There are many benefits of collecting continuous bicycle and pedestrian counts, both long-term and short-term. These include (but are not limited to):

- Bicycle ridership over time at the city-wide level can serve as a concrete yet simple performance measure. This can be achieved through annual manual counts at recurrent locations, short term (anywhere from 1 hour to 1 month) automated counts at recurrent locations, or the installation of permanent automated counters. The latter provides the most complete view of how ridership varies over time, but former options can yield a more spatially distributed picture at lower cost.
- Before and after studies of infrastructure improvements can help guide the design of future projects. Documentation of changes in bicycle and pedestrian use after facilities for these users are improved can be used as evidence in future grant applications.
- More accurate estimates of annual pedestrian and bicycles volumes can be derived from continuous counts than from typical 2-hour counts.
- Volumes serve a valuable role in assessing roadway risk — the number of pedestrian crashes per pedestrian present is far more valuable than simply the number of pedestrian crashes.
- Published volumes can help to normalize walking and bicycling and encourage more travelers to use these modes.
- Long-term (24+ hours) volume profiles can help demonstrate whether activity on a given facility is primarily utilitarian, recreational, or some combination of the two.
- A widespread view of where and when people are walking or bicycling can help the City prioritize outreach efforts to encourage more of these activities, or to highlight problems in the network that are discouraging pedestrians or bicyclists.

However, the process of establishing a count program from the ground up has not been well documented to date. Ryan documents the establishment of a regional bicycle and pedestrian monitoring program across San Diego County (Ryan, 2013). In this case, sensor sites were selected by stratifying across three dimensions (population density, employment density, and median household income) and sampling across these strata. San Diego County is much larger and far more heterogenous than the City of Davis in these measures (especially in the densities), so such a rigorous sampling methodology is not as needed for Davis. The key is to attempt to vary site locations across these contextual factors to provide a comprehensive view of the state of walking and bicycling.

This plan details a phased approach to the adoption of automated counting in Davis. To motivate this plan, a brief overview of the technologies in the plan is given, as is an overview of previously collected bicycle volume data within the city. Next, a phased approach to automated data collection deployment is discussed. Finally, some potential uses of the data to be collected are discussed.

1.1 Primer on Automated Counting Technologies

In recent years, a number of technologies for automating the process of counting pedestrians and bicycles have emerged on the market. These technologies have great potential for reducing the long term costs of volume data collection for agencies, although most units are priced in the $2,000-$5,000 range, which can be a difficult cost to bear for some agencies. Automated counting has the significant advantage over manual counting of providing continuous volumes across an entire day or multiple days, as opposed to only during a limited (typically 2-hour) time period. 2 hour counts are often used to estimate annual averages, which presumes some knowledge as to whether the selected 2 hours are during the peak or not and whether the day on which data is collected is representative of average “normal” conditions. Systematic variations in volumes occur based on the day of the week, time of year, weather conditions, and due to special events.

One disadvantage of automated counts, however, is they are systematically inaccurate for a variety of reasons. The following descriptions of the types of technologies under consideration consider a brief description of some of the known or suspected sources of inaccuracy with each technology type.

Passive infrared/Pyroelectric: Passive infrared sensors detect passersby based on the body heat that they emit. This technology does not distinguish between pedestrians and bicyclists, but it is fairly accurate with error rates around 5% (Nordback et al., 2011). The sensor in most products is simply comprised of a small lens that detects infrared radiation, a battery, and a logger that saves the count values. These units are available in both mobile and permanent configurations. The permanent versions are typically installed in conjunction with another technology type that counts bicycles to allow for differentation between bicyclists and pedestrians in the pyroelectric unit’s count.

Figure 1: Example of a mobile pyroelectric sensor mounted to a pole.

One of the main sources of inaccuracy in passive infrared sensors is known as occlusion.

Occlusion occurs when two or more people pass the sensor simultaneously, and one blocks the other from being "seen" by the sensor, leading to an undercount. This effect has been shown to vary as a function of volume in pedestrian-only environments, and can thus be corrected for using an adjustment factor that varies by volume (Schneider et al., 2012).

Inductive Loops: Inductive loops are used throughout the road network for signal preemption and counting motor vehicles. However, bicycle-specific counting units exploiting this technology have become available on the market and have been installed in a number of cities in recent years. Inductive loops are loops of wire installed either on top of the ground in a rubber adhesive materials, or more frequently in grooves cut into the ground and capped with a sealant. The wires have an electric current running through them, which generates a magnetic field in the area above the loops. When this field is disturbed by a metal object, the current in the loop is affected and a count is recorded. Bicycle-specific units have even been shown to detect carbon fiber bicycles (Nordback et al., 2011).

Inductive loops technologically work quite accurately. However, they suffer the shortcoming of having a constrained detection zone. This is not as large of a problem in detecting motor vehicles, as they often follow expected paths and are much larger than bicycles. Bicyclists, however, do not always ride over the detector and thus miss being counted. This is particularly a difficulty with indcutive loops installed in bicycle lanes (as compared to on off-street paths).

Pneumatic Tubes: Pneumatic tubes are compressible rubber tubes that are laid across the street or path surface and affixed using adhesive tape or nails and brackets. Counts are recorded based on the air pulses that travel through the tubes when they are compressed. Pneumatic tubes are applied for short-term periods (typically one week or less), as they can be damaged over time by passing vehicles. This is on one hand a disadvantage (doesn't allow for year-round monitoring), but on the other hand is an advantage to the extent that a single unit can be deployed at multiple sites around the city.

Figure 2: Example pneumatic tubes under use in a bike lane.

Errors arise in manual counts as well due to data collector fatigue and overwhelming high volumes situations, but these can typically be corrected for by the introduction of a second data collector. These technologies are only a sampling of those available on the market, but they are some of the most widely used to date for non-motorized traffic monitoring. Additionally, both inductive loops and pneumatic tubes are widely used for monitoring motorized traffic. These three technologies have been selected for the Davis bike and pedestrian counting plan because they can be used in various combinations and configurations to count both pedestrians and bicyclists at fixed sites and at varied sites while keeping the variety of technologies (and thus potential implementation difficulties) to a minimum.

2 Background of Bicycle and Pedestrian Counting in Davis

The City of Davis does not have a recurring bicycle or pedestrian count program. Counts have been historically collected somewhat sporadically. The most recent round of bicycle counts for the city were conducted in May 2013. It had been six years since the previous round of counts. No records of pedestrian counts within the city have been located. UC Davis has had separate pedestrian and bicycle counts conducted as a part of its 2009 Bicycle and Transit Network Study. Each of these data sources is discussed in this section.

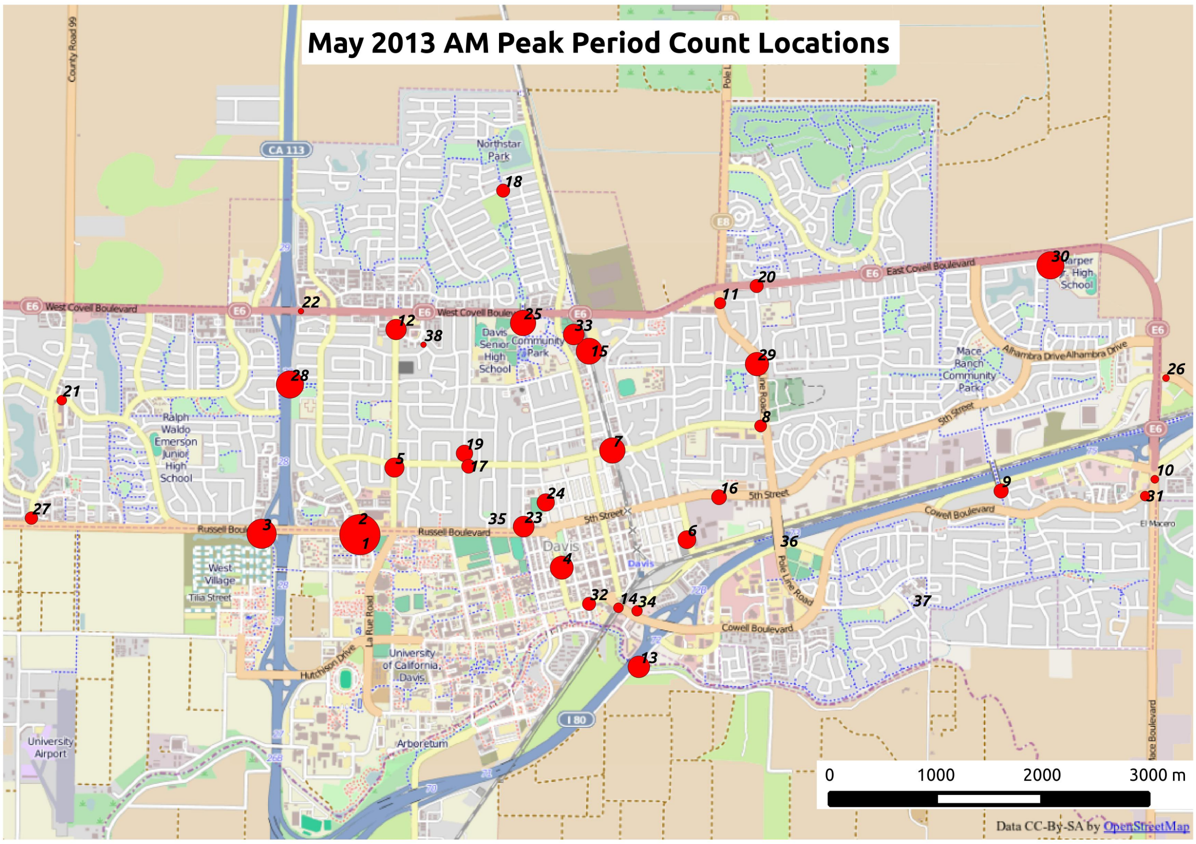

Figure 3: City of Davis Spring 2013 AM Peak Hour Counts. Sizes of points are proportional to volumes.

The City's 2013 counts were conducted by a volunteer class of UC Davis students. 38 sites around the city were identified and ranked by priority, and members of the class elected which sites to cover. Most of the sites were counted for both an AM and PM peak period hour. However, these data were not collected at consistent "peak" hours. For example, sites located adjacent to primary/secondary schools had their peaks roughly

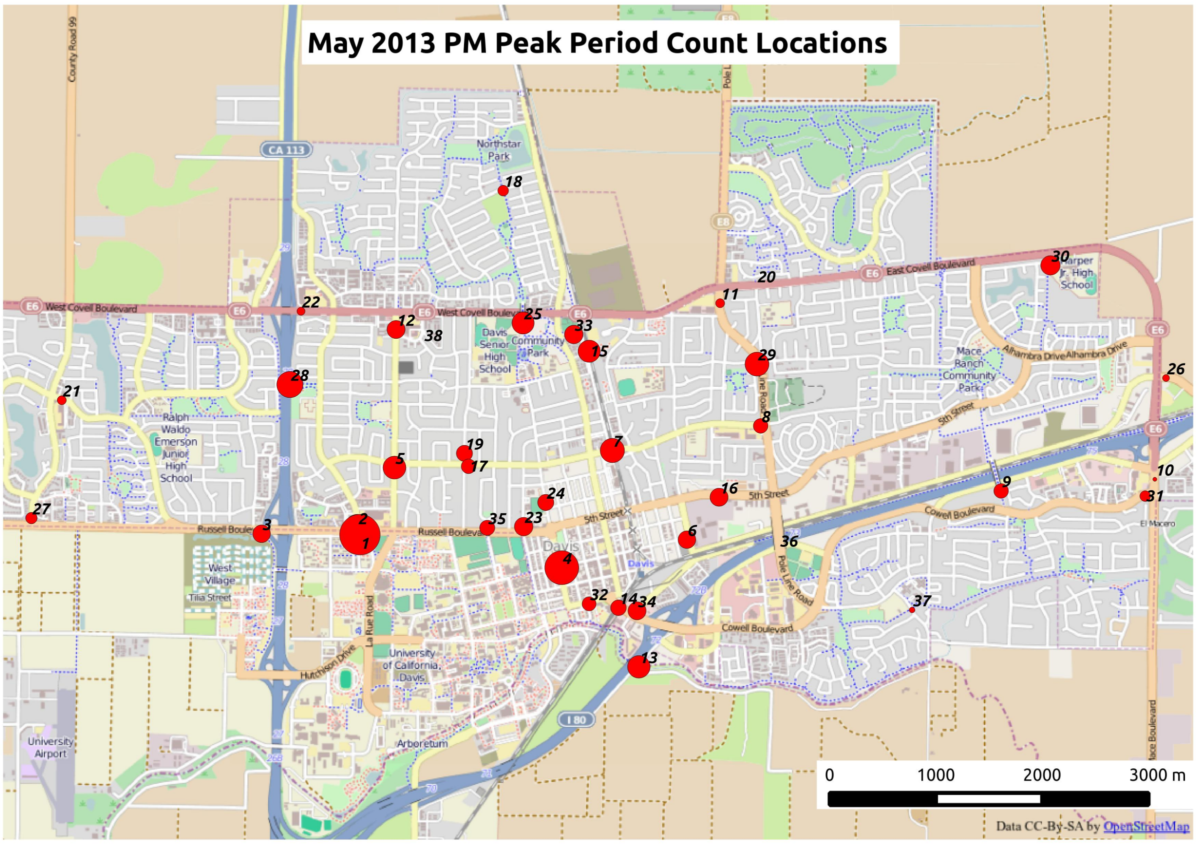

Figure 4: City of Davis Spring 2013 PM Peak Hour Counts. Sizes of points are proportional to volumes.

coincident with the beginning and ending of school, while most sites in the downtown area had their counts performed from 5-6 PM. The results of this counting effort can be seen in Table 5 (in appendix) and Figures 3 and 4.

Based on these counts, the highest AM peak hour bicycle volumes appear to be located along the University's northern perimeter, and crossing major boundaries to the central part of Davis (Covell Boulevard, Highway 113, and the North-South Railroad tracks). Frances Harper Jr. High School, located at the northeast-most corner of the city, also has high volumes adjacent to it. The PM peak hour volumes show a similar distribution around the city.

UC Davis's most recent publicly available counts were conducted as part of the 2009 Campus Bicycle and Transit Network Study. While the City has little input into campus data collection activities, the University has a significant interface with the City from which volumes within the City's jurisdiction can be estimated.

One permanent automated counter (Figure 5) has already been installed in Sycamore Park, near the intersection of Sycamore Lane and Villanova Drive, as a part of an ongoing National Coopeartive Highways Research Program project investigating various technologies for automating the process of counting pedestrians and bicyclists. The unit installed at this site is an Eco-Counter Eco-Multi, which has a pyroelectric sensor and inductive loops installed in parallel with each other giving data on both the number of bicyclists and the number of pedestrians. This site is on a multi-use path that runs through the park to a bicycle/pedestrian bridge over Highway 113. There is also an elementary school nearby. The City of Davis will be able to purchase this device at the termination of the project at discount, and with no installation costs.

Figures 6 and 7 show some examples of the data collected since the Sycamore Park counter was installed in May 2013, to provide an example of the additional data that can be generated using a long-term continuous counter and to demonstrate some of the volume characteristics of this site. Figure 6 shows the average hourly volumes across the week for both modes at this site. A number of interesting features are apparent in this plot:

- Volumes of bicyclists at this site are much higher than volumes of pedestrians, at every hour of the week.
- Bicycle volumes are far lower on the weekend than on weekdays. Pedestrian volumes, however, are fairly consistent throughout the entire week.
- Pedestrian volumes do not exhibit a strong peaking characteristic, while bicycle volumes appear to peak once in the morning and once in the evening on weekdays.
- Bicycle activity through the park appears to continue later into the night than pedestrian activity.

Figure 5: Pyroelectric Sensor (inside wooden post) and Inductive Loops (grooves in asphalt) installed in Sycamore Park.

Figure 7 demonstrates another important aspect of this site. Namely, we see that volumes of bicyclists drop by half during the summer at this site. This suggests that volume here are very closely tied to school related activity, likely due both to the nearby primary school and the University. Pedestrian volumes, on the other hand, are considerably more stable across the months sampled here.

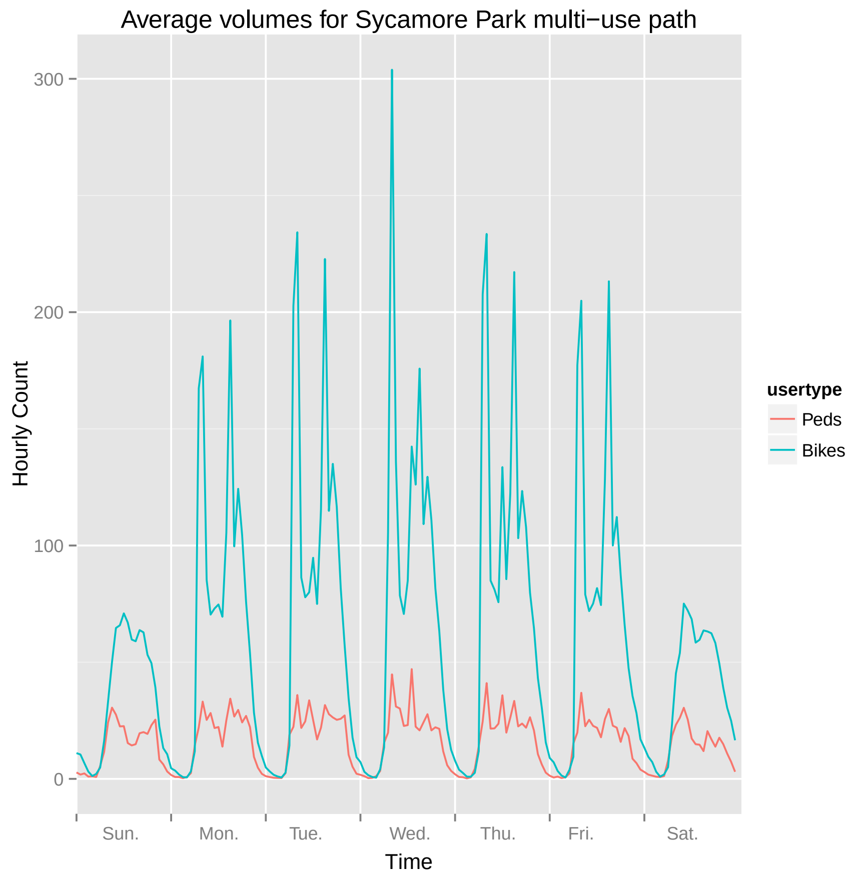

Figure 6: Average hourly volumes of bicyclists and pedestrians at Sycamore Park between May and November, 2013

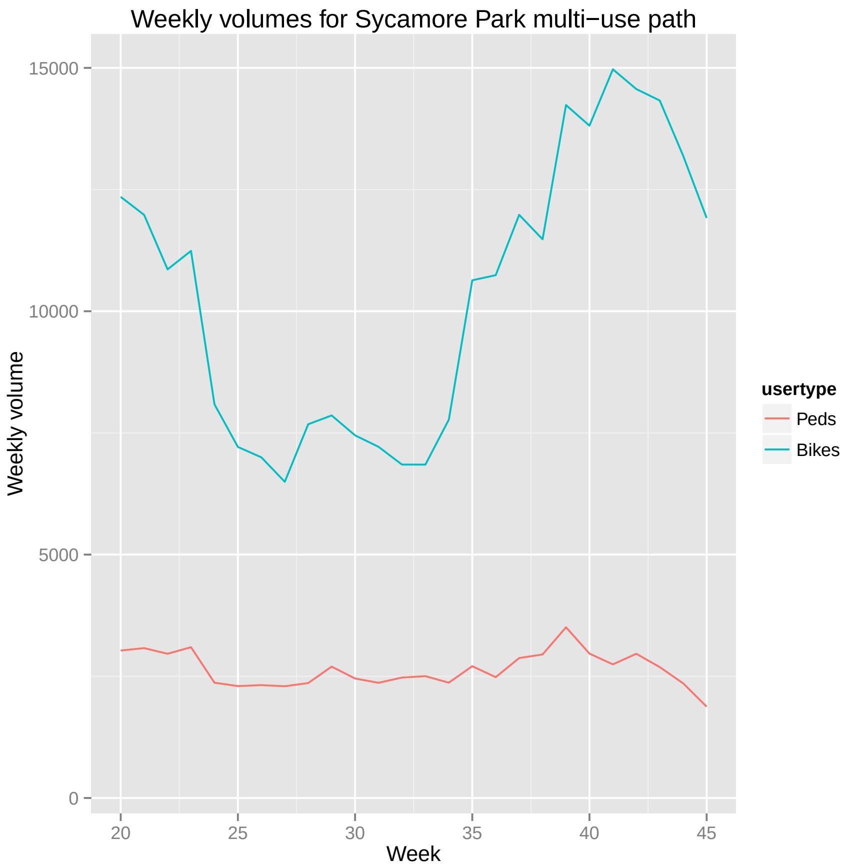

Figure 7: Weekly volumes of bicyclists and pedestrians at Sycamore Park between May and November, 2013

3 Count Plan

3.1 SACOG Grant

The City of Davis applied for a Sacramento Area Council of Governments grant in August 2013 to fund a bicycle and pedestrian wayfinding program. This grant application also included dedicated funding for the purchase of automated counting equipment. $74,000 was budgeted in the application, based on a sketch plan for the counting program. This plan suggested purchasing the following equipment with installation costs estimated as specified:

All of this equipment is from the vendor Eco-Counter, and the price estimates are based on a vendor quote.

The plan described here is broken into two phases, along with some guidance on how to develop subsequent phases. The first phase assumes that the City receives the full value of the SACOG grant ($74,000). The second phase assumes an extra $50,000 is available. Further funding has not been identified here, but this money could conceivably come from future external grants or from within the city. This does not necessarily need to occur all at one time. Subsequent additions to the program should follow similar logic in terms of site selection, but tend progressively towards more permanent count sites.

Table 1: Initial SACOG grant application purchasing plan.

Unit Name	Technology Type	Number	Unit Price	Total Price
Eco-Totem Counter (2 sided, backlit)	Inductive loops (w/ digital display)	1	$25,000	$25,000
Eco-Totem Installation		1	$2,500	$2,500
Eco-Multi Counter	Combination pyroelectric & Inductive loops	6	$4,550	$27,300
Eco-Multi Installation		6	$1,000	$6,000
Eco-Zelt Counter	Inductive loops	2	$3,600	$7,200
Eco-Zelt Installation		2	$500	$1,000
Eco-Tubes Counter	Pneumatic tubes	2	$2,500	$5,000

Additionally, the larger the program gets the more operating expenses will need to be budgeted for. These include battery replacements, pneumatic tube replacements, GSM fees (if used), maintenance and labor costs (e.g. for moving mobile sensors), and data analysis.

3.2 Phase 1

The first phase of the Davis bicycle and pedestrian counting program will consist of permanent counters placed at various points in the network where volumes are expected to be high. These points occur on all of the borders of Central Davis as a result of large transportation infrastructure — namely, Highways 113 and 80, Covell Boulevard, and the Union Pacific railroad tracks running North-South adjacent to H street. These strategically chosen points will be supplemented with an Eco-Totem inductive loop sensor and visual feedback kiosk in downtown Davis, annual manual counts, and a small stock of portable counters to be rotated through sites around the City year round on a monthly cycle. Year round counts are suggested because a greater breadth of data can be collected per counter purchased, as opposed to exclusively focusing on permanent counters at fixed locations.

The data produced by the permanent and short-term counters can be used in conjunction with each other in the following ways:

- Permanent counters will help refine where to locate short-term counters over the course of years, as a clearer picture of where people are bicycling or walking at various times of year will emerge.
- Permanent counters can aid in the estimation of year-round volumes at the short-term sites by providing scaling factors for the short-term counts. After the count equipment has been installed continuously for some amount of time, weekly and monthly activity patterns will emerge that can provide insight into levels of pedestrian and bicycle activity when the short-term sites are not being monitored. These patterns may be consistent city-wide, or may be more closely tied to local site characteristics such as proximity to schools, shopping centers, or recreational facilities.

Table 2: Phase 1 Purchasing Plan

Unit Name	Technology Type	Number	Unit Price	Total Price
Eco-Totem Counter (2-sided, backlit)	Inductive loops (w/ digital display)	1	$25,000	$25,000
Eco-Totem Installation		1	$2,500	$2,500
Eco-Multi Counter	Combination pyroelectric & Inductive loops	4	$4,550	$19,000
Eco-Multi Installation		4	$1,000	$4,000
Eco-Tubes Counter	Pneumatic tubes	4	$2,850	$11,400
Replacement Tubes		10	$150	$1,500
Eco-Pyro	Pyroelectric	2	$3,475	$6,950

One possibility for expansion to year-round volumes would be to classify each site as being driven primarily by recreational activity (volumes higher on weekends and at mid-day), utilitarian activity (standard AM/PM peaks and higher weekday volumes), and mixed. If there is a significant difference in the month-to-month volumes, this classification would allow for more accurate expansion.

One case of month-to-month variation that has already been observed with the Sycamore Park counter is that volumes are significantly lower during the summer months than the winter months. This likely reflects both the large number of UC Davis students living in the city, and the high levels of children who bicycle to school in Davis. Accordingly, this pattern will probably hold throughout the city, but may attenuate at greater distances from the university.

- Short-term counters can be used in parallel with permanent counters at a site to determine the number of people taking an alternate path than that being observed by the permanent counter (as these devices have a limited detection zone). One place this has been suggested is on Third Street at B Street. At this site, an Eco-Totem counter (inductive loops with a digital display screen) has been recommended, with its inductive loops to be located in the bicycle lane segment abutting the East side of the intersection. Supplemental counts are suggested using pneumatic tubes on the opposite side of the street to see whether the patterns on the two sides of the street mirror each other or not.

For the first phase, the following sites have been selected for permanent counter installation. These permanent locations will be used to provide insight on the longer-term trends in volumes (i.e. seasonal variations). As such, they are located at locations that are expected to have the highest volumes, so that random fluctuations in volumes will be less likely to overwhelm the seasonal effects. The sites were selected to be distributed around different parts of town because the patterns differ. For example, in the vicinity of U.C. Davis volumes are likely to be driven largely by university activity, while along the Covell Greenway this effect might be less pronounced.

Figure 8: Intersection of 3rd & B. U.S. Bicycling Hall of Fame on righthand side.

3rd & B: The United States Bicycle Hall of Fame is at this intersection, so this site has been selected to install the Eco-Totem counter with display. 3rd Street is also a major access route to the University with a peak PM volume of over 400 bicyclists recorded in 2013. The Eco-Totem uses a set of inductive loops to conduct counts. These will be placed in the bike lane on the North side of the street, and the display stand will be placed in the buffer zone directly adjacent. This site is expected to provide insight into volumes downtown, as this is a major corridor through downtown.

Sycamore Park: Sycamore park already has a combination inductive loop/pyroelectric sensor installed on a multi-use path connecting to a bike/ped bridge over highway 113. This site is important as it is one of the few routes between downtown and West Davis, so volumes here are likely a good indication of bicycle activity for this part of the City. There is also an elementary school adjacent to the park which could be driving volumes, and would be worth investigating. The Davis Bike Loop passes through Sycamore Park on this path, as well.

Covell Greenway Overpass: The Covell Greenway Overpass location (located in Community Park) is desirable for similar reasons to Sycamore Park. Covell Boulevard is a four lane arterial dividing central and north Davis. While this presents more crossing opportunities than Highway 113 has, the overpass from Community Park to the Covell Greenway is the only crossing option for bicyclists and pedestrians grade separated from the road. This site is therefore also likely to serve as a pinch point in the network and provide detailed volumes from North Davis. A combination counter will also be installed at this site, likely on the Community Park side of the bridge.

Figure 9: Covell Boulevard overcrossing, Community Park side. Photo: Robert J. Schneider

H Street Railroad Tunnel: This tunnel is one of the few crossing points under the north-south running railroad tracks parallel to H Street. The multi-use path on the east side of the tunnel would be a good place to install a counter, as the path splits on the west side of the path to two ramps, so some users would be missed. Additionally, the Davis Bike Loop also passes through this site and it is along a major corridor from East Davis (Drexel/Loyola).

Figure 10: H Street bicycle tunnel. Photo: Philip Neustrom

Putah Creek Bicycle Undercrossing: The Putah Creek Undercrossing (under I-80) connects South Davis with downtown and UC Davis, and hence serves as a pinch point. This point is also on the Bike Loop.

Figure 11: Putah Creek undercrossing. Photo: Philip Neustrom

To supplement the permanent counter installations, a stock of four sets of bi-directional pneumatic tubes and two pyroelectric sensors will be purchased for portable count set-ups. These will be rotated around the following sites on a 1 month cycle, as detailed in Table 3 and shown Figures 13-24. To take down counters at one site and set them up at another site is anticipated to take approximately 45 minutes, so moving and setting up the entire set of sensors will require approximately half a day of work. If a volunteer intern can be recruited, this would be a task ideally suited for them. Four sets of pneumatic tubes are suggested so that two streets can be covered, as a separate set of tubes is required for each side of the street.

The supplementary counters are employed here to allow for a wide breadth of data while operating under a budget. Ideally year-round counts would be available at all of these sites, but the use of portable counters in combination with the permanent devices will allow for both depth (at the permanent sites) and breadth (with many short-term sites) of data.

The selection of sites for the short-term counts was fairly ad hoc and can be refined as the program develops. However, a number of considerations went into the site selection, including:

- Distribute sites around the city to provide information on rates of walking and bicycling in a variety of locations.
- Target a mix of on-street and off-street facilities.

- Co-locate multiple sets of pneumatic tubes for sites which require two sets to collect all bicycle volume.
- For some mixed bicycle and pedestrian sites, include both a pyroelectric sensor and pneumatic tube to get separate volumes by user type.

3.3 Phase 2

Phase 2 of the count plan entails scaling up the number of permanent count locations. The locations selected here have been chosen using a similar methodology to in Phase 1, but these can be modified based on the greater knowledge of volume patterns within the city that is achieved during Phase 1. A map of the new count sites is shown in Figure 12.

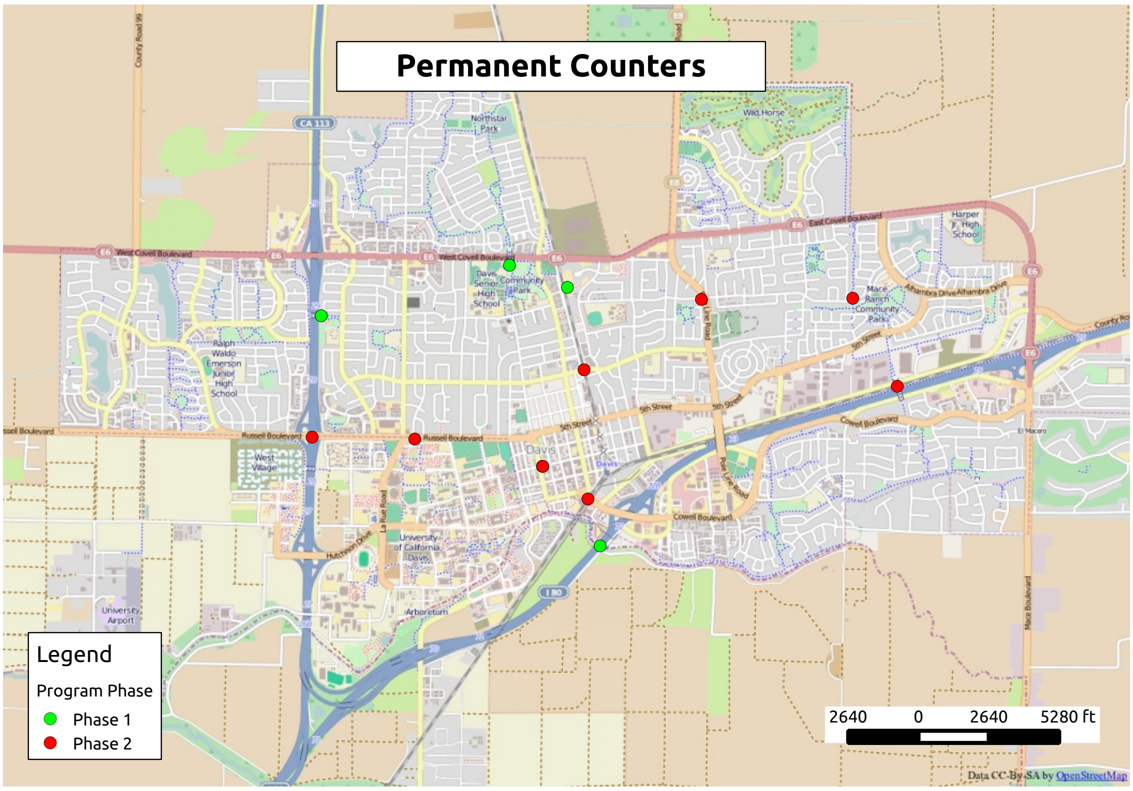

Figure 12: Locations selected for permanent counters during phase 1 and phase 2.

Dave Pelz Overcrossing: The Dave Pelz Bike/Ped Overcrossing crosses I-80 in the eastern part of the city. This bridge serves as a critical connection between the southeast and northeast parts of the city and is also located on the Davis Bike Loop. This site was not included for a permanent counter in Phase 1 because the site is towards the edge of town, but has been included because it is a signature bike/ped facility and despite its peripheral location appears to carry a significant amount of traffic (accoridng to the Spring 2013 manual counts). An Eco-Multi is recommended here on the South approach to the bridge.

Russell Boulevard Bikeway near Sycamore Lane: The Russell Boulevard Bikeway runs along the edge of U.C. Davis. According to the Spring 2013 manual counts, this site had the highest peak hour volume of any in the city during both the morning and the afternoon. An Eco-Multi is recommended here east of Sycamore Lane.

Table 3: Monthly Rotation Plan for Mobile Counters.

Month	Tubes 1	Tubes 2	Tubes 3	Tubes 4	Pyro 1	Pyro 2
Jan	Putah Creek Greenway	8th & B	8th & B		Putah Creek Greenway.	F Street
Feb	Pole Line & Loyola	Harper Junior High	Old Lincoln Highway		Pole Line & Loyola	Francis Harper Jr. High
Mar	Russell East of Anderson	Wildhorse Greenbelt	Covell Blvd	Covell Blvd	G St between 2nd & 3rd (West side)	Wildhorse Greenbelt
Apr	Russell & 113	Russell West End	Covell & 113		Covell & 113	
May	Dave Pelz Overcrossing	Covell Greenway	Anderson & 8th	Anderson & 8th	Dave Pelz Overcrossing	
Jun	Mace Blvd Overcrossing	Mace Blvd Overcrossing	Richards Blvd	Putah Creek Greenbelt	Richards Blvd	Putah Creek Greenbelt
Jul	Pole Line & Loyola	5th Ave	Olive Dr	Olive Dr	Pole Line & Loyola	5th Ave
Aug	Redwood Park	3rd & B	Arroyo Park	Old Lincoln Highway & Pole Line	Redwood Park	3rd & B
Sept	Amtrak Entrance	Amtrak Entrance	Anderson & Hanover	Anderson & Hanover	Amtrak Entrance	
Oct	14th & B	14th & B	Rancho Yolo	Rancho Yolo	14th & B	
Nov	8th at Railroad Tracks	8th at Railroad Tracks	8th & Anderson	8th & Anderson		
Dec	Wilson Way Greenbelt	Pole Line & 8th	8th & Anderson	Aspen Greenbelt	Wilson Way Greenbelt	Aspen Greenbelt

Table 4: Phase 2 Purchasing Plan

Unit Name	Technology Type	Number	Unit Price	Total Price
Eco-Multi Counter	Combination pyro-electric & Inductive loops	6	$4,550	$27,300
Eco-Multi Installation		6	$1,000	$6,000
Eco-Zelt Counter	Inductive loops	2	$3,600	$7,200
Eco-Zelt Installation		2	$500	$1,000
Eco-Tubes Counter	Pneumatic tubes	2	$2,500	$5,000
Replacement Tubes		10	$150	$1,500
Eco-Pyro	Pyroelectric	2	$3,475	$6,950

Richards Boulevard Undercrossing: The Richards Boulevard Undercrossing is a bike/ped tunnel under the railroad tracks on the south side of downtown. Along with the Putah Creek Undercrossing and, the Richards Boulevard undercrossing is part of one of the two main direct connections to downtown Davis from south Davis. The volumes at this site are lower than at the Putah Creek site, but insights could arise as to which of these routes are preferred at varying times of day or year which are not possible with two-hour counts. An Eco-Multi is recommended here.

Pole Line & Loyola Cut-through Path: The Pole Line & Loyola Cut-through Path is a short path segment along the Drexel/Loyola corridor, a East-West bicycle axis on the north end of town. The cut-through path obviates the need to divert north on Pole Line Road, a heavier traffic road, and thus this path segment is heavily used by children accessing nearby Holmes Junior High School. An Eco-Multi is recommended here.

Wilson Way Greenbelt: This greenbelt is on the east side of town and runs North-South. Counts have not been conducted at this site so existing volumes cannot be used to recommend this site. However, this part of town is lacking in permanent count representation, so this site is recommended for an Eco-Multi to serve as a control.

Russell Boulevard I-113 Overcrossing: An Eco-Multi should be installed where Russell Boulevard crosses I-113. This site is another of the few (along with Sycamore Park) locations where bicyclists and pedestrians can cross over the highway. This site is very near to the University, as well, and hence the crossing likely attracts many residents of West Davis who are traveling towards the campus. However, it is a potentially less safe crossing than the one in Sycamore Park, as vulnerable road users must cross the on- and off-ramps to the highway. It would be good to know whether or not this is a substantial problem, and if it appears to be to divert traffic towards the crossing in Sycamore Park.

8th Street at Railroad Tracks: This on-street site is recommended for Easy-ZELT inductive loops in the bicycle lanes on both sides of the street. Similar to the H Street tunnel, 8th Street is one of the few locations where bicyclists can cross the Union Pacific railroad tracks, and hence this site likely carries most of the east-west traffic across the railroad tracks.

3rd & B Street: The Eco-Totem counter recommended for 3rd & B will only have one set of inductive loops (on the westbound side of the street), so a second set of loops is recommended on the eastbound side of the street to explore how the activity patterns along this corridor mirror each other.

Short-term counts: Many of the short-term count sites from phase 1 have been supplanted by permanent count sites in phase 2. Accordingly, these counters will be freed up to use at other sites. Specific locations have not been identified here, but there are a number of options to use these counters for more focused studies. One option is to conduct counts at each of the crossings of a given bicycle barrier in the city (e.g. I-80, I-113) to see what proportion of the traffic in a given month uses each crossing point. These findings could then be used to estimate total annual volumes between regions of the city. Another potential use is conducting counts on a sample of (presumably) low-volume residential streets.

4 Data Applications

The following section details some potential uses of the count data that is developed under this plan. These are not an exclusive list of the options that could be pursued. There are a number of different metrics that can be monitored to provide insight into the state of active transportation within a given community. Some options include volumes over time at a repeated or continuous sites, total miles traveled within the city, percent mode share by number of trips (for commute trips alone or for all trips), number of pedestrian or bicyclist involved crashes (normalized by bike/ped activity).

4.1 Monitoring of rates of bicycling across the city

The most straightforward application of the automated count data is in monitoring rates of activity in different parts of the city.

The permanent counters serve multiple functions in this regard. First and foremost, they provide an estimate of annual traffic at the permanent count locations without the need for substantial inference.[1] This is a substantial advantage over any short-term counts (non-motorized or motorized), as in those cases whenever annual volumes are estimated assumptions must be made around what fraction of the annual volume the count period represents.

However, placing permanent counters at all locations where data is desired in one wave of installations is not economically feasible. The unit costs for the devices are higher, as are the installation costs. Most importantly, however, mobile counters allow for data to be collected a greater number of sites for the same device cost. The downside is that counts are not collected across the entire year. This can be circumvented in two ways:

[1] The one exception is that counts should be adjusted to correct for systematic errors, such as those arising from occlusion.

1. Short-term counts should be performed at the same locations in the same month of the year to allow for direct comparisons of data. For example, “bicycle volumes at the Amtrak station entrance have risen 24% during this September over the previous September.” There is no inference required in this statement and it has more direct meaning in terms of changes of rates in bicycling than, for example, “bicycle volumes at the Amtrak station entrance have risen 32% during this September over last November.” Comparing different months between years could lead to a conflation of the overall level of activty on a year-to-year basis with the systematic variation that occurs on a month-to-month basis.

2. The permanent count data can be used to infer annual volumes at the short-term sites. There are a number of options for performing an extrapolation of this form. The simplest option is to calculate the fraction of the annual volumes that a given month’s volume comprises at each of the permanent locations, take the average of these across all sites within the city, and adjust the short-term counts accordingly. For example, if May is found on average to comprise 18% of the annual bicycle volumes across the permanent count sites, and volumes on the Dave Pelz Overcrossing for the month of May are found to total 1,500 bicyclists, the annual bicycle volume on the Dave Pelz Overcrossing can be estimated as $1,500 * \frac{1}{0.18} = 8300$ bicyclists. This could alternatively be subdivided by part of town (e.g. “volumes during May in downtown Davis make up 18% of the annual volume, while volumes during May in South Davis make up 12% of the annual volume”), or by type of usage pattern (e.g. “May volumes on utilitarian facilities comprise 12% of the annual volume, whereas May volumes on recreational facilities comprise 20% of the annual volume.”).

4.2 Mode share estimation

Mode share, or the percentage of travel undertaken using a specific mode, is defined with some ambiguity. One can consider the percentage of work trips made using a given mode (as is done in the American Community Survey), the percentage of all trips made with a given mode, the percentage of miles traveled using a given mode, or the percentage of people passing a specific point in space using a specific mode. The first two definitions are very valuable and are best collected using surveys. The third option can be estimated using automated counts, as detailed in the following subsection, but the last definition can be estimated more directly with the assistance of automated counts. One difficulty in estimating the number of users of each mode at a specific site is that while automating the count of motor vehicles is fairly straightforward, automating the count of the number of people within each of those vehicles is not so easy. Assumptions can be made about the number of riders in each car and on each bus. Alternatively, a manual data collector could attempt to collect this data via field observation while automating the count of pedestrians and bicyclists, which might otherwise require a second data collector.

5 Considerations for the Future

5.1 Surveys

The utility of the bicycle and pedestrian count data described in this plan could be augmented substantially with the use of surveys. For an general overview of the activity characteristics of bicyclists and pedestrians, the Pedestrian and Bicycling Survey (PABS) is a good option Forsyth et al. (2012). PABS is a survey instrument and sampling strategy designed to achieve results that can be generalized across a given community's entire population. Alternatively, site-based intercept surveys could be used to confirm that users of a facility presumed to be utilitarian or recreational are correctly classified, to get information on origins, destinations, and other trip and user characteristics, and to collect attitudinal data to supplement volumes. For example, respondents might provide some insight into why a given facility is more highly used than other options.

5.2 Program Expansion

Future expansions of the City of Davis's bike and pedestrian counting program should be made when possible. However, there a number of considerations that should be taken into account in deciding how to structure that growth:

- Permanent counters are largely a fixed cost item (aside from GSM fees), while mobile counters (especially pneumatic tubes) are a variable cost item. Portable pneumatic tubes and pyroelectric counters require on-site set up everytime that they are to be used, and the rubber hoses on the pneumatic tube devices wear out overtime and can be easily damaged by street sweepers. Accordingly, expansion plans should strive for a mix of implementing new permanent count sites and substituting permanent sites for the current short-term sites. In short, the long-term costs of the program would grow far more quickly if too many mobile counters are relied upon. They have been heavily used here to develop a baseline of data but in many respects permanently installed counters would be more desirable.

- Regardless of the types of counters used, there will be some increasing variable costs associated with operating the program as it goes. These include replacement of consumables (most notably batteries), GSM fees (if selected), and staff time to monitor the devices and to put the data to use. These costs should not be a deterrent from expansion, but simply must be budgeted for.

- Selection of new sites should be informed by existing data. As a clearer picture of the patterns of movement within the community emerges, additional counters will help to provide more nuance to this view and to confirm the lessons. For example, for a given school, it may become apparent based on an intial count that there are very high volumes of students bicycling to school. An additional counter could be utilized to see whether this holds on approaches to the school from other directions.

- Future expansions should take place in conjunction with U.C. Davis, as well. In particular, it would be worthwhile to conduct counts along the campus periphery to see where campus affiliates are choosing to enter the campus, and to inform safety analysis along the boundary. The number of pedestrian and bicycle crashes along the campus periphery is fairly high, which likely reflects the high volume of users in this particular location. It would be in the interest of both the City and the University to have a more quantified view of where the highest risk locations near the University are to help rectify these problem areas.

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6 Appendix

6.1 Spring 2013 counts

Table 5: 2013 City of Davis Bike Counts

ID	Description	AM Time*	PM Time*	AM Count	PM Count
1	Russell Blvd Bike Path East of Sycamore Lane	9:30 AM	4:00 PM	663	598
2	Sycamore Lane North of Russell Blvd	8:00 AM	5:00 PM	272	270
3	Russell Blvd Bike Path East of Arthur Bvd West of 113 On Ramp	8:00 AM	5:00 PM	356	115
4	3rd St East of B Street	11:00 AM	5:00 PM	221	423.5
5	Anderson Rd South of W 8th Street	8:00 AM	5:00 PM	158	194.5
6	3rd St West of L Street	9:00 AM	5:00 PM	135.5	118
7	East 8th Street East of RR Tracks	8:00 AM	5:00 PM	267	217
8	East 8th Street West of Pole Line	8:00 AM	5:00 PM	61	78
9	Dave Pelz I-80 Bicycle Overcrossing	7:00 AM	3:30 AM	87.5	83
10	Mace Blvd South of Chiles Rd	7:30 AM	5:00 PM	30.5	9
11	Pole Line Rd South of Covell	7:30 AM	5:00 PM	58.5	31
12	Anderson Rd South of Covell	8:00 AM	5:00 PM	176	120.5
13	Putah Creek Bicycle Undercrossing	8:00 AM	5:00 PM	193.5	187.5
14	Richards Blvd. Bicycle Undercrossing	10:30 AM	4:30 PM	46.5	91.5
15	H Street Undercrossing (RR Tunnel)	7:15 AM	3:15 PM	279	183.5
16	5th Street Bike Path between L and Pole Line	8:00 AM	5:00 PM	93.5	125
17	8th Avenue east of Oak	8:00 AM	5:00 PM	84	80
18	Grande Ave Bike Path Crossing	7:30 AM	2:45 PM	74.5	41.5
19	Oak Ave North of Eighth St bike lanes	8:00 AM	5:00 PM	113	97.5
20	Covell at Birch Bike Crossing	7:45 AM	2:45 PM	74	N/A
21	Arlington Blvd East of Lake Blvd EB and WB Bike Paths and Lanes	8:00 AM	5:00 PM	46.5	30
22	Covell Blvd East of HWY 113 lanes and paths	11:30 AM	5:00 PM	15	25
23	A Street North of Russell Blvd.	8:00 AM	5:00 PM	180	129
24	B St north of 6th Street	8:00 AM	5:00 PM	128	99.5
25	Covell Blvd Bike Overcrossing Near HS	7:30 AM	2:45 PM	268.5	180.5
26	Road 32A east of Mace Blvd	7:30 AM	5:00 PM	20.5	21
27	Lake Blvd North of Russell	8:00 AM	5:00 PM	67.5	48.5
28	SR 113 Overcrossing	7:30 AM	3:00 PM	307	256
29	Loyola Dr and Pole Line Bike Path cut through	7:45 AM	3:15 PM	226	210
30	Bike Path Entrance to Harper Junior High	7:30 AM	3:30 PM	309	140
31	Cowell Blvd west of Mace	7:45 AM	2:45 PM	42	44
32	1st Street Bike Path between C and D Streets	11:45 AM	3:45 PM	75	71.5
33	Little League Path (Between H St and F St)	7:00 AM	3:00 PM	183	128
34	Olive Drive East of Richards	7:30 AM	5:00 PM	52	124
35	College Park North of Russell	8:00 AM	5:00 PM	N/A	89
36	Pole Line Rd I-80 Overcrossing	7:30 AM	3:15 PM	N/A	N/A
37	Danbury Avenue Bike Undercrossing (Putah Creek Greenbelt)	8:00 AM	5:00 PM	N/A	17
38	Scripps Drive South of Hanover	11:00 AM	5:00 PM	14	N/A

*Data was collected for 1 hour. These are the start times.

6.2 Phase One Monthly Count Location Maps

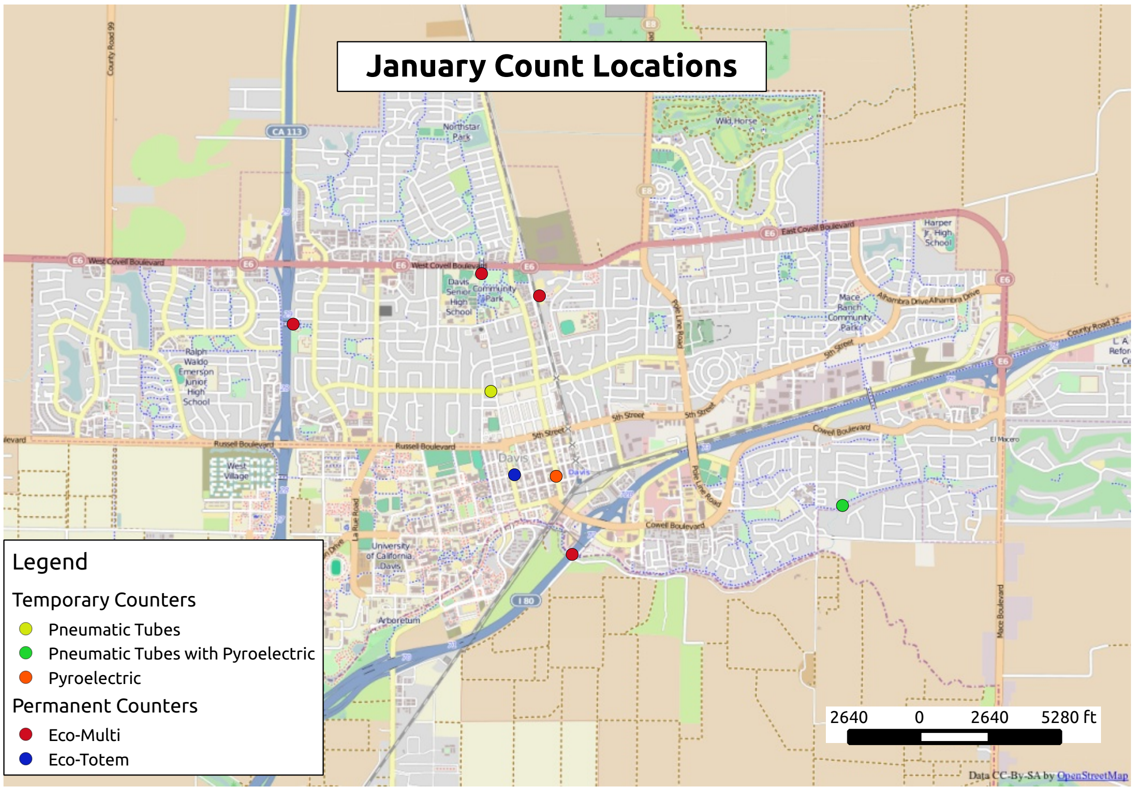

Figure 13: Map of count locations for month of January.

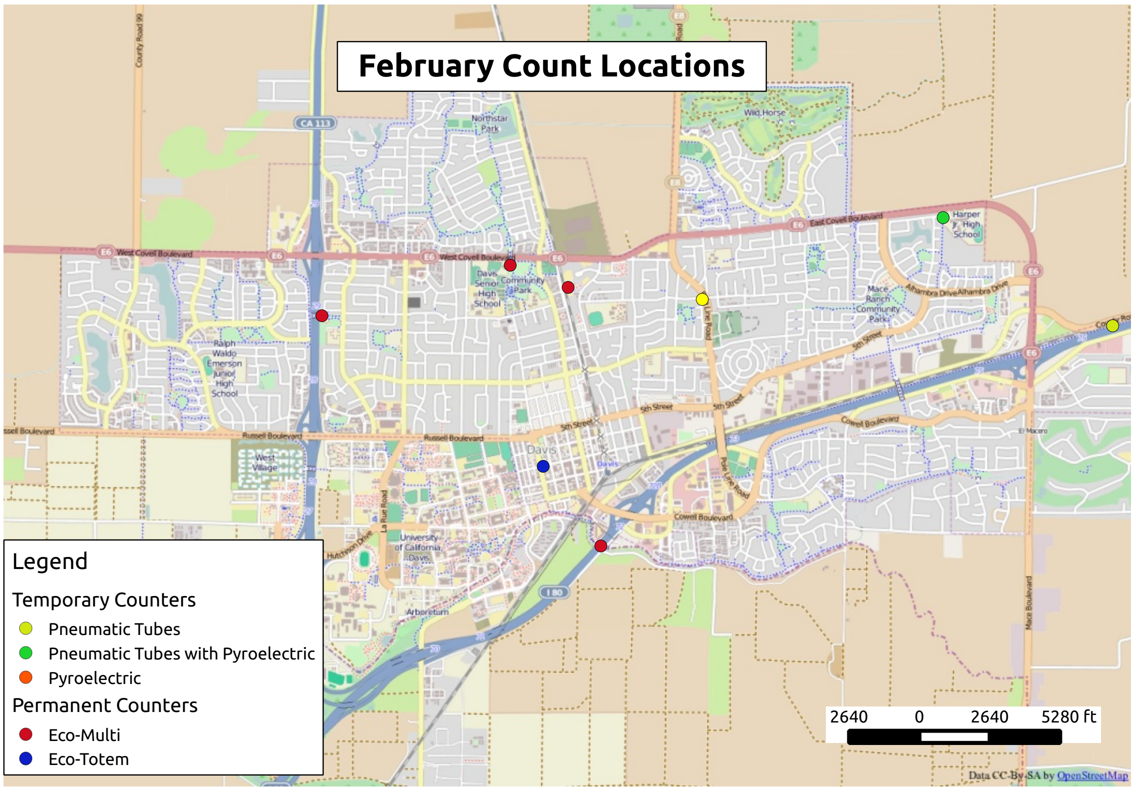

Figure 14: Map of count locations for month of February.

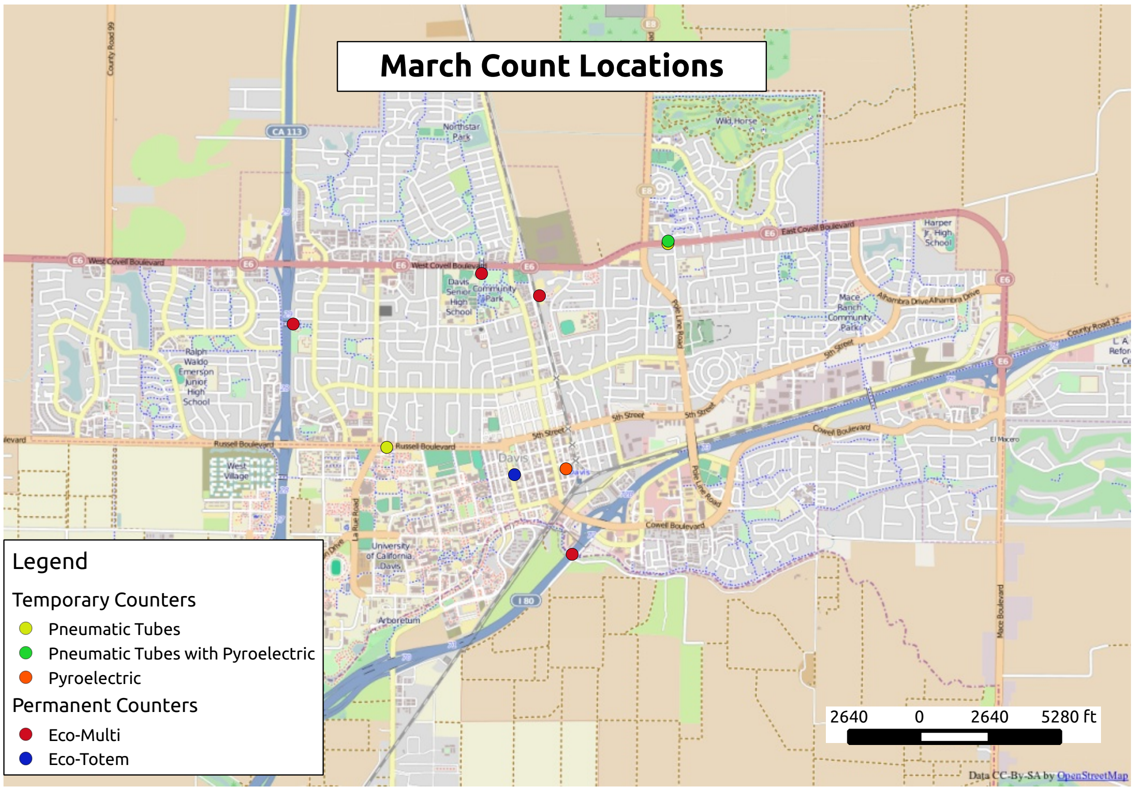

Figure 15: Map of count locations for month of March.

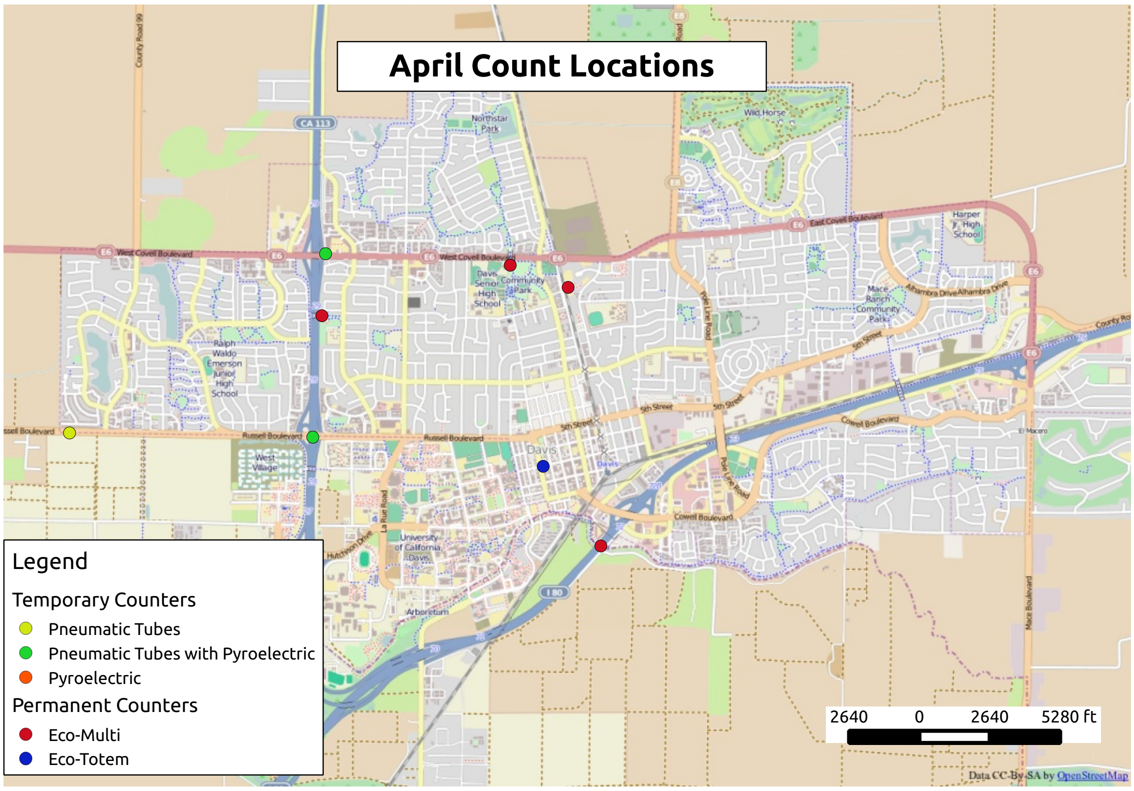

Figure 16: Map of count locations for month of April.

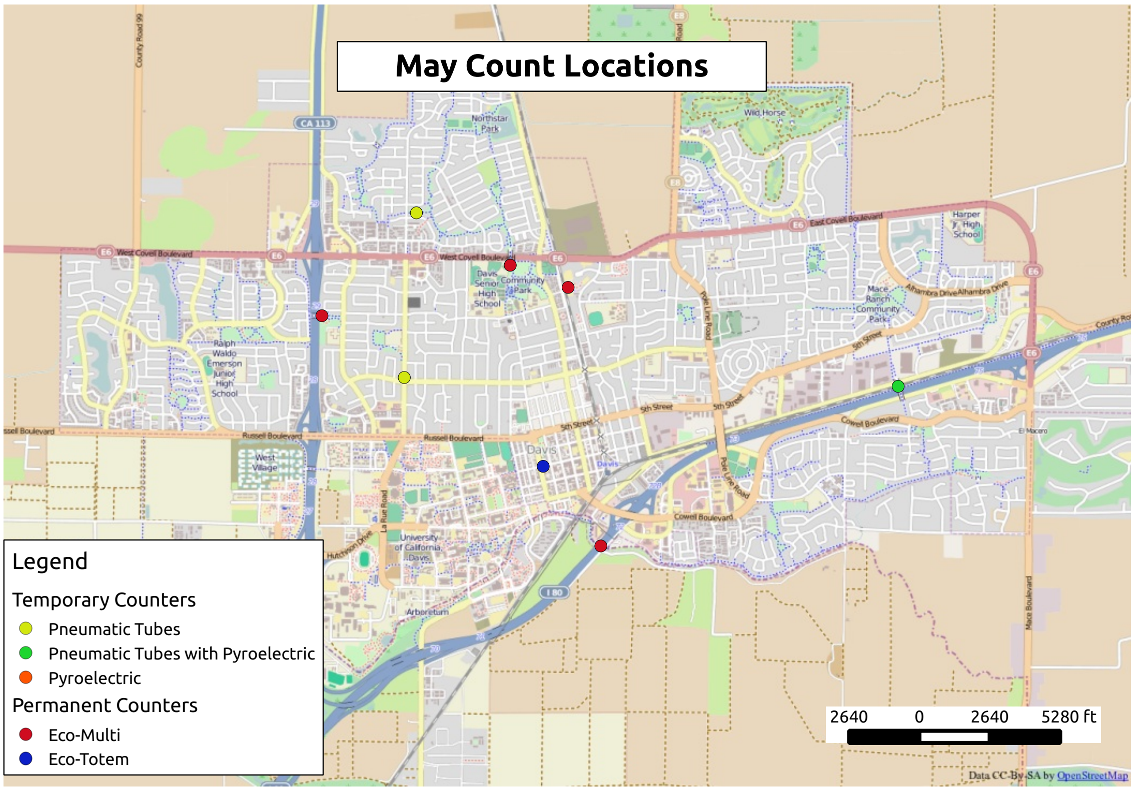

Figure 17: Map of count locations for month of May.

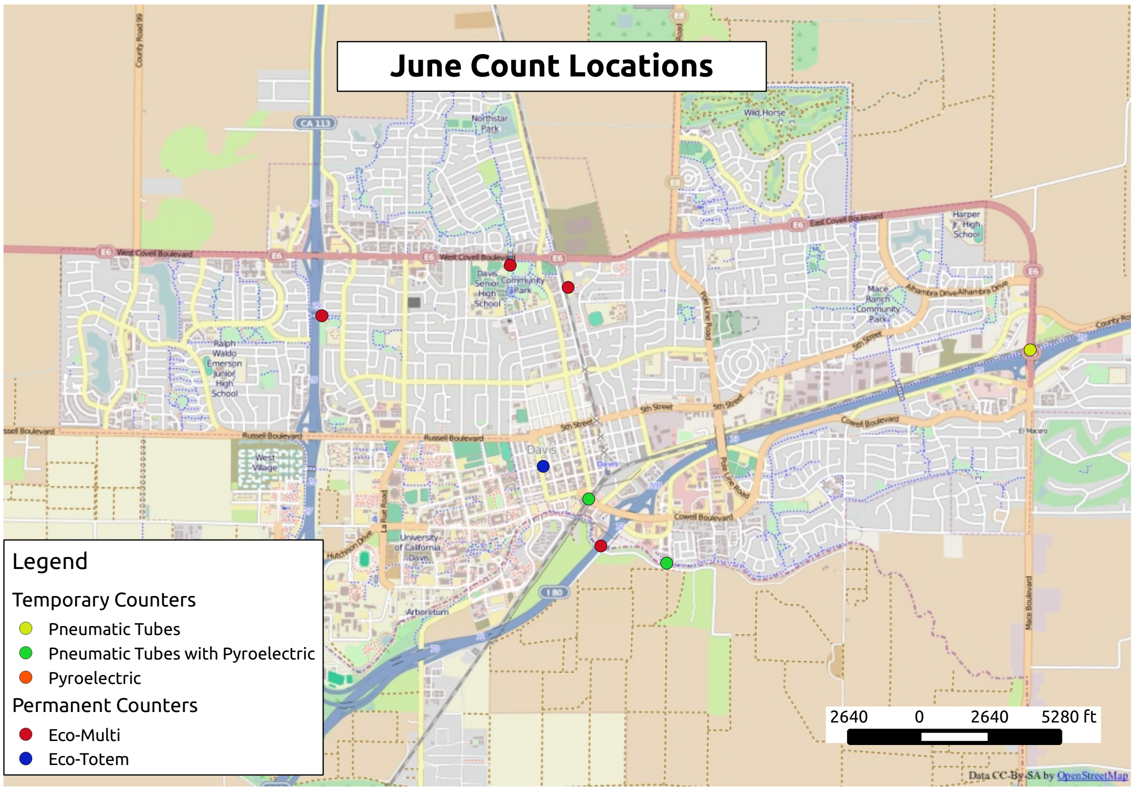

Figure 18: Map of count locations for month of June.

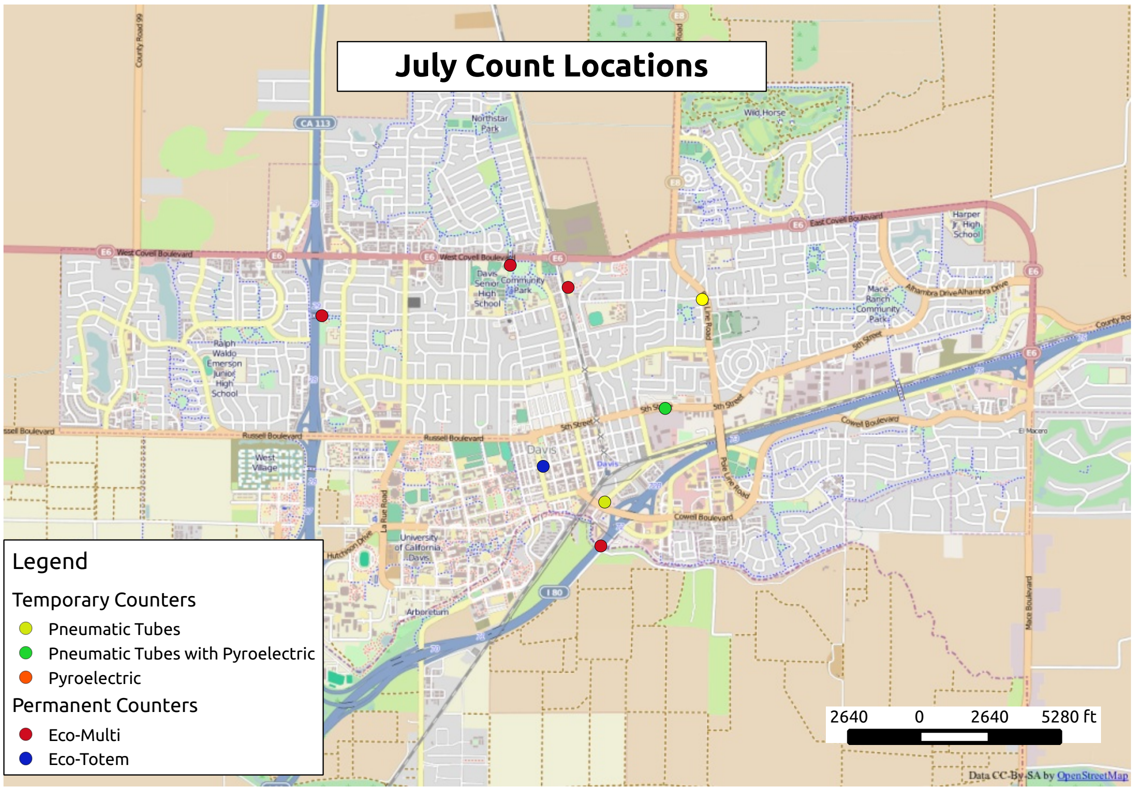

Figure 19: Map of count locations for month of July.

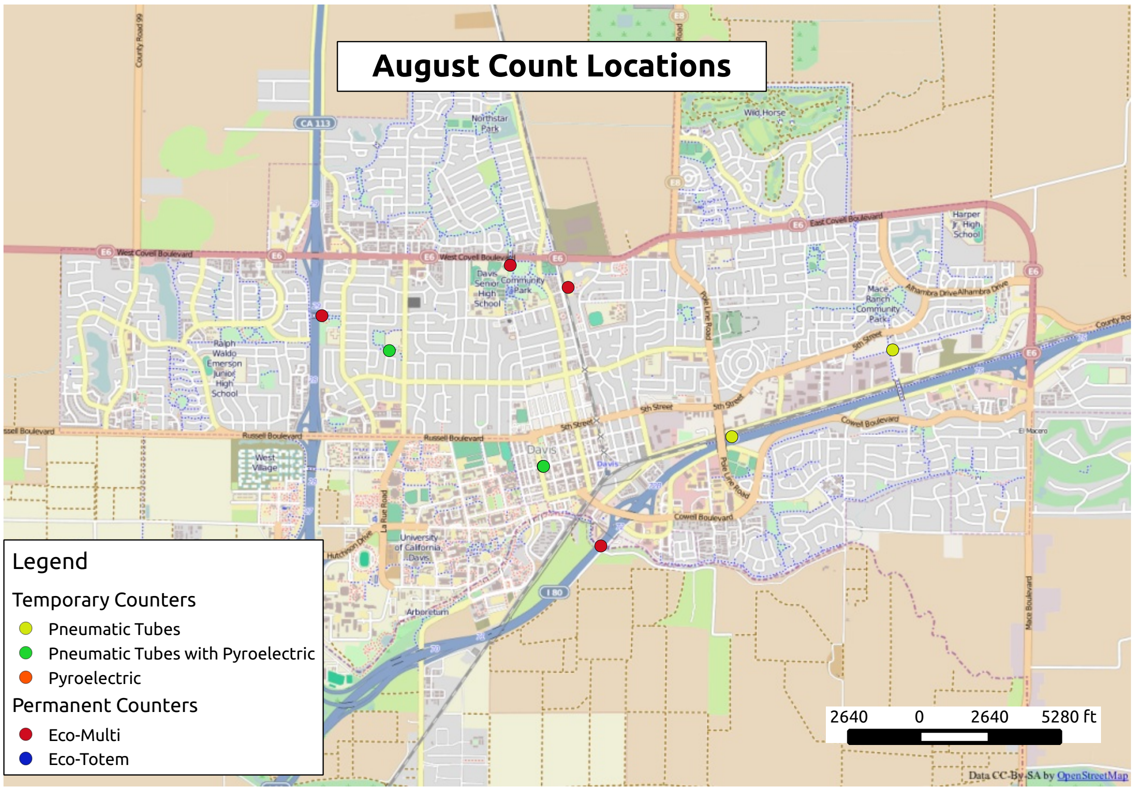

Figure 20: Map of count locations for month of August.

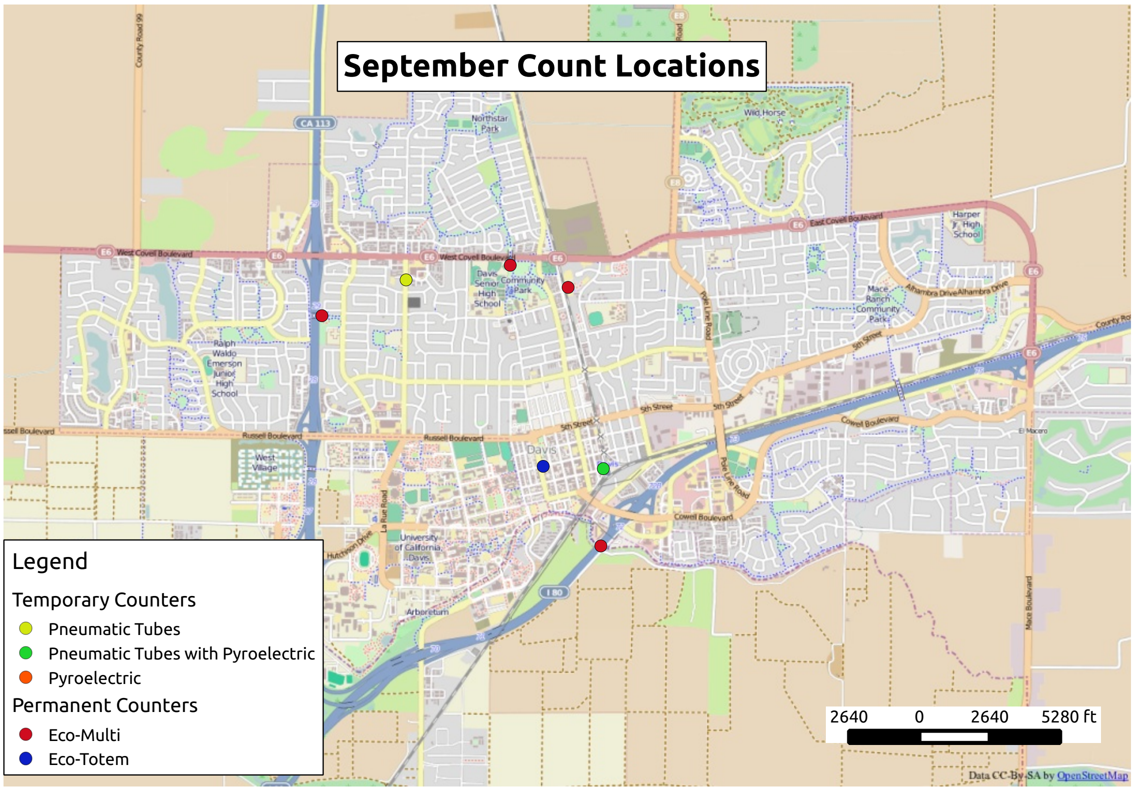

Figure 21: Map of count locations for month of September.

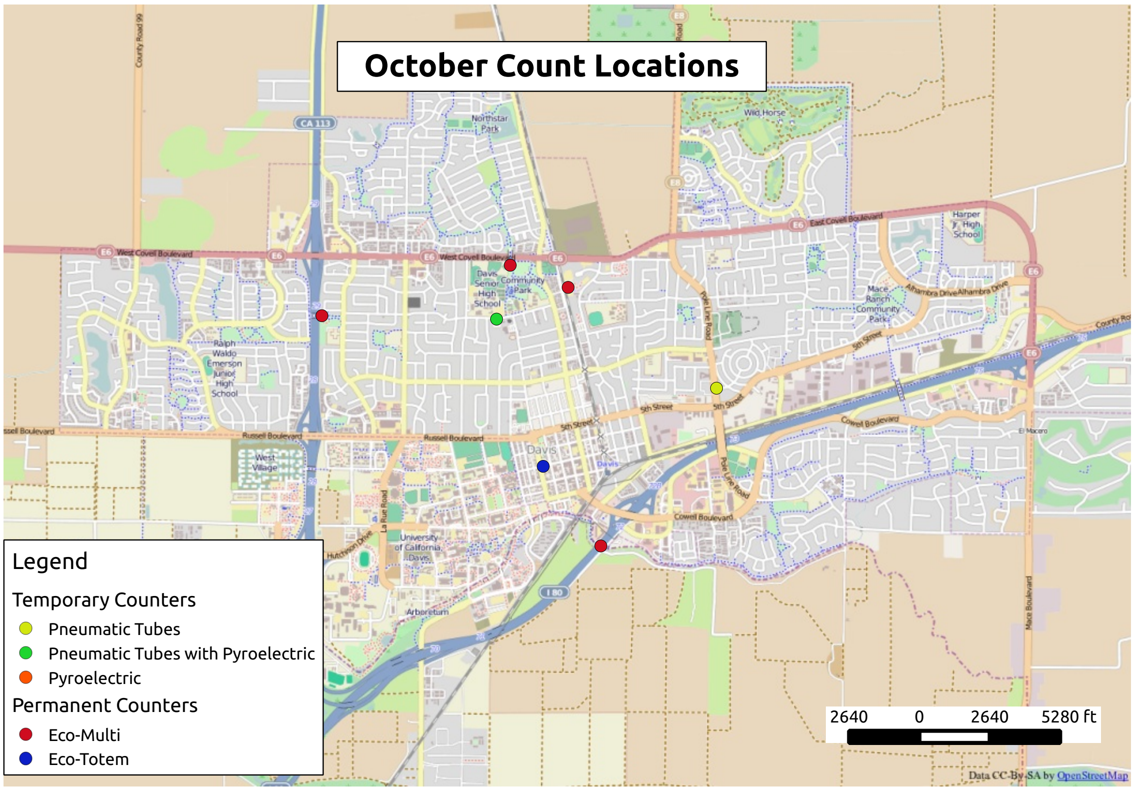

Figure 22: Map of count locations for month of October.

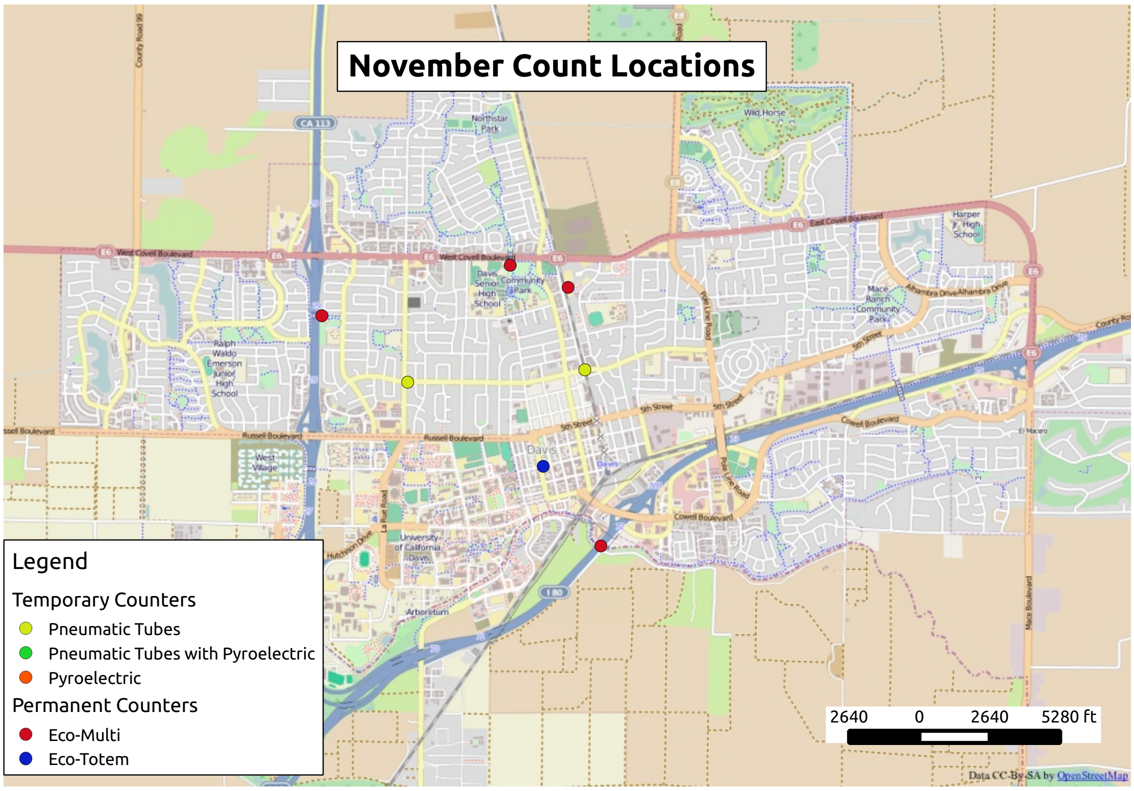

Figure 23: Map of count locations for month of November.

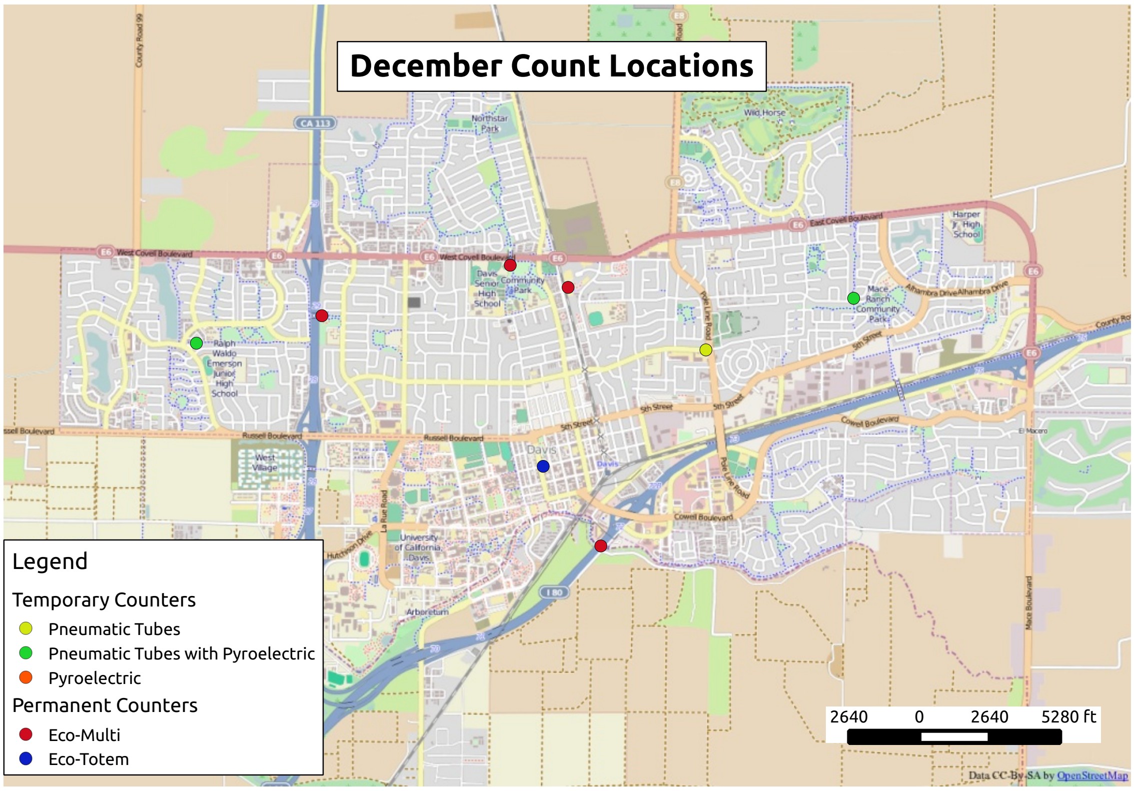

Figure 24: Map of count locations for month of December.