Best Practices Guide for Selecting and Deploying Equipment to Meter Vehicular Traffic at USACE Project Site Areas

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1. Introduction

The U.S. Army Corps of Engineers (USACE) operates 402 lake and river water resource Projects (Projects) throughout the United States that provide recreation access and services for the public. As one of the nation's largest providers of Federal outdoor recreation and the largest manager of domestic water resources, the USACE manages nearly twelve million acres of lands and waters, including 55,000 miles of shoreline that provide access to water-based recreation and related activities. USACE delivers vital public services that energize the economy by accommodating about 370 million visits per year. The Corps also delivers vital engineering services for a variety of Civil Works projects to strengthen our Nation's infrastructure, improve management of limited water resources and reduce risks from disasters.

USACE is a core member of the Federal Lands Transportation Program (FLTP). USACE is therefore eligible for funding to support transportation program administration, operations and maintenance of transit assets, project development, environmental mitigation, and construction of Federal lands transportation facilities. Key factors in how the FLTP allocates funding are the visitation volumes reported by the member agencies, and on the efficacy of the metering programs that produce this data.

USACE has developed a program that accurately captures the visitation statistics for its Projects at the Project Site Area (PSA) level. Most PSAs are segregated areas of recreation within a Project, and they typically have access roads that enable visitation traffic to be metered separately from other PSAs. Primarily by using battery-powered vehicle counting systems (also termed "meters"), USACE produces monthly visitation counts for each of its nearly 5,000 PSAs. Some PSAs have multiple meters, but many small areas have none, and visitation is estimated using statistically proven methods. However, meters are the USACE preferred method for capturing visitation at day-use or multi-purpose areas. All visitation data is consolidated into the Visitation Estimation and Reporting System (VERS), which USACE uses as a system of record for visitation as well as a tool to identify and resolve anomalous visitation data.

The variety of physical layouts and road surfaces at Corps Projects requires a flexible approach to collecting vehicle counts. This document establishes best practices that will enable the Corps to more accurately and cost-effectively collect vehicle counts under many different circumstances. This purpose of this guide is to inform USACE Projects about the range of technologies available to count vehicles and to describe considerations about the strengths and weaknesses of each during the technology selection and deployment processes.

1.1 How to Use This Guide

This document is intended for use by USACE Project staff to guide them in the development of their vehicle metering programs. Projects will generally fall into one of three categories:

- **Use Case #1 –** The Project staff has decided to install new vehicle meters throughout its recreation areas, and needs to determine what meters will best suit their requirements. In this case, the Project staff will need to determine the best locations for vehicle meters and how suitable each of the various metering options is with regard to the physical and environmental conditions at these locations. The Project staff will need to consider the level of effort required during installation, as well as ongoing configuration and maintenance.

- **Use Case #2 –** The Project is replacing or upgrading some of its meters that are either non-functioning or are obsolete. In this case, the metering locations are well-established and known to be generally effective at capturing visitation data. The Project staff will need to determine whether existing meter infrastructure, such as housings or road loops, can be reused or requires replacement.

- **Use Case #3 –** The Project has an effective metering program and would like to ensure best practices for operating and maintaining its meters. Utilizing information contained in this guide about various meter types and sources of errors, the Project can take appropriate steps to improve its process and its accuracy.

This guide is structured to allow USACE staff to first determine which use case best suits their Project, and then turn to the respective section that will enable them to find the information they need. Section 2 describes considerations for Use Case #1, while Section 3 describes Use Case #2, and Section 4 describes Use Case #3. However, Projects needing new meters may need to reference multiple sections and incorporate a hybrid of multiple use cases in order to assist them in making final decisions. A chart summarizing conditions that affect meter selection, and ratings of how well each meter type performs under those conditions is provided in Appendix A.

Section 2 describes factors that are important to all USACE Projects regardless of use case, including meter location and how meter data is processed in VERS.

1.2 Traffic Metering

Systems used for counting vehicles are comprised of three components:

1. A detection technology
2. A data logger
3. A power source

While there are many detection technology products available commercially, only a few have been integrated into complete metering systems. It is important to keep in mind that all counting technologies are imperfect. Various conditions and local configurations can result in errors. This best practices guide aims to explain the factors that affect the accuracy of these technologies so they are selected, installed, utilized and maintained in ways that minimize errors and inaccuracies resulting in improved visitation estimates.

1.2.1 Meter Location Best Practices

While there are conditions that should be avoided that are particular to each meter type, there are some overarching principles that should be considered as best practices:

- Place meters in locations where generally only visitation traffic is present. When possible, place the meter beyond where local residents or Corps offices are located.

- Locate meters so they meter only the traffic to a particular PSA. Ideally PSAs can be isolated, but if one is located inside another, VERS can accommodate this condition. See VERS instructions on PSA types.

- Some metering technologies such as breakbeams or infrared focused beams, detect both people and vehicles. When attempting to meter vehicular traffic, it is important to find locations where pedestrians rarely also pass through the beam.

- Avoid placing meters where traffic comes to a stop. Stopping or slowing traffic can cause many types of meters to produce inaccurate counts.

- Try to capture both inbound and outbound traffic. This is because most Corps roads do not have a centerline, so vehicles sometimes will drive down the middle when no opposing traffic is present. Exceptions to this best practice are as follows:

    - When the meter needs to be placed near where exiting traffic must stop before entering a busy roadway. In this case, the best practice is to place the meter in the entry lane and install it in such a way that exiting traffic is rarely if ever counted.

    - When the roadway is divided by a median.

    - When the road has a centerline and traffic is so heavy that entering and exiting traffic may often pass simultaneously. In this case, the best practice is to meter only one lane.

- If a PSA has multiple access roads, they should all be metered in the same direction with a similar meter type. For example, if a PSA has an existing meter on the entry lane of a roadway, then all other meters should also be on the entry lane, even if they use different detection technologies. If metered lanes are mixed, then a vehicle will either be not counted or counted twice if it exits using a different road. If capturing both inbound and outbound traffic, then be sure to do so for all access roads. In other words, try to employ the same metering strategy at all entry and exit points if a PSA has multiple access roads.

  If traffic stops at a gatehouse, it is best to meter the entry lane AFTER the gatehouse, when vehicles are pulling away. This reduces the likelihood that vehicles will stop at the meter, which can result in inaccurate counts. This position will also reduce the impact of vehicle counts associated with visitors who are turned away at the gatehouse.

1.3 Visitation Estimation and Reporting System (VERS) Software

VERS was developed by USACE to serve as its central repository for data related to the vehicle meters at its recreation areas and as the mechanism for using that data to calculate visitation at all of its Projects. VERS processes vehicle counts using load factors to produce monthly visitation estimates. More than just a data entry system for monthly meter readings, VERS requires specific information related to meter type, placement, settings and configuration in order to convert readings into accurate traffic counts. USACE has made several administrative decisions about how traffic data should be collected and reported, which are listed below:

- **Do not reset the meters -** VERS is expecting to receive traffic counts as accumulating totals, so meters should not be reset every month. If a meter fails, is replaced, or if the count is reset (accidentally or because batteries were replaced), it is important that this fact be recorded in VERS as you enter the data. Systematic reporting by Projects of meter failure will allow for the identification of poor performance in meters and support the justification of future meter purchases.

- **Provide only "raw" data –** VERS handles all of the processing that converts meter readings into accurate traffic counts. It is important that Project staff do not adjust the data before entering it into VERS. The registration information about each meter enables VERS to understand if the meter is counting cars in one direction or both directions, and if road tube systems are set up to count axles or cars. As long as the registration information is correct, VERS will calculate the traffic counts accurately. It is therefore important to check these settings periodically to ensure they are correct.

- **Collect data on a monthly basis –** At some large Projects, it may take several days to collect the meter data from every PSA. To produce consistent results from one month to the next, it may be necessary to use a similar route and routine each month so that each meter's data is within a day or two of a one-month count. This will help identify meters that are beginning to miscount.

- **Resolve issues as they are discovered –** USACE is most interested in making sure that future data is correct, so if meters need to be moved or replaced, or even if PSA boundaries need to be redrawn in order to better capture and isolate a PSA's visitation data, it is best to do this sooner rather than later.

1.3.1 Pneumatic Tubes and VERS

This cautionary note is placed here at the front of this document because of a common and significant error encountered when examining pneumatic tube meters

Figure 1 - Diamond Traffic Tally 77

throughout USACE. When using pneumatic tube meters, it is essential to determine if your meter counts axles or vehicles. Some tube meters increment their count once each time an axle crosses the tube, while others (such as the K-Hill Wee) increment once for every other axle. And some, such as the Diamond Traffic Tally 77, can be configured either way. They use the term “Divide by 1” for axle counting, and “Divide by 2” for vehicle counting.

When registering your meter in VERS, if your meter counts axles, you must select the “Increment of Count” as 1. If your meter records “vehicles,” you must record the “Increment of Count” as 0.5. If you are not sure, it is important for you to test your meter by driving a vehicle across it and noting how it increments. Marking this question incorrectly in VERS will result in an order of magnitude error in your visitation numbers.

2. Use-Case #1: Selecting and Installing New Meters

This section is intended to be used by USACE staff that is planning on installing new meters at its recreation areas. Other users may find value in this section, because it may reveal that the meters they are currently using may not be optimal given the site conditions.

2.1 Factors in Selecting New Meters

If you are installing vehicle meters for the first time, the first thing you need to do is determine the best locations to install them. This is essential in ensuring that a particular PSA's visitation is isolated from others. Determining the meter location is an important first step in choosing a meter because the traffic speed and density and roadway configuration are not known until the location is selected.

The factors that influence meter selection include:

- Accuracy of various commercial products;
- Purchase price and other acquisition considerations;
- Roadway configuration;
- Traffic speed and density;
- Power/Battery life;
- Ease of installation;
- Ease of data collection;
- Maintenance; and
- Vandalism Potential.

Identifying appropriate meter locations should come first, and the practices associated with this are discussed in the previous section. Then managers need to consider the available technologies and identify one or more device types that may best suit the needs of the site and capacity of staff who will be responsible for reading and maintaining the meters. Since local Corps management is responsible for purchasing, installing, maintaining and collecting data from the meters, it is important to select systems that are not only able to accurately count the traffic in a particular environment, but are reliable and easy to install and use. Many Corps Projects are large and the configuration of recreation areas requires extra travel time between sites to read meters. Consideration should be given to metering systems that provide a digital display of the meter count. Be aware, before purchase, that some technologies may require the data be retrieved using a laptop and a cable.

Clearly there are many things to consider when selecting meters. The key discriminators, and how well each meter category rates for each, are provided in the chart in Appendix A.

2.1.1 Accuracy of Various Commercial Products

What makes a system "accurate" is the product of several factors, that include how well it was installed and configured, and whether or not the traffic situation at the selected location lends itself to accurate metering. Below, each of the technologies and selected brands have been ranked according to their accuracy as seen during USACE testing, along with observed characteristics that supported those rankings

1. **Inductive loops –** These systems provide metering that is as close to foolproof as modern technology can provide. Generally, if a car passes over any part of a properly installed loop, it will be counted; otherwise it will not. Once they are in place, they require very little configuration and maintenance. Unfortunately, installing a loop requires some effort. The road surface must be cut with a saw and the loop wire must be laid in place and sealed. If it weren't for the effort involved, almost all metering requirements would be met using this technology. Arguably the best loop metering system currently available is the Diamond Traffic Tally 51. It is simple and straightforward to use, and while it provides several configuration settings, failure to pay attention to these has not been shown to result in poor metering results. The only scenario that should be avoided is locations where traffic often stops on the loop. Barring that, if you have the ability and willingness to install inductive loops, your metering program will have reliable data.

2. **Magnetometers –** Typically, magnetometers are rather reliable vehicle detection technologies. Unfortunately, the TRAFx magnetometer, which is by far the most commonly used magnetometer in the Corps (and the only one currently available as a complete metering system), is not the best implementation of this technology in a metering device. In its efforts to make the device compact, TRAFx sacrificed some of the physical properties that make magnetometers easy to configure. Most magnetometers are polar by nature; that is, they are long and narrow, and only detect traffic in one plane. The magnetometer in the TRAFx vehicle counter is short, and therefore has a detection zone that is almost completely circular. This makes it prone to detecting cross traffic as well as people with metal objects, such as keys and cell phones, walking near it in all directions. Also, like all magnetometers, the TRAFx will detect larger metal objects from further away, making it difficult to meter one lane without detecting nearby trucks or trains traveling just beyond that one lane. That said, it is possible with some effort to configure the TRAFx magnetometer to provide reliable metering in most conditions, but the effort that you save by not cutting asphalt for a loop will go into the repeated on-site testing and tweaking of the threshold and delay settings of the device.

3. **Breakbeams –** Although breakbeams were developed primarily as a trail metering technology, they have proven to work fairly well in many vehicle metering applications. But unlike inductive loops and magnetometers, breakbeams will detect all people and animals that pass through the beam. This causes them to be inaccurate in some circumstances. However, they also are a best choice in other circumstances. In places where it is unavoidable that traffic stops at the metering location, a breakbeam is the only technology that works well. Breakbeam meters also work well where there is little or no entry road (such as a roadside parking lot), or if the roadway is more than 40 feet wide. Some of these devices can work on roadways more than 100 feet wide.

4. **Pneumatic Tubes –** There are almost no situations where pneumatic tubes are a best choice. This technology is easy to deploy, but notoriously inaccurate even in well-installed conditions. Crossing a tube at an angle can result in excessive counts; too slowly and it will undercount. Tubes can wear out quickly, resulting in holes that leak air and cause the meter to miss some vehicles. Pneumatic tube meters are also vulnerable to vandalism and snow plows. But most importantly, some pneumatic tube systems increment once per axle; others once per every two axles, and some are selectable. This requires great care when entering a meter's configuration in VERS; otherwise visitation numbers can be adversely affected. The many ways in which errors can occur is the reason why pneumatic tubes are not a good choice.

5. **Infrared Focused Beams –** These systems were primarily designed for trail counting applications, but can operate as vehicle meters in certain situations. They function similar to a breakbeam, but without a reflector. The infrared (IR) beam can only sense objects within 12-15 feet of the sensor, so they should only be used on single lane roads, and only in places where there are few if any pedestrians or bicycles.

2.1.2 Purchase Price and Acquisition Considerations

In spite of the vast range of technologies and optional features that are commercially available, vehicle meters generally range from between $300 and $600 each. Acquisition strategies will be driven by site conditions and by how many meters are required. If the Project does not have the appropriate staff or the equipment required to install the meters, the cost of contracting out the installation will likely exceed the cost of the equipment.

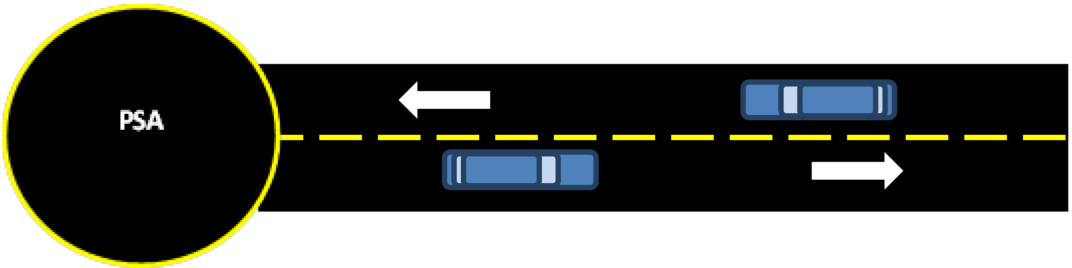
While most metering systems are available from U.S. sources, the TRAFx meters are not. They are currently sold exclusively by their Canadian manufacturer. This fact may complicate acquisition of these popular metering systems due to issues related to the Buy American Act.

2.1.3 Roadway Configuration

The roadways that enter USACE sites vary greatly from site to site, and usually vary within each site. Each roadway configuration has characteristics which present challenges for some vehicle sensor technologies. These characteristics are described below.

1. Two Lane, Two Way Access Road

A single entrance, two lane road is by far the most common vehicle access type at USACE recreation areas. VERS refers to this as a Type A PSA, denoting one way in and one way out. Most technologies can work in this situation, but each must be configured in a particular manner to minimize errors.



- **Inductive Loops –** Inductive loops, which have been shown to be the most accurate counting technology, also provide the most flexibility, because the loop can be cut across one lane or both lanes. Cut the loop across both lanes of traffic. Traffic can have the tendency to drive toward the middle of the road until opposing traffic approaches, so placing a single loop across both lanes is a best practice. Loops will work reliably even when they are 24 feet wide, and they do not need to extend to the shoulder of the road. If any part of each vehicle passes over the loop, it will likely be counted. Loops can be installed in dirt or gravel roads as well, but it is recommended that the wire be run inside PVC conduit for protection if the road surface erodes.

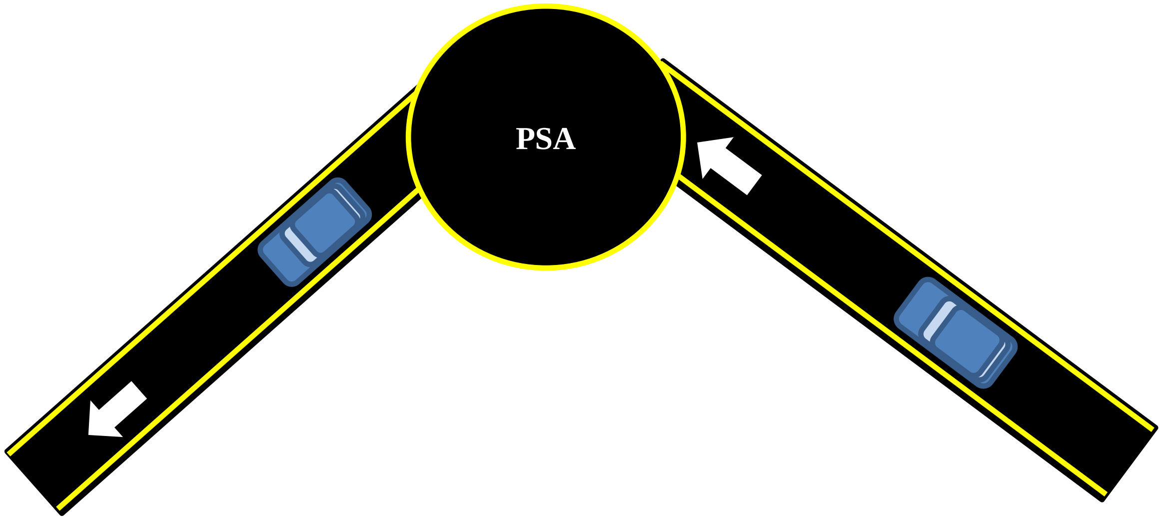
- **Magnetometers –** Generally, you will want to set up magnetometers so they detect traffic traveling in both directions. This is because if you try to detect only one lane, large vehicles in the opposite lane may also be detected. If a particular roadway is too wide to detect both travel lanes (which is rare) then you will need to tune the magnetometer to detect only the adjacent lane as best you can.

- **Breakbeams –** In this situation, breakbeams are not optimal because a receiver or reflector cannot be placed between lanes. It must be placed across the entire roadway (so that both entry and exit traffic is counted). If traffic enters and exits simultaneously, you will likely only count one vehicle. In VERS, you must state that both lanes are being metered, so it will adjust the raw meter count to provide an accurate visitation number. Beam strength should not be an issue, as beams tend to work reliably in excess of 100 feet, which is much wider than any Corps road identified in the field.

- **Road Tubes –** Generally, a road tube should be extended across both lanes. Even when vehicles pass in opposite directions at the same time, it is highly unusual for them to strike the tube at exactly the same moment, so usually, both vehicles will be counted. When extending tube across two lanes, additional points for securing to the roadway should be added to ensure that tube does not bounce or stretch. Remember that using road tubes on gravel roads can produce unpredictable results, and require frequent repair/replacement of the tube. Also, it’s important to be sure the manner in which it counts (half count or full count) is properly recorded in VERS.

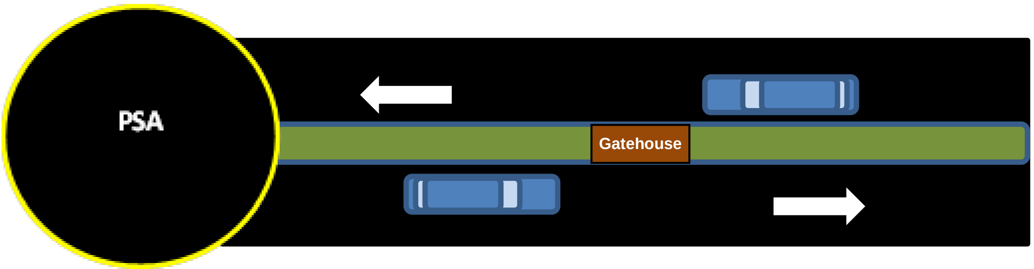
2. One Lane, One Way Entrance, One Way Exit Roads

The ideal situation for counting vehicles is when there are separate single inbound and outbound lanes, as depicted below. Although this configuration is also considered to be a Type A in VERS (because there is only one access road), it is much easier to meter.



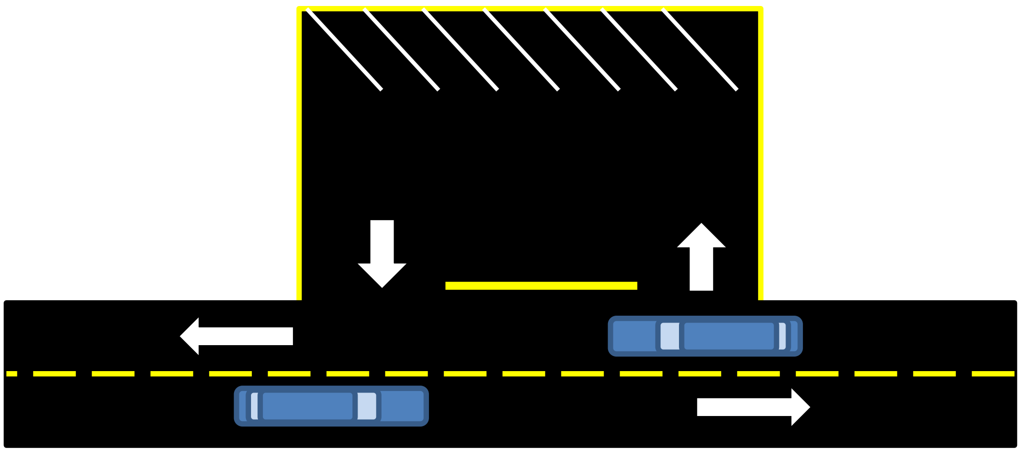
This configuration enables most counting technologies to work effectively because you don't have the complication of simultaneous entry-exit. Because the traffic travels in one direction, only one of the roads needs to be metered. Preference should be given to the road where traffic is less likely to stop. In this condition, there is no concern about the threshold settings of magnetometers, as long as the delay and rate settings are appropriate for the typical speed of the traffic. Breakbeams will work well as long as there are insignificant numbers of pedestrians or bicycles that would also trip the beam.

Divided Two Way Road



Divided roadways, or roads where a gatehouse separates inbound from outbound traffic are essentially similar to one-way roads. When there is some physical separation between inbound and outbound traffic, most traffic metering systems can be configured to count vehicles in one lane only. However, since traffic will sometimes stop at a gatehouse, the meter should be placed after the gatehouse, where traffic is pulling away, and on the outside shoulder to maximize the physical separation from traffic traveling in the opposite direction. Breakbeams should not be placed near gatehouses because people walking near or around the gatehouse will trip the beam.

3. Roadside Parking Areas



For areas that have little or no roadway on which to meter traffic, your options for automated counting are limited. The choice to meter roadside parking may require the installation of barriers to force traffic by the counter. Magnetometers do not work well because the best location for metering is so close to the main roadway that cars on the road will also be counted. Inductive loops will work on the inbound lane, but the loop must be cut small enough so that vehicles backing out of parking spaces do not get counted again. Road tubes are not a good choice here, because vehicles entering this parking lot will be turning, so the meter will sometimes count 4 tires instead of 2 axles. Breakbeams are actually the best choice for this scenario, but only if pedestrian traffic is minimal; otherwise inductive loops are the only good choice.

If a parking area is small (< 20 spaces), it is recommended not to meter this type of lot and instead use the Recreation Unit Day Availability (RUDA) method to estimate visitation. Refer to the VERS system for more on this estimation method.

2.1.4 Traffic Speed and Density

The characteristics of some vehicle sensor technologies cause them to sometimes miscount when traffic is moving very slowly or when vehicles are tailgating one another. This is the case with most proximity sensors, including inductive loops and magnetometers. These sensors detect large metal objects, but need a second or two to reset before they can reliably detect subsequent vehicles. Therefore, it is a best practice to place these types of meters in locations where the traffic rarely stops.

Most types of meters can count traffic moving at high speed, but some require special configuration. The TRAFx magnetometer, for example, should be set to a Rate of Fast if vehicles regularly travel at speeds in excess of 35 MPH.

Breakbeam sensors are often used in locations where tailgating is common because they can detect even the smallest of separation between vehicles, regardless of how fast they are moving. However, errors can occur for other reasons. If the sensors are placed near a fee collection facility, people walking in the area can trip the sensors and affect the vehicle count. Also, breakbeam counts are most accurate when used on one-way or lightly traveled roads where simultaneous entry-exits are rare.

Pneumatic tubes are also used in high traffic density environments because they are not very susceptible to problems from tailgating or by unintentional triggering by pedestrians. However, they sometimes fail to count when vehicles are moving slowly because the velocity of the air inside the tube is insufficient to trip the air switch. They should also not be used on unpaved surfaces or at curves in the roadway, and they must be removed when snowplows are in operation.

2.1.5 Power/Battery Life

All technologies used for metering visitation contain electronic components, and these require power in order to operate. Since these systems are often used in remote locations, most include options that enable them to operate for many months or years on battery power. When selecting a metering system, it is important to understand its expected battery life for a particular environment, and consider if planned maintenance schedules will assure continuous operation.

Monthly testing of meter batteries with a volt meter is a best practice, because it provides you with a sense of how quickly batteries are discharging. If you record these measurements, you will likely recognize that some meters discharge faster than others, and you will be able to know when batteries need to be replaced prior to meter failure.

2.1.6 Ease of Installation

The cost and effort involved in installing a visitation metering system is a consideration in the selection process. If it weren't for the effort involved in installation, most Projects would use inductive loop metering systems because of their accuracy and low ongoing maintenance. Some Projects are phasing these out in favor of magnetometers, which can be easily mounted inside a housing on a roadside post. However, it should be noted that the time required to properly configure a magnetometer on site can rival the time required to install a loop in the road. Breakbeam systems must be housed on stanchions that are very sturdy, which involves embedding a large post in concrete. The reflector itself must also remain stable, and a cover, or "hood," should be installed to protect the reflector from rain and other impediments. Road tubes require a tube to be terminated and nailed to the road surface, which is not much difficult, but the maintenance involved can require more work later.

Another factor that affects ease of installation is the housing type that is required to protect the metering equipment. This factor is discussed further in Section 2.1.9 Vandalism Potential.

2.1.7 Ease of Data Collection

Typically, local USACE personnel or contractors are responsible for collecting the data and performing limited maintenance procedures (such as changing batteries and ensuring the equipment is free from water or other environmental conditions that could adversely affect performance). Systems that require a computer download of data require much more effort than those that feature a built-in display, and systems that require frequent battery changes are not as desirable as systems whose batteries last for one or more years.

2.1.8 Maintenance

Systems that require lens cleaning, manual resets, vacuuming, etc. are also not as desirable as those that do not. Inductive loop systems typically require the least amount of ongoing maintenance. Once every few years, the loop sealant may need to be reapplied, and most have batteries that last 6-12 months. Once properly configured, magnetometers also require little ongoing maintenance as long as they are kept dry, but in some models, the built-in display is an optional add-on. Breakbeam systems work well as long as the beam apertures are kept clear (insects often build nests in them), and their reflectors do not work well in rain and at sunrise and sunset (sunspot blindness) unless they are hooded. Pneumatic tube systems require the most ongoing maintenance because tubes can wear out, are prone to vandalism, and must be removed when snow plows are in operation.

2.1.9 Vandalism Potential

Some meters are more susceptible to vandalism than others. In some cases, the meter housing can mitigate this risk. Generally, road tubes are the most vulnerable, because the tubes themselves can be easily damaged or removed from the roadway. Meters that have large electronic units need to be housed in a secure enclosure, so large devices require large housings, which can be expensive and are more easily noticed. Steel housings offer good vandalism protection, and testing at USACE sites has revealed that the metal does not have a significant negative impact on the performance of magnetometers should these be used, however the raising and lowering of the lid or metal objects on the meter reader can trigger extra counts. Magnetometers can also be buried a few inches below the road surface; however heavy rains can flood most buried housings, and the monthly reading process can be challenging.

Inductive loops have a low potential for vandalism because the loop is embedded in the roadway. Breakbeam systems require an aperture in the housing to detect vehicles, which can be obstructed by vandals or insects.

3. Use-Case #2: Upgrading or Replacing Obsolete Meters

As existing metering systems begin to age, they will require repairs or replacement. Since new meters cost only a few hundred dollars, it is often simpler to simply replace a malfunctioning meter. Exceptions to this include:

- The reuse of existing infrastructure would save the effort and expense of performing a new installation. For example, if your Project has a set of breakbeam meters that are no longer manufactured, and they are mounted to stanchions embedded in concrete, it may be preferable to repair old meters rather than incur the cost of new meters along with new installations.
- Inductive loop meters are generally very accurate, and the primary reason they are not used universally is that installing the loop wire in the roadway requires special skills and equipment. However, if you have an existing loop in the roadway that is functional and in a good location, but the meter has failed, it is better to purchase a new meter and reuse the loop. Some meters use the same loop connectors as others, but even if the connector needs to be changed, it is a trivial task.

If it is time to replace an obsolete meter, it is also a good time to consider whether or not it should be moved. Visitation traffic might be better isolated in other locations, and meter performance might be improved if it were located further from traffic issues such as stop signs, intersections or wide shoulders. A chart showing the various meter selection factors and how well each meter category rates for each is provided in Appendix A.

Below are repair and replacement options for some of the most commonly-used meters in the Corps. Configuration suggestions for these meters are provided in Section 4.

3.1 Inductive Loops

Many USACE Projects use one of the many types of Diamond Traffic Tally inductive loop meters. These include the Traffic Tally 14, 21, and 41 models. While these are no longer manufactured, Diamond Traffic will repair defective meters. Their current product, the Traffic Tally 51, costs only $400 as of July 2015 and uses the same loop connector as its predecessors.

The Streeter-Amet 161 (also sold as the Streeter-Richardson 161) was first introduced in the 1980s. These meters are still being sold by Peek Traffic as the JR 161. The design has changed little over the years. Although this design does not tolerate low battery voltage conditions as well as the Diamond Traffic Tally products, it has proven to be a reliable metering system. If you are considering replacing a Streeter-Amet 161 with a Traffic Tally 51, changing the loop connector is a relatively simple task.

The K-Hill BST is the only inductive loop meter offered by the K-Hill Signal Company. These meters have been commercially available for decades, and the design has slowly been modernized over the years. In spite of this, it was found that these meters are less tolerant of large loop sizes, low voltage and humid conditions than Traffic Tally meters. Also, these meters are particularly prone to false counts when they are moved, so care should be taken not to move them when reading the meters. If you are considering upgrading your K-Hill BST meters, the only thing you would need to do is change the loop connector.

3.2 Pneumatic Tubes

Most of the companies in the vehicle metering business (including Diamond, Peek, K-Hill, and IRD) offer a pneumatic tube product. While pneumatic tube meters are relatively easy to install, they require significant maintenance to ensure the road tube does not wear or break. Also, it is not unusual for vandals or snow plows to cut the tube. And finally, pneumatic tube meters have shown to have a lower degree of accuracy than inductive loop meters. While they work relatively well under ideal conditions, there is almost always a better metering option available for a particular situation. Additionally, some pneumatic tube meters count axles while others count vehicles, so the opportunity for additional errors exists. It is for these reasons that Corps Projects should consider upgrading to a different metering technology. If this is not practical, then care needs to be taken to ensure that the Increment-of-Count setting in VERS corresponds to how these meters are configured to count vehicles.

3.3 Breakbeam Meters

Most Corps Projects use one of two types of infrared breakbeam meters: The Cuesta System RS-501 and the Diamond Traffic TTC-4420. Both were designed primarily to be trail counters, but have proven to work well as vehicle counters under certain conditions. They should not be used where pedestrians or cyclists will often break the beam, as this visitation is generally captured in other ways. They should also not be used if bushes or other vegetation sometimes grow around the meter or reflector and break the beam when the wind blows.

The Cuesta RS-501 is no longer manufactured, but existing meters can be repaired by Alasco Rubber and Plastics Corporation. This is important because some Projects invest heavily in the housings required to keep the breakbeam meter motionless and vandal resistant. While Diamond Traffic manufactures a similar product with a similar form factor, it may not fit in some custom-built housings without modification.

The Diamond TTC-4420 is a good replacement for the RS-501 if a particular unit cannot be repaired. It is available from Diamond Traffic, and it is also sold by IRD as the Millennium Trail Counter. Before replacing an existing breakbeam meter with another, it is a good idea to consider if pedestrian or bike traffic has increased since it was originally deployed. If so, it may be necessary to replace it with either a magnetometer or and inductive loop meter.

4. Use-Case #3: Improving Operation and Maintenance of Existing Meters

This section is intended to be used by USACE Projects that have already invested in metering equipment, and are interested in achieving more precise visitation counts. Each of the most common metering systems used by USACE Projects for metering vehicular traffic are examined in detail, and the best practices for installation and configuration in an effort to minimize conditions that can result in errors are provided. Projects that have not yet decided which technology is best for them may find the details of what is involved in proper installation and configuration to be helpful in making that decision.

4.1 Inductive Loops

Inductive loops are simply wires that are embedded in the road surface to detect the presence of vehicles. They detect changes in the magnetic field caused by the ferrous metal in a passing vehicle. They do not detect pedestrians or non-metal objects. They are commonly used to change traffic lights from red to green, or to hold the green light until the traffic has passed. Also, they require little maintenance unless they are struck by lightning or the road surface is damaged or repaved, or if the wire degrades to the point of failure.

In general, inductive loops are the most foolproof of all car counting technologies. They require the least amount of time to calibrate, and are most responsive to challenging conditions. Properly installed, they always increment the count when any part of a vehicle passes over the loop, and never increment the count when vehicles miss the loop. Because of this, when selecting a technology for counting vehicles, inductive loop systems should be considered as a first choice, even though they are more laborious to install than other metering systems.

The one condition to be avoided is placing the loop where vehicles tend to stop. This can cause the meter to produce unpredictable results. Also, inductive loops sometimes have trouble detecting the separation between vehicles, but usually only if they are following extremely closely. Again, placing the loop where traffic does not normally stop is a best practice.

Figure 22 - Example of a properly cut single-lane loop

In asphalt or concrete roads, installing induction loops requires slots be cut into the road surface, into which the loop wire can be implanted and covered by epoxy or other waterproof sealant. These wires are run to a loop controller that provides a nominal current to the wire and senses changes in the resulting magnetic field. When installing inductive loops in dirt, sand or gravel roads, it is a best practice to lay out rectangular sections of PVC conduit, run the wire through the sections, cement the sections together, and then bury the conduit. Inductive loops will function well when buried up to 6 inches deep.

Loop wire should not be bent at sharp 90 degree angles because it can damage the wire. When cutting a slot for a loop, it is important to cut 45 degree angles for the corners. However, it is also important not to cut a rectangle and then diagonal slots. This will result in triangles of asphalt that can become loose and result in a pothole.

When running the loop wires back to the meter, be sure to twist the wires. This can be done quickly by inserting them into the chuck of a power drill. Twisting the wires is important because if they separate, they can form small loops that can trigger the meter to count when metal passes near them or when they move.

Loops can be cut in a variety of shapes and sizes. If traffic allows, it is a best practice to cut the loop across both lanes, metering traffic in both directions. This is especially true if the road has no centerline, as traffic will have a tendency to travel along the middle of the road when there is no opposing traffic. Ideally, loops will be approximately 6 feet long and can be up to 24 feet wide. It is best not to cut the loop within 3 feet of the road's shoulder, or within 2 feet of the centerline for single-lane loops. The loop only needs to be wide enough so that some part of each vehicle passes over it. In almost all cases, running the loop wire through the slot 3 times is ideal. Finally, it is important to seal the wire with loop sealant. Every few years, the slot should be resealed to ensure that wires do not become exposed and vulnerable to breakage. When roads are resurfaced, it is usually not necessary to replace the loop unless the current road surface is milled or regraded. Most inductive loops will function properly even beneath 8-10 inches of road surface

While inductive loops tend to provide years of accurate and maintenance-free counting, they require some effort and a diamond saw blade to install them in asphalt or concrete. Generally, if a Project has good working loops in good locations, but has problems with its counters, it is best to replace the counters than to replace everything by switching technologies. This is because inductive loops are recognized to be very accurate and maintenance-free once the loops are properly installed. The sections below describe some of the most popular inductive loop meters being used throughout the Corps, and how best to configure and maintain them.

4.1.1 Diamond Traffic Tally 14, 21, 41 and 51

Figure 3 - Diamond Traffic Tally 51

These meters are generally the same, except in the manner in which they are housed. Currently, only the Traffic Tally 51 is commercially available. It is housed in a fiberglass Pelican case which provides superior moisture protection to the aluminum housings used in prior versions.

These meters have an internal battery pack. Most models hold 8 D-cell batteries, and a set of alkaline batteries should last at least a year. Earlier models held fewer batteries or lantern batteries. One advantage of the Traffic Tally 14, 21, 41 and 51 are that they are tolerant of low battery conditions. While 8 fully charged batteries should produce a voltage in excess of 13 volts, some of the meters tested continuing to operate at less than 4 volts.

These meters have a separate internal battery that is intended to maintain the count when batteries are being changed. This is helpful because it is a best practice to never reset the meter count. However, some early models had internal batteries that did not last the life of the meter, so it is best to either develop a process to replace the D-cells while using a temporary power source, or to use alkaline batteries and change them only once per year.

Other adjustments available on these models include:

Figure 4 - Diamond Traffic Tally 14

- Counter Reset – NEVER USE unless the meter is being redeployed to a different PSA. It is Corps policy to leave existing counts on meters and allow them to accumulate.
- Detector Reset – Fear not, as this will not affect the count. This resets the inductive loop detection and is helpful if the meter appears to be too sensitive or not sensitive enough. This is a rare condition. Press it for two seconds and release it, then wait 20 seconds before testing.
- Delay time – This can be adjusted from Short to Long (0.1 seconds to 4.0 seconds). If the delay is too short, it can miscount slow moving cars. If the delay is too long, it can miss some tailgating cars. Short is for highway speed vehicles, which is not typical for most Corps roadways. In most cases, setting the dial to about 80% toward Long is about right, but you should then test to ensure proper counting. If you switch on the delay light when testing, the light will illuminate indicating it will not count again until it goes out. Most Corps roads see traffic moving at about 20 MPH, so a delay of 1-2 seconds is ideal. Fortunately during testing, it was found that these meters rarely double count even if the delay is set to short.

4.1.2 Streeter-Amet 161

These meters were first developed in the early 1980s and are still being sold by Peek Traffic, using the model number JR161. A number of companies also provide repair services for these meters today. Other names such as Streeter-Richardson and Streeter JR were used for this same basic design over the years. These meters have a physical numeric ferrule (like an old odometer), so the count is not reset when batteries are changed. Unfortunately, the energy required to increment the count

Figure 5 – Streeter-Amet 161

is significant; therefore the meter will fail once the battery voltage drops below about 8 volts.

These meters were designed to use two 6-volt lantern batteries, although any 12 volt power source will work. They are contained in cast aluminum housings which have proven to stand up to the elements well over the decades.

The meter has a 3-position toggle switch. In the center, the meter is off and will not count. Up is to test the battery, and a red LED will illuminate if the battery voltage is acceptable. Testing of USACE meters revealed that marginal batteries may light up the lamp even though the meter is on the verge of failure due to low voltage, so using a volt meter to test the batteries each time monthly readings are collected is considered a best practice. It is important to remember to return the switch back to the ON position for it to count vehicles.

Below the switch are small potentiometers for adjusting the gain and delay. As was the case with the Traffic Tally meters, adjusting these was not normally required. The meter has shown to have good tolerances regardless of how these are set. As with all meters, it is important not to place the inductive loop where traffic often slows or stops, or it can produce inaccurate counts.

4.1.3 K-Hill BST

K-Hill has been producing counting systems for over 50 years. They produce mostly road tube meters, but the BST is its only inductive loop system. Although it was developed in the 1980s using a similar design as the Streeter-Amet, the company still produces them today. Like the Streeter, the K-Hill BST was designed to use two lantern batteries, and the meter is contained in a cast aluminum housing. The K-Hill meters are distinctive in that they have a much more "homemade" look to them. In some of the meters encountered during testing, the circuit board needs to be insulated from the batteries, so it is important to place a piece of plastic or cardboard between the batteries and the circuit board to prevent the meter from shorting out.

Figure 6 - K-Hill BST

Like the Streeter, the K-Hill has a toggle switch that is designed for testing the batteries. Again, the best practice is to use a volt meter for testing the batteries instead, and to replace batteries when they fall below 9 volts. The switch needs to be returned to the ON position for operation. These meters were found to be particularly prone to false counts when they are moved, so care should be taken not to move them when reading the meters.

4.2 Magnetometers

Magnetometers are devices that detect changes in the magnetic field that surrounds it, which can be caused by the presence of a large metallic object such as a motor vehicle. They do not detect people or other non-metallic objects. To count vehicles, most magnetometers work equally well regardless of whether they are mounted on a roadside post or buried a few inches underground. Once they are properly configured, magnetometers require very little maintenance, and rarely fail unless they are struck directly or indirectly by lightning.

Magnetometers do not work well in environments where there is little separation between vehicles. Magnetometers need a few seconds for the environment to “reset” before they can detect a new vehicle. For this reason, they should not be placed in locations where traffic stops or hesitates before entering a main road. Also, the most common magnetometers detect vehicles in all directions, so they should not be placed close to a cross road when you are only interested in measuring the traffic on the road that intersects it.

When reading or testing magnetometers, metal objects on your person can trigger additional meter counts. This includes cell phones, radios, and cameras. In particular, when testing the meter, use caution to avoid triggers that will result in inaccurate results.

4.2.1 TRAFx Vehicle Counting System

Currently almost all the magnetometers used by the Corps are the TRAFx Vehicle Counting System. Model numbers G1, G2 and G3 are all substantially the same with just some internal enhancements over time. Although many types of magnetometers are commercially available, the TRAFx is the only one that is currently available as a complete metering system. While these meters require little physical effort to install, there are many issues that need to be taken into account in order for the system to count properly.

Figure 7 - TRAFx Vehicle Counting System

Purchasing

Currently, TRAFx meters are only sold by the manufacturer in Canada, which can pose some acquisition challenges. As an initial purchase, TRAFx wants users to purchase a kit that includes 3 meters, software and a G3 dock and cable. The dock and cable are necessary in order to set up and configure the meters. The software, which comes on a CD, should be installed on a laptop that you can bring with you to the deployment site to configure and test your meters. Once properly deployed, you will not need to bring the laptop to the sites again.

The one option that TRAFx offers on its meters is a digital display for a nominal fee of about $50, which provides many benefits. The display shows the current count, so when conducting monthly readings, you only have to look at it. Without the display, the only way to obtain monthly counts is to connect the dock to the meter and download the data. The display also makes it easy to verify the proper operation of the meter without attaching the dock. In addition, the display provides a backup because it does not reset even if you accidentally erase the internal data. It can even maintain the count for a few seconds when changing batteries. To improve the likelihood that you will not reset the meter, you should change the batteries one-at-a-time to minimize the amount of time the system is without power so the display count does not reset to zero. Testing revealed that the display will reset to zero after the C-cell batteries are removed for about 10-15 seconds. This time is likely to get shorter as the meter (and its internal battery) ages.

Housing

TRAFx meters should be placed inside a lockable housing and mounted to a fixed post on the side of the road. These meters can also be buried a few inches below the ground, but they are water resistant, not waterproof, so heavy rain can damage them if they are not housed in waterproof burial boxes.

When mounting the housings on a post, the Wiegmann HW-J60604CHQR was found to be an ideal housing for the TRAFx meters. It is just large enough for the meter to sit flat inside, and it has a hasp so that a padlock can protect the meter from all but the most determined vandals. While the housing has external mounting holes, most Projects run screws through the inside to make them more difficult for vandals to remove.

Our testing has found that the TRAFx meters work adequately well inside aluminum or even steel housings. There is only a minor degradation in detection range, which can usually be compensated for using the Threshold setting. The key problem in using steel housings is that since magnetometers are metal detectors, opening the lid of a steel housing, or picking up and moving a meter in the course of conducting monthly readings will generate spurious counts. For this reason, selecting housings that are non-metallic are suggested. If steel housings are used, you should take steps to move the meter as little as possible when taking monthly readings.

Figure 8 - Example of proper TRAFx installation

Meter Placement

It is a best practice to place TRAFx meters in locations where traffic is moving at a steady rate. They should be set back from stop signs, and be close enough to the roadway to detect vehicles traveling in both directions. If it is more than 40 feet to the opposite shoulder, there is a possibility the meter will not detect some cars in the opposite lane. Only by testing can you know for sure. NOTE: For two-way roads, it is a best practice to always meter traffic in BOTH directions. Magnetometers detect large vehicles from a further distance, so it is NOT advisable to attempt to count only the traffic in the adjacent lane. However, when the roadway is wide, or when the meter cannot be located far enough from a cross street as to not detect traffic, one way counting may be the only viable approach.

While most magnetometers are polarized, in that their detection range is greater when it is pointed a certain way, the detection zone of a TRAFx meter is almost circular, with the short axis being only slightly more sensitive than the long axis. This means care needs to be taken when selecting a location to ensure that traffic on cross roads or within the parking area is not also being counted.

Configuration and Testing
IMPORTANT: The TRAFx vehicle meters have factory default settings that do not work well in typical recreation area traffic conditions. The key issue is the delay setting. The default is too brief for slow moving traffic, causing some vehicle to increment the counter more than once. The process for selecting a good delay time is described below.

To set up a TRAFx meter, it is best to bring it to the selected location, along with a laptop that is running the TRAFx Communicator software and the G3 Dock and data cable. There are three configuration modes to choose from: VEH-1s, VEH-2s and VEH-4d. In most cases, you should be using VEH-2s for one-lane roadways, and VEH-4d for two-way roads.

VEH-2s and VEH-4d have different threshold scales. The minimum (most sensitive) setting for VEH-2s is 003, and for VEH-4d it is 008. In almost every case, the threshold should be set higher than these minimum settings, because at these settings, the TRAFx meter has been seen to increment when no vehicles are present. The threshold should be set to the highest (least sensitive) number that provides 100% counting of small vehicles in the farthest lane from the meter. This is because you want to make the radius of detection as small as possible to minimize multiple counts, and to minimize the occurrence of spurious counts caused by people walking past the meter with cell phones and keys, or when taking monthly readings. To properly count vehicles on two-way roads in a typical recreation areas (where traffic travels approximately 20 MPH), a good starting point is to select VEH-4d, with a threshold of 014, a delay of 016, and a rate of SLOW. The delay should be set as short as possible, but long enough to never double-count cars that are moving near typical speed. But most importantly, these settings need to be tested to ensure proper counting is occurring. Here's how:

1. Place the meter on the side of the road, and open its cover.

2. Connect the G3 Dock to the meter, and run the cable to the laptop.

3. Start the laptop and start the TRAFx Communicator software.

4. Note the meter Name, Mode, and Battery Voltage. Write them down. A new set of C-cell batteries should provide at least 4.5 volts. The meter will not function properly below 3.0 volts. It is best to use Alkaline batteries, and change them every 6 months, or when they are depleted below 3.3 volts.

5. Press N to enter a name for this meter. You should use the meter's name as shown in VERS.

6. Press “V” to view the current settings. Write them down. (The Period setting is unimportant for metering, but some Projects like to download and view the data produced over time. 001 is a good setting for this.) Most importantly, note the Delay, Threshold and Rate.

7. Press T for Test, and Y for Yes to proceed with current settings and N to not erase existing records. After a few seconds, it will display the current date and time. This indicates it is ready to begin testing.

8. If standing in close proximity to the meter, remain motionless so that keys and cellphones are not detected as moving. Have a colleague drive a vehicle past the meter using a variety of speeds and patterns that visitors might use. TRAFx Communicator will count up once each time it detects a vehicle. If the road is two-way, drive in both directions to confirm.

9. If the meter always counts one time the vehicle drives past in either direction, and you are not detecting traffic on a cross street, you are done. Press ”zzzz” to exit test mode, then L to Launch (start) the meter, Y to keep the settings, and N to not erase existing records. The red light should be flashing rapidly. Note: The meter will not begin counting vehicles again until the start of the next hour, at which point the red light will stop flashing and counting will begin. Consider the time of day when performing meter testing to reduce lost counts.

    a. The meter will not launch if the current date/time is incorrect. Use 2 digits for each, and use military (24 hour) time. Press C to Configure, and enter the date as year-month-day,hour:minute (yy-mm-dd,hr:mn). Enter a time to begin counting. If the time entered is earlier than the top of the next hour, the counting will begin at the top of the next hour. Press enter to keep each of the other settings, then press L to launch.

10. Press S if you need to change the mode. VEH-2s is best for most single-lane (inbound only or outbound only) roads, and VEH-4d is best for most two-way streets or very wide roadways. Be aware that these modes have different Threshold scales.

11. Select C to make changes to the settings of the meter. If the meter sometimes counts more than once when a vehicle passes, you need to extend the delay time. If traffic at this location almost always travels slower than 30MPH, you should set the Rate to SLOW. This will increase both the delay and the battery life. A delay of 016 is a good starting point for most recreation area traffic. You want the delay to be long enough to not double-count vehicles, but short enough to count tailgating cars separately. Only testing can reveal the best delay setting for the meter.

12. Change the Threshold if necessary. The threshold should be as high as possible while still detecting vehicles 100% of the time in both lanes. The higher the threshold, the fewer

false counts will be encountered from passing cell phones, lawn mowers, etc. Also as the radius of the detection zone is reduced, the amount of delay needed to not double-count vehicles is also reduced. For wide 2-lane roads using VEH-4d, 014 is a good starting point. For narrow, 1-lane roads using VEH-2s, 005 is a good starting point. Once again, only through repeated testing can the optimal Threshold setting for a particular layout be known.

13. Change the Rate if necessary. For most recreation area roads, the SLOW setting is best. This doubles the delay, and increases the battery life. However, if traffic travels past this meter at 35MPH or greater, a rate of FAST should be used; otherwise the meter may fail to detect fast-moving vehicles.

In the rare condition where the roadway is too wide to reliably meter traffic in both directions, it will be necessary to "tune down" the meter so that it only counts vehicles in the adjacent lane. To do this, a good setting is to use the VEH-2s mode, increase the threshold (016 is a good starting point) and testing repeatedly. Once you reliably count vehicles in the adjacent lane, and you never count vehicles in the far lane, and you have a good delay setting for single counting, you are done. Remember to indicate in VERS that you are metering traffic in only one direction; otherwise your traffic volumes will be incorrectly calculated.

4.3 Pneumatic Tubes

For decades, pneumatic tubes have been used to detect and count vehicles. They are still used to indicate the arrival of customers at a gas station, and are popular traffic counters for rural areas because they require little power to operate. The air inside a pressurized tube moves when a vehicle runs over it, causing a diaphragm in the detector to trip a switch. Pneumatic tube sensors detect each axle in a vehicle, so they are ineffective in counting a mixture of cars and trucks because some trucks may have up to 5 axles. Conversely, they are unaffected by tailgating, so they work well in areas with dense traffic, as long as the traffic moves fast enough for the detector to reliably sense it (about 5 MPH).

IMPORTANT: Some pneumatic tubes are configured to count axles, while others are intending to count vehicles, by incrementing their count once for every two axles. Some systems, such as the Diamond Traffic Tally 2 and Traffic Tally 77, can be set to work either way. It is important that you test to see how your meter counts vehicles, and capture this information correctly in VERS. When VERS asks you for the "Increment of Count," select 1.0 if your meter counts axles, and 0.5 if your meter increments once for every two axles. Failure to capture this data correctly in VERS will result in an order of magnitude error in your visitation statistics.

Many pneumatic tube meters have adjustments for high speed vs. low speed traffic. This is because the velocity of the air moving through the tube is much greater with high speed traffic. While meters in low speed environments need to be more sensitive, those in high speed environments need to protect against "chatter," where the shock to the diaphragm will cause it to reverberate, resulting in multiple counts. The sensitivity setting aims to electronically mitigate this phenomenon.

In using pneumatic tubes, it is important to ensure that the tubes are affixed to the pavement using a nail or screw. They should also be placed on a straight section of roadway because on curves, individual wheels may be counted rather than axles resulting in abnormally high counts. It is also important to avoid locations where vehicles will typically be slowing or accelerating, because this action can pull, roll or abrade the tube. Pneumatic tubes cannot be used in cold weather climates where snowplows are used, or where puddles develop on the roadway and then freeze. They should also not be used on unpaved roads, or roads with a gravel topcoat, as the tubes will wear quickly and puncture.

Some pneumatic tube counting systems use multiple tubes, and can capture additional information such as speed and direction. The VERS software can accommodate either type of counter. However, due to the seasonal limitations of road tubes, as well as their limited durability and susceptibility to vandalism, these counters are rarely the best choice for any application.

4.3.1 K-Hill 'WEE' Counter

The K-Hill 'WEE' Counter is currently the single most popular traffic meter in the Corps. This compact unit is factory sealed, so it is not recommended that users attempt to change batteries or service the device. It has a lithium battery that is warrantied for 5 years, and has proven to last longer in many instances. It has a 7-digit display that provides the current count, and is available in a low-speed or high-speed unit. Low speed units are more sensitive, because the velocity of air moving through the tube is slower, and are more appropriate for most visitation applications where traffic often travels slowly.

Figure 9 - K-Hill Wee Counter

It is important to note that 'WEE' counters will only increment their count once for every two axles, to it is critical to ensure that in VERS "Increment of Count" is set to 0.5; otherwise your visitation numbers will be processed by VERS according to the setup and will result in a reduction in the traffic volume estimates.

4.3.2 Diamond Traffic Tally 77

Figure 10 - Diamond Traffic Tally 77

The Traffic Tally 77 uses the same cast aluminum housing as Diamond's family of inductive loop meters, but it provides settings appropriate for pneumatic tubes. The Traffic Tally 77 has a toggle switch that enables you to choose axle counting ("Divide by 1") or cars ("Divide by 2"). In VERS, Divide by 1 is equivalent to "Increment of Count=1.0," and Divide by 2 is equivalent to "Increment of Count=0.5". There is no best practice for how to set this switch, but its setting must be properly reflected in VERS. The Traffic Tally 77 also has a sensitivity setting for low speed vs. high speed. Most recreation areas have low-speed roads (less than 30 MPH) It is designed to run on four D-cell batteries, but can use any power source between 4 and 14 Volts DC.

4.3.3 Diamond Traffic Tally 2

The Diamond Traffic Tally 2 is a compact pneumatic tube meter, which requires the use of a magnet to set up the meter and retrieve its data. There is a red dot on the right side of the unit and a yellow dot on the left side which you swipe the magnet over to work through the setup and operation menus. The options include both Divide by 1 or 2 and High or Low speed traffic. Once again, most visitation traffic travels at low speed. The selection of "Divide by 1" or "Divide by 2" is unimportant, so long as what you select is correctly captured in VERS under "Increment of Count". There is also an option to reset the count, which should never be done unless the unit is being redeployed to a new location.

Figure 11 - Diamond Traffic Tally 2

The Traffic Tally 2 has a long-life lithium battery, and Diamond will sell you the gaskets and O-rings needed to change it yourself, if you choose to do so. Since this device is used outdoors and susceptible to moisture, it may be safer to send it back to Diamond when the battery needs to be replaced. Beware of using a different type of counter when the original is sent for battery replacement. It's important to verify that the increment of count is set the same, and recorded correctly in VERS.

Figure 12 - NanoCount Axle Counting System

4.3.4 VehicleCounts NanoCount 1000

The NanoCount 1000 uses a CR2032 battery which only lasts for about 6 months. It is designed to be replaced by the typical user with only a Philips head screwdriver. This meter has adjustments for traffic speed and Divide by 1 or 2. It is housed in an aluminum sleeve with a hole that a long padlock or locking cable can be used to secure it. Because of the short duration of the battery life, this meter is not the best choice for Corps visitation metering because loss of data due to a battery failure is a strong possibility.

4.4 Breakbeams

Breakbeams (sometimes also called photoelectric sensors) are devices that emit a beam of light (visible or invisible), and detect when that beam has been interrupted. They are either two separate devices (an emitter and collector) or a single emitter/collector unit, and a reflector.

While these systems were originally designed as trail meters, it was found that they work quite well in many vehicle metering environments.

Breakbeams are best used in applications where there is little or no entry road into a parking area, and where there is low likelihood that pedestrians or bicycles will cross the beam. These meters are designed to detect the separation between vehicles, even at slow speeds. Breakbeams work best when there is either lane separation (so that one-way traffic is metered) or light traffic, so that traffic moving in the opposite direction simultaneously is rarely missed.

These systems should be mounted so that the beam is about 3 feet above the ground, which is at about fender height for most vehicles. If the meter is installed so the beam is too high, cars with windows down can produce inaccurate counts. If it is too low, the beam may pass completely under some vehicles, which will also result in counting inaccuracies. Also, each component must be mounted to sturdy posts so that there is no movement. Flimsy mounts will result in inaccurate counts, and eventually alignment may be lost, and no counts will be captured. Therefore, meter mounting posts should be at least 6"x6", and reflector posts should be at least 4"x4", and installed at least 2 feet into the ground and embedded in concrete. It is a good idea to use rain visors over the reflectors, because a wet reflector will render the meter temporarily inoperable.

4.4.1 Cuesta Systems RS501

The RS501 was manufactured by Cuesta Systems, mostly in the 1990s. They no longer manufacture new meters, but Alasco Rubber and Plastics Corporation owns the Cuesta name and has the ability to repair malfunctioning units. There are many of these meters currently in operation throughout the Corps.

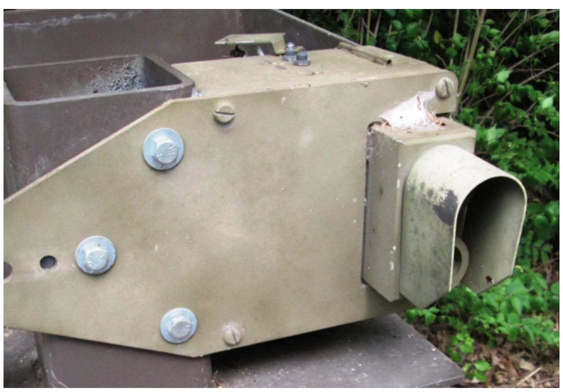


Figure 13 – Cuesta Systems RS501

This meter has the emitter and collector together in a single unit, and requires only a reflector on the opposite side of the roadway. The roadway can be up to 120 feet wide. It operates on 4 C-cell alkaline batteries, which last about 1 year. It has a 6-digit display on the back of the unit. When setting it up, it is important to bolt the breakbeam unit to a sturdy stanchion. Then push the ALIGN button on the top of the meter. A loud chirp will sound. Aim a reflector back toward the unit from the opposite side of the road. When the chirp stops, the reflector is in alignment. Use the chirp to find the center of the beam, then mount a post at this location and after retesting the alignment and confirming proper height, affix the reflector to the post. The meter should work properly. If alignment is ever lost, it is usually easiest to reinstall the reflector post. If the beam is simply too high or low, it should be possible to shim the RS501 by inserting washers on the bolts between the unit and the post.

4.4.2 Diamond Traffic TTC-4420

The TTC-4420 was also conceived as a trail counter but has been shown to work effectively in many vehicle counting applications. It is functionally similar to the Cuesta meter, except that you must use a magnet to program the meter or to read the display (note some Projects reported experiencing meter resets in instances when staff was unfamiliar with using the magnet). Also, it is commercially available and a suitable replacement for Cuesta that cannot be repaired (although housings may need to be modified). It can be used on roadways up to 75 feet wide. It has an optional serial port so that data can be analyzed on an hourly time-slice basis.

Figure 14 - Diamond Traffic TTC-4420

The TTC-4420 uses four D-cell alkaline batteries which should last a year. To install it, mount the unit to a sturdy post at fender height (about 3 feet above the roadway) and the unit will begin to chirp as soon as the batteries are installed. Locating the reflector in the proper location silences the chirp. Install a post at the center of the beam and permanently mount the reflector in the selected location. The display will indicate the beam strength. Alignment of 80% or higher is recommended; otherwise the reflector may need to be reinstalled. Test the meter by driving a vehicle past the meter. The meter will chirp when the car is detected. Properly installed, it should chirp only once per vehicle even with the windows down. The meter will begin normal counting (and stop chirping) in about 20 minutes.

4.5 Infrared Focused Beam

An infrared focused beam is essentially an infrared area sensor that is looking through a narrow aperture so that it operates much like a breakbeam, but requires no reflector or receiver. The infrared (IR) focused beam relies on the natural range limitation of the IR sensor to prevent distant objects from resulting in false alarms. It is effective in detecting both vehicles and people, within a few feet of the sensor. This technology is often used in trail counting applications.

4.5.1 TRAFx Trail Counter

Almost all of the IR focused beam meters currently in use by Army Corps Projects today are the TRAFx Trail Counter. As its name implies, the TRAFx Trail Counter was designed to count people and bicycles on trails. However, USACE testing indicates it is a reliable vehicle counter under certain conditions. It should only be used to count slow moving cars (5-15 MPH) on a single-lane roadway. The range limitation of the TRAFx Trail Counter is about 12-15 feet, so opposite lane traffic may or may not be counted, depending on the heat contrast of the vehicle to the background. Also, it will count people, animals and bicycles that pass in front of it. These limitations render the Trail Counter ineffective in many applications, so it should only be used for single-lane metering where pedestrians and bicycles are rarely encountered.

Figure 15 - TRAFx Trail Counter in a fiberglass housing

The Trail Counter uses an Infrared sensor inside a tube, which must be able to see the traffic. It also uses the same controller card as the TRAFx vehicle counter, so it produces the same time-sliced meter data, which some Projects find beneficial. It may be considered for use in some roadside parking areas, so long as the entry lane does not exceed 15 feet, because the IR beam is only 2-3 feet wide. This makes it able to meter traffic entering a roadside parking lot without being affected by traffic passing on the adjacent roadway.

4.6 Other Meter Types

This Best Practices Guide covers the majority of vehicle meters currently being utilized at Corps Projects. However, this does not cover the full spectrum of vehicle meters that exist in the marketplace, and there may be a few select Projects that have vehicle meters not described in the Guide. Additionally, vehicle meter technologies are rapidly evolving.

If your Project has a vehicle meter not described in this Guide, please follow instructions provided with the device, and direct initial inquiries to the manufacturer.

5. Conclusion

The selection of the best metering system for a particular situation is part science and part art. There are many factors to take into consideration, and it is unusual for a Project to find that one system meets all its metering needs. In general, inductive loops are the most adaptive for differing conditions and require little maintenance, but they are also the most challenging to install. Many Projects are migrating toward TRAFx magnetometers, which are easy to install, but are challenging to configure properly for each situation. Breakbeams and IR focused beams can work in some situations but are not effective where bicycles and pedestrians pass in front of them.

Pneumatic tubes continue to be widely used throughout the Corps, but they are not a good fit in many situations. They should not be used on gravel roads, curved roads or places where there is frequent vandalism or where snow plows are used. Projects that choose to used pneumatic tube meters should expect to have to repair or replace the tubes regularly. These systems also need to be properly registered in VERS so the Increment of Count matches the settings of the meter.

Regardless of the technology selected for metering, it is always a best practice to test the meter periodically to confirm it is counting properly, and to tune it to optimize performance. This testing, along with the collection of data, is most easily accomplished if the meter has a built-in digital display. When purchasing meters, it is a good idea to choose one that has a display to facilitate monthly readings and periodic testing.

Finally, it is important to confirm that each meter is configured properly in VERS. The fields that are most critical are the number of lanes being metered, and the Increment of Count for pneumatic tube systems. Failure to record this information correctly will result in an order of magnitude error in your visitation numbers that will recur month after month. Correctly recording the make and model of each meter is also important, because the Corps is refining load factors that account for how each meter typically counts vehicles with trailers.

Appendix A – Application Matrix

The table below provides ratings for each technology for various meter selection factors. The sections of the report where each technology is discussed in detail are shown in the heading.

	Inductive Loops [Sections 2.1, 3.1, 4.1]	**Magnetometers** [Sections 2.1, 4.2]	**Pneumatic Tubes** [Sections 1.3, 2.1, 3.2, 4.3]	**Breakbeams** [Sections 2.1, 3.3, 4.4]	**Infrared Focused Beams** Sections 2.1, 4.5]
One-way roads (or roads with medians)	🟢	🟢	🟡	🟡	🟢
Two-way roads (no medians)	🟢	🟡	🟡	🟡	🔴
Roadside parking	🟢	🔴	🔴	🟢	🟡
Traffic stops at meter	🟡	🔴	🔴	🟢	🟡
Effect of pedestrians on the accurate counting of vehicles	🟢	🟢	🟡	🔴	🔴
Very wide roadways	🟡	🟡	🟡	🟢	🔴
Curved roadways	🟢	🟢	🔴	🟢	🟢
Dirt or gravel road	🟡	🟢	🔴	🟢	🟢
Slow moving traffic	🟢	🔴	🔴	🟢	🟢
Winter operation	🟢	🟢	🔴	🟡	🟡
Tailgating traffic	🟡	🔴	🟢	🟢	🟡
High speed traffic	🟢	🟢	🟡	🟢	🔴
Vandalism (secure meter housing used)	🟢	🟢	🔴	🟡	🟡
Initial cost (equipment only)	🟡	🟡	🟢	🟡	🟡
Cost or effort to install	🔴	🟢	🟢	🟡	🟡
Effort required to configure and test	🟢	🔴	🟢	🟡	🟢
Cost or effort to maintain	🟢	🟢	🔴	🟡	🟡

Legend:
- 🟢 Good Choice
- 🟡 Can work, but challenges exist
- 🔴 Not a good choice

Appendix B – Manufacturer Index

Manufacturer	Meter Name(s)	Contact Info	Inductive Loops [Sections 2.1, 3.1, 4.1]	Magnetometers [Sections 2.1, 4.2]	Pneumatic Tubes [Sections 1.3, 2.1, 3.2, 4.3]	Breakbeams [Sections 2.1, 3.3, 4.4]	Infrared Focused Beams Sections 2.1, 4.5]
Diamond	Diamond Traffic Tally 2, 14, 21, 41, 51, 77 models; Diamond Traffic TTC-4420	http://diamondtraffic.com	✓		✓	✓	
TRAFx	TRAFx Vehicle Counting System; TRAFx Trail Counter	https://www.trafx.net/		✓			✓
Peek Traffic	JR161, (formerly Streeter-Amet 161 and Streeter-Richardson 161)	http://www.peek-traffic.com	✓		✓		
K-Hill Signal Company	K-Hill BST; K-Hill GMH; K-Hill Wee	http://www.khilltrafficcounters.com	✓		✓		
Alasco Rubber and Plastics Corporation	Cuesta RS-501 (no longer manufactured, but Alasco provides repair services)	http://www.alasco.com				✓	
IRD	Traffic ACE; also reseller of Diamond TTC-4420	www.irdinc.com			✓		
VehicleCounts	NanoCount 1000	http://www.vehiclecounts.com/			✓		