Continuous cycle counting trial

ViaStrada Ltd

January 2009

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Project name:
Status:
Date:</td><td colspan="3">184-2
Continuous Cycle Counting Trial
Final
January 2009</td></tr>
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Summary

The NZ Transport Agency (NZTA) commissioned ViaStrada Ltd to undertake a trial of two types of inductive loop cycle counting equipment. The equipment was evaluated for both off-road and on-road conditions.

The benefits of continuous cycle counting over techniques currently used in New Zealand (such as manual counting or temporary pneumatic tube counting) include being able to establish seasonal trends without having to frequently supervise a site or check and replace equipment. It is considered that continuous cycle counting will be a useful tool in monitoring cycle volumes and trends and therefore planning and designing for cycling.

Two inductive loop devices were examined: ZELT (from France) and Bicycle Recorder (from the UK). The trial was undertaken in Christchurch at one off-road and four on-road sites. Manual counting was used to validate the results and comparisons with pneumatic tubes and existing traffic signal detection systems, known as SCATS loops, were made where possible.

From this research it was concluded that:

1. inductive loop counting equipment is generally easy to purchase and use
2. inductive loop cycle counting equipment can provide cycle counts of reasonable accuracy in mixed traffic – often around 90%
3. the ZELT system is suitable for use in New Zealand to count cycles continuously at both off-road and on-road sites
4. the Bicycle Recorder system is suitable for use in New Zealand to count cycles continuously at off-road sites
5. the accuracy of the Bicycle Recorder was not directly comparable with that of the ZELT in mixed traffic (on-road) due to a lack of product support
6. more on-road testing and calibration of the Bicycle Recorder would be required to confirm its ability to detect cycles in mixed traffic
7. pneumatic tubes and SCATS loops can give counts of similar accuracy to inductive loop products for off-road locations
8. pneumatic tubes are not considered to be as reliable in mixed traffic conditions on roads and SCATS cannot distinguish cycles from motor vehicles
9. other continuous cycle counting technologies, including piezoelectric detector systems, are evolving rapidly and should be assessed for New Zealand conditions
10. working closely with product developers can greatly enhance the outcomes and ensure a detection system appropriate to New Zealand conditions
11. to allow continuous cycle counting to be undertaken in a robust, coordinated and consistent manner throughout New Zealand, cycle counting programmes and appropriate funding mechanisms need to be developed.
12. continuous counting of cycles can be included in road controlling authorities routine traffic monitoring programmes

Table of contents

Glossary

Term	Definition
Aggregation	The representation of a group of individual data as one piece of information.
Bicycle recorder	A type of inductive loop continuous cycle counting equipment manufactured by English company, Counters and Accessories and distributed by Aspect Traffic, Australia.
Bin	A time interval over which data is aggregated.
Bunch	A group of more than two cyclists.
Continuous	Spanning a period of several months at least.
Eco-tubes	Pneumatic tube counters manufactured by French company, Eco-Counter.
Inductive loop	A system using wire loops to detect changes in the electromagnetic inductance occurring when a metallic object (such as a cycle) passes over the loop.
Logger	The component of an inductive loop counting system responsible for storing data.
Manual counter	A person responsible for recording the number of cyclists (and other road or path users) passing through a site during a survey.
MetroCount tubes	A brand of pneumatic tube counters that can be used for short term cycle counting. Manufactured by Australian company, MetroCount.
Mixed traffic	On-road traffic conditions where both cyclists and motorists share the same lane.
Pneumatic tubes	A system that uses rubber tubes to detect changes in air pressure when ridden over by cycles (or vehicles).
SCATS	'Sydney coordinated adaptive traffic system' – the system used for controlling and coordinating traffic signals on many New Zealand road networks.
Site	A specific location where counting equipment is tested.
Survey	The complete duration of testing of a particular type of cycle counting equipment at a specific site which comprises multiple 15-minute tests that may not all follow each other immediately but all utilise the same device settings and loop layout.
Test	An individual 15-minute interval during which cycle counting equipment is operated and compared with manual counts. A survey at a site comprises multiple tests.
Transducer	A sensing device which detects information and reports it to a logger device. Settings related to the sensitivity of detection can be adjusted in the transducer.
Trial	The overall study of different types of counting equipment.
ZELT	A brand of inductive loop continuous cycle counting equipment manufactured by French company, Eco-Counter.

Acknowledgements

We wish to acknowledge the assistance of a number of people with this project.

Several Christchurch City Council employees have provided support, data and knowledge. We are especially grateful to Barry Rawlings and Michael Ferigo for their help with site selection, Bruce Kelly for providing SCATS and volume count data, Bin Sharma for providing pavement data and Romany Sharobim for his help with purchasing the equipment.

Merrett Smith, of Merrettorious Surveys, in addition to undertaking numerous manual counts provided useful observations regarding the behaviour of cyclists and also frequently assisted testing of equipment by cycling through sites.

Peter Gallavin of Traffic Control Systems arranged the installation of all the loops and provided useful, on-going support throughout the trial. Peter also liaised directly with Eco-Counter over technical issues related to the loop specifications.

Alan Street and the team at AgFirst performed the MetroCount surveys and were helpful in explaining their experiences of the installation, limitations and benefits of the equipment.

The staff at Eco-Counter provided a high standard of customer support. Jean-Francois Rheault, our main contact, spent much time answering questions and working with us to improve the ZELT's performance. His availability, especially given the time-difference between New Zealand and France, was impressive. Jean-Claude Dubois, Eco-Counter's development engineer, worked hard to improve the ZELT and adapt it to the New Zealand context.

Finally, we appreciate the dedication of the NZ Transport Agency, especially Tony Lange and Doug Miller, in commissioning and supporting this research. We believe continuous cycle counting is an important activity that should be implemented throughout New Zealand as part of the process in monitoring and achieving the New Zealand Transport Strategy's objectives and targets for sustainable transport.

Introduction

Cycle counting in New Zealand is currently performed predominantly through manual counts and devices that use pneumatic rubber tubes. Manual counts can be accurate (but are subject to human error) and can provide additional information on user characteristics and behaviour. Manual counts are limited to about two hours continuous duration for one person. Pneumatic tubes can provide continuous counts for up to a week or two at a time. Because of a greater need for longer-term data to aid funding, prioritisation, design and monitoring, the ability to count cycles continuously is becoming more important in New Zealand.

In June 2007 the NZTA (then Land Transport New Zealand) commissioned ViaStrada Ltd to undertake an international literature review of technologies for counting cycle traffic continuously (the report is available at: www.ltsa.govt.nz/sustainable-transport/cycle-counting-in-nz/2.html). 'Continuous' was taken to mean periods of several months or more, thus including permanent count sites. The research also included a survey of all local and regional councils and Transit New Zealand offices (now part of the NZTA) about their experience with various types of cycle traffic counting, including continuous, automatic and manual counts.

The technologies reviewed for continuous cycle counting claimed a range of abilities and limitations. In addition to simply counting the presence of cycles, many of the technologies can record other information, such as the direction of travel, speed and even position of cycles. Some can distinguish between bicycles and motor vehicles and thus can be used in mixed traffic situations; others can distinguish between cyclists and pedestrians and thus are appropriate for shared use, off-road paths where the numbers of pedestrians are also required.

From this literature review, inductive loop technology appeared to be the best for counting both on-road and off-road cycle traffic. This was based on an overall assessment that considered the ability of different devices to distinguish direction, speed and position; ability to count pedestrians as well; ability to count on- and off-road; ability to distinguish between cycles and motor vehicles; conspicuousness; and quoted accuracies. Two products were found to be readily available, albeit from overseas suppliers – these were Counters and Accessories' Bicycle Recorder (supplied via their Australian representative, Aspect Traffic) and Eco-Counter's ZELT.

The survey of NZ agencies illustrated a high degree of interest in cycle counting among road controlling authorities and regional councils and suggested, as two thirds of the respondents have cycle projects in their forward works programmes, investigating cycle counting methods would be a valuable exercise.

The international review in 2007 made the following recommendations:

- The Bicycle Recorder and the ZELT counters should be acquired to ascertain their ease of use (including data downloads) and reliability through a pilot study.
- Counts should be done with both counters simultaneously in a variety of locations, ideally in Christchurch, including both off-road and on-road. The counters should be calibrated against existing loop detectors where feasible and manual counts.
- A report should be prepared summarising the findings and recommending a counter or counters for use in New Zealand for continuous cycle counting, in both off-road and on-road situations.

These recommendations were accepted and following the submission of a pilot study trial proposal (of the two inductive loop counting systems) the NZTA then commissioned ViaStrada to undertake the trial in Christchurch.

The objectives of the trial were as follows:

- Determine the availability, costs and ease of installation/use of the two induction loop counters.
- Determine the accuracy of the induction loop counters (validation by manual counting).
- Compare the induction loop counters with current pneumatic tube technology.
- Compare the induction loop counters with current SCATS loop technology.

- Determine any limitations with the two induction loop counters.
- Document the trial outcomes and present findings/recommendations in a report.
- Consider any other continuous cycle counting trials being undertaken in New Zealand and Australia and incorporate available results in the report.

The majority of testing was carried out in June 2008. Testing of the equipment during winter resulted in cycle volumes lower than desirable; however it is considered that the samples are large enough for the results to be valid.

The trial methodology and results are detailed in this report along with recommendations in relation to use and limitations of the counting equipment.

It should be noted that this study was undertaken when previous research indicated that inductive loops were the most suitable technology for counting cycles in mixed traffic. However, other counting technologies are likely to evolve over time and may prove to be equally reliable and accurate. For example, piezoelectric counters have been developed by a number of manufacturers and offer similar advantages to inductive loops, such as being below ground. If these devices are able to distinguish between cycles and motor vehicles they could be another option for counting in the mixed traffic environment.

1. Inductive loop detectors

Cycle counting in New Zealand is currently performed through manual counts, which cannot span long, continuous periods, or through the use of rubber pneumatic tubes, which can provide continuous counts for up to a week or two at a time but are not durable enough to withstand traffic wear and tear for long periods. A practical advantage of loop systems over other counting technologies is that the loops themselves are hidden below the pavement surface and recorders can generally be housed in secure cabinets. This means that inductive loops are more durable than conventional rubber tubes, which gives them the ability to provide continuous count data over months or years at a time. The nature of the loops also makes them less likely to affect the behaviour of road users and limits the opportunity for vandalism.

Inductive loops operate by detecting an electromagnetic change that occurs when a piece of metal passes the loop. Inductive loop detectors are already used extensively in New Zealand for detecting motor vehicles so that the Sydney Coordinated Adaptive Traffic System (SCATS) can control signal timings. The Christchurch City Council (CCC) can obtain cycle traffic information from SCATS inductive loops where shared use pedestrian and cycle paths have signalised road crossings.

The CCC has also experimented with SCATS inductive loops to detect cyclists crossing in large signalised road intersections so that the amber phase could be extended to allow cyclists to cross safely. However, the results of the trial were unsatisfactory. The major problem encountered was that the loops did not distinguish between cycles and motor vehicles and often the phase would be extended by a motor vehicle turning left or progressing through the intersection at the end of the amber phase. This significantly decreased the efficiency of the intersection. CCC also found it difficult to specify the optimum position of the loop as cyclists did not always ride in the same alignment through the intersection.

The ZELT and Bicycle Recorder systems use specialised algorithms and loop layouts to detect bicycles based on the electromagnetic signals experienced by the inductive loops when a cycle passes over them. SCATS, on the other hand, does not make any distinction between vehicle types based on the electromagnetic signal pattern or strength but detects only when a change occurs. SCATS can be used to determine direction of cyclists. For example, Christchurch's railway cycleway uses SCATS loops to detect cyclists approaching the crossings and verify their direction and call the crossing phase when appropriate. Cyclists leaving the crossing do not call the phase.

However, given that SCATS is a tool developed primarily for motor vehicle detection purposes and that motor vehicles travel in lanes with specified directions of travel, SCATS is also not currently configured to record information on cyclists travelling in a specific direction. It may be possible to adapt existing SCATS loops to count cycles, but this would require further research and development of new algorithms.

A limitation of inductive loop technologies is that they rely on metal and will therefore not always detect cycles made from non-metallic materials such as carbon-fibre. While the use of carbon-fibre cycles is an increasing trend which may affect how reliable inductive loop counting may be in the future, this issue is not yet sufficiently significant that inductive loops should not be used. Most counters claim an accuracy of about ± 5%, so a small proportion of carbon-fibre cycles would not introduce excessive errors. As many carbon fibre bicycles often have metal spokes and the ZELT and Bicycle Recorder detect the electromagnetic signature of bicycle wheels they will still detect some carbon fibre bicycles.

Inductive loops do not detect pedestrians, which is a useful property if only cyclist volumes are required, but can make inductive loops less useful for projects where a combination of cyclists and pedestrians are to be counted. It is important to understand where cyclists will travel in order to properly place the loops and gain accurate counts.

1.1 Bicycle recorder inductive loop system

The Bicycle Recorder manufactured by Counters and Accessories (in England) is an inductive loop detector used for counting cycle lane traffic. It is currently in use at four exclusive cycle lane sites in South Australia and has had a high success rate at three of these locations. The location that does not achieve accurate results has a high proportion of heavy motor vehicles that drive in the cycle lane. When tested by the South Australian road controlling authority, the equipment did not record shopping trolleys, prams or other metal objects.

Counters and Accessories claimed a 95% accuracy of a study where they had chosen the site; no additional information (for example the sample size and method of analysis) was available regarding this study.

The Bicycle Recorder is powered by four 1.5 volt (D size) batteries and the loop can have a width of 1.25 – 2.50 m. An advanced model, the bike rack can be powered by mains or solar power and can be fitted with a global system for mobile communications (GSM) modem which allows remote data download.

1.2 ZELT inductive loop system

The ZELT inductive loop sensor system, schematically illustrated in Figure 1, is manufactured by Eco-Counter (in France) and claims to be able to detect the characteristic electro-magnetic signature of bicycles and distinguish them from motor vehicles. The French Government Transportation Research Lab found a +/-5% accuracy for the ZELT when used in mixed-traffic situations. In a study conducted by the research lab, 91% of bicycles (156 out of 171) were correctly detected, 6% of motorcycles (7 out of 120) were incorrectly classified as bicycles and no other motor vehicles were classified as bicycles.

Figure 1: Eco-Counter's ZELT inductive loops

ZELT claims its counter can work for a lane width of up to 3 m. The logger runs on two 3.6 volt batteries which have a lifetime of one year and are cheap to replace (or can be recharged). There is no remote download option available for the ZELT in New Zealand yet, although the option is available in Europe and Eco-Counter is exploring the possibilities for provision in New Zealand.

1.3 Equipment specifications and installation details

1.3.1 Bicycle recorder

Availability and technical support

The Bicycle Recorder equipment was purchased from Aspect Traffic, the Australian representative for English manufacturer, Counters and Accessories.

The technical support provided by Aspect Traffic includes a design drawing for the loop configuration and recommendations on site selection. Aspect Traffic did not require detailed information on individual sites during the selection process and stated that the Bicycle Recorder is a very basic system that should be easy to install without specialist advice. Aspect Traffic cited that they have a help desk that operates 24 hours a day, 7 days a week to handle any problems that may arise during installation or testing.

The Bicycle Recorder sensor and logging unit plus cables comes with a two year warranty and costs approximately $5,000, including shipping but not batteries.

Equipment components

The Bicycle Recorder, as illustrated in Figure 2, consists of four main components:

- A sensor and logging unit, which processes and records the data and from which the data are downloaded.
- A battery pack, which supplies power to the logging unit.
- A download cable, which is attached to a computer to retrieve the data.
- A loop connector; which joins the loops to the logging unit.

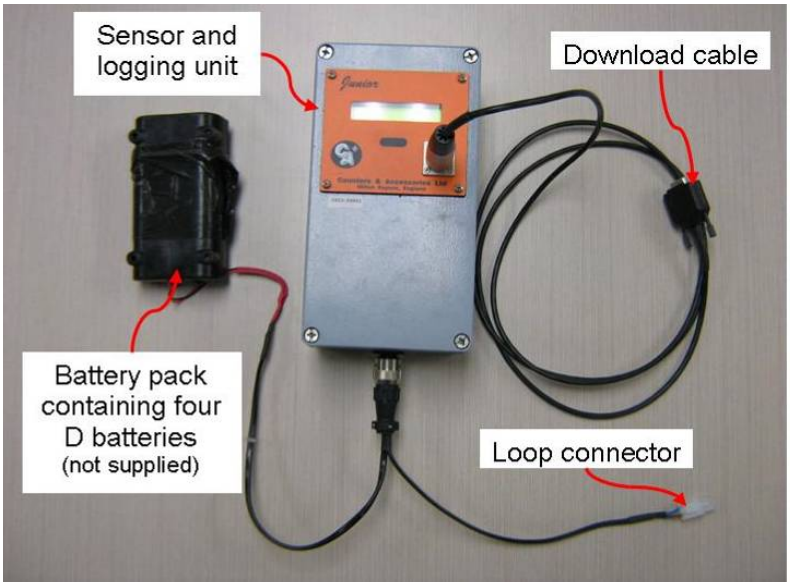


Figure 2: Bicycle recorder components

There are four switches that can be adjusted within the recorder. These are located within the recorder casing and to access them the casing must be taken apart by removing four screws. The switches, shown in Figure 3, are configured as follows:

- Switch 1 (brown) –distinguishes between a loop installed on the road surface (down) or loop that is buried below the ground (up).

- Switch 2 (red) –selects the suppression mode if mains interference is present (down).
- Switch 3 (orange) – distinguishes between the "cars and bikes" mode (down) or the 'bikes only' mode (up).
- Switch 4 (yellow) – distinguishes the speed of bikes - up to 25 km/h (down) or over 25 km/h (up).

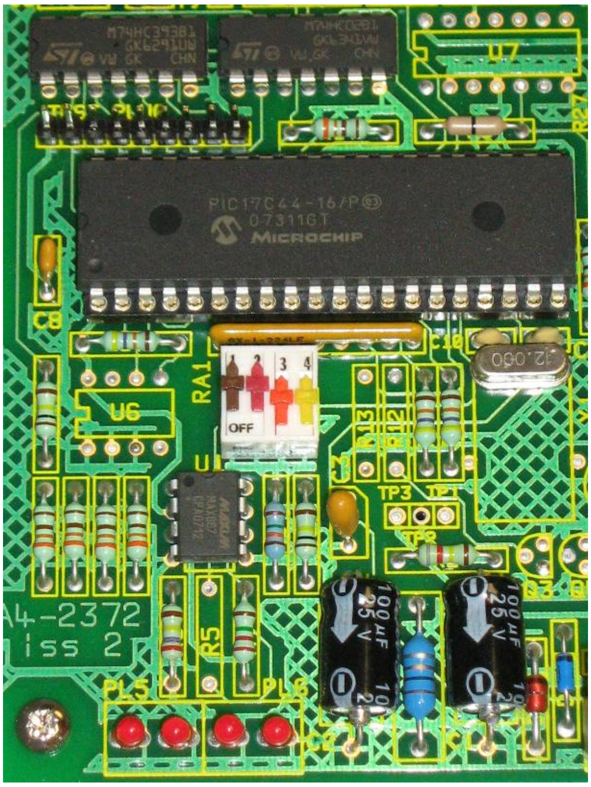


Figure 3: Switch configuration in the Bicycle Recorder

It was expected that when the 'cars and bikes' mode was selected (by turning switch 3 to the down position) that two channels of data, one for cars and one for cycles, would be included in the output. This was consistent with the information supplied in the Bicycle Recorder manual and suggestions made by the suppliers. However, the output only ever included one channel of data and no explanation of this was available.

Data, software, download method and calibration

Data come in speed bin format with a 1, 5, 15, 30 or 60 minute bin capability, ie the equipment aggregates data rather than recording each cyclist passing by with a unique time-stamp (as occurs with MetroCount rubber tube counters). The system can hold 8150 bins of data; this equates to about 85 days worth of data if set to a 15 minute bin size. Data are downloaded from the Bicycle Recorder by connecting a cable between the recorder and a computer which has the appropriate software installed. CollectXP, the software that facilitates download, is available on Counters and Accessories' website. The software Vehicle Data Analyser Pro can then be used to analyse the data.

The manufacturers stated that calibration is performed within the system and should not be required from users.

Installation and loop configuration

Aspect Traffic verified that the equipment can be installed by regular contractors who install SCATS loops. The South Australian users also install the loops themselves rather than employ Aspect Traffic to do so. The same wire used for SCATS loops can be used for the Bicycle Recorder loops. Four turns of the wire are required to form each loop. Traffic Control Systems (TCS) was chosen to carry out the installations for the Christchurch trials.

As can be seen in Figure 4 the loop is trapezoidal in shape. The loop can be a maximum of 2.5 metres wide (W), the shortest side is always 1 metre, the longest side (L) is related to the width so that a 45 degree angle is maintained.

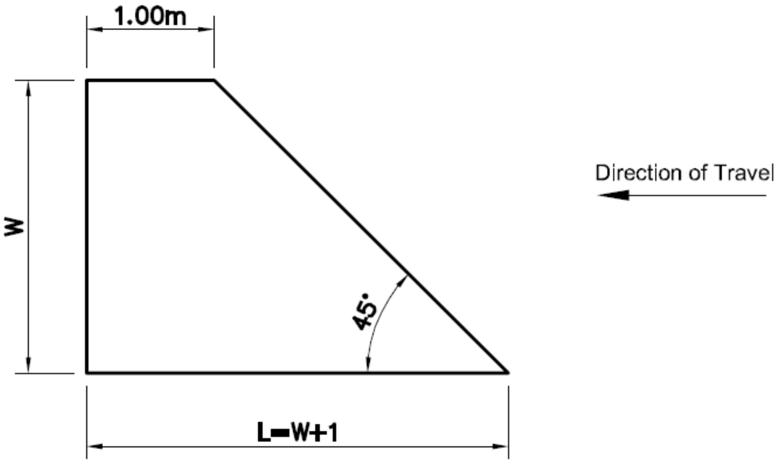


Figure 4: Bicycle recorder loop configuration

For uni-directional (ie on-road) situations the longest edge (L) is positioned adjacent to the kerb so that the cyclist crosses the sloped edge first, as shown in Figure 4. For count locations with bi-directional cycle travel (ie generally off-road locations) it is not important which way the loop is configured and counting will occur in both directions.

Counters and Accessories manufacture a Haldo pillar (shown in Figure 5) which can be used to store the Bicycle Recorder adjacent to the count site. Alternatively, any waterproof housing can be used. For the trial, the recorder was supervised at all times so did not require housing.

Figure 5: Haldo pillar for Bicycle Recorder storage

1.3.2 ZELT

Availability and technical support

The ZELT equipment was purchased directly from the French manufacturer, Eco-Counter. At present, Eco-Counter does not have any representatives in New Zealand, although they are currently developing relationships with potential suppliers.

The technical support provided by Eco-counter included pre-installation site selection advice. This step is the most important as, if sites are selected appropriately and the equipment is matched to the site, it is likely that the system will work well. This step was undertaken as part of the site selection process. An Eco-Counter project manager was in NZ for an unrelated business matter shortly after the arrival of the equipment and took this opportunity to visit two of the trial sites with ViaStrada to clarify loop layouts, installation processes and answer general questions about the product.

Once the equipment was installed, Eco-counter provided support with software use and worked with ViaStrada to improve the accuracy of the counters by adjusting sensitivity levels.

Two loggers were purchased, the Eco-Twin for off-road sites with travel in both directions and the Eco-Pilot for on-road sites with travel in only one direction. Figure 6 shows these two loggers.

Figure 6: The ZELT Eco-pilot (left) and Eco-twin (right) recorders

The ZELT equipment comes with a two-year warranty. Any faulty equipment that requires replacement or repairs must be sent back to France. Each logger/transducer/battery set cost approximately $5,000, including shipping. Different loggers are needed for off-road and on-road situations.

Equipment components

The ZELT system, illustrated in Figure 7, consists of:

- a logger, which displays count information and from which data are downloaded
- a transducer, which is the “brains” of the operation and contains information regarding the sensitivity settings to be used
- a battery pack
- loop connectors, which connect the logger to the loop(s).

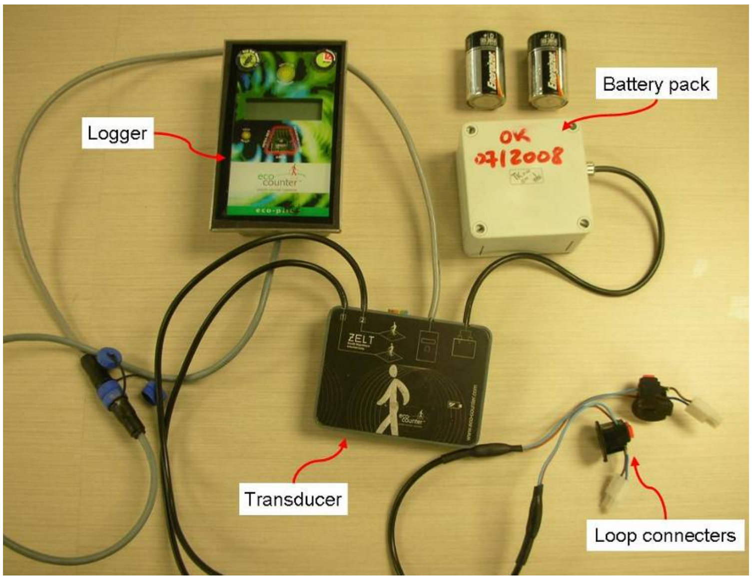


Figure 7: ZELT eco-twin components

Data, software, download method and calibration

The ZELT data are also aggregated and come in bins of 15 minute minimum duration. The logger also includes a real-time display of the total count and hence, by watching the display, individual cycles can be verified. This is useful as a calibration process. The counts are not available as individual, time-stamped data. Eco-Counter chose to develop the ZELT this way because recording time-stamped data requires greater storage capacity and higher battery consumption. Eco-Counter have identified that it would be possible for them to develop a version of the ZELT that runs off mains power and provides individual, time-stamped records but feel that the majority of their customers would a prefer battery operated product and would find 15 minute bins adequate for their analysis purposes.

The storage limit of the data logger is 21 months. Data are downloaded via infra-red capability by holding a pocket PC, on which the Eco-counter software (EcoPC) is installed, approximately 30 mm from the counter, as shown in Figure 8 .

Figure 8: The ZELT download method

No remote download option is available yet for New Zealand, although GSM download is available in France and Eco-Counter plan on having a similar system developed for New Zealand and Australia. Eco-Counter currently has customers using a variety of their products, mainly beam counters, in Australia and New Zealand. They are also working on a satellite version for remote locations such as national parks.

The ZELT equipment is waterproof so can be accommodated in any type of housing, or left exposed. A minimum storage space of 300 x 300 x 200 mm is needed. Eco-Counter do not manufacture housings specific to the ZELT. During the trial the counter was supervised at all times so did not require housing.

If calibration is performed it involves adjusting the sensitivity settings of the ZELT (to a level suggested by Eco-Counter) using a pocket PC.

Installation and loop configuration

Eco-Counter verified that a local contractor experienced in installing inductive loops was able to install the ZELT. Traffic Control Systems was chosen to carry out the installations for the trials. The same type of loop wires as currently used for SCATS loops can be used for the ZELT so extra loops do not need to be purchased directly from Eco-Counter. Eight turns of the wire are required for each loop (nine if the loop width is reduced below 1.1 metres). The shape of the loop is shown in Figure 9.

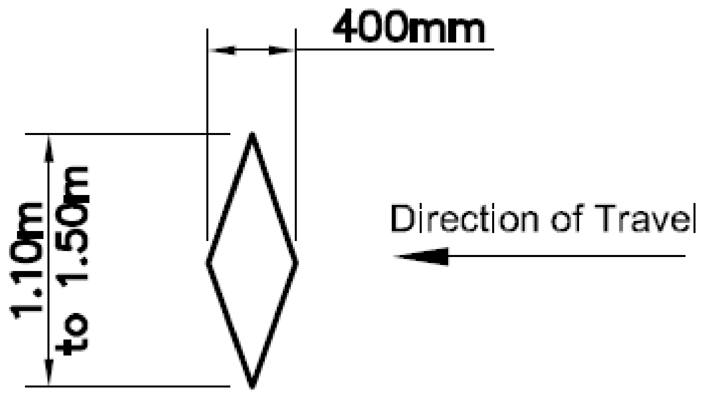


Figure 9: ZELT loop configuration

The diamond-shaped loops are positioned so that the long axis of the diamond is perpendicular to the direction of cyclists' travel. For this reason, loops should not be positioned on curves or at locations where several cyclist trajectories are likely. Loops must be at least 4 m from any other electrical equipment such as traffic signals or other inductive loops, to avoid interference.

Eco-Counter also supplied a 'white box' and test loop which were used prior to loop installation to test for electrical interference at the site (eg due to high voltage power lines). This equipment, being used for testing electrical interference at the railway cycleway site, is illustrated in Figure 10.

Figure 10: ZELT test loop and white box

As mentioned earlier, different ZELT systems are used for off-road and on-road locations. This is due to the various types of difficulties experienced in each situation. For off-road locations motor vehicles are not present but it is likely that groups of cyclists may ride over the detectors at one time. For an off-road path where direction of travel is important and two sets of loops are required, the spacing between these two sets of loops must also be at least 4 m. The layout is shown in Figure 11.

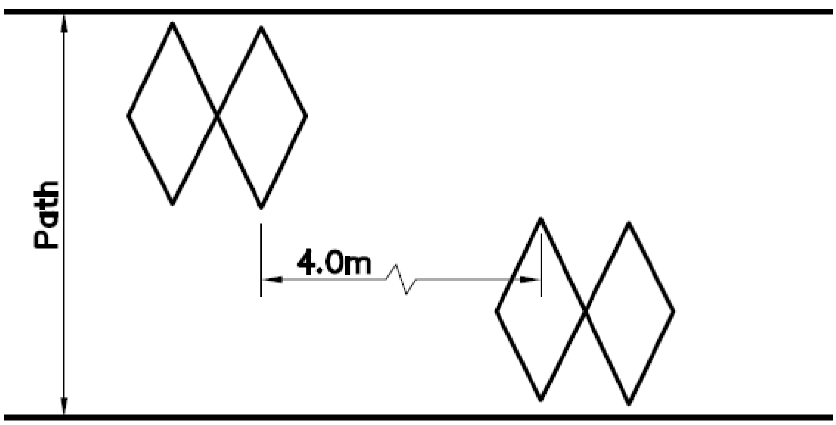


Figure 11: ZELT off-road configuration

For on-road locations it is likely that cyclists will ride in single-file and the most likely source of error is that a motor vehicle will be mistaken as a bicycle. Thus on-road systems aim to distinguish between single cycles and all other traffic but do not detect cyclists riding in groups, while off-road systems apply less stringent rules to determine what kind of object is activating the system and so are more likely to detect two cyclists riding side by side.

2. Trial of inductive loops

This section describes the trial sites and methodology used, including the installation, validation and the analysis methods. The trial was originally planned for summer but several factors prevented this from occurring and the majority of the testing was performed during winter, when cycle volumes tend to decline. This was unfortunate but it is considered that the trial results are not significantly compromised because of the winter testing. For some surveys cycle numbers were boosted by cyclists tasked with riding over the loops repeatedly. Using cyclists who were aware of the survey purpose also had the benefit of being able to direct cyclists where to ride on the loops or at what speed for testing purposes.

2.1 Trial sites

The sites for the trial were selected in conjunction with the Christchurch City Council (CCC). A list of 16 potential sites was presented by CCC staff to the ViaStrada team as a starting point for consideration. These were chosen on the basis that continuous counting would be considered for these sites if the technology was available and successful. Subsequent discussions with the CCC then allowed the list to be reduced to five sites.

A map of Christchurch showing the five site locations is included in Appendix 1.

The sites represent a variety of situations where cycle counting would be likely to be undertaken by a road controlling authority. They cover on-road / off-road situations, different speed environments and differing lane configurations. The sites also include a range of surface types (chip seal, emulsion mix and asphalt). The testing at each of the on-road sites was undertaken on one side of the road only.

The table below summarises the locations and site characteristics:

Site	Section of road	Off-road or on-road	Road type	Speed limit	Cycle lane	Gradient	Road/path surface	Road environment comments
Site 1 Railway cycleway	Between Matai St and Fendalton Rd	Off	NA	NA	NA	Flat	Asphalt	Wide off-road path, SCATS loops for comparison
Site 2 Riccarton Road	Between Straven Rd and Mona Vale Rd	On	Arterial	50	No	Flat	Asphalt	High cycle volumes, limited separation
Site 3 Main Road	Causeway at McCormacks Bay	On	Arterial	50	Yes	Flat	Asphalt	Cycle lane, good separation
Site 4 Sparks Road	Between Hendersons Rd and Halswell Rd	On	Arterial	80	No	Flat	Chipseal	Narrow shoulder, high speed
Site 5 Dyers Pass Road	Between the Takahe and Kiwi signs (both sides)	On	Arterial	50	No	Downhill	Emulsion mix	Steep gradient and high cycle speeds, narrow shoulder

Table 1: Site summary

The following factors were considered when determining the best location to install the loops at each site:

- Safety and comfort of site for manual count staff – isolation from traffic lane, shade, amenities;
- Safe location for induction loop installation contractor to work;
- Ability to be positioned so that all cyclists passing through the site cross the loop(s); and

- Enables the limitations of equipment to be assessed.

A more detailed discussion on each site follows. Site plans are included in appendix 2.

2.1.1 Site 1: Railway cycleway (near Fendalton Road)

This cycleway is an off-road facility adjacent to a railway line and is popular with both cyclists and pedestrians in Christchurch. The path is used extensively by school children cycling in the area, mainly riding in groups. The site was located close to Fendalton Road, where a signalised midblock crossing enables path users to cross the high volume arterial road safely.

SCATS loops in the path detect cyclists heading towards the traffic signals and trigger the cycle crossing phase, from both the south and north approaches. SCATS can store cycle volumes but it is not known how accurate SCATS is at counting cycles; this is one reason why this path was chosen for the trial. MetroCount rubber tube counters were installed for comparison with the loop results. An Eco-Counter selective pneumatic tube counter (referred to hereafter as eco-tubes) was lent to ViaStrada; this was installed halfway through the testing at this site to allow comparison of the inductive loops with another pneumatic tube product.

Manual counts were performed to validate the equipment counts; this process is described in detail later on in the report. At the railway cycleway pedestrians and prams were recorded by the manual counter to test the ability of the different equipment to distinguish these users from cyclists.

The loops were installed in the path on the northern approach to the midblock crossing signals at Fendalton Road and covered the entire path width. The Bicycle Recorder was configured as per f and is illustrated in f. The ZELT loop configuration was as per Figure 11 and is illustrated in Figure 13.

Figure 12: Bicycle recorder loop on the railway cycleway

Figure 13: ZELT loop and eco-tubes on the railway cycleway

The railway cycleway site was examined first as its off-road nature meant that reinstallation of loops would not disturb motorised traffic if initial testing suggested the loops needed repositioning. The path surface consists of 15-25 mm of asphalt; this caused an issue for the ZELT loop installation as nine turns of the inductive wire were required due to the width of the loop (less than 1.1 metres). Essentially, a deep, narrow saw cut was not possible due to the base course material falling into the cut, accentuated by a 'wet cut' process. The solution to this was cutting a wider slot for the wire loops and using a filler material that dried quickly and provided a bond between the asphalt either side of the cut. The depth requirements of both loop types were therefore not achieved, however given this path does not have motorised traffic loadings this was not considered detrimental to the loops' functioning ability.

The site plan for the railway cycleway installations is shown in appendix 2.1.

2.1.2 Site 2: Riccarton Road (between Straven Road and Mona Vale Road)

Riccarton Road is a busy arterial road with approximately 26,000 motor vehicles per day in the vicinity of the site and also services several bus routes. There are no cycle lanes on Riccarton Road in the vicinity of the site. However, there are high cycle volumes especially during the peak times. Figure 14 and Figure 15 illustrate the site.

Figure 14: Riccarton Road trial site facing east (Bicycle Recorder in use)

Figure 15: Riccarton Road site facing west towards ZELT loop

The location of the trial was just east of Picton Ave, on the south side of the road adjacent to a road narrowing. This location was selected as it does not have kerbside parking and therefore cyclists are contained within a reasonably defined space. In addition, the site provides shade for the manual counter and good access for the installation contractor.

The ZELT loop configuration required two diamond loops, each 1.1 m wide and 100 mm apart, as detailed in Figure 16. The Bicycle Recorder loop was 2.3 metres wide, ensuring the same transverse coverage as the ZELT.

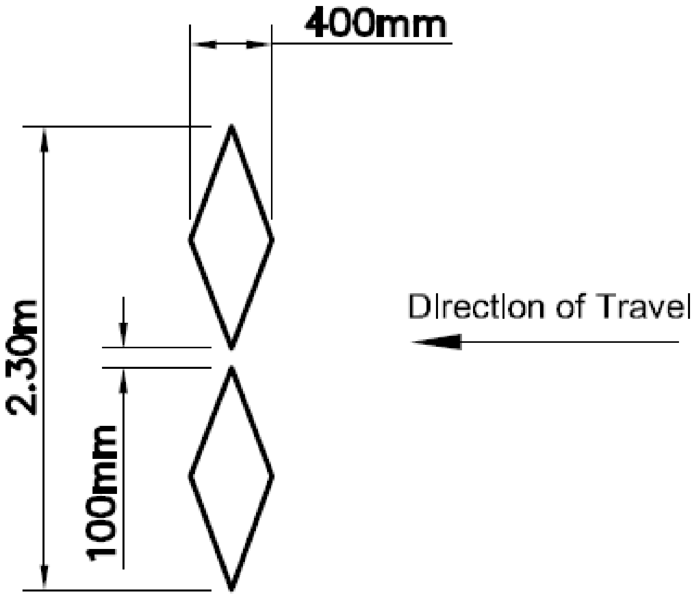


Figure 16: ZELT loop layout for Riccarton Road, Dyers Pass Road and Sparks Road

The road is surfaced with asphalt (at least 80 mm thick) at this location and no issues with installation were encountered.

Motor vehicles travelled over the loops at this and other on-road sites, allowing testing of the counters' abilities to distinguish between cycles and other vehicles. The ZELT counter initially counted approximately 10% of motor vehicles passing over the loops. This was reported to the supplier and a number of measures were undertaken to address this. Eventually the number of motor vehicles detected was reduced to effectively zero. This is discussed in more detail in the results section.

The site plan for the Riccarton Road installations is shown in appendix 2.2.

2.1.3 Site 3: Main Road (causeway at McCormacks Bay)

Main Road is an arterial road with high motor traffic volumes (approximately 19,000 motor vehicles per day) and was considered by CCC staff to have high cycle volumes. It has 1.5 m wide (measured from the kerb face) cycle lanes on each side of the road. The speed limit is 50 km/h however the mean operating speed is closer to 60 km/h. The cyclists who use the site are both commuters and recreational cyclists. Some of the cyclists using the site travel in groups and therefore form bunches (more than two cyclists).

The test location was on the south side of the road, adjacent to a reserve allowing easy access by the installation contractor, as illustrated in Figure 17. This location also provided a safe manual counting position. The ZELT loop configuration only needed one 1.5 metre wide diamond and the Bicycle Recorder loop was also 1.5 metres wide. The loops extended across the entire cycle lane and 200 mm into the motor vehicle lane, as shown in Figure 18.

Figure 17: Main Road trial site

Figure 18: ZELT loop on Main Road

The road is surfaced with asphalt (at least 50 mm deep) at this location; and no issues with installation were encountered.

A tube counter was installed for comparison, however, this did not extend as far into the carriageway as the loops. The tube installer was not willing to extend the tubes further as exposure of the cycle tubes to motor vehicles reduces their life span significantly and it was considered likely that the tubes would break and therefore not collect count data. This is discussed further in the results section of the report.

The site plan for the Main Road installations is shown in appendix 2.3.

2.1.4 Site 4: Sparks Road (between Hendersons Road and Halswell Road)

Sparks Road is an arterial road with a speed limit of 80 km/h and a traffic volume of 11,000 motor vehicles per day. There are no cycle lanes so cyclists generally use the narrow, 1.0 metre wide, shoulders on each side of the road. Both commuting cyclists and recreational cyclists use the site. It was observed that bunches of cyclists extend beyond the shoulder into the carriageway; because of this the loops were extended into the carriageway.

The ZELT and Bicycle Recorder loop configurations were as per Riccarton Road (see Figure 16).

The chipseal surface on Sparks Road was found to be less than 10 mm thick, and thus is too thin for the ZELT loop which required eight turns of the wire and 20 mm cover due to the traffic loading. The solution used at the off-road site was not appropriate as Sparks Road is subject to high traffic volumes and heavy vehicles. It was considered too risky to create a wide saw cut in the chipseal and hope that the filler material would hold the sections of seal together. To allow the appropriate installation depth a 60 mm deep asphalt pad was installed, as seen in Figure 19. The Bicycle Recorder loop was installed successfully in the chipseal, as shown in Figure 20, but did not have a great depth of cover.

Figure 19: Sparks Road trial site – ZELT loops

Figure 20: Sparks Road trial site –Bicycle Recorder loop

The site plan for the Sparks Road installations is shown in appendix 2.4.

2.1.5 Site 5: Dyers Pass Road (between the Sign of the Takahe and Sign of the Kiwi)

The Dyers Pass Road site, illustrated in Figure 21, is located beyond the urban area of the city and is used heavily by recreational cyclists to access the Summit Road on the Port Hills and the harbour roads. It is an arterial road with a speed limit of 70 km/h and average annual daily volumes of approximately 3000 motor vehicles. Cyclists coming down the hill can reach speeds of up to 60 km/h. The shoulder width varies but is generally narrow and motor vehicles are required to slow down when following cyclists uphill if there is oncoming traffic.

The location used for the trial was near a bend with a pull-off area that allowed space for the installation contractor to work from. There are also safe positions for the manual counter. The loops were installed on the downhill side to test the influence of speed on the loops' counting abilities.

Figure 21: Dyers Pass Road –trial location (looking south and uphill)

The ZELT and Bicycle Recorder loop configurations were as per Riccarton Road but they were extended across the traffic lane to near the centreline as some cyclists will use the lane. The ZELT loop is illustrated in Figure 22.

Figure 22: ZELT loops at Dyers Pass Road site

The road is surfaced with emulsion mix over chipseal (at least 30 mm deep) at this location; therefore no issues with installation were encountered. The site plan for the Dyers Pass Road installations is shown in appendix 2.5.

2.2 Trial methodology

2.2.1 Installation of loops and trial sequence

The exact layout of the loops at each site was determined in conjunction with the manufacturers' recommendations and detailed observation of the cycle travel path. The first step in the loop installation process was to ensure there was no electrical interference that could affect the induction loops. The ZELT system relies on a 'test white box' for this purpose, the Bicycle Recorder did not come with any specific equipment for this purpose. If there had been any interference detected the location would have been reviewed; as it happened no sites experienced inference issues. The two loop systems also required at least 4.0 m separation to ensure no interference with each other.

Installation at site 1 (the railway cycleway) was undertaken first to ensure there were no issues with loop positioning. As this site is off-road and bi-directional, two sets of ZELT loops were required (see Figure 11). A site visit with the Eco-Counter Project Manager, Jean-Francois Rheault, allowed confirmation of the layout. The Bicycle Recorder loop was a 2.5 m wide trapezoidal loop positioned 4 m from the ZELT setup.

The inductive loops also needed to be 4 m from the current SCATS loops; this meant that the loops for the three systems were spread over 20 metres. This was not considered to be an issue as cyclists could not leave the path at any point over this distance. As the SCATS loops only cover half the path width, cones were used to channel the cyclists over the loops so that they could also be used for cycle counting.

The results from the first site were analysed and it was concluded that the loop layouts were acceptable. The installation at site 2 (Riccarton Road) was then undertaken.

As discussed earlier, surveys at site 2 found that the ZELT counter was also detecting motor vehicles; this issue was eventually resolved. The Bicycle Recorder was found to be undercounting at this site but limited guidance was available to resolve this. Further trials were undertaken at site 2, despite the outstanding issues with the Bicycle Recorder. These are discussed in full in section 4.

The next site to be tested was site 3 (Main Road). The Bicycle Recorder continued to undercount despite repeated attempts to resolve the issue. The ZELT system began to undercount the bicycles so further discussion with the supplier was required. The sensitivity was adjusted with some success and short tests were undertaken to determine the effect of bicycle speed and position on the loop. This is discussed in full in section 4.74

The remaining two sites were tested over a weekend period as the weekday commuter volu/*mes had reduced due to the winter conditions.

The installation of the loops cost, on average, $1200 per site, including temporary traffic management.

2.2.2 Validation process

Validation of the inductive loop and pneumatic tube counts was undertaken by comparison with manual counts of cyclists. As well as recording the time of each cyclist, the manual counter also noted whether any cyclists passed through the site without riding over the loops (which would suggest the positioning of the loops was poorly chosen) and any motor vehicles, motorised scooters, pedestrians or prams that travelled over the loops (to identify whether any non-cyclists were counted by the loops).

The manual counting was performed by Merrett Smith of Merrettorious Surveys. Merrett has counted bicycle traffic for many years for the CCC and was the main manual counter employed by ViaStrada for a project concerned with the validation of rubber tube counters on the Little River Rail Trail carried out between October 2007 and March 2008.

Due to the lack of permanent recorder housings at the sites, the recorders were only used at the sites during the periods of manual counting. It was considered that loop counts outside the times of manual counting would not be of any use as the manual counts were required for verification of the loop counts.

Comparison with MetroCount's pneumatic tubes was made at all the sites except for the Riccarton Road site (due to logistical difficulties of coordinating the MetroCount installers, inductive loop installers and manual count staff). However, as detailed previously, there were some discrepancies between the coverage of the different equipment as the MetroCount tubes could not be installed as far into the path of motor traffic as the inductive loops. At the railway cycleway comparison with existing SCATS loops as well as the Eco tubes supplied by Eco-Counter was made.

As the smallest bin size that can be achieved by the ZELT is 15 minutes and the two types of equipment were required to be tested according to the same criteria, the Bicycle Recorder was also set to record with 15 minute bins. The ability of the ZELT to update the count displayed each time a cyclist is recorded (as opposed to the Bicycle Recorder which simply displays the count obtained during the most recent bin) allowed the manual counter to verify exactly which cyclists were counted by the ZELT and therefore make more accurate observations regarding the limitations and abilities of the ZELT.

In order to explore the abilities of the Bicycle Recorder, some of the Bicycle Recorder data were gathered in 1 minute bins and then aggregated into 15 minute bins, this was done using Microsoft Excel as the software used for downloading and examining the Bicycle Recorder did not have the ability to change bin sizes once data had been collected. This process was somewhat awkward and it is considered that the software could be significantly improved by allowing aggregation of bins after data collection. Although the ZELT did not have the ability to record with one minute bins its software was able to aggregate data into bins of greater length after collection.

The periods of testing are outlined in Table 2 below. These periods were chosen to reflect time when the cycle volumes were considered at their peak.

Site	Location	Manual count day (initial surveys)	Manual count period	Manual count times	Tube counter comparison	SCATS comparison
1	Railway cycleway	3 weekdays (4 count sessions)	1.5-2 hours	4pm-5.30pm 8am-9.30am 2.30pm-4.30pm 8am-9am	YES	YES
2	Riccarton Road	2 weekdays	2 hours	4pm-6pm	NO	NO
3	Main Road causeway	1 weekend session	2 hours	1pm-3pm	YES	NO
4	Sparks Road	1 weekend session	1.5 hours	10am-11.30am	YES	NO
5	Dyers Pass Road downhill	1 weekend session	3 hours	1pm-4pm	YES	NO

Table 2: Initial survey periods

2.2.3 MetroCount data adjustments

The MetroCount software was found to be not as well suited to the requirements of the analysis process as the software for the ZELT and Bicycle Recorder. In addition to this, the classification systems available for MetroCount have been shown previously to be inaccurate for cycle counting projects. For these reasons, the MetroCount data required several adjustments before they could be used in the analysis. The process used in adjusting the MetroCount data is detailed in appendix 3.

2.3 Analysis method

2.3.1 Disaggregated measures

As previously mentioned, the ideal way to assess the accuracy of a cycle counter is to gauge, for each cycle passing the site whether this cycle was recorded accurately by the equipment. This would take the form presented in equation 1:

$$CBA_e = \frac{C*_s}{M_s}$$

Equation 1: Cycle-based accuracy

Where: CBA_e = cycle-based accuracy of equipment e

$C*_s$ = total number of cycles counted correctly by equipment e during survey s

M_s = number of cycles counted manually during survey s

Possible types of error for the cycle-based accuracy of a piece of cycle counting equipment include when the equipment fails to count (i.e. "misses") a cycle or if it double-counts a cycle. These errors could also be presented as proportions of the total number of cycles actually involved in the survey by replacing C* in equation 1 with the error type.

Human error may also be a factor in the analysis methods as it relies on manual counting for verification and data input and analysis. This will be a factor in all the measures presented in this report as manual counting is considered to be the most accurate method of counting cycles, even if it is not fool-proof. It is accepted that some level of human error will occur but all steps have been taken to ensure the reliability of the manual counters and data analysts employed in this research.

Another sort of error that may occur is that motor vehicles may also be detected and incorrectly classified as a cycle. As this error would not be included in the cycle-based accuracy measure, another measure would be to assess the accuracy of the detection. This is presented in equation 2:

$$DBA_e = \frac{C*_s}{D_s}$$

Equation 2: Detection-based accuracy

Where: DBA_e = detection-based accuracy of equipment e

$C*_s$ = total number of cycles counted correctly by equipment e during survey s

D_s = number of cycles claimed to be detected by equipment e during survey s

The two accuracy measures presented may cause confusion if used together and it is therefore preferable to quote only one.

It is considered that the cycle-based accuracy measure is probably more similar to the general understanding of accuracy and is therefore favoured over the detection-based accuracy.

In order to account for the number of motor vehicles detected as cycles it would be advisable to also quote the percentage of motor vehicles passing through the site that were incorrectly classified as cycles, as detailed in equation 3:

$$VDR_e = \frac{x_s}{V_s}$$

Equation 3: Vehicle detection rate

Where: VDR_e = accuracy of equipment e

x_s = number of motor vehicles incorrectly classified as cycles by equipment e during survey s

V_s = total number of motor vehicles passing through site during survey s

2.3.2 Aggregated measures

It is common in statistics to compare aggregated properties of samples, such as means and standard deviations; this results in the total count comparison measure detailed in equation 4, where the total number of cycles recorded by the equipment are compared with the total number of cycles counted manually over the entire survey duration.

$$TCC_e = \frac{C_s}{M_s}$$

Equation 4: Total count comparison

Where: TCC_e = total count comparison for equipment e

C_s = total number of counts recorded by equipment e during survey

M_s = number of cycles counted manually during survey

However while the total count comparison is the most simple statistical test available it is not appropriate in this situation. Aggregating the number of cycles counted over long periods (ie the whole study period) could significantly mar the results, especially if under-counts and over-counts are of similar sizes and balance each other out.

Thus, because of the level of aggregation used, the total count comparison measure does not give a very useful assessment of the equipment's ability and, unless it can be proven by more thorough analysis that equipment is extremely accurate (or has consistent inaccuracies that can be accounted for), this measure should not be used.

Another statistical approach is to consider a series of tests. The outcome of each test is termed either 'success' (where the result is what was predicted/desired) or 'failure' (where the actual and predicted/desired results differ). The overall performance of this approach comes from combining the results of individual tests.

For the purposes of this analysis, each 15 minute interval (the lowest possible level of aggregation common to both sets of inductive loop equipment) was considered to be a test and therefore each survey (taken as the entire validation period) comprised of multiple tests over several days, at a given site.

Manual counts were compared with the equipment's results to determine successes and failures. Two types of failure were possible – under-counting and over-counting. Under-counting occurred when a cycle was recorded by the manual counter during the test period but was not recorded by the equipment. Over-counting occurred for example when any object other than a cycle was counted or one cycle was counted as two. Success occurred only when the total number of cycles counted by a piece of equipment for a test was equal to the total number of cycles recorded by the manual counter for the same test. The overall accuracy of the equipment depends on the number of successful tests (if a piece of equipment fails some tests it does not mean that the equipment itself is a 'failure'). It was anticipated that all counters would experience some failed tests as none of the manufacturers claimed 100% accuracy.

This approach results in the success rate measure detailed in

Equation 5, defined as the proportion of successful tests to total tests for each type of equipment at each site.

$$SR_e = \frac{\sum_{t=1}^{T} S_t}{T}$$

Equation 5: Success rate

Where: SR_e = success rate for equipment e

T = number of tests

t = t^{th} test

S_t = success index (a dummy variable for test t where S_t = 1 if test t was successful, S_t = 0 if test t failed).

It is acknowledged that, in the same way under-counting and over-counting could balance each other out and give a total count comparison value that seems favourable but is actually very inaccurate, the success rate measure may also be affected. However, this effect is reduced in the success rate measure compared with the total count comparison measure because of its lower level of aggregation – there is a lower chance that over or under counting will occur in a 15 minute sample than a sample several hours long. The only way to completely avoid this effect would be to analyse the data at the level of each individual cycle passing through the site, which is impossible given the recording limitations of the equipments which record cycles in bins of data rather than as individual events. (As detailed previously, the ZELT could be assessed at a level of individual cyclists by observing the counter display while the test is taking place; the Bicycle Recorder, however, does not have this ability).

As part of the analysis process, it was debated whether or not tests occurring during a survey where no cycles were present should be included in the analysis. On one hand, it may be seen as skewing the data, given that a test where no cycles were present should be successful and would therefore improve the success rate without actually testing the equipment. On the other hand, it is possible that over-counting can occur due to pedestrians, buggies or motor vehicles and therefore the equipment was still being tested even when there were no cycles present during a test. Survey periods were chosen during peak cycling times to maximise the chance of cyclists being present, so the proportion of tests with zero cyclists during a survey period was reasonably low. Taking all these factors into account, it was decided to include tests where no cyclists were present in the analysis.

For each test, the number of over-counts and under-counts were calculated; these values were summed for each survey. The difference between over-counts and under-counts for a survey was generally not equal to the difference between the total number of cycles counted by the equipment and the manual counter. This illustrates the phenomenon of under-counts countering over-counts and confirms the appropriateness of examining individual tests rather than total counts.

The correct cycles index (equation 6) was developed as an attempt to give more weight to the number of cycles correctly counted by the equipment, rather than considering individual tests, over which was a great range in cycle volumes. The premise for this was that whether a test was successful or not would be more critical depending on the number of cycles present during that test. For example, equipment that correctly counted 49 out of 50 cyclists in a test is obviously more accurate than equipment that correctly counted 1 out of 2 cyclists in a test, but both tests would be deemed as failures under the success rate method.

$$CCI_e = \frac{\sum_{t=1}^{T}(C_t - O_t - U_t)}{\sum_{t=1}^{T} M_t}$$

Equation 6: Correct cycles index

Where: CCI_e = correct cycle index for equipment e

C_t = number of cycles counted by equipment e for test t

O_t = number of over-counts by equipment e for test t

U_t = number of under-counts by equipment e for test t

M_t = number of cycles counted manually for test t

While it cannot be known exactly how many cycles were correctly counted during a test (due to the aggregation of the data) it was assumed that in each test a certain amount of cycles were counted correctly; if the equipment under-counted during a test then it was assumed that the number of cycles counted by the equipment was correct, if the equipment over–counted for a test it was assumed that the number of cycles counted by the manual counter was correctly counted by the equipment.

However, this method favoured equipment that tended to over-count, as although the equipment had inaccurate tests (where the number of cycles counted by the equipment was greater than the manual count) it was assumed that all the cycles counted manually had been counted by the equipment. Thus it was possible for a piece of equipment to be highly inaccurate and yet get a perfect score by this measure.

It was therefore decided that the correct cycles index should not be used and a similar measure, the error adjusted index (equation 7) was developed instead.

$$EAI_e = \frac{\sum_{t=1}^{T}(M_t - O_t - U_t)}{\sum_{t=1}^{T} M_t}$$

Equation 7: Error adjusted index

Where: EAI_e = error adjusted index for equipment e

M_t = number of cycles counted manually for test t

O_t = number of over-counts by equipment e for test t

U_t = number of under-counts by equipment e for test t

This measure attempted to better the previous one by subtracting the errors made by a piece of equipment from the actual total counted manually. The downside of this was that, in some cases where the number of over-counts was greater than the actual number of cyclists, this could result in a negative index for a test. While this measure still didn't give a completely accurate analysis of the actual number of cycles correctly counted it was considered that it gave a more appropriate estimate of the accuracy of the equipment.

3. Trial results

This section discusses the results of the trials specific to each site. For many of the sites, the trial process required a series of surveys with intermediate modifications made to the equipment settings and loop layouts before conclusive results were obtained. This section presents the final results. Intermediate results and more details of the trial process are contained in appendix 4 to appendix 7.

3.1 Railway cycleway

One survey was conducted was conducted on the railway cycleway during peak periods on Wednesday 16 and Thursday 17 April 2008 (remember that 'survey' refers to a collection of 15 minute bins that were not necessarily conducted immediately after each other but all involved the same device settings and loop layout). The Eco-Tubes were only operational for the latter part of the survey, due to initial installation problems. **Error! Reference source not found.** presents the summary data for the four types of counting equipment for the direction towards Fendalton Road according to the measures discussed in section 2.3, **Error! Reference source not found.** presents the summary data for the direction away from Fendalton Road and **Error! Reference source not found.** presents the summary data for the SCATS detections for both directions.

	ZELT	BR	Eco tubes	Metro tubes
Manual count	269	269	137	269
Number of 'cycles detected'	269	262	137	239
Total count comparison	100%	99%	103%	89%
Number of 15 min tests	26	26	14	26
Success rate	31%	42%	36%	35%
Error adjusted index	88%	87%	88%	81%
Total over counts	16	14	10	10
Total under counts	16	21	6	40

Table 3: Railway cycleway survey results 16/17 April 08 (direction: towards Fendalton Road)

	ZELT	BR	Eco tubes	Metro tubes
Manual count	178	178	111	178
Number of 'cycles detected'	222	161	110	152
Total count comparison	126%	91%	99%	86%
Number of 15 min tests	26	26	14	26
Success rate	42%	42%	57%	50%
Error adjusted index	74%	85%	94%	82%
Total over counts	46	6	3	4
Total under counts	0	21	4	28

Table 4: Railway cycleway survey results 16/17 April 2008 (direction away from Fendalton Road)

	SCATS
Manual count	447
Number of 'cycles detected'	432
Total count comparison	97%
Number of 15 min tests	26
Success rate	23%
Error adjusted index	88%
Total over counts	20
Total under counts	33

Table 5: Railway cycleway SCATS survey results 16/17 April 08 (combined directions

According to the total count comparison measure, each of the different types of counting equipment appeared to be highly accurate in both directions. However, the success rate and error adjusted index values suggested otherwise. This highlights the dangers of using aggregated measures for statistical analysis.

The success rates were higher for the direction away from Fendalton Road than for the direction towards Fendalton Road for the ZELT, Eco tubes and MetroCount tubes; for the Bicycle Recorder the success rates were equal for both directions. The difference in success rates of the different directions may be related to the fact that the two directions had significantly different sample sizes. The ZELT had the lowest success rate; the Bicycle Recorder performed the best for the direction towards Fendalton Road and the Eco tubes performed the best for the opposite direction (and had the best success rate overall).

The error adjusted index, which attempts to deduce whether each individual cycle was counted correctly, gave much higher results than the success rate (as expected, given the properties of the two measures). According to this measure, the ZELT and Eco tubes performed the best for the direction towards Fendalton Road and the MetroCount Tubes performed the worst. In the opposite direction the Eco tubes performed the best (again this was also the best result overall) and the ZELT was the least successful.

The Eco tubes had the lowest rates of over- and under-counting. The ZELT had equal numbers of each for the first direction, hence its perfect score according to the total count comparison measure. However, for the opposite direction, the ZELT had a very high rate of over-counting. The Bicycle Recorder and MetroCount tubes were each more prone to under-counting.

Given the poor success rates it was difficult to determine any relationship between occurrences of cyclists in groups, pedestrians, push-chairs, carbon-fibre cycles or other unusual events and the miscounts of the equipment. The manual counter observed that cyclists occasionally rode in such a way that they either missed both sets of ZELT loops or rode over both sets, either because they were avoiding pedestrians or swerving for fun. Eco-Counter have since reviewed the loop layout for bi-directional paths and are likely to re-configure the loops for full coverage of a path, this will overcome any issues of cycles missing the loops entirely or riding over two adjacent loops.

SCATS was not able to supply information on the direction of cyclists so the combined counts for both directions were analysed and were therefore not directly comparable with the results of the directional counters. SCATS had a lower success rate than all the other counters. This may in part be due to the location of the SCATS loops – they were located on the left side of the path and, although cones were positioned to encourage cyclists to ride over the loops, several cyclists were noted to miss the loops.

SCATS does not use algorithms to distinguish cycles from other metallic objects; thus it was expected that SCATS would be less accurate than the other inductive loop counters. The undercounts exhibited by SCATS are expected to be due to two or more cyclists riding close together and being registered as only one period of change in inductance and therefore counted as only one cycle. The over-counts exhibited by SCATS are expected to be due to other metallic objects such as push-chairs, scooters and skateboards etc.

Discussions with the CCC engineer responsible for SCATS revealed that he is not aware of SCATS being used to store directional counts but that it may be possible to do so. Given that the two SCATS loops are used to determine direction (and hence whether or not the crossing phase should be called) it should simply be a matter of storing this information that has already been extracted. Subsequently, a change in algorithm would be required to use SCATS as a directional cycle counter.

Overall, it appears that the Eco tubes were the most successful equipment for the off-road cycle counting on the railway cycleway. The inductive loop counters did not prove themselves to be more accurate than the MetroCount tubes. The two inductive loop counters generally achieved similar results but the Bicycle Recorder appears to be slightly better as it was the most consistent across the two directions. However, subsequent on-road trialling led to modifications made to the ZELT algorithms (as discussed in the following section) which are likely to improve the accuracy of the off-road ZELT counters as well.

3.2 Riccarton Road

Riccarton Road was the first on-road site to be examined. The first survey (detailed in appendix 4.1) identified that mixed traffic presented a challenge in terms of detecting only cycles with the inductive loops. A total of six surveys were required at this site to achieve results that gave confidence that inductive loops can count cycles effectively. These trials predominantly focused on the ZELT product as Eco-Counter worked actively with the researchers to overcome the issues influencing the count results. As previously mentioned, the Riccarton Road trial did not involve MetroCount tubes.

During the first survey the ZELT consistently over-counted and the Bicycle Recorder consistently under-counted. The Bicycle Recorder achieved one successful test and had a slightly better error adjusted index. The ZELT was observed to count several motor vehicles, which explains the high over-counting rate.

The two channels of data expected from the Bicycle Recorder when set to 'cars and bikes' mode were not given (only one channel, presumably relating to cycles, was available). Guidance on why this occurred, or how to rectify it, was not provided.

Under the guidance of Eco-Counter, the sensitivity of the ZELT was adjusted in an attempt to eliminate the detection of motor vehicles. This did not prove to be an adequate solution and so Eco-Counter supplied a new transducer as a further attempt. A second survey was undertaken with the new transducer, the results of which are detailed appendix 4.2. It was intended to also adjust the Bicycle Recorder and use it in this second survey but, due to a lack of guidance on the use of the recorder settings the Bicycle Recorder was not available for this survey. This meant that the Bicycle Recorder was not directly comparable with the ZELT as the ZELT was given more opportunity (in terms of calibration and testing) than the Bicycle Recorder. However, the suppliers of the Bicycle Recorder were given the same opportunities as the ZELT suppliers to improve the product and provide support, which means that the customer service aspects of the testing were directly comparable between the two types of equipment.

The ZELT performed better with the replacement transducer, with significant improvements to its success rate and error adjusted index. Results for the third survey are given in appendix 4.3. The ZELT vastly over-counted in the first Riccarton Road survey. However, it under-counted in the second survey but to a lesser extent. This indicates that there is a fine balance between the two sensitivity levels used. As the results were still not providing the level accuracy expected, a further survey was planned to determine any variables that were causing issues (ie speed, position on the loop, bike type, groups).

In the third survey, the counter display on the ZELT was used to determine its accuracy. This gave the lowest level of aggregation possible as each cycle passing the site was analysed individually (except in the case where a group of cyclists passed the loops and some of the cyclists were counted but it was not always clear as to which ones). The third survey was an hour long with three cyclists employed to frequently ride past the loops in order to boost cycle volumes. Additional information regarding the cyclists' position on the loops, travel speed and type of cycle (ie whether it was a road bike or a mountain bike) and whether or not the cyclists were part of a group was recorded.

It was found that there was no variable that had a significant effect on the success of the ZELT. In general, cyclists travelling by themselves were more likely to be counted than those travelling in a group. Cyclists travelling at slower speeds (ie less than 27 km/h) were more likely to be counted, as are those travelling between the two loops.

During the third survey further testing of the Bicycle Recorder was also undertaken using one-minute bins to achieve the lowest possible level of aggregation. This involved two hours of data (the first hour corresponded to the ZELT individual comparison survey outlined previously). Three settings combinations for the Bicycle Recorder's switches were examined; firstly the recommended setting for this mixed traffic site and then two random variations in lieu of any guidance. None of the three settings used were particularly successful.

It was decided at this point to abandon the Bicycle Recorder from further testing at Riccarton Road, as no guidance was available regarding any possible modifications that could be made. Further guidance from Eco-Counter was provided and led to a fourth survey where the sensitivity setting was adjusted. Results are detailed in appendix 4.4. During this fourth survey the ZELT significantly over-counted, which indicated that the distinguishing cycles from motor vehicles was still an issue.

At this point, Eco-Counter decided that the loop configuration could be at fault and (at their own expense) installed another set of loops. The revised layout can be seen on the site plan in appendix 2.2 and is summarised in Figure 23. Essentially, the loops were each widened to 1.3 m and the distance between the m reduced from 100 mm to approximately 60 mm. The distance between the two loops can affect the number of cyclists that are double counted (if the two loops are too close together it is too easy for them both to detect the same cyclist) and the number of cyclists that are not detected at all (if the loops are too far apart cyclists riding between them may not be detected by either).

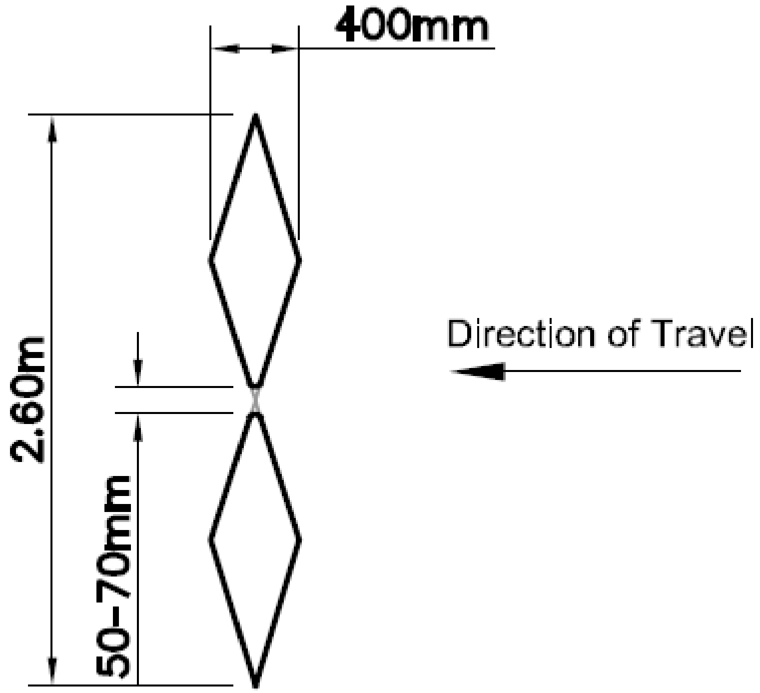


Figure 23: Revised ZELT loop layout on Riccarton Road

The fifth survey was similar to that of the third whereby the counter display on the ZELT was used to determine its accuracy and any variables that were causing the problem. The results are detailed in appendix 4.5.

As the results of the fifth survey still did not achieve the accuracy Eco-Counter expected of the equipment they sent an engineer to New Zealand to investigate the issues further. After observations and testing at the four on-road sites, the Eco-Counter engineer's conclusions were:

- cyclists in New Zealand often travel at speeds greater than 27 km/h
- New Zealand has a lower proportion of mopeds in traffic than Europe

- New Zealand has a higher proportion of four-wheel drive motor vehicles in traffic than Europe. Four-wheel-drive motor vehicles have high ground clearance, making them difficult for loop detectors to identify
- some of the trial sites have many groups of cyclists present
- the motor vehicles incorrectly counted as cycles during the surveys were generally buses, trucks, four-wheel drives, vans or low vehicles, although some 'normal' cars were also counted.

Given an understanding of the composition of New Zealand traffic and the actual speeds travelled by cyclists, the Eco-Counter engineer was able to adjust the ZELT algorithm parameters to include cycle speeds of up to 40 km/h and also to reduce the number of motor vehicles being detected. Following the adjustments, a final survey was conducted, the results of which are shown in Table 6. Note that these results are disaggregated. It was intended that the aggregated results would also be presented to allow comparison with the aggregated results of the initial surveys. However, it was found that the manual records for this survey did not accurately record the occurrence of the start of every 15 minute bin, so it was not possible to aggregate the results.

	ZELT
Manual count	142
Number of 'cycles' detected	145
Cycle-based accuracy	88.0%
Cycles double counted	4.2%
Cycles missed	7.7%
Number of motor vehicles counted	8
Approx. vehicle volume during test	1300
Proportion of motor vehicles generating false counts	0.6%

Table 6: Riccarton Road final ZELT survey results

As shown in Table 6, the final adjustments made to the ZELT algorithms, resulted in an accuracy of 88%, which was more in line with the expectations of Eco-Counter. The number of motor vehicles detected was significantly reduced in this final survey, with less than 1% of motor vehicles being detected.

It should be noted that these results (and those of the final tests for all the on-road sites) come from testing performed in conjunction with the Eco-Counter engineer's final verifications. As for some of the previous surveys, this process involved using test cyclists to ride past the loops. Sometimes these test cyclists were directed by the engineer regarding where to ride and at what speed, in order to test the limits previously identified. This means that the final survey was probably more demanding on the ZELT than if it were exposed to 'normal' conditions counting cyclists who were unaware of the trial and were cycling according to their own decisions rather than directions to test the equipment. Thus, the results presented are probably conservative estimates and it is reasonable to assume that the ZELT may have an even better accuracy than quoted in Table 6.

Eco-Counter have expressed plans to further improve the ZELT settings to suit the New Zealand traffic environment.

3.3 Main Road

Two surveys were undertaken at Main Road, as well as some supplementary tests and observations. The first survey involved three types of counting equipment (ZELT, Bicycle Recorder and MetroCount tubes); the results of this are shown in appendix 5.1.

During the first survey (which was undertaken prior to the subsequent surveys on Riccarton Road) none of the equipment was particularly successful. The Bicycle Recorder and MetroCount tubes did not achieve any successful tests. All three of the equipment types consistently under-counted cycles. The manual counter confirmed that many motor vehicles drove over the loops / tubes but it appeared that the ZELT did not count any of these; based on the bin volumes it appeared that the same was true of the Bicycle Recorder.

The manual counter also observed many bunches of cyclists; it was not expected that any of the equipment types would count these accurately. Neither the ZELT nor the Bicycle Recorder claim to be able to count bunches at on-road locations due to the difficulty of distinguishing groups of cyclists from motor vehicles. It was observed in the Little River Rail Trail project that the MetroCount is also unable to accurately detect bunches of cyclists.

The ZELT achieved the best scores for the total count comparison, success rate and error adjusted index of the three equipment types, however its results were still far from the 95% accuracy levels expected.

Following the investigations and subsequent modifications at Riccarton Road, a second survey of the ZELT only was undertaken at Main Road using the adjusted transducer. The results are shown in Table 7:

	ZELT
Manual count	80
Number of 'cycles' detected	72
Cycle-based accuracy	88.8%
Cycles double counted	0
Cycles missed	10.0%
Number of motor vehicles counted	1

Table 7 Main Road final ZELT survey results

The total number of motor vehicles passing through the site was not counted at the time of the survey, but counts taken for a similar day previously indicate that, during the time of 7:30-9:00 am approximately 1300 motor vehicles would have passed through the site in the westbound direction. This equates to a proportion of motor vehicles generating false counts of less than 0.1%.

3.4 Sparks Road

Three types of counting equipment were tested at the Sparks Road site. The first survey comprised a total of only 12 cycles, which was not enough to gain statistical confidence but was considered useful in assessing limitations. The results are shown in appendix 6.1.

Again the ZELT tended to over-count and the Bicycle Recorder tended to under-count. The two inductive loop counters achieved the same (somewhat low) success rate but the Bicycle Recorder had a higher error adjusted index. The MetroCount tubes were, however, the most accurate of the three types of equipment. Given the small sample size of this survey these results should be considered with caution.

A second survey (of the ZELT only) was held during the visit of the Eco-Counter engineer using the adjusted transducer. The results of this survey are shown in Table 8:

	ZELT
Manual count	41
Number of 'cycles' detected	43
Cycle-based accuracy	90.2%
Cycles double counted	0.0%
Cycles missed	9.7%
Number of motor vehicles counted	2
Approx. vehicle volume during test	500
Proportion of motor vehicles generating false counts	0.4%

Table 8: Sparks Road final ZELT survey results

It should be noted that the sample size for the final Sparks Road survey was again very low. However, the 90% accuracy presented in Table 8 indicates that the accuracy of the ZELT was vastly improved for the conditions at the Sparks Road site.

3.5 Dyers Pass Road

Three types of counting equipment were tested at the Dyers Pass Road site; the survey comprised a total of 49 cycles and the results are shown in appendix 7.1.

The Bicycle Recorder consistently under-counted, it is assumed that this was due to the high speeds of cyclists at the downhill site. The ZELT again tended to over-count (although not to the same degree as the Bicycle Recorder's under-counting). The ZELT achieved the highest error adjusted index and was therefore the most successful piece of equipment at this site, but it should be noted that the MetroCount tubes achieved a similar index.

As for the other on-road sites, a final survey of the ZELT was conducted at Dyers Pass Road, in conjunction with the visit of Eco-Counter's engineer, using the new transducer and improved settings. Again, no further assistance was provided for the Bicycle Recorder and so it was abandoned from further testing and is therefore not directly comparable with the ZELT from an accuracy perspective. The results for the final survey are presented in Table 9:

	ZELT
Manual count	37
Number of 'cycles' detected	38
Cycle-based accuracy	75.7%
Cycles double counted	0.0%
Cycles missed	24.3%
Number of motor vehicles counted	1
Approx. vehicle volume during test	120
Proportion of motor vehicles generating false counts	0.8%

Table 9: Dyer Pass Road final ZELT survey results

The final survey at the Dyers Pass road site yielded the lowest accuracy of all the sites, however it should be noted that the low sample size (only 37 cycles) does not allow much confidence in the result. Also, as for the other sites, the limits of the ZELT were tested as much as possible and the steepness of the Dyers Pass Road site allowed for extremely high and low speeds to be tested. Generally the cycles that were not counted were road cycles travelling at very high speeds (as these cyclists were not test cyclists their exact speeds were not known, but it was estimated that they were travelling well in excess of 40 km/h). It was also determined that cyclists travelling at speeds of 4 km/h or slower would not be detected (at this speed it was very difficult for the test cyclist to ride, either uphill or downhill, without falling off so it was considered that this lower limit would not limit the ZELT's application). This test led to the recommendation that, if sites with steep gradients are required, the ZELT should be used on the uphill direction. The only vehicle detected was a motorbike.

3.6 Summary of trial results

Table 10 below summarises the results of the trial. It shows the best results achieved for each inductive loop device. The results were not necessarily achieved during the same test, but are the best from a range of tests. It is noted that the ZELT participated in more tests and therefore had more opportunity to achieve a higher accuracy than the Bicycle Recorder.

	Railway path (2 directions)	Riccarton Road	Main Road	Sparks Road	Dyers Pass Road
ZELT	75% and 88%	88%	89%	90%	76%
Bicycle recorder	85% and 87%	47%	36%	50%	10%

Table 10: Summary of the results (best result achieved for each inductive loop device)

4. Trial discussions

4.1 ZELT

The ZELT initially experienced both under-counting and over-counting errors (depending on the sensitivity setting) at on-road sites. However, due to the continued support from Eco-Counter, these were essentially overcome. The final set of surveys at on-road sites (while being wary of those surveys that had varying sample sizes) indicated that the ZELT can achieve an accuracy of around 90% for on-road cycle counting, with less than 1% of motor vehicles being detected. The nature of the testing, which involved test cyclists directed to ride in ways known to be close to the limits of the ZELT, while not the most scientifically rigorous approach, offers greater confidence in the ZELT's ability.

The accuracy achieved by the ZELT at the off-road site was around 80%, but this differed significantly between the two directions of travel. It is considered that, with a loop configuration that encompasses the entire width of the path and adjustments to the speed threshold, future updates of the ZELT will achieve a higher accuracy at off-road sites.

The ZELT loops require eight to nine turns of the detector wire and on busy roads need around 20 mm cover. This is likely to be an issue on chipseal roads in New Zealand, as was found on Sparks Road where an asphalt pad was required. This issue should not preclude the use of ZELT but does add further cost to the installation phase.

Eco-Counter are continually developing the ZELT product in terms of its ability to detect cycles accurately, its software capabilities, its download system and remote access option (which is already available in some countries). Remote access of count stations throughout New Zealand would be a useful tool for counting authorities and the NZTA to monitor cycle volumes with respect to targets set in local and national strategies. One of Eco-Counter's goals is to develop a counter that can use 16 or 32 channels to detect and classify both cycles and different types of motor vehicles.

Given the dedication observed of Eco-Counter throughout the trial (including prompt customer support, remote research, the visit of the sales representative and the final visit of the engineer) it is expected that Eco-Counter will follow through on their stated plans to continue developing their products. Thus it can be expected that the ZELT will be improved even further to suit the New Zealand market.

4.2 Bicycle recorder

As identified previously, the Bicycle Recorder tended to under-count cycles; this is probably due to its classification algorithms being too strict and has resulted in it having a much lower count total than the manual count. The tests indicate that the Bicycle Recorder cannot be relied upon to accurately count cycles at on-road locations. Overseas experience suggests that the Bicycle Recorder may be effective for on-road cycle lanes that are not traversed by vehicles; however the Main Road site (which was the closest to this description) was an unsuccessful location for the Bicycle Recorder.

Attempts to improve the Bicycle Recorder's performance by changing the settings were unsuccessful. Because of a lack of guidance from the manufacturer or supplier, testing of the Bicycle Recorder was effectively abandoned for the latter part of the trial.

On the off-road path, the Bicycle Recorder performed better, at over 85% accuracy and was consistent in each direction. The simple one loop configuration which can cover paths of width up to 2.5 m was considered to be a distinct advantage of the Bicycle Recorder for the off-road situation.

4.3 MetroCount tubes

The MetroCount tubes were tested at four of the five sites – the railway cycleway (in both directions), Main Road, Sparks Road and Dyers Road. The MetroCount tended to under-count cycles, probably due to the same reasons identified in the Little River Rail Trail project and coverage issues.

The MetroCount tubes at the off road site achieved a similar degree of accuracy to the inductive loop products. However, it has always been a premise of this investigation that pneumatic tube products are not a solution for continuous cycle counting. The problems experienced at Main Road, Sparks Road and Dyers Road, where the mixed traffic situation prevented the tubes from being installed to the same width into the traffic lane as the inductive loops highlights a limitation of the tube products.

It is considered that the accuracy of the tubes will be a good indication of the accuracy of other similar MetroCount products, for example the piezoelectric counters currently being examined in Palmerston North. It was hoped that results of that trial could be incorporated into this research and used to compare piezoelectric counters with inductive loop counters. However, at the date of this publication, results were not available.

4.4 Eco tubes

The Eco tubes, which were tested at the railway cycleway site in both directions for part of the total survey, had similar rates of over- and under-counting which results in the total cycle count being similar to that of the manual count for the same period. Therefore, at an aggregated level, the Eco tubes may be able to give a good indication of cycle volumes. They would, however, experience the same problems as MetroCount tubes in terms of wear and tear and vandalism so would not be suitable for long-term continuous counting.

4.5 SCATS

SCATS loops were compared with the other inductive loop counters at the off-road path only. Despite SCATS' lack of algorithms to distinguish between groups of cyclists, the aggregated data were similar in accuracy to those of the ZELT and Bicycle Recorder. SCATS was not able to give directional counts but it was considered that it would be possible to achieve this. The biggest problem with the SCATS loops used at the site was that they were installed across only half of the path and, for the purposes of the trial, traffic cones were used to ensure all cyclists passed by the SCATS loops. If having to reinstall SCATS loops to cover the path it may be preferential to install one of the other counters instead. Overall, it seems that SCATS loops, if properly positioned, would be a viable off-road alternative to purchasing an algorithm-based inductive loop counting device, but needs to be connected to a nearby traffic signal controller. SCATS' inability to distinguish between cycles and motor vehicles prevents it from being an on-road cycle counting option.

4.6 Usefulness of this research

This trial of inductive loop technology in the New Zealand environment was necessary as the products currently available are from European countries and were thus developed under different circumstances, especially those of traffic composition, cyclist behaviour and pavement characteristics. The effects of these circumstances have become clear over the course of this research. It is considered that most authorities wishing to count cycles would desire an off-the-shelf product and that the amount of time and effort that has been put into this research would be outside their resources. Many potential users would not consider the need for testing and calibration and would be likely to install the equipment and trust the results without verifying them. Had an authority installed any of the products tested without the guidance from this research, results would be similar to the results of the first surveys conducted and potentially inaccurate cycle counting data would be obtained.

This trial has highlighted some of the challenges encountered when applying the inductive loop products in New Zealand. The ZELT manufacturer, having visited the New Zealand trial sites, now have an understanding and appreciation of the New Zealand context and will aim to improve their product to suit New Zealand conditions. Given the improvements in accuracy achieved by Eco-Counter during the ZELT trial process and the dedication of the company that was observed, it is anticipated that the product will be improved further in the near future.

4.7 Summary of equipment characteristics

The following tables outline the features of the equipment used in the trial and also the advantages and limitations of these counting devices as were discovered in the trial and from experience.

	Use	Download and software	Instructions	Technical support	Advantages	Limitations
ZELT	▪ Real time count display makes it easy to verify counter is working on-site ▪ Multiple loops must be correctly named and connected to the right points on the transducer ▪ Settings can be adjusted via Pocket PC.	▪ Requires pocket PC with infra-red capabilities ▪ Pocket PC transfer creates an extra step between download and analysis ▪ Pocket PC transfer useful if logger to be kept on-site ▪ Can increase bin size after collection ▪ User-friendly software	▪ Excellent installation instructions and pictures ▪ Software manual ok, not much on adjusting sensitivity ▪ Instructions for 'test box' verbal only ▪ Trouble-shooting (FAQ) advice provided but limited in usefulness	Eco-Counter: ▪ Quick responses to queries via email and phone ▪ Initial visit from rep was a very useful bonus ▪ High level of commitment to resolving issues ▪ EC staff also supportive in liaising with installers ▪ Engineer's visit critical in resolving issues	▪ Useful mechanism for on-site downloads ▪ Works in mixed traffic ▪ Displays current count	▪ Staggered loop layout for directional counts at wide locations – potential problems with double counting or no counting ▪ Two loops used for wide locations can count cycles twice ▪ Doesn't count groups of cyclists effectively ▪ Data only available in periods of 15 min or greater ▪ Requires surfacing material to be at least 40 mm deep
Bicycle recorder	▪ Counter displays previous bin total, no real-time display option ▪ Display automatically turns off after short period of time, takes a while to scroll through information to get to count when turned back on ▪ Need to remove front cover of unit to access setting switches	▪ Download only via cable to laptop, no intermediate option (makes it harder for on-site downloads). ▪ Can't change bin size after collection (except by transferring to Excel) ▪ Manual contains details that relate to different product	▪ Limited documentation and trouble-shooting advice ▪ No detailed installation manual ▪ Installation manual was developed and obtained from external source ▪ Information relating to switches doesn't explain where they are – potential to damage equipment	Counters and accessories: ▪ Some software help ▪ Slow responses (and not always useful) Aspect traffic: ▪ Pre-sales information misleading ▪ No post-installation help given	▪ Quick download process ▪ Only one loop in all situations ▪ Data available in periods of 1 min and greater ▪ Better on off-road sites	▪ Need to take laptop to site for on-site download ▪ Doesn't appear to work in mixed traffic ▪ Doesn't count groups of cyclists ▪ Significant under-counting problems ▪ Poor technical support and guidance

Table 11: Summary of continuous counting products

	Use	Download and software	Instructions	Technical support	Advantages	Limitations
Eco tubes	• Real time counter display • Same logger as ZELT - familiarity	• Requires pocket PC with infra-red capabilities • Pocket PC transfer creates an extra step between download and analysis • Pocket PC transfer useful if logger to be kept on-site • Can increase bin size after collection	• Useful instructions on installations • Similar to MetroCount for installation • Good software manual	Eco-Counter: • Quick responses to queries via email and phone • High level of commitment to resolving issues •	• Useful mechanism for on-site downloads • Displays current count •	• Can be a trip hazard for pedestrians • Not suitable for long-term continuous counting
MetroCount tubes	• Familiar technology, experienced installers available throughout NZ • Can be some problems if installers aren't familiar with using MetroCount specifically for cycle counting	• Downloaded by installer • Excellent software • Can't produce report that classes motor vehicles and separates into 15 minute time intervals	• Useful instructions available in software and on website	MetroCount: • Quick and useful responses to queries via email and phone	• Familiar technology • Works in mixed traffic •	• Can be a trip hazard for pedestrians • Not suitable for long-term continuous counting • Inaccuracies in classification systems • Not designed specifically for cycle counting

Table 12 Pneumatic tube counters

5. Broader considerations

This research has dealt with detailed aspects regarding the use of cycle counting equipment. Significant progress has been made in terms of the installation and operation of the ZELT system in particular and subsequent recommendations regarding its use as a continuous cycle counting system have been made. It should, however, be emphasised that there are many other aspects that should be considered by an authority wishing to use the ZELT. This research was not intended to address higher-level, strategic issues required to formulate an effective cycle counting programme but it seems appropriate to highlight a few components that should be considered.

The need for continuous cycle counting is becoming increasingly recognised. The recently updated New Zealand Transport Strategy (NZTS) and associated Government Policy Statement (GPS) on land transport funding include targets to increase the number of walking and cycling trips made in NZ. Regional and local strategies have (or will have) targets aimed at reaching these national targets.

To measure progress towards these targets, reliable data are required. The cost of purchasing and installing counting equipment and collecting and analysing data, coupled with finite resources available to fund these processes means that site selection and counting durations must be prioritised. A "cycle counting programme" including manual and automatic (both short term and continuous) cycle counts would need to be developed by any agency interested in monitoring cycle traffic. To be effective, the programme would need to consider the following key elements:

- Selection of sites – strategically placed throughout the jurisdiction to record representative volumes, monitor both off-road and on-road situations, and show trends.
- Appropriate types of count for each site – long / short term, cyclist types or age groups, including / excluding pedestrians or other users.
- Type of counting equipment to be used and corresponding layouts and operational characteristics.
- Consistency with pedestrian and motor vehicle monitoring systems and programmes.
- Data compilation, analysis measures and key statistics to be produced.
- Programme review and monitoring.

It will be the responsibility of the jurisdiction's road controlling authority to manage the cycle count programmes. Regional councils, while they are generally not road controlling authorities, will have an interest in ensuring consistent and reliable cycle counting data exist. To ensure best practice is employed and to achieve consistency among the different road controlling authorities, guidelines should be produced on how to develop a cycle counting programme and manage the six key elements listed above. This is an initiative that the NZTA should lead for the benefit or all road controlling authorities and regional councils.

Funding assistance for cycle counting programmes could be considered by the NZTA under the following funding categories:

Activity classes 1 & 2 – Maintenance and operation of roads

W/C 151: Network and asset management – traffic count surveys (for the ongoing costs of the programme).

Activity classes 5 & 6 – Improvement of roads

W/C 321: Traffic management – traffic monitoring equipment (for initial equipment purchase).

Activity class 8 – Use of the land transport system

W/C 412: System use studies (setting up of programme).

6. Conclusions

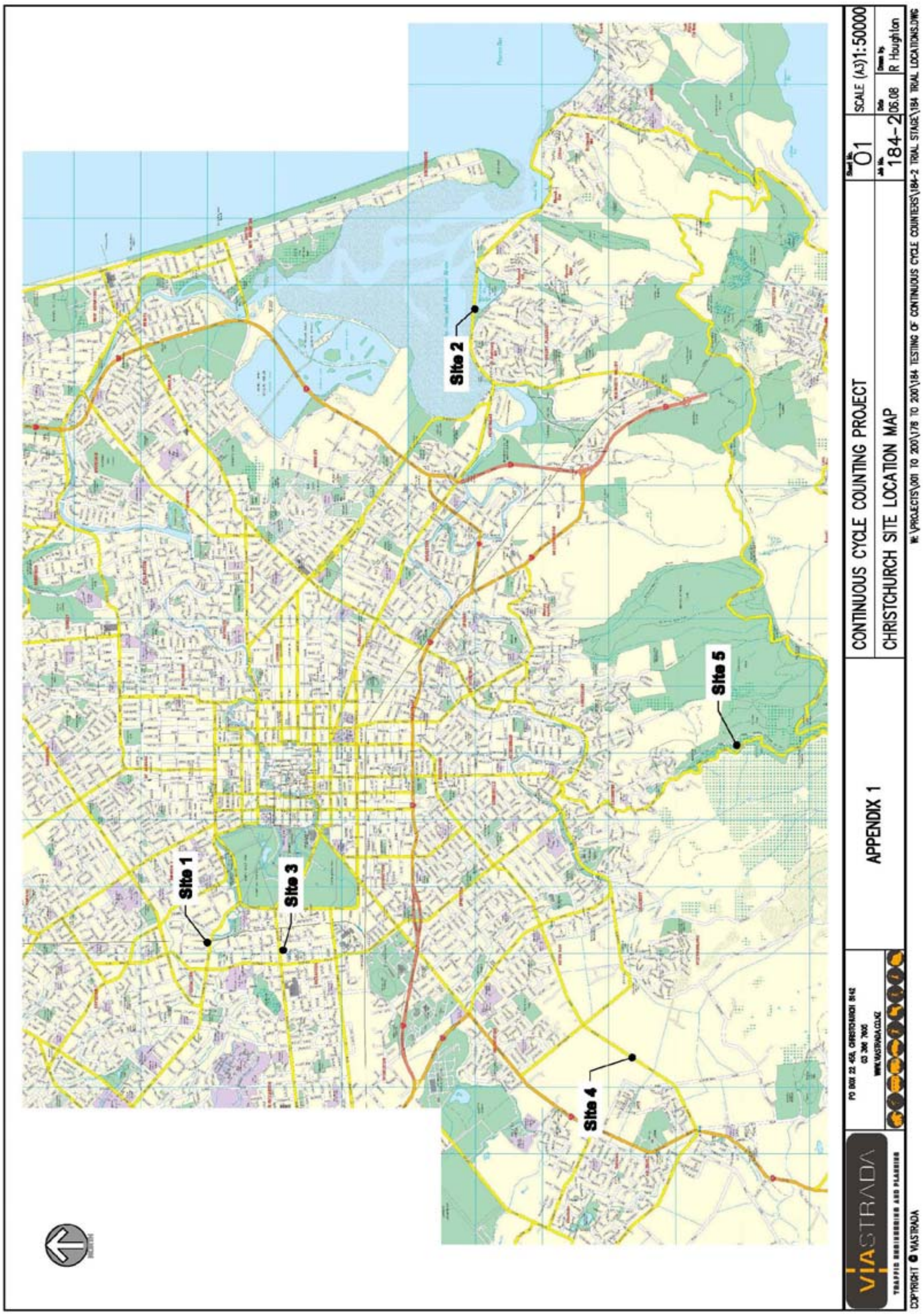
The following conclusions have been drawn from both the trial and the broader considerations discussed above with respect to cycle counting:

1. Inductive loop counting equipment is generally easy to purchase and use.
2. Inductive loop cycle counting equipment can provide cycle counts of reasonable accuracy – often around 90%.
3. The ZELT system is suitable for use in New Zealand to count cycles continuously at both off-road and on-road sites.
4. The Bicycle Recorder system is suitable for use in New Zealand to count cycles continuously at off-road sites.
5. The accuracy of the Bicycle Recorder was not directly comparable with that of the ZELT in mixed traffic (on-road) due to a lack of product support.
6. More on-road testing and calibration of the Bicycle Recorder would be required to confirm its ability to detect cycles in mixed traffic.
7. Pneumatic tubes and SCATS loops can give counts of similar accuracy to inductive loop products for off-road locations.
8. Pneumatic tubes are not considered to be as reliable in mixed traffic conditions on roads and SCATS cannot distinguish cycles from motor vehicles.
9. Other continuous cycle counting technologies, including piezoelectric detector systems, are evolving rapidly and should be assessed for New Zealand conditions.
10. Working closely with product developers can greatly enhance the outcomes and ensure a detection system appropriate to New Zealand conditions.
11. To allow continuous cycle counting to be undertaken in a robust, coordinated, and consistent manner throughout New Zealand, cycle counting programmes and appropriate funding mechanisms need to be developed.

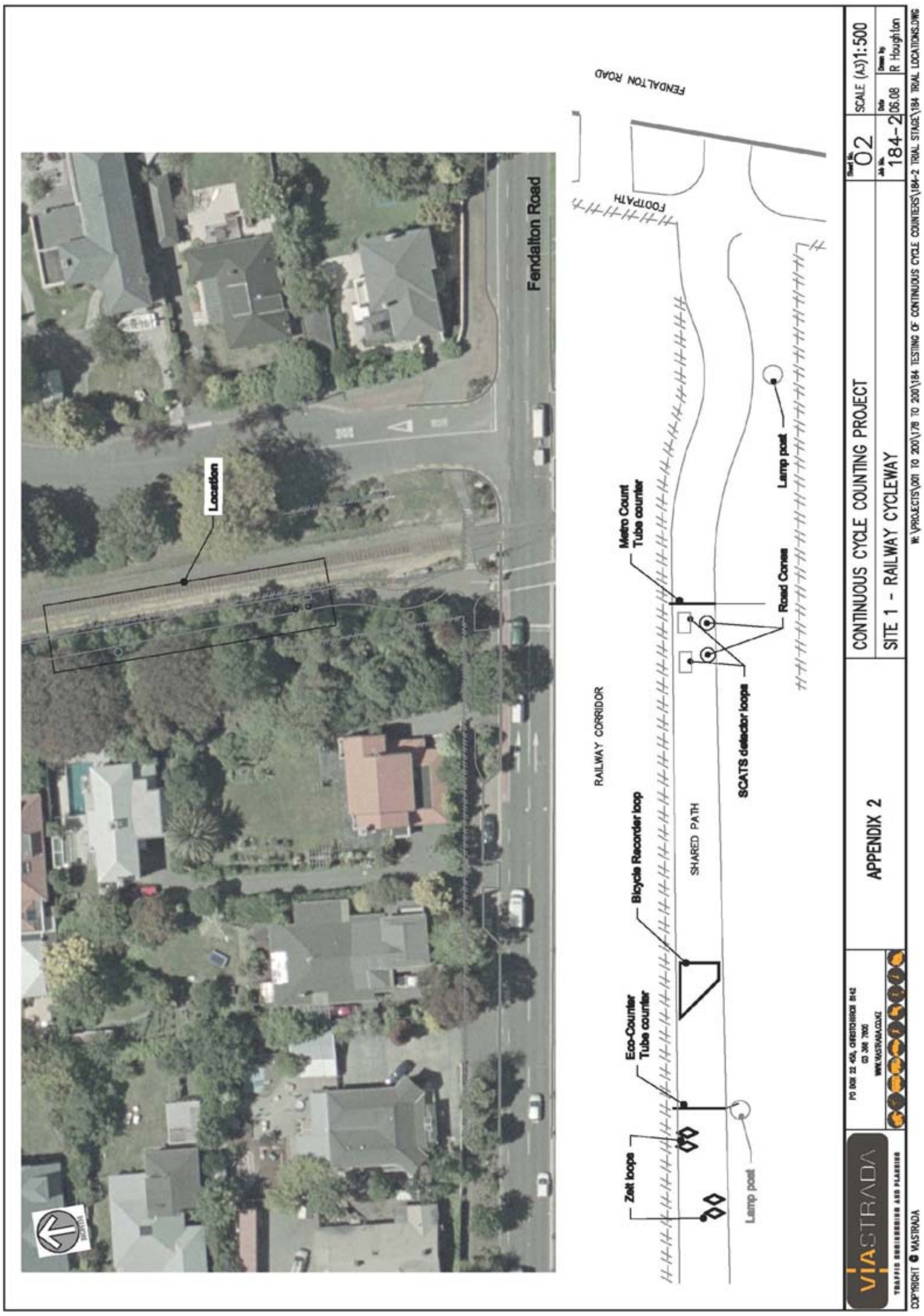
7. Recommendation

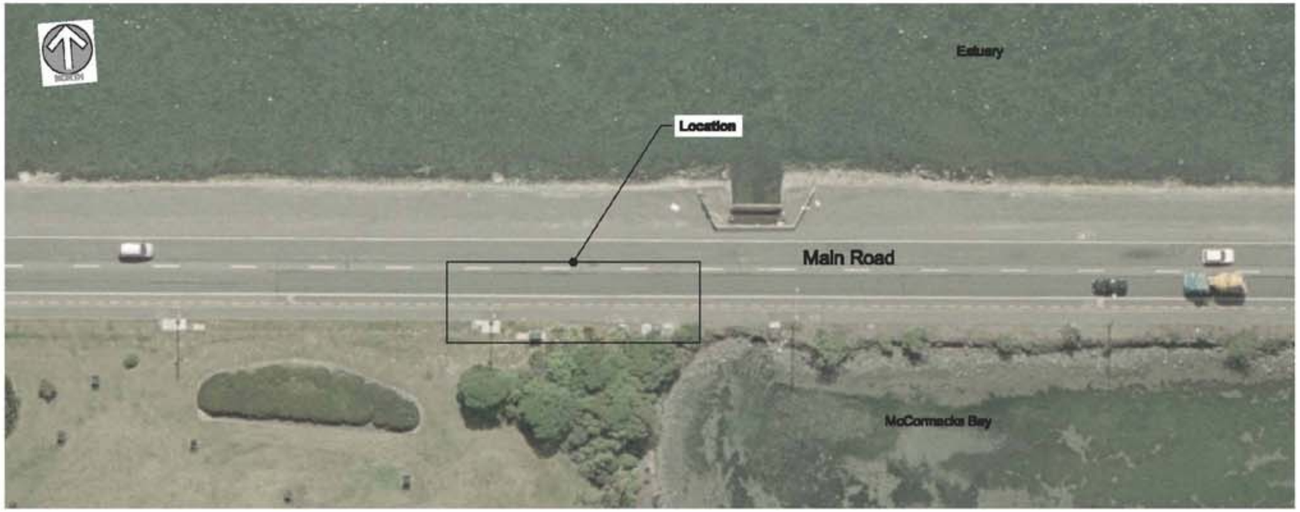
Based on the trial and the discussions presented in this report, it is recommended that road controlling authorities in New Zealand develop cycle counting programmes that include manual, automatic and continuous counts

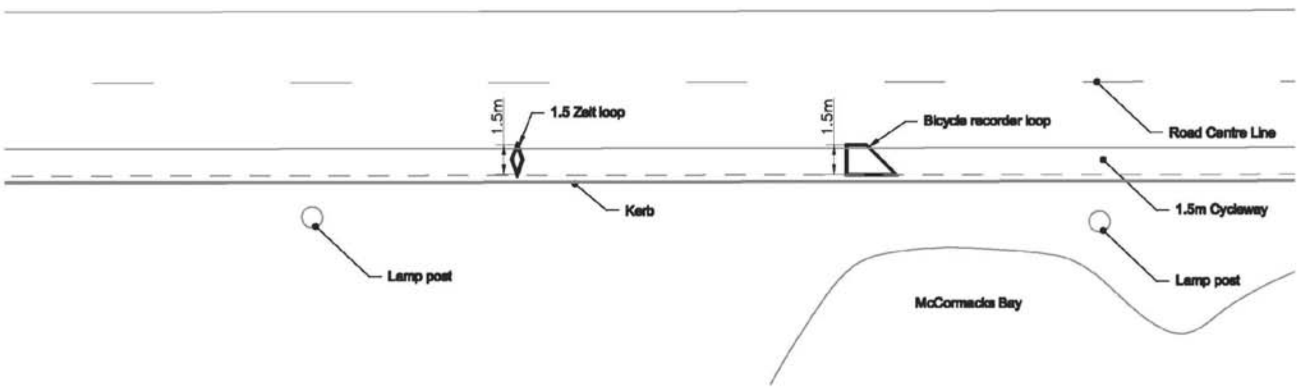
Appendix 1: Trial sites location map



Appendix 2: Site plans







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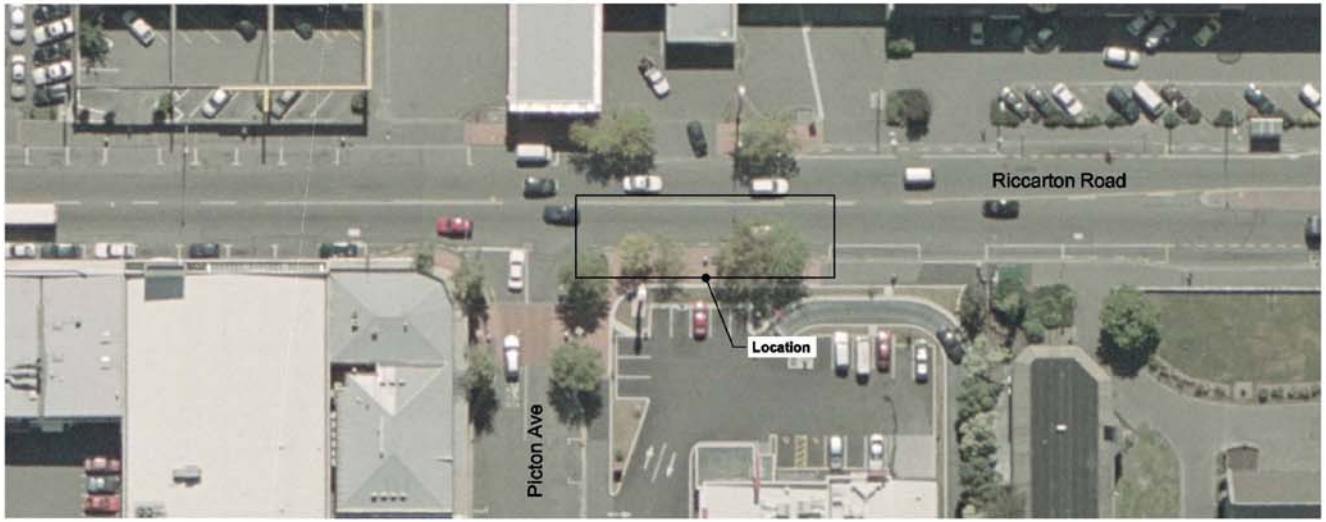

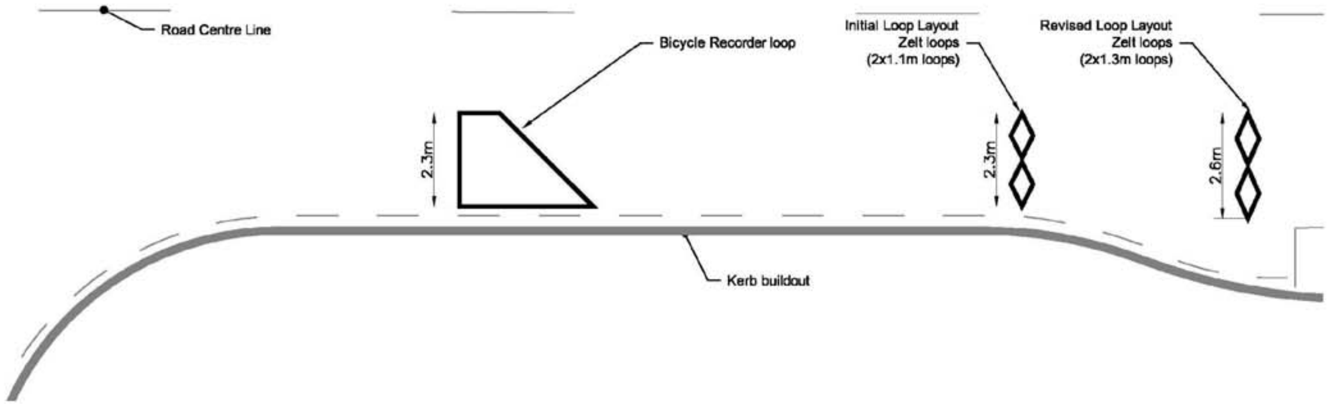

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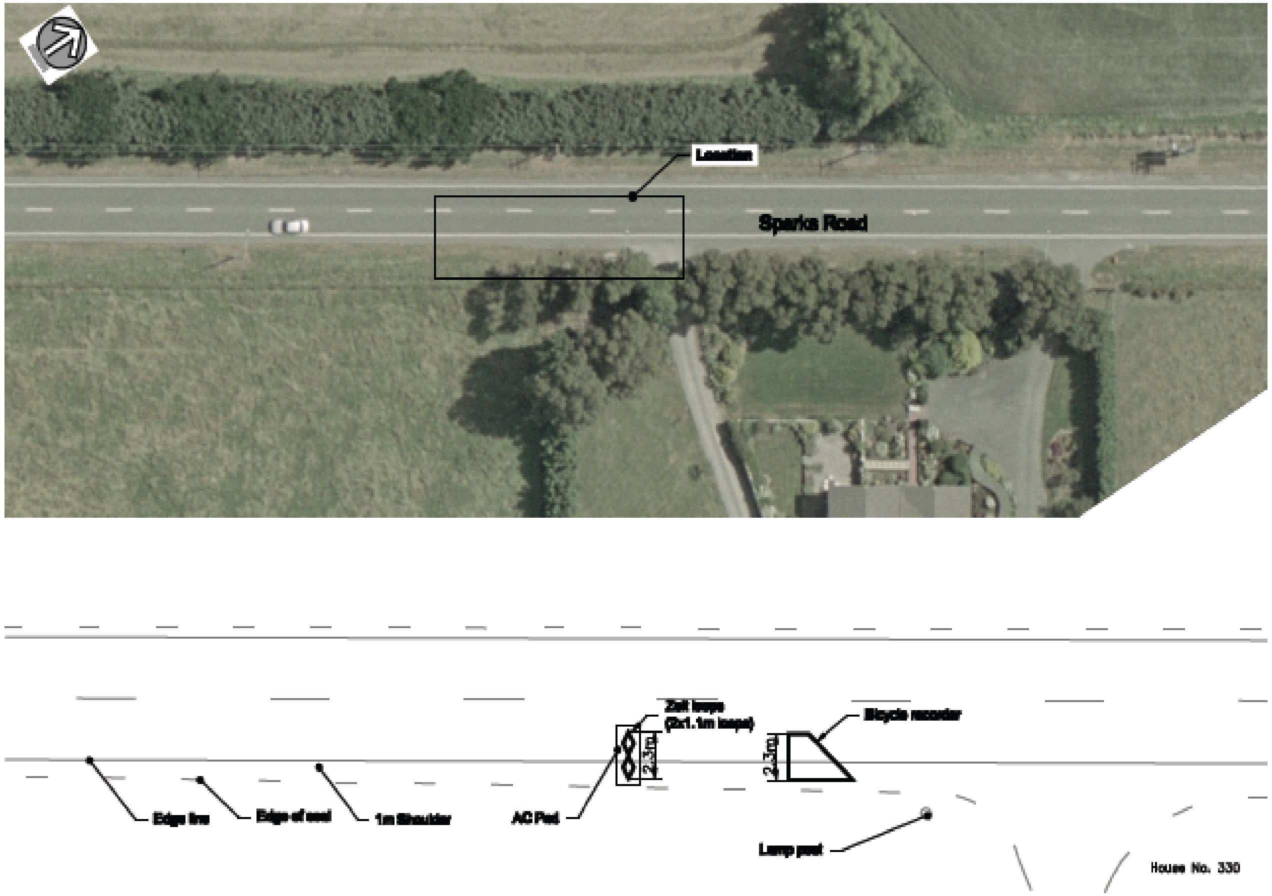

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TRAFFIC ENGINEERING AND PLANNING

APPENDIX 2

CONTINUOUS CYCLE COUNTING PROJECT

SITE 4 - SPARKS ROAD

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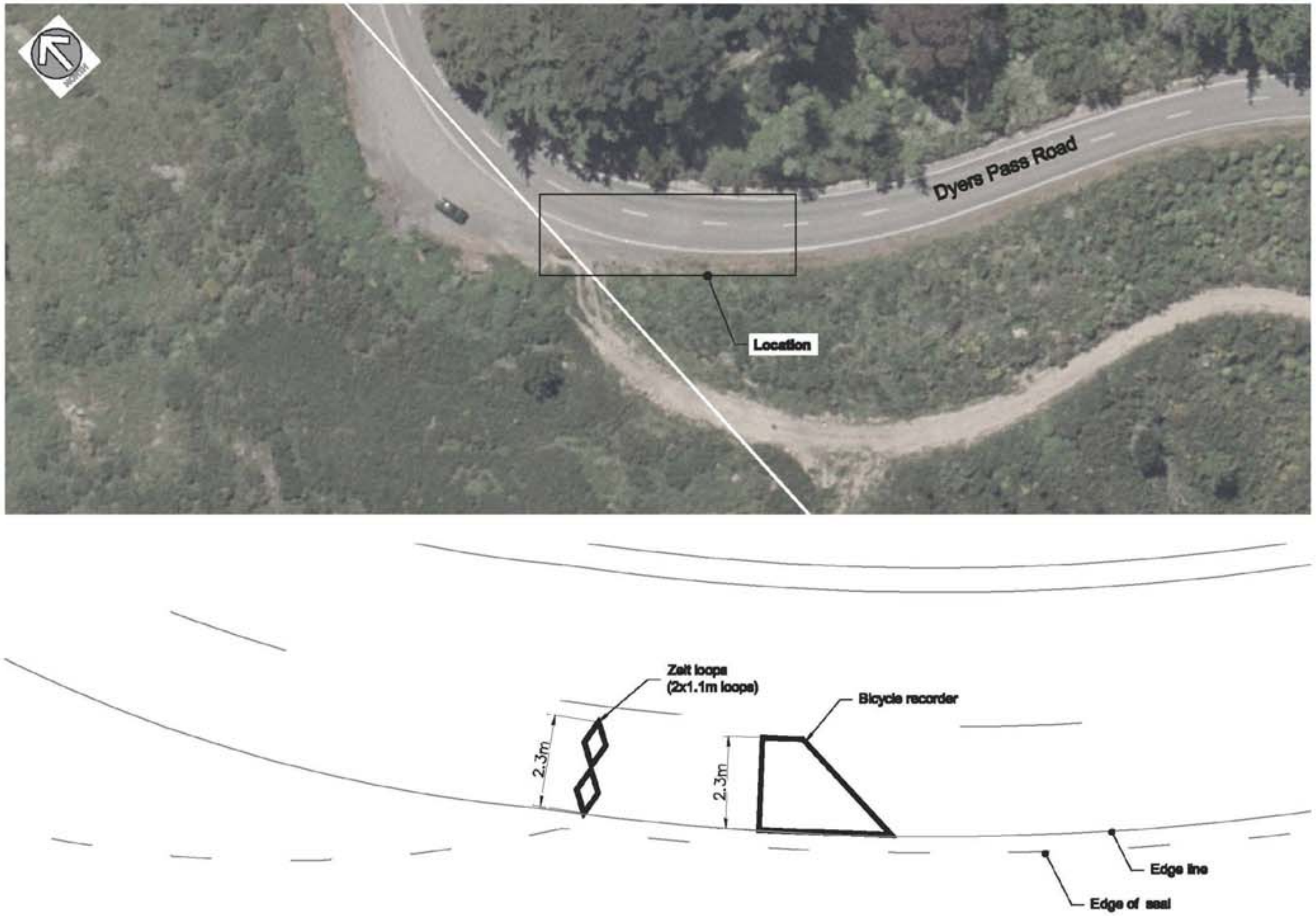
05.08

R Houghton



VIASTRADA TRAFFIC ENGINEERING AND PLANNING	PO BOX 22 458, CHRISTCHURCH 8142 03 366 7600 WWW.VIASTRADA.CO.NZ	APPENDIX 2	CONTINUOUS CYCLE COUNTING PROJECT	Sheet No. 06 / SCALE (A3) 1:500
			SITE 5 - DYERS PASS ROAD	Job No. 184-2 / Date 06.08 / Drawn by R Houghton

W:\PROJECTS\001 TO 200\178 TO 200\184 TESTING OF CONTINUOUS CYCLE COUNTERS\184-2 TRIAL STAGE\184 TRIAL LOCATIONS.DWG

Appendix 3: MetroCount adjustments

Via Strada has recently completed a study for the Christchurch City and Selwyn District councils on the cycle volumes of the Little River Rail Trail. This study employed several counts using MetroCount tubes in order to gauge cycle activity at different locations over a period of time and validated the MetroCount results with manual counting information.

It was found that the standard vehicle classification schemes used in NZ that distinguish between different vehicle types (one of which is cycles) were inaccurate for cycle counting. The two schemes examined were the TNZ1999 and the ARX, both of which include a class for cycles. Even though the counts were performed on an off-road path, the schemes often indicated that various types of motor vehicles had passed over the tubes. The motor vehicles 'detected' were likely to have been groups of cyclists whose combined wheels were incorrectly identified by the MetroCount classification process as a truck or truck and trailer combination. This error was easily fixed by determining the equivalent number of cycles based on the number of axles. However, it was also found that two cyclists were often counted as one, or vice versa. This second error was not easily remedied and there was no obvious pattern for when it occurred.

Thus, for the Little River Rail Trail project, a different method known as the axle method was used. The axle method counted cycles by taking the number of axle hits on one tube and dividing it by two. As only one tube was used it was not possible to distinguish the direction of the cycles; this was adequate for the Little River Rail Trail project but would not be adequate for the railway path site for this analysis as direction is one of the criteria on which the counters are to be assessed. The axle method would also not be appropriate for the on-road sites (even though there is no need to distinguish direction for these sites) as it is likely that not all of the hits on the tubes would be due to cycles; some would be due to motor vehicles driving on the tubes.

Therefore, it was decided that while the classification methods used in conjunction with the MetroCount tubes have been shown to be inaccurate for cycle counting this is the best option available. It was decided to use the ARX method, as this has the most appropriate category for cycles in terms of wheelbase length. The railway cycleway data were adjusted to equate motor vehicles to cycles but the on-road site data were not adjusted, as it was possible that motor vehicles had driven over the tubes. It was accepted that there would be some errors where groups of cyclists were classified as motor vehicles but there was no practical method of distinguishing this from the presence of actual motor vehicles.

A further complication regarding the MetroCount data was that it was not possible to create a 'report' (the name given to the forms of MetroCount data output) that separated data into vehicle classes and aggregated data at 15 minute intervals. Thus it was necessary to produce a list of individual vehicle records and aggregate these using Microsoft Excel. This process was somewhat clumsy as it required filtering the cycles from the other motor vehicles (or, in the case of the railway cycleway, adjusting vehicle records to the equivalent cycle numbers), determining which 15-minute bin each record belonged to and introducing new fields to sum the data and determine the last record (i.e. that with the bin total) for each bin.

While this process was somewhat complicated, it should be emphasised that the fact that the MetroCount software can produce a list of individual vehicle records is a major advantage over the software of the ZELT and Bicycle Recorder. As is discussed in Section 0 it would be preferable to analyse individual cycles rather than aggregating data into bins; the reason this was not done was that the ZELT and Bicycle Recorder were not able to produce lists of individual cycles. Therefore, the fact that the MetroCount software cannot automatically produce a report separating data into classes and individual bins should not be taken as a major weakness compared to the software for the other equipment, given that the MetroCount software is capable of producing an individual vehicle report, which is more accurate and desirable than the reports of the other software.

Appendix 4: Riccarton Road data[1]

First Riccarton Road survey (19/20 May 2008)

This was the first survey undertaken at the Riccarton Road site and involved both the ZELT and the Bicycle Recorder. The survey comprised a total of 182 cycles (as was manually counted).

	ZELT	BR
Manual count	182	182
Number of 'cycles' detected	289	85
Total count comparison	159%	47%
Number of 15 min tests	14	14
Success rate	0%	7%
Error adjusted index	41%	47%
Total over counts	107	0
Total under counts	0	97

Table 13: Riccarton Road survey results 19/20 May 08

Second Riccarton Road survey (9/10 June 2008)

As a result of the first survey, the ZELT settings were adjusted and a second survey undertaken with the ZELT (the survey comprised a total of 152 cycles).

[1] Note Railway cycleway results are in Section 3.1

	ZELT
Manual count	152
Number of 'cycles' detected	123
Total count comparison	81%
Number of 15 min tests	14
Success rate	36%
Error adjusted index	81%
Total over counts	0
Total under counts	29

Table 14: Riccarton Road survey results 9/10 June 08

Third Riccarton Road survey (3 July 2008)

Further testing on Riccarton Road was undertaken to determine the types of situations causing errors to the ZELT's counting. This survey was based on observations of individual cycles and so is presented in a different format to the previous results which involved aggregation of data. The survey comprised a total of 166 cycles.

Single/group	Speed (under/over 25 km/h)	Cycle type (road/other)	Position on loops	Total counted	Total missed	Success rate
Single	under	other	edges	10	7	59%
Single	under	other	centre	28	14	67%
Single	under	other	between	14	9	61%
Single	under	road	centre	1	0	100%
Single	under	road	between	0	1	0%
Single	over	other	edges	4	6	40%
Single	over	other	centre	13	15	46%
Single	over	other	between	6	4	60%
Group	under	other	edges	3	5	38%
Group	under	other	centre	4	10	29%
Group	under	other	between	4	1	80%
Group	over	other	edges	1	1	50%
Group	over	other	centre	3	2	60%
Total				91	75	55%

Table 15: Riccarton Road survey results 3 July 08 – summary of characteristics

The following three tables show the breakdown of all the data for the individual variables of whether the cyclist was riding as a single or in a group, whether the cyclist was riding slower or faster than 25 km/h and the positioning of the cyclist over the loops (at the edge of either loop, near the centre of either loop or between the two loops). As only two road cycles were observed during the survey no road cycle comparison has been made.

	Counted	Not counted	Success rate
Single	76	56	58%
Group	15	19	44%

Table 16: Riccarton Road survey results 3 July 08 - Single vs group

	Counted	Not counted	Success rate
Under 25 km/h	64	47	58%
Group 25 km/h	27	28	49%

Table 17: Riccarton Road survey results 3 July 08 – Speed

	Counted	Not counted	Success rate
Edges	18	19	49%
Centre	49	41	54%
Between	24	15	62%

Table 18: Riccarton Road survey results 3 July 08 – Position on loops

	ZELT
Manual count	211
Number of 'cycles' detected	129
Total count comparison	61%
Number of 15 min trials	8
Success rate	33%
Error adjusted index	61%
Total over counts	0
Total under counts	82

Table 19: Riccarton Road survey results 3 July 08 - ZELT 15 min aggregated data

	Bicycle recorder			
	Total	Setting 1	Setting 2	Setting 3
Manual count	204	37	122	45
Number of ‘cycles’ detected	215	5	188	22
Total count comparison	105%	14%	154%	49%
Number of 1 min trials	105	16	77	12
Success rate	25%	13%	29%	17%
Error adjusted index	2%	14%	-15%	15%
Total over counts	105	0	103	2
Total under counts	94	32	37	25

Table 20: Riccarton Road survey results 3 July 08 - Bicycle Recorder 1 min aggregated data

Where the bicycle recorder settings relate to:

Setting 1: buried loops, no mains suppression, bikes and cars, speeds up to 25 km/h.

Setting 2: buried loops, no mains suppression, bikes only, speeds over 25 km/h.

Setting 3: buried loops, mains suppression, bikes and cars, speeds up to 25 km/h.

Fourth Riccarton Road survey (6 August 2008)

The fourth survey on Riccarton Road (where only the ZELT was examined) comprised a total of 77 cycles.

	ZELT
Manual count	77
Number of ’cycles’ detected	104
Total count comparison	135%
Number of 15 min tests	8
Success rate	0%
Error adjusted index	35%
Total over counts	27
Total under counts	0

Table21: Riccarton Road survey results 6 August 08

Fifth Riccarton Road survey (13 August 2008)

The fifth survey on Riccarton Road (as for the fourth survey this involved only the ZELT) comprised a total of 227 cycles.

	ZELT
Manual count	227
Number of 'cycles' detected	256
Total count comparison	113%
Number of 15 min tests	11
Success rate	0%
Error adjusted index	79%
Total over counts	38
Total under counts	9

Table 22 Riccarton Road survey results 13 August 2008 – aggregated data

	ZELT
Manual count	248
Number of 'cycles' detected	271
Cycle-based accuracy	88.3%
Cycles double counted	2.8%
Cycles missed	8.9%
Number of motor vehicles counted	35

Table 23: Riccarton Road survey results 13 August 2008 – disaggregated data

Appendix 5: Main Road data[2]

First Main Road survey (14 June 2008)

The first survey on Main Road comprised a total of 96 cycles.

	ZELT	BR	Metro tubes
Total cycles counted	73	35	59
Total count comparison	0.76	0.36	61%
Number of 15 min tests	9	9	9
Success rate	0.11	0.00	0%
Error adjusted index	0.72	0.36	61%
Total over counts	2	0	0
Total under counts	25	61	37

Table 24: Main Road survey results 14 June 08

[2] Note Railway cycleway results are in Section 3.1

Appendix 6: Sparks Road data[3]

First Sparks Road survey (11/14 June 2008)

The first survey on Sparks Road comprised a total of 12 cycles. This is not large enough to draw statistically sound conclusions but was used to give an indication of the problems experienced by the different equipment types.

	ZELT	BR	Metro Tubes
Total cycles counted	16	6	9
Total count comparison	133%	50%	75%
Number of 15 min tests	6	6	6
Success rate	33%	33%	50%
Error adjusted index	33%	50%	58%
Total over counts	6	0	1
Total under counts	2	6	4

Table 25: Sparks Road survey results 11/14 June 08

[3] Note Railway cycleway results are in Section 3.1

Appendix 7: Dyers Pass Road data[4]

First Dyers Pass Road survey (15 June 2008)

The first survey on Dyers Pass Road comprised a total of 49 cycles.

	ZELT	BR	Metro
Total cycles counted	63	5	73
Total count comparison	129%	10%	149%
Number of 15 min tests	12%	12%	12%
Success rate	8	17	8
Error adjusted index	55%	10%	51%
Total over counts	18	0	24
Total under counts	4	44	0

Table26: Dyers Pass Road survey results 15 June 08

[4] Note Railway cycleway results are in Section 3.1