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High School Composting Trial

Evaluation of waste reduction infrastructure and services in six Western Australian high schools

10 January 2019

Final report

Department of Water and Environmental Regulation

Waste Wise Schools Program

encycle consulting

waste less, achieve more

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Executive Summary

Encycle Consulting was engaged by the Department of Water and Environmental Regulation (DWER) to conduct an evaluation of the Waste Wise Schools (WWS) trial implementation of recovering food waste to composting in 6 WA high schools to divert waste from landfill. In total, 6 schools were originally involved in the trial, 4 schools implemented an on-site treatment process using a 'Closed Loop' accelerated composting machine and 2 schools collected food in separate 240 L wheelie bins for removal and composting off-site. During the trial, one school (School B) decided to opt out from completion of the trial. The main reason given for this was the onerous nature of what was required to recover the food for limited benefit.

This evaluation report presents the findings of the of the evaluation process; to demonstrate the outcomes and learnings from the trial and provide recommendations for consideration if this approach is likely to be rolled out to other schools in Western Australia.

The evaluation process has focussed on both quantitative and qualitative assessments to evaluate the amount of food successfully diverted from landfill and also the change in attitudes and understanding of the problems of food waste and how to use systems to manage food waste.

Initial findings showed that food is a significant proportion of general waste currently going to landfill from the trial participant schools (between 27% and 42% of the waste stream by weight).

Based on the self-reported daily records from each school (March – October 2019), it is estimated that about 390 kg of food waste in total was diverted from landfill from schools using the Closed Loop machines on-site and about 5 tonnes from School F, using an external service provider to remove the food to a commercial composter (School F was the only school with boarding students; preparing and serving cooked meals throughout the day on site). Standardising the food collected shows that on average, about 6 g of food per student per day were collected for non-boarding high schools and about 26 g per student per day for School F. However, between 35% and 79% of available food was found to remain in the general waste stream (varying significantly between schools). While there was clearly food material diverted from landfill by the participant schools, it is worth noting the school that delivered by far the highest diversion rate had a commercial kitchen (and no Closed Loop machine on site).

The baseline attitudinal surveys indicate that there was already a relatively high level of engagement among staff and students as to the importance of diverting food from landfill (or not wasting it) and also a willingness to dispose of food into a separate bin for composting rather than into the general waste stream. Comparison with the survey after the trial, did not show any significant changes.

There have been some setbacks with the implementation of the trial (discussed in Section 2) which have delayed the project and interrupted the delivery of the full evaluation.

The core outcomes that could be achieved through implementing this food waste recovery program in Western Australian schools are likely to include:

1. Diversion of food waste from landfill and avoidance of associated climate change impacts (from methane generation under anaerobic conditions in landfill)
2. Use of the program to raise awareness among students of:
    - The environmental impacts of food waste
    - Practical ways to manage food waste in kitchens at home
    - The cycle of carbon and nutrients through using the compost product on school gardens to grow vegetables and fruit and then composting the peelings etc. from the food

To maximise the opportunities to achieve these 2 outcomes, Encycle has presented a range of recommendations in Section 5.

The main recommendations to achieve diversion of food waste from landfill are:

- Ensure teachers and all relevant stakeholders (including cleaners, kitchen staff and caretakers were engaged in the process and understood the systems)
- Assess the value of the financial investment in the Closed Loop machines in relation to the benefit realised from capturing the food waste and diverting from landfill (in comparison to other approaches including alternative technologies and the option of removing waste for off-site processing)

The main recommendations to drive behaviour change, engagement and awareness raising are:

- Deliver educational materials as a package that enables the key messages and information to be delivered as part of the curriculum
- Engage the students throughout the process of composting. Some schools expressed an interest in using the process of food waste segregation for composting as a means to explain the cycle of carbon and nutrients through our food system

In summary, this trial was successful at delivering a reduction in waste to landfill from the participating schools. However, if diversion of food waste from landfill is the sole aim of this trial, other institutions or organisations with commercial kitchens clearly represent the greatest opportunities and should be targeted first. It is also worth noting that a high proportion of standard dry recyclables were found in the waste streams at these high schools and targeting paper and commingled containers may represent an easier 'win' in terms of tonnes diverted from landfill.

There is value in continuing with this program in high schools if the opportunities to use the system as an educational tool are realised. There are various learning opportunities for students from learning about the impacts of food waste, the cycle of nutrients (e.g. carbon and nitrogen) through the food system and the practical tools for implementing food waste systems (e.g. home composting) for themselves. Provision of educational material to assist teachers with including the systems within their lesson plans would potentially deliver meaningful outcomes for this program.

1 Introduction

1.1 Evaluation of high school food waste segregation

The Waste Wise Schools program (WWS) works with Western Australia's schools to deliver educational strategies for reducing waste to landfill by implementing the three Rs: reduce, reuse and recycle, while developing positive environmental values in students and the whole school community. WWS offers resources and support for schools to plan, implement and maintain projects that minimise waste to landfill such as recycling, composting and worm farming.

Schools that participate in the WWS program model responsible environmental behaviours through hands-on learning experiences that are linked to the Australian Curriculum. WWS schools set up infrastructure and provide resources aimed at changing attitudes and behaviour in regard to sustainable waste management.

The purpose of this project is to evaluate the effectiveness of the Waste Wise Schools (WWS) trial of the school-wide food waste composting system in six WA high schools. The trial commenced in March 2017 and is due for completion in December 2018. The evaluation will assess the two different trial methods of removing food waste from the general waste stream destined for landfill: an electronic organic waste accelerated composting machine and an organic waste collection service (where waste is composted in a 'Bedminster' industrial composting facility).

This report presents the findings of the evaluation process and provides a summary of activities including baseline setting for quantities of food waste generated at the schools and the attitudes of staff and students. It also includes information from the mid-way site visits to evaluate the trial and to identify any operational challenges being experienced and the final food waste audits conducted at each participating school.

1.2 Trial delivery Team

Several parties were involved in the delivery of the trial. The parties and their key roles are summarised in the table below.

Organisation	Key responsibilities
Department of Water Environmental and Regulation	Project management of the trial Communication with schools
Closed Loop	Install and maintain accelerated composting machines Testing of end product
SUEZ	Provision of collection service for off-site composting
Eco Change Consulting	Provide support for schools involved in the trial
Encycle Consulting	Evaluation of the trial
Department of Education	Approve research: audits and surveys

2 Food waste trial

2.1 Food waste trial rationale

WWS research shows that worm farming, composting and recycling have been more widely adopted in primary schools than high schools in Western Australia. Although 70 per cent of 18 high schools surveyed reported that students and staff are interested in reducing waste and increasing recycling, only one school out of the 18 surveyed collected fruit and vegetable scraps from the whole school (Waste Wise Schools Program 2016).

Most schools reported that they did not have a system in place to collect fruit, vegetable and food scraps. The main barriers identified were sorting the waste, contamination, lack of infrastructure and lack of time. The vast majority of staff surveyed (78 per cent) considered that electric composters would be very useful in managing food waste at school.

Based on the level of interest in reducing waste to landfill in high schools and as a means of providing infrastructure, WWS has implemented a trial of electric composters or a commercial food waste collection service (for off-site composting) in 6 selected high schools in 2017/2018. The infrastructure will be used to compost fruit, vegetable and food scraps (including bread) from the various areas within the school.

The desired outcomes of the trial include:

- **Ultimate outcome**
  To reduce the amount of organic waste going to landfill
- **Intermediate outcome**
  To change school communities behaviour in regards to disposing of food scraps
- **Immediate outcome**
  To raise awareness of the need to divert food scraps from landfill

This evaluation seeks to answer the follow questions about the effectiveness of the trial:

- How much food waste from the participating schools currently goes to landfill?
- Where is food waste generated in the participating schools?
- Does the school community care about diverting waste from landfill and understand why it is important?
- Do the schools involved know how to use the food segregation and treatment systems effectively?
- Were the collection bins for off-site composting effective?
- Were posters and stickers effective?
- Has the trial led to an increase in knowledge within the participating schools about importance of diverting food scraps to do it?
- Has the trial contributed to changing the behaviour of students and school staff in regards to diverting food waste from landfill?

2.2 Original trial timeline

At the commencement of the trial the following timeline was proposed by the Waste Wise Schools team (Figure 1).

February 2017	>	Project team start up meeting
May 2017	>	Baseline audits
July 2017	>	Baseline survey to be distributed
September 2017	>	Waste audits to be undertaken at all 6 schools preliminary report due
October 2017	>	Consultation workshop on preliminary report
November 2017	>	Post-implementation surveys and audits
January 2018	>	Final report due

Figure 1: Original timeframe

2.3 Revised timeframe and project delays

The delivery of the trial, in particular the installation of the composters was delayed. A timeline showing the delivery of the project to date and revised timeframe for the remainder of the project is shown in Figure 1. The delays were caused by two main issues:

1. The research was being undertaken in six schools and this required the approval of the Department of Education. The research approval process typically takes 12 weeks however it was more complex than anticipated because of occupational health and safety concerns and potential industrial action concerns. The Department of Education approved the research in November 2017.
2. The project was further delayed whilst waiting for internal approvals of the 2017/18 budget due to the change in State Government.

The flow-on effect of the delays discussed above was a misalignment of the trial timeline with the school calendar. The trial commencement was changed to the 2018 calendar year instead of the 2017 calendar.

The electric composters were installed in four schools in March 2018. The remaining 2 schools had a food waste collection service for off-site composting which also commenced in both schools in March 2018.

Once the trial had begun, there were more incidents which prevented the trial from being rolled out as originally planned. Two out of the four schools with the Closed Loop machine experienced problems with the machines which meant they had delayed starts or were not working for a period of time. For this reason, mid trial waste audits were replaced with mid trial site visits where data was collected on challenges and successes to date, bin locations and program management.

February2017	>	Project team start up meeting
May 2017	>	Baseline waste audits undertaken at all 6 schools by Encycle Site visits undertaken by Eco Change to assess needs and what support needed
January 2018	>	Site works and Closed Loop machine installation
February 2018	>	Baseline surveys distributed by Encycle
March 2018	>	Collection bins, posters and education materials distributed by Eco Change
April 2018	>	Baseline survey closed
May 2018	>	Mid-way site visits to School C and School D
June 2018	>	Trial officially launched by Minister Dawson at School C (15th June) Mid-way site visit to School A
August 2018	>	Mid-way site visits to School E and School F Preliminary report submitted
September 2018	>	Final waste audits undertaken at schools
October 2018	>	Audit data analysed
November 2018	>	Final report to be produced
December 2018	>	Project completion

Figure 2: Revised timeframe for evaluation project delivery

2.4 Profile of participating schools

All high schools in WA participating in the Waste Wise Schools Program were invited to be a part of the trial. Six schools were selected to be involved. This selection included both public and private schools located in the metropolitan area and in rural areas. The schools are not named but will be referred to as School A - F throughout this document. The profile of the each of the schools is provided here:

School A

School A is an Independent public school located in South West WA. It has a population of 1377 students in 2018, with students from year 7 to year 12. Along with ATAR pathway classes it also runs a Vocational Education and Training Program.

School B

School B is an independent public school located in the Eastern Metropolitan area of Perth. It has a population of 892 students in 2018, with students from year 7 to year 12. It offers students access to specialist programs in both Hospitality and Drama.

School C

School C is an independent public school located in the northern suburbs of Perth. It has a population of 1059 students in 2018, with students from year 7 to year 12. It offers students access to specialist programs in Aviation and Volleyball.

School D

School D is an Independent public school located in the Fremantle area. It has a population of 1645 students in 2018, with students from year 7 to year 12. It runs Gifted and Talented Arts Programs in Ballet, Contemporary Dance, Drama, Media Arts, Music, Music Theatre and Visual Arts as well as a Specialist Soccer Program. The school offers Vocational Education and Training in arts related industries.

School E

School E is an Independent public school located in the Eastern region of Perth. It has a population of 1162 students in 2018, with students from year 7 to year 12. Along with ATAR pathway classes it also runs a Vocational Education and Training Program.

School F

School F is a private boy's school located in the Southern suburbs of Perth. School F has approximately 1,300 students from a broad range of metropolitan, rural and international backgrounds, including 160 boarding students. The College is split up into three sub-schools: Junior School - Co-educational (Pre-kindergarten to Year 4); Middle School Co-educational Years 5 and 6 (and boys only Years 7 and 8); Boys only Senior School (Year 9 to Year 12).

2.5 Collection bins

In order to determine the most suitable collection bins for the trial, Eco Change consulting was engaged to conduct a literature review, identify any potential and conduct a site-visit to each school.

As part of the pre-trial planning, Waste Wise Schools and Eco Change identified several potential challenges and as a result the decision was made to offer schools a choice between the following bin types (Figure 3 and Figure 4).

In order to support the schools in educating and engaging the school community bin label stickers and educational posters were developed and produced for the schools. They can be seen in Figure 5, Figure 6 and Figure 7.

Figure 3: Kitchen caddy style bin top and side view

Figure 4: Larger 20L bin with lid (hole cut in lid for use) top and side view

Figure 5: Food waste bin sticker design

Figure 6: Food waste bin sticker design of what cannot be included

Figure 7: Educational poster

2.6 Closed Loop CL010 machine

Four of the six schools received a Closed Loop accelerated composting unit to use for the duration of the trial. These schools were School A, School C, School D and School E. Closed Loop states that the organics units are fully contained, commercial on-site composting units that can reduce food waste volume by up to 90 % in 24 hours (this has not been verified). Closed Loop says that the units decompose and pasteurise food and organic waste in an aerobic environment using controlled temperatures, agitation, airflow and organic starter material. The unit features a ventilation and deodorisation system that promotes decomposition without any unpleasant smells. See Figure 8 for more information.

Figure 8: Information about the Closed Loop CL010 machine

When installing into a school the electric compost units require:

- Shelter from the weather (both rain and sun).
- Adequate ventilation. The units are raised off the ground and draw air from underneath the unit. The air flow is used in the composting process.
- A level concrete platform on which to sit.
- A dedicated power source. The unit requires AC240V electricity. The unit is left on (just like a fridge).
- Plumbing. The odour emitted is pleasant. Even so, it's desirable to have an exhaust pipe. A standard 150mm PVC piping is connected to the exhaust point of the unit and run to an elevated external point.

- Access to the rear of the unit. This will be required so that a staff member can remove the screw cap at the base of the T section (condensation trap) for a weekly clean.
- Security may be required (lockable access).

2.7 Service provider collection

Two of the six schools were selected to receive a food waste collection service for the duration of the trial. Suez provided the food waste collection service and bins to the schools. This service was organised and paid for by WWS as part of the research. A representative from Suez assessed the school's service needs. Suez determined the number and type of bins needed prior to rolling out the service.

Food waste is typically collected in a 240 wheelie bin (rather than a skip bin). Bins and compostable liners were provided. The bins were then collected by Suez and taken to an off-site composting facility.

3 Evaluation Methodology

3.1 Summary of approach to evaluation of the trial

The evaluation of the trial of food waste collection (for treatment or collection) started in March 2017. The stages of the evaluation process are set out here in Table 1

Table 1: Summary of the tools used to evaluate the various stages of the trial

Stage	Data/information to be collected	Findings reported
Pre-implementation of machines/ food collection service	Service provider data collected – 12 months Attitudes/behaviour survey General waste physical sort audit	Preliminary Report
Implementation	Machines installed; waste service provider collection commences	Preliminary Report
Post-implementation (initial)	Mid-trial evaluation (revised approach): Planned audits replaced with site visits attitude and behaviour surveys omitted (see discussion in Section 4.2)	Preliminary Report: Summary of evaluation 1 and initial recommendations
Post-implementation	Final evaluation: - Service provider data (monthly) - Attitudes & behaviour survey - Audits 2: food waste and general waste	Final report: Summary of evaluation and final recommendations

3.2 Service provider data

Waste service provider data for October 2017 to November 2018 was obtained from the Department of Education for the high schools located in the Perth metro area (School E, School B, School C, School D and School F). School A data was not available. The data included most of the waste and recycling streams serviced, bin type/size, number of collections per month and total weight of the materials (based on calculation from number of bin lifts rather than using scales to determine weight).

The data showed the period prior to and after the implementation of the trial and was used to demonstrate performance of the trial on general waste reduction. The data provided was for 12 months, but was missing some reporting for some schools.

3.3 Waste audits (physical sorting of general waste)

Physical sorting of the general waste stream (audits) were undertaken at each of the six schools. The general waste from a 24-hour period was collected and sorted into 2 categories:

1. Compostable material (food scraps)
2. General waste

The audit process included close liaison with each school to ensure that a full 24 hours' worth of material was collected from the whole school on a 'representative' day (i.e. no special

activities planned that might affect the results). The source of each bag of waste was required to be identified and teachers/cleaners ensured each bag was labelled appropriately prior to being collected as part of the cleaning process. The bagged waste was presented for the audit in a location away from staff and students.

The sorting of the material was carried out by fully trained staff, wearing appropriate personal protective equipment. Each bag was sorted and food waste was extracted from the remaining material in the general waste stream. Both the segregated food waste and the remaining general waste from each bag were weighed and the data recorded onto a data sheet. The data was entered into a spreadsheet and analysed.

A final physical audit of the segregated food waste and general waste stream for one day (24 hrs) was undertaken for each participating school at the end of the trial. The audits were conducted in September 2018. The audit of the food waste stream involved sorting food manually to determine the composition of the food waste and the level and type of contamination present in areas where food bins were located. The audit of the general waste was to identify the amount of food not being segregated that could potentially be gathered. Data was recorded by weight to provide a percentage composition and contamination (of food waste). The data from the baseline and final audit have been compared to determine the impact of the trial food waste program for each school.

3.4 Attitudinal surveys

Attitudinal surveys were conducted prior to the start of the trial and towards the end of the trail period using an online survey application to assess the behaviours and attitudes of staff and students towards food waste in general and to the program at their school specifically.

The surveys used closed-ended questions with simple options regarding the extent to which the respondent agrees with a statement or to select from a list of responses (tick box). Questions were kept to a minimum so that the survey was not onerous to complete. A copy of the survey questions are provided in Appendix C.

The aim of the survey is to identify (as a minimum):

- The level of awareness of food waste quantities at school
- The extent to which staff and students see food waste as a problem
- The ways that the relevant educational components of the curriculum have changed their understanding of food waste as a problem and the opportunities for recovery of food waste
- The perceived negative impacts of food waste (e.g. waste of money, attraction of pests, moral issue associated with others being hungry, environmental impact etc.)
- Level of awareness that options exist for managing food waste (other than landfill)
- The extent to which staff/students are likely to separate food if they understand it will be turned into compost rather than landfilled
- The knowledge of the food segregation and treatment program
- Recognition of the signage and awareness of meaning and consistency of message
- The level of support for the food segregation and treatment program

- The awareness of what materials can/can't be separated for composting

The pre-trial surveys were opened for respondents on 14 February 2018 and closed on 9 April 2018. The final surveys were opened for respondents on 13 September 2018 and closed on 31 October 2018. The purpose of the surveys was to understand the attitudes and behaviours of staff and students towards the wastage of food, composting and the program implementation (including response to signage and strategies).

3.5 Food waste data collection

Schools were asked to record the quantity and source of food waste input materials collected during the trial. Encycle created a recording spreadsheet for recording the volume of food material collected from each previously defined area within the school. The data collected on these forms was forwarded to Encycle to incorporate into the trial analysis. Standard densities of food waste will be used to calculate the quantity of food by weight that is collected each day from each defined school area.

3.6 Site visits (*in lieu* of post-implementation audits)

Given the delays discussed in Section 2.3, it was agreed that the planned mid-trial audits would not generate any meaningful data (the trial had not been in place for sufficient time to deliver observed differences at this stage). Site visits were made to all of the six schools in May, June and August 2018 at times when the schools representatives were available. Both Encycle and Eco Change were present for the site visits.

The site visits involved an informal interview with the school staff responsible for the program and short tours to view the collection bins and the Closed Loop machines. The schools provided Encycle with information on the number and locations of collection bins, location of the Closed Loop machines, processes for managing the collection and processing of the waste and any issues with the data collection sheets. Eco Change asked some questions about the barriers and benefits experienced so far in the trial. The main findings from each school can be seen in Section 4.2.

During the mid-trial site visit, School B identified that they no longer wanted to be a part of the trial. The main reason given for this was the onerous nature of what was required for limited benefit. The other five schools have continued to the finalisation of the project.

4 Evaluation findings

The evaluation process has been designed to provide some answers to the evaluation questions listed in section 2.1. This section summarises the outcomes of the trial and presents an overall evaluation of the results observed.

4.1 How much food waste from the participating schools goes to landfill?

4.1.1 Encycle waste composition audits

Two sets of waste physical sorting audits were conducted: the first set at all 6 schools in May 2017 to establish a baseline before the trial commenced and a follow-up suite of audits in October 2018 at the end of the trial. The first set of audit data was used to assess how much food waste potentially goes to landfill in a high school when there are no or limited diversion programs in place. The second audits were conducted to collect data to show on a given day how much food waste is being diverted from landfill and also how much food waste is still in the general waste stream. The reduction of food waste in the general waste stream in the second audit, indicates a change in behaviour as a result of staff and students utilising the food waste bin.

Note that physical sorting of waste to audit the composition is accurate for the day of the audit. However, caution should be applied when extrapolating the findings to all schools across Perth/Western Australia given that it is only one day and may or may not be a representative day for the whole year. That said, we have used these figures to find an average amount of waste per student. Note that one of the schools (School F) is a boarding school and as such produces significantly more food waste in the process of providing full catering for the students. School F offers a boarding service for over 160 students who are offered 6 meals over the course of each 24 hour period as well as a standard school canteen service. In comparison, all of the other schools offer a standard canteen service alone. For this reason, the School F figures have been separated from the other schools' data.

On average, (excluding the boarding school, School F) about 32% of the general waste stream is food. Close to 36% of the general waste stream was food at the standard high schools (with day attendance only). At School F (with boarding and meal provision) 42% of the general waste stream is food. Every student at the standard high schools generates, on average about 33 g of food waste per day. The food per student per day is between 25 g and 44 g per student at standard high schools and 142 g per student at School F.

Table 2: General waste and food waste per school (total, percentage and per student)

School	General Waste (kg)	Food Waste (kg)	Total (kg)	Number of students	% Food in general waste	Food waste /student/ day (g)
School A	93	34	127	1377	27%	25
School B	68	25	93	892	27%	29
School C	89	47	136	1059	35%	44
School D	113	63	176	1645	36%	38
School E	59	33	92	1162	36%	28
School F	236	173	409	1300	42%	133
Total	**657**	**375**	**1033**	**7435**		
Average (ex. School F)					32%	33

Figure 9 illustrates the general waste and food waste being generated per student from the sample audited.

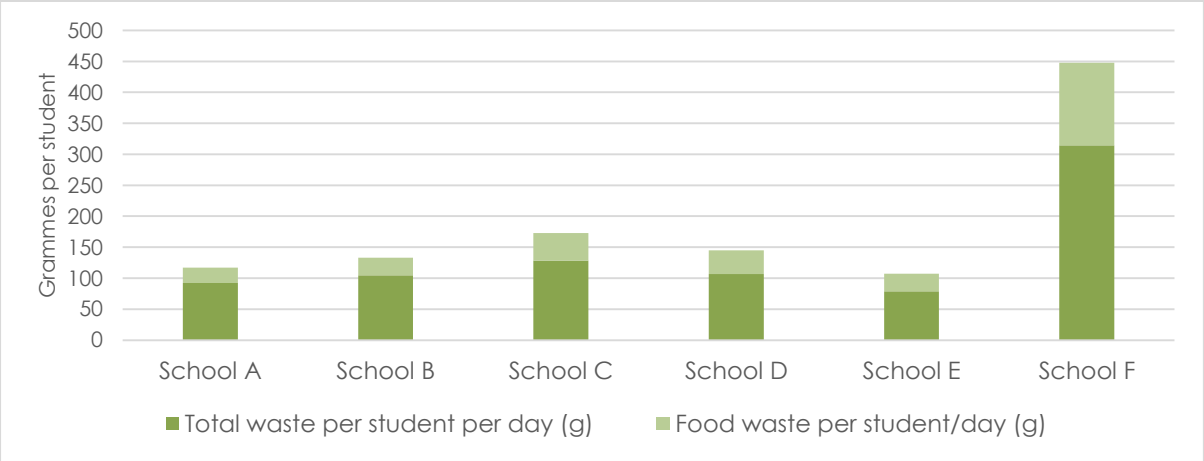


Figure 9: Pre-trial audit of general waste to identify food waste over a 24 hour period, shown on a per student for each school

The baseline audits conducted in May 2017 showed the vast majority of food waste from all schools involved was sent to landfill. A couple of the schools (School A and School D) composted small amounts of their organic waste on an *ad hoc* basis in small scale worm farms or compost tumblers (no data available).

Table 2 shows the total weight of food waste in the waste stream when the schools were audited in May 2017. See Appendix A for photos from the audits. See Appendix B for more detailed waste audit results.

The audit data in Table 2 shows that between 90 kg and 409 kg of food waste was disposed to landfill from the participating schools across this 24 hour period.

4.1.2 General waste data from waste service providers

Waste service provider data was collected where available from participating schools. Note that some data was patchy/not available. A summary of the data provided by waste service providers is shown in Table 3.

Table 3: Summary of waste service provider data (tonnes per annum) for Nov 2017- Oct 2018

	General waste (tpa)	Recycling (tpa)	Recycling rate	Total waste & recycling per day (kg)
School A	no data	4.9	-	
School B	no data	0.3	-	
School C	53.1	No data	-	295
School D	19.0	No data[1]	-	110
School E	37.5	11.7 [2]	24%	274
School F	77.6	91.9 [3]	54%	942

Table 3 shows that the available data is a little patchy for some schools. From the data available from the waste service providers, a key point to note is that there are relatively low volumes of dry recyclables (commingled containers and paper). Even where there is a recycling rate reported (e.g. School E and School F), a significant proportion of this material is green waste. During the physical sorting audits, large numbers of recyclables were found in the general waste stream, including readily segregated materials such as paper and containers from the kitchens (e.g. milk bottles).

A standard approach to improving recovery of waste to landfill in institutions is to target 'easy' recyclables that are readily recognisable and easily handled before moving on to more challenging materials with more complex segregation and recovery processes. While measurement of the volume of recyclables in the general waste stream was not included in this project, it seems likely that tackling the standard recycling streams is an area of opportunity for both diversion from landfill and student engagement.

Note that when comparing the audit data (Table 2) to the high level service provider data (Table 3), for most schools on average, more waste is reported to be collected per day from the waste service provider than was analysed for this audit. There are several likely explanations and possibly it is due to a combination of all four:

[1] School D recycling only available for 2016 data (not considered comparable)

[2] School E recycling includes green waste

[3] School F recycling includes green waste and 3 tonnes of food waste from the trial

1. Some material was missed from the audits. This is possible although unlikely to have been from high food-generating areas
2. The scales used for measurement (on waste vehicles and platform scales for the audit) are not both accurately calibrated
3. The audit day was not representative of 'average' waste generation. There is a high variability in waste generation some schools (note the significantly higher maximum waste generation showing a strong deviation from the average)
4. Waste service provider data is based upon multiplying the number of bins collected by a standard conversation factor to obtain weights (and these standard conversion rates are unlikely to provide an accurate weight for the school's actual waste)

Since this project focusses on the audit data as a major source of information about food waste generating, it is discussed here.

4.2 Has the trial resulted in a reduction in the amount of food waste going to landfill?

4.2.1 Post-trial audit (physical sorting) results

Table 4 shows the amount of food waste segregated per school. Table 5 shows the adjusted data to provide a comparison on a 'per student' basis.

Table 4: Results from post-trial sorting of general waste and separated food waste

School	General waste (kg)	Food waste in general waste (kg)	Separated food waste (kg)	Percentage of food collected (of available food)	Percentage food left in general waste
School A	109	70	45	39%	39%
School B	n/a				
School C	74	30	8	22%	29%
School D	276	58	15	21%	17%
School E	145	7	10	58%	4%
School F	327	46	86	65%	12%
TOTAL	**932**	**210**	**164**		

The data in Table 4 shows that in the 24 hour period (of the audit), 164 kg of food from across all participating schools was recovered (not sent to landfill) for composting either on-site or by an off-site facility. Multiplying this number by 180 school days per year to derive a rough estimate of how much food waste these 5 schools could divert from landfill in a year. These 5 schools combined could potentially divert approximately 30 tonnes of food waste from landfill in a year assuming a similar amount of food is segregated from the schools each day, on average.

Table 4 shows that between 21% and 65 % of the available food was being segregated on the audit day. This indicates that while the trial appears to have achieved some food recovery, there is an opportunity for better segregation (between 35% and 79% is being missed based on the audit data).

In order to make an assessment of the overall reach of the program if it was potentially rolled out, the food waste generated and the food waste segregated has been calculated per student per day and per year as seen in Table 5 and in Figure 10.

Table 5: Results from post-trial sorting of general waste and separated waste per student

School	General waste per student (g)	Food waste in general waste per student/ day (g)	Separated food waste per student/ day (g)	Food waste in general waste per student/ year (kg)	Separated food waste per student/ year (kg)
School A	79	84	33	15.1	5.9
School B	n/a				
School C	70	36	8	6.5	1.4
School D	168	44	9	7.9	1.6
School E	125	14	8	2.5	1.4
School F	252	101	66	18.2	11.9
Average (exc. School F)	**110**	**44**	**14**	**7.9**	**2.5**

Note there are approximately 180 days in an average school year in Western Australia

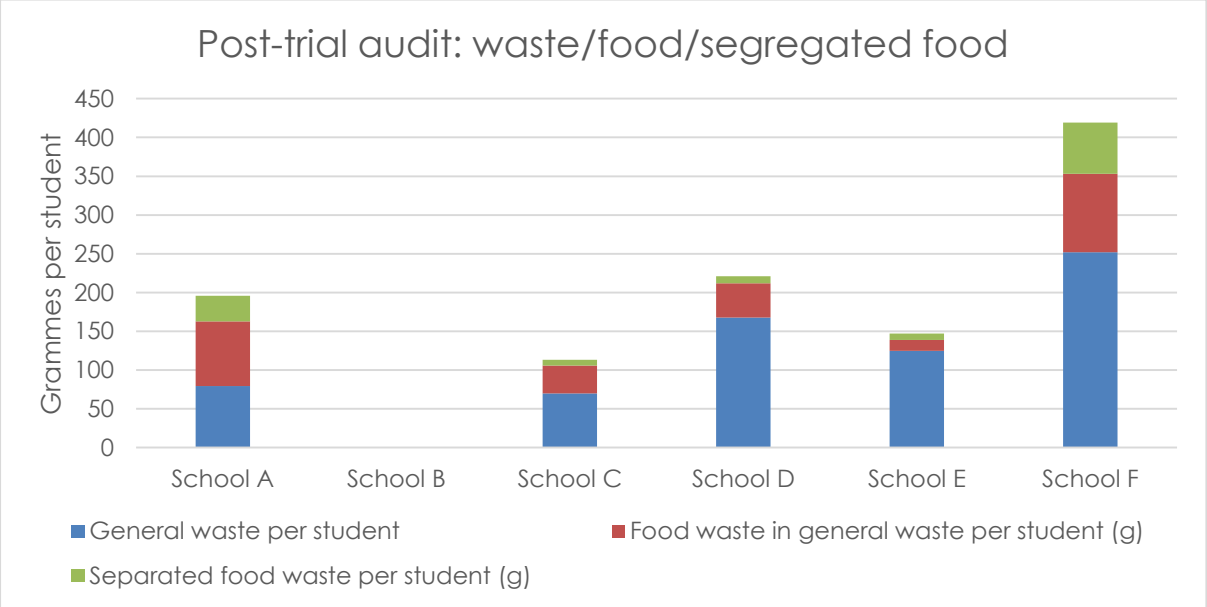


Figure 10: post-trial audit (physical sorting) of the general waste stream plus segregated food collected over 24 hours on a 'per student' basis

From this extrapolation of food waste generated per student per day to per year it is possible to estimate that if this program was rolled out to other schools and if those schools implemented it in a similar way that they could expect to divert approximately 2.5 kg of food

waste per student per year from landfill. Note that this is a very rough estimate based upon one day of audit data and a wide margin of error should be assumed.

4.2.2 Food waste volumes collected by waste service providers

School F placed food waste into 240 L bins for collection and transfer to off-site composting at a commercial facility. Data for the number of bins of food waste collected from School F were provided by the waste service provider (Suez). Note the data provided assumes full 240 L bins collected on each occasion and applies a standard conversion factor of 0.15 kg per litre. Data is provided in Table 6 (note that volumes and weights are conversions using standard factors based upon number of bins collected (whether filled or not). At the start of the trial, School B also sent food waste off-site for composting (for less than one month) but discontinued with their participation of the trial.

Table 6: Food waste collected from School F for off-site composting (data from Suez)

	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	TOTAL
Bins collected	17	32	7	35	25	22	**138**
Volume (m^3) (based upon full 240 L per bin)	4.1	7.7	1.7	8.4	6.0	5.2	**33.1**
Weight (t) (based on 0.15 kg/L)	0.6	1.2	0.3	1.3	0.9	0.8	**5.0**

School F completed data sheets to record the estimated volume of material collected in on-site bins before the bins were collected. This method of data collection has some inherent inaccuracy but was felt to provide at least a guide about the volume of food waste being diverted from landfill. Table 7 provides a summary of the amount of food waste collected during the trial period (estimated volumes have been converted to weights) and a comparison with reported weights (based on bin lifts) from the waste service provider (Suez). Given both sources of data have inherent limitations, it is interesting to see that the averages per week and per student (per day) are relatively similar. The data for total food collected is different as the data are for different time periods.

Table 7: Comparison of school datasheets with service provider data for School F

	Average per week (kg)	Total food (t) (for available data) [4]	Per student per day (g)
School F datasheets	171	2.9	26
Waste service provider data	191	5.0	29

[4] School datasheets only available from May to September. Service provider data obtained for May - October

4.2.3 Estimates of food waste processed on-site (schools data sheets)

The schools with Closed Loop machines on-site for the processing of food waste completed data sheets to record the estimated volume of material collected in on-site bins before the bins were emptied into the machines each day. This method of data collection has some inherent inaccuracy but was felt to provide at least a guide about the volume of food waste placed into the machines. Table 8 provides a summary of the amount of food waste collected during the trial period from each school with a machine (estimated volumes have been converted to weights).

Table 8: Summary of food waste collected from each school as reported in school datasheets

	Average per week (kg)	Total food (kg)	Total per student (g)	Per student per day (g)
School A	35	417	303	5.1
School C	26	410	387	4.8
School D	47	379	231	5.8
School E	50	349	301	8.6
Average	**39**	**389**	**305**	**6.1**

The data sheets may not have been completed totally accurately (estimating % of the bin filled is potentially subjective; different members of staff entered the information and sometimes information may have been missed). However, a rough guide to the extent to which the food waste was collected was obtained.

4.2.4 Annual data from waste service providers

The amount of general waste collected from schools before and during the trial is shown in Figure 11. A 4-period moving average has been included to provide an indication of the overall trend.

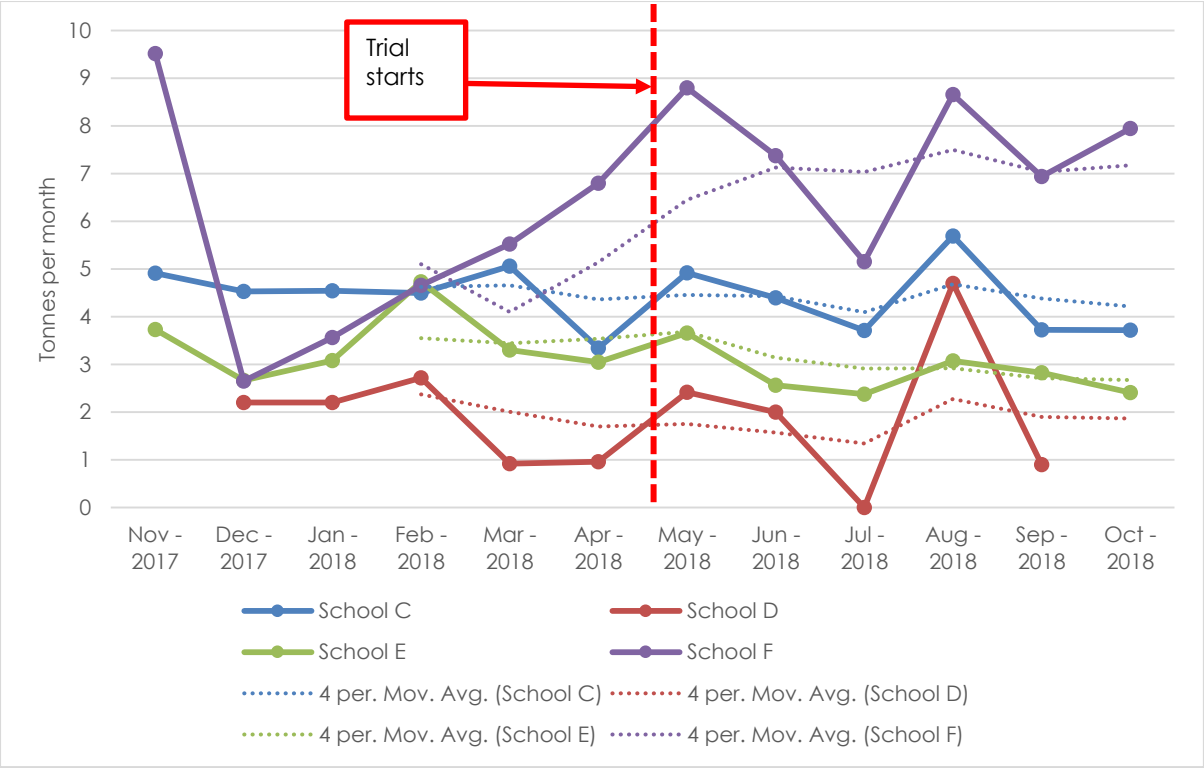


Figure 11: General waste (tonnes per month) before/during the trial period

There are 2 key observations from the data shown in Figure 11:

1. **No discernible trend before/after the trial**

   The food waste segregation trial did not impact upon overall general waste volumes collected. This is most likely due to the use of 3 m3 front lift bins which would still have been collected whether filled or not. Most school general waste data appears to show variability over the year but there is no clear trend. There is a slight dip in general waste volumes collected in June (the month following trial commencement) although the data is possibly not sufficiently detailed to draw firm conclusions about the impact of the trial on general waste generation

2. **General waste shows lower seasonality than anticipated**

   Given the highly seasonal nature of school activities, it is interesting to note that volumes of waste collected and invoiced are mostly consistent each month, even during the summer holidays (apart from a few notable outliers which may be data errors/anomalies).

4.2.5 Site visits: mid trial findings

The trial has been managed slightly differently at each of the six participating schools. The trial representatives within the schools have determined the locations of the food waste bins using the results of the baseline audits to identify the area's where most of the food waste was generated. The schools also chose the type of collection bins, who was responsible for collecting them, who was responsible for operating the machines or managing the contractor collection and how the message was communicated to the school community.

Information was collected during the site visit to each school about how the trial was being managed. Some of this data was also collected by Eco Change about barriers and benefits experienced to date in the trial. This information is summarised in Table 9. During the site visits, it was noted that some teachers were bringing food waste into school to compost in the Closed Loop machines (School D). This is a good outcome for diverting waste from landfill, but will impact upon the meaningful interpretation of the data.

Each of the schools involved in the trial has had a variety of barriers and benefits although there have been some commonalities. All schools have found the setting up of the trial to be time consuming in such ways as raising awareness, collecting bins and managing issues with the machines. All the schools see value in separating food waste for composting ongoing in some way or another (see Table 9). School B decided to withdraw from the trial half way through the year as the trial was found to be too time -consuming with not enough benefits to continue. School B stated that the benefits would have been increased for them if they had a composting machine rather than a food waste collection service. The school already had worm farms, composting systems and chickens at the school and wanted to use this composting trial to deal with the remaining problematic organic wastes. School B purchased smaller composting machines and started to use these for meat, bread and dairy scraps. The compost from the machines is then fed through the worm farms. The use of smaller machines may be an option for schools with small amounts of food scraps or where the machines are to be used in conjunction with other systems.

Table 9: Results of mid-way site visit at each school as reported by lead teachers/coordinators

School	Site visit date	Composting system	Bin numbers and locations	Collection managed by	Benefits to date	Barriers to date
School D	29th May 2018	Closed Loop machine	2 x 60 L bins in courtyard, 1 x 60 L bin in undercover area and 1 x 60 L bin in year 7 area. Schoolyard collection currently	Gardener	Teachers engaged and bring food waste from their homes. The bucket with the lid and hole cut has worked well, birds haven't been able to get to the food waste. The school is interested in exploring a novelty factor for the collection bins to attract the students. The canteen has a full food waste bin. It makes their general waste bin easy to handle. Gardener collects the buckets and takes out contamination. Not much contamination, just some plastic wrap. Not a burden just gets done with the yard clean after lunch.	The trip switch had been activated over a weekend so machine stopped. Bad smell and moisture built up and destroyed seals. School fixed it themselves but hard to access trip switch. Have to remove cover of the machine. Massive volume reduction of waste from the machine was unexpected. School wanted more product to use on gardens. 1st batch of machine by-product went to Baileys for testing, but the results were not received. Slowed the momentum of the program as they didn't want to advertise or use the product until it was confirmed that it was safe to use.
School C	31st May 2018	Closed Loop machine	10 bins in school yard, 2 kitchen caddy's in Home Economics room	Intensive English program	Intensive English Program students currently doing collection and they are very conscientious about it.	At first, integrated science students were collecting food waste bins but weren't consistent with the process

			and 1 caddy in canteen Schoolyard collection currently	students plus teacher	Contamination easy to remove. Easy to raise awareness through daily notice sheets. 15th June minister Dawson launched program at the school.	During the first week the cord on the machine got wet and trip switch set off. The switch is behind a panel so had to get a technician out which took time and cost the school money. Also had to make the flue pipe longer as the odour although not offensive is intense and was problematic. Issue with cleaning bins as no water where machine is located. Some contamination (plastic bags or wrap).
School A	11th June 2018	Closed Loop machine	18 x 60 L bins in external areas and 17 x small bins in staff office areas Schoolyard collection currently	Year seven science class plus teacher and lab technician	Commercial kitchen, and home economics department all on board. Use product from the machine on school grounds. Easy to inform through year assemblies and daily notices Haven't communicated to parents yet but there is evidence that kids are telling their parents. Bins get left out all the time and no issues with birds etc.	There has been a mixed response to the program in the school. About half the students are engaged. Most have needed reminding about the right bins to use. Is time consuming. Logistics hard for the science teacher whose class is responsible for collecting the food waste bins. Rain is an issue with outdoor bins. Staff/students have to tip water out. Use bin liners - have been getting them for free from the council but would be an expense if the school had to buy them.

					Is hard to measure now how effective it is but it is part of a bigger push in school, all initiatives support each other. They were expecting more contamination than the small amount they actually get. Some plastic in 3 or 4 bins each time. Easy to remove.	Some bins have nothing in them when collected.
School F	2nd Aug 2018	SUEZ collection	7 x 120 L bins collected weekly 120 L bins used in dining rooms 60 L bins used in kitchen No schoolyard collection	Cleaners plus Facilities Manager	Staff are really positive and want to help. The school is establishing an environmental committee and will eventually get student representative council involved. The trial has opened people's eyes, they are going back to real plates in dining room, biodegradable take away containers, ordering keep cups for all staff for 95 year celebration. Great potential for the school to save money.	Took a couple of weeks to train and remind kids but now not much contamination at all (kitchen and boarding staff stood near bins). The Facilities Manager is not directly involved with students so at this point there are no food waste bins around the schoolyard.
School E	6th Aug 2018	Closed Loop machine	8 x kitchen caddy in each department 2 x 10 L bins in Home	2 x Lab techs – and some	Plan to have students name machine to create some engagement.	Had difficulties with machine so far. Machine got wet and has been out of operation. The machine had only been

			Economics room, 1 x 20 L bin in the canteen and 1 x 20 L bin in the staff room. No schoolyard collection	student volunteers		running 2-3 weeks at the time of the site visit. The program is time consuming so far Contamination has been an issue. Students are not involved yet.
School B	20th Aug 2018	SUEZ collection	1 or 2 x 120 L to SUEZ per fortnight No schoolyard collection (trialled for one month)	Horticulture/ Education Support teacher	Lots of maths lessons could be integrated for Education Support students. As a result of lessons learned as a part of this trial the teacher has purchased a small food waste dehydrator to process bread and meat etc. so processed product can be added to compost.	The school has decided to pull out of the trial. There is a lot of contamination in the bins. Prior to the trial the school was already doing a lot to divert food waste from landfill. The school needed something to complement and not compete with the existing composting systems. The trial had taken food waste away from chickens and worm farms. Hard to split the waste as still want veg scraps for chickens. Staff stopped bringing in scraps from home as didn't want to affect new system. By food waste going off-site, there was no product to see at the end. Students can't see where food waste goes. The trialled approach is time consuming.

						Education support students were collecting the bins and it was taking them at least an hour every afternoon People not supportive. Tried to have the collection bins in schoolyard for one month, but they got damaged and not used appropriately. The teacher suggests that in future it should be mandatory to speak to and engage all staff at the beginning of the project. Main contact for the trial is isolated in Ed Support and no teacher in main school was involved who sees most of the students. Need a team of people who see majority of the kids.

4.3 Where is food waste generated in the participating schools?

Ten locations around each school which produced the most food waste were identified and shared with each school to enable them to determine appropriate locations for collecting food waste. The locations varied from school to school but all schools found that the canteen and home economic areas were in the top producers of food waste. At School F, the boarding house dining rooms were the major source of segregated food waste.

Some schools chose strategic locations to start collecting food waste, i.e. from the highest producing areas, at least initially. While others placed bins all around the school.

During the physical sorting of waste (audit) before and after the trial, the bin location identifiers were noted to allow a clear determination of the highest food generating areas. Unfortunately, the schools all moved external bins around during the trial which prevented meaningful data from being obtained.

However, it was possible to identify that bins in kitchen, canteen and home economics areas gathered the majority of food waste while other bins around the school were not particularly successful.

4.4 Was contamination of segregated food waste a problem?

Information from the school data sheets provide an overview of the contamination observed in the food collection bins (see Table 10.) While contamination was present in less than a quarter of instances, the data may simply not always have been recorded. Note that School D did not record contamination instances. The data does not always make it clear whether the contamination was serious or not, however during mid-trial site visits, a number of the schools mentioned that the contamination could be easily rectified by simply pulling the material out of the food before composting.

Table 10: Contamination recorded on school data sheets

	Bins collected	Contamination issues noted	Percentage of instances
School A	860	109	13%
School C	281	65	23%
School D	207	Not recorded	n/a
School E	205	33	16%
School F	262	39	15%

Some schools provided a guide as to the nature of the contamination. At School E, the contamination found was relatively minor and included fruit stickers, napkins and tea bags.

During the physical sorting audits of the food waste, the types of contamination found included:

- Cling wrap (often with food inside it)
- Plastic sandwich bags (with and without the food inside them)
- Tins from the school canteen
- Chocolate bar wrappers

While there is clear evidence of contamination that should be addressed through delivery of clear messages, the schools reported that contamination was not a significant issue and could generally be removed from the food prior to emptying into the Closed Loop machine. The waste service provider responsible for removing the food waste from School F for off-site composting was unable to comment on the level of contamination as the food material was tipped directly into a collection vehicle.

4.5 Quality of compost generated by Closed Loop machines

Before being able to proceed with the trial beyond the first batch of compost, the schools had to wait for results from testing of the product to confirm that compost was suitable for use on school grounds. This testing was conducted by Baileys. The results can be seen in Appendix E.

The compost product from all schools had a relatively low pH (<pH 5.0) which is quite acidic (pH 7.0 is neutral). All schools produced a compost that was rich in nitrogen and carbon but had slightly high levels of phosphorus and electrical conductivity indicating the presence of salts. There was some concern from schools about pathogens or the presence of contaminants. However, the compost testing showed that the product was safe to use as a soil amendment however it was recommended that it be mixed with soil and used 4 L/m^2 for sensitive plants and 16 L/m^2 for less sensitive plants.

Unfortunately, there was some miscommunication and results were not shared with the schools in a timely manner. This caused some issues as schools were understandably reluctant to widely publicise the trial, start educating and engaging the students or use the product until they were confident that it was safe to do so. This led to some loss of momentum in getting the trial running at several of the schools.

4.6 School attitudes and understanding of food waste

4.6.1 Does the school community care about diverting waste from landfill and understand why it is important?

In order to gain some insight into the attitudes of the school community toward food waste several questions were asked in the both the pre-trial and post-trial surveys. The first question asked if the respondent thought that food waste going to landfill was a problem. A high proportion (77% pre-trial and 73% post-trial) of the respondents replied that this was a problem. However, 16-17% responded that they were unsure both before and after the trial (Figure 12). The lack of measurable change in converting respondents who were uncertain about the problems associate with food in landfill indicates that the introduction of the food waste collection and composting systems did not contribute in any significant way to raising the awareness that food waste going to landfill is a problem. However, these results do indicate that there was a high level of awareness of the problem within the schools without any intervention. This is an ideal starting point for a program such as this one. The sample population are aware of the problem and are also willing to do something about it (see Figure 12).

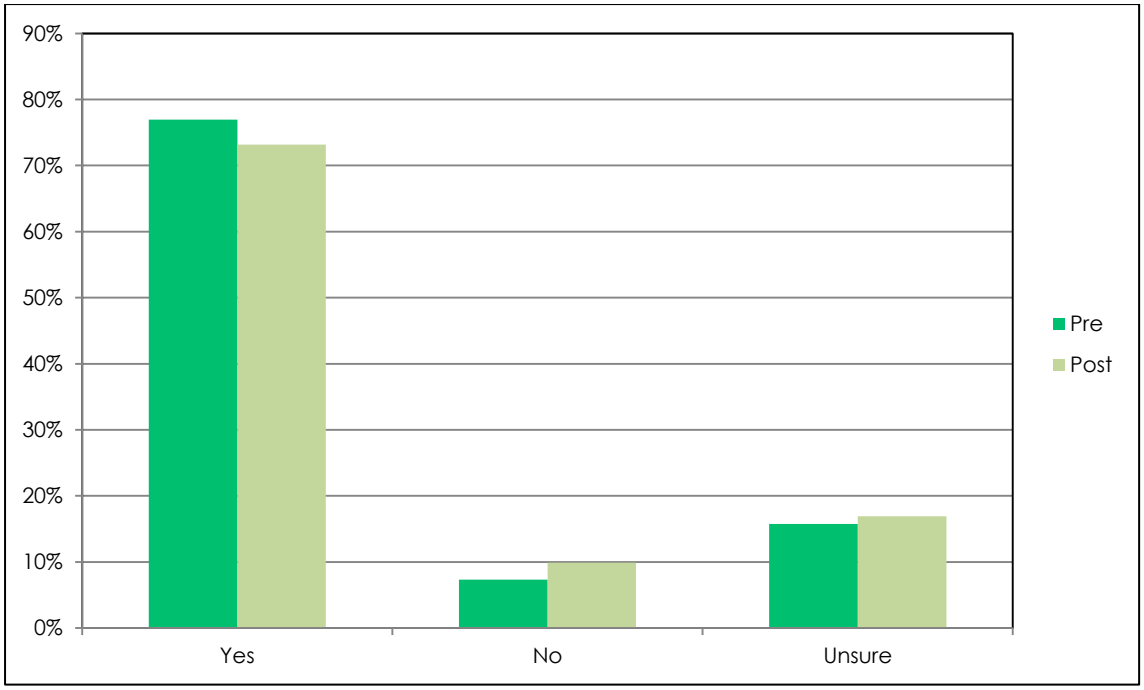


Figure 12: Food waste from your school currently goes to landfill. Do you think this is a problem?

Those who did say that food waste going to landfill was a problem were asked to choose responses which explained why it was a problem. The three responses which were the most popular can be seen in Figure 13: Why do you think food waste going to landfill is a problem? These responses were not ranked in order of preference. The top three responses were chosen by 65% to 76% of respondents. The three most popular responses became slightly more popular after the trial which may indicate a focus of teaching around these areas, particularly relating to climate change impacts of food in landfill which rose from 67% to 76% selection.

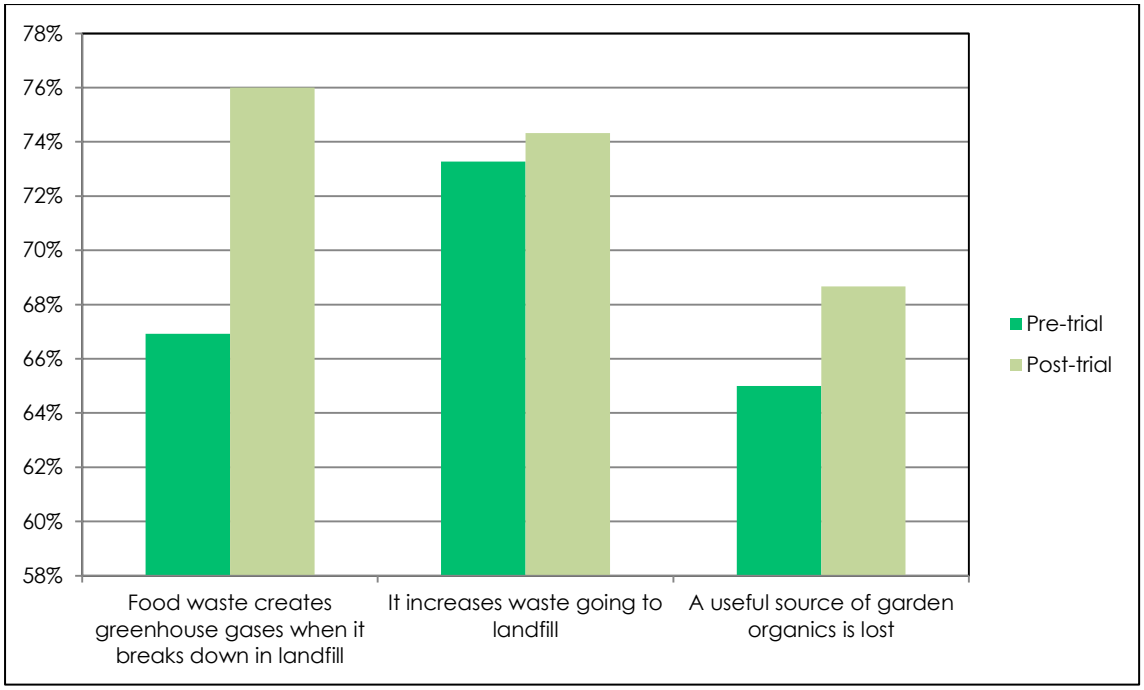


Figure 13: Why do you think food waste going to landfill is a problem?

Before the trial about 90% of respondents indicated a willingness to use a separate food waste bin at school if one was available in order that food waste could be composted at school. However, after the trial, about 41% of students responded that they sometimes or 33% always used the separate food bins (Figure 14). This indicates that while there is a willingness to do 'the right thing', this does not always lead to behaviour change. Note that these responses are self-reported and we are not able to test whether all respondents who indicated that they used the bins actually did use them.

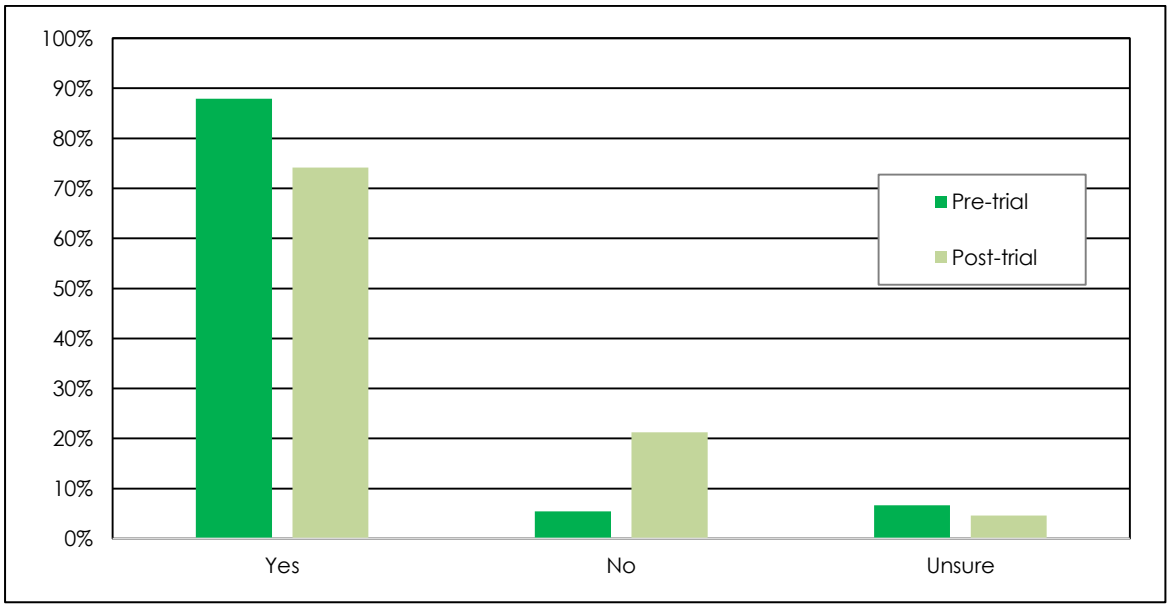


Figure 14: Would you/did you put your food scraps in a separate bin to be composted at school?

Of the 82 (out of 689 pre-trial) and 35 (out of 414 post-trial) respondents who said they were unsure or that they would not put their food scraps in a separate bin, the most common response as to why was that it would be too hard to do so. About 77% pre-trial and 66% post-trial respondents chose this answer (Figure 15). The idea that the bins would be smelly or dirty was not as much of a concern. Although only a minority of total respondents said they would not use food waste bin because it was too hard. This highlights the need to ensure that the bin systems are easy to use and attractive. This includes both the types of bins and openings but also the location of these around the school.

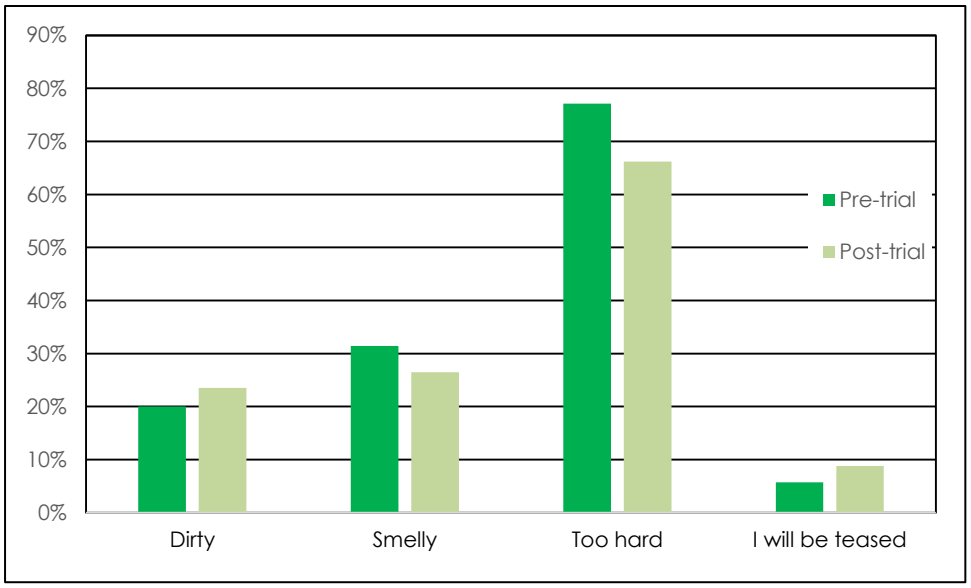


Figure 15: Why would you choose not to use a separate food scrap bin?

In summary, although a high proportion of respondents think that it is a problem to send food waste to landfill, a proportion of these don't always use the right bins because it is too hard to do so.

4.6.2 Do the schools involved know how to use the systems effectively?

Before the trial began the schools were asked if they knew what kinds of waste were going to be collected and composted. The answers received show a high level of understanding of what types of waste can be composted generally (Figure 16).

All of the options to choose in this question except for plastic are organic wastes which are compostable in ideal conditions. In general however bones, meat, dairy and bread can be problematic in small scale composting processes so are often avoided. On the other hand paper and cardboard can be used in small scale composting processes to balance the process. With the Closed Loop system it is recommended to avoid placing paper and cardboard within the machines but they are ideal for composting small bones, meat, dairy and small amounts of bread. It is interesting to note here and assume that it is for the before mentioned reasons that responses for including bones, meat, dairy and bread and excluding paper and cardboard changed over the period of the trial. It is possible that that this is due to teaching about the nature of which foods can be composted.

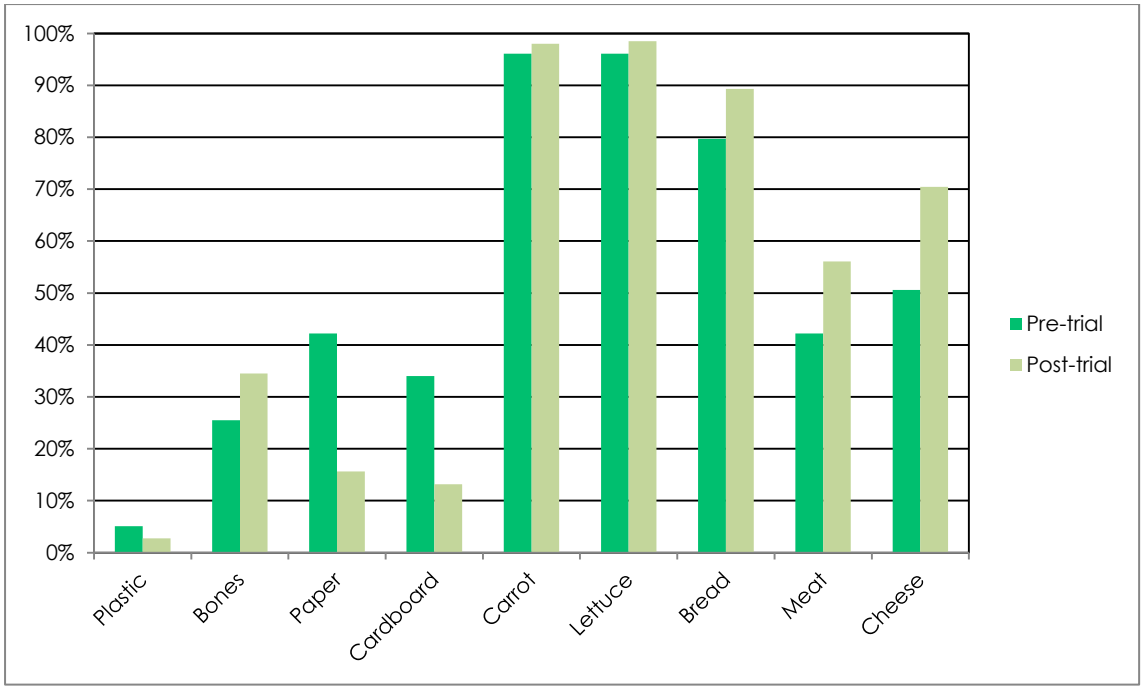


Figure 16: What do you think can go in the compost collection bins?

4.6.3 Were the collection bins effective?

All the schools used a different mix of collection bins. Overall the bins have been useful to date however there has been a couple of recommendations for improvement. School D are interested in designing a more engaging bin system which would attract students to use it. They are finding that although some students are using the bins correctly there is still a lot of food waste being missed as it is still being put in the general waste bins. School A has had some issue with the bins in the rain filling with water and all the schools mentioned that the bins are being moved around so they can't always be found in the same place when looking for them.

4.6.4 Were posters and stickers effective?

Not all the schools have used the posters. This has been for a variety of reasons such as students not being involved in the trial yet, nowhere to place the posters close to where the bins are located and the posters have not been given to the main contact person.

During the site visits all schools made comment about how the students need to be educated and reminded ongoing about what should be put in the food waste bins. The bin stickers and posters were not enough to communicate this. The other methods used by the schools which involved students in the separation of the waste (School A, School C, School D and School F) at the time of the site visits, were through daily notices and also staff supervision near bins telling students which one to use.

In the post-trial survey respondents were asked how they knew what to put in the food scrap bins. The responses, as seen in Figure 9, show how important the bin stickers and labels were in informing the participants about what items can go in the food scrap bins. The next two most common responses were school notices and reminders and the teachers supervising and reminding.

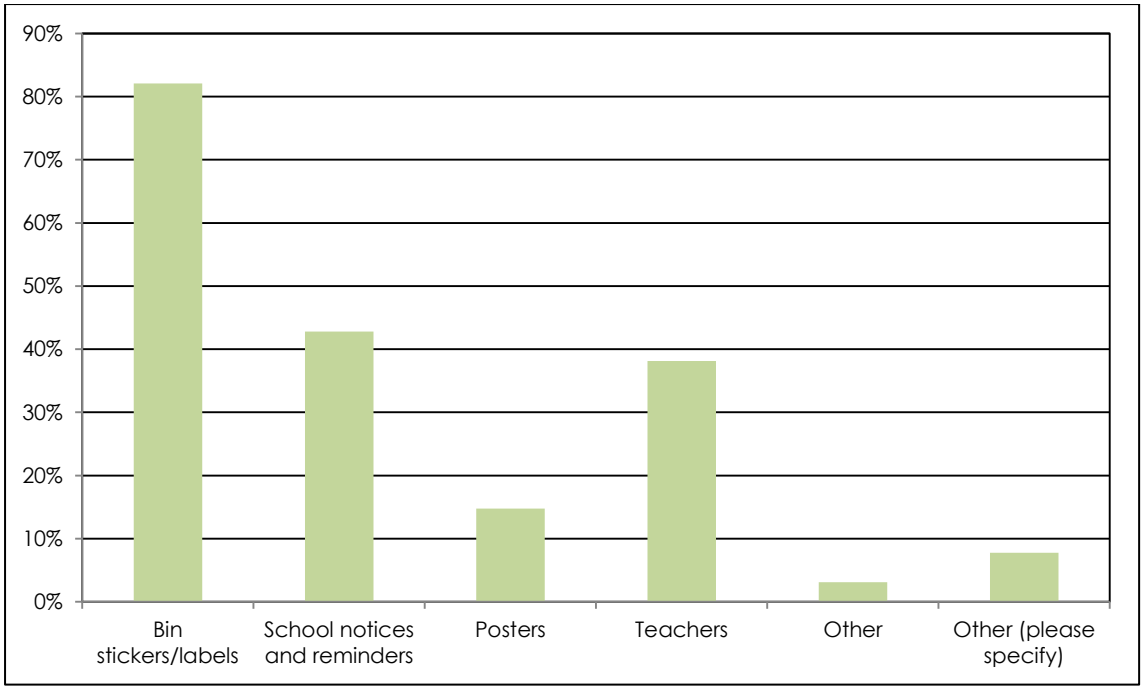


Figure 17: How do you know what to put in the food scrap bins?

4.6.5 Did the trial impact upon behaviour outside school?

Through the surveys, the school communities were asked what they did with their food waste at home (see Figure 18). In the pre-trial survey the majority of respondents said that they put their food waste in a general waste rubbish bin at home. Interestingly around 35% of respondents said they composted food scraps at home and around 10%-20% fed food scraps to chickens or worm farms. After the trial, a slightly higher proportion said that they put food in the rubbish bin (72% compared to 66% pre-trial). This is likely to indicate that there is no measurable difference in behaviour, but simply that the observed difference is within the error margin for this dataset. There were fewer survey respondents after the trial and it is possible that some pre-trial respondents who did not dispose of food to landfill were not captured during the post-trial survey.

There is some anecdotal evidence from at least two of the schools that teachers have started bringing their food waste from home into school to place in the compost collection bins there.

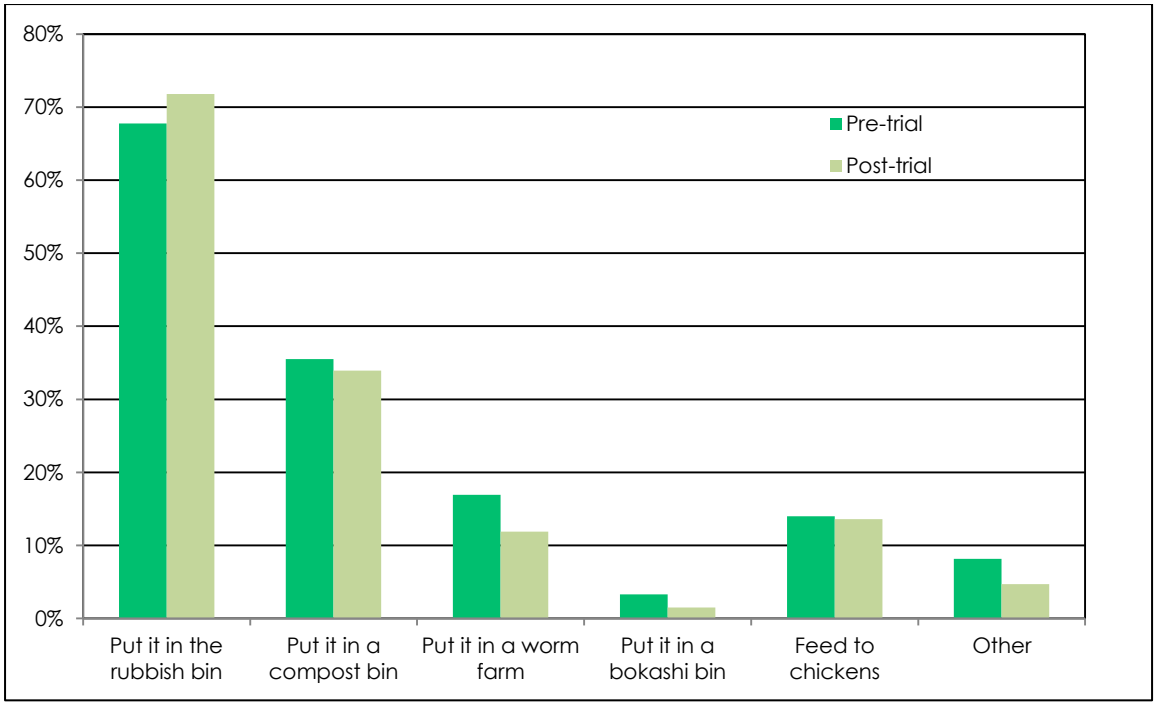


Figure 18: What do you do with your food waste at home?

5 Conclusions and Recommendations

5.1 Main findings

This evaluation has identified some key findings:

- Compostable food waste is a significant proportion of the general waste stream at the trial schools (between 27% and 36%).
- Recovery of food waste was measurable but not significant (apart from at School F which operates a commercial kitchen for boarding students). High schools probably do not represent the best opportunity for food waste diversion in simple tonnage terms (compared to food service or food retail industries[5].
- All schools which completed the trial have changed their waste management practices and are composting food scraps as a result. All of the schools could do more to capture a higher proportion of the food scraps from the general waste.
- Food waste is mainly generated from the canteen and home economics areas. These areas also happen to be the food waste generation areas within each school that have a high level of adult involvement and supervision over the bin collection areas.
- The school with the greatest diversion of food waste (both in total tonnage and percentage terms) was the boarding school preparing and serving meals on site from a commercial style kitchen. Diversion from schools without on-site kitchens was low by comparison.
- Before the trial started there was already a high awareness among staff and students that sending food to landfill is problematic. This indicates that schools are ready to start addressing this waste stream. The trial did not increase this awareness among the participating schools.
- There was a relatively high reported willingness to separate food waste into a different bin from general waste and this was broadly observed in the reported actual use of bins during the trial (88% reported initial willingness and later 74% reported actually using bins) Almost 90% said they would use the food scrap bins but only 30% used them always and 40% sometimes.
- The amount of resources required to establish and manage the trial program in some schools was reported to be high and may present a potential barrier to successful implementation elsewhere unless the staff are extremely engaged in the process.
- The process of setting up the Closed Loop machine, fixing issues, testing the compost product and engaging the students was reported to take longer than originally anticipated by some schools and may have caused some loss of momentum with participation in the trial.
- Several schools thought a benefit of the machines would be using the final product on their school vegetable gardens. The low volume of compost product and the delay

[5] Department of Sustainability, Environment, Water, Population and Communities (ESEWPAC) C'wealth: Encycle & SRU Consulting (2013) *A study into commercial and industrial (C&I) waste and recycling in Australia*. www.environment.gov.au/system/files/resources/91b2180c-b805-44c5-adf7-adbf27a2847e/files/commercial-industrial-waste.pdf

due to late delivery of testing results, has meant that the schools were unable to use the product in the way they had planned.

- All the schools with the composting machines expressed a desire to use the machines to explain how composting of food scraps and using them back on a garden was a demonstration of the cycle of nutrients. The delays in compost result delivery and also the small volume of compost produced compromised their ability to achieve this outcome within the trial period.
- The laboratory assessment of the compost product from the Closed Loop machines for quality and composition found that while the product had good nutrient value, it had a pH less than 5 (i.e. was quite acidic) and contained salts and phosphorous levels that could be damaging to some plants. The laboratory recommendation was that the product material was mixed with soil or other compost prior to addition to the soil. However, it is not clear that the schools were made sufficiently aware of this requirement and may have inadvertently added the material directly to their soils.
- Contamination has been an issue at some schools and not at others. The contamination (if any) has been easy to remove and is not as much of an issue as was anticipated prior to trial commencement.
- There has been a mixed response to the trial from students across the schools which have included schoolyard collection bins so far. Students have possibly not been sufficiently engaged in understanding the outcomes from segregating food waste to appreciate why they should use these bins.
- Identifying the correct technology (i.e. machine or collection) for food waste processing can be important in the success of the program for individual schools.
- Given that the capacity of the Closed Loop machines is 20 kg per day or 100 kg per week (See Section 2.6) the machines were mostly under-utilised.

5.2 Additional findings (not directly part of this scope)

The purpose of the waste audits was only to identify the quantity of food in the general waste stream and which locations generated the most. The food waste mostly consisted of fruit peelings/cores and uneaten or partially eaten sandwiches/rolls. During the waste audit process the auditors observed some issues anecdotally that may require further investigation beyond this trial.

The findings and opportunities to achieve reduced general waste from schools are provided in Table 11 (other observations about positive findings (not related to this scope) are included here).

Table 11: Summary of additional findings and opportunities identified through this project

Finding	Opportunity
Anecdotal evidence of high volumes of recyclables in the general waste stream including paper and commingled recyclables	Potentially significant volumes of material could be captured through the implementation of standard recycling systems for paper in classrooms and containers in kitchens
Reusable drinks bottles and lunch boxes in the general waste	Engage students in waste avoidance and reuse messages
Unopened, out of date food from the canteens	Implement waste avoidance measures in addition to composting (move up the waste hierarchy)
The awareness-raising impact of the trial caused one school (School F) to move away from single-use plates, back to washable crockery	Develop the themes associated with this trial and implement broad education and awareness raising to both staff and students in participating schools to empower them to deliver beneficial outcomes at their school.

5.3 Recommendations

Considerations for successful implementation

This type of program can achieve an optimal outcome if the following factors are incorporated:

Communication

- Relevant staff are engaged including informing all staff at whole school staff meetings and then supporting the specific staff running the program
- Provide the schools with a consistent education package including teaching materials so that waste hierarchy and resource efficiency messages can be incorporated into the curriculum easily
- Encourage schools to develop awareness raising activities to promote the program.
- Students understand what is needed and are involved in decision making around the program

Implementation

- There is a focus on food generating areas such as home economics and the canteen first.
- The key benefit of the Closed Loop machines is the opportunity to demonstrate the link between food and composting (nutrient cycle). If schools have a collection rather than compost on site this is harder to demonstrate but perhaps schools could organise excursions to a composting facility to see the process.
- To avoid contamination: a) provide a clear messaging strategy and b) provide a general waste bin alternative at the same location as food bins.
- To optimise collection of food, limit the number of bins placed throughout the school grounds to the high generating areas (canteens and home economics classes) so that the logistics of managing the collection does not outweigh the benefits of the program.

Optimising the outcomes

- It is recommended that a cost benefit analysis is undertaken to determine if the volumes of food waste diverted from school general waste is a sound justification of the costs of leasing machines and bins to inform the decision about extending this program
- Should the program be found to be a viable option, other solutions for the processing of food waste should be considered (alternative machines/off-site processing) to provide flexibility for the schools involved to meet their specific needs.
- It is crucial to engage more fully with the student body to ensure that the opportunities for awareness raising, educational outcomes and behaviour change are maximised.
- Ideally, other (more standard) recycling and waste reduction initiatives should probably be implemented prior to commencing food waste collection to minimise the general waste stream (to landfill) and raise awareness/educate staff and students starting with the easy wins. The benefits of recycling can be more easily achieved (than through a food segregation system) and this will start the engagement process staff and students about recycling before expecting them to tackle more complex waste streams (such as food waste).

5.4 Summary

Overall, this trial was successful at delivering a reduction in waste to landfill from the participating schools. The volume of food material diverted from landfill from most participating schools was minimal compared to the school with a commercial-style kitchen. While there is always benefit in implementing food waste reduction schemes, the volume delivery in most high schools make this program hard to justify unless there is a clear educational element.

Implementation of a food waste recovery program in high schools would be a meaningful part of the educational curriculum in enabling schools to demonstrate the practical considerations and benefits of food waste segregation. Greater success would be achieved through optimising the recovery of 'standard' recyclables from schools (paper and containers), engaging with teaching staff and other relevant stakeholders within the schools (e.g. kitchen staff), providing teaching materials to enable schools to deliver clear educational outcomes and ensuring that schools are fully aware of the use and also the limitations of the composted product.

Appendix A: Waste physical sorting audit photos

Pre-trial audit

Pre-trial audit

Post-trial audit

Post-trial audit

Figure 16: School A physical waste audit

Pre-trial audit

Figure 17: School B physical waste audit

Pre-trial audit

Post-trial audit

Pre-trial audit

Post-trial audit

Figure 18: School C physical waste audit

Pre-trial audit

Post-trial audit

Figure 19: School D physical waste audit

Pre-trial audit

Post-trial audit

Figure 20: School E physical waste audit

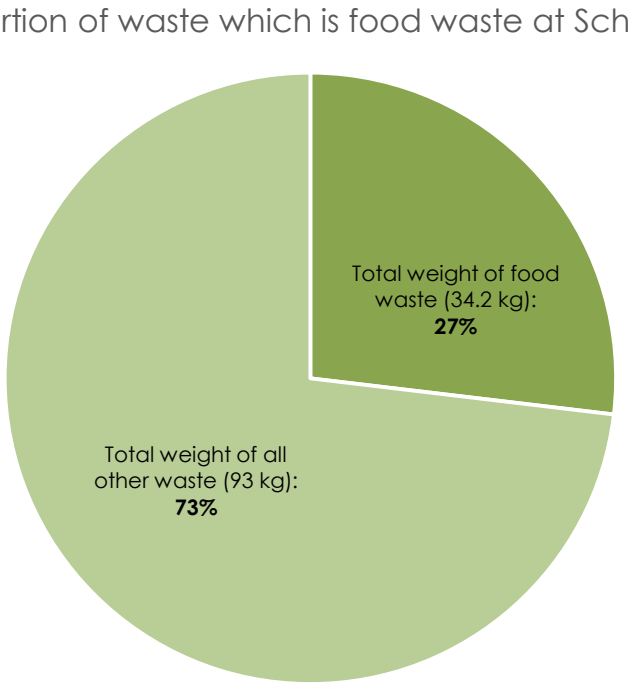
Pre-trial audit

Post-trial audit

Figure 21: School F physical waste audit

Appendix B: Results from physical waste audits

School A	
Date: Wednesday 24th May 2017	24 hour period
Regional public high school	1352 students



Total percentage of food waste: 26.8%

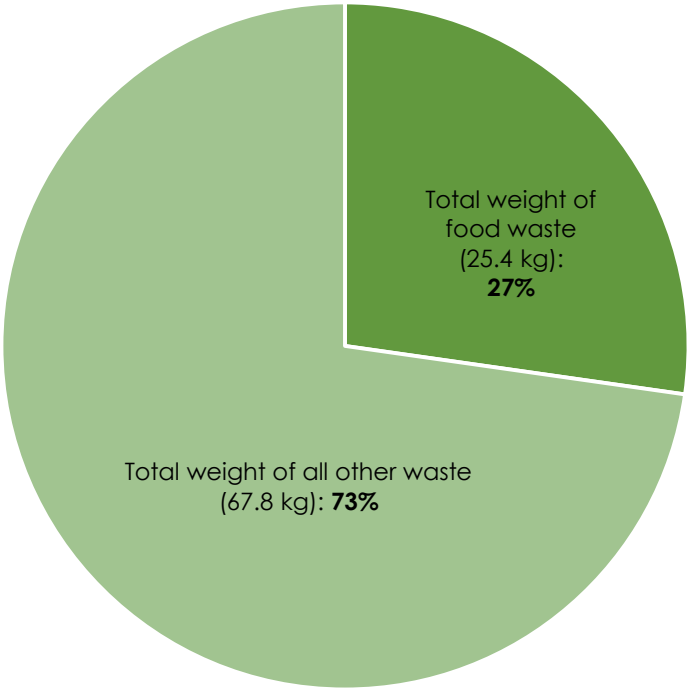
Areas with highest weight of food waste	
Area	Weight (kg)
Outside kitchen	7.0
Outside egrit wing	5.0
Ext back of gym	3.5
A6 outside English	3.2
Back of gym	1.3
Outside front perf. arts	1.2
Centre quad	0.9
Grass back of HASS	0.9
Gazebo back of math	0.8
Outside art	0.8
Total food waste	17.8

Areas with the highest % of food weight	
Area	%
Outside egrit wing	59.8
Outside front perf. arts	51.7
Outside perf. arts	51.7
Staff room	50.0
Ext back of gym	49.6
Outside kitchen	49.6
Back of gym	49.1
Gazebo back of math	48.5
Outside art	45.7
A6 outside English	45.1

*Please note areas with highest percentages of food waste in a bin are included here to show areas where segregation may be easier to achieve.

School B	
Date: Wednesday 17th May 2017	24 hour period
Metropolitan public high school	845 students

Proportion of waste which is food waste at School B



Total percentage of food waste: 27.31%

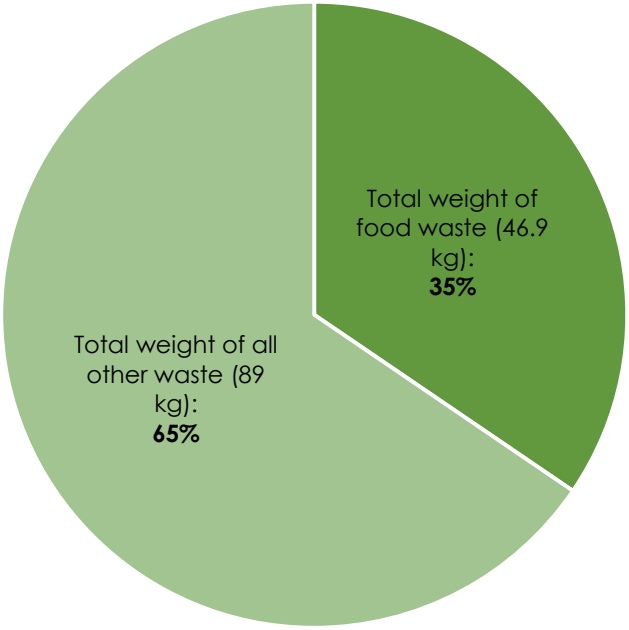
Areas with highest weight of food waste	
Area	Weight (kg)
Math food prep	3.4
Technology	3.3
Math	2.5
Humanities	1.9
General	1.2
Gym/toilets	1.0
Technology	0.9
Humanities	0.8
Perform. arts	0.7
Home Economics	0.7
Total food waste	16.5

Areas with the highest % of food weight	
Area	%
Technology	100.0
Math food prep	81.9
Gym/toilets	66.7
General	64.9
Home Economics	58.3
Perf. arts	50.0
Math	49.5
Science	38.9
Admin including toilets	38.1
Humanities	35.8

*Please note areas with highest percentages of food waste in a bin are included here to show areas where segregation may be easier to achieve.

School C	
Date: Thursday 18th May 2017	24 hour period
Metropolitan public high school	1071 students

Proportion of waste which is food waste at School C



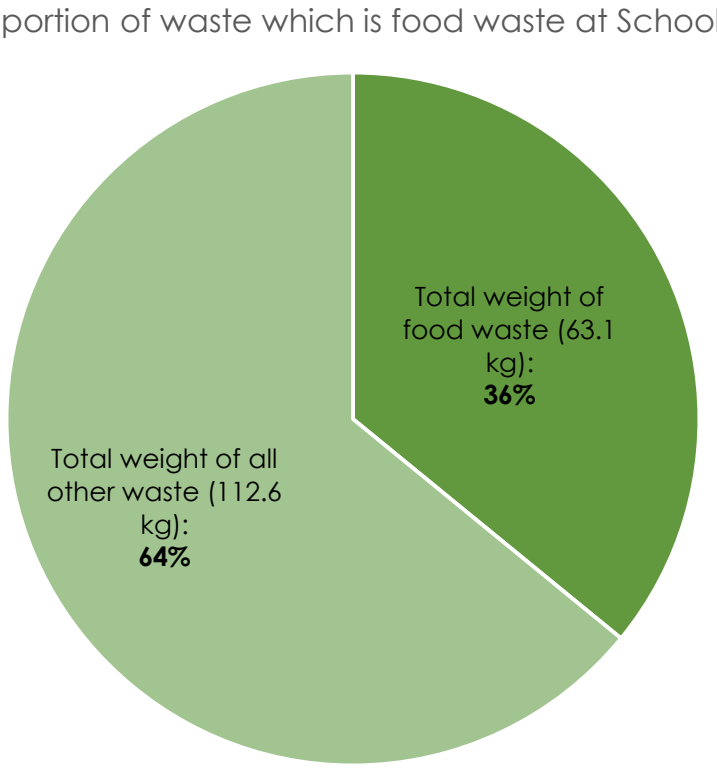
Total percentage of food waste: 34.5%

Areas with highest weight food waste	
Area	Weight (kg)
Exterior canteen	5.9
Canteen	5.0
Canteen	2.1
Economics	4.8
Home Economics	4.7
IEC	2.6
IEC	1.7
IEC	1.5
Courtyard 1	1.6
Basketball	1.6
Total food waste	31.8

Areas with the highest % of food weight	
Area	%
Economics	80.0
Home Economics	69.8
IEC	69.7
Home Economics	62.9
IEC	59.0
IEC	58.0
IEC (internal)	57.0
IEC	54.5
Firepit	55.5
Canteen	54.9

*Please note areas with highest percentages of food waste in a bin are included here to show areas where segregation may be easier to achieve.

School D	
Date: Tuesday 23rd May 2017	24 hour period
Metropolitan public high school	1597 students



Total percentage of food waste: 35.9%

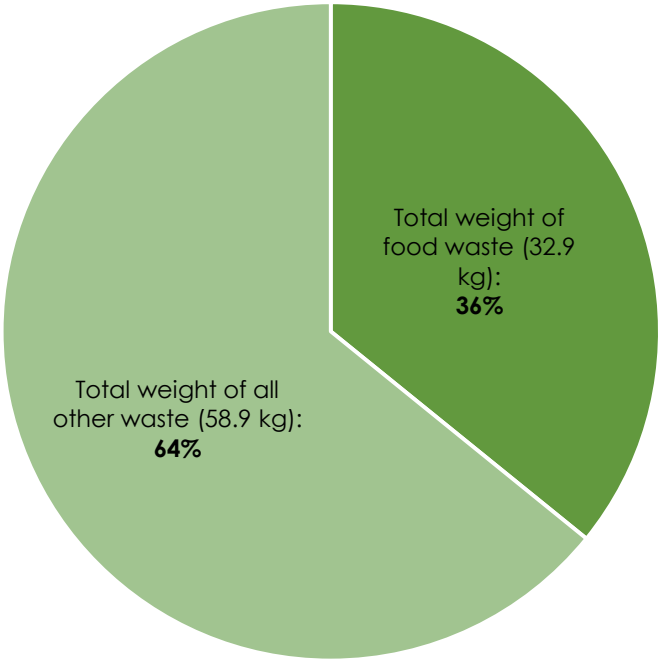
Areas with highest weight of food waste	
Area	Weight (kg)
F block	4.3
Home Economics	3.8
Main quad	3.0
F block	3.0
Ellen St theatre	2.8
Main quad	2.7
Main quad	2.6
F block	2.6
Main quad	2.6
Main quad	2.6
Total food waste	30.3

Areas with the highest % of food weight	
Area	%
F block	100.0
Theatre	70.4
Home Economics	69.1
Main quad	63.9
F block	60.4
Main quad	60.4
F block	58.9
Main quad	50.9
Main quad	53.6
Main quad	48.2

*Please note areas with highest percentages of food waste in a bin are included here to show areas where segregation may be easier to achieve.

School E	
Date: Friday 19th May 2017	24 hour period
Metropolitan public high school	1146 students

Proportion of waste which is food waste at School E



Total percentage of food waste: 35.8%

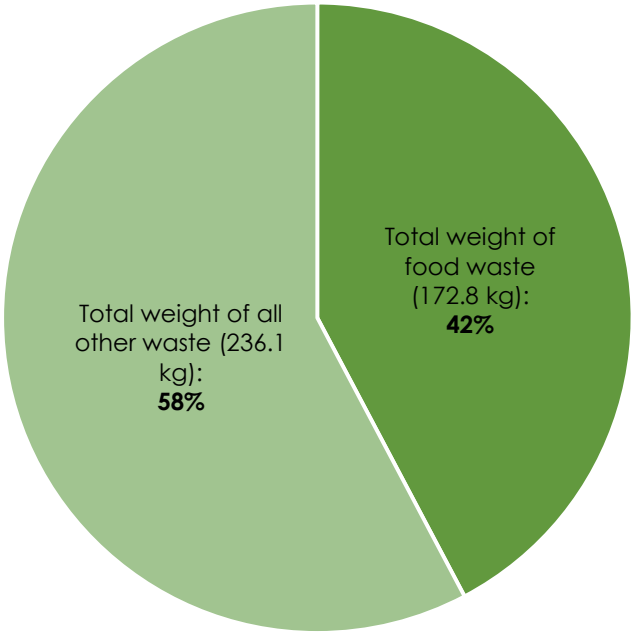
Areas with highest weight of food waste	
Area	Weight (kg)
Front lawn	2.0
Home economics	1.7
Front lawn	1.3
s/s	1.2
103	1.1
Home economics	1.1
406	1.1
Home economics	1.1
Canteen quad	1.1
Outside internal	1.1
Total food waste	13

Areas with the highest % of food weight	
Area	%
Outside internal	73.3
Home economics	68.0
Front lawn	65.8
Front lawn	63.5
Home economics	62.2
103	58.9
406	57.8
Canteen quad	56.4
S/s	53.2
Home economics	50.0

*Please note areas with highest percentages of food waste in a bin are included here to show areas where segregation may be easier to achieve.

School F	
Date: Friday 31st May 2017	24 hour period
Metropolitan private high school	1300 students

Proportion of waste which is food waste at School F



Total percentage of food waste: 42.3%

Areas with highest weight of food waste	
Area	Weight (kg)
Boarding/dining	22.1
Kitchen	18.6
Boarding/dining	7.9
Boarding/dining	7.2
staffroom	6.3
M3, M4, M5	6.2
AFL oval	5.6
Boarding House	5.5
staffroom	4.2
Residential	4.2
Total food waste	87.8

Areas with the highest % of food weight	
Area	%
Boarding/dining	100.0
Boarding/dining	86.7
Kitchen	84.4
Boarding/dining	83.9
Boarding/dining	83.2
Boarding/dining	76.6
Canteen	68.5
Kitchen	68.1
Kitchen	66.7
Staffroom	65.0

*Please note areas with highest percentages of food waste in a bin are included here to show areas where segregation may be easier to achieve.

Appendix C: Survey questions

Your school has been selected to trial a food waste composting system, either electronic composters or a food waste collection.

The following survey contains a number of questions to gather information about how people feel about food waste in schools. The survey will take approximately 5 minutes to complete.

Please answer honestly. There is no right or wrong answer. All answers are anonymous.

1. Which school do you attend/work at?

- School A
- School B
- School C
- School D
- School E
- School F

2. Please select your gender

- Male
- Female
- Other

3. Are you a student/teacher/other staff?

- Student
- Teacher
- Canteen staff
- Gardener
- Cleaner
- Other

4. Which year level are you in?

- 7
- 8
- 9
- 10
- 11
- 12
- N/A

5. Food waste from your school currently goes to landfill. Do you think * this is a problem?

- Yes
- No
- Unsure

6. Why do you think food waste going to landfill is a problem? (Choose as many responses as you need to)

- Food waste creates greenhouse gases when it breaks down in landfill
- It increases waste going to landfill
- A useful source of garden organics is lost
- Other
- Other (please specify)

7. If you were given the opportunity, would you put your food scraps in a separate bin to be composted at school?

- Yes (go to question 9)
- No (go to question 8)
- Unsure (go to question 9)

8. If no, why would you choose not to use a separate food scrap bin? (Choose as many responses as you need to)

- Dirty
- Smelly
- Too hard
- I will be teased
- Other (please specify)

9. What do you do with your food waste at home? (Choose as many responses as you need to)

- Put it in the rubbish bin
- Put it in a compost bin
- Put it in a worm farm
- Put it in a bokashi bin
- Feed to chickens
- Other (please specify)

10. Your school is about to start a trial with a separate compost bin. What do you think can go in this bin? (Choose as many responses as you need to)

- Plastic
- Bones
- Paper
- Cardboard
- Carrot
- Lettuce
- Bread
- Meat
- Cheese

Appendix D: Number of participants in the survey

	Pre-trial		Post-trial	
School	**All**	**Students**	**All**	**Students**
School A	46	23	24	9
School B	35	0	0	0
School C	195	135	146	134
School D	171	120	88	54
School E	50	17	89	86
School F	192	123	67	11
TOTAL	**689**	**400**	**414**	**294**

	Pre-trial		Post-trial	
Respondents	**Percentage**	**Number**	**Percentage**	**Number**
Male	44%	301	35%	146
Female	56%	388	65%	268
	Answered	689	Answered	414

Compost analysis AS4454:2012 Test Report

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Date Sampled	Product	Customer
08/10/2018	Compost	Closed Loop Recycling
Sample ID	Lab No.	Date Reported
School A	M615	22/10/2018

Characteristic	Units	AS 4454: 2012 Requirements for Pasteurized Product[1]	Result
pH	pH units	Minimum 5.0	4.86 [2]
Total $CaCO_3$ equivalent	% dry matter	To be determined and stated if pH>8.0	N.R.
Electrical conductivity	dS/m	Maximum 10	10.9 [3]
Ammonium-N	mg/L in soln	No requirement	4
Sodium	% dry matter	<1%	0.50
Boron	mg/kg	<100	10
Nitrate-N	mg/L in soln	Convert to mg/kg and see below	1.8
	mg/kg dry matter	≥ 10 if a contribution to plant nutrition is claimed	265
Soluble Phosphorus:	mg/L in soln	≤ 5 for products that claim to be for phosphorus-sensitive plants	247 [4]
Total Phosphorus:	% dry matter	≤ 0.1 for products that claim to be for phosphorus-sensitive plants	0.27 [4]
Nitrogen Total	% dry matter	≥ 0.8 if a contribution to plant nutrition is claimed	2.5
Organic Carbon	% dry matter	≥ 20	47
Carbon : Nitrogen Ratio	(C:N)	Level appropriate for application	19 [5]
Particle size grading	% mass retained by sieve	<5 mm / >16 mm: Soil Conditioner: <20% (<5 mm:)	87%
		Fine Mulch: <20% <20% / Coarse Mulch: ≥70% (>16 mm:)	0.8%
Classification	-	Based on Particle Size Grading	Soil Conditioner
Physical Contaminants	% dry matter	Glass, metal + rigid plastics ≤ 0.5%	0.00%
		Plastics- light, flexible or film ≤ 0.05%	0.009%
		Stones and lumps of clay (>5 mm) ≤ 5%	10.8% [6]
Wettability	Minutes	< 7 minutes for the < 10 mm fraction	> 10 min [7]
Moisture content	%	Minimum 25%	3.0% [8]

Compost analysis AS4454:2012 Test Report

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Date Sampled	Product	Customer
08/10/2018	Compost	Closed Loop Recycling
Sample ID	Lab No.	Date Reported
School A	M615	22/10/2018

Characteristic	Units	AS 4454:2012 Requirements	Result
Chemical Contaminants HM + Organic contaminants	Limits for unrestricted use taken from AS 4454:2012, table 3.1(C)		
Arsenic	mg/kg	20	< 5
Cadmium	mg/kg	1	< 0.1
Chromium	mg/kg	100	2
Copper	mg/kg	150	6
Lead	mg/kg	150	<1
Mercury	mg/kg	1	<0.02
Nickel	mg/kg	60	1
Selenium	mg/kg	5	< 2
Zinc	mg/kg	300	25
Aldrin	mg/kg	0.02	< 0.01
Dieldrin	mg/kg	0.02	< 0.01
Total DDT Analogs	mg/kg	0.5	< 0.04
Chlordane	mg/kg	0.02	< 0.01
Heptachlor	mg/kg	0.02	< 0.01
HCB	mg/kg	0.02	< 0.01
Lindane	mg/kg	0.02	< 0.01
Total BHC Analogs	mg/kg	0.02	< 0.02
PCB Total	mg/kg	0.2	< 0.2
Pathogen indicators (For Products from high risk materials, e.g food waste)			Result
Pathogen Indicators	-	Salmonella spp: Absent in 50g	Absent
	MPN/g	Faecal Coliforms: < 1000 MPN/g	< 10

Comments:

1. Recommended values are based on a pasteurized product. No judgement on the pasteurization or maturity of the compost can be made without further testing. Pasteurization can be determined with temperature data during composting.
2. pH values lower than 5.0 may have a noticeable acidifying effect on soils.
3. Due to the Electrical Conductivity of the sample, application rates should be limited to 2.5 L/m2 or less for sensitive plants, and 10 L/m2 or less for more tolerant plants. This is based on incorporation into the soil to a depth of 5 cm. Rates can be doubled if incorporated to a depth of 10 cm.
4. This product should not be recommended for use on phosphorus sensitive plants. This product contains high levels of soluble phosphorus and care should be taken when applying to sandy soils near watercourses.
5. Finished compost with a C:N ratio of less than 30 will provide nitrogen to the soil. C:N ratios of greater than 30 will draw down nitrogen from surrounding plants.
6. Value includes large lumps (> 5 mm) of unidentified objects.
7. Sample was regularly checked, final check at 1 hour and 30 min observed sample had drained. For hydrophobic samples such as this one a wetting agent is recommended.
8. A good moisture content (i.e. > 25%) aids in lowering water usage when wetting out upon use.

External report numbers: 181010_16564; 18-15169; H4893

Completed By: Raymond Bosman (Chemist)

Date: 22/10/2018

Appendix E: Compost testing results (post-trial 2018)

Compost analysis AS4454:2012 Test Report

Date Sampled	Product	Customer
09/05/2018	Compost	Closed Loop Recycling
Sample ID	**Lab No.**	**Date Reported**
School C	M585	05/06/2018

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Characteristic	Units	AS 4454: 2012 Requirements for Pasteurized Product[1]	Result
pH	pH units	Minimum 5.0	4.9 [2]
Total $CaCO_3$ equivalent	% dry matter	To be determined and stated if pH>8.0	N.R.
Electrical conductivity	dS/m	Maximum 10	6.80 [3]
Ammonium-N	mg/L in soln	No requirement	< 100 [4]
Sodium	% dry matter	<1%	0.51
Boron	mg/kg	<100	7.1
Nitrate-N	mg/L in soln	Convert to mg/kg and see below	< 1
	mg/kg dry matter	≥ 10 if a contribution to plant nutrition is claimed	< 100
Soluble Phosphorus:	mg/L in soln	≤ 5 for products that claim to be for phosphorus-sensitive plants	250 [5]
Total Phosphorus:	% dry matter	≤ 0.1 for products that claim to be for phosphorus-sensitive plants	2.4 [5]
Nitrogen Total	% dry matter	≥ 0.8 if a contribution to plant nutrition is claimed	2.2
Organic Carbon	% dry matter	≥ 20	48
Carbon : Nitrogen Ratio	(C:N)	Level appropriate for application	22 [6]
Particle size grading	% mass retained by sieve	Soil Conditioner: <5 mm: –, >16 mm: <20%; < 5 mm:	85%
		Fine Mulch: <5 mm: <20%, >16 mm: <20%; > 16 mm:	4%
		Coarse Mulch: <5 mm: –, >16 mm: ≥70%	
Classification	-	Based on Particle Size Grading	Soil Conditioner
Physical Contaminants	% dry matter	Glass, metal + rigid plastics ≤ 0.5%	0.0%
		Plastics- light, flexible or film ≤ 0.05%	0.08%
		Stones and lumps of clay (>5 mm) ≤ 5%	15% [7]
Wettability	Minutes	< 7 minutes for the < 10 mm fraction	> 7 min [8]
Moisture content	%	Minimum 25%	5.0% [9]

Compost analysis AS4454:2012 Test Report

Date Sampled	Product	Customer
09/05/2018	Compost	Closed Loop Recycling
Sample ID	**Lab No.**	**Date Reported**
School C	M585	05/06/2018

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A.B.N: 30 008 747 911

Characteristic	Units	AS 4454:2012 Requirements	Result
Chemical Contaminants HM + Organic contaminants	Limits for unrestricted use taken from AS 4454:2012, table 3.1(C)		
Arsenic	mg/kg	20	< 5
Cadmium	mg/kg	1	< 0.1
Chromium	mg/kg	100	2
Copper	mg/kg	150	4
Lead	mg/kg	150	<1
Mercury	mg/kg	1	<0.02
Nickel	mg/kg	60	2
Selenium	mg/kg	5	< 2
Zinc	mg/kg	300	22
Aldrin	mg/kg	0.02	< 0.01
Dieldrin	mg/kg	0.02	< 0.01
Total DDT Analogs	mg/kg	0.5	< 0.04
Chlordane	mg/kg	0.02	< 0.01
Heptachlor	mg/kg	0.02	< 0.01
HCB	mg/kg	0.02	< 0.01
Lindane	mg/kg	0.02	< 0.01
Total BHC Analogs	mg/kg	0.02	< 0.02
PCB Total	mg/kg	0.2	< 0.2
Pathogen indicators (For Products from high risk materials, e.g food waste)			Result
Pathogen Indicators	-	Salmonella spp: Absent in 50g	Absent
	MPN/g	Faecal Coliforms: < 1000 MPN/g	< 10

Comments:

1. Recommended values are based on a pasteurized product. No judgement on the pasteurization or maturity of the compost can be made without further testing. Pasteurization can be determined with temperature data during composting.
2. pH values lower than 5.0 may have a noticeable acidifying effect on soils.
3. Due to the Electrical Conductivity of the sample, application rates should be limited to 4 L/m2 or less for sensitive plants, and 16 L/m2 or less for more tolerant plants. This is based on incorporation into the soil to a depth of 5 cm. Rates can be doubled if incorporated to a depth of 10 cm.
4. Due to strong colour interference a more accurate result could not be determined.
5. This product should not be recommended for use on phosphorus sensitive plants. This product contains high levels of soluble phosphorus and care should be taken when applying to sandy soils near watercourses.
6. Finished compost with a C:N ratio of less than 30 will provide nitrogen to the soil. C:N ratios of greater than 30 will draw down nitrogen from surrounding plants.
7. Value includes large lumps (> 5 mm) of unidentified objects.
8. Sample was regularly checked, final check at 30 min observed sample had drained. For hydrophobic samples such as this one a wetting agent is recommended.
9. A good moisture content (i.e. > 25%) aids in lowering water usage when wetting out upon use.

External report numbers: 180516_16122; 18-07400; H0455

Completed By: Raymond Bosman (Chemist)

Date: 05/06/2018

Compost analysis AS4454:2012 Test Report

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Date Sampled	Product	Customer
18/09/2018	Compost	Closed Loop Recycling
Sample ID	**Lab No.**	**Date Reported**
School D	M612	22/10/2018

Characteristic	Units	AS 4454: 2012 Requirements for Pasteurized Product[1]				Result
pH	pH units	Minimum 5.0				4.94 [2]
Total $CaCO_3$ equivalent	% dry matter	To be determined and stated if pH>8.0				N.R.
Electrical conductivity	dS/m	Maximum 10				9.26 [3]
Ammonium-N	mg/L in soln	No requirement				7
Sodium	% dry matter	<1%				0.36
Boron	mg/kg	<100				18
Nitrate-N	mg/L in soln	Convert to mg/kg and see below				2.4
	mg/kg dry matter	≥ 10 if a contribution to plant nutrition is claimed				12
Soluble Phosphorus:	mg/L in soln	≤ 5 for products that claim to be for phosphorus-sensitive plants				358 [4]
Total Phosphorus:	% dry matter	≤ 0.1 for products that claim to be for phosphorus-sensitive plants				0.29 [4]
Nitrogen Total	% dry matter	≥ 0.8 if a contribution to plant nutrition is claimed				2.1
Organic Carbon	% dry matter	≥ 20				40
Carbon : Nitrogen Ratio	(C:N)	Level appropriate for application				19 [5]
Particle size grading	% mass retained by sieve		<5 mm	>16 mm	< 5 mm:	94%
		Soil Conditioner		<20%		
		Fine Mulch	<20%	<20%	> 16 mm:	0.0%
		Coarse Mulch		≥70%		
Classification	-	Based on Particle Size Grading				Soil Conditioner
Physical Contaminants	% dry matter	Glass, metal + rigid plastics ≤ 0.5%				0.002%
		Plastics- light, flexible or film ≤ 0.05%				0.03%
		Stones and lumps of clay (>5 mm) ≤ 5%				6.4% [6]
Wettability	Minutes	< 7 minutes for the < 10 mm fraction				3m 20s
Moisture content	%	Minimum 25%				4.1% [7]

Compost analysis AS4454:2012 Test Report

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A.B.N: 30 008 747 911

Date Sampled	Product	Customer
18/09/2018	Compost	Closed Loop Recycling
Sample ID	**Lab No.**	**Date Reported**
School D	M612	22/10/2018

Characteristic	Units	AS 4454:2012 Requirements	Result
Chemical Contaminants HM + Organic contaminants	Limits for unrestricted use taken from AS 4454:2012, table 3.1(C)		
Arsenic	mg/kg	20	< 5
Cadmium	mg/kg	1	0.2
Chromium	mg/kg	100	41
Copper	mg/kg	150	17
Lead	mg/kg	150	4
Mercury	mg/kg	1	0.02
Nickel	mg/kg	60	18
Selenium	mg/kg	5	< 2
Zinc	mg/kg	300	99
Aldrin	mg/kg	0.02	< 0.01
Dieldrin	mg/kg	0.02	< 0.01
Total DDT Analogs	mg/kg	0.5	< 0.04
Chlordane	mg/kg	0.02	< 0.01
Heptachlor	mg/kg	0.02	< 0.01
HCB	mg/kg	0.02	< 0.01
Lindane	mg/kg	0.02	< 0.01
Total BHC Analogs	mg/kg	0.02	< 0.02
PCB Total	mg/kg	0.2	< 0.2
Pathogen indicators (For Products from high risk materials, e.g food waste)			Result
Pathogen Indicators	-	Salmonella spp: Absent in 50g	Absent
	MPN/g	Faecal Coliforms: < 1000 MPN/g	< 10

Comments:

1. Recommended values are based on a pasteurized product. No judgement on the pasteurization or maturity of the compost can be made without further testing. Pasteurization can be determined with temperature data during composting.
2. pH values lower than 5.0 may have a noticeable acidifying effect on soils.
3. Due to the Electrical Conductivity of the sample, application rates should be limited to 2.5 L/m^2 or less for sensitive plants, and 10 L/m^2 or less for more tolerant plants. This is based on incorporation into the soil to a depth of 5 cm. Rates can be doubled if incorporated to a depth of 10 cm.
4. This product should not be recommended for use on phosphorus sensitive plants. This product contains high levels of soluble phosphorus and care should be taken when applying to sandy soils near watercourses.
5. Finished compost with a C:N ratio of less than 30 will provide nitrogen to the soil. C:N ratios of greater than 30 will draw down nitrogen from surrounding plants.
6. Value includes large lumps (> 5 mm) of unidentified objects.
7. A good moisture content (i.e. > 25%) aids in lowering water usage when wetting out upon use.

External report numbers: 181010_16564; 18-15169; H4893

Completed By: Raymond Bosman (Chemist)

Date: 22/10/2018

Compost analysis AS4454:2012 Test Report

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Date Sampled	Product	Customer
18/09/2018	Compost	Closed Loop Recycling
Sample ID	**Lab No.**	**Date Reported**
School E	M613	22/10/2018

Characteristic	Units	AS 4454: 2012 Requirements for Pasteurized Product[1]				Result
pH	pH units	Minimum 5.0				4.96 [2]
Total $CaCO_3$ equivalent	% dry matter	To be determined and stated if pH>8.0				N.R.
Electrical conductivity	dS/m	Maximum 10				8.13 [3]
Ammonium-N	mg/L in soln	No requirement				6
Sodium	% dry matter	<1%				0.53
Boron	mg/kg	<100				11
Nitrate-N	mg/L in soln	Convert to mg/kg and see below				2.5
	mg/kg dry matter	≥ 10 if a contribution to plant nutrition is claimed				13
Soluble Phosphorus:	mg/L in soln	≤ 5 for products that claim to be for phosphorus-sensitive plants				285 [4]
Total Phosphorus:	% dry matter	≤ 0.1 for products that claim to be for phosphorus-sensitive plants				0.31 [4]
Nitrogen Total	% dry matter	≥ 0.8 if a contribution to plant nutrition is claimed				2.7
Organic Carbon	% dry matter	≥ 20				46
Carbon : Nitrogen Ratio	(C:N)	Level appropriate for application				17 [5]
Particle size grading	% mass retained by sieve		<5 mm	>16 mm	< 5 mm:	83%
		Soil Conditioner		<20%		
		Fine Mulch	<20%	<20%	> 16 mm:	3%
		Coarse Mulch		≥70%		
Classification	-	Based on Particle Size Grading				Soil Conditioner
Physical Contaminants	% dry matter	Glass, metal + rigid plastics ≤ 0.5%				0.00%
		Plastics- light, flexible or film ≤ 0.05%				0.03%
		Stones and lumps of clay (>5 mm) ≤ 5%				12.8% [6]
Wettability	Minutes	< 7 minutes for the < 10 mm fraction				1m 23s
Moisture content	%	Minimum 25%				4.4% [7]

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18/09/2018	Compost	Closed Loop Recycling
Sample ID	**Lab No.**	**Date Reported**
School E	M613	22/10/2018

Characteristic	Units	AS 4454:2012 Requirements	Result
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Arsenic	mg/kg	20	< 5
Cadmium	mg/kg	1	< 0.1
Chromium	mg/kg	100	2
Copper	mg/kg	150	4
Lead	mg/kg	150	<1
Mercury	mg/kg	1	<0.02
Nickel	mg/kg	60	<1
Selenium	mg/kg	5	<2
Zinc	mg/kg	300	21
Aldrin	mg/kg	0.02	< 0.01
Dieldrin	mg/kg	0.02	< 0.01
Total DDT Analogs	mg/kg	0.5	< 0.04
Chlordane	mg/kg	0.02	< 0.01
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HCB	mg/kg	0.02	< 0.01
Lindane	mg/kg	0.02	< 0.01
Total BHC Analogs	mg/kg	0.02	< 0.02
PCB Total	mg/kg	0.2	< 0.2
Pathogen indicators (For Products from high risk materials, e.g food waste)			Result
Pathogen Indicators	-	Salmonella spp: Absent in 50g	Absent
	MPN/g	Faecal Coliforms: < 1000 MPN/g	< 10

Comments:

1. Recommended values are based on a pasteurized product. No judgement on the pasteurization or maturity of the compost can be made without further testing. Pasteurization can be determined with temperature data during composting.
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External report numbers: 181010_16564; 18-15169; H4893

Completed By: Raymond Bosman (Chemist)

Date: 22/10/2018

Appendix F: Data limitations

On reviewing the information and data obtained during this evaluation, some limitations to accuracy have been identified. These limitations are listed here to provide and understanding about the extent to which the data could be extrapolated or otherwise interpreted

- School self-reported data was not always available, it is likely that information about every bin was not captured.
- Schools did not all have access to scales and hence school data was captured as percentage filled and cross referenced with estimated bin sizes. The estimates of percentage that the bin was full can be subjective. While not accurate, this measure does provide a guide as to the volume of food collected.
- Waste service provider data for food (and possibly for general waste) is based upon multiplying number of bins collected by standard conversion factors to obtain volumes and weights which will be a source of error in the data.