Zero Waste Events: Assessment of Biodegradable Catering Products

Zero Waste SA

FINAL REPORT

29 November 2005

ZERO WASTE EVENTS: ASSESSMENT OF BIODEGRADABLE CATERING PRODUCTS

FINAL REPORT

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Quality Assurance Statement	
Client:	Zero Waste SA
Project Name:	Zero Waste Events: Assessment of Biodegradable Catering Products
Internal Project Code:	ZWSA03
Project Manager:	Raya Giffard
Prepared by:	Raya Giffard, Richard Stewart
Document Status:	Final Report
Date of Issue:	29 November 2005

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1 Introduction

1.1 Background

On 25 October 2004, Zero Waste SA launched the Zero Waste Events Program in Adelaide, South Australia. The Zero Waste Events Program provides financial assistance and advisory support to event organisers wishing to improve waste management practices at events held within South Australia.

The primary aims of the Program are to maximise the source separation and diversion of event waste from landfill and to promote Zero Waste objectives in the community.

One way of increasing the volume of event waste diverted from landfill, is to use disposable biodegradable catering products that can be processed at a commercial composting facility. These catering products are available in wide range of materials including paper, cardboard, grass fibre, wood and biodegradable plastics.

Although biodegradable materials are able to be broken down by micro-organisms, they are not all necessarily broken down sufficiently in the time frames used for composting. To ensure the use of appropriate catering products at Zero Waste Events, Zero Waste SA aims to provide event organisers with a list of biodegradable catering products that are suitable for composting.

To achieve this, Zero Waste SA engaged Flinders Bioremediation to assess the 'compostability' of a range of biodegradable catering products available in Australia. This report presents the findings of the project.

1.2 Project Aims

The primary aims of the project were to:

- Compile a list of biodegradable catering products available in Australia including their distributors;
- Review and summarise composition and biodegradability information for the various biodegradable materials;
- Conduct trials to assess the biodegradation of a range of materials under controlled conditions.

2 Biodegradable Products List

With a view to providing a useful resource for Zero Waste Event organisers, a list of biodegradable products available in Australia was developed based on a preliminary list of distributors provided to Flinders Bioremediation by Zero Waste SA.

Each of the listed distributors was contacted for specific information on the range of biodegradable products available through their company. Products listed were limited to biodegradable catering products only and included cups, plates, straws, other food containers (eg. trays and clams), tabletop products (eg. napkins and table covers), cutlery, and bin liners.

Selected distributors were also asked to provide samples of one or more of their product range for use in the compostability trials discussed in Section 4 of this report.

A list of biodegradable catering products assessed as part of this study and their respective distributors has been included in Appendix A. Contact details for distributors have been provided in Appendix B.

The list of distributors is not necessarily exhaustive and it is recommended that, if it is made publicly available, the opportunity is provided for listed distributors to update their company's information, and for distributors that are not currently listed to provide their company details.

3 Biodegradable Materials

Materials used in the manufacture of biodegradable catering products available from Australian distributors include cardboard and paper, starch-based biodegradable plastics, wood, and grass fibre.

3.1 Cardboard and Paper

A wide range of catering products manufactured from cardboard and paper is available. These include cups for hot and cold beverages, a wide range of plates and bowls, straws, other food containers and table top products.

Although the biodegradability of cardboard and paper is well established, non-biodegradable materials such as polyethylene are sometimes used to coat these products to improve performance characteristics such as durability and water resistance. Catering products intended to be composted should be uncoated or coated with a biodegradable material such as wax or biodegradable plastic.

3.2 Starch-based Biodegradable Plastic

The American Society for Testing and Materials (ASTM D 6400-99) defines biodegradable plastic as "*a degradable plastic in which the degradation results from the action of naturally occurring micro-organisms such as bacteria, fungi and algae*" (Environment and Plastics Industry Council, 2000).

Biodegradable plastics may be naturally occurring or synthesised from renewable (eg. crops) or non-renewable (eg. petro-chemicals) resources. Although a wide range of biodegradable plastics are used for various applications, the biodegradable plastics most commonly used in the production of catering products available in Australia are starch-based resins or the starch derivative, polylactic acid (PLA). This discussion therefore focuses on starch-based biodegradable plastics.

Starch-based biodegradable plastics may be opaque or transparent, are relatively strong, and are suitable for use with cold beverages. However, these materials are affected by heat and are therefore not suitable for hot food and beverages.

Starch sourced from crops such as corn, wheat or potatoes, is used in the production of starch-based biodegradable plastic. Heating the starch under high pressure causes it to destructure, resulting in a thermoplastic polymer, which can be processed in a similar way to traditional plastics. Starch-based polymers are commonly blended with other natural or synthetic biodegradable polymers to achieve the specific properties required for the intended application. Starch content may range from as little as 10% to greater than 90% (Nolan, 2002).

During degradation of starch-based plastics, enzymes attack the glucosidic linkages enabling the microbial degradation of the resultant sugar units. The higher the starch content of the plastic, the more readily the material degrades (Nolan, 2002).

PLA is a product of fermentation of the cornstarch sugars by bacteria. Starch extracted from the endosperm of the corn kernels is converted into dextrose with the addition of enzymes. Bacterial cultures are subsequently used to convert the dextrose into lactic acid. Water is removed to produce lactides, which bond together to form polylactic polymers. These polymers are then melted and moulded into products using conventional extrusion and thermoforming equipment. PLA-based polymers can be modified to suit a wide range of disposable food service applications including clear cups, coatings for paper cups, plates and bowls, cutlery, drinking straws, food trays and bin liners.

It is claimed that PLA is fully biodegradable under commercial composting conditions (Cargill Dow, 2004). The material undergoes a two-stage degradation process. Initially, the PLA degrades into smaller polymers and in the presence of the moisture and heat of the compost pile, these polymers are converted to lactic acid. Micro-organisms are then able to utilise the lactic acid as a nutrient source. The degradation products under aerobic conditions are carbon dioxide, water and humus. Under anaerobic conditions, carbon dioxide, methane and humus are produced. Degradation is heavily dependent on temperature and moisture.

Typically, the PLA catering products available in Australia are certified by one or more of the international certification schemes, such as “OK Compost” (EU), “Kompostierbar” (Germany), “Compostable” (USA) and “Greenpla” (Japan). This certification ensures that manufacturers’ claims of compostability are valid according to the relevant standards.

However, catering products such as cutlery produced from starch-based resins, are not typically certified and little information relating to the composition and compostability of the products is available.

3.3 Wood

Catering products manufactured from wood are limited to cutlery items and are widely available. Wooden cutlery is a good alternative to cornstarch cutlery for use with hot foods. As for cardboard and paper, the biodegradability of wood has been well-established and small items such as knives and forks are expected to degrade under composting conditions.

3.4 Grass Fibre

Grass fibre is used to produce a limited range of catering products, including cups, plates and bowls. Grass fibre products are similar to conventional paper pulp products, however they have the advantage of being manufactured from a readily renewable resource. For example, sugar cane off-cuts, also known as ‘bagasse’, are generated as a by-product of the sugar refining process. For the production of biodegradable catering products, the bagasse is washed, oxygen bleached, pulped and pressed in a manner similar to that used in the production of paper pulp products.

Grass fibre products are suitable for hot and cold foods, are relatively strong and, because they are uncoated, fully biodegradable. Grass fibre products, typically manufactured in China, are increasing in popularity and availability.

4 Compostability Trials

4.1 Objectives

The main objective of the compostability trials was to investigate the degradation of catering products made from of a range of 'biodegradable' materials, in a typical commercial composting environment.

It should be noted that the term 'biodegradable' in relation to catering products refers to the ability of these products to be biologically degraded in general. The term 'compostablity' refers specifically to the ability of the product to be degraded under standard commercial composting conditions and timeframes.

4.2 Methodology

a) A range of product samples, representative of those available in Australia, was collected for an assessment of their compostability under simulated open windrow composting conditions. Details of the specific items are included in Table 1 below.

Table 1: Samples used in biodegradability trials

Catering Product	Material	Source
Cup	Paper	National 1
Plate	Paper	Deeko (purchased)
Cup	PLA – Nature Green	Wei Mon Industry Co.
Tray	PLA – Nature Green	Wei Mon Industry Co.
Spoon	Cornstarch	Wei Mon Industry Co.
Fork	Cornstarch	Environmental Enterprises
Spoon	Wood	Adelaide Bag & Packaging
Plate	Grass fibre	Environmental Enterprises

Figure 1: A typical sample tray prior to burial in a compost pile

b) Eight identical samples of each item were tagged (to assist in their identification following composting) and placed in four trays (see Figure 1 above).

c) On 08 November 2004, a compost pile of approximately 30 m^3 was established at the Southern Waste Depot, Maslin Beach, South Australia. A pile of approximately 6 m in diameter and 3 m high was established to achieve and maintain conditions representative of those achieved under commercial composting conditions.

d) The pile consisted of a 2:1 (v/v) mix of shredded green organics and a partially pre-composted green organics-based material.

e) The four trays containing the biodegradable items were buried in the pile, approximately 1 metre from the base (see Figures 2 & 3 below).

Figures 2 & 3: Establishment of the composting pile

f) The compost pile was carefully dismantled at the end of two, four and twelve weeks, at which time one of the trays was removed for assessment. At weeks two and four, the pile was then turned and re-established, incorporating the remaining trays. The use of a loader to turn the piles facilitated the recovery of the trays and catering products.

g) Trays removed from the pile were inspected for recoverable products, which were visually assessed and photographed. Control samples (not subjected to burial) and the week twelve samples were oven dried and weighed.

h) The internal temperature (middle and top) of the pile was recorded at 30-minute intervals throughout the twelve-week composting process.

i) The pH and moisture content of the pile was assessed throughout the trial as an internal check to ensure that conditions were representative of those present in a typical commercial composting environment.

4.3 Results

The internal temperature of the compost pile was maintained above 60^{o}C, except during and immediately after turning events. This demonstrates that the internal temperature of the pile was representative of that likely to occur in a commercial-scale windrow. Temperature data

are provided in Appendix C. The moisture content of the pile was maintained between 40% and 45% (w/w) for the duration of the trial.

Photographs of products provided in Appendix D demonstrate the progress of product degradation over the twelve-week composting process. Table 2 below provides average dry weights for samples before (i.e. uncomposted control) and after (i.e. week 12) composting. Where a sample could not be recovered at the end of the trial, no data was recorded.

Table 2: Dry Weight of Samples Before and After Composting

Material	Item	Dry Weight (g)	
		Control	Week 12
Paper	Cup	10.65 (± 0.14)	5.84 (± 0.74)
	Plate	5.70 (± 0.02)	-
Cornstarch	Spoon	3.78 (± 0.01)	3.96 (± 0.06)
	Fork	4.80 (± 0.05)	3.65 (± 0.05)
PLA	Cup	6.22 (± 0.04)	-
	Tray	9.03 (± 0.01)	-
Wood	Spoon	2.96 (± 0.32)	2.49 (± 0.30)
Grass Fibre	Plate	13.39 (± 1.04)	-

'-' indicates not measured as item not recovered

Cardboard and paper catering products tested included cups and plates from different manufacturers. The paper cups were still identifiable at the end of the twelve-week composting process, although were significantly degraded (refer Table 2 above). The rim and base of the cup were most resistant to degradation, while the corrugated paper sides degraded relatively quickly leaving the translucent plastic coating (see Appendix D, Week 12). The paper plate had degraded significantly by the end of week two (see Appendix D, Week 2) and no remnants of the product remained after four weeks.

Cornstarch products tested included spoons from Wei Mon Industry Company and forks from Environmental Enterprises. Although both products were essentially intact at the end of the composting process, some degradation was evident (see Appendix D, Week 12). During composting, both products became brittle and the fork distorted and reduced in mass significantly (refer Table 2 above).

PLA products tested included cups and trays. These products degraded rapidly and no remnants were detectable at the end of four weeks of composting. After composting for two weeks, the products were identifiable only as small, very brittle, opaque fragments (see Appendix D, Week 2).

Wooden spoons were recoverable at the end of the twelve-week composting process, although some degradation was evident (see Appendix D, Week 12). The spoons darkened and lost their rounded shape within the first two weeks of processing. The products became increasingly brittle throughout the process.

Grass fibre plates degraded significantly throughout the composting process and were present as fragments only at the end of the process (see Appendix D, Week 12).

Results from preliminary lab-based temperature trials, suggest that heat and moisture alone are insufficient to cause significant degradation (data not shown).

4.4 Discussion

The rate and extent of degradation of the various catering products tested under simulated composting conditions varied considerably. The paper and PLA products degraded significantly within the first two weeks of treatment, with the exception of the heat resistant cup. The observed resilience of the heat resistant cup was possibly due to the coating used to improve heat and water resistance, the glue used to hold together its constituent parts and/or the relative thickness of the base and rim. By the end of the composting process, the grass fibre plates had also degraded extensively.

Although some signs of degradation such as increased brittleness were evident, the cornstarch and wooden cutlery were still essentially intact at the end of the composting process.

It should be noted that during this composting trial, the products tested were not subjected to any physical agitation as would normally occur in a commercial scale composting process (i.e. during regular windrow turning). It is likely that this would further assist in the degradation of the products by reducing the size and therefore increasing the surface area of the products, already weakened by the composting environment. Similarly, shredding or grinding the waste prior to composting would also enhance degradation and some commercial composters indeed use this method prior to batching.

Under a full scale commercial composting operation, items such as cornstarch and wooden cutlery, which did not degrade completely within the twelve-week composting cycle, would generally be screened out with other oversized material and may be incorporated into the next composting cycle. Alternatively, the oversized fraction may be used as refuse-derived fuel (e.g. biomass incineration) or landfilled, depending on the level of contamination. Significant fragmentation of these cutlery items is undesirable as small fragments could not easily be separated from the composted product during screening and may be visually unacceptable in the final product.

Although no Australian Standard or certification program currently exists for biodegradable plastics, a draft Australian Standard addressing the requirements for the certification of biodegradability plastic products was released for public comment in September 2005. The Australian Environmental Labelling Association has recently released a voluntary labelling standard for Compostable Biopolymer Products (AELA 12-2005), which specifies the environmental performance requirements to be met by starch-based biodegradable plastic products.

Internationally, a range of standards, relating to the performance of plastics claiming to be biodegradable or compostable have been developed. These include DIN V 54900-1 (Germany), EN 13432 (EU), ASTM D 6400 (USA) and GreenPla (Japan). While slight

technical variances exist between the major international standard specifications for compostable plastics, three factors have been identified as critical in demonstrating compostability (ASTM, 2001):

- Ability to disintegrate, so as not to be visually detectable after composting;
- Inherent biodegradability, measured by the evolution of carbon dioxide; and
- No impact on the ability of the composted product to support plant growth.

The techniques used to assess biodegradability in the trial reported here were limited to an assessment of compostability, providing only an assessment of physical disintegration. It is also possible to measure the rate of biodegradation of materials by measuring carbon dioxide emissions generated through hydrolysis and microbial action. The methodology for this type of testing is described in Australian Standard AS ISO 14855-2005.

It may also be beneficial for compost processors to test the impact of biodegradable plastics on the quality of the end product to ensure that no persistent or toxic residues remain.

5 Conclusions

A wide range of biodegradable catering products is currently available in Australia. Materials used in the manufacture of these products include cardboard and paper, starch-based plastics, wood and grass fibre.

In general, Australian distributors of these products were able to provided only limited information regarding the composition and biodegradability of their products, particularly in relation to biodegradable plastic products. This highlights the need for the introduction of standards and a certification scheme for biodegradable plastics in Australia

The rate of degradation of the various catering products was tested in a simulated composting environment. With the exception of the heat resistant paper cups, all paper and PLA products degraded completely during the trial. These products and the grass fibre products, which also degraded significantly, are therefore considered suitable feedstocks for commercial composting. The plastic lining in the heat resistant paper cups did not degrade to any extent during composting, and therefore deems this product unsuitable for commercial composting.

The various international standard specifications for biodegradable plastics require that the degradation of the material does not impact on the ability of the composted product to support plant growth. Therefore, where non-certified biodegradable plastics are to be composted, the potential effects of their degradation should be further investigated to provide composters with confidence that the quality of their final product will not be compromised.

The cornstarch and wooden products showed some visual signs of degradation, but were essentially still intact after composting. During commercial composting, the wooden products could be removed during screening and re-composted until fully degraded. Whether the cornstarch products would ever fully degrade under this scenario remains to be tested. Alternatively, the cutlery retained in the oversized fraction during screening may be disposed of to landfill or used as a refuse derived fuel, dependent on the level of contamination.

The additional physical agitation that occurs during commercial composting (i.e. intensive windrow turning) would further assist in the degradation of the biodegradable catering products tested in this trial. Pre-treatments such as chipping or shredding the feedstocks would also enhance degradation by increasing the surface area, but risk fragmentation of contaminants, such as glass and plastic, thereby minimising any opportunity to screen these materials out.

6 Recommendations

Based on the conclusions above, it is recommended that:

- Catering products made from the following materials are considered to be compostable and therefore suitable for use at Zero Waste Events:
    - cardboard and paper (with the exception of plastic lined products);
    - PLA; and
    - Grass fibre.
- The compostability of the biodegradable catering products, which persisted during this trial (i.e. cornstarch and wooden cutlery) should be further assessed on a larger scale during the planned Zero Waste Events waste treatment trials;
- Where non-certified biodegradable plastics are to be composted, the potential effects of their degradation products on plants should be further investigated to provide composters with confidence that the quality of their final compost will not be compromised.

7 References

ASTM (2001), *ASTM Standardization News April 2001*, [Online] Available: www.astm.org [20 October 2004].

Cargill Dow LLC (2004), *Nature Works TM PLA Polymer 2002D Extrusion/Thermoforming*, [Online] Available: http://www.cargilldow.com/corporate/search.asp?keyword=2002D [20 October 2004].

Environment and Plastics Industry Council (2000), Technical Report - Biodegradable Polymers: A Review, [Online], Available: www.cpia.ca/files/files/files_BIODEGRADABLE_POLYMERS_A_REVIEW [20 October 2004]

Nolan-ITU (2002), *Biodegradable Plastics -Developments and Environmental Impacts*, [Online] Available: www.deh.gov.au/settlements/publications/index [20 October 2004].

APPENDIX A

Biodegradable Catering Product List

Biodegradable Catering Product List

Company Name	Cardboard / paper						Cornstarch / PLA						Sugarcane fibre			Wood
	Cups - hot drinks	Cups - cold drinks	Plates / bowls	Straws	Other food containers	Tabletop products	Cups - cold drinks	Plates / bowls	Cutlery	Straws	Other food containers	Garbage bags / liners	Cups - hot drinks	Cups - cold drinks	Plates / bowls	Cutlery
A & W Hollier	X	X	X		X	X										X
Adelaide Bag & Packaging *	X	X			X	X										X
Auscorp Industrial Group							X	X	X	X	X					
BSB Packaging	X	X	X		X	X										
Bunzl Ltd *	X	X			X	X										
Detpak Packaging *	X	X	X		X	X			X							X
Encore Tissue Pty Ltd						X										
Environmental Enterprises		X		X			X		X	X		X	X	X	X	
Galipo Food Co *	X	X	X		X	X			X							X
Kent Paper	X	X	X		X	X										
Lombard The Paper People	X	X	X		X	X										X
Merino Food Services			X			X										
Mick Savill Packaging *	X	X	X		X										X	X
National 1 *	X	X	X		X	X			X							X
Northland Distributors *	X	X	X		X	X										
Sydney Packaging	X	X			X	X						X				X
Northside Paper & Packaging	X	X	X		X	X										X
Pak-Rite *			X			X										X
ProTem Solutions	X	X	X		X	X	X	X	X	X		X				X
Shop Basics	X	X	X		X	X	X		X	X		X				X
Signum							X	X			X					
Visy Recycling	X	X			X											
Wei Mon Industry Co. Ltd *	X	X	X		X		X		X	X	X	X				X

* denotes South Australian based distributor

APPENDIX B

Biodegradable Catering Product Distributor List

SOUTH AUSTRALIAN DISTRIBUTORS

ADELAIDE BAG & PACKAGING
Bruce Morey
(08) 8346 5733
340 South Road CROYDEN PARK SA 5008

BUNZL LTD
Allan Turbill
(08) 8348 9405
601 South Road REGENCY PARK SA 5010
www.bunzl.com

DETPAK PACKAGING
Ann Burr
(08) 8348 3810
51 East Street BROMPTON SA 5007
www.detpak.com

GALIPO FOOD COMPANY
Nick Lakes
(08) 8168 2000
Unit 5 Commercial Court DRY CREEK SA 5094

MERINO FOOD SERVICES
Chris Franklin
(08) 8354 4454
L1 / 51-53 Henley Beach Road MILE END SA 5031
www.merinoptyltd.com.au

MICK SAVILL PACKAGING
Gary Savill
(08) 8349 5355
87 Research Road POORAKA SA 5095
www.micksavill.com.au

NATIONAL 1
Jack Minchenko
1300 363 608
614-616 South Road REGENCY PARK SA 5010
www.national1.com.au

NORTHLAND DISTRIBUTORS
Carolyn Perrotta
(08) 8262 4481
8 McLeod Court CAVAN SA 5094

PAK-RITE
Stephen Green
(08) 8398 2872
13 Crompton Road MT BARKER SA 5251
www.pak-rite.com.au

WEI MON INDUSTRY CO LTD
Rob Horrocks (Venue Clean SA)
0417 811 484

www.weimon.com.tw

NATIONAL DISTRIBUTORS

A & W HOLLIER
Warren Gibson
(02) 9757 3333
33 Victoria Street SMITHFIELD NSW 2164

AUSCORP INDUSTRIAL GROUP
Bill Mihaloudis
(03) 9484 6864
1 Kerr Street PRESTON VIC 3072
www.acigroup.com.au

BSB PACKAGING
Stewart Bedford
(03) 9801 9255
5 Wadhurst Drive BORONIA VIC 3155
www.bsbpackaging.com.au

ENCORE TISSUE PTY LTD
Jeff Paull
(03) 9931 1488
37-41 Gilbertson Road LAVERTON VIC 3028

ENVIRONMENTAL ENTERPRISES
Tao Triebels
(02) 4620 9248
25 Colonial Street CAMPBELLTOWN NSW 2560

KENT PAPER
Cedrick Walker
(02) 9949 6666
9-13 Hayes Street BALGOWLAH NSW 2093
www.kentpaper.com.au

LOMBARD THE PAPER PEOPLE

(03) 9376 2500
162 Silverwater Road SILVERWATER NSW 2264
www.lombard.com.au

PRO TEM SOLUTIONS
Ted Cooper
(03) 5224 2720
L1 / 124 Lyrie Street GEELONG VIC 3220
www.protem.com.au

SIGNUM
Robin Tuckerman
(03) 9301 7226
47 Dallas Drive BROADMEADOWS VIC 3047
www.signum.com.au

VISY RECYCLING
Vanessa Stratos
1801 550 132
232 Albert Road SOUTH MELBOURNE VIC 3205
www.visyclosedloop.com

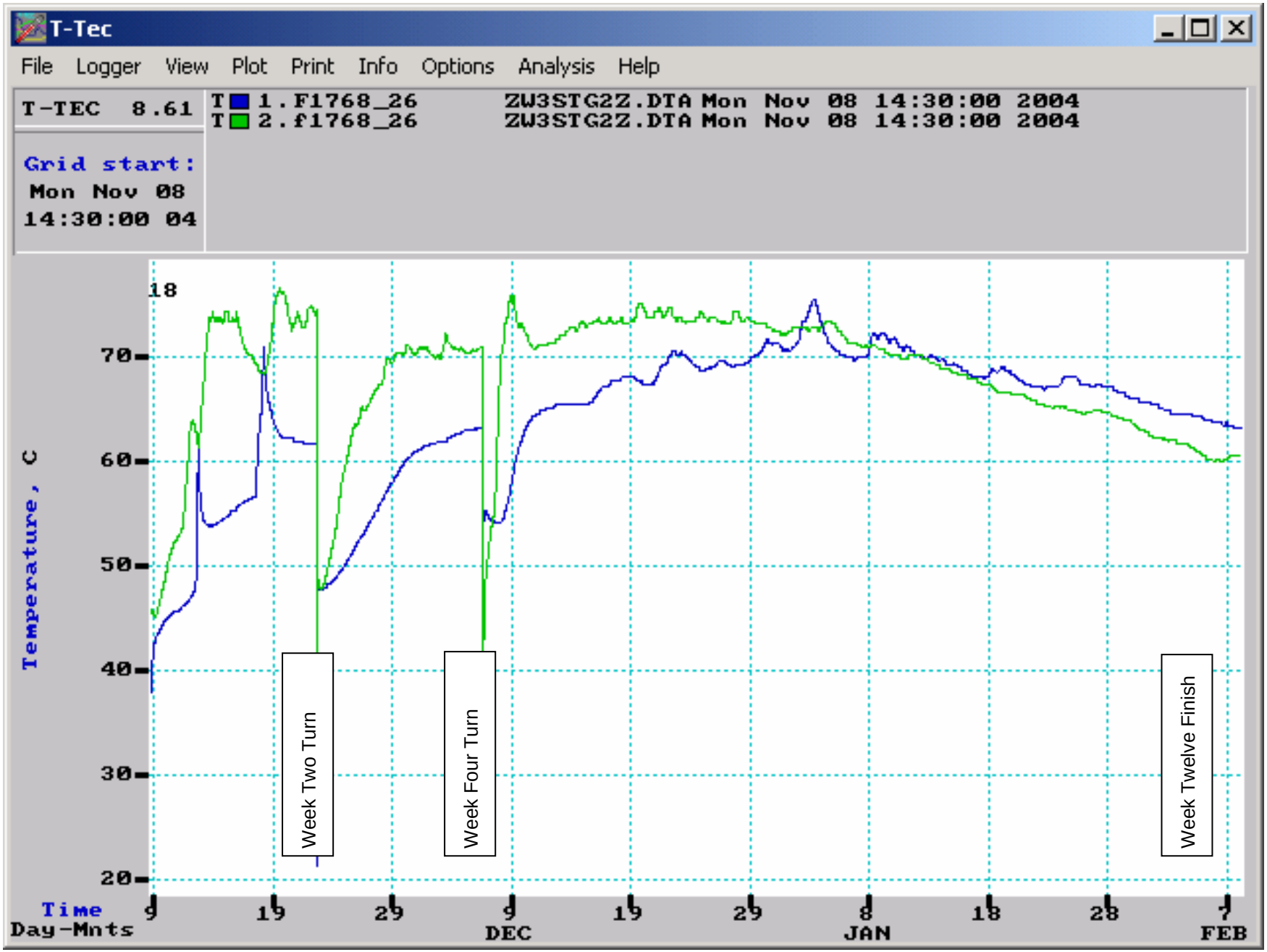
NORTHSIDE PAPER & PACKAGING
Barry Melament
(02) 9476 6656
10 Kelray Place ASQUITH NSW 2077
www.northsidepaper.com.au

SHOP BASICS
Maryke Booth
(02) 6280 4128
301 Canberra Avenue FYSHWICK ACT 2609
www.shopbasics.com.au

SYDNEY PACKAGING
Sonia Modellino
(02) 9737 9377
2b/172 Siverwater Road SIVERWATER NSW 2264
www.sydneypackaging.com.au

APPENDIX C

Temperature Curves



ZWSA 03 – Temperature Profile for Composting of Biodegradable Catering Products (Blue Line – Tray Temp & Green Line – Top Temp)

APPENDIX D

Degradation Photographs

Biodegradability Trial – Progress of Degradation During Composting

	Original	Week 2	Week 4	Week 12
Paper Cup				
Paper Plate			No remaining product	
Cornstarch Spoon				

Biodegradability Trial – Progress of Degradation During Composting

	Original	Week 2	Week 4	Week 12
Cornstarch Fork				
PLA Cup			No remaining product	
PLA Tray			No remaining product	

Biodegradability Trial – Progress of Degradation During Composting

	Original	Week 2	Week 4	Week 12
Wooden Spoon				
Grass Fibre Plate