

Development of Reprocessing Options and End Markets for Used Oil Containers

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Association Inc. and The Australian Institute Of
Petroleum**

1. EcoRecycle Victoria

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The Advisory Committee especially wishes to thank all those who have contributed to the study, and who are listed in the Appendix to the Report

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DRAFT REPORT

2. INTRODUCTION

It is estimated that currently some 3500-4000 tonnes per year of plastic oil containers, predominantly HDPE with a probable partially crushed container volume equivalent of 50 million litres, are delivered to landfill sites in Australia each year. This quantity is likely to increase significantly over the next few years as substitution of metal pails by polypropylene pails commences. In addition, tests during this project indicate that over 10% by weight of residual oil remains in each container after draining so that together with those containers which reach landfill undrained, over 500 tonnes of lubricating oil may be co-deposited each year.

Disposal directly to landfill occurs because currently there are no facilities specifically installed or operational for environmentally sound collection, cleaning and shredding of these containers for subsequent conversion and re-use as plastic containers or for other applications. It has been noted that incidental incorporation of a small proportion of plastic used oil containers into recycling streams occurs, and that in some cases contamination by residual oil presents processing difficulties and necessitates special handling.

In 1997 trials were initiated in Victoria using an extrusion compounding facility at Compco Pty Ltd which was able to process pre-shredded plastic oil containers. The output was evaluated for oil bottle production in a conventional manufacturing facility, and although the containers were basically sound, the process was found to be unacceptable due to severe fume emission during moulding.

Recognising the importance of identifying practical and workable solutions which would enable the plastic recycling industry to address this so far unsolved and growing problem, five potential stakeholders (namely the Australian Institute of Petroleum, the Plastics & Chemicals Industry Association Inc., Southcorp Packaging, Viscount Plastics and Visy Plastics) approached EcoRecycle Victoria for limited funding support. This funding was readily granted and used to supplement the considerable "in-kind" financial contributions planned by the stakeholders, and the stakeholders would like to thank the support of EcoRecycle Victoria for this Project.

The information contained in this Report represents all relevant details identified during literature searching, correspondence and discussion with organisations and companies locally and overseas, and listed in the Appendix.

Project Description

The objective of the project was to identify and trial commercially and technically viable recycling avenues for used HDPE oil containers, as alternatives to current landfill disposal. The project has been a joint cooperation between the oil and plastics industries, to allow examination of the whole process from collection of used bottles to end products and assist rapid commercialisation of identified viable recycling avenues. Administration of the grant was managed by the Plastics and Chemicals Industries Association (PACIA), with the Australian Institute of Petroleum (AIP) responsible for day-to-day project management.

3. EXECUTIVE SUMMARY

Methodology

The project was carried out by addressing each of the following issues:

- Confirming current practice in Victoria and other Australian States as appropriate
- Seeking an understanding of world best practice
- Identifying appropriate recycling machinery and equipment requirements and availability
- Arranging environmentally sound collection of used oil containers for recycling trials
- Supervising the granulation, washing and extrusion trials to produce oil free/reduced oil content recycled polymer
- Exploring potential markets for this recycled polymer
- Carrying out moulding trials to produce oil containers using this recycled polymer
- Testing and evaluation of these containers
- Trialing recycled polymer for extruded pipe manufacture
- Ascertaining the feasibility of constructing an economic model to provide a basis for supporting project recommendations

The outcomes are summarised below with detailed findings in the main body of the Report

Current Practice in Australia

As mentioned in the introduction, some incidental inclusion of used plastic oil containers into plastic recycling streams occurs and provided this is limited to a very small proportion of the stream, no adverse consequences have been reported where washing and extrusion into pellets is the process being carried out. Where mixed plastics streams are processed for example to directly produce heavy outdoor furniture and underground equipment protection boxes, noticeable oil contamination during the process sometimes occurs and necessitates segregation for subsequent diluted use with “clean” streams.

A few examples of specific collection and segregation of plastic oil containers have been noted, together with an example of collection of containers of used oil from service stations and other locations – currently the oil is drained and collected for value added use as diesel extenders and recycled lubricants, and also for boiler fuel, and these containers are then deposited in considerable quantities to the local landfill site. Current oil container design promotes entrapment of oil and “sludge” and hence subsequent carry over of oil to landfill.

Otherwise, ratepayers who telephone enquiring to municipal councils, generally receive advice to take the containers to EcoRecycle Victoria’s nominated chemical waste centres which are open to receive goods at specified times.

Overseas Practice

Literature searching provided details about a number of collection and recycling schemes in USA and Canada together with information about work carried out in some countries in Europe.

In following up these references there was frequently a limited response both from PACIA’s “Sister” organisations as well as from recyclers – this latter reluctance presumably due to perceived confidentiality constraints.

Nevertheless useful examples of kerbside and other collection systems were identified, together with recycling process patents, and referral to equipment suppliers, environmental agencies and potential alternative use programs.

Equipment Suppliers

Discussion with local and international machinery and equipment suppliers indicates that complete “off-the-shelf” systems are available from at least four European suppliers. Alternatively, specialised items of equipment could be purchased from European suppliers, with local machinery manufacturers providing specific items of equipment which would be common to both oil and non oil capability recycling lines. Of particular importance would be not only the oil removal and oil washing equipment but also the equipment for transporting the material during processing.

Potential Markets

The project participants agreed that the primary focus of investigation should be the recycling of the plastic back into lubricating oil bottles and pails. This would create a closed loop, if the economics were appropriate. However the project also sought to assess the relative merits of certain alternative uses. These were:

- Extrusion for use in underground piping – with washing prior to extrusion
- Use in mixed streams for heavy outdoor or underground applications, and for cement applications – without prior washing
- Extrusion to pellets for large panels, pallets, railway sleepers and cement mixes – with washing prior to extrusion
- Conversion to cement kiln fuel, and pyrolysis

Collection of Containers

As well as the collection of used containers together with sump oil referred to above under “current practice”, in a number of cases Shire Councils recommended drop-off points for used oil containers, and one large lubricating oil consumer has installed a facility for draining containers prior to supply to a plastics recycling company.

For completeness some overseas practices relating to kerbside collection of used oil containers have been identified and are referred to later in this Report. It should be noted however that the committee does not favour kerbside collection for Australia as previous research by A.I.P./EcoRecycle Victoria showed the optimal collection method to be via waste transfer stations with specially designed draining racks at these centres.

Trial Production of Washed/Reduced-Oil Pellets

- a) In order to establish the effectiveness of using conventional aqueous/detergent processing, Visy Plastics agreed to trial a small quantity of semi-drained containers. This trial confirmed the expected unsuitability of a conventional process, and whilst no further trials using this

procedure are currently planned, the possibility of doing so later in conjunction with detergent bottles may be considered.

- b) TP Recyclers agreed to “jury-rig” a solvent-washing unit purchased from a recycler who had been developing a procedure for oil containers. HDPE and PP flake were washed in this unit and extruded via a conventional extruder to provide HDPE and PP pellets with total lubricating oil content between 1 and 3%ww (down from approx 10%ww on unwashed HDPE flake). After this initial pelletising, the HDPE pellets were re-extruded through a vacuum vented extruder to assess whether significant further reduction of oil content occurred. The first HDPE extrusion process produced a resin with MFI increased to 0.39, and the second vacuum vented extrusion process further increased the MFI to an average figure of 0.47. – Laboratory evaluation results are shown in detail later in Section 8.1.

These results indicate that vacuum venting may not significantly further reduce oil content of the resin, indeed secondary extrusion results in a deleterious aspect in the form of an unwanted increase in the MFI. On this basis it was deemed unnecessary to re-extrude the PP pellets.

The oil-reduced HDPE pellets were delivered to Southcorp/Priority Plastics and the oil-reduced PP pellets to Viscount Plastics.

Moulding Trials by Southcorp/Priority Plastics and by Viscount Plastics.

(i) **HDPE:** During the trials it was noted that for this extrusion blow-moulding process, in addition to the normally applicable criteria for bottle quality, the addition of odour as a semi quantitative variable is required. The most likely quality problems to occur would be the physical variations in bottle quality (top load, colour variation and pin holes from large inclusions being the main concerns).

(ii) **PP:** A blend of 75% virgin polymer with 25% recycled polymer was successful in the trial to produce 4 litre pails. Prior to complete acceptance for the larger 20 litre pails, a further production trial would be required to confirm the ratio of recycled polymer for these larger pails.

Alternative Uses. A number of potential alternative uses have been identified in the body of the Report and these are summarised on Page 9 (a) – (f). Some of these may well be attractive niche markets particularly for South Australia, Queensland, New South Wales and perhaps country Victoria. Specifically for Victoria it was concluded that extrusion of recycled HDPE for underground pipe could represent an alternative to re-use for oil containers. In the case of PP, in the short term, the preferred option remains for re-use in PP oil pails.

Conclusion and Recommendations

Although insufficient data could be collected during this Project to construct a definitive economic model, the stakeholders have concluded that the following outline recommendations are technically viable, specifically for Victoria, to solve the growing problem of oil container disposal. The project participants believe the recommendations in this Report may also be applicable in whole or in part for some other States. In particular for example if the re-use for oil container option is adopted, and if no recycler outside Victoria is prepared to initially install a suitable washing plant, the collected and granulated containers could be transported to Victoria for processing at a probable cost of around \$100-\$150/tonne from several States.

Alternatively, if for example the NSW requirements can be recycled in McCoy Global Resources' new equipment, this in conjunction with Polymer Corporation's claimed capability in Queensland would reduce the need for recycling to oil containers in those States. The study is unable to make a recommendation regarding Tasmania, Western Australia or Northern Territory, from whom some useful additional input could be sought at a later date.

It is stressed however that statutory influence is already in existence in the form of the Packaging Covenant so that it would be in the interest of all Brand Owners beyond the scope of this project that a further evaluation be undertaken to flesh out an economic model that will show the necessity or otherwise for external intervention (ie funds injection) to ensure a viable recycling program.

(i) Collection

Municipal councils should be encouraged to provide specific information to residents which would require lidded plastic oil containers with or without used oil in them be left at the nearest EcoRecycle Victoria approved Waste Transfer Station, Council Tipping Site or other specified sites in a storage area specifically provided for these containers which then would be regularly collected for example by a used oil recycling company. If feasible, on-bottle promotion via the current mode of container decoration may enhance the collection process, but in any case there is a clear need to ensure that adequate details are available to users to assist the process for example via point-of-sale information, council newsletters etc.

Note: The specified sites, the agreed collecting company and the oil recycling company would receive state government environmental and “duty of care” approval via the Victorian EPA and from EcoRecycle Victoria, and commercial/quality approval from A.I.P./PACIA.

The collection company (which could also be a used oil recycling company) would collect these containers in a vehicle fitted with an oil storage vessel and a small banded granulator to reduce collected HDPE container volumes (PP containers could simply be “nested” and stored pending delivery to the recycler – this would assist in minimising contamination of HDPE by PP). After delivery to the oil recycling company’s depot, the oil would be pumped to a central bulk storage and the granulated plastic containers placed into woven plastic bulk bags for eventual transport with the “nested” PP containers to a plastics recycling company.

This could also apply for cities and towns in rural districts, but for areas outside these districts the plan would rely on farmers and other residents returning the containers to an agreed location such as those currently under review by the National Farmers Federation and The Agricultural/Veterinary Chemical Industry for the AGSAFE Container Management Program “drumMUSTER”.

(ii) Washing And Conversion To Pellets

As the Victorian tonnage would initially be insufficient for more than one recycler, A.I.P. and PACIA would jointly provide commercial and technical/quality approval to the appointment of one company for a specified period. The successful tenderer would have demonstrated the

ability to remove the free oil and as much as possible of the entrapped oil and would have assessed the economics of purchasing and installing the required new specialised washing-line/equipment outlined in this study, or of modifying/improving equipment already on-site and will have confirmed the viability of the end markets identified in this study – in particular for re-use as oil containers. In addition the successful recycler would have demonstrated the capability of meeting, and would have received technical approval from “EcoRecycle Victoria for compliance with, specified product stewardship and environmental standards.

(iii) End Markets For The Recycled Polymer

▪ Oil Containers

Recycling of used oil containers within a “cradle to grave” concept is technically feasible for both HDPE and PP – for HDPE as a trapped layer within an inner and an outer layer of virgin HDPE, and for PP as a 25% blend with virgin polymer (subject to further trials).

▪ Other Applications

- (a) Extruded pipe – A trial by Vinidex Tubemakers Pty Ltd demonstrated that the recycled HDPE is technically suitable for agricultural pipe if incorporated as 25% by weight of HDPE feed.
- (b) As noted in the body of the Report, in Victoria, Australian Recycling Technologies Pty Ltd in Ballarat currently processes plastic streams which may include a proportion of unwashed post consumer oil containers (also at Omnipol Pty Ltd in South Australia), and it is recognised in the medium term, adoption of any of these recommendations may progressively reduce the proportion of oil containers in A.R.T.’s input stream. Nevertheless this usage represents a small but useful on-going outlet for unwashed containers.
- (c) McCoy Global Resources pending facility at Temora, NSW is likely to be able to absorb much if not all of the potential NSW availability of HDPE and PP, and this can be assessed later in 2000. McCoy Global Resources may decide to erect a similar plant in Victoria, and if so this may provide a further option to the re-use for oil container options some time in the future.

- (d) Pyrolysis – Energy Developments Ltd is presently erecting a waste reduction facility near Wollongong , NSW, and consideration of this option cannot be quantified before late 2000 early 2001.
 - (e) Incineration – Until Teris (Aust) Pty Ltd is in a position to offer this service, incineration as cement kiln fuel is not an option.
 - (f) Preliminary discussion with Fernz Construction Materials Pty Ltd suggests that later in 2000 a potential use for flake or granules may be developed, and the economics of this can be assessed as part of the proposed follow-up study.
- (iv) **The preferred option for Victoria is outlined on the chart shown on the following page.**

4. CURRENT PRACTICE – AUSTRALIA

3.1. Plastic Oil Containers – Landfill

Due to the difficulty of cleaning/de-oiling plastic, predominantly HDPE, oil containers after use, the majority of containers end up in landfill sites. Confirmation of this was obtained via NSW Consultant Enviro Filtration who advises the NSW EPA has expressed concern about this practice.

A 1996 AIP survey estimated 30 million litres of virgin lubricants were sold into the Australian DIY market. Other more recent estimates indicate overall Australian retail sales of some 50 million litres, which suggests that currently in excess of 14 million packages with an equivalent in weight of over 3000 tonnes per annum of HDPE and possibly as high as 4000 TPA (an earlier estimate suggested up to 5000 TPA based on production for oil containers, but it is now acknowledged that some of these packaged goods are exported and also some containers are co-incidentally included in input streams to recyclers) are deposited in landfill each year; perhaps 1000-1500 TPA in Victoria alone.

There is no evidence that any of these HDPE containers are flattened by users prior to disposal so that in the worst case the above figures could translate to an empty container volume equivalent nationally of some 50 million litres delivered to landfill sites, possibly up to 20 million litres in Victoria, for some degree of compaction at these sites during landfill operations.

In addition, based on an estimated 10-15% by weight of residual oil remaining in these containers, it is also likely that well in excess of 500 tonnes/annum of motor oil is co-deposited into landfill by this means. In support of the estimate it was noted that after initial draining, approx 100ml of oil remained in 5 litre containers which had held virgin lubricating oil, and that this was largely due to the container design. Similarly, due to the “sludge” present in used oil, without close attention being paid to draining, the residual oil content will be as high or even higher. (“Controlled” draining by Coast &

Valley Oil Distributors NSW still results in approx 10% by weight of residual oil.)

It is noted that Viscount Plastics plans to manufacture and supply 20 litre poly propylene oil containers which are expected to progressively replace much of the tin plate currently in use for this market, the potential for which is estimated at approx 4000 tonnes per annum of PP in the longer term. These containers are mainly intended for the 'professional' market in which case they are less likely to find application in the domestic DIY market. In these circumstances eventual collection and recovery for recycling is unlikely to pose a significant problem, even from many rural areas as farmers are already responding to other recycling initiatives by the chemical industry.

Currently, both the HDPE and PP are potentially fully recyclable provided an economic and environmentally sound collection procedure is developed. However it should be noted that some smaller packages of specialised automotive products are produced from highly coloured vinyl resins, and although these may be able to be adequately recycled in the future, it is understood that equipment/technology currently in place precludes any large scale activity of this kind in the short term.

3.2. **Plastic Oil Containers – Collection**

One significant container collection procedure has been identified via Coast & Valley Oil Distributors in Berkeley Vale NSW, who collects 2000-3000 plastic containers per week containing used oil from about 40 collection sites around Sydney and adjacent areas. After collection and transport to Berkeley Vale these oil containers are inverted and drained into a receiving vessel for recovery of the oil and its subsequent conversion. Currently the containers are then disposed of via landfill, and the NSW EPA has expressed concern and is understood to be contemplating serving notice for an alternative disposal method.

Discussion with recycling companies also suggests that the Victorian EPA may be planning to increase the frequency of inspections of service stations and automotive repairers to ensure proper records are kept regarding disposal of motor oil, motor oil containers and oily rags etc.

Although enquiries to interstate municipal authorities were not undertaken, limited information has been obtained indicating for example at least one South Australian Municipal Council has established a “drop-off” location for used oil containers with a person employed to supervise the draining into receptacles provided for this purpose. Also a South Australian plastics recycling company has provided a special draining rack to a large user of lubricants and hydraulic oils (see later in this Report).

Local enquiries however indicate that municipal councils may be providing varying advice to enquirers. For example, advice could be to place empty containers into the garbage bin or in other cases to dispose of empty oil containers via periodic hard-waste kerbside collections. In this respect, EcoRecycle Victoria from time to time inserts advertisements in local community newspapers drawing householders’ attention to the need for care. One of these features a media personality holding a motor oil container and saying, *“Do your bit, sort it out. When your recycling is collected, it is sorted again by hand. So, do the sorters a favour keep oil, paint and poisons out of your recycling container.....”*. Similarly, a recent edition of “Royal Auto” contained the following item:- *“Keeping your car maintained is a good way to retain its value and ensure it performs as efficiently as possible. But be sure not to harm the environment at the same time. Even a small amount of oil can severely contaminate waterways. Oils are toxic to aquatic life and cause problems by smothering plants and animals. To limit oil pollution, keep your car maintained so it doesn’t leak oil or petrol, and dispose of oil responsibly. Contact your local council to find out what collection facilities are available, or ring EcoRecycle Victoria on 1800 353 233 to enquire about their free Household Chemical Collection. To help keep our air clean, stay tuned.”*

It is also noted that some municipal councils suggest that residents can take plastic containers with oil to an oil recycling company (one such company is Nation Wide Oil at Braybrook, Victoria, to whom Maribyrnong City Council often refers ratepayers. Nation Wide advises that householders who bring containers with oil are asked to take the container after emptying to the council tipping site or to an EcoRecycle Victoria nominated collection point) or to the local tipping site for a nominal fee, or to a local service station. As a result of these varying recommendations it has not been possible during this study to determine the most common practice by householders but discussion with EcoRecycle Victoria suggests the inconvenience of the current

procedures may create a potential for environmentally unsound disposal by some householders.

W.M. Waste Management Services Pty Ltd, Boronia provides a hard waste collection service to many municipalities and has advised that if residents leave full oil containers for kerbside collection, these are not collected and a note is left for the resident asking them to contact the local council who usually inform them of the next scheduled EcoRecycle Victoria sponsored household chemicals collection centre, or to take the items to a local service station. Empty oil containers, along with empty paint tins etc, are disposed of by W.M. Waste Management Services via authorised waste disposal procedures.

Discussion with Visy Plastics suggests that where plastics packages containing significant quantities of oil are received in incoming plastics streams, these can be isolated and removed via manual inspection. On the other hand limited quantities of drained HDPE containers can be and are processed in the HDPE recycling equipment along with other HDPE packages, with little effect on the output quality. In this respect it is noted however that the melt flow and other characteristics would be significantly affected if anything other than very limited quantities of oil containers were incorporated, and continual precautionary laboratory evaluation of the extruded pellets is necessary – the expertise of the individual recycler providing the basis for ensuring each batch meets the specific processing requirements of their end customer notwithstanding the possible inclusion of some drained HDPE packages in the input stream.

3.3. **Plastic Oil Containers – Recycling**

3.3.1. **Segregated as HDPE Polymer**

As reported earlier, specific recycling of these containers by washing and processing for resale as HDPE polymer is not currently carried out due to the difficulty of satisfactorily removing the residual oil. This was demonstrated by Visy Plastics who confirmed for this project that the process is not feasible using either currently installed aqueous/detergent washing procedures or equipment

currently in use for internal material handling and transport.

A “mothballed” non aqueous solvent washing plant incorporating appropriate material handling capability was located at TP Recyclers Reservoir, Victoria, who several years ago had purchased a partially developed but untried unit from another recycler. This unit was used to provide washed HDPE and PP for this project and will be referred to elsewhere in this Report.

Also Polymer Corporation, Carole Park, Queensland has advised that if oil companies, or other third parties, can organise the collection of used oil containers and then re-draining and compaction or granulation of the empty containers, purchase of all such waste could be undertaken for sale to existing users of recycled polymer. It is unclear whether Polymer Corporation currently has a viable washing procedure, but if so it would be reasonable to assume there would be sufficient recycling capacity for the Queensland oil packages to be recycled locally – verification to confirm this capability in due course would be appropriate.

Although in 1997 Compco Pty Ltd, Mordialloc, Victoria, had sufficient compounding/extrusion capacity installed to produce unwashed pellets from the HDPE containers currently used for motor oil in Victoria (provided these were pre-shredded by a third party), it is now possible that only part of the availability may be able to be processed. An indicative cost of 30-40 cents/kg has been provided however for the extrusion step and it is noted that Compco would only undertake this provided a firm market existed at the time for compounded product containing the 10+ % oil, and has suggested it is possible if blended in appropriate proportion with recycled HDPE from other sources, such a market may be able to be developed for extruded pipe.

3.3.2. Inclusion in Mixed Streams

Contact was established with recyclers who either purchase specific post consumer plastic goods for reduction and blending to produce saleable products, or who take mixed plastics directly into their processes to manufacture saleable products. Several of the firms contacted have indicated they are unable to include oil

containers in their input, but two companies do accept these as follows:

Omnipol Pty Ltd, South Australia

Omnipol produces a range of products including vineyard posts and can accommodate up to 10% by weight of used completely drained oil containers in combination with plastics from other sources. These posts are marketed in competition to pine posts at a value of about 40cents/kg.

The input is based on zero cost other than labour and power etc with no washing prior to conversion, and expansion of capacity is underway with a potential off-take of oil containers amounting to several hundred tonnes per year.

A video showing Omnipol's operation is held in project files for reference as required, and a product information brochure is shown as Attachment 11.1.

Omnipol has advised that some S.A. municipal councils have established drop-off locations for used oil containers and problems of inadequate draining in one instance led to employment of a person to supervise the draining. Omnipol has also supplied a special rack to Toyota Prolift in SA for use prior to conversion by Omnipol, and this has resulted in excellent draining after about 10 minutes.

Australian Recycling Technologies Pty Ltd, Ballarat

A.R.T. is currently able to process with no washing, 10 tonnes/week of mixed plastics including some used oil containers. This company specialises in heavy outdoor furniture, plastic lumber and underground equipment protection boxes.

Sometimes, recycled plastic input is received in bales which obviously contain substantial loose oil (eg via careless disposal by consumers, of containers either partially or completely full of used oil). In these cases A.R.T. can progressively use this material at around 10% dilution with other plastics. A.R.T. is expanding production, and on this basis, properly drained oil containers mixed with other plastics waste should be completely acceptable for use with potential off-take of several hundred tonnes per year.

Product brochures, price lists and company information are shown as Attachment 11.2.

Enquiries suggest no plastics recycling companies in NSW or QLD currently produce items directly from mixed plastics streams so that in the short term it appears likely that oil container disposal by this means is limited to Ominipol Pty Ltd in South Australia and Australian Recycling Technologies Pty Ltd in Victoria.

McCoy Global Resources

McCoy Global Resources at Temora in NSW has advised a facility, which it is claimed will be able to process mixed plastics including oil containers to produce railway sleepers and other items, is nearing completion. It appears likely McCoy Global Resources will be able to use these HDPE oil containers even with 15-20%ww residual oil, and this would alleviate a disposal problem being experienced by Southern Oil Refining Co at Wagga Wagga in NSW (which is evidently similar to the experience of Coast & Valley Oil Distributors discussed elsewhere in this Report).

On the above basis it could be possible to absorb much of the NSW oil container stream by late 2000 thereby potentially reducing the need for a new NSW based washing and pelletising plant, and McCoy Global Resources' "on the ground" capability by that time should be taken into account by interested pellet producing recycling companies in NSW.

It is understood that McCoy Global Resources may be contemplating a similar unit in Victoria in which case at some time in the future could be added to project recycling options.

Energy Developments Ltd

This company is potentially able to offer a plastics recycling capability – for further details see later under Section 5 "Waste Reduction and Associated Services".

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For interest, a number of other recycling companies were also contacted during this study and although unable to currently accept oil containers, the following comments summarise their comments.

Some local recyclers obtain at least part of their HDPE containers and other items for no cost, with some purchases at 10 - 15c/kg if received as 'virgin' scrap polymer of the required melt flow characteristic. Currently, however, the local pricing of HDPE grades by producers and importers is such that some potential users prefer to purchase ex the manufacturer rather than purchase recycled material, and as a consequence there may be a considerable tonnage of recycled HDPE in storage awaiting sale. In general, however, it appears that many recyclers have developed long term commercial associations with moulders and extruders and source changing by users between recycling suppliers/sources may be infrequent. It is noted that significant quantities of recycled HDPE are used by pipe extruding companies.

The current market price for recycled PP, for example flower pots, appears to be somewhat stronger than for HDPE, possible partly due to the fact that a higher proportion of HDPE containers and other items have been available for feedstock, thereby leading to some degree of oversupply. However even prices for virgin PP polymer have been offered at prices which have resulted in recycler's margins being vigorously squeezed if they wish to maintain supply to their existing customers, principally for planters/pots where thin wall strength is important.

Discussion suggests that where 'in-house requirements dictate the specific characteristics of recycled polymer input (eg. melt flow, colour, impact etc.), recycle moulders who granulate their own requirements may be prepared to pay between 25-35cents/kg for items such as "clean" wheelie-bins and milk bottles etc. where these can be shredded and blended/used with no pre-washing, (and interestingly, 20 litre farm chemical containers which have been pre-washed prior to delivery).

Vic Fam Plastics Recycling Co, North Laverton

Preliminary discussion with Vic Fam Plastics Recycling Co indicates that even well

drained oil containers would not be acceptable in their process for producing plastic pallets. Currently there is adequate supply of plastic milk containers and other suitable low-density polyethylene feed stock, and Vic Fam is therefore unlikely to represent an off-take for oil containers in the short term.

Repeat Plastics Pty Ltd, Lilydale Victoria

Repeat Plastics produces a wide range of products using plastic waste which was previously disposed of in landfill. These products include highway guideposts, jetty and walking track materials, marker posts, temporary kerbing, speed humps, streetscape bollards and furniture etc.

Currently Repeat Plastics Management prefers not to process used oil containers as many of these containers are black and would present unnecessary difficulties for Repeat's production of mainly light coloured items.

Unimould Pty Ltd

Unimould, a Recyclers of Australia Pty Ltd subsidiary, produces substantial quantities of rigid plastic sheeting from recycled HDPE using low pressure injection moulding, and much of the output is in green or pastel shades for which recycled HDPE oil containers would be unsuitable. Some output is as black sheeting and although Unimould has not ruled out the use of clean recycled oil containers in the longer term there is a preference in the current over supply situation to continue to source requirements elsewhere.

For the future however, when commercial quantities of HDPE from oil containers become available, Unimould is willing to examine the possibility of use as black masterbatch provided consistent quality is maintained.

3.3.3. The *drumMUSTER Container Management Program*

DrumMUSTER is the national program for the collection and recycling of empty cleaned non-returnable crop protection and animal health containers, and is funded via a 4 cents/litre levy on all containers over 1 litre.

Avcare through the subsidiary Agsafe has provided some useful background to the drumMUSTER program, and as at 9th December 1999, 76 councils from a total of 192 had signed-on to the program (refer to Attachment 11.3 for details). 88 collections had been carried out via 39 of these 76 councils, and 28 further collections have been scheduled, with information/education forums for councils and farmers programmed in each State and Territory for February 2000.

From the point of view of the oil container recycling project, subject to further discussion with Agsafe, there appears to be some potential for a degree of participation in the Agsafe program specifically in rural areas. The economics of this should form part of the flow-on study to develop the accurate economic model referred to elsewhere in this Report.

5. PREVIOUS TRIALS IN AUSTRALIA

In 1997 a trial 1 tonne of HDPE oil containers was shredded by Wilson Plastic Recyclers (now Polymer Processors Pty Ltd) and compounded into granules by Compco Pty Ltd. The resulting granules containing the residual oil were supplied to Priority Plastics (now Southcorp).

Priority Plastics moulded these granules into a central layer of a three layered bottle with no reported processing difficulties other than odour - one of these reprocessed containers is still retained by Compco who advise it retains an oily odour.

Southcorp at that time also produced a single layer bottle which had high residual odour and was deemed uncommercial, but more importantly the high level of fuming during the blow moulding process rendered it unacceptable at the manufacturing site for any future reconsideration.

6. LOCAL WASTE REDUCTION AND ASSOCIATED SERVICES

Two companies who might have been able to provide a container washing capability were contacted ie: Environmental Recovery Services Pty Ltd, South Croydon, who could potentially supply a container washing facility to service stations, and National Resource Recovery Pty Ltd, who had indicated a potential interest in supplementing their current extensive collection of non-oil containers for washing and re-use. At the time of concluding this Report neither company believes their facilities could realistically be considered in this recycling project so that their initial interest has simply been recorded for future reference.

(a) Teris (Aust) Pty Ltd, Hallam specialises in eliminating hazardous wastes by converting them to cement kiln fuels, and was requested to advise cost estimates for inclusion of shredded unwashed oil containers in their input stream to the converter. Teris has sought advice and comments from their European parent company based on experience in Germany.

So far no cost indication can be provided although it is understood that several installations in Europe are using waste plastics as energy, and that these are heavily subsidised by the German Recovery Plan as the investment and operating costs for collection, transport, pre-processing and injection are quite high.

(b) Energy Developments Ltd, NSW - Correspondence received from Energy Developments Ltd indicates that a process has been developed to separate Biomass including plastic film and other cellulosic packaging from household waste, and convert it to “green” electricity. It is understood that rigid and semi-rigid plastics can be separated and shredded for energy recovery via pyrolysis or recycled depending upon market conditions.

This system is know as EDL’s Solid Waste Energy Recycling Facility (SWERF). Attachment 11.4 refers to an announcement in the Illawarra Mercury 25 March 1999 re construction of a \$40m facility near Wollongong NSW, and also includes pages 1, 2 and 6 from an EDL publication “Answers to Frequently Asked Questions”.

7. OVERSEAS PRACTICE

6.1. Collection/Draining

6.1.1. U.S.A.

Currently in the United States, several technologies exist for recycling motor oil bottles after collection and prior to washing. Companies use either the B.O.B. (Bottom of the Bottle) method, centrifuge, bail and drain the containers, granulate and drain the containers (or go straight to a granulated chemical wash system).

The B.O.B. (Bottom of the Bottle) technology relates to a patented tool from Plastic Oil Products in Santa Monica and is designed for the homeowner as a single unit, or to be joined together for larger sites such as service stations etc. It sells for \$US6.95-9.95 and caters for “quart” oil bottles, and although the principle itself should be of interest, in its present form it may have limited application here in Australia where a significant proportion of the containers are 4litre & 5litre sizes.

Plastic Oil Products claim the typical user leaves 4% of oil in each container and that as each “trash bag” used for collection contains 45-50 quart bottles, about one quart of oil is delivered to the recycler unless “B.O.B.” is used. It is further claimed that after draining via B.O.B., when co-mingled with other #2 plastics including detergent bottles, the slight remaining film is easily “cut” by the detergent and water. (See Attachment 11.5)

Plastic Oil Product’s sales literature includes reference to a Napa County (CA) study performed by Gamble, Roberts & Associates, January 1997: “Pigmented HDPE plastic bottles appear to be the most neglected container to the residents with 52.6% of the total generated put in the garbage. It would appear that targeted education to inform the householder that pigmented HDPE bottles from bathrooms, laundry rooms, and garages should also be recycled would be beneficial in increasing diversion”. Also to a six-city study performed in 1992 and 1993, sponsored by the American Plastics Council, published in the September 1994 issue

of Resource Recycling Magazine: “It was observed during the sorting that containers generated outside of the kitchen area were less likely to be recovered for recycling.”

Turbo Spin Inc, Albuquerque, USA manufactures and sells “Filter Fuge” equipment for 6-minute cycle centrifuging of used oil filters, and price details together with pictures are shown in Attachment 11.6. (Incidentally two of these machines have been purchased by B.H.P. Minerals in New Mexico) Turbo Spin advises the equipment can be used for oil bottles if a different design of device to hold the bottles in place is used, and presumably they are able to provide this if required. Currently the largest machine costs \$US8400, has a 125gallon waste reservoir and holds 16 filters of varying combinations of dimensions up to 8.5inches x 19.5 inches so that it seems likely in principle this equipment could be suitably modified for the majority of used oil containers in Australia.

The California Integrated Waste Management Board advised that Fixcorp International, Beachwood, Ohio signed a world-wide agreement with Allied Signal Inc giving rights to a process for separating motor oil from HDPE containers, and referred to as “George™”.

Project “George™” was made possible by a grant awarded by the California Integrated Waste Management Board and is the name of the machine which grinds plastic, extracts oil from oil containers, reclaiming the oil and the recycling plastics, thus generating value added renewable end products. The money is derived from a 4cent state sales tax per quart of oil and the technology was developed by Allied Signal Inc. George™ was designed and is managed by FIXCOR Recovery Systems who built a portable oil separation unit and ran pilot programs at six different sites in California over six months beginning in October 1998. The study was completed during 1999 and demonstrated that George™ helps to expand existing contracts accepting HDPE post-consumer bottles by allowing kerbside programs, recycling centres and household hazardous waste programs to accept used motor oil containers which currently most cannot do satisfactorily due to the oily residue.

Fixcor claims the project also helps to develop a collection system for motor oil container recycling through a partnership with a service provider working with used oil collection programs operated at retail sites (eg. auto parts, oil change locations and municipal airports). At the same time the project helps to develop a collection system working with existing Material Recovery Facilities (MRF's), household hazardous waste collection sites and mobile oil recycling programs.

Although we have requested further information direct from Fixcor Recovery Systems in USA, it now appears they are not prepared to offer fixed or mobile equipment for sale into Australia. Meanwhile for general interest a copy of Fixcor's 'flyer' is included in this Report as Attachment 11.7.

An abstract from an article in Resource Recycling October 1998 page 27-28 refers to a scheme run by the South Carolina, USA, Department of Health and Environmental Control for collecting and recycling empty automotive oil bottles.

An estimated 30m such bottles are discarded at service stations and other automotive outlets which would otherwise end up in landfills. A pilot project funded with the aid of the US Environmental Protection Agency was begun in 1995 and in 1996 a collaborative programme was begun with KW Plastics who developed a washing system for materials recycling centres.

Initial sorting of commingled material and polyethylene terephthalate (PET) bottles was found to be messy and labour intensive. A modified programme requiring caps to be left on bottles has greatly reduced surface contamination.

Currently 26 counties in South Carolina collect motor oil bottles and these are manually (one quarter of a person/day) sorted with oil draining as necessary. 3/8inch flakes are discharged into gaylord containers by gravity. KW Plastics accepts these gaylords and washes the flake. (Note - an earlier request to K.W. Plastics for information provided only sketchy details, confidentiality being an impediment to significant input from them regarding the washing system for this project.) Apparently there is no net profit although revenues received by the MRF cover costs.

Charleston and Lexington counties also participated in two motor oil bottle recycling projects. In 1997, state regions were established to collect motor oil bottles commingled with other plastic bottles as well as glass and metal containers. About 60% of the material collected was from kerbside programs, with the remaining 40% from drop-offs. The education to the public was very important and the residents were told to leave the caps on the motor oil bottles. After collection, the bottles were taken to a MRF and manually sorted from other containers. The material was granulated and the flakes taken to a reprocessing company for washing and marketing for the manufacture of new plastic motor oil bottles and other end product.

It appears that in the Los Angeles area no special collection procedure exists, so that oil bottles are placed for kerbside collection with other items, although containers with used oil remaining should be taken to specified “drop-off” points.

In 1992, Houston became the first major city in the country to establish a kerbside used motor oil recycling program. The city currently provides kerbside used motor oil collection to 115,000 homes by using recycling trucks that have been retrofitted with used oil collection racks.

Now recycling used motor oil has been made easier, as the same city recycling trucks that pick up aluminium cans, plastic containers, newspapers and glass are equipped to collect used oil for recycling. Householders are requested to put the oil in a proper container and place it on the kerb along with other recyclables (making sure not to mix used oil with any other material).

For further details see Attachment 11.8 which also demonstrates a receptacle for receiving oil at “drop-off” locations.

Also, two other references relating to collection and drop-off points have been obtained as follows, and are included as Attachments 11.9 and 11.10.

- “Perfecting the Plastics Drop-Off”, sponsored by the American Plastics Council and Proctor & Gamble

– “Lessons from Model Cities Demonstration Program”

6.1.2. CANADA

ABC Group, Rexdale, Ontario Canada, developed a pilot operation to clean the flakes using only hot, pressured air -not-water - to clean motor oil bottle flake. It requires bottles with plastic labels only, sleeves or stick-on. (Those with paper labels have to be pulled out at the sorting line.) ABC hopes to commercialise the process in the next few years.

Plastics World August 1995 refers to ABC Groups patent for a recycling process for HDPE motor oil bottles which uses only hot, pressurised air, not water, to clean the bottle flake. The process relies partly on a novel line-up of hot-air centrifuge and hot-air conveyors and partly on a proprietary compound, developed by ABC's Salflex Polymers, which adds an oil absorber and fillers such as calcium carbonate/glass/talc to produce an extrudable mixture. The trial run relied on plastic labels rather than paper labels, and produced about 50,000 lb of material, with comparable top load and ESCR properties to the virgin HDPE. Other properties generally exceeded or matched those of the original resin. Details of this US patent 5,225,137 for Bottle Recycling are shown as Attachment 11.11.

Note: An article on Page 31 of Plastics World August 1995 referring to Polymer Properties via this process is also shown as Attachment 11.12.

In the Canadian Province of Alberta a non-refundable environmental handling system exists for lubricating oil, oil filters and oil containers. The oil container charge is 5cents/litre of container size and the fee is not a government tax but is collected by the Alberta Used Oil Management Association (AUOMA). The AUOMA Flyer is included in this Report as Attachment 11.13.

6.1.3. EUROPE

Enquiries made to relevant industry associations for information regarding the situation in Europe has not generally been fruitful. Contact with European

machinery/equipment manufacturers however indicates that several manufactures can offer equipment suitable for washing plastic oil containers. Clearly therefore some continental European countries have procedures in place to collect and process oil containers, and this is supported by a number of references and other information as follows:

- Polychem Pty Ltd has advised that Enretec in Germany recycles oil bottles using equipment purchased from Herbold ZT – see details later in Section 7(i) “Equipment Suppliers Offering Oil Washing Capability”.
- Europlastics Machinery in the UK advise that at the moment the collection of oil containers in the UK, specifically below 5 litres is not well organised with no one body wanting to initiate separate collections. There is no incentive for collector or recycler, but a E.U. Directive may put some pressure on by the end of 1999/early 2000.
- A literature search for Italy (A. Pellegrini “Reuse of Plastic Materials From Post Consumer PE and PVC Bottles” Proc Recycle – ‘92 p.H/3-1) states in summary:-

Recycling of HDPE Motor-Oil Containers: HDPE motor oil containers are presently being recycled in a closed loop manner, by a number of service station chains (eg. Agip in Italy). The HDPE bottles are collected from service stations and thus need minimal sorting. They are transported to a washing plant where they undergo washing and oil removal to eliminate some of the 8% residual oil. Even after intensive washing, the bottles tend to retain about 3% oil, which internally plasticises the polymer. As a result of the plasticising effect of the residual oil, the melt flow index increases to 0.4 g/10 min. compared with 0.25 g/10 min. for the original polymer. While hot water washing at 80°C does remove more oil, the extra cost involved is not warranted. Even with hot washing in combination with surfactants, the oil content of the polymer does not drop below 1-1.5%. The strong odour of this residual oil limits the use of the recyclate to the production of new motor oil containers.

- Details of a UK “Titan Waste Oil Well” have been located (Refer Attachment 11.14) intended for convenient, leak-free, safe storage of waste oil. The brochure recommends use at landfill sites, vehicle dismantlers, commercial vehicle operators etc, thus clearly suggesting that this European manufacturer has identified an opportunity to assist with proper disposal of used oil in plastic containers.
- System for recovery of materials from motor oil containers with favourable economic and ecological balance: Stassinopoulos A: Conference Proceedings: R’95 Volume III.

Summary: Used motor oil containers, contaminated with oil residue, are considered hazardous waste demanding special treatment. A system is described for the separate collection of plastic containers and oil residue and the reprocessing of plastic waste into pellets and eventually back into plastic motor oil containers.

The above mentioned paper is show as Attachment 11.15 and in summary, prior to the progressive introduction of bulk lubricating oil facilities at vehicle service centres in several European countries, substantial tonnages of containers and motor oil (it is claimed in Greece up to 20%ww oil remained in these containers). The paper indicates that in Germany in 1995 empty containers were collected independent of the municipal waste system for transport to the closest incineration facility, and some 1500 service stations were equipped with heated shrink equipment to reduce subsequent transport costs. Strassinopoulos’ paper set out to assess whether this procedure was economically beneficial compared to a similar collection process with eventual conversion to polymer pellets, and tables include the basis on which the recycling to pellets option appeared more beneficial.

- If further information regarding European oil container collection procedures is felt necessary, no doubt enquiries by Ecorecycle Victoria directly with European equivalent organisations may be appropriate.

6.2. Overseas Alternative Uses For Recycled Oil Containers

The following alternative use references are only those identified from relevant enquiries and which are not already under consideration in Australia.

6.2.1. CANADA

Fixcorp's Canadian subsidiary advised that an example of their use of recycled HDPE from oil containers and other sources is for POWER PAL 2000, the "Pallet of the Future" which is claimed to have many advantages over wooden pallets - Fixcorp provided information about these pallets relevant items of which are shown as Attachment 11.16. Fixcor Canada offers incentives on some incoming plastic items and charges a fee to accept others where extra processing is required during recycling.

6.2.2. EUROPE

- (a) Social and Technological Aspects of Small and Large Scale Packaging Materials Recycling Streams – Alexis Stassinopoulos: Paper Presented at REC'93 – See Attachment 11.17.

Summary: This paper discusses costs of solid fuel produced from a mixture of used motor oil containers and wood fibres to produce dustless briquettes which burn as cleanly as dry hardwood and low sulphur oil.

- (b) A System for Recovery of Materials from Motor Oil Containers with Favourable Economical and Ecological Balance – Alex Stassinopoulos: ARGO 1995 Conference Proceedings – See Attachment 11.18.

Summary: Outlines options for incineration, conversion to briquettes and material recovery via hot water or centrifuging, and concludes that due to energy savings over incineration with energy recovery, material recycling via collection at service stations equipped with heat shrinking equipment to reduce volume to

10%-15%, and reuse 30/70 with virgin polymer is the best option.

- (c) Reuse of Materials from Post Consumer Bottles: Pellegrini A: Macplas; 17, No.142, Oct. 1992, p57-8 – See Attachment 11.19.

Summary: Details are given of technical and economic trials undertaken in Italy on the recycling of plastics bottles and reuse of the reclaim in the manufacture of new products. Reclaim from HDPE detergent bottles was used in the production of new bottles and in films, bags, refuse sacks, pallets and film spools. HDPE reclaim from motor oil containers was reused in a similar application, and PVC reclaim from mineral water bottles was used in sewer pipes and fittings.

8. EQUIPMENT SUPPLIERS OFFERING OIL WASHING CAPABILITY

Enquiries were made to the Australian Distributors of European plastics recycling equipment, to a UK based distributor, and to a US manufacturer – contact details appear in the Appendix. The information obtained and provided in this Report is intended as a guide or starting point for plastics recycling companies planning to process and re-extrude plastic containers previously used for motor oil, and further contact by interested parties to these organisations is recommended.

Polychem Pty Ltd in NSW represents Herbold ZT. Stolat (Machinery) Pty Ltd in NSW represents Plastics Recycling Technology Co. Italy, B.K. Sales Pty Ltd in Victoria represents Neue Herbold, Erema Austria, and Technofer CMII Italy. Europlastics Machinery in Gloucestershire, UK represents OMP Prealpina, Italy, and ADF Trading SA in Switzerland represents Sorema, Italy. These agencies would welcome follow-up enquires from interested plastics recycling companies – refer Appendix for contact information.

It should also be noted that a number of Australian equipment manufacturers contacted have indicated a preparedness to manufacture certain specific pieces of equipment to purchasers' specification where recyclers may not wish to purchase a complete plant from an overseas

supplier. Local manufacturers contacted include Cameron and Castanedo Pty Ltd, Emmans Granulators Pty Ltd, Hydra-Pac Pty Ltd, Shred Tech Pty Ltd (Brentwood Systems) and Wastech Engineering Pty Ltd – Refer Appendix for contact information.

- (i) Polychem Pty Ltd in NSW, as agent for Herbold ZT, has provided a schematic plant layout for a processing unit capable of handling 1500kg per hour, but can offer units down to 500kg per hour. The process includes a wet granulator and centrifuge, and the FOB price indication is approx 0.62M D.M. For future interest and assistance, although not included in the Attachments, Polychem has also provided prices for individual pieces of relevant equipment should this be preferred, and Polychem would welcome enquiries from interested recyclers regarding this equipment and/or the mobile granulator referred to below.

Herbold ZT's plant suggestion layout diagram for a 1500kg/hr unit is shown as Attachment 11.20. In summary however they advise that the oil bottles are collected in bags which are then fed to a shredder. The shred is moved via a screw conveyor to a centrifuge, then via conveyor belt with integral metal detector to a wet grinder producing 12mm flakes.

Washing is carried out in a friction washer using water, passed through a separation tank and then pre dried via a turbo drier to residual moisture approx 10%. Final drying takes place via a thermal drier to residual moisture approx 1%.

The output is clean dry flakes which are processed 70/30 with virgin polymer to produce new oil bottles.

Herbold ZT can supply all the equipment, but suggest that the recycled water system complete with the oil separation system would be available in Australia, as well as a suitable HR75 shredder.

Also, as a matter of interest a company in Germany, Enretec, has installed a 500kg/hr washing line incorporating Herbold equipment. In this case feeding of the line is carried out manually to ensure separation of any full oil containers prior to the granulation step, and warm water washing (with an undisclosed additive/solvent) achieves residual oil content down to approx 1% ww.

Polychem Pty Ltd has also assisted in obtaining a price indication and details for a mobile granulator with a banded oil receiver – this type of equipment would be necessary if the later recommendations in this Report are to be adopted.

Complete details of this equipment are provided in Attachment 11.21, and an indicative cost FOB is approx 0.11DM complete with spare parts and ready for mounting on a flat tray lorry vehicle. In summary the equipment incorporates dry grinding of the oil bottles and subsequent discharge facility which allows the oil to collect in a storage container. Over 30 of these units have been sold including exports to Israel and Switzerland (in this latter case as a fully mobile unit).

- (ii) Plastics Recycling Technology Co. Italy - P.R.T. is represented in Australia by Stolat (Machinery) Pty Ltd in NSW who would welcome enquiries from interested parties. Relevant information and diagrams about P.R.T.'s equipment is shown in Attachment 11.22 and in summary the recommended procedure is as follows:-

A wet granulator incorporating powerful water jets allows primary separation of the polluting material and includes a de-watering auger to transport the granulated polymer to an intermediate stainless steel separation centrifuge. The material then passes to a hot water (60°-70°C, detergent is not necessary) washing tank where the surface paddles push the floating polymer to a rotary extractor and a de-watering auger feeding the drying centrifuge.

The final drying stage incorporates a washed flake storage-feeding silo equipped with discharging cyclone including forced hot air ventilation.

A dosing-feeding unit is located between the dried flake silo and the extruder, and the recycling line is equipped with electric control panel, hydraulic screen changer, hydraulic power unit, pressure gauge, and die face cutter. A price indication of approx 550M lire is provided for a 250KG/HR throughput – individual components would be available if preferred and Stolat (Machinery) Pty would welcome enquiries relating to this capacity or larger if required.

- (iii) Europlastics Machinery – UK - agent for O.M.P. Prealpina S.R.L. in Italy has provided the following information –

Processing of post consumer oil containers requires centrifugal removal which allows very fast removal of all remaining oil as opposed to some adherence, particularly with the heavier grades. The equipment for this approach requires firstly a wet type shredder/grinder which reduces the material to a consistent and free flowing particle size. Next the material leaves via a drainage auger to go to a “Turbowash” centrifuge cleaner. This removes all labels and non-plastic contamination using warm water and intensive washing. The next stage is to a settlement tank where only the PE fraction floats (some PET oil containers are being used). This material is centrifugally dried and passed in warm air to the extrusion process where the material can be coloured to suit specific moulding applications. The extruder should have additive/powder dosing capability, good vacuum venting and minimum 35:1 L/D ratio output.

The washing machine is crucial to the absolute cleanliness of the resultant material so that all the oil can be recovered in this system as well as the polymer. In addition, Europlastics Machinery as agent for the Darcy/Boden oil/water separator, has provided details of a mobile unit which will be of interest – shown as Attachment 11.23.

In order to maintain the best quality of the PE reprocessed material and to ensure that it can be successfully blown back into bottles/containers without losing much of its mechanical properties the addition of antioxidants at the time of compounding is strongly advised.

If it is proposed to set up a pilot plant for this project a Demonstration machine is available at the factory in Italy and this is currently for sale (approx 400kgs per hr).

Europlastics Machinery has provided a description and schematic diagram for the washing and drying plant relating to this proposal, and this is included as Attachment 11.24. At our request the initial price indication is based on a plant requirement with throughput of approx 500kg/hr, and the indicated F.O.B. cost is approx 0.45M Euro for one plant.

In addition Europlastics Machinery has offered the possibility, if required, of sending a bale or two of oil bottles to Italy for processing in the demonstration facility where the

results/process could be video recorded for interested parties.

- (iv) Sorema – Italy – Detailed information received directly from ADF Trading in Switzerland by a plastics recycler is currently being held in Project Files. Relevant sections of this information, (except for any details deemed confidential) describing the recommended process are now included as an Attachment 11.25. The F.O.B. price indication for the complete specified system capable of processing 700KG/HR is approx 2,900M Lire, and Sorema would be interested to receive enquiries for equipment to satisfy the requirements specified by other recyclers. In summary the process is as follows:–

The system is designed to operate with or without detergent, and to minimise water consumption. Contaminated oil bottles are fed to a shredder and then to a “rotating sifter” where some oil is removed. The material then passes to a wet/dry grinder which further reduces the size before it is passed to a steam centrifuge which removes further oil.

Decontaminated flakes are then delivered to a washing silo and pass to hot water rinsing equipment, following which the washed polymer passes from the separation tank to a washing centrifuge and then to a drying centrifuge prior to extrusion.

- (v) Technofer CM11, Erema GMBA and Neue Herbold general sales literature has been received, and is held in the Project Files for review if requested by interested parties, meanwhile a selection is shown as Attachment 11.26(i) (ii) and (iii). These three organisations are represented in Australia by B.K. Sales Pty Ltd in Victoria.

9. PROJECT TRIAL

8.1. HDPE and PP Collection and Washing

Earlier in this Report reference has been made to a “mothballed” non-aqueous solvent washing plant located at TP Recyclers, Reservoir. TP Recyclers agreed to “jury rig” this equipment and carry out trials to ascertain the effectiveness of the equipment which had been purchased some time ago from a recycler who had closed his business prior to

commercial use of this equipment.

During these trials, modification of the equipment and washing procedure became necessary resulting in delays in achieving the anticipated completion dates.

Nevertheless both HDPE and PP containers were separately treated to produce recycled polymer typically containing approx 1-3%ww oil (excluding “extractables” in the virgin polymer) - for HDPE see table on page 37; for PP see Section 8.4. The recycled HDPE pellets were then processed by Southcorp/Priority Plastics to produce multi-wall 5 litre containers and 1 litre containers, and the recycled PP was processed by Viscount Plastics to produce 4 litre pails and lids – full details are provided in Section 8.

The source of the post consumer oil containers was as follows –

HDPE

- (i) Section 3.2 above refers to the procedure used by Coast & Valley Oil Distributors, Berkley Vale, NSW, to collect used oil from various collection points. Coast & Valley agreed to pay especially close attention to the draining of a quantity of containers and to accumulate them in a skip kindly loaned by Cleanaway, Wyong, pending transport to Melbourne.

For reasons of transport logistics, Coast & Valley sought to reduce the overall volume by utilising a small baler loaned by Cleanaway. The crushing capability of this baler turned out to be inadequate as the containers tended to partially resume their original dimensions when released from the baler. As a consequence a mobile shredding service operated by Tilkey Pty Ltd, Brisbane, was used to shred the containers which were then loaded into woven plastic bags on pallets and transported directly to TP Recyclers at Reservoir.

- (ii) A number of pallet loads of containers which had held virgin motor oil were supplied by Valvoline (Australia) Pty Ltd and held in storage courtesy of Nationwide Oil, Braybrook. These pallets were delivered to TP Recyclers but on examination were shown to each still contain approx 100ml of oil which created unacceptable “splashing” during the preliminary granulation step.

As TP Recyclers had no viable method at this time of pre-draining sufficient quantities prior to granulation it was agreed these containers would not be further processed for this trial and were subsequently disposed of in an environmentally approved manner. It was also felt that more representative results for the future would be achieved by only utilising HDPE containers which had held used oil.

Laboratory testing by Southcorp demonstrated that even after the controlled draining by Coast & Valley (and by TP Recyclers on a portion of the Valvoline containers), and allowing for estimated losses during mobile shredding by Tilkey, the granulated input to TP Recyclers washing plant typically contained about 10% ww retained oil – some as incorporated oil and the remainder as free oil.

Polypropylene

Pails supplied by Viscount Plastics were filled with lubricant by the Shell Company, and after storage the oil was decanted and the pails and lids delivered to TP Recyclers. No processing difficulties were experienced as a result of oil remaining in the containers, principally due to the open head of the container facilitating good draining.

Processing Data at TP Recyclers

Due to the above mentioned need to modify various items of the equipment during processing, necessitating a series of small runs, the output data is not representative of a larger single processing run. Nevertheless it is included for general interest, although TP Recyclers has advised that based on normal throughput approx 90% recovery could be anticipated.

HDPE

Gross weight granulated HDPE ex Coast & Valley	638kg (incl. sludge)
Less Tare	<u>110kg</u>
	528kg
Less sludge and other washing losses	<u>83kg</u> (3 runs)
Washed/granulated HDPE to extruder	445kg
Extrusion losses	<u>70kg</u> (3 runs)
Delivery to Visy Plastics	375kg
Losses during vacuum vented extrusion	<u>17kg</u> (1 run)
Net weight HDPE pellets for Southcorp trial	<u>358kg</u>
	(Recovery 68%)

PP

Net weight approx 1000 Viscount PP pails/lids delivered ex Shell (off pallets)	1000kg approx
Less oil residue and other washing losses	<u>122kg</u> (3 runs)
Washed flake	878kg
Extrusion losses	<u>250kg</u>
Net weight pellets for Viscount trials	<u>628kg</u> (3 runs) (Recovery 63%)

8.2. Extrusion Blow Moulding trials at Southcorp/Priority Plastics

The trials demonstrated that the use of post consumer resin (PCR) oil bottles is possible provided the granulated resin has been processed to remove all free and some of the (resin) absorbed oil. There are constraints, however, on the scope of re-use of the PCR for oil bottles.

- Monolayer bottles are possible, but the colour is limited to black bottles because of the mix of colours of the feed bottles.
- The bottles have to be made slightly heavier because of a decrease in top load: this is a direct function of the reduction in polymer chain length that occurs during the recycling process.
- There is a measurable increase in bottles ex the moulder with pin-holes and hence associated quality problems and costs. This problem can be mitigated with additional resin filtration just prior to the blow moulding operation, but this adds costs.
- Odour is clearly evident and the monolayer bottles have a higher odour problem than three layer bottles. The concern is that this will be carried into the filled bottle and there may be a consumer perception that the package contains used or recycled oil.
- The process is more difficult to control. With both monolayer and multilayer bottles, there is clearly a narrower process window, and over time this would add to costs through manufacturing variance costs.

Three layer bottles with the PCR as a trapped inner layer between two layers of virgin PCR overcome most of the problems associated with a monolayer bottle except that there is still a diminished, but perceptible odour.

8.3. **HDPE Extrusion Trial at Vinidex Tubemakers**

Washed pellets were processed by Vinidex at the Clayton Manufacturing Facility to produce extruded rural pipe using 100% recycled material. An odour difference was noted but no processing difficulties were reported during the 100kg trial.

The finished pipe was tested in the laboratory and met all dimensional, MFI and pressure testing requirements. Production management indicated that prudent environmental stress control would allow for incorporation at 25% of HDPE feed to the extruder and that an offtake in Victoria of 1000-1500 tonnes per annum would be technically feasible: clearly the applicable price at the time would dictate demand and some reduction below regular feed stock may be necessary.

8.4. **PP Injection Moulding Trial at Viscount Plastics**

8.4.1 **Material Testing**

1.1 **General**

1000 Pails were filled with lube oil at Shell Oil and stored for 1 month before they were decanted and sent to TP Recycling for granulating, non-aqueous washing and re-processing into pellets.

1.2. **Sampling**

Samples from TP Recycling were collected as follows:

- (i) Unwashed flake
- (ii) Washed Flake
- (iii) Extruded pellets

1.3. Testing

These samples were given to Montell Polyolefins for evaluation and comparison with virgin Polypropylene (PP). The results of this evaluation are shown below. For the purpose of reporting, the tests have been split into the following 3 categories.

(a) Physical Properties

<u>Test</u>	<u>Units</u>	<u>Virgin PP</u>	<u>Unwashed Flake</u>	<u>Washed Flake</u>	<u>Extruded Pellets</u>
Melt Index (230°C/2.16kg)	g/10min	5.0, (7.1*)	8.1	7.4	7.6
Flexural Modulus	MPa	960			750
Tensile Strength	MPa	25.6			23.5
Notched Izod Impact @ 23°C	KJ/m ²	11.0			20.9
Notched Izod Impact @ 0°C	kJ/m ²	5.7			7.8
Notched Izod Impact @ -20°C	kJ/m ²	4.4			5.4
Falling Weight Impact @ -40°C	J	15.5			2.1
Rockwell R Hardness		68			34
Moisture	ppm	40	250	140	140
Oxidation Induction Time	min	6.8			4.6

* The melt index value of 7.1 g/10min was measured on the virgin pail.

(b) Oil Testing

<u>Test</u>	<u>Units</u>	<u>Virgin PP</u>	<u>Unwashed Flake</u>	<u>Washed Flake</u>	<u>Extruded Pellets</u>
Surface Oil	% w/w	N/A	3.1	1.2	N/A
Total Oil	% w/w	N/A	3.1*	TBA	TBA
Absorbed Oil	% w/w		0	-	-

* After deducting “extractables” in virgin polymer.

(d) Odour Testing

Re-processed Oil Pail pellets and Virgin PP pellets were sealed in vials and heated in an oven at 70°C for two hours. A panel of six performed three different tests, as follows;

Test1: Triangular odour testing to “pick the odd one out”.

Test 2: Rating the strength of the odour of the re-processed oil pail pellets. The rating was on a scale from 1 to 10, with one being low odour and 10 being high odour.

Test 3: Panel members were asked to describe the odour.

The results are as follows;

<u>Panel Member</u>	<u>Test 1 Pick the odd one out</u>	<u>Test 2 Score out of 10</u>	<u>Test 3 Describe the odour</u>
1	Identified odd vial correctly	4	Burnt smell (not like wood)
2	Identified odd vial correctly	6	Rubbery, pungent smell
3	Identified odd vial correctly	6	Slightly offensive smell
4	Identified odd vial correctly	8	Strong smell, pungent/offensive
5	Identified odd vial correctly	6	Just annoying, astringent
6	Identified odd vial correctly	8	Sulfur like smell

1.4 Conclusions

Physical Properties

- Minimal melt index shift as a result of washing and re-processing into pellets.
- Flexural Modulus and Tensile Strength are lower than Virgin PP.
- Notched Izod Impact of the Re-processed Pellets is higher than Virgin PP at all three temperatures. Several of the Re-processed Pellet samples exhibited ductile behaviour at room temperature. This is consistent with a lower value for Flexural Modulus and Tensile Strength.
- In contrast to the Izod Impact, the Falling Weight Impact of the Re-processed Pellets is considerably lower than the Virgin PP.
- The Oxidation Induction Time is lower for the Re-processed pellets, indicating some loss in thermal stability, relative to Virgin PP.

Oil Testing

- The Surface Oil content and the Total Oil content of the Unwashed Flake are the same (3.1 %w/w), indicating that the Lube Oil had not been absorbed into the pail wall.

- There is a 1.9 %w/w loss in Surface Oil as a result of washing (from 3.1 to 1.2%w/w).
- The test results for the Total Oil content of the Washed Flake and the extruded pellets, although not recorded in the above table, appeared abnormally high. This test will be repeated and results reported at a later date.

Odour Testing

- All six panel members were able to identify the Odd Sample Out easily. This indicates that there was a significant odour difference between the Virgin PP and the Re-processed Oil Pail pellets.
- The average Odour Rating was 6 out of 10, indicating a moderately strong odour if the Re-processed Oil Pail pellets.
- The odour was described as a moderately strong and unpleasant smell.

8.4.2 **Moulding Trial**

2.1 **General**

Re-processed pellets received from TP Recycling were injection moulded at Viscount Plastics to produce a 4 litre pail (base and lid).

2.2 **Samples**

A number of samples with varying levels of re-processed PP were prepared in order to determine the optimum level for injection moulding 4 litre pails. The following formulations were prepared;

- (i) 100% Re-processed Pellets
- (ii) 50% Re-processed Pellets and 50% Virgin PP
- (iii) 25% Re-processed Pellets and 75% Virgin PP
- (iv) 100% Virgin PP

2.3 Moulding Trial Outcome

- 100% Virgin PP was moulded first to establish moulding conditions.
- 100% Re-processed PP could not be moulded consistently due to product warpage and product jamming in the mould. Several alternative moulding conditions were tried without success.
- 50% Re-processed PP was moulded with some success, however there was a 25% penalty in cycle time.
- 25% Re-processed PP moulded satisfactory. Although moulding conditions were altered from Virgin PP, minimal problems were encountered relative to Virgin PP.

2.4 Conclusion

A formulation of 25% Re-processed PP mixed with Virgin PP was used to successfully mould 4 litre pails. Although 25% Re-processed PP was successful during this trial, more extended production runs with larger size pails, when the tool is available, are required prior to recommending a ratio of Re-processed PP with confidence.

8.4.3 Pail Testing

3.1 General

The 4 litre pails and lids produced during the moulding trial were subjected to a series of tests. The main purpose is to determine whether there is a loss in properties as a result of adding re-processed PP.

3.2 Testing

All tests were carried out at Viscount Plastics, and wherever possible in accordance with AS2767-1994. The results of this evaluation is as follows;

<u>Test</u>	<u>Test Method</u>	<u>100% Virgin</u>	<u>25% Re-processed</u>	<u>50% Re-processed</u>	<u>100% Re-processed</u>
<u>Pail:</u>					
Weight (g)		169.4	170.3	170.9	171.7
Top Rim Ø (mm)		199.0	189.9	199.0	189.6
Base Ø (mm)		174.8	174.7	174.6	174.5
Height (mm)		188.8	188.5	188.5	188.3
<u>Lid:</u>					
Weight (g)		54.9	55.1	54.6	55.1
Diameter (mm)		201.9	201.9	201.5	201.3
Compression strength (kg)	VP	287	270	243	235
Creep (32.5kg/40°C/28days)	AS2767	pass	pass	pass	-
Leak	AS2767	pass	pass	pass	-
ESCR (% var.)	AS2767	no change	no change	no change	-
Permeability (% var.)	AS2767	no change	no change	no change	-
<u>Drop test from 1.2m:</u>					
Flat on base	AS2767	pass	pass	50% fail	-
45° on base	AS2767	pass	pass	pass	-
Side impact	AS2767	pass	pass	pass	-
Flat on lid	AS2767	pass	pass	pass	-
45° on lid	AS2767	fail	fail	fail	-

3.3 Conclusion

There is minimal loss in pail performance as a result of adding 25% re-processed oil pail material. The loss in compressive strength at the higher levels is of concern.

10.CONCLUSIONS AND RECOMMENDATIONS

Abbreviated project recommendations are recorded in the Executive Summary, and the following details are intended to expand where appropriate on the above mentioned conclusions and recommendations.

1. Data

- a) Whilst accurate production data was achieved for the blow moulding trials at Priority Plastics, the injection moulding trials at Viscount Plastics, and the pipe extrusion at Vinidex Tubemakers, the necessity to make alterations and improvements to TP Recyclers washing and transport equipment meant that conversion details were not representative of larger production runs.
- b) Similarly, whilst interstate transport costs for granulated material were incurred together with taxi-truck intra-suburban movement, in view of (a) above it was deemed unnecessary in this study to refine these down to a most likely transport cost for pick-up at oil distributors (or similar) premises and delivery to a plastic recycler. As suggested earlier, economic modelling may be appropriate in a later specific evaluation of these recommendations.
- c) TP Recyclers indicated that based on recycling costs and assuming low input cost for the granulated unwashed oil containers, it would be necessary to achieve a selling price for polymer pellets equivalent to about 2/3 virgin material pricing. The existing jury-rigged equipment is potentially capable of processing approx 250-300 kg/hr, although the site at Reservoir is unsatisfactory for any on-going activity using drained oil containers.

Relocation to a new site would be essential together with some further modification to the equipment including erection of a distillation unit for solvent recovery to minimise sludge disposal requirements. TP Recyclers estimate a cash injection of \$0.125-0.15M would be necessary and subject to acceptance of the Report conclusions, is likely to approach EcoRecycle Victoria for some assistance – later in this section of the Report, reference is made to the alternative approach of other recyclers who may be considering

an investment in aqueous washing capability.

In this connection, one project trial was carried out using conventional washing facilities which had been designed to process PCR HDPE that has contained aqueous based materials (primarily HDPE milk bottles). This trial failed on two counts.

- The material handling equipment up to the point of the washing unit was not designed to process a bottle containing a viscous organic material and oil leakage and pneumatic conveying of flaked shredded material created real processing problems.
- The washing unit itself was not entirely effective and the finer granulated flake after washing coated the interior of pipe-work and cyclone separators.

(It is possible that a change in material conveying and washing systems may solve these problems for currently erected plants, and this would require detailed discussion by potentially interested recyclers with equipment suppliers to follow up the information already included elsewhere in this Report).

2. Collection

The apparent differences albeit minor, in approach by municipal councils suggests at the minimum a re-education program via EcoRecycle Victoria directed at council service officers and waste management officers to ensure a consistent approach. It may also be useful to help them provide ratepayers with the appropriate advice and guidance to assist responsible behaviour particularly during the introductory phase.

This would be an interim step prior to introducing the recommended collection scheme which in turn of course requires agreement from each Council and from other strategically located sites to commence storage of capped containers at nominated sites prior to the next step, ie pick-up from these sites by a collector (including, if interest is shown, possibly oil recovery companies such as Nation Wide Oil or similar) with vehicles equipped with oil storage and granulation capability. This preliminary granulation/volume reduction should ensure maximum separation of the oil at this stage to minimise the load on the subsequent

washing operation.

This activity by the Municipal Authorities and the Oil Recovery Company would probably need to be cost neutral as a minimum requirement.

3. Washing and Conversion to Pellets

Some aspects of this are already included in 1(c) above. To this should be added that the body of the Report includes substantial reference to recommendations and advice received from European recycling equipment suppliers and local machinery producers. It is clear that if a complete recycling line is imported and installed, the final cost is likely to vary between \$A0.6 million and \$A3 million depending on throughput requirements and whether an extrusion line is included. Each manufacturer has been very helpful and direct contact by potentially interested recyclers is encouraged to discuss individual requirements and whether sourcing of some locally manufactured items would be appropriate in combination with the highly specific equipment offered by overseas manufacturers.

No assumption has been made whether interested recyclers would consider such an investment independently or where some assistance would be sought. It is recognised however that such a decision would ultimately rest on the findings of an economic model as proposed in the Executive Summary. What also needs to be taken into account by prospective recyclers is the importance of producing as consistent product as possible, particularly the MFI – it may ultimately prove necessary, particularly for HDPE, to blend pellet feed to ensure the MFI stays within agreed limits.

4. End Markets for Recycled Polymer

Whilst this study recommends re-use for oil containers subject to the final economics, one of the more promising application for HDPE is use for pipe extrusion. This has been referred to in earlier discussion of the project trials, under Section 8.3.

Various other potential and current applications have also been referred to earlier and in particular summarised on Page 9, but for completeness they include pyrolysis, incineration, cement mix, and in particular production of railway sleepers via McCoy Global Resources'

pending facility, and vineyard posts, outdoor furniture etc as currently carried out by Australian Recycling Technologies Pty Ltd and Omnipol Pty Ltd.

5. Economic Issues

Construction of a Financial Model

Specific commercial interests of the parties contributing to the project precluded accurate collection of data that would enable a financial model to be constructed. The project did, however, enable an understanding of the current issues and protagonists involved (see Fig 1 – Page 52) to the degree that an independent party could research and construct such a model if representatives agreed to provide information to such a party (see concluding recommendation).

The various parties and associated cost considerations involved are:

Bottle Collection

Some used oil collectors provide facilities for collecting used oil in plastic oil bottles. No charge is made for this on the consumer, with the collector aiming to cover the cost of the bottle disposal from the proceeds of recycling the used oil.

Bottle Shredder

The equipment specialisation, level of utilisation and the capital associated with shredding equipment would seem to dictate that a portable shredder be used to service a number of bottle collection sites (when considered from a National perspective). Such services are already in existence and interested oil recyclers may also be interested in providing this service via equipment supply identified in this Report. The other factor that favours mobile shredding is the relative freight efficiencies of whole bottles versus flaked bottles. The flaked product has an 18x increase in bulk density relative to a random sample of bottles (of various volumetric sizes, but typical in their size distribution).

The shredded flake can be transported in large flexible bags with replaceable liners. Typically a 1.2m x 1.2m x 1.8m high bag would carry in excess of 1 tonne of flake.

Washing & Pelletising

Bottle Manufacturer

The fact of a 3 layer bottle adds capital to the process of blow moulding. Most blowmoulders are standard with an extrusion head that makes a single layer parison that is subsequently blown into a bottle. A 3 layer bottle requires a special extrusion head and control circuitry. Typically, this would add circa \$250,000 to the cost of a blowmoulder. There are also additional processing costs associated with the extrusion of post consumer resin. Furthermore, some bottles would have to be made heavier to match the top load strength of an identical bottle made from virgin HDPE.

Thus relative to the manufacture of conventional bottles from virgin HDPE, the Blow Moulding Company has additional capital costs to amortise and process costs to carry, and the bottle manufacturer would have to purchase the PCR at a discounted price to virgin HDPE to remain cost neutral.

Bottle Filler

Assuming that the bottle is received from the bottle manufacturer to the same specification as that of a virgin bottle and that consumer acceptance does not factor into product discounting or promotion anomalies, the bottle filler should not experience any incremental costs compared to use of virgin HDPE bottles. Hence the Filler can be ignored in the economic equation, except if there is promotion of PCR use and a premium charged for the product because of this. If free market forces are allowed to prevail, then ultimately, this seems a reasonable assumption.

Consumer

Whilst the consumer is a key element in the equation, the voluntary packaging covenant backed by the the legislative force of the National Enviroment Protection Measure should ultimately result in all players capitulating to recycling, with the consumer making up any cost deficiency resulting from this change to the status quo: the force field construct in Fig 2 (Page 53) outlines the economic forces at work.

Concluding Recommendations

It is recommended that a follow-up project be scoped and submitted for financial support. The key issues that require further analysis are:

1. Oil Container Recycling

The cleaning and pelletising process could be made more efficient and effective than the modus operandi used for this project. For example, TP Recyclers' estimate for the cost to upgrade and relocate the solvent washing facility could be "fleshed-out", and similarly simple changes to material handling may enable an existing facility to be used to evaluate the feasibility of aqueous washing using a surfactant and/or a caustic medium to clean oil from the flake; this would be valuable in assessing the need for plant modification versus purchase of new equipment.

2. Financial Modelling

The composition of the controlling committee and proprietary interests of outside parties made it difficult to input accurate information into a financial model. It is recommended that during a subsequent project, a reputable, totally independent Accounting Firm be agreed to by all parties concerned. This firm should then be approached to collect cost information from the parties and construct a model that provides a financial analysis of the total recycling process. The model should also identify cost variables and provide a sensitivity analysis that in turn delineates where a recycling process is at economic risk.

Appendix

References: Enquiries Made To:-

i. Plastics Recyclers:-

- AGC Plastics Pty. Ltd. - 38 Sarton Road, Clayton, Victoria
- Astron Plastics/OJ Plastics Pty. Ltd. - 1-3 McGuire Street, Cheltenham, Victoria
- Australian Recycling Technologies Pty Ltd - 50 Elsworth St, Ballarat, Victoria
- Compco Pty. Ltd. - Japaddy Street, Braeside, Victoria
- Cromford Pty Ltd - 42 Macaulay Street, Williamstown, Victoria
- Eaglebrook Plastics Inc. - 2600 West Roosevelt, Chicago, Illinois, USA
- Fernz Construction Materials Pty Ltd, NSW
- Graham Packaging Inc. - 505 Windsor Street, York, PA USA
- Heron Plastics Pty. Ltd. - 29 Elizabeth Street, Newport, Victoria
- Intershred - 10 Longford Court, Springvale, Victoria
- K.W. Plastics Inc. - PO Box 707 Troy, Alabama, USA
- McCoy Global Resources – PO Box 177 Temora NSW, 2666
- Omnipol Pty Ltd – 5 Browning St, Gillman, South Australia
- Plastic Granulation Services Pty. Ltd. - 14 Inwood Ave., Kilburn, S.A.
- Plastic Recyclers - Polytrade - 22 Lakeside Ave., Reservoir, Victoria
- Plastics Recycling Inc., - 10252 Highway 65, Iowa Falls, Iowa USA
- Polychem Inc. - 132 Central Street, Foxboro, MA, USA
- Polymer Corporation (Aust) Pty Ltd – 18 Antimony St, Carole Park, Queensland
- Polymer Processors Pty. Ltd. - 1-11 Japaddy Street, Braeside, Victoria
- Sims Plastics - Mephan Street, Footscray, Victoria
- Repeat Plastics Pty Ltd – 157 Beresford Road, Lilydale, Victoria
- Solvay - Belgium
- Toll Recycling - 9 Somerton Park Drive, Campbellfield, Victoria
- Tyler Trent PLC - CW5 Creamery, Down Ampey Cirencester, Gloucestershire UK
- T.P. Recyclers - 30 Lakeside Ave., Reservoir, Victoria
- Unimould Pty. Ltd. - 26 Gilbertson Road, Laverton North, Victoria
- Vic Fam Plastics Recycling Co. - 20-22 Somerleigh Rd, Laverton North, Victoria
- Vic Plas Recyclers - Clelland Road, Altona North, Victoria
- Vision Granulation - 68 Parkhurst Drive, Knoxfield, Victoria
- Visy Plastics - 268 Edwardes Street, Reservoir, Victoria
- Visy Technical Centre – 13 Reo Crescent, Campbellfield, Victoria

ii. Recycling Equipment Suppliers:-

- ADF Trading SA – Via Olgiati 6, 6904 Lugand, Switzerland
- B.K. Sales Pty. Ltd. - 1368 Heatherton Rd, Dandenong
- Cameron & Castanedo - 15 Grandview Parade, Moolap, Victoria
- Emmans Granulators Pty. Ltd. - 227 Broadhurst Ave., Reservoir, Victoria
- Fixcor Recovery Systems Ltd. - 177 Juniper Ave., Sherwood Park, Alberta Canada
- Fixcorp International Inc - 1835 James Parkway, Heath, Ohio USA
- Hydra-Pac Pty. Ltd. - 39 Georges Street, Wingfield, S.A.
- Polychem Pty. Ltd. - 38 Billarga Road, Westleigh, NSW
- Shred Tech Pty. Ltd. (Brentwood) - PO Box 59 Regents Park, NSW
- Stolat (Machinery) Pty Ltd - PO Box 193 Rose Bay, NSW
- Turbo Spin MFG Inc - Albuquerque - New Mexico, USA
- Wastech Engineering - 21 Capital Drive, Dandenong, Victoria

iii. Industry Associations; Other

- Avcare Ltd – AMP Tower, 1 Hobart Place, Canberra City, ACT
- American Petroleum Institute
- Automated Recyclers Group, Sydney, NSW
- Association of Plastics Manufacturers -Europe (Brussels)
- British Plastics Federation - 9 Bath Place, Rivington, London UK
- California Integrated Waste Management Board, Sacramento, California, US
- Manningham City Council – 699 Doncaster Road, Doncaster, Vic
- Fraunhofer Institute, Freising, Germany
- Maribryong City Council – Napier Street, Footscray, Vic
- NAPCOR - 2015 Water Ridge Parkway Charlotte, NC USA
- Ohio Environment Protection Agency - PO Box 1049 Columbus Ohio USA
- The Environment & Plastics Industry Council (Ontario Canada)
- The Macarthur Waste Board – Level 3, 6 Bolger St, Campbelltown, NSW
- The Society of the Plastics Industry Inc Washington USA
- Vinidex Tubemakers Pty Ltd – 86 Whiteside Road, Clayton, Vic
- Whitehorse City Council – 379 Whitehorse Road, Nunawading, Vic
- Yarra City Council – 333 Bridge Road, Richmond, Vic

iv. Oil Recyclers and Waste Reduction - Environmental Recovery Services:-

- All Waste - 53 Albemarle Street, Williamstown, Victoria
- Burgess - 72 Pipe Road, North Laverton, Victoria
- Chemsal Pty. Ltd. - 83 Dohertys Road, North Laverton, Victoria
- Cleanaway – 27 Pavitt Crescent, North Wyong, NSW
- Cleanaway Brambles Pty. Ltd. - 64-68 Ordish Road, Dandenong, Victoria
- Coast & Valley Oil Distributors - 15 Apprentice Drive, Berkeley Vale, NSW
- Container Save - 14 Stephenson's Road, Seaford, Victoria
- Energy Developments Ltd – Suite 6, 600 Military Rd, Musman, NSW
- Enviro Filtration Pty. Ltd. - C2/144 Oakville Road, Oakville, NSW
- Envirochem Technologies Pty. Ltd. - 104 Merola Way, Campbellfield, Victoria
- Environmental Oil Ltd. - 166-170 Fitzgerald Road, North Laverton, Victoria
- Environmental Recovery Services Pty. Ltd. - 38 Research Drive, South Croydon, Victoria
- Hines Waste Technology Pty. Ltd. - 126 Barry Road, Campbellfield Victoria
- Nation Wide Oil - 236 Ballarat Road, Braybrook, Victoria
- National Resource Recovery - 3 Kearney Street, Bayswater, Victoria
- Nuplex Jennings - 88-90 Ordish Road, South Dandenong, Victoria
- Oiltrans Pty. Ltd. - 4/124 Keys Road, Moorabbin, Victoria
- Pacific Waste Management - 48 Alex Ave., Moorabbin, Victoria
- Plendrive Liquid Waste - 8 Lyndal Court, Berwick, Victoria
- Teris (Aust) Pty. Ltd. - 1/47 Melverton Drive, Hallam, Victoria
- Theiss Environmental Pty. Ltd. - Muir Road, Chullora, NSW
- W.M. Waste Management Services Pty Ltd – 10 Macquarie Place, Boronia, Vic
- Wilsolve Pty Ltd – 76 Ordish Road, Dandenong, Vic