GR4CM

GYPSUM RECYCLING FOR CEMENT MANUFACTURE

WASTE MINIMISATION FUND FEASIBILITY STUDY

MILESTONE ONE REPORT

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1.0 Introduction

The Gypsum Recycling for Cement Manufacture (GR4CM) feasibility study was launched on August 1, 2011 with an overall objective of "reducing the amount of waste plasterboard entering the waste stream by 32% per annum through improved design and onsite management practices and increasing the amount of plasterboard being collected and recycled in the Canterbury region by 3,000-6,000 tonnes per annum".

Funding of $90,000 (plus GST) has been sought from the Ministry for the Environment's Waste Minimisation Fund to cover the majority of the project's budgeted cost of $140,000 (plus GST). The ministry has indicated it views this application favourably and a confirmed funding deed is expected by the end of September, 2011. The project has been initiated utilising the $50,000 funding received from the project stakeholders, namely:

- Winstone Wallboards Ltd (WWB)
- Holcim Cement Limited (HCL)
- Christchurch City Council (CCC)
- BRANZ
- 5R Solutions Limited (5R)

The feasibility study has four overriding goals:

- Identify (by 31 March, 2012) a financially viable waste reduction, collection and recycling scenario that can then be implemented, promoted and scaled up over time
- Achieve a 10% reduction in plasterboard waste generated on new building projects by 31 December 2012
- Achieve an additional 200% (3,000-6,000 tonnes) of plasterboard collection in the Canterbury region per annum by 31 December 2013
- Achieve an additional 200% (3,000-6,000 tonnes) of plasterboard recycling in the Canterbury region per annum by 31 December 2013

At its core the feasibility study is about identifying or designing, if possible, **a business model for large scale waste plasterboard collection and recycling for cement manufacturing use by HCL**.

The project is split into five key milestones:

- Milestone 1 (due 16 September, 2011): *Industry overview* (key deliverable is a report detailing a situation analysis and map of the current industry)
- Milestone 2 (due 14 October, 2011): *International Industry Trends* (key deliverable is a report providing an overview of key international trends and technological developments in the industry internationally, and how the selective application of these might improve the industry in New Zealand)

- Milestone 3 (due 2 December, 2011): *Potential Scenarios* (key deliverable is a report detailing potential new waste plasterboard collection and recycling systems, and the risks, financial implications and potential benefits of each scenario)
- Milestone 4 (due 3 February, 2012): *Stakeholder Collaboration* (key deliverable is detailed business cases for scenarios, including pilot trial plans)
- Milestone 5 (due 30 March, 2012): *Scenario Pilot Trials* (key deliverable is a final report detailing pilot processes and outcomes, and scenario details and implementation plan)

This report addresses the requirements of the first milestone, 'Industry Overview', which are to:

- Thoroughly analyse the existing industry and mechanisms for production, collection, recycling and end use of waste plasterboard in Christchurch.
- Undertake interviews with key stakeholders and service providers to build understanding of industry activities, issues and relationships.
- Gather external information and historical data about the industry.
- Build a model demonstrating the current cost structures and revenue streams in the industry at current volumes.
- Identify and explore key barriers, issues and limitations to scale in the current market.

2.0 Industry Overview

While it is difficult to ascertain exact figures, it is estimated that between 20,000 and 40,000 tonnes of waste plasterboard are generated annually in New Zealand. This waste comes from the manufacturing process, residential and commercial construction activities, and residential and commercial building demolition.

The Canterbury region accounts for approximately 20% of all commercial and residential construction in New Zealand. This would indicate that between 4,000 and 8,000 tonnes of waste plasterboard is produced in the Canterbury region each year. Estimations from industry sources suggest this may in fact be in excess of 9,000 tonnes per annum.

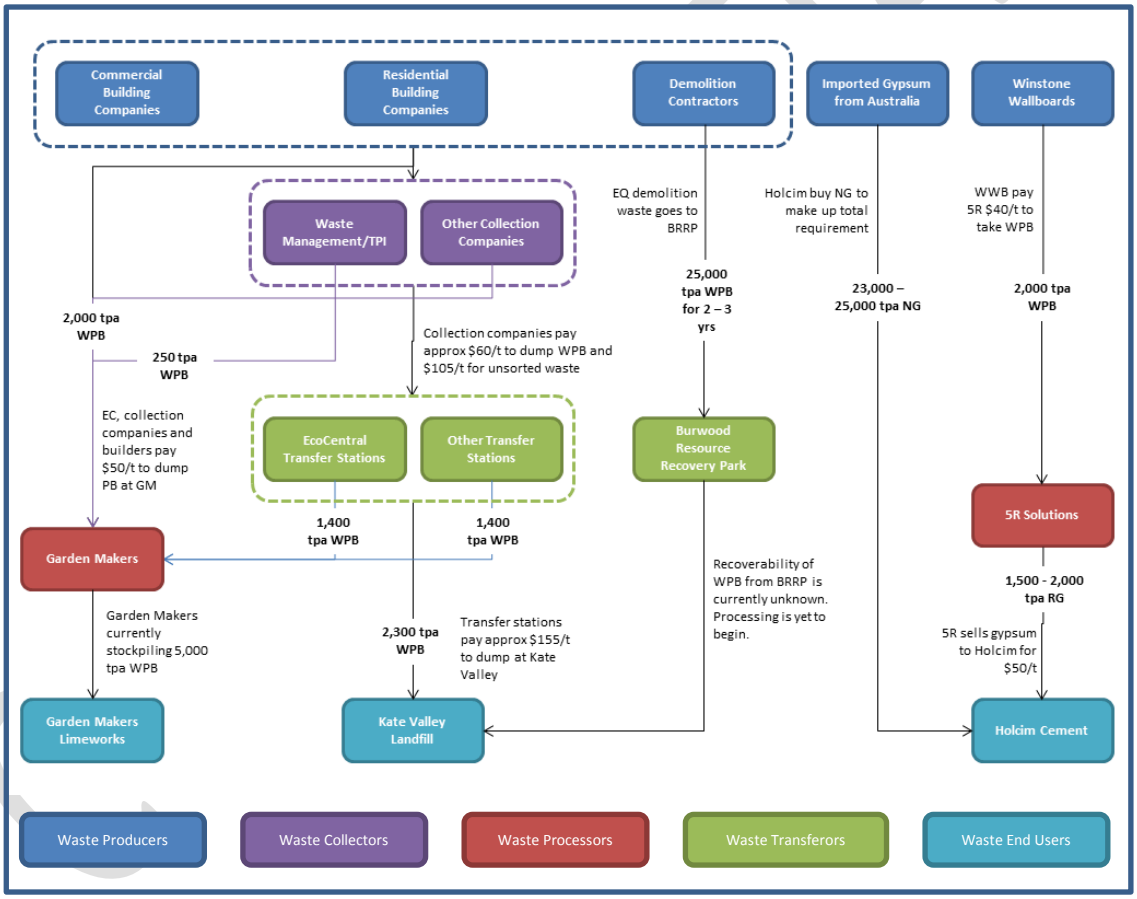
Over the next three years this will surge significantly in Christchurch as between 1,000,000 and 2,000,000 tonnes of earthquake-related demolition rubble are sorted at the Burwood Resource Recovery Park (BRRP) north of the city. The Canterbury Earthquake Recovery Authority (CERA) estimate that 4% of residential demolition material and 5% of commercial demolition material will consist of waste plasterboard. Transpacific Industries Group (TPI), which is contracted to oversee the operations at BRRP, estimate that it will take two to three years to receive and process this waste, suggesting that an additional 25,000 tonnes of waste plasterboard per annum will be introduced into the waste stream during this period.

It is therefore evident that waste plasterboard is a significant component in the waste stream, with as much as 35% of the current volume being disposed of at Kate Valley Landfill in North Canterbury.

There are currently two key streams in terms of the flow of waste plasterboard in Christchurch:

- Building and demolition waste plasterboard is collected and sorted with a modest level of recovery. Approximately 35% of waste plasterboard is diverted to landfill. Of the recovered plasterboard, almost all of this ends up at Garden Makers Limited (GML) in Wigram which recovers gypsum for agricultural use.
- Manufacturing waste from WWB is processed on-site by 5R and sold to HCL based in Westport for use in cement manufacture

The following map shows the approximate flows of waste plasterboard in Christchurch:



Each element of this map is explored in the following sections.

As the costs of disposal of mixed waste increase (two price increases will have occurred at Kate Valley by the end of 2011) there is a greater financial incentive for waste producers, waste collection companies and waste transfer operators to recover waste plasterboard and find new end uses. In doing so, they can divert plasterboard from the waste stream and potentially save over 70% of the disposal cost.

There are currently two options for diverting waste plasterboard from the waste stream.

- Paying GML to take waste plasterboard (at a cost of approximately $50 per tonne) ostensibly for processing into gypsum for use as an agricultural soil conditioner
- Paying 5R to take waste plasterboard (at a cost of between $40 and $50 per tonne) for processing into gypsum for use in cement manufacture

The disposal cost of waste plasterboard at Kate Valley landfill is approximately $155 per tonne including transportation costs.

Currently the strength of the relationship between 5R and HCL effectively makes 5R a monopoly supplier of recycled gypsum to HCL, and it is unlikely that the only other organisation with plasterboard recycling infrastructure (GML) will be successful in supplying recycled gypsum.

For this reason, discussions have already begun between 5R and a number of the collection companies that currently supply GML with waste plasterboard with a view to diverting this resource into 5R's operations. It is highly likely that this will occur and grow as a raw material supply source.

The current volume of processing by 5R is relatively low (and has at times reduced to zero) at 1,500 tonnes per annum, due to the lack of a processing facility. This facility has been provided historically by WWB at their Christchurch plant, but manufacturing requirements have meant that the required space is no longer available.

The need to lease space (at an estimated cost of $120,000 per annum) provides an overhead cost to the processing operation that has not historically existed. This is a key factor in assessing the ongoing viability of gypsum recycling as it must be undertaken at a scale that accommodates this fixed cost.

3.0 History

Plasterboard recycling in Christchurch began in 2001 when Brian Cribb of GML began testing waste plasterboard to determine if it was safe to recycle for agricultural use. The results of this testing suggested there were no safety impediments to such processing.

WWB, seeking to reduce its waste disposal costs, began supplying its waste plasterboard from manufacture to GML, which shredded the waste and extracted the gypsum at its Owaka Road site in west Christchurch. This processing operated sporadically due to frequent compulsory shutdowns by Environment Canterbury over concerns with dust pollution levels.

This site was subsequently taken over by Terra Nova/Meta New Zealand (MNZ), although Environment Canterbury shutdowns actually meant only two batches were ever processed on the site. GML, which owns a limeworks site north of Christchurch, continued receiving waste plasterboard from WWB and began processing on the limeworks site under existing resource

consents. GML also began receiving construction and demolition waste at its Parkhouse Rd site in west Christchurch and transporting this to its limeworks site for processing.

In 2005 Terra Nova began a trial with HCL to investigate the feasibility of using recycled gypsum in cement manufacture. This showed promising results, but did not move forward primarily due to the lack of a price advantage for HCL. MNZ only produced 500 tonnes of gypsum, and all of this was applied to agricultural use.

In 2009 MNZ was purchased by CCC and rebranded as CCC2, with ECL being a part of this venture. At this point MNZ Business Development Manager Chris Grant left and established 5R.

5R secured a lease of equipment for processing waste plasterboard and began working closely with WWB and HCL to create a successful process for extracting the optimum amount of gypsum from waste plasterboard and generating a high quality resource. 5R took over WWB's waste plasterboard from GML in late 2009, and began processing on the WWB Christchurch site in early 2010.

5R signed an MOU with HCL in early 2010 and began supplying recycled gypsum to a target volume of 2,000 tonnes per annum. Considerable effort, including quality testing, was undertaken by HCL, WWB and 5R during 2010 to ensure the process of extracting gypsum, and the quality of the final product, was optimised.

4.0 Waste Plasterboard Supply

There are currently four key sources of waste plasterboard in Christchurch:

- Manufacturing waste from WWB
- Commercial and residential construction waste
- 'Ordinary' commercial and residential demolition waste
- Earthquake-related commercial and residential demolition waste

Each of these sources is inevitably impacted by the recent earthquake activity in Christchurch. Statistics New Zealand has released figures showing that for the June 2011 quarter residential New Zealand building activity is down nearly 12% on 2010, while non-residential work is down nearly 1.5%. The overall impact of this apparent slump is a net 6.6% reduction in overall building activity, a result that matches exactly the reduced construction activity recorded in the March 2011 result.

This figure reflects a New Zealand wide slump in building activity, and Canterbury is only one of many regions with weak results. However Canterbury will, unlike other regions, shortly begin the post-earthquake reconstruction process which will comprise the construction of in excess of 4,000 new homes, and the demolition of an equivalent amount of existing damaged homes and hundreds of commercial buildings.

The construction of 4,000 residential homes equates to approximately 16,000 tonnes of additional plasterboard requirement for construction, with a resulting boost in waste volume. Commercial building activity will potentially produce even larger volumes. The waste stream from demolition, spread over the next five to ten years, will obviously be many times larger than this again.

This imminent boost in supply volumes will be a significant issue for Christchurch over the coming years as the volumes of waste plasterboard generated via manufacturing, construction and demolition will markedly increase compared to the relatively low volumes that are currently being generated as a result of a building slump.

4.1 Manufacturing waste from WWB

While ongoing efforts are made by WWB to reduce manufacturing waste, a degree of waste is inherent in the manufacturing process. WWB's Christchurch plant operates at world class recovery levels in excess of 99%, with a total waste volume of only 2,000 tonnes per annum. Of this 2,000 tonnes, some is relatively wet and the remainder is dry.

Prior to mid-2011 this waste was stockpiled at the WWB plant in Christchurch, and batch-processed by 5R when space on site allows. As this space is no longer available 5R will, once an off-site facility is secured, begin transporting the waste to its new facility for processing. This will still be on a batch-processing basis, so stockpiles will remain at WWB's facility.

Manufacturing waste is the preferred source of gypsum for cement manufacture because it is completely clean and not contaminated by organic or other building materials as is the case with building and demolition waste. This provides for a high quality recycled product.

Once off-site processing commences, WWB will pay $40 per tonne for 5R to take its waste plasterboard. A new agreement reached between WWB and 5R will see this cost reduced as low as $10 per tonne over the period of several years as third party supplies come on line and allow 5R to reduce its 'gate fee' to WWB as a result of scale.

4.2 Commercial and residential construction waste

It is estimated that approximately 4,000 tonnes of new construction waste is generated in Christchurch every year. As earthquake-related construction begins to scale up in 2012, this volume will also greatly increase.

Waste often occurs in building because plasterboard is considered a very low cost item and little effort is made to avoid waste due to the time-cost involved. To address this WWB is currently considering ways in which waste may be avoided. Ironically, given that WWB currently offers GIB plasterboard in a number of custom lengths to reduce waste, provision of GIB in a single (6 metre) sheet may help reduce waste as off-cuts are more likely to be of a re-usable size.

While reliable figures on construction waste recovery are difficult to obtain, it is estimated that approximately 60% of construction waste plasterboard (approximately 2,300 tonnes per

annum) is sent to landfill in Christchurch. Most of the plasterboard recovered (approximately 1,700 tonnes per annum) appears to come from commercial construction projects where on-site sorting is more common.

Sebastian Stapleton, Managing Director of Mastagard, advises that when sorting is undertaken on the building site using dedicated bins, the overall recovery of resources from the waste stream is approximately 80%. When sorting is done off-site by the collection company this drops to between 20% and 30% due to contamination from other materials.

Both Hawkins Construction, who work exclusively with Mastagard, and Fletchers Construction undertake some level of resource sorting on site. In the case of Hawkins Construction this includes sorting plasterboard into a separate bin.

Marc Mendonca of Fletchers Construction advises that while Fletchers does undertake sorting, plasterboard is not typically extracted. Fletchers have recently undertaken a pilot trial based on the construction of the Southern Cross hospital in Christchurch that includes separation of waste plasterboard. This may become standard practice depending on the outcomes of the trial.

The major barriers to sorting and setting aside waste plasterboard on commercial building sites are, according to Mendonca:

- *Space on site*. Between one third and one-half of commercial building sites do not have sufficient space for the number of bins required for separation of waste plasterboard.
- *Education*. Ensuring that staff and contractors know in which bin to dispose of various materials is paramount to achieving optimum recovery levels. Once these guidelines are understood, personnel must also follow them, which does not always occur depending on time pressures.
- *Servicing*. Frustration can occur if each bin is not picked up by the collection company at the right time.

Stapleton estimates that construction companies that do effectively sort waste can save up to half of their waste collection and disposal costs, although these savings may not provide a large enough incentive to outweigh the time-cost of doing so. Mendonca suggests that the incentives, at an economic level, do not really 'kick in' until a large scale construction project (such as a stadium) are being considered, but the branding benefit of 'doing the right thing' is always a consideration, albeit at a level secondary to economic concerns.

Overall, Stapleton estimates that only about a third of construction waste is sorted prior to collection. Much of this unsorted waste comes from residential construction.

The low volume of waste generated on a residential site (which is typically less than one cubic metre, or between 600 and 800 kg) and the frequent difficulty of site access means that waste sorting is somewhat unusual. This is further compounded by the fact that builders pay a flat rate (of between $300 and $400 per skip) for skips. As the volume of waste plasterboard is

considerably less than a full skip's worth, and hence its removal from the skip would incur no saving, the financial incentive to sort is non-existent.

There is evidence that some residential building companies (such as Stonewood Homes) are keen to trial sorting for environmental and/or branding reasons, but wide adoption of on-site sorting is unlikely to be sustainable unless there is a cost saving for builders or a regulatory requirement is in effect.

4.3 'Ordinary' commercial and residential demolition waste

While there is no reliable data on the volume of 'ordinary' demolition waste in Christchurch, it is estimated at approximately 3,300 tonnes per annum (by extracting known volumes from the total waste stream). If the annual volumes of waste plasterboard received by GML are as reported (5,000 tonnes per annum) this would suggest that virtually all of this demolition waste plasterboard ends up with GML.

It is widely accepted that the quality of demolition waste plasterboard is comparatively low, and its desirability as a raw material for recycling is low. HCL have indicated a reluctance to use gypsum obtained from demolition waste because of the high likelihood of contamination.

Demolition waste is also usually stockpiled and stored outdoors, meaning it will frequently become wet. This is problematic as it becomes more difficult to process once moisture is introduced.

4.4 Earthquake-related commercial and residential demolition waste

In addition to the typical levels of demolition waste that is generated in Christchurch annually, a large volume of waste has been created by the demolition of earthquake damaged buildings, both residential and commercial. This waste stream is being transported to the Burwood Resource Recovery Park (BRRP) north of the city.

Gareth James, South Island General Manager for TPI, has overall responsibility for BRRP and expects to receive between 1,000,000 and 2,000,000 tonnes of earthquake demolition rubble over the next two to three years, at a rate of 2,000 – 2,500 tonnes per day. James reports that CERA has advised TPI to expect between 4% and 5% of this rubble to consist of waste plasterboard. This equates to between 40,000 and 100,000 tonnes of waste plasterboard, or approximately 25,000 tonnes per year for two to three years.

TPI have purchased a processing line that is capable of sorting plasterboard and their plan is to aim for 50% recovery from the waste stream. If this was achieved the available plasterboard for recycling would greatly increase, but it is likely that the level of contamination would be high. The contractors tasked with earthquake-related demolition are undertaking no sorting in terms of the waste stream that ends up at BRRP and the emphasis on speed in the demolition process means that the resultant rubble is highly contaminated, although efforts are made to remove 'garage waste' such as weedkiller prior to demolition.

The rubble, once delivered to BRRP will be stockpiled until processing begins, and James estimates that processing will take between five and ten years. This means that waste plasterboard will likely have broken down well before processing takes place and will be unusable.

James has indicated, however, that TPI would be willing to undertake basic sorting and stockpile plasterboard separately on-site. This pile could then be the first material processing once this is initiated in early 2012. Regardless of the level of contamination and water damage, it is still somewhat unlikely that this supply of waste plasterboard for recycling will produce a high quality end product for use by HCL. The appearance of the rubble currently at BRRP certainly does not give rise to strong hope in this regard.

5.0 Waste Plasterboard Collection and Transportation

While a small amount of waste plasterboard is taken by builders and private 'do-it-yourselfers' to transfer stations, the majority is removed from building and demolition sites by waste collection companies and demolition contractors.

Sebastian Stapleton, Managing Director of Mastagard, estimates that TPI/Waste management have approximately 50% of the waste collection market, with Mastagard having approximately 10% and Envirowaste also having about 10%. The remaining 30% of the market is split between smaller operators.

Waste collection companies charge between $300 and $400 to builders for collected skips and these are provided typically on a flat rate basis. This provides little incentive for on-site sorting unless sufficient bins are provided to warrant differential pricing.

The companies pay a $155 gate fee for dumping mixed waste at Kate Valley (including transport costs) and $50 - $60 for sorted plasterboard. It would appear that Garden Makers receives the majority of ordinary building demolition waste, whereas the three EcoDrop transfer stations in Christchurch (part of ECL) receive most of the construction waste, but only as sorted loads as they do not sort in these facilities.

Mastagard and TPI, and at least some of the other waste collection companies sort at their own transfer stations as the gate fee cost saving for sorted waste is economically attractive. As mentioned previously, this sorting is less desirable for the purposes of this project because of the contamination that occurs and the lower rates of recovery.

It is worth noting that the waste collection industry in Christchurch is highly competitive, which has given rise to a desire in the companies to look for innovative ways to reduce costs and provide customers with a point of difference. Both TPI and Mastagard are focusing development efforts on schemes designed to promote on-site sorting of plasterboard on residential building sites.

These companies have asked that the details of their plans be kept confidential at this stage due to commercial sensitivity, but there is clearly recognition of the potential for separation at source of recoverable resources. Both schemes have recognised that the financial viability of such schemes is tenuous, and will likely depend on high compliance by builders in terms of sorting on site, as well as a high degree of clustering in building sites to reduce collection costs.

6.0 Waste Plasterboard Processing

There are currently two processing facilities in Christchurch with the capability of extracting usable gypsum from waste plasterboard:

- Garden Makers
- 5R Solutions

It was initially believed that TPI's operations at the BRRP would include the ability to process waste plasterboard, but TPI have confirmed their intention to sort plasterboard only and make this available to third parties. Their processing equipment does not include plasterboard shredding capability.

6.1 Garden Makers

Garden Makers is based in Wigram, east of Christchurch city, and operates as a sorting facility and supplier of a wide range of home, garden and landscaping products such as soils, barks and firewood, much of which is recovered from dumped waste.

GML also owns a limeworks at View Hill in north Canterbury, which also houses a plant for processing waste plasterboard. GML owner Brian Cribb estimates that they receive in excess of 5,000 tonnes of waste plasterboard each year, primarily from demolition contractors such as Frews, Waste Management and Demolition Solutions. GML also receives all of the recovered waste plasterboard from ECL (ECL pays between $40 and $50 to GML for this, suggesting a margin to ECL of $10 to $15 for transporting the waste, which they do not sort, a relatively short distance).

It is important to note that the figure (5,000 tonnes per annum) given by Cribb is contested by some other operators as being an exaggeration and no independent verification has been obtained. A figure of 5,000 tonnes would suggest that virtually all of the demolition waste plasterboard in Christchurch is received by GML, with very little being sent to landfill. This is counterintuitive given the difficulty of sorting demolition waste at high recovery rates.

Notwithstanding the limitations in certainty noted above, Cribb estimates that he is able to process 5,000 tonnes of waste plasterboard per annum to any required quality standard, and would invest as required in any additional quality improvements. He also notes that he is in possession of machinery that can dry gypsum, potentially counteracting the impact of weather exposure.

The site in View Hill also includes a 1,000 tonne capacity undercover storage area to keep waste plasterboard and recovered gypsum dry, however the initial collection and sorting facility in Wigram is exposed to the weather and the level of contamination of the plasterboard appears high.

Cribb advises that up until two years ago he received the waste manufacturing plasterboard from WWB, having done so for eight years, and is unsure as to why the supply was lost. Simon Cooper at WWB explains that GML did not have a market for the recycled gypsum, and could only sell a modest amount as soil conditioner, so chose to divert this resource to 5R. Cribb has confirmed that most of the recycled gypsum is indeed stockpiled pending a market.

Cribb is also somewhat perturbed that he has been (in his words) 'blocked' from selling this resource to HCL, given the volume of gypsum and his commitment to meet quality standards. HCL advise that they have concerns about GML's ability to produce a quality product, and are focused on developing their relationship with 5R.

6.2 5R Solutions

5R Solutions was started by Chris Grant in September of 2009, with Grant contacting WWB to determine where their manufacturing waste was being sent. As it was being stockpiled, which WWB felt was undesirable, WWB agreed to make this waste available for on-site processing for cement manufacturing. Grant then began working with HCL and WWB to develop the processes necessary to produce gypsum of a sufficient quality for use in cement manufacture. HCL undertook testing of the recycled material and concluded that quality levels were

surprisingly high. Further testing indicated that 50% (and potentially even more) recycled gypsum could be used in the cement manufacturing process.

Working with a shredder leased (on an 'informally exclusive' basis) from Maugers, Grant began processing waste plasterboard at WWB's Christchurch site in early 2010. Simon Cooper at WWB worked closely with Grant to create processing screens that would produce the optimal particle size for the recycled gypsum. These screens are owned by WWB and are worth in excess of $100,000.

Grant reached an informal agreement with WWB to take the waste plasterboard and invested considerable time in customising the process and the machinery used to ensure a quality outcome. Moisture content was a key issue, as both wet and dry waste plasterboard must be processed. Considerable effort was also required to meet Environment Canterbury pollution standards due to the dust created in processing. Moisture could be added to reduce dust, but too much moisture also gave rise to processing issues. WWB, HCL and 5R all report that 'getting the process right' took time, expertise and resources and that the resulting knowledge is considered unique intellectual property.

The maximum recovery from waste plasterboard is 90%, as 10% of the weight of plasterboard comes from the paper backing. While the exact level reached by 5R is considered commercially sensitive, it is a very high recovery rate that yields a very pure gypsum product. HCL testing indicates that the final product is approximately 98% gypsum (calcium sulphate dihydrate) with the remainder being 'plaster of paris' (calcium sulphate hemihydrate). Between 1% and 2% of the volume of recycled product received by HCL is reported to be paper, which is also within HCL's acceptable limits.

In March of 2010 5R reached an agreement to supply HCL with gypsum at a rate of 2,000 tonnes per annum, with an indicated maximum volume of 10,000 tonnes per annum. It was agreed that HCL would handle transportation of the recycled gypsum to their plant in Westport.

HCL was able to secure lower than market rates for this transportation by backloading trucks with gypsum. The rate secured, at approximately $34 per tonne, meant that HCL was able to obtain recycled gypsum at a cost of approximately $85 per tonne. This compares favourably to the cost for natural, imported gypsum at $115 per tonne, although this imported gypsum price is currently trending downwards and is expected to reach as low as $105 including transport costs, resulting in a premium over recycled gypsum of only 24%.

Currently 5R is only supplying 30 tonnes of gypsum per week (equal to 1,500 tonnes per annum) due to storage and processing restrictions at the HCL Westport site. HCL require capital expenditure of approximately $40,000 to resolve these issues and this is expected to be undertaken in the next few months.

Grant advises that 5R has the capacity to process in excess of 10,000 tonnes of waste plasterboard per annum and meet all of HCL's current volume requirements. In order to increase capacity, and because of the fact that space is no longer available at WWB's

Christchurch facility, 5R is currently seeking to lease a facility in which to undertake processing. Grant estimates that this will cost $120,000 per annum and require one full-time operator to oversee.

In order to support the increased overheads of this facility 5R has created a plan to increase processing volume to 8,000 tonnes per annum within five years, consisting of equal volumes of manufacturing, earthquake demolition, ordinary demolition and rebuilding waste plasterboard.

In order to reach these volumes 5R is intending to offer waste collection and demolition companies the ability to dump sorted waste plasterboard at a gate fee below that currently offered by ECL or GML, likely $40 - $45 per tonne. Both TPI and Mastagard have indicated that they would look upon such an arrangement favourably and would generally dump where the gate fee is lowest.

As the operation scales up, 5R has agreed to offer WWB a lower rate per tonne for manufacturing waste. This, in addition to a desirable end use for recycled gypsum, are key components in WWB's commitment to 5R.

The business model for 5R allows for the following source of income:

- Gate fee from WWB
- Gate fees from other sources of waste plasterboard
- Revenue from gypsum sales to HCL
- Potential revenue from sales of waste paper-related products

The specific economics of 5R's operations, subject to confidentiality, are considered in Section 8.0. Clearly the success of this business model lies in achieving economies of scale from increased processing volume. Grant considers the key issues in scaling up the 5R operation to be:

- Sourcing a facility at a reasonable price
- Securing a contractual commitment from WWB for manufacturing waste plasterboard
- HCL undertaking the required capital expenditure to resolve recycled gypsum storage issues
- Establishing, over time, viable residential building waste plasterboard collection mechanisms

7.0 Waste Plasterboard End Uses

There are currently three 'end uses' or destinations for waste plasterboard:

- Recycling for cement manufacture
- Recycling for agricultural use
- Disposal in landfill

7.1 Recycling for cement manufacture

HCL is the only manufacturer of cement in the South Island, and is therefore considered to be the only end use customer within the parameters of this project. Currently HCL utilises 25,000 tonnes of gypsum per annum, of which 1,500 – 2,000 tonnes is recycled. The remainder is natural gypsum imported from Australia.

HCL has the potential to receive all of the recycled gypsum that can be processed within Christchurch (and beyond), provided that the quality is acceptable. As mentioned previously the quality levels produced by 5R took some time and experimentation to reach, and this was without any of the contamination that would result from either building or demolition waste being utilised. It would be expected that scale up would involve working through the issues created by differing levels of contamination from co-mingling of waste.

From HCL's perspective utilising recycled gypsum as opposed to natural gypsum offers a number of benefits:

- Recycled gypsum (at $85 per tonne) offers a price advantage over natural gypsum (currently at $115 per tonne). This price advantage is reduced by the current need for HCL to spend $40,000 on capital expenditure to provide dry storage facilities for the gypsum, as moisture causes the gypsum to become sticky and clog the cement manufacturing line. This expenditure roughly equates to one year's worth of cost savings at current pricing. HCL advise that for the price advantage to be considered material it needs to be at least $20 per tonne at a volume of at least 5,000 tonnes per annum, or $100,000 per annum.

- Recycled gypsum performs at least as well, and potentially slightly better than natural gypsum

- Using recycled gypsum provides a brand advantage to HCL. HCL has a commitment to using recycled and recovered resources and in fact has a division – Geocycle – which has the responsibility for securing such materials. HCL is reluctant to continue using non-renewable resources where this is reasonably avoidable.

- Using recycled gypsum provides an advantage in terms of its internal corporate structure. Reducing the use of non-renewable resources is required both by parent company shareholders and in accordance with internal policy targets. HCL also advises that such activities improve HCL's standing within the wider corporate structure and improves its internal reputation, which in turn attracts additional resources and support.

HCL intend, by the end of 2014, to move their cement manufacturing operation from Westport to Weston near Oamaru. This plant will have a greater capacity than Westport and could, as production increases, require a doubling of volume of gypsum used.

HCL advise that this move will not diminish their desire for or commitment to the use of recycled gypsum, but it should be noted that a reduction in natural gypsum transport costs

may result from this move. Currently imported gypsum arrives in the Port of Nelson and is trucked by road as required to Westport. Once HCL moves to Weston, the nearest port (Timaru) will be considerably closer. As freight is the major component in the cost of natural gypsum (which as a resource sells for as little as $15 per tonne), this may significantly reduce the price advantage of recycled gypsum.

This potential reduction in price may be somewhat offset by world price increases (despite a current downward trend) due to the Thai government's decision to place a permanent moratorium on gypsum exports, reducing world supply.

Overall, HCL advise they are committed to soaking up any recycled gypsum supply within Canterbury for the foreseeable future.

7.2 Recycling for agricultural use

Recycled gypsum can be used as a soil conditioner for agricultural application and has been sold as such in New Zealand and internationally for many years. Other than the activities undertaken by 5R for HCL, this is the only other productive use for recycled gypsum in Christchurch.

Recycled gypsum is sold at relatively low volumes for this purpose, as evidenced by the large stockpile (20,000 tonnes) that has been amassed by GML. This is equivalent to at least four years total production.

The recent addition of fibreglass to GIB plasterboard has created some concerns as to its ongoing suitability as an agricultural soil conditioner, although initial testing has indicated this application is likely to be safe.

There are no known agricultural applications for recycled gypsum that have the potential to utilise greater than current volumes.

7.3 Disposal in landfill

Much of the waste plasterboard in Christchurch currently ends up in Kate Valley landfill. Not only is this a more expensive destination for the waste, but there are some extremely undesirable outcomes from sending waste plasterboard to landfill.

US and European studies have indicated that waste plasterboard disposed of in landfills has created a dangerous gas called hydrogen sulphide. This gas, known for its 'rotten egg' smell is lethal in high concentrations. The gas is created by the co-mingling of waste plasterboard with organic waste as occurs at a landfill. If waste plasterboard, combined with organic matter, is exposed to rain in an anaerobic environment, hydrogen sulphide emissions can result.

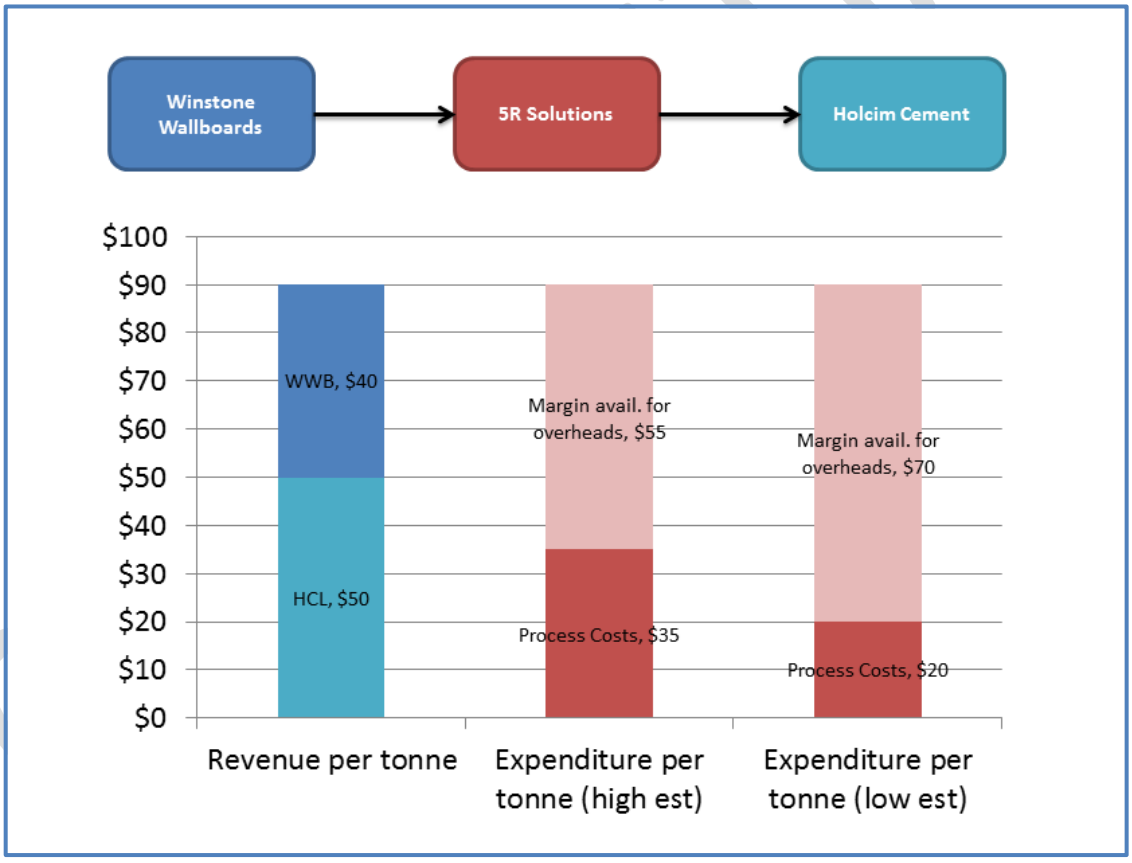
In response to this a number of US states are considering banning waste plasterboard in landfills. In Europe waste plasterboard cannot be dumped in ordinary landfills, and must be disposed of in special landfills where no organic matter is present.

In addition to these risks the potential value of the recycled gypsum would suggest that, subject to the creation of a sustainable business model, disposal of waste plasterboard in landfills should be avoided. It should also be noted that the general expectation is that the cost of dumping in the Kate Valley landfill will continue to rise over time.

8.0 Supply Chain Viability and Sustainability

In order to consider the viability of the current model of processing waste plasterboard it is necessary to start with the processing function and consider supply and demand in either direction.

5R Solutions current processing model can be understood as illustrated in the following diagram. As direct processing costs are commercially sensitive a high and low estimate of these costs are provided.



These figures provide the following scenarios at current volumes (short term volume until HCL storage solution implemented and typical current volume):

	Volume at 1,500 tpa	Volume at 2,000 tpa
WWB revenue	60,000	80,000
HCL revenue	75,000	100,000
Total Revenue	**135,000**	**180,000**
Direct processing costs	30,000 – 52,200	40,000 – 70,000
Building costs	120,000	120,000
Estimated staffing costs	50,000	50,000
Estimated administration and other costs	20,000	20,000
Total Expenditure	**220,000 – 242,200**	**230,000 – 260,000**
Net Revenue	**(107,200) – (85,000)**	**(80,000) – (50,000)**

It is apparent that from 5R's perspective the current volumes and pricing do not represent a viable and sustainable business model. This view is reinforced by 5R's own analysis. Given that both WWB and HCL have expressed a strong sensitivity to price increases (and WWB is, in fact, expecting price reductions) economic viability must come from increased scale and/or decreased costs.

At the current cost structure breakeven point is at between 2,800 and 3,500 tonnes per annum, and 4,000 tonnes per annum would return between a $30,000 and $90,000 profit. Given the current availability of additional waste plasterboard (particularly from building waste through collection companies) these volume targets would appear feasible.

5R has suggested that its processing costs may be reduced by the purchase of equipment which is currently leased. At current costs this will not make a sufficient difference, but will result in a modest decrease in volumes required for viability, or an increase in profit margin on processing. 5R has also indicated that it may be able to earn revenue from the 10% waste paper produced through the plasterboard recycling process, which may further reduce required volumes.

Regardless of these considerations however, it is apparent that the current business model for processing is not viable due largely to the recent requirement for 5R to secure its own processing facility at considerable cost. This is a key driver in 5R's desire to increase volumes, and 5R will need to secure additional supply in order to achieve financial sustainability. It is clear that 5R's ability to do so will depend largely on its ability to secure clean building waste from residential and commercial construction. While further investigation into securing supply of waste plasterboard from demolition activities may be warranted, the degree of contamination is likely to prohibit cost effective processing and if used, processing costs may increase or recovery rates decrease.

The easiest source of additional volume is likely to be from waste collection companies, most of whom are sending waste directly to GML or to GML via ECL. Securing this source is likely to yield an additional 1,500 tonnes per annum. Feedback from TPI and Mastagard would suggest that there is little impediment to securing their waste plasterboard.

Currently 5R is operating with little publicity as to its processing activities; making its operation more prominent and its relatively low gate fee known will stimulate further interest

and volume, but 5R may not be in a position to handle small, frequent deliveries of waste and may need to restrict access to larger operators.

Larger waste plasterboard volumes will require additional on-site sorting activities in residential and/or commercial construction. Sorting on-site is critical due to the vastly decreased recovery rates from off-site sorting. Increasing commercial on-site sorting is relatively straightforward as the industry trend is already moving in this direction. This will be further aided by the greatly increased activity in commercial construction over the next five years as a result of the Christchurch earthquakes.

Increasing recycling of waste plasterboard from residential construction is also key in increasing volumes. This happens at a very low level currently, and efforts to increase this type of activity in pilot trials have met with limited success. Minimising waste by considering how plasterboard is used in residential construction, and designing better systems for on-site sorting and collection, have rapidly emerged as key focal points for this project.

The challenge in considering whether residential construction on-site sorting and collection is feasible at scale is overcoming the longstanding inclination for builders and subcontractors to co-mingle all building waste. Furthermore, the costs of additional mechanisms for on-site sorting will prove difficult to offset with savings given the relatively low volume of overall waste on the building site. The lack of space on the typical residential building site will also prove a hurdle to be overcome.

It appears unlikely that, even if processing volumes increase, 5R will be subjected to increased competition. This is largely due to the specialised nature of the equipment and processing knowledge required to effectively process waste plasterboard to HCL's exacting requirements. The strong relationship between WWB, 5R and HCL is also a compelling barrier to entry for others, and effectively denies any other processor a market for product supply.

This in itself is a risk, as the continued strengthening of an absolute monopoly poses inherent risks for the market. It is probable that the only other current processor, GML, will divest itself of its processing capability in time as it will not be economically viable to continue. The risks around such a monopoly are mitigated, however, by the alternatives available to WWB and HCL. WWB is free to divert waste to landfill and HCL is free to purchase natural gypsum. These market forces act to constrain the potential for any monopoly advantage to be unfairly exploited.

Viability and sustainability in terms of WWB appears likely as long as 5R is able to secure a facility and continue to receive WWB manufacturing waste. With projected growth in production, particularly as a result of the earthquakes, the volume of WWB plasterboard manufacturing waste will increase. 5R is clearly anticipating this and has allowed for it in its projections.

The final element to consider in terms of current feasibility is HCL. HCL currently has issues in terms of receiving recycled gypsum due to the need to secure covered storage for it at its Westport site. It is anticipated that the $40,000 capital expenditure will be approved, but

failure to obtain this funding will threaten the viability of utilising recycled gypsum even at current volumes.

HCL have also stated that the do not consider 2,000 tonnes to be a sufficient volume on an ongoing basis, and would feel more satisfied with a volume of 5,000 tonnes per annum so as to realise adequate cost savings for their investment to date. There is no indication, however, that failure to achieve these volumes would prompt HCL to remove itself from the market.

9.0 Conclusions

The market for waste plasterboard recycling for the purposes of supply to cement manufacturing possesses all the elements required for success. There is enough raw material to achieve the required scale, there is sufficient capability and capacity to process the raw material and there is an established demand for as much product as the industry can produce.

The overall supply chain is somewhat unusual in that the processor is (or rather shortly will be) paid to take the raw material and is then paid for the processed product. This factor allows for economic viability at lower volumes than would otherwise be required. The supplier of the raw material (WWB and waste collection companies) benefits from the process as they pay a lower fee for disposal than they would if the waste plasterboard were sent to landfill. The processor (5R) benefits in that they are able to make a margin on processing. The end user (HCL) benefits in that they are able to enjoy cost savings and a branding advantage versus the alternative product.

These factors strengthen the feasibility of the supply chain and aid the sustainability of the industry.

The key complicating factor in the Christchurch supply chain is the lack of availability of the free processing space that 5R has enjoyed to date at WWB's Christchurch site. This arrangement made processing at current volumes feasible, and its cessation renders the current model unfeasible due to the significant overhead costs a dedicated facility incurs.

The focus now shifts to a series of events that must occur for the supply chain to regain viability:

- HCL must invest in a covered storage facility in Westport
- 5R must secure a cost-effective facility
- 5R must secure at least 1,000 tonnes (and realistically 2,000 tonnes) of additional waste supply

Failure of any of these will cause immense strain if not total failure of the supply chain. While the first two are considered imminent, the final tasks is more challenging and considering innovative ways to secure increased supply of clean waste is a key requirement for this

project. This requirement becomes even more prominent given a key goal of this project is to increase waste plasterboard recycling by as much as 6,000 tonnes per annum.

It is encouraging to know that there is general consensus within the stakeholder team that reaching the volumes required for ongoing viability is certainly achievable.

10.0 Next Steps

Key issues are already emerging from the initial industry overview, and the next step is to look to international operations to consider how these issues have been addressed overseas. Specifically, attention will be focused on:

- Achieving builder buy-in and high degrees of compliance for on-site residential construction sorting
- Economically viable models of residential sorted waste collection
- Considerations (and viability) in utilising construction and demolition waste for recycling plasterboard for cement manufacture

These learnings will be fed into scenario designs for team collaboration and piloting.