GR4CM

GYPSUM RECYCLING FOR CEMENT MANUFACTURE

WASTE MINIMISATION FUND FEASIBILITY STUDY

MILESTONE FIVE 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 obtained 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 project has also received $50,000 funding from the project stakeholders, namely:

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

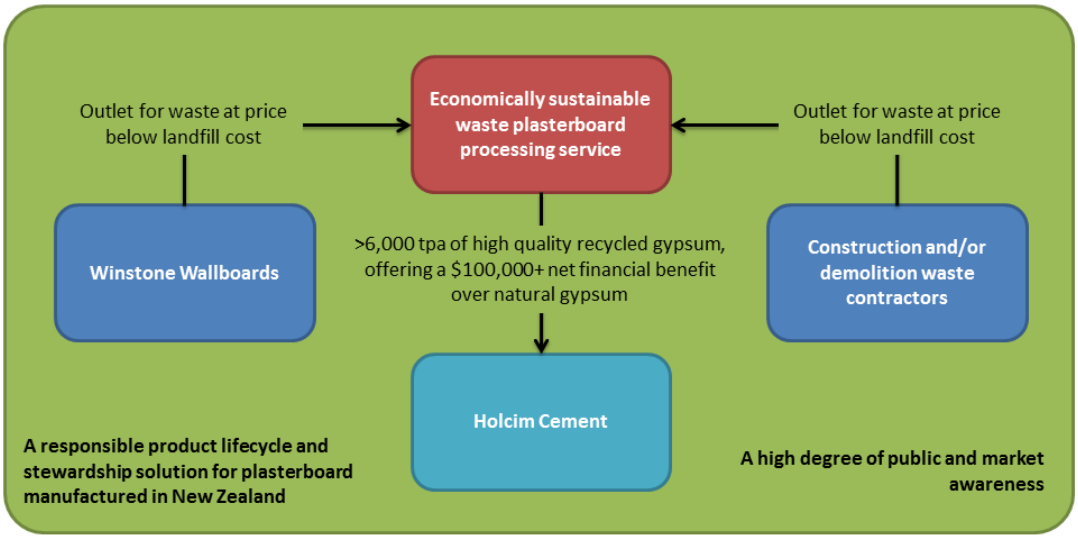
The feasibility study has four overriding goals:

- 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

Based on the information gained to date the high level vision for this project may be expressed as:

- A waste plasterboard processing service that **is economically sustainable** in the long term, and;
- Provides a **high quality recycled gypsum product** to Holcim Cement Limited at a delivered price that is materially below that of substitute products and at volumes in excess of 6,000 tonnes per year, and;
- Offers Winstone Wallboards an outlet for all of its **manufacturing waste** at a price that is materially below that of landfill disposal, and;

- Captures a significant portion of **construction waste and demolition waste** plasterboard by offering a **collection process that is acceptable and convenient** for waste owners at a price materially below that of landfill disposal, and therefore;
- Offers a **responsible product lifecycle and stewardship solution** for plasterboard manufactured in New Zealand with a **high degree of market and public awareness**.



The project is split into five key milestones:

- Milestone 1 (completed 16 September, 2011): *Industry overview* (key deliverable is a report detailing a situation analysis and map of the current industry)
- Milestone 2 (completed 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 (completed 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 (completed 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 fifth milestone, 'Scenario Pilot Trials', which are to:

- Build detailed evaluation criteria and mechanisms for pilot trials, and gain endorsement from stakeholders.

- Implement pilot trial of feasible scenario options.
- Evaluate pilot trials and market test scenarios that meet key criteria.
- Evaluate market testing.
- Undertake presentation and workshop with stakeholders to analyse and ensure understanding of implications of trials before preparing final report.
- Select and refine preferred scenario for implementation.

2.0 Residential Construction Pilot

2.1 *Pilot Process*

The pilot for residential construction focused on two potential solutions offered by competing waste contractors:

- *Mastagard* offered a multiple bin system with a skip for general waste, a skip for plasterboard, timber and steel and four smaller bins for other recyclable waste such as polystyrene and cardboard. The aim of this solution was to, through the use of multiple bins, remove the need for a third skip on the building site and hence realise building company cost savings.

- *Transpacific* provided a 'flexibin' system, consisting of a proprietary polypropylene bag. This was provided to installers as a small handheld folded bag that could then be assembled into a two or three cubic metre unit for receiving waste plasterboard. A customised gantry truck was employed by Transpacific to facilitate pick up of these units.

Mastagard's system was offered to volume builders *Stonewood Homes,* with the stated benefits of both separating out all recyclable material and offering a small cost benefit. As the collection units were all standard, no additional infrastructure or transportation movements would be required to facilitate collection.

Transpacific's system was trialled by Stonewood (as a direct comparison to Mastagard's system) as well as volume builders *Jennian Homes* and *Enterprise Homes*. The flexibin, which resides indoors, was offered as an inexpensive and convenient way to collect waste plasterboard without exposing it to weather and with minimal opportunities for contamination from other waste.

Stonewood Homes is a Christchurch-based volume builder that builds about 150 homes a year in Christchurch. They have a 'zero waste' target and tend to be the most active in the market in terms of environmental initiatives, such as HomeStar. Stonewood have a reputation for being progressive and innovative in terms of their building systems and are evidently highly organised and professional. As opposed to the sixteen week build that most companies offer, Stonewood guarantees a maximum build time of ten weeks, with eight being typical.

Jennian Homes is a franchised volume builder that also builds between 85 and 100 homes in Christchurch annually. Jennian markets itself as being a 'national company, emphasising quality construction'. While it does not market itself in terms of

environmental or waste minimisation benefits, it believes its customers have a 'reasonably high level of concern' about such matters and, while waste reduction is not an active policy in Jennian's process, waste costs are a growing concern and are 'beginning to appear on the radar'.

Enterprise Homes builds approximately 45 homes a year in Christchurch, and considers itself a 'follower of trends, rather than a leader'. Enterprise Homes' dwellings are considered 'fairly conventional' and they rate waste and environmental concerns as very low in their priorities. They also consider that their customers, and indeed the market, do not consider waste or environmental issues as significant when compared to price and quality. Enterprise does not have policies around waste reduction, and simply build current waste costs into their pricing. They consider that a focus on waste will likely appear if costs rise considerably.

The three building companies engaged in the residential construction pilot are considered to cover the spectrum of concern about waste and environmental matters, and also similarly cover the spectrum of innovation and leadership in building practices. This is useful in terms of the pilot giving a reasonable degree of confidence in extrapolating the results.

Overall, residential plasterboard waste collection was piloted in eighteen homes: one with Mastagard and the remainder with Transpacific. This pilot was undertaken from mid-December, 2011 to mid-March, 2012, primarily in Rolleston (southwest of Christchurch), Yaldhurst (western Christchurch) and Pegasus (north of Christchurch).

Briefings were undertaken with builders and installers and planning documents completed as contained in the Milestone 4 Report.

2.2 *Pilot Results - Mastagard*

The Mastagard pilot only comprised one Stonewood home in Rolleston. Both the delivery and set up of the system were considered unsatisfactory by Stonewood, who found that the small 'woolsack' bins provided for recyclables (pictured left) as part of the overall system were particularly unacceptable and the space taken up on site was too great.

These units were found to be 'tricky' to use and (as illustrated) the sacks were prone to fall off the frames. The steel/timber/plasterboard bin worked reasonably well, but was apparently a concern for Stonewood due to its positioning (outside) leaving it prone to waste co-mingling, the avoidance of which was a significant aim for the pilot in Stonewood's view.

It became quickly apparent that Stonewood had little appetite for this particular solution and, despite requests to reconsider, did not wish to pursue any trialling of a solution other than the flexibin beyond this initial effort. Mastagard were approached to identify an alternative building company to trial this solution but were unable to find a willing participant within the time available for the pilot. Since the conclusion of the pilot, Stonewood have agreed to reconsider their stance and recommence a trial with Mastagard. But this has not yet been initiated.

As the results from this trial cannot be reliably used, the Mastagard system is not further considered in this report. A successful trial with Stonewood may see the system being offered beyond the scope of this project.

2.3 *Pilot Results - Transpacific*

The initial conversations with Transpacific coincided with an internal market push to offer the flexibin as a growth service for 'home DIYers'. A fast response and research undertaken by Transpacific concluded that the flexibin had the potential to work as a plasterboard collection unit. The work that had already been undertaken in pushing this product meant that the infrastructural requirements needed to offer a collection service – particularly in terms of a specialised gantry hi-ab truck – were already in place.

Collection services were offered to Stonewood, Enterprise and Jennian Homes, with each being asked to supply five to ten homes for a trial. Stonewood and Jennian were clearly excited and enthusiastic to participate in the pilot, whereas Enterprise were somewhat reserved and sceptical; apparently participating as a 'favour' to Transpacific.

Initially a two cubic metre unit was trialled, but this was found to be inadequate, particularly for larger offcuts. The smaller unit was replaced after the first few homes with the larger three cubic metre unit.

The earliest on-site feedback – from Enterprise's installers – was not positive. Their advice was that the unit, which needed to be kept indoors to ensure the plasterboard stayed dry, 'got in the way'. Their process was to unwrap and assemble the flexibin as early as possible in the process, and deposit offcuts in it as they went. This created a potential tripping hazard in the garage, and proved to be 'an annoyance' to the installers, particularly as they came to install the plasterboard in the garage and had to work around the unit. Their solution was to install plasterboard in the garage first, which partly alleviated their concerns.

The other installers (for Stonewood and Jennian) quickly concluded that filling the bin progressively throughout the installation was not desirable, and so instead left offcuts in each room as they installed.

Once installation was complete they would assemble the flexibin and collect offcuts and waste from around the home in one quick process. This also largely circumvented the other primary concern about the unit, which was its lack of rigidity. The unit did not perform well in terms of being freestanding, as it depends simply on the strength of its corner seams to stay upright. The response from plasterboard installers (across all companies) was to use offcuts and 'lean' these into the corners to provide stability. This worked adequately if the bin was being filled all at once, but was not adequate where the bin was being filled progressively, as the slightest knock would cause it to collapse in on itself.

Enterprise Homes' plasterboard installers, East Coast Fixers, ultimately felt frustrated with the flexibin and expressed a strong disinclination to use it in the future. It was clear from visiting their sites that they produced a large number of sizable offcuts, which were not reused, and the flexibin was not ideally suited to this kind of waste due to its size restriction. East Coast Fixers reported that they regularly fill an entire skip on larger jobs and would prefer to continue to operate in this way. They did advise, however, that if the flexibin was more rigid, and had a cover so that it could reside outside the home, they would feel considerably more favourable towards it.

The other three installation companies involved in the pilot (two for Stonewood and one for Jennian) were generally ambivalent or positive about the flexibin and had no strong objections to it becoming standard practice on building sites. They had various suggestions for improving the system, such as supplying both sized bins ($2m^3$ and $3m^3$) to the installers themselves (rather than delivering a single bin with the plasterboard order as was the chosen method of supply) so that they could elect which units to use based on projected waste volumes. Two points of feedback were common to all installers: the flexibin would be more usable if made more rigid and if provided with a 'pull-over' cover that would allow it to be stored outside if internal space was an issue as it frequently was.

Overall the installers felt that they received little benefit from the use of a flexibin, other than avoiding taking waste outside to a skip in inclement weather, but most felt that its use was not materially more difficult, time-consuming or inconvenient that pre-existing methods of waste collection. In the case of Jennian and Stonewood the installers were advised of the building companies' commitment to recycling and merely complied without material objection.

Each of the three building companies largely followed the perspectives of their installers and relied substantially on the installers' opinions.

Enterprise, who stated that they participated in the trial with the hopes of saving money, reported that while the solution was 'more or less the same price' as the pre-existing solution, the negative response from their installers would be enough to dissuade them from continuing to handle waste plasterboard in this way.

Both Stonewood and Jennian intend to continue using flexibins on building sites and have made arrangements to do so. Each advised that the flexibin (at approximately $140 + GST including pick-up) was an additional cost if no reduction in other waste receptacles was possible, but that they intended to look at flexibins or some other dedicated receptacle for cardboard and/or insulation offcuts in order to avoid the need for a third skip. Both companies thought this was feasible. Jennian felt that even greater benefit could be realised from the flexibin if it were 'bright green' and branded to demonstrate to customers visiting homes during construction (which is typical) that waste from the construction of their home was being responsibly managed and recycled.

Both Jennian and Stonewood, like their installers, felt that the addition of improved rigidity and a weatherproof cover would allow the flexibin to work in any situation. Both also queried whether the flexibin was reusable, a concern raised also by several of the stakeholders in the project.

Transpacific advised that the flexibin has been built to a price point and is sufficient for one use only, after which it is recycled. If the existing unit was reused, the increased health and safety risk from the bag splitting is unacceptable. Sourcing a more robust bag that could be reused is a possibility but is likely to increase the price, which the market would not readily bear.

In addition to passing on the feedback of their installers, each of the building companies reported concern about delays in picking up the bins. The expectation of the building companies was pick-up within 24 hours, whereas this stretched out to 48 hours or 72 hours several times.

It became evident that when this happened the flexibin, full of plasterboard, would then be contaminated with waste from the plasterboard-stopping process, particularly stopping compound, which causes issues in the recycling process. Transpacific stated that delays were caused by the lack of a dedicated driver, which they intended to employ based on a successful pilot.

Overall, Transpacific reported that they were extremely pleased with the pilot process and intended to promote and continue to provide the service.

Part of the key to Transpacific successfully providing the service was its size and scale, and level of existing infrastructure. The truck used for service provision (show to the left) has been specially designed for the task and includes a number of in-house innovations and customisations aimed at smoother service provision, notably:

- The lifting mechanism (outlined above) includes in-line scales that weigh the flexibin at pick-up to allow for accurate billing.
- The lifting mechanism also includes an in-house designed quick release unit to allow the strops that pick up the flexibin to be freed after the unit is deposited in the truck and the lifting tension is released. This means that climbing into the unit and operating at potentially unsafe heights in order to release the bag is not required and considerable time is saved in the process.
- The gantry arm has an extremely long reach to allow bags to be retrieved from inside garages. This makes quick accessing of homes (which is critical to economic service provision) considerably easier and allows flexibin retrieval even if there are skips or earthworks present which impede access.
- The gantry arm is operated by a waist-mounted wireless remote control unit which enables the operator to achieve greater placement accuracy and avoids potentially hazardous operating situations as a result of limited visibility.

Transpacific have advised that they consider the service viable at only very low volumes (slightly larger than the trial) and are confident in being able to gain enough business to make it attractively profitable. The service has been provided to date with existing resource and a single dedicated truck. Transpacific will, once a volume of three to four pick-ups a day is reached, employ a full-time driver to deliver the service. As part of the relationship with Stonewood, Transpacific have also arranged to provide additional flexibins for other waste to further reduce Stonewood's waste costs and levels of recycling. Transpacific believe this kind of broader service has genuine merit and cost advantages and are keen to offer it to other building companies.

5R Solutions, the waste processor, advised that the pilot worked well once initial confusion about the communications for waste disposal were corrected. The processes for weighing and documentation of waste worked well and the quality of waste was very good, with little contamination. The waste was uniformly dry.

Overall the pilot involved:

- 18 homes pick-ups
- An average of just under 700kg of waste per home
- An average waste volume of 3 m^3
- Total waste collected of slightly over 12 tonnes
- Minimal levels of waste contamination
- Dry waste, with no dampness from weather
- An average waste figure (percentage of plasterboard ordered by building companies that was wasted) of 13%
- Acceptance from three out of four installers
- Acceptance from two out of three building companies

In addition to the primary pilot outcomes, both Stonewood and Jennian Homes advised that they had never been made aware of the level of plasterboard wastage that occurs on their building sites, and both have expressed shock at the level of waste their installers produce.

While there is clearly a trade-off between wastage and installation time, as taking greater care in installation and re-use of offcuts takes greater time, both Stonewood and Jennian have expressed a desire to reduce this wastage, armed with accurate information from the new recycling system. Stonewood have already discussed a scheme with their installers to reward them with 'a crate of beer' if they meet more stringent waste targets. These kinds of efforts have the potential to substantially contribute towards the GR4CM goal of reducing plasterboard waste from new building activity by 10%.

The key risks identified as part of Milestone Three for a residential construction collection pilot, and the actual pilot results were as follows:

Success Factor	**Overall Fail Risk**	**Pilot Result**
Given the low volume of plasterboard waste on a residential construction site, and hence the low likelihood of a reduced waste receptacle cost, a **lower overall cost of waste disposal** and collection is highly desirable. The aim should be 25% lower than existing co-mingled waste costs.	Moderate – High	The actual marginal cost to building companies was difficult to determine as most of the building projects are still in process and waste costs have not yet been finalised. However, all of the building companies felt the costs would be similar for a flexibin system as with pre-existing systems, which echoed Transpacific's view. Only one of the building companies felt this was unacceptable.

Success Factor	Overall Fail Risk	Pilot Result
The **process for sorting and disposing** of waste plasterboard must be simple and convenient.	Moderate	For the most part the process was viewed as straightforward once the best system had been identified. One installer felt that the need to wait until the end of installation to use the flexibin was unacceptable, whereas the others found it not substantially more inconvenient than existing waste solutions. Two of the installers felt the solution, being indoors, would be more convenient whereas the others would prefer it to be located outdoors.
The **system for collection** by the waste contractor must be economically viable at reasonably low volumes to ensure sustainability.	Moderate	Transpacific confirm that their system is economically viable at one run per day, equating to three to four homes. This would be equivalent to securing the business of two medium to large sized building companies, which has apparently occurred with the ongoing commitment of Jennian and Stonewood to the service.
Staff involved in construction activities that involve separation and storage of plasterboard must receive **appropriate education and training** on processes and waste separation and contamination avoidance. Ultimately culture change is required to ensure separation becomes standard practice.	Moderate	All installers received proper instruction on using the flexibins. Contamination tended to come from plasterboard stoppers where pick-up by Transpacific took more than 48 hours.
5R capacity must be sufficient to accept a volume of waste plasterboard that is acceptable to waste contractors.	Moderate	5R confirms that its capacity to handle all plasterboard from residential construction is more than adequate. No issues have been struck during the pilots.
Enforcement of acceptance protocols for on-site separation and contamination must be enforced by site managers. The waste delivered to 5R must be relatively free from contamination.	Moderate	5R confirm that the quality of waste from the pilot was very high, with very low levels of contamination.
The overall system developed must be able to be rolled out and **scaled up progressively** to achieve desired volumes.	Low – Moderate	Transpacific have confirmed that they have the ability, resources and intention to scale up provision of the service.
Construction sites must have **sufficient space on site** for the proposed waste separation/ storage solution.	Low - Moderate	This is an issue with the flexibin at a moderate level where the garage is small, but is circumvented by filling the bin at the end of the process. The addition of a cover to the flexibin, allowing it to be stored indoors or outdoors would provide further flexibility here.
The collection system must offer **easy and accurate weighing and quality determination** of waste and invoicing of the waste or demolition contractor.	Low – Moderate	Inline scales as part of the lifting mechanism on Transpacific's truck made this process extremely easy and quick.

Success Factor	Overall Fail Risk	Pilot Result
Plasterboard waste **receptacles must be kept undercover** or otherwise covered from the weather to ensure plasterboard stays dry. Receptacles must also be protected from unauthorised dumping by members of the public.	Low – Moderate	This is a moderate issue where the installer is reluctant to fill the bin at the end of the process. Where the bin is kept indoors, no problem arises. Once again, the addition of a cover would provide flexibility and protection here and has been recommended for consideration by Transpacific.
Waste pick up must be undertaken in accordance with customer expectation and requirements, at convenient times and as soon as possible after request.	Low – Moderate	This was a reasonably significant issue in the pilot due to the low overall volume requiring rationalisation of pick-ups by Transpacific. Ultimately this was not enough of an issue to dissuade Stonewood and Jennian from continuing, but must be rectified by Transpacific, as is their intention as volumes increase.
Loads must be **visually inspected** before collection to avoid the need to reject loads off-site because of contamination.	Low – Moderate	This was undertaken, but no rejection was required because of the low levels of contamination.
A **range of receptacles** (bags, bins, skips) must be offered to residential builders to allow for differing waste volumes.	Low - Moderate	Two flexibin sizes were offered ($2m^3$ and $3m^3$). In most cases these were more than adequate. Enterprise Homes produced larger offcuts, which caused some issue, although breaking offcuts to fit is not viewed as difficult by other installers.
Stored **plasterboard must be kept dry** or at least kept from excessive exposure to moisture.	Low	All plasterboard was dry as it was stored indoors.
The **gate fee for disposal of plasterboard** for waste contractors must be competitive with the costs of sending waste to landfill, given the sorting and additional transportation required.	Low	The gate fee is viewed as acceptable by Transpacific. 5R have indicated this can reduce as volumes increase which may assist Transpacific in offering a more competitive service.
Plasterboard waste **receptacles must be easy to fill and easy to remove** from the construction site. Risks to damage of homes under construction must be eliminated or minimised.	Low	The specialised truck used by Transpacific was able to handle the different situations with relative ease. The fine control available with the unit prevented any damage occurring.
On site separation must occur.	Low	This occurred in every situation.
Waste contractors must be able to reliably **deliver plasterboard waste** to the 5R site at times convenient to them and must have the ability for the waste weight and quality to be determined upon delivery.	Low	Communication issues occurred in the first deliveries due to lack of clarity around the process, but these were quickly resolved and no further issues were encountered.
Acceptance protocols for waste plasterboard (specifying what can and can't be accepted) must be clear and robust with little room for interpretation.	Low	These were provided to Transpacific and the building companies and were clearly understood.

Success Factor	Overall Fail Risk	Pilot Result
The 5R site must be **conveniently located** in Christchurch to minimise transportation costs for waste contractors.	Low	Two sites were used, both of which were viewed as convenient by Transpacific.

2.4 *Feasibility*

The pilot for residential construction plasterboard waste recycling has demonstrated that it is feasible, but that uptake will depend on the effective engagement of building companies.

The greatest argument for the feasibility of this service is the simple fact that two out of the three building companies that participated in the pilot are continuing to recycle plasterboard using the flexibin service offered by Transpacific. It is worth noting that these two companies are seen as somewhat more progressive and innovative than Enterprise which suggests that the service may not be adopted by all sections of the market.

Informal research with two additional building companies following the conclusion of the pilot suggests a willingness to trial the service and a general acceptance of the need to both minimise and recycle waste. It appears likely that so long as the service is not more expensive than the incumbent waste management system, and provided installers do not strongly resist, a wide uptake is certainly possible.

In general, those companies that make some effort towards waste minimisation (either because of environmental or cost factors) are likely to see advantages from utilising the service. The companies that make no such effort will see little benefit.

Efforts are more likely to be made by larger volume builders that recognise the potential cost savings and 'responsible practice marketing' advantages that they can realise. It is highly likely that the rebuild in Christchurch will favour volume builders as they are more readily able to access insurance and can offer faster turnaround and lower costs due to security and reliability of subcontracting arrangements.

The feasibility of the residential construction plasterboard collection and recycling service would be further enhanced by:

- Combining flexibins for plasterboard with solutions for other recyclables to remove the need for a third skip on site. Genuine and material costs savings will result if this is done.
- Improving the rigidity of the flexibin and considering a weatherproof cover. This would allow greater flexibility of use, but must be balanced against increased cost.

- Greater uptake from builders. Unit costs for Transpacific will decrease with greater uptake, likely resulting in lower customer pricing and greater marginal benefit to builders. Greater volume will also reduce Transpacific's dumping cost at 5R.

2.5 *Implementation and Scale-up Requirements*

It is evident from discussions with builders that there is a willingness to discuss plasterboard recycling, combined with a 'healthy scepticism' about the economics of the service. Implementing the service in Christchurch will require the presentation of strong communications material about the service and effective presentation of its benefits to all builders and building companies. Those that are viewed as more progressive or professional are likely to be faster to adopt such a service as it requires a moderate degree of internal effort and a willingness to make change. Larger companies that have a higher degree of influence over installers are also more likely to successfully implement plasterboard recycling.

As mentioned above, the service is most compelling (and cost effective) when combined with solutions to recycle other waste so as to save the costs of a third skip on the building site. There are several ways this can be achieved, and these different pathways would need to be communicated and costed for building companies as part of the overall business case presented.

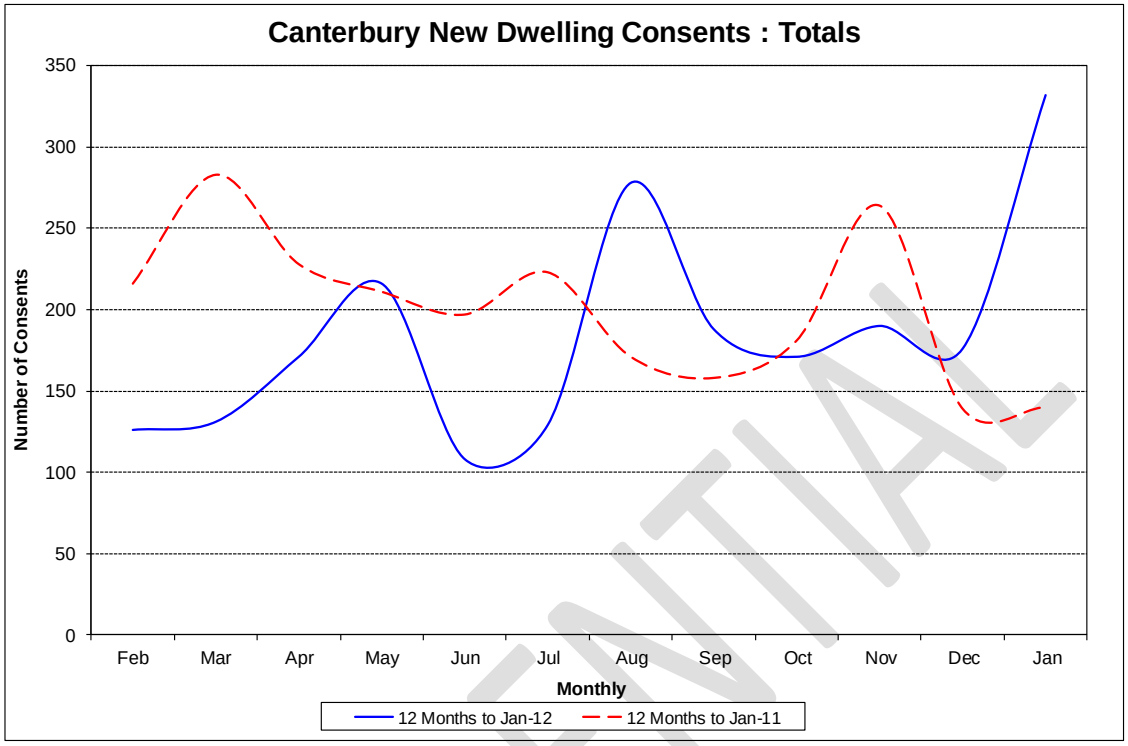
It is also evident, from discussions held with several industry players, that there are moves within the building industry towards individual trade subcontractors being responsible for their own waste. This would involve, for example, plasterboard installers providing an 'all-inclusive' rate for builders, including removal of waste. One large Christchurch-based plasterboard installer, Cochrane and Associates, recently advised that they have begun to see this in their business, with one building company insisting they handle their own waste.

This trend provides an even stronger case for residential construction waste plasterboard recycling, as installers do not have to balance the economics of using a flexibin with using a mixed waste skip. Cochrane and Associates, which undertakes installation for approximately 400 homes a year, has confirmed that the flexibin system would be ideal for their requirements and would meet their price expectations compared to other alternatives.

As the volume undertaken by such a company is greater than all but the largest of building companies, the engagement of such installers in recycling would be extremely significant and would also be a key strategy in rolling out the service. In this regard the New Zealand Association of Wall and Celling Industries (AWCI), which represents plasterboard installers and enthusiastically received information about this project, would be a key ally in encouraging the participation and support of installers in recycling programmes.

The Canterbury Development Corporation estimates that the residential rebuild will take five years, with repair activity concluding slightly quicker than this. Building companies report that demand has increased sharply over the last quarter, but this is primarily in outlying areas such as Rolleston and Pegasus.

Statistics NZ building consent data also shows that activity has experienced a sharp increase recently:



Despite the benefits of this, a significant upsurge in building activity will be challenging, given that:

- The new foundation requirements for residential homes will potentially add between $10,000 and $30,000 to the cost of a new home
- Insurance for new properties continues to be very difficult to obtain
- A large increase in consenting activity will inevitably challenge council timeframes
- While new subdivisions and subdivisions stages are being fast-tracked (notably in the southwest of the city) titles are still some months away for most of these sections, and only 6,000 sections are expected to become available in 2013 (whereas in excess of 15,000 homes are to be demolished)
- The huge increase in building activity required to complete the process in five years is likely to lead to skilled labour shortages, including the availability of plasterboard installers.

These factors are likely to move more of the market to volume builders (who can obtain insurance and have greater access to subcontracting resource), indicating these larger companies should be the initial focus for engagement.

3.0 Commercial Demolition Pilot

3.1 *Pilot Process*

The process of piloting the receipt of waste plasterboard from commercial demolition sites simply involved offering 5R Solutions as a venue for the receipt of waste plasterboard.

This new service was promoted through Canterbury Earthquake Recovery Authority (CERA) contractor meetings, direct approaches and the preparation of an invitation letter and flyer. All other aspects of this process were already supported by the existing demolition industry, in that they were already engaged in removing plasterboard and transporting it to a disposal site.

The stated benefit to potential participants was that plasterboard could be received by 5R Solutions at a cost of $40 + GST per tonne, as opposed to the cost to send the waste to landfill which varied from $90 - $140 + GST per tonne depending on the contractor. In addition, the 5R depot was conveniently located close to the Christchurch CBD.

5R was confident that it could handle any level of volume of plasterboard that the CBD demolition could present and so, given the speed with which the exercise was being undertaken, the decision was made to offer the service widely.

Once the decision was made to make waste plasterboard recycling services available in the commercial demolition space, activities were immediately commenced to engage CERA's assistance in publicising the service. CERA's primary concern appeared to be the regulatory compliance of the plasterboard waste processing facility. Confirmation of regulatory compliance was secured from Environment Canterbury and the Christchurch City Council. This confirmation allowed presentation of the service offering to key demolition contractors at a CERA meeting.

This contact provided opportunities for further discussion with contractors, but these contractors were extremely difficult to 'pin down' for meetings to discuss the merits of the offering. Extensive efforts were required to engage those contractors that participated in the pilot, namely *Ward Demolition* and *Protranz*.

3.2 *Pilot Results*

The pilot process was heavily influenced by the unpredictable nature of the CBD demolition and the types of buildings being demolished. Most of the demolition done to date, according to CERA, has been older buildings in poor states of repair that have been essentially 'bowled over'.

Much of the demolition left to undertake, which is estimated at 50% of the overall demolition by floor square meterage, consists of multi-storey buildings which must be deconstructed. It is these types of buildings that best support the recycling of plasterboard according to both Ward Demolition and Protranz.

Ward Demolition deposited 29 tonnes of waste at 5R from the deconstruction of the Grand Chancellor Hotel. 5R advised that this was good quality waste, and Ward Demolition felt the process was easy and convenient and the pricing more than acceptable.

Ward Demolition advised that most multi-storey buildings must be deconstructed and the plasterboard removed in sheets to facilitate the room by room, floor by floor approach that is required in these situations. As the plasterboard is source separated in this way, locating it to a dedicated bin and diverting it to 5R for processing – at a substantially lower gate fee than landfill – is clearly viewed as an attractive option.

Ward Demolition advised that they are very happy with the service provided and will continue to use it for waste plasterboard from their demolition projects.

Protranz were engaged in the later stages of the pilot and had only delivered 6 tonnes of waste to 5R by the conclusion of the formal pilot, although waste will continue to flow. Protranz are contracted to demolish the BNZ and Westpac buildings and intend to divert this waste to 5R for processing.

The feedback provided by Protranz was very similar to that from Ward Demolition: recycling waste plasterboard from a commercial, multi-storey demolition made good sense. Protranz did comment, however that the process of keeping plasterboard waste separate from other waste did involve more time and expense (as opposed to “chucking it out the window into a skip”) and felt that the pricing needed to be lower to make this a truly competitive option. They also provided unsolicited feedback suggesting that contractors should be compelled legally to recycle plasterboard given the “serious dangers involved with plasterboard going into landfill”. Protranz was well-informed about the dangers of sulphur dioxide being released from waste gypsum coming into contact with organic materials and felt that this is a major risk being ignored by environmental authorities. This was a surprising comment from someone in the waste industry.

The key risks identified as part of Milestone Three for a commercial demolition pilot, and the actual pilot results were as follows:

Success Factor	Overall Fail Risk	Pilot Result
5R capacity must be sufficient to accept a volume of waste plasterboard that is acceptable to demolition contractors.	Moderate	The volume of waste so far has been low, and 5R has had no issues coping with these volumes.
Stored **plasterboard must be kept dry** or at least kept from excessive exposure to moisture.	Moderate	5R reports that waste received has been dry.
Enforcement of acceptance protocols for on-site separation and contamination must be enforced by site managers. The waste delivered to 5R must be relatively free from contamination.	Moderate	Most of the waste received has been in 5R's Category 2 waste classification, with contamination levels of up to 5%. This means a fee of $45+ GST as opposed to $40 + GST for uncontaminated waste, somewhat dampening price competitiveness.
Plasterboard waste **receptacles must be kept undercover** or otherwise covered from the weather to ensure plasterboard stays dry. Receptacles must also be protected from unauthorised dumping by members of the public.	Low – Moderate	Uncovered skips have been used, but no dampness issues have thus far been encountered.
The collection system must offer **easy and accurate weighing and quality determination** of waste and invoicing of the waste or demolition contractor.	Low – Moderate	The 5R depot has provided access to a weighing station, with waste being visually inspected for contamination levels. 5R report that this has worked well.
Plasterboard must be stripped out of structures before demolition to avoid contamination and sorting issues, in a way that is economically viable for demolition contractors.	Low	This is standard practice for multi-storey commercial demolition.
Demolition sites must have **sufficient space on site** for the proposed waste separation/ storage solution.	Low	There have been no known issues in this regard.
The **system for collection** by the waste contractor must be economically viable to ensure sustainability.	Low	Waste delivery has been undertaken in the same way as delivery to the Burwood Resource Recovery Park (the alternative waste depot). 5R's depot is, in fact, considerably closer to the CBD.
The **gate fee for disposal of plasterboard** must be competitive with the costs of sending waste to landfill, given the sorting and additional transportation required.	Low	The gate fee is clearly cheaper than landfill costs, but some demolition contractors are (apparently) looking to process their own plasterboard for agricultural use at as little as $12 per tonne. Little is known about this, but it may become an issue in time, despite the relative absence of end-use markets.
On site separation must occur.	Low	This is standard practice for multi-storey commercial demolition.

Success Factor	Overall Fail Risk	Pilot Result
Staff must receive **appropriate education and training** on processes and waste separation and contamination avoidance. Ultimately culture change is required to ensure separation becomes standard practice.	Low	This is standard practice for multi-storey commercial demolition.
The overall system developed must be able to be rolled out and **scaled up progressively** to achieve desired volumes.	Low	Progressive scale-up is systemically possible, but the nature of the demolition process is unpredictable and the supply is 'lumpy'. Ultimately scale-up depends on contractor awareness and willingness to engage.
Demolition contractors must be able to reliably **deliver plasterboard waste** to the 5R site at times convenient to them and must have the ability for the waste weight and quality to be determined upon delivery.	Low	There have been no known issues in this regard.
The **process for sorting and disposing** of waste plasterboard must be simple and convenient.	Low	This is standard practice for multi-storey commercial demolition.
Acceptance protocols for waste plasterboard (specifying what can and can't be accepted) must be clear and robust with little room for interpretation.	Low	A clear acceptance protocol was provided to participating demolition contractors.
The 5R site must be **conveniently located** in Christchurch to minimise transportation costs for waste contractors.	Low	The 5R site is very close to the CBD.

3.3 *Feasibility*

The recycling of waste plasterboard from earthquake-related commercial demolition is evidently feasible. Ongoing participation by engaged contractors is a strong indication that diverting plasterboard to a recycling facility offers compelling economic benefits.

It is apparent that the demolition process in Christchurch – particularly residential, but also commercial – is driven primarily by price and speed; environmental or resource recycling concerns are almost completely absent.

Because of this, the feasibility of waste plasterboard recycling from commercial demolition is likely to be limited to those applications where the time taken to recycle is not significantly greater than existing processes and where there is a marginal cost saving versus landfill disposal of plasterboard. Multi-storey commercial buildings that are being deconstructed are the obvious candidates for this process, and may be the only ones where it is likely to be adopted.

The clear message from the demolition industry (as noted in the following section) is that where source separation is not required the time and cost involved in removing plasterboard makes it very unattractive.

3.4 *Implementation and Scale-up Requirements*

The speed and limited nature of the Christchurch CBD demolition requires that implementation and scale-up occur quickly, as the number of appropriate buildings will quickly reduce over time. Experience in engaging with demolition contractors suggests that this industry is under extreme time pressure and is sceptical of any deviations from current practices, whether they offer cost savings or not. Hence engaging contractors in open discussions about alternatives is very difficult.

In order to achieve this it is recommended that consideration be given by the GR4CM stakeholders to enlisting political support and public attention to the recycling service.

Engaging political forces (through CERA or the Ministry for the Environment) would assist in the creation of an atmosphere of desirability or necessity for demolition contractors to at least consider recycling. By engaging high profile political office holders such as Nick Smith, Gerry Brownlee or Roger Sutton and persuading them of the benefits of recycling plasterboard it is intended that, through CERA, demolition contractors could be encouraged to evaluate plasterboard recycling as a possibility. This process would not require any compulsion, but should assist efforts to engage contractors in initial discussions, which has proven difficult thus far.

This would be further assisted by telling ‘the good news story’ of plasterboard recycling in the public domain. This public communication would be achieved by seeking endorsement of the process from relevant political office holders and issuing a media release for television and print media. It would be intended that this would, once again, raise awareness of the service offering and assist in the engagement of potential sources of waste plasterboard.

These public and political activities would not secure additional sources of waste, but would rather raise the level of willingness of potential source owners to engage in further discussions. It is intended that the proposition would still need to be economically compelling, as indeed it would be in relation to multi-storey buildings.

In addition to any public activity, it is recommended that a compelling and well-presented information pack be prepared and issued to all demolition contractors, with individual face-to-face follow-up to present the service offering.

4.0 Residential Demolition Pilot

4.1 *Pilot Process and Results*

Efforts to engage a demolition contractor in a residential pilot began in October, 2011 with meetings with CERA, who advised that the residential demolition process was due to commence in December, 2011. CERA subsequently advised that delays in negotiations with insurance companies resulted in the process commencement being delayed until February 2012.

Once demolition contractors were engaged in January 2012, contacts were made with the two largest Project Management Offices (PMOs), being Arrow and Hawkins. Securing contact with the correct person at each of these PMOs took several weeks, and actual face to face meetings did not take place until March, 2012. The difficulty in penetrating the layers that exist within the demolition industry and securing meetings is indicative of both its structure and the time-pressure that has rapidly descended on the industry, exacerbated by the delays in commencement of the demolition. These difficulties also highlight the potential benefit in public attention and political pressure being brought to bear on the merits of considering recycling, rather than simply landfilling the majority of earthquake demolition debris.

Initially two demolition contractors, one engaged by Arrow and one by Hawkins, agreed to consider source separation and recycling of plasterboard after initial scepticism.

The firm contracted to Arrow, *Jamon Construction*, agreed to a face to face meeting and was persuaded of the potential cost benefits of considering removal of plasterboard prior to demolition of a home. They agreed to identify two suitable homes for trialling.

The pilot plan was for two labourers to spend six to eight hours in the home to remove as much plasterboard as they could within this timeframe. This plasterboard would then be weighed and the cost savings from diverting plasterboard offset against the labour costs involved.

Assuming three tonnes could be extracted in this time, with a total dumping cost of $120 + GST versus $300 + GST to send to landfill, $180 could be applied to labour costs. At $20 per hour this saving would be insufficient, so part of the pilot plan was to work with the demolition contractor to identify other resources that could be extracted concurrently to offset the labour costs.

As of the date of writing, Jamon had not identified a house they deemed to be appropriate, being one where the plasterboard was likely to be in a reasonable condition and where safe access was not a concern. It is likely that, should a suitable house be identified, this opportunity will be followed up by 5R Solutions.

The firm contracted to Hawkins, *Jenkins Contracting*, initially expected labour to be supplied for the pilot and removed themselves due to a labour shortage brought on by the rapid increase in demolition activity. They instead suggested contact be made with *City Salvage*, a company that has extensive experience with plasterboard removal from residential dwellings.

The key contact at City Salvage confirmed they had years of experience in removing plasterboard from residential dwellings for recycling and application to agricultural purposes. City Salvage advised that, in their experience, removal of plasterboard by three experienced labourers took two days, with an additional day required for removal of ceiling plasterboard.

In their view this was not possible for earthquake-related demolition for three reasons:

- The cost in time far exceeds the savings made by avoiding landfill dumping fees
- The economic returns from other resources in the home such as framing or wiring were minimal, and did not meet the cost savings shortfall
- The PMOs allow two days *in total* for the demolition of a home. Increasing this to four or five days for removal of plasterboard would not be permitted by PMOs

City Salvage confirmed their intention to recycle plasterboard in multi-storey commercial buildings but said they had evaluated recycling in residential situations and felt that it was simply not possible. It is worth noting that, in their view, the speed pressures from PMOs is a greater barrier to recycling than the cost factors.

Not surprisingly, City Salvage declined to participate in a residential demolition recycling pilot, based primarily on their own experience in undertaking just this kind of activity. Due to the pilot timeframe restrictions, no further demolition contractors were successfully engaged in pilot activity.

The key risks identified as part of Milestone Three for a commercial demolition pilot, and the actual pilot results were as follows:

Success Factor	Overall Fail Risk	Pilot Result
Plasterboard must be stripped out of structures before demolition to avoid contamination and sorting issues, in a way that is economically viable for demolition contractors.	Moderate - High	Demolition contractors do not feel that this is economic and that available timeframes do not permit this to be undertaken.
5R capacity must be sufficient to accept a volume of waste plasterboard that is acceptable to demolition contractors.	Moderate	5R has sufficient available capacity to accept large volumes of plasterboard, and two alternative storage sites have been secured to handle overflows.
Stored **plasterboard must be kept dry** or at least kept from excessive exposure to moisture.	Moderate	This was unable to be tested in the pilot.

Success Factor	Overall Fail Risk	Pilot Result
Enforcement of acceptance protocols for on-site separation and contamination must be enforced by site managers. The waste delivered to 5R must be relatively free from contamination.	Moderate	This was unable to be tested in the pilot.
Plasterboard waste **receptacles must be kept undercover** or otherwise covered from the weather to ensure plasterboard stays dry. Receptacles must also be protected from unauthorised dumping by members of the public.	Low – Moderate	This was unable to be tested in the pilot.
The collection system must offer **easy and accurate weighing and quality determination** of waste and invoicing of the waste or demolition contractor.	Low – Moderate	This was unable to be tested in the pilot, but performance in commercial demolition trials suggests this would present no issues.
Demolition sites must have **sufficient space on site** for the proposed waste separation/ storage solution.	Low	This was unable to be tested in the pilot.
The **system for collection** by the waste contractor must be economically viable at to ensure sustainability.	Low	This was unable to be tested in the pilot.
The **gate fee for disposal of plasterboard** must be competitive with the costs of sending waste to landfill, given the sorting and additional transportation required.	Low	It is evident that the combined recycling gate fee and labour cost for plasterboard removal is insufficient to act as a driver for demolition contractors, particularly given the time constraints.
On site separation must occur.	Low	This is considered to be impractical and uneconomic by demolition contractors.
Staff must receive **appropriate education and training** on processes and waste separation and contamination avoidance. Ultimately culture change is required to ensure separation becomes standard practice.	Low	This was unable to be tested in the pilot.
The overall system developed must be able to be rolled out and **scaled up progressively** to achieve desired volumes.	Low	This was unable to be tested in the pilot.
Demolition contractors must be able to reliably **deliver plasterboard waste** to the 5R site at times convenient to them and must have the ability for the waste weight and quality to be determined upon delivery.	Low	This was unable to be tested in the pilot, but performance in commercial demolition trials suggests this would present no issues.
The **process for sorting and disposing** of waste plasterboard must be simple and convenient.	Low	This was unable to be tested in the pilot.

Success Factor	Overall Fail Risk	Pilot Result
Acceptance protocols for waste plasterboard (specifying what can and can't be accepted) must be clear and robust with little room for interpretation.	Low	This was unable to be tested in the pilot.
The 5R site must be **conveniently located** in Christchurch to minimise transportation costs for waste contractors.	Low	This was unable to be tested in the pilot, but performance in commercial demolition trials suggests this would present no issues.

4.2 *Feasibility*

Based on the degree of activity that has been undertaken in this sector, both in terms of demolition activity to date and in terms of actual piloting under the auspices of this project, feasibility cannot definitively be either confirmed or denied.

As with other sources of plasterboard, such as residential construction, past failures to develop a workable system do not necessarily mean a workable system cannot be determined. The proposed pilot with Jamon Construction that has not yet taken place due to the unavailability of homes would still be worth pursuing to determine decisively whether residential is an economically viable source of waste plasterboard.

Having said this, the lack of willingness of contractors to consider plasterboard removal and recycling (with the exception of Jamon) combined with the informed and experienced conclusion reached by City Salvage, would suggest that viability is marginal at best. If, as City Salvage suggests, a substantial plasterboard removal process takes 48 to 72 person hours to undertake, removal of plasterboard alone will not be economically viable. Feasibility could only come if other valuable resources are being extracted at the same time.

The only resources that would require plasterboard removal as part of the process are wiring, timber framing and pipes. Both Jamon and City Salvage have advised that pipes and wiring are not being removed as they are seen as low value items, and only more sought after timber (such as rimu) is being extracted.

Based on this information, and subject to the outcomes of any pilot undertaken in the future with Jamon, it is difficult to see how retrieval of plasterboard from homes slated for demolition could be feasible.

5.0 Commercial Construction

5.1 *Current Status and Feasibility*

Subject to confirmation by Gerry Brownlee (which is expected to be given imminently), virtually all of the new commercial building activity in the Christchurch CBD will require compliance with the new Building a Sustainable Environment (BASE) assessment developed by the New Zealand Green Building Council in conjunction with the Christchurch City Council. Compliance with assessment will be required where at least 80% of a building's floor area consists of commercial office space, residential spaces (over two storeys in height) and/or retail spaces.

The BASE assessment, which considers the comfort, facilities, materials, services, and site elements of a building plan, requires that plans achieve a 'pass' mark in order to proceed. The standard has been set between 'standard practice' and 'best practice' and considered to be reasonably achievable in most circumstances. The assessment includes a range of 'must-dos' plus a range of other desirable 'optional add-ons' that generate a certain number of points. In addition to compulsory elements, a building must achieve 10 optional points.

It is a compulsory requirement that building projects employ a waste minimisation plan to divert waste from landfill. This plan, which must be in accordance with BRANZ's Resource Efficiency in the Building and Related Industries (REBRI) guidelines, must include estimates of the waste to be produced and the amounts involved as well as descriptions of recycling/re-use methods for each material. The amount of waste taken from a building site and the amount diverted from landfill must also be monitored monthly, with a minimum target of 30% diversion of total waste.

In addition to increasing waste diversion, it is hoped that the requirement to prepare a waste minimisation plan will also contribute to the GR4CM project's goal of reducing plasterboard waste from new building activity by 10%.

To date, there are only two commercial buildings in process which would be subject to the BASE assessment requirements: the Harcourts Building and the Latimer Hotel. Neither of these is, as yet, at the lining stage of construction.

CBD demolition is expected to continue for at least another twelve months, while construction activity timeframes are revised following every significant aftershock, the latest of which hit on December 23. The Canterbury Development Corporation is currently estimating that the commercial rebuild will take fifteen years, potentially providing a steady stream of waste plasterboard over this timeframe.

Feasibility is very much a known quantity with commercial construction, as source separation and recycling have been occurring for some years. The mechanisms to undertake this are already in place, but these will be tested by the required scale and speed of the rebuild in Christchurch.

5.2 *Implementation and Scale-up Requirements*

The basic requirement in terms of commercial construction is around awareness and communication of the economic advantages of source separation and recycling of plasterboard.

In addition to marketing activities to be undertaken by 5R Solutions and the various waste transportation/logistics contractors, the BASE assessment provides exactly the kind of initial driver required for plasterboard waste recycling to be seriously considered by all commercial builders. A waste minimisation plan is a requirement of the BASE assessment, and 30% waste diversion is a minimum (and modest) target. If waste plasterboard diversion can be seen as an easy and cost effective way to achieve a significant portion of the waste diversion target, a high level of participation should result.

One of the challenges of this, however, will be the method used by the builder to measure waste. The BASE Waste Minimisation Plan requirements state that "the waste may be measured by either volume (m3) or weight (tons), as long as the same metric is used consistently throughout the calculations. A mix of volume and weight is not allowed." Plasterboard is significant in terms of volume, but not necessarily in terms of weight, particularly when compared to wood, bricks and other heavy materials. Thus, its significance to builders as a component of their waste diversion target may depend on the method used to measure waste.

However this occurs, it is likely that direct marketing activities, combined with the requirements of the BASE assessment will persuade commercial builders to at least evaluate waste plasterboard source separation and recycling if it is not already being done as standard practice. In addition, Kevin Crutchley, Resource Efficiency Programme Manager at Christchurch City Council, has expressed an intention to work behind the scenes to ensure that builders are aware of the opportunities to recycle plasterboard as a matter of course when completing BASE assessment plans.

6.0 The Supply Chain

In addition to testing individual waste plasterboard sources, the pilots undertaken also sought to test the different elements in the supply chain, namely:

- Processing – 5R Solutions
- Transportation to Westport
- Storage and deployment at Westport – Holcim Cement Limited

The key supply chain risks identified as part of Milestone Three, and the actual pilot results were as follows:

Success Factor	Overall Fail Risk	Pilot Results
5R must maintain **reliable and consistently available plasterboard processing** infrastructure with the ability to process required volumes.	Moderate	5R was able to reliably process plasterboard once site issues were resolved early in the pilot.
HCL must continue to source **low transportation rates** for recycled gypsum.	Moderate	Transportation rates have remained unchanged and extremely competitive.
The **price of recycled gypsum** (including transportation costs) must continue to offer a reasonable saving over the cost of imported natural gypsum. A net annual financial benefit of at least $100,000 must be delivered to HCL. Movements in the market price for natural gypsum may impact this saving.	Low - Moderate	Potential savings continue to exist, but this is dependent on volume, which have not yet been realised at high levels. Increasing volumes to realise savings must be a key focus for implementation.
At least 2,500 tonnes per annum of waste plasterboard must be secured from **new sources of waste** such as residential construction, commercial construction, residential demolition or commercial demolition. To cover overheads and generate a reasonable return on investment, 5R must process at least 4,000 tonnes of waste plasterboard per annum at current market prices and costs.	Low - Moderate	This has not yet occurred, but is viewed as highly likely based on pilot results.
HCL must construct a **covered storage facility** for recycled gypsum at its Westport site.	Low - Moderate	This has been completed.
In terms of sustainability, HCL must continue to purchase recycled gypsum following **relocation to the Weston site**.	Low - Moderate	This is not yet known as the relocation has not yet taken place, but HCL have expressed a resolute intention to continue to source recycled gypsum.
5R must continue to attract a **gate fee for waste plasterboard**, although this may be able to reduce form its current minimum level of $40 per tonne as volumes increase.	Low	This gate fee has been charged for all waste plasterboard received.

Success Factor	Overall Fail Risk	Pilot Results
The **gate fee for disposal of plasterboard** for waste contractors and demolition contractors must be competitive with the costs of sending waste to landfill, given the sorting and additional transportation required.	Low	This has been achieved to varying degrees for residential construction, commercial construction and commercial demolition, but not for residential demolition.
5R must continue to earn **sales revenue from supply of recycled gypsum** to HCL.	Low	This has continued unchanged.
The **quality of recycled gypsum** supplied to HCL must be maintained.	Low	There are no known issues with recycled gypsum quality.
An **increased cost of plasterboard disposal at landfill**, or restrictions or banning of disposal of plasterboard in landfill is desirable from a motivational perspective.	Low	There are unconfirmed indications that landfill costs are set to rise, but no restrictions on waste plasterboard disposal have been indicated.
5R must have access to a **storage and processing facility** of sufficient size to allow it to handle and process the targeted volumes of waste. If its ability to store waste temporarily is insufficient, or if its ability to process waste to the required volumes is insufficient, targets will not be met and suppliers may lose confidence in the service. The space must be undercover to protect stored waste and must be able to be closed off in order to ensure that dust cannot escape, an Environment Canterbury requirement in order for processing to be a Permitted Activity. The site must be available at a cost no greater than $120,000 per annum.	Low	5R have secured a temporary processing facility and a storage facility. A suitable custom facility is currently being constructed and will be ready to occupy within the next quarter.
The 5R **site must be fully consented** in accordance with regional and city council requirements.	Low	Environment Canterbury and the Christchurch City Council have confirmed that the current site is fully compliant.
The 5R site must be **conveniently located** in Christchurch to minimise transportation costs for waste contractors.	Low	The current site and the site under construction are both in convenient and accessible locations close to the CBD.
Acceptance protocols for waste plasterboard (specifying what can and can't be accepted) must be clear and robust with little room for interpretation.	Low	These have been prepared and widely distributed with generally positive feedback from waste owners. It is acknowledged by 5R that the waste protocol is a desirable standard but that flexibility is required, as has been the case in the pilot.
5R must continue to earn **sales revenue from the sale of recycled paper** from waste plasterboard.	Low	This has continued unchanged, but details are not available due to commercial sensitivity.

Success Factor	Overall Fail Risk	Pilot Results
5R must continue to be able to source **plasterboard manufacturing waste from WWB**.	Low	This has greatly diminished due to the significant reduction in building activity in Christchurch following the earthquakes, and the continual delays in commencement of the rebuild. Logically, as the rebuild activity increases, the volume of waste from WWB will also increase.
The requirement for **waste management plans** and minimum levels of waste diversion from commercial building sites is highly desirable to support plasterboard separation and recycling.	Low	This is a requirement of the new BASE assessment.

The key issues that have arisen in the pilots in terms of the supply chain have been:

- Lower than expected volumes of recycled gypsum to HCL
- Issues with limited infrastructural resources at 5R

A recent GR4CM stakeholder meeting discussed at length the reality of low volumes of waste plasterboard currently reaching 5R for processing, despite expectations that volumes would increase as the project progressed. Ultimately the lack of volume is due both to delays in Christchurch demolition and rebuilding activities and the focus in the project on establishing feasibility, rather than building volumes. It is intended that up-scaling and implementation activities beyond the project's focus will aid in increasing and realising potential volumes.

Volume issues are in part also linked to limitations in 5R's infrastructure. As a small company, the availability of 5R staff to actively promote recycling services is limited, particularly where accessing the correct person is challenging and a face to face meeting is required. In addition, the current inability of 5R to have staff permanently on site at its depot has caused minor issues in receiving waste. It is envisaged that these problems will be exacerbated in the short term as volumes rise, but 5R has expressed an intention to engage additional resource in the medium term once volumes justify this.

Overall, there are no major concerns in terms of the ability of the supply chain to provide the intended service, but it should be noted that the overall supply chain has not yet been tested by the presence of greatly increased volumes.

7.0 Overall Feasibility and Future Requirements

The GR4CM project has been focused on building a robust and sustainable business model to capture as much waste plasterboard as is practicable from the Christchurch building and demolition waste streams. The project has demonstrated that base feasibility exists in terms of processing and demand, and has established that there are a number of feasible new sources of waste that can be captured.

Systems to viably capture waste from residential and commercial building sites clearly exist. While the marginal economic benefits on the former are low at best, and unacceptable to some, a reasonable proportion of the residential building industry are likely to adopt these mechanisms, particularly with the backing and reliable service of the largest waste transportation operator in Christchurch behind them. Transpacific's vested interest in the service, and their desire to increase the value of the benefit delivered by offering compelling complementary services to handle other waste, bodes well for the future of this waste stream.

Commercial construction activity is also likely to be significant for the next fifteen years with several hundred buildings to be constructed. The existing practice for many building companies of recycling plasterboard, combined with the regulatory requirements of the BASE assessment suggest that commercial construction may in fact be the easiest source of waste plasterboard to obtain. Activity is slowly starting to appear in this sector and will, as stated, continue for many years.

The waste streams from these sources are extremely difficult to reliably estimate. If 15,000 homes are to be constructed over the next five years, with an average of 700kg of waste plasterboard per home, the flow of waste will be 2,400 tonnes per annum. If 80% of this can be captured this would lead to an approximate doubling of the amount of waste plasterboard currently being recycled annually. Again, while commercial waste production is extremely difficult to estimate, it is hard to imagine the volume would be any less than that produced in the residential sector, and is likely to be several times larger for a much longer period of time.

Capturing a significant proportion of these waste streams would, in all likelihood, meet the aims of the GR4CM project and meet HCL's minimum volume requirements, especially once increased manufacturing waste as a result of greater building activity is factored in.

The ongoing viability of commercial demolition waste recycling is less certain. While in certain scenarios this is highly attractive, it is difficult to secure information as to volumes and timeframes around the waste flow. It is likely that commercial demolition in the CBD will continue for at least another year, and current information suggests that most of the properties suitable for plasterboard extraction, being multi-storeyed buildings, have yet to be completed. It is likely that commercial demolition will provide a sharp increase in volumes for a short time, but is clearly not a reliable source beyond this.

It is viewed as highly improbable that significant volumes of waste plasterboard will be source separated and recovered from residential demolition. This is particularly disappointing given the 80,000 tonnes or more of recyclable plasterboard present within homes to be demolished.

Ultimately the time and cost pressures of the demolition process, and its sheer scale, appear to preclude the kind of careful effort required to extract the plasterboard. Without strong political direction, regulatory constraint or a sharp increase in landfill costs, this is unlikely to be a sizable source of waste for recycling. There is a remote possibility that some of this waste may be able to be sorted and extracted at the Burwood Resource Recovery Park, as plasterboard is one of the items to be sorted on their line, but the poor state of the materials at Burwood would suggest that this is unlikely.

Moving from the feasibility stage to implementation will require skilled resource able to effectively communicate the benefits of the recycling process to prospective waste sources. There are a large number of builders, plasterboard installers and demolition contractors that need to be individually engaged in order to persuade them of the merits of plasterboard recycling. Experience in undertaking the pilot for this project suggests that obtaining initial meetings is difficult due to a lack of basic awareness and the low initial perception of value, and that engagement does not occur until an effective economic case is made to the key person of influence within an organisation. This is time consuming and resource intensive.

This activity needs to be matched with more conventional forms of marketing such as direct mail and advertising and, it is recommended, with engagement of the media to tell 'the good news story of Christchurch rubble being recycled into the building materials that will rebuild the city'.

The opportunity also exists to engage organisations such as the Association of Wallboard and Ceiling Industries and the Master Builders Federation and enlist their support in increasing levels of recycling of plasterboard among their membership. Initial conversations with AWCI would suggest they are extremely supportive of such initiatives.

In addition, it should be noted that the systems required to successfully collect waste plasterboard are young and not yet 'bedded in'. It is likely that new challenges and problems will emerge and that, without some level of active oversight, entropy will cause potential opportunities to be lost. To this end, it is recommended that resource be engaged to support the establishment of new systems for collection of new sources of waste plasterboard for six to nine months until these systems are stable and any 'bugs' are resolved.

Both intensive volume development activities and system oversight are likely to be beyond 5R's ability to resource, and consideration should be given by the project stakeholders to the merits of allocating resource to such activity to ensure that the potential volumes identified within the project are realised.

Beyond Christchurch, it is considered probable that potential exists for rollout of residential and commercial waste plasterboard collection systems. As a first step it may be worthwhile evaluating the economics of collecting waste at regional hubs and transporting it in bulk back to Christchurch for processing. This might initially encompass activity in the wider Canterbury region, with extension to neighbouring regions if viable. 5R has already reached agreement with the Waimakariri District Council to establish a hub for receipt of waste from up-surging building activity in Rangiora and Kaiapoi, and this is understood to be working well.

A steady and carefully managed rollout with tight monitoring has the potential to capture waste volumes well beyond Christchurch.

Further afield, consideration should also be given to other main centres, particularly those that can supply the needs of Golden Bay cement in the Far North. Once again this would need to involve careful investigation and monitoring, but the application of the lessons learnt in the GR4CM pilot to other regional sources of waste plasterboard is clearly desirable.

In terms of implementation and rollout, the first task should be the preparation of a step by step plan to first increase local volumes. The next step should be the investigation and evaluation of the economics and practicality of capturing waste plasterboard volumes beyond Christchurch.

How these activities should be undertaken, and by whom, will be a task for discussion among the project stakeholders. This group will also need to decide whether the informal grouping currently that has assembled for the GR4CM project will continue as an informal or formal association focused on the goal of increasing waste plasterboard recycling to provide gypsum for cement manufacture.

Ultimately what this group and this project have established is that a feasible business model for large-scale waste plasterboard recycling exists. It is, as yet, not fully realised and in some ways fragile, but the potential for this overall business model to build on new collection systems to achieve long-term self-sustainability is apparent.

How the next phases of implementation and rollout are managed will be key in determining the future success or failure of this business model to meet stakeholder expectations.

8.0 Project Conclusions

Whereas there have been several goals and objectives in the GR4CM project, the focus has ultimately been on identifying barriers to the successful establishment of a sustainable market for plasterboard recycling and determining whether these barriers can be overcome.

The first milestone 'Industry Overview' successfully mapped out what is currently occurring in the waste industry with regard to plasterboard, and signalled that base-case feasibility existed in the market. If the supply chain issues could be resolved, the market had the potential to be sustainable.

The second milestone 'International Industry Trends' gathered and processed the lessons and strategies from waste plasterboard markets around the world. The best processes and systems were identified, and the likely barriers and potential solutions that the project would face began to come into focus. The almost universal presence of regulatory support for waste plasterboard markets internationally (through landfills bans, waste minimisation plans and the like) was highlighted as a primary point for consideration.

The third milestone 'Potential Scenarios' began to lay out proposed strategies for capturing waste plasterboard from four new sources. The analysis done in this milestone suggested that the outlook for securing plasterboard volume and operating a successful business model was positive, and that the Christchurch earthquake presented both an opportunity to capture large volumes and an incentive for those intending to send waste to landfill in significant quantities to consider new possibilities.

The fourth milestone 'Stakeholder Collaboration' saw the project stakeholders reach consensus on the structure of pilots that would test new strategies for capturing waste plasterboard from residential and commercial demolition and construction. With a number of high profile partners engaged in the testing process, the pilots were set up to determine definitively whether a sustainable business model was likely to emerge.

The fifth milestone 'Scenario Pilot Trials' has seen three out of the four new potential sources of plasterboard present as feasible, with significantly increased volumes of recycled gypsum for cement manufacture as a probability. The pilots have produced real and reliable data on the generation of waste plasterboard that can now drive the development of the market for recycling. The collection, transportation and processing systems showed themselves to be robust, with any technical issues being quickly resolved.

The overall conclusion of the project is that the majority of the waste plasterboard produced in Christchurch can indeed be economically recycled. There is no need for any waste plasterboard - with the probably exception of residential demolition waste – to wind up in landfill. While the level of activity in Christchurch supports the sustainability of the plasterboard capture systems, there is nothing in the project to suggest that these systems could not also work in - at least - other major centres such as Wellington and Auckland. The potential for regional hubs and transportation systems to be established to capture volume in smaller centres is also a real possibility worthy of further exploration.

The economics of waste plasterboard collection and recycling essentially distil down to the price differential between collection and recycling, and whatever alternatives exist.

Considering residential construction by way of example, the cubic metre rate for collection of plasterboard is roughly the same as the cubic metre rate for collection of general waste. The reduced disposal costs for the waste collector roughly offset the increased collection costs (around $50 per m^3). In order to realise savings therefore, the builder and waste collector need to ensure that the total volume of mixed waste (including the receptacle) is reduced proportionately to the volume of waste plasterboard collected. This differential will improve as economies of scale take effect, but the case is only marginally acceptable. Waste plasterboard recycling levels will ultimately be driven by this price differential and the extent of awareness of it wherever waste plasterboard is being generated.

It is clear that, in this case, the builders and installers are willing to participate, but improved economics will certainly improve uptake and commitment.

This then begs the question so prominently raised by Milestone 2: does the market require some form of regulation to ensure its sustainability? Certainly the only current form of support in this space is landfill costs, which are generally considered to be increasing over time. Whereas a ban on landfilling plasterboard may be too strong a move, increasing landfill costs for plasterboard would, without question, increase the rate of recycling by improving the economic advantage in doing so. Such special rates for particular resources already exist, with polystyrene being an example, and the known risks around hydrogen sulphide gas production (as detailed in Milestone 2) would seemingly justify such action.

In addition to this, tools such as the BASE assessment with its requirement for a waste minimisation plan are a useful low-level method for increasing awareness and consideration of recycling waste plasterboard and should certainly be in place for both commercial and residential construction. Such tools would not necessarily *require* recycling of plasterboard waste, but the requirement to *evaluate* it would provide an opportunity for the economic advantages to be demonstrated.

An unexpected but significant success of this project has been the way in which the GR4CM stakeholder team and external partners have worked together to ensure positive project outcomes. Notably:

- 5R has flourished in its role as the processor of the waste and has worked extensively to secure pilot partners and lay the groundwork for increased volumes
- Holcim as end customer have invested in their infrastructure and worked internally to ensure any barriers to increased use of recycled gypsum have been overcome
- BRANZ have continually contributed through their knowledge of REBRI and their influence over the BASE assessment development
- CCC have ensured any regulatory requirements have been understood and have maintained a consistent passionate voice for resource recycling

- WWB have provided extensive expertise and support in pilot development and roll-out and influenced processes consistently towards economic realism
- Transpacific has invested significantly in creating a viable residential waste collection process
- Enterprise Homes, Jennian Homes and Stonewood Homes have given extensively of their time and personnel to ensure a workable system is developed

This team has worked tirelessly and contributed much to the success of this project, and it is hoped that this group can continue to play an active role in taking a feasible business model and implementing it fully to recycle large volumes of plasterboard waste.