Final Report

Occupational Health, Safety and Environment (OHSE) Risk Assessment: Use of Recovered Crushed Glass in Civil Construction Applications

For the

Packaging Stewardship Forum

of the

Australian Food and Grocery Council

by

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Executive Summary

1. **About the issue:** There is an increasing need for more markets to be established for products containing recycled materials. Glass continues to be one of the principal waste products generated by the public and recovered by the recycling industry. One such market for recovered crushed glass (known as RCG) that has been developing, is its use as an alternative material to replace sand in civil construction applications (for example, in asphalt, concrete, road base and utility trench backfill) .

2. While the engineering aspects of this use are beyond the scope of this report, evidence is accruing for the suitability and usefulness of application.

3. Safety concerns have been raised as a possible issue for acceptance of RCG as a civil construction material. These concerns are based on the potential abrasive properties of RCG, and the possibility that exposure to the dust may have long term health problems, based on perceptions of its alleged silica content.

4. **About this report:** This report has been prepared at the request of the Packaging Stewardship Forum of the Australian Food and Grocery Council.

5. The terms of reference for this project are:
   - Identify potential Occupational Health Safety and Environmental (OHSE) issues relating to the proposed use of RCG;
   - Conduct an OHSE risk assessment for RCGs, based on the newer materials now being manufactured (preferably using a risk matrix);
   - Develop a simplified method of risk scoring for individuals and organisations considering using RCG, and for those already using this product;
   - Assess OHSE risks and recommend suitable controls for proposed uses;
   - Prepare a Material Safety Data Sheet (MSDS) on RCG for users;
   - Make suggestions on how RCG can be better promoted from an OHSE perspective

6. With regard to the abrasive properties of RCG, users of the coarser forms of baseless RCG used in earlier trials (particles were greater than 5 mm, with elongated, splintered or angular shapes) reported problems of abrasion, and this may have created a barrier to marketing and use if workers remain reluctant to use the product. However, if the recycled glass is crushed to smaller particles (in the

range of ~ 3 mm), the particles become rounder with less long pieces, thereby decreasing the risk of skin injury.

7. With regard to the issue of long term health problems from exposure to silica (silicosis and lung cancer), this perception is without foundation and misleading, as the risks from sand are higher (see points 58-62). The main silicosis and lung cancer risks are from inhalation of respirable crystalline silica. Ordinary sand contains less than 1% respirable crystalline silica; RCG contains virtually none.

8. A risk assessment conducted for the various hazards of RCG in civil construction applications shows that while some hazards exist in RCG use and handling, these risks are not significantly different to the risks associated with the use and handling of ordinary sand. All identified hazards of the material can be managed using standard work practices and with the exception of use in suitably ventilated areas, wearing conventional personal protective equipment, such as overalls, safety boots, particulate masks, safety eyewear and gloves. Information on suitable work practices and control of exposure to RCG can be made available to workers through supply of a Material Safety Data Sheet (MSDS) for this material.

9. The promotion of RCG to the civil construction sector and to its workforce, from an OHSE perspective, should focus on the material being:
   - equivalent to sand with regard to engineering applications;
   - similar to sand with regard to environmental factors;
   - similar in safety to sand with respect to abrasive properties if smaller sized particles are used (that is, in the range of ~ 3 mm);
   - much safer than sand with respect long term health problems, because RCG contains substantially less respirable crystalline silica than sand.

10. As well as marketing the usefulness of RCG to organisations such as state government agencies, local councils and construction companies, building workers unions should be made aware of the OHSE implications and benefits of the use of RCG as outlined in point 9 above.

Background

Scope of Report

11. In September 2011, AusTox CCS was commissioned by the Packaging Stewardship Forum of the Australian Food and Grocery Council (PSF) to undertake a risk assessment of the use of recovered crushed glass (RCG) in civil construction applications. The PSF has been actively working with local and state governments, the recycling industry, civil construction contractors and road authorities to demonstrate the benefits of the use of RCG in civil construction applications (for example, in asphalt, concrete, road base and utility trench backfill).

12. The terms of reference for this project are:

- Identify potential Occupation Health, Safety and Environment (OHSE) issues relating to the proposed use of RCG;
- Conduct an OHSE risk assessment for RCG, based on the newer materials now being manufactured (preferably using a risk matrix);
- Develop a simplified method of risk scoring for individuals and organisations considering using RCG, and for those already using this product;
- Assess OHSE risks and recommend suitable controls for proposed uses;
- Prepare an Material Safety Data Sheet (MSDS) for RCG for users;
- Make suggestions on how RCG can be better promoted from an OHSE perspective.

13. This project constitutes:

- a review of various documents supplied for preparation of this report;
- a review of the scientific and medical literature on matters to this report;
- preparation of this report.

14. AusTox CCS is n ot aware of any conflict of interest that could compromise the independence of this report. AusTox CCS believe the facts in this report are accurate, and that the opinions expressed are true.

Introduction

Identify potential OHSE issues relating to the proposed use of RCG

15. There are a number of occupational health, safety and environmental (OHSE) issues relating to the use of RCG in civil construction applications. These are discussed below, and include:

    - Declining availability of sand
    - Availability of RCG.
    - Occupational Health and Safety impacts.
    - Environmental and economic impacts.

Declining Availability of Sand

16. The process of constructing roads or digging utility trenches is common. Such processes have used sand in road surfaces, road base or trench backfill for many years, but in many parts of Australia, the availability of natural sand from quarries is decreasing or needs to be transported far greater distances than in previous years, at increased costs to the civil construction sector. There is therefore a need to identify alternative, more sustainable materials that can replace the sand used in civil construction activities.

Availability of RCG

17. As recycling continues to grow, there is an increasing need for more markets to be established for products containing recycled materials.

18. Specifically, glass continues to be one of the principal waste products generated by the public and recovered by the recycling industry. Yet a large portion of collected glass is crushed into pieces that become too small to colour sort, and therefore are unable to be recycled back into glass containers.

19. Over the past few decades, alternate markets for RCG have been developing overseas, especially in the USA, with significant activity in states such as Texas, Minnesota, California, Washington, Oregon, New York. In New Zealand, almost half the glass collected each year on the South Island is now being used as RCG by the civil construction sector. In Australia, over the past two years the PSF has been actively working to develop opportunities for its use in a range of civil construction activities.[1]

20. When RCG is used as construction aggregate, there is less need for the cullet to be free of contaminants.[2,3] The use of RCG as a construction aggregate is becoming more widespread as the results of research and laboratory testing studies on RCG become better known, and as economic and environmental benefits become better understood.[4,5]

21. Within construction, RCG has the potential to be used in aggregates for structural or drainage applications. Some of these applications include road surfaces (asphalt and concrete), base and sub-base, embankments, structural fills, and utility trench backfill.[3,6,7,8]

22. While use of RCG in roadway construction is increasing, many agencies, local governments and civil construction contractors are still reluctant to consider it as a suitable substitute for materials already being used. This is mainly due to unfamiliarity with the engineering properties of RCG and a lack of suitable sources that supply RCG quantities to specification.

Occupational Health and Safety Impacts

23. The main issues around worker safety, are:

- the relative safety of RCG as it is concerned with the material it is replacing (sand);
- the abrasive nature of RCG in use and handling to skin and eyes;
- the risks of inhaled materials, with respect to the terms inspirable (inhalable) and respirable; and
- the carcinogenic potential of dusts arising from RCG with regard to the content of crystalline silica.

24. These are discussed below.

Abrasiveness

25. It has been reported that some of the coarser forms of crushed RCG have abrasive properties, and that this may present as a barrier to marketing and use if workers remain reluctant to use the product.

26. Experience in the USA and in Sydney NSW has shown that if RCG particles are greater than 5 mm, employees will report problems of abrasiveness and skin problems. At this size, some particles may be elongated or have splintered or angular shapes.

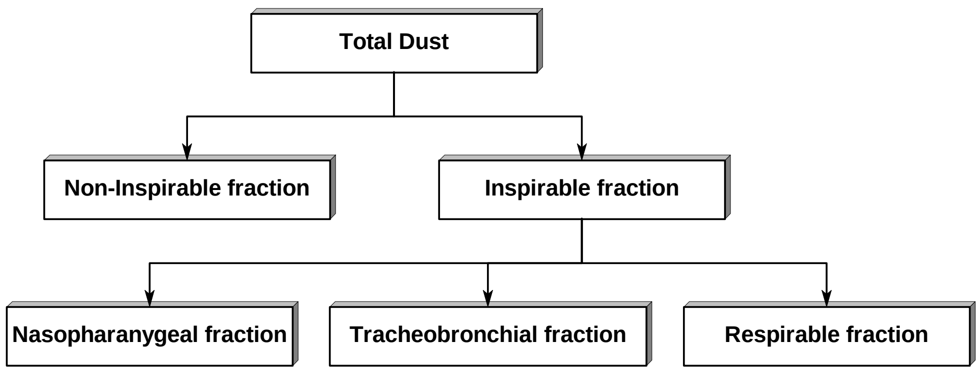
27. However, if the RCG is crushed to smaller particles (in the range of ~ 3 mm), the particles become rounder with less long pieces, thereby decreasing the risk of skin injury.[2]

Inspirability and Respirability

28. Risk assessments that are based on the total concentration of airborne dust alone are poor practice. For example, if beach sand is 95% crystalline silica, and crystalline silica is carcinogenic, then a trip to the beach is a carcinogenic risk. The respiratory hazards of dusts are based on their ability to be inhaled into the respiratory system. In turn, this is dependent on the particle size of the dusts, as large particles fall out of the air quickly and are not available to be inhaled.

29. For workplace safety purposes, dusts and particulates are divided into particulate size specific fractions, based on their ability to enter and penetrate into the respiratory system. The main fractions of a total aerosol are shown in Figure 1.[9]

Figure 1: Size Selective Components of Particulates



30. Total dust is divided into a *non-inspirable* fraction and an *inspirable* fraction (or inhalable) fractions. For a particulate to have a toxic effect in the respiratory system, it must be inhaled. So for the purposes of workplace safety, the non-inspirable fraction (often a substantial part of the total dust) can be discounted.

31. The largest inhaled particles, with aerodynamic diameters greater than 30 µm, are deposited in the upper airways of the respiratory system, which is at the air passages from the point of entry at the nostrils or lips to the larynx (the *nasopharyngeal* fraction). During nasal breathing, particles are captured by nasal hairs and by impaction onto the mucosal lining of the nasal turbinates and upper airways.

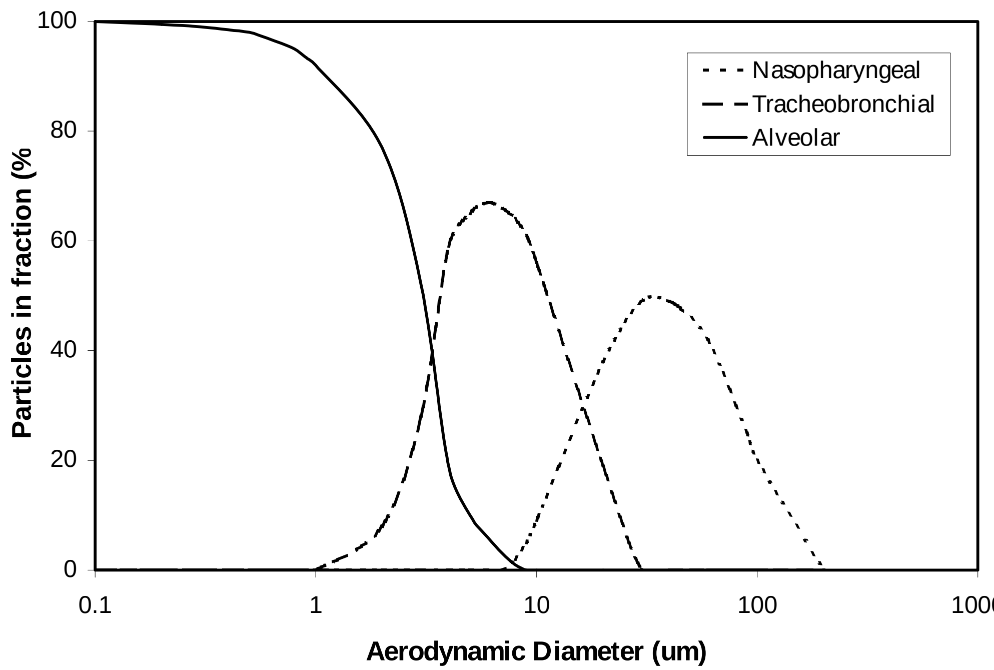
32. Of the particles that fail to deposit in the nasopharyngeal fraction, the larger particles will deposit in the tracheobronchial airway region and can either be absorbed (if soluble or capable of dissolution) or be cleared by mucocilary clearance. This is the *tracheobronchial* fraction.

33. The remaining particles not deposited in the nasopharyngeal and tracheobronchial regions can penetrate to the alveolar region, the

region of gas exchange with the body. This is the *respirable* fraction.

34. Much work has gone into establishing the limits of regional and total deposition of particulates in the respiratory system based on size. It is generally considered that the nasopharyngeal region collects particles of above about 7 (to 30) µm, that particulates of 2-30 µm are captured in the tracheobronchial region, and particles of less than 7 µm can penetrate to the alveolar regions. However these values are approximate, and there is a discernable range of particle sizes that fall into nasopharyngeal, tracheobronchial and respiratory fractions (see Figure 2).

Figure 2: Particulate Deposition in the Lungs by Size and Region



35. Therefore, when considering the risks of respiratory exposure, knowing the fraction of inspirable and respirable dust is more important than knowing the total dust concentration.

36. Further, as seen in Figure 2, as only dust particles with an aerodynamic diameter of less than 10 µm will reach the deeper parts of the lungs, this becomes a limit as to which sized particles will affect the deeper parts of the respiratory system.

Silica

What is Silica?

37. Silica is a complex occupational hazard. Silica is silicon dioxide (SiO_2) and is found in nature in various forms. Among other things,

it is found in beach sand, rocks containing quartz, and diatomaceous earth.

38. There are two main forms of silica: amorphous and crystalline.

39. Amorphous silica is the term used to describe forms of silica which have no regular crystal structure and this includes a wide range of different materials, of which fossilised skeletal remains of marine organisms (for example, diatoms) is the most common.

40. Crystalline silica is found in a variety of forms, the most common of which is quartz. Other types of crystalline silica include the high temperature minerals tridymite and cristobalite.

The Risks of Silica

41. The toxic form of silica is its crystalline form. Toxicity is related to the extremely small particles of silica that are respirable, that is, they can reach the inner parts of the respiratory system. Respirable particles are those that can penetrate the airways of the respiratory system with a particle size less than ten micrometres (below 10 µm). When respirable crystalline silica particles are inhaled, lung tissue reacts by developing fibrous tissue around trapped silica particles. Over time and continuing exposure, this tissue damage increases, and reduces the ability of oxygen to be absorbed into the body.

42. Human exposure to silica (usually as quartz) occurs most often during occupational activities that involve movement of earth, including mining, tunneling, quarrying, or manufacturing or using silica-containing products, and the generation of respirable dusts. Trades and industries that are involved in such work include brick manufacture, construction, metal foundries, sandblasting, ship and bridge repair, glass manufacture, ceramics manufacture, the refractory industry, and the like.[10]

43. In general, materials containing more than 1% crystalline silica are considered a health and safety issue (for example, they are prohibited from use in abrasive blasting).

44. Short term exposure to high levels of respirable crystalline silica particles (for example, during abrasive blasting) produces acute silicosis. Long term exposure (more than ten years) of exposure in occupations such as mining or quarrying can lead to chronic silicosis.

45. While there is some scientific evidence that amorphous silica may occasionally cause adverse health effects, most silica-related disease has been the result of inhaling crystalline silica. Most information on exposure and health problems is available from quartz exposure, most often from mining or quarrying.

46. There are many epidemiological studies of occupational cohorts exposed to respirable quartz dust. Silicosis, usually a nodular pulmonary fibrosis, is the disease most commonly associated with exposure to respirable crystalline silica and was one of the earliest recognised occupational diseases.[11] Although the reported mortality associated with silicosis and severe cases of silicosis have become increasingly less common as levels of occupational exposure have decreased over the past several decades, many workers continue to be exposed to crystalline silica.[12]

47. As well as silicosis, lung cancer and pulmonary tuberculosis are associated with occupational exposure to quartz dust.[13] Statistically significant increases in deaths or cases of bronchitis, emphysema, chronic obstructive pulmonary disease, auto-immune-related diseases (for example, scleroderma, rheumatoid arthritis, systemic lupus erythematosus), and renal diseases have been reported.

48. Escalating evidence of the cancer causing potential of silica was reviewed by the WHO International Agency for Research on Cancer (IARC) in 1997, which established silica as a proven human carcinogen.[13]

49. In 2004, the National Occupational Health and Safety Commission (NOHSC, now Safe Work Australia) halved the exposure standard for crystalline silica from 0.2 mg/m^3 to 0.1 mg/m^3.

Silica and Sand

50. The sand usually used in construction (beach sand or river sand) is composed almost totally (above 95%) of crystalline quartz. However, the size of particles in this sand is invariably too large to be a health problem.

51. If such sand were to be abraded into fine particles of a size below 10 µm (and at a concentration in air above 0.1 mg/m^3), such particles are the respirable crystalline silica that can cause silicosis.

Silica and Glass

52. Glass is the product of molten crystalline silica (and other ingredients), and has been bound into the glass matrix. Glass has no regular crystal structure, and is considered a form of amorphous silica.

53. While dusts can be generated from the glass crushing process, they are not likely to be present except as a very small proportion of the total particulates. Further, the nature of any dust will be of an amorphous, not crystalline, structure, and the concentration of the respirable fraction of this dust would be miniscule. As such, the

possibility of exposure to respirable crystalline silica is absent and the possibility of exposure to dust from RCG is very small.

54. Lastly, size for size, RCG particles (2.2-2.5 g/cm^3) are denser than sand (1.8 g/cm^3) particles. This means they are proportionally heavier, and will fall out of the air quicker than sand particles.

Environmental and Economic Impacts

55. RCG used in civil construction does not need to meet the more stringent requirements of colour and lack of contamination that recycled glass needs for use by packaging manufacturers.

56. However, RCG may contain food materials (such as sugars or food oils). To address this, RCG is screened or vacuumed when reprocessed to produce glass sand.[14]

57. Further, there are environmental and economic benefits from using recycled materials.

    - The availability of sand is becoming a problem in some urban areas of Australia, requiring supply at increasingly greater distances from outside of cities;
    - Using recycled materials conserves natural resources (that is, the extraction of sand);
    - Using recycled materials reduces landfill needs;
    - There are potential carbon offsets to the supply of materials within cities as opposed to supply from materials outside of cities;
    - There are substantial supplies of glass waste available;
    - In some instances, RCG is cheaper than mined sand.

Conduct an OHSE risk assessment for RCG, based on the newer materials now being manufactured

58. OHSE risk assessment and control is a part of the Model Work Health and Safety Regulations Model Codes of Practice by Safe Work Australia. This requires employers to identify hazards, assess risks, and where risks are assessed as hazardous, eliminate or control them. Occupational Health and Safety legislation is performance based, and does not specify how this process should be carried out.

59. Nevertheless, there are a range of tools and approaches that are available by which such workplace risks can be assessed. One such approach is risk assessment process using a risk matrix.

Risk Assessment and Control

60. The most common form of risk assessment using matrices is using a two dimensional risk matrix. The approach for the Risk Assessment in this project outlined below is based on the approaches outlined in ANZ/NZS ISO 31000[15] and the methodology of Taouk et al, 2001[16] and Makin and Winder, 2007.[17]

61. The first stage in the risk assessment and control proceed is to identify the hazards that exist. This seems intuitive but can sometimes be difficult.

62. Once the hazards have been identified, the risk associated with each scenario is assessed separately in terms of two parameters: "severity of harm" and "likelihood of occurrence". Because of the performance based nature of Occupational Health and Safety legislation, there are no formal recommendations regarding the number of categories for either of these parameters, what each category means, or the way in which they are used.

63. **"Severity of harm"** is an inherent characteristic of the hazard, which should be initially rated independent of any control measures that may be in place. Ratings for this parameter can be qualitative (such as rare, unlikely, possible, likely, almost certain) or be measurable (such as nuisance only, discomfort, temporary injury, permanent injury, loss of life) (see Table 1).

Table 1: Guidance on Severity of Harm

Descriptor	Examples of Description
Nuisance	No injuries. Annoyance.
Discomfort	First aid required. Short – term distress
Temporary Injury	Medical treatment required. Impact extends to family but is resolvable. Longer term distress.
Permanent Injury	Extensive or multiple injuries. Permanent severe health effects. At least one in patient hospitalisation. Trauma.
Life Threatening	Death of one or more people. Tragedy.

64. **"Likelihood of Occurrence"** is usually an assessment of the probability or likelihood that a scenario will actually occur given the current control measures that are in place (see). As for severity of harm, ratings for this parameter can be qualitative (such as Rare, Unlikely, Possible, Likely, Almost certain) or be semi-quantitative (such as Highly likely, Likely, Possible, Unlikely, Highly unlikely) (see Table 2).

Table 2: Guidance on Likelihood of Occurrence

Descriptor	Examples of Description
Rare	The consequence may occur in exceptional circumstances only. Not reported in this industry (at least in the past decade). Very low probability of loss or harm. Usually requires multiple system failures.
Unlikely	The consequence is not likely to occur. Known history of occurrence in other organisations. Low probability of loss or harm.
Possible	The consequence could occur at some time. History of at least one occurrence in the organisation. Moderate probability of loss or harm.
Likely	The consequence will probably occur in most circumstances. Known history of occurrences in organisation. High probability of loss or harm.
Almost certain	The consequence is expected to occur in most circumstances. Common or repetitive occurrence in organisation. Very high probability of loss or harm.

65. **Categorising the risk:** Ratings for each of these two parameters can then be interpolated using a risk matrix, for example as shown in Table 3, and the risk can be inferred from the risk categories in the table.

Table 3: Assessing Occupational Health and Safety Risk Categories Using a Matrix

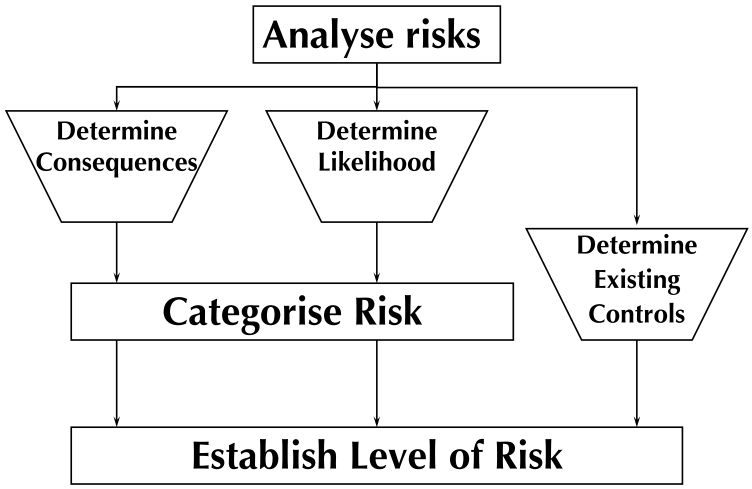
Severity of harm	Likelihood of occurrence				
	Highly likely	**Likely**	**Possible**	**Unlikely**	**Rare**
Life threatening	High	High	High	Medium-High	Medium
Permanent injury	High	High	Medium-High	Medium	Low
Temporary injury	High	Medium - High	Medium	Low	Low
Discomfort	Medium-High	Medium	Low	Low	Low
Nuisance only	Medium	Low	Low	Low	Low

66. Note that the use of this matrix provides a risk category, but it doesn't provide any information about how the risk should be treated or controlled. For example, should an activity categorised as a High risk be allowed to proceed? What if it is already an existing activity (for example, an electrician fixing a broken electrical circuit)? For this reason, guidelines are needed on what decisions should be made for "High", "Medium-High", "Medium" and "Low risks".

67. Further, the risk that has been categorised is as a worst case scenario, which does not factor in the impact of any available controls. Therefore this first phase risk assessment is as an <u>initial</u>

risk, and a second phase risk level needs to be characterised (see Figure 3).

Figure 3: Making Decisions about Risk



68. From this evaluation stage, the value of performing the risk ranking exercise both *with* and *without* the existing controls is highlighted. The first phase, of characterising the risk allows the full spectrum of the risk to be considered, but that includes a consideration of existing controls allows a more accurate depiction of the risk, providing a level of the risk in its fuller context. This then allows the categorisations made in Table 3 to have some relevance to actual workplace conditions.

69. If such decision making can be formalised, for example, High risks are considered a breach of Occupational Health and Safety duty of care and must never be permitted to proceed, then such decision making can be incorporated into the risk matrix, as shown in Table 4.

Table 4: Assessing Risks as Decisions

Severity of harm	**Likelihood of occurrence**				
	Highly likely	**Likely**	**Possible**	**Unlikely**	**Rare**
Life threatening	**Risk unacceptable Must not proceed**				
Permanent injury					
Temporary injury		**Risk acceptable Proceed with controls**			
Discomfort					
Nuisance only				**Risk negligible Can proceed**	

70. While more (or less) complex systems can be used, it is best to keep the decisions made from such assessments as simple as possible.

As shown in Table 4, sample conclusions such as Negligible, Acceptable or Unacceptable allow efficient and transparent decision making. For example, these could mean:

- **Negligible Risks:** Risk assessments that conclude that risks from proposed activities are “Negligible” and can be allowed to proceed using standard workplace practices. Generally, these require minor or no controls.
- **Acceptable Risks:** Risk assessments that conclude that risks are “Acceptable” can be allowed to proceed, providing that suitable controls are in use, approvals in place and appropriate supervision given, and providing that stakeholders understand the level of residual risk (the risk remaining after risk control plans have been implemented). The general aim is to select and use equipment, procedures and rules in accordance with the hierarchy of controls, to reduce all risks to “negligible” whenever it is practical to do so.
- **Unacceptable Risks:** Risks that conclude that risks are “Unacceptable” are problematic. If true, this conclusion may constitute a record that indicates an unacceptable risk exists, that is, a risk that cannot be eliminated or controlled to a level as low as reasonably practicable, which itself could indicate a breach of Occupational Health and Safety legislation. Therefore, risk assessments that make such a conclusion should *not be allowed to proceed* without further fuller consideration of specific information on the importance of the activity and the stringency of necessary controls by supervisors and if necessary, a senior manager, to bring down the risk to an acceptable or negligible level.

71. Hazards that are first deemed to have a high level of risk without any existing controls represent potential dangers because the reliability of existing controls methods may be subject to change depending on the unique circumstances at the time. Where there is a large differential between the level of risk evaluated before and after the application of current controls, organisations need to be mindful of the potential for exposure and vulnerability.

72. The existence of clear risk evaluation criteria moves the decision-making process forward by determining:

- whether the risk should receive further risk control;
- whether the activity should be undertaken at all, and most importantly;
- the priority of options for risk controls.

73. A draft risk assessment Table for using and handling RCG is shown in Appendix 2.

74. This Table has been developed to look at the workplace risks of handling RCG, and the exposure control methods that should be used to contain them.

75. From this Table, it is apparent that there may be some hazards of using and handling RCG, but these can be adequately controlled using standard workplace practices and personal protection.

Develop a simplified method of risk scoring for individuals and organisations considering using RCG, and for those using this product

76. The risk assessment process outlined in the previous section is relatively simple to follow and allows transparent decision making with regard to whether a risk is:

- High, and not acceptable to proceed; or
- Medium or Medium-High, and is acceptable to proceed as long as the recommended OHSE exposure controls are used; or
- Low, and is negligible can proceed where only standard workplace practices are required.

77. This offers a simplified method of risk scoring that not only provides a measure of the risk, but also what should be done to deal with the risk.

Assess OHSE risks and recommend suitable controls for proposed uses

78. As can be seen from the Risk Assessment and Control table in Appendix 2, all identified risks were assessed as being acceptable or negligible.

79. Overall, the main problem with working with RCG is inhaling the dust if sufficient airborne dusts arise, for example in pouring RCG, or on windy days, or if the RCG particles get in the eye. These can be controlled using standard work practices and personal protective equipment, as directed.

80. One persisting misapprehension is that RCG contains crystalline silica. This is not only untrue (most RCG is of the amorphous silica type), but misses the point that beach sand is over 95% crystalline silica (although only a small proportion of this is respirable). Therefore, whenever the "does RCG contain crystalline silica?" gets asked, it must be strongly restated that compared with sand, the risk of respiratory exposure to any form of silica is vanishingly small.

Prepare a MSDS for recycled glass for users

81. A draft Materials Safety Data Sheet (MSDS) for using and handling RCG is shown in Appendix 3.

Make suggestions on how RCG can be better promoted

82. As shown in this report, there are perceived safety hazards in relation to the use RCG compared with the material that it is replacing, that is, natural sand

83. Firstly, there are issues related with the hazards of a well known material (that is, sand), with the unknown hazards of a new material (RCG).

84. Secondly, the promotion of RCG to the construction sector and to its workforce should focus on the material being:

    - equivalent to sand with regard to engineering applications;
    - similar to sand with regard to environmental factors;
    - better for the environment from a recycling perspective;
    - similar in safety to sand with respect to abrasive properties if the smaller sized particles are used (that is, in the range of ~ 3 mm);
    - much safer than sand with respect long term health problems, because RCG contains substantially less respirable crystalline silica than sand.

85. Thirdly, as well as marketing the usefulness of RCG to organisations such as state government agencies, local councils and construction companies, building workers unions should also be targeted.

Conclusions

86. Application of RCG as a fine aggregate in civil construction offers significant benefits towards sustainability by diverting waste from landfills and utilising it in manufacturing value-added products.

87. In areas with limited availability of durable natural aggregates, using locally produced RCG can reduce the cost and environmental impact of importing aggregates from elsewhere.

88. Use of RCG in road base construction is suitable in terms of engineering performance, environmental impact, cost comparability with natural aggregates, and is strong, clean, safe, and economical.

89. A comparison of the workplace safety aspects of using RCG as a replacement for sand indicate that if the right particle size is supplied (that is, in the range of ~ 3 mm), the potential abrasion

hazards to respiratory system, eyes and skin are comparable to those of sand.

90. A comparison of the workplace safety aspects of using RCG as a replacement for sand indicate that while the risk of silicosis and lung cancer for exposure to the respirable crystalline silica in sand is low, the risk from exposure from respirable dusts of RCG is qualitatively much lower.

91. Promotion of the safety aspects of this material should focus on its equivalence to sand for short term health effects, and much better safety with regard to less risk of long term health effects.

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17 Makin, A.-M., Winder, C. Risk assessment and control. Chapter 8 in: *Master OH&E Guide*, second edition. CCH Australia, Sydney pp 121-132, 2007.

Appendix 1: Risk Assessment and Control Table

Hazard	Effects	Severity of harm	Likelihood of occurrence	Initial risk	Existing controls	Final level of Risk	Risk Decision	Additional Controls
This risk assessment is for using and handling RCG in road base construction. For the purposes of this risk assessment, RCG is crushed, recycled glass to a particle size of 3 mm or less.								
Dust, inhalation	**Short term:** nose and airways irritation, aggravation of asthma	Temporary injury	Possible	Low	Wherever possible, avoid exposure to dust. Work in well ventilated areas. Use wet methods to suppress any airborne dust. Where dust levels are high, wear a P2 respirator.	Low	Acceptable (use OHSE controls)	
	Long term: asthma, bronchitis, respiratory disease	Life threatening	Rare	Medium		Low	Acceptable (use OHSE controls)	
Silica, inhalation	**Short term:** nose and airways irritation, aggravation of asthma	Temporary injury	Possible	Low		Low	Acceptable (use OHSE controls)	
	Long term: asthma, bronchitis, respiratory disease, silicosis, lung cancer	Life threatening	Rare	Medium		Low	Acceptable (use OHSE controls)	No smoking on site
Dust, eye contact	Eye irritation from contact with dust	Temporary injury	Possible	Low	As for “dust, inhalation”, **Plus** Wherever possible, avoid eye contact. Where eye contact possible, wear eye protection (at least safety glasses).	Low	Acceptable (use OHSE controls)	Eyewash should be available
	Eye damage from contact from rubbing dust in the eye	Permanent injury	Possible	Medium-High		Medium	Acceptable (use OHSE controls)	

Hazard	**Effects**	**Severity of harm**	**Likelihood of occurrence**	**Initial risk**	**Existing controls**	**Final level of Risk**	**Risk Decision**	**Additional Controls**
Dust, skin contact	Skin irritation and abrasion from contact with dust	Temporary injury	Possible	Low	As for “dust, inhalation”, **Plus** Wherever possible, avoid skin contact (for example, wear overalls, do not handle the material). Where skin abrasion is possible, wear skin protection, such as gloves. Use good hygiene, such as washing hands before breaks. Launder clothing before re-use.	Low	Acceptable (use OHSE controls)	
Manual handling	Musculoskeletal injury from handling heavy loads	Permanent injury	Possible	Medium-High	Use mechanical aids, such as shovels, wheelbarrows and the like to reduce handling	Medium	Acceptable (use OHSE controls)	
exposure to solar radiation	Skin cancer	Permanent injury	Possible	Medium-High	Avoid exposure to sunlight, especially during the middle of the day. Wear clothing, hat and sunglasses and sunscreen (SPF30)	Medium	Acceptable (use OHSE controls)	Sunscreen should be available
Storage	Exposure to dusts	Temporary injury	Possible	Low	As for “dust, inhalation”, **Plus** Cover stockpiles of loads to prevent airborne dust levels.	Low	Acceptable (use OHSE controls)	Security procedures may be necessary where theft is a problem

Hazard	Effects	Severity of harm	Likelihood of occurrence	Initial risk	Existing controls	Final level of Risk	Risk Decision	Additional Controls
Transport	Exposure to dusts	Temporary injury	Possible	Low	As for "dust, inhalation", **Plus** Cover truck loads to prevent airborne dust levels.	Low	Acceptable (use OHSE controls)	
Pollution	Environmental damage from other contaminants in product	Nuisance	Unlikely	Low	None	Low	Negligible	
Risk assessments are prepared for workplace exposures to hazards that may affect health for the majority of workers. However, there may be some individuals with allergies, sensitivities or susceptibilities that this risk assessment may not protect. In such cases, each worker should discuss hazards, exposures, effects and controls with their supervisor.								

Appendix 2: Material Safety Data Sheet

This Material Safety Data Sheet (MSDS) for RCG has been created for this project. It is based the requirements outlined in the latest edition of the Safe Work Australia *National Code of Practice for Preparation of a Safety Data Sheet.*

Any organisation supplying, using or handling RCG may add their name, contact details and other information to this SDS where "?" appears, for use by their customers or employees.

Materials Safety Data Sheet

SDS No:		Issued	?
Product Name:	**Recovered Crushed Glass (RCG)**		
Other names:	Glass Fines, Crushed glass, Glass Granulates, Glass Aggregate		

Hazard Classification: Not classified as being a Hazardous Substance according to the classification criteria of Safe Work Australia.

Section 1: Company and Product Details

Company Details:

Company Name:
Address:
Telephone: Fax:
Emergency contact: Mobile:

Product Details:

Product Name: RCG

Product Use: Crushed recycled glass for use in construction of road base or trench backfill.

Section 2: Identification of Hazards

Hazard Classification:

Hazardous Substance: No classification
Dangerous Goods: No classification
Poisons Schedule: No schedule

Health Effects:

Precautionary Note: While this material does not meet hazard classification criteria, It is still considered that exposure to this dust may be irritating and it is recommended that wherever possible, exposure be avoided, or where this is not possible, recommended respiratory eye and skin protection be used, as indicated in Section 8.

Inhaled: Inhalation of dusts may cause irritation of the airways of the nose, throat and respiratory system
Repeated inhalation may add to the serious health effects caused by smoking tobacco.

Eyes: Contact of the dust to the eyes may cause irritation, production of tears, redness, stinging or sore eyes, and blurred vision.

Skin: Contact of the dust to the skin may cause skin irritation, with redness and itchiness. Abrasion may occur if the dust is rubbed against the skin

Swallowed: if the dust is swallowed, this may cause irritation to the mouth (including lips and tongue), and gastrointestinal system if swallowed. This may lead to nausea, vomiting, diarrhoea and abdominal discomfort.

Long term: The effects of long term exposure to the dust are not known. Repeated exposure to glass dust may exacerbate pre-existing respiratory disorders, such as asthma, bronchitis and lung cancer, and may increase the risk of scleroderma (thickening of skin and other protective tissue) and kidney disease.

Section 3: Ingredients

The main ingredient in this material is crushed glass.

The ingredients of Glass are:

Ingredient	CAS Number	Proportion
Bound amorphous silica	112945-52-5	20-80%
Bound metal oxides (mainly oxides of sodium and calcium)	-	20-30%
Free crystalline silica	14808-60-7	below 1%

Section 4: First Aid and Medical Measures

First Aid:

Inhalation: Removed exposed person(s) to fresh air.
Apply resuscitation if exposed person is not breathing, but do not use direct mouth to mouth method if exposed person has inhaled or swallowed any dust – use alternative respiratory support method.
If trained personnel and equipment available, administer oxygen if breathing is difficult.
Seek medical advice for any loss of consciousness or signs of respiratory distress. Otherwise, keep exposed person warm and rested until fully recovered.

Eye: If the dust gets into the eye, flush with plenty of fresh, tepid water for at least 15 minutes, ensuring the eyelids are held open. Seek medical advice if symptoms of irritation or discomfort arise.

Skin: If the dust contacts the skin, removed contaminated clothing and immediately wash the skin gently with cold water to remove the dust. Seek medical advice if skin irritation occurs. Launder clothing before reuse. Clean footwear before use.

Swallowed: If more than a teaspoonful of the dust is swallowed, DO NOT induce vomiting. Rinse out mouth with water, then give 3-4 glasses of water to drink. Seek medical advice.

Fist Aid Facilities:

First Aid Facilities: An eye wash station should be located close to where exposures to RCG may occur.

Advice to Doctor:

Treatment:	No special treatment known. Please treat symptomatically. Exposure to dust may aggravate any pre-existing asthma.

Section 5: Fire Fighting Measures

Fire Hazards:	RCG is not combustible or flammable. It does not support combustion of other materials and does not cause dust explosions. If involved in a fire, it is unlikely that irritating, corrosive or toxic gases or smoke will be produced. However, the fire hazard of adjacent materials should be considered.
Extinguishers:	In case of fire where this material is located, choice of extinguishers will depend on other materials present. Otherwise foam, dry chemical or carbon dioxide extinguishers or water spray are suitable. Use water spray to cool fire exposed containers, surface and to protect personnel.
Fire Fighting Procedures:	Fire fighters to wear full protective clothing and self contained breathing apparatus in confined spaces, in oxygen deficient atmospheres or if exposed to the products of combustion, pyrolysis or decomposition.

Section 6: Accidental Release Measures

Large Spills:	Contact emergency services (Fire Service or Police), depending on the type of spill. Inform them of location (as precise as possible), amount spilled, hazards of the material (see Section 2), if vehicles are involved and any other relevant or useful information. In emergency situations where dusts may arise, wear recommended respiratory, eye and skin protection (see Section 8). If possible, contain the spill if it can be done without risk. If not, minimise the spill area using barriers or bunds. Care should be taken to prevent spill of material into drains, waterways or other water catchments. Keep unauthorised persons away. Stay upwind.
Small Spills:	Collect dust into labelled containers for later re-use or disposal.

Section 7: Handling and Storage

Containers:	RCG should be stored in appropriate containers or stockpiles that do not allow any dusts from the material to be released.
Storage:	RCG is not classified as a Dangerous Good, and no special storage arrangements are required. The material should be contained and stored so that it does not pollute the workplace. For example, the sides of stockpiles should not be so steep that they collapse and cause accidents or contamination.

Section 8: Exposure Controls

Exposure Standards:

Exposure Standards:	No exposure standards are established by Safe Work Australia for RCG or any of its ingredients.

If dusts do arise from occupational exposure to RCG, the Safe Work Australia exposure standard for a substance that is of inherently low toxicity and free from toxic impurities (sometimes called nuisance dust) of 10 mg/m^3 (Inspirable) is applicable.

Exposure Controls:

Workplace Practices: Wherever possible, situations where high levels of dust can arise should be avoided.

Ventilation: Where dust concentrations may be high, exposure to RCG dust must be carried out in well ventilated areas, or using ventilation (preferably mechanical or local exhaust ventilation).

Equipment: Any equipment that becomes covered in dust should be decontaminated with a vacuum cleaner, or washed with water.

Personal Protection: Where personal protection is used, workers should be trained in fit and proper use. All available personal protection should be compliant with suitable standards, and decontaminated/clean before use.

Clothing: Work overalls and work boots as a general requirement

Respiratory: Avoid inhaling dust. Where dust levels occur, at least a P2 dust respirator should be worn. Respirators should comply with AS/NZS 1715 and 1716.

Eyes: Avoid the dust getting into the eyes. Where dust levels occur, suitable eye protection should be used, such as safety glasses, face shield or goggles. Eye Protection should comply with AS/NZS 1336.

Skin (hands): Gloves suitable for handling an abrasive material, such as leather. Hand protection should comply with AS/NZS 1336.

Section 9: Physical Properties

Appearance: Granular material with a transparent to light brown colour

Melting point: Approximately 900°C
Boiling Point: Not available
Specific Gravity: 2.2 to 2.5
Solubility: Not soluble in water
pH: Not applicable

Vapour Pressure: None
% Volatiles: None
Flash Point: Does not burn
Flammability: Does not burn
Upper Explosive Limit: Does not burn/explode
Lower Explosive Limit: Does not burn/explode
Autoignition Temp: Does not auto-ignite

Section 10: Stability and Reactivity

Stability: Stable in normal conditions of use.

Incompatibilities: None known

Section 11: Toxicological Information

Toxicity of Dust: No information is available for the toxicity of RCG.

	However, the main toxic hazard from exposure to the dust in irritation of the airways and eyes.
Toxicity of Ingredients:	While crystalline silica is used to manufacture glass, dusts from RCG are in the form of amorphous silica.

Section 12: Ecological Information

Ecotoxicity of Dust:	No information is available for the ecotoxicity of RCG or its ingredients.

Section 13: Disposal Considerations

Disposal:	In amounts less that 1 Kg, RCG is not a hazardous substance and should be collected into leak proof containers and disposed in domestic or industrial waste. Large spills should be collected into leak proof containers and returned to the supplier. Spill areas may be cleaned with water spray.

Section 14: Transport Information

Transport:	RCG is not classified as a Dangerous Good, and no special transport arrangements are required. The material should be contained and transported in such a way that it is safe and does not pollute the environment.

Section 15: Regulatory Information

Hazard Substance:	Not classified as being a Hazardous Substance according to the classification criteria of the Hazardous Substances Information System of Safe Work Australia.
Dangerous Good:	Not classified as being a Dangerous Good according to the classification criteria of the latest edition of the Australian Dangerous Goods (ADG) Code.
Poisons Schedule:	Not scheduled as a Poison according the latest edition of the Commonwealth Department of Health and Ageing Standard for the Uniform Scheduling of Drugs and Poisons (SUSDP).

Section 16: Other Information

Contact:Job title: **Phone:**
Fax:
Email:

Date of Preparation:

This Materials Safety Data Sheet (MSDS) was prepared from information sources assumed to be accurate and in accordance with the latest edition of the Safe Work Australia National Code of Practice for Preparation of a Safety Data Sheet.

The information and advice summarises's best knowledge of the health, safety and environmental risks of the product and how to use and handle the product in the workplace.

Appendix 3: Biography of the Author of this Report

1 This report was prepared by Christopher Winder, formerly Professor in Toxicology and Occupational Health at the School of Risk and Safety Sciences, University of New South Wales from 1992-2011. Presently, he is an Adjunct Professor in OHS Management at the Australian Catholic University and Principal Consultant in Chemical Safety, AusTox CCS Pty Ltd.

2 Qualifications :

- a BA (Hons) in Biology and Psychology from the Open University, UK, 1979.
- a MSc in Neurophysiology from the City of London Polytechnic, London, UK, 1981.
- a PhD in Toxicology and Pathology from the Royal Postgraduate Medical School, University of London, London, UK, 1983.
- a MPH in Toxicology and Public Health from the University of New South Wales, Sydney, [under examination].
- The intensive course in Occupational Hygiene, University of Sydney/Worksafe Australia, Sydney, 1990.
- The short course Occupational Health and Safety Management Systems Auditing, University of New South Wales, July 2003.
- The Graduate Certificate in Occupational Health and Safety Management, University of New South Wales, October 2004.

3 Positions held:

- Senior Research Fellow, Royal Postgraduate Medical School, University of London, 1979-83.
- Post-Doctoral Research Fellow, Cot Death Research Laboratories, University of Sydney, 1983-84.
- Principal Toxicologist, Commonwealth Department of Health, Canberra, 1984-85.
- Director and Chief Toxicologist, Chemicals Section, NOHSC, Sydney, 1985-87.
- Senior Lecturer in Toxicology, National Institute of Occupational Health and Safety, Sydney, 1987-92.
- Co-ordinator, Hazard Evaluation Program, NOHSC, Sydney, 1987-92.
- Senior Lecturer in Occupational Health, Department of Occupational Health, University of Sydney, Sydney, 1990-95.
- Senior Lecturer in Chemical Safety, Department of Safety Science, University of New South Wales, Kensington, 1992-95.
- Associate Professor in Chemical Safety, School of Safety Science, University of New South Wales, Kensington, 1995-2006.
- Head of School, School of Safety Science, University of New South Wales, Kensington, from 1997-2003 and 2007-08.
- Professor in Toxicology and Occupational Health, School of Risk and Safety Sciences, University of New South Wales, Kensington, 2006-11.
- Adjunct Professor in OHSE Management, Faculty of Business, Australian Catholic University, from 2011.

4 Professor Winder has written three books, over thirty chapters in books, and over two hundred monographs, papers, reviews and abstracts in toxicology and chemical safety. Of particular reference to the topic of effects of chemicals and chemicals management at work are the following publications:

- Winder C., principal consultant. *Hazard Alert: Managing Workplace Hazardous Substances*. CCH International, Sydney, 1995-2007.
- Winder, C. Applying risk management approaches to chemical hazards. *Journal of Occupational Health and Safety - Australia and New Zealand* 15: 161-169, 1999.
- Winder, C. Mechanisms of multiple chemical sensitivity. *Toxicology Letters* 128: 85-97, 2002.
- Makin, A.-M., Winder, C. Managing hazards in the workplace using organisational safety management systems: A safe place, safe person, safe systems approach. *Journal of Risk Research* 12: 329-343, 2009.
- Winder, C., Stacey, N.H., editors. *Occupational Toxicology*, second edition. CRC Press, Boca Raton, 2004.
- Winder, C. Toxicity of gases, vapours and particulates. Chapter 15 in: *Occupational Toxicology*, second edition, Winder, C., Stacey, N.H., editors. CRC Press, Boca Raton, 2004, pp 399-424.
- Makin A.-M., Winder, C. Risk assessment and control. Chapter 8 in: *Master OH&E Guide*, second edition. CCH, Sydney pp 121-132, 2007.

5 Prof Winder’s first professional involvement with exposure of workers to chemicals was in 1984-1985 as a toxicologist with the Commonwealth Department of Health in Canberra. At that time I began reading the medical and scientific literature and evaluating data on, among other things, the health effects of chemicals and pesticides.

6 Thereafter Prof Winder continued his involvement in this area when I began working as Chief Toxicologist and Director of the Chemicals Section, Worksafe Australia (the National Occupational Health and Safety Commission). My role at this section was to direct the work of the section and to investigate the effects of chemicals on the health of workers. He was extensively involved in the development of chemical safety policies, including for MSDS, exposure standards, lead, and legislation for industrial chemicals.

7 Prof Winder also organised and ran training courses on chemical safety for Worksafe Australia from 1988 onwards and lectured at the University of Sydney, University of New South Wales and the NSW College of Nursing since at least 1989. In addition, He have undertaken research projects and supervised doctorate and masters students undertaking research projects in a wide variety of toxicological and chemical safety topics. He continued in teaching and research in chemical safety and toxicology on my appointment to the University of New South Wales in 1992. In 1995, I was promoted from senior lecturer to associate professor, and promoted to professor at the end of 2006. I was Head of the School of Risk and Safety Sciences from 1997-2003, and from 2007-08. The School was closed in December 2010, and he left UNSW in August 2011.

8 Prof Winder is presently working as Adjunct Professor of OHSE management at the Faculty of Business, Australian Catholic University.

9 Prof Winder has been reading, researching, teaching, and providing advice on the health effects of chemicals since the late 1970's.