THE BENEFICIAL USE OF WASTE

Submitted to:

Alberta Environment
Calgary, Alberta

Submitted by:

AMEC Earth & Environmental
Calgary, Alberta

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Dear Mr. Fernandes:

Re: Beneficial Use of Waste Project for Alberta Environment

Please accept this report as fulfillment of AMEC Earth & Environmental's commitment to produce a report entitled "The Beneficial Use of Waste" as per Contract No. 06-0130. As requested, we have provided four copies of the report.

If you have any questions or concerns regarding this report, feel free to contact the undersigned at 403-569-6589.

Yours truly,

AMEC Earth & Environmental

Tracy L. Chambers, P.Eng.
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TLC/sms

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AMEC Earth & Environmental would like to acknowledge the following people who made significant contributions to the report:

- *Connie Nichols* – Agrium;
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- *Todd Kruszewski* – Cement Association of Canada;
- *Michael Lloyd* – Florida Institute of Phosphate Research;
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- *Julie Buffenbarger* – Lafarge North America;
- *Todd Sherman* – Lafarge North America;
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- *Peter May* – Western Co-operative Fertilizers Ltd.

EXECUTIVE SUMMARY

AMEC Earth & Environmental was contracted by Alberta Environment in September of 2005 to conduct a study titled “The Beneficial Use of Waste”. This study identifies three industrial waste types generated in Alberta that could be taken from a waste management system to a resource management system and provides direction on the proposed management processes.

Additionally, current provincial, national and international programs that involve managing waste as a resource were investigated and discussed.

The study was conducted in the following manner:

- identification of Alberta’s current industrial waste profile;
- *Literature Review* – a preliminary review of waste type characteristics and reuse potential;
- *Team Workshop* – a team and client review of information gathered to determine top waste types;
- *Review of Secondary Resource Programs* – a review of local, provincial, federal and international Beneficial Use programs to determine applicability in Alberta;
- *Research of Identified Waste Types* – a detailed review of the top three waste types characteristics, generation and use in Alberta and potential reuse alternatives;
- evaluation of collected data; and
- recommendation for beneficial strategies.

Through the course of this study, three priority waste types were identified for further review for beneficial use in Alberta: phosphogypsum (PG), fly ash and cement kiln dust (CKD). Each of these waste types investigated were found to have ample secondary uses. The uses most suitable for Alberta and the current market situation were evaluated in more detail.

The beneficial use programs reviewed were found to be very helpful in determining the tools available for the encouragement of secondary resource management in Alberta. Specific programs also were found that could provide technical information, information sharing programs and even the possibility of funding for research into secondary resource applications.

Phosphogysum (PG) is the most challenging waste type given the negative perceptions associated with its NORM properties and the current lack of secondary use. Good potential does exist for the utilization of this waste type in the following manners:

- daily landfill cover;
- tailings flocculant;
- compost/soil amendment;
- cement additive; and
- road building.

While the potential is there for PG use, it requires significant commitment from all stakeholders in the form of both time and money to deal with gaps in the science association with use and the barrier of NORM perceptions.

Both coal fly ash and wood fly ash have accepted markets established in Alberta. For coal fly ash, the majority of it is used as a supplementary material in concrete or as a Portland Cement replacement. Wood ash has been approved by Alberta Environment for use as a liming material for agricultural land. Considering the use of fly ashes as a secondary resource remains around 15 to 20%, and the potential markets, there is obvious room for growth. In general, growth in the existing markets should be encouraged and supported before exploring other opportunities.

CKD was found to be well on its way to 100% utilization a secondary resource. One of the two generators identified in Alberta was found to be recycling all generated CKD already while the other has a plan in place to achieve 100% secondary use or recycling in a three year time frame. While there are many alternatives for secondary use of CKD, recycling within the cement plant is the most common. In Alberta the reuse of CKD in road building is currently being established. Little action would be required at this point to maintain this momentum but keeping watch on the situation would be advised.

LIST OF ACRONYMS

AAFC	Agriculture and Agri-Food Canada
AENV	Alberta Environment
Agrium	Agrium Inc.
AlPac	Alberta Pacific
ASTM	American Society for Testing and Materials
Bq	Bequerel
BUSWM	Beneficial Use of Solid Waste in Maine
C_2P_2	Coal Combustion Products Partnership
CaGBC	Canada Green Building Council
CAPP	Canadian Association of Petroleum Producers
CCPs	Coal Combustion Products
CFI	Canadian Fertilizer Institute
CIRCA	Association of Canadian Industries Recycling Coal Ash
CKD	Cement Kiln Dust
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
CTMP	Chemi-thermomechanical Pulp Mills
ECOBA	European Coal Combustion Products Association
EIP	Eco-industrial Park
EPRI	Electric Power Research Institute
EWMCE	Edmonton Waste Management Centre of Excellence
FGD	Flue-gas-desulphurization
FHWA	Federal Highway Administration
FIPR	Florida Institute of Phosphate Research
ICON	International Centre for Sustainable Development of Cement and Concrete
IS4IE	International Society for Industrial Ecology
Kg	Kilograms
LEED	Leadership in Energy and Environmental Design
MDRV	Municipal District of Rocky View
MP	Member of Parliament
MSDS	Material Safety Data Sheet
MW	Mega Watts
NISP	National Industrial Symbiosis Programme
NJDEP	New Jersey Department of Environmental Protection
NORM	Naturally Occurring Radioactive Materials
NO_X	Oxides of Nitrogen
NRCan	Natural Resources Canada
NYSDEC	New York State Department of Environmental Conservation

O&G	Oil and Gas
OSB	Oriented Strand Board
PG	Phosphogypsum
RCC	Resource Conservation Challenge
RMRC	Recycled Materials Resource Centre
S/S	Solidification/Stabilization
SCM	Supplementary Cementing Material
SO_2	Sulphur Dioxide
UK	United Kingdom
US EPA	United States Environmental Protection Agency
USDOT	United States Department of Transportation
WBCSD	World Business Council for Sustainable Development
WDNR	Wisconsin Department of Natural Resources
Westco	Western Cooperative Fertilizers Ltd.
WMCC	Waste Management of Canada Corporation

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1.0 INTRODUCTION

Each year thousands of tonnes of wastes are disposed of in landfills. Specific data on industrial waste management in Alberta is difficult to obtain, but an indicator can be assumed with Statistics Canada's estimates that, in Alberta, an estimated 1,035 kilograms of "wastes"[1] per capita are generated. Of this quantity, only 14% is diverted from disposal for recycling or reuse which ranks Alberta well below the national average of 24% (Statistics Canada, 2000). The balance of generated wastes are placed in landfills or storage which results in the occupation and degradation of valuable land. In addition to the disposal concerns mentioned supplemental effort and energy must now be expended to extract and/or process virgin resources to fill the need for consumers and producers.

The reuse of wastes as inputs to other processes would alleviate disposal concerns and reduce the need for virgin resources. Countries not as rich in natural resources as Canada have recognized the need to reuse products traditionally handled as "wastes". In the Netherlands programs like the Waste Materials Policy, taxing the use of natural materials and waste disposal are just some of the actions taken place that have helped to achieve recycling/reuse rates of 100% for some "waste" streams (Holtz *et al.*, 2000). Alberta Environment (AENV) has recognized the opportunity to solve the problem of on going waste disposal and realize the economic benefit of having a product rather than waste generation. To move forward with this ideology AENV is in the process of developing a new waste strategy for the province.

As part of AENV's new waste strategy they commissioned AMEC Earth & Environmental (AMEC) to identify solid industrial wastes currently generated in the province which would be good candidates to switch from traditional waste management to management of resources for beneficial uses and develop strategies to accomplish this objective.

[1] Includes only non-hazardous residential and non-residential solid waste managed off site.

2.0 PROJECT DESCRIPTION

The determination of waste types suitable for diversion to a resource strategy proceeded in a systematic fashion. The major steps of this process were:

- identification of Alberta's current waste profile;
- literature review;
- team workshop;
- evaluation of Secondary Resource Programs;
- research of identified waste types;
- evaluation of collected data; and
- recommendation of beneficial strategies.

The approach to each of these steps is outlined in Sections 2.1 to 2.8.

2.1 Identification of Alberta's Current Waste Profile

There are hundreds of different types of wastes generated in the province of Alberta. To determine which of these wastes has the potential for beneficial reuse a study was conducted to determine the quantities of industrial waste generated in Alberta. This was accomplished using a combination of literature and primary research. This task concentrated on providing a list of wastes and the associated industries that produce a waste in a quantity and quality suitable for waste to resource strategy development. The generated list was not intended to provide exact quantities generated but to provide a starting point for more in depth review.

Several different approaches were taken to develop a "hit list" of waste types generated in Alberta. The research methods included:

- a telephone survey of key landfill operators in Alberta to obtain a listing of the high volume and/or high resource potential wastes currently accepted in their landfills;
- recommendations of Alberta Environment;
- recommendations of project team including the Edmonton Waste Management Centre of Excellence and additional AMEC personnel; and
- a review of the findings of the "Consultations on a Canadian Resource Recovery Strategy" the Edmonton/Prairie Provinces Consultation (NRCan, 2002).

In some cases, the industries associated with the researched waste types were obvious. For example cement kiln dust comes only from cement manufacturing plants that are part of the ready-mix concrete industry. In other situations the determination of the associated industry was ambiguous. An example of this type of situation is the contaminated soil waste type. This waste type is general and could come from several types of industries. Nearly any industry could produce some contaminated soil, so the type of contaminant as well as the expected volume generated would vary along with the industry. In these situations an industry generator was chosen that generated large quantities and consistent waste types.

2.2 Literature Review

A preliminary literature review was completed to review the characteristics, potential uses and processes for the waste types identified in profiling. If, prior to secondary use, the waste required some modification, the technology to process the waste was researched as well as the availability/feasibility of the process. The reviewed resources consisted of periodicals, books and electronically available documents.

2.3 Team Workshop

A one day team workshop was held to “brainstorm” the results of the waste profiling and literature review exercises. Present at the workshop were project team members as well as key Alberta Environment representatives. In total there were eight Alberta Environment attendees and nine project team members. The workshop provided:

- project background;
- the results of the waste profiling to date;
- a review of barriers to promote waste utilization and the tools to eliminate the barriers; and
- a forum for input to select the top waste types for secondary resource management.

The workshop goal was to utilize the knowledge and experience of the workshop attendees to provide direction on what the selection of the waste types for further study should be. Again, this approach was qualitative and meant to provide an efficient method of getting to the “low hanging fruit” (i.e., determining the best waste types to pursuing a waste to resource management program). A listing of the top waste types along with selection criteria for the top waste types was generated at the workshop. This information was utilized to develop a “selection matrix” to determine the top three waste types for study.

2.4 Review/Evaluation of Secondary Resource Programs

Currently active programs for waste to resource utilization were identified by information provided by Alberta Environment, the Project team and using electronic search engines. The programs evaluated included those that were conducted provincially, federally and internationally.

The programs included in the report reflect those that:

- could represent a material produced in Alberta in a significant quantity;
- would be sustainable;
- represent an established and trustworthy institution or association;
- could offer a resource such as funding, the provision of information or an information sharing relationship; and
- would likely be accepted by public/industry.

2.5 Research of Identified Waste Types

This research expanded on that done in the Literature Review for the selected waste types. The characteristics, quantities and locations of the identified waste types was determined, followed by research of the potential secondary uses. To collect this information data available on the internet, in scientific papers and in articles was utilized. The primary source of investigation, however, was by contacting generators, users and researchers for current information and opinions.

2.6 Evaluation of Collected Data

Barriers to the development of a secondary resource management system were identified and potential remedies were suggested. Current market demands, costs and implementation requirements were also discussed. For each industry/site impacted by the selected secondary resources changes needed to the current waste production process were identified. The changes that were reviewed included the required characteristics of the secondary resource, new processing requirements, transportation issues and product liability concerns. Barriers that were considered included:

- regulatory concerns;
- new process challenges;
- liability issues;
- material consistency;
- negative perceptions of products made from wastes;
- less expensive alternatives;
- legal concerns;
- quantities of waste available; and
- location of available wastes.

The management tool that best addressed the identified barrier was discussed, and included:

- regulatory simplification;
- new regulatory requirements;
- profit potential identification;
- elimination of disposal concerns;
- cost savings through tax deductions;
- improved industry image to stakeholders;
- technical assistance/information exchange programs;
- research and development and demonstration programs;
- financial compensation;
- industry and/or consumer education; and
- industry partnerships with secondary resources users.

For some of the identified barriers a combination of the listed management tools was recommended.

2.7 Recommendations

The recommendations describe specific activities that could be undertaken to promote beneficial use and overcome identified barriers. Some of these approaches were universal to beneficial use in general and others were waste type specific.

3.0 ALBERTA'S WASTE PROFILE

Several methods were used to develop a listing of waste types of significant volume in Alberta each of the methods and their results are discussed in Sections 3.1 to 3.3.

3.1 Landfill Telephone Survey

The landfills selected for the survey represented those that were known high volume industrial, and regional landfills since they also accept industrial waste. The detailed results of the survey are included in Appendix A, along with data from a preliminary literature search on selected waste types. A response to the survey was not obtained from all operators contacted; however the waste profiling exercise was not intended to be all inclusive, so the lack of response from these operators was not considered a barrier to the production of the waste "hit list". While some volumes/tonnages of industrial wastes were provided the amounts were taken as indicators only since they represented snap shots in time of the quantities received not on-going amounts. The operators that supplied information included:

- Canadian Crude Separators;
- BFI (Calgary Regional);
- Clean Harbours (Safety Kleen);
- Hazco;
- Newalta Corporation;
- Paintearth Resource Recovery Centre (Capital Environmental Resource Inc. Ltd.);
- Swan Hills Treatment Centre (Earth Tech);
- Byram Industrial Services Inc.;
- Waste Management of Canada Corporation (WMCC);
- WasteCo (Newalta Co.);
- Edmonton Landfill (Cloverdale);
- Lethbridge Landfill;
- Red Deer Waste Management Facility;
- Medicine Hat Regional Landfill;
- Fort McMurray Regional Landfill;
- Drayton Valley Regional Landfill Authority; and
- East Peace River Regional Landfill Authority.

The top volume waste types identified in this review are listed in Table 1.

Table 1: High Volume Waste Types Identified in the Landfill Telephone Survey

Waste Type	Associated Industry	No. Operators/ Landfills Identifying This Waste Type	Comments
Miscellaneous Demolition Wastes	Construction/Demolition/ Renovation	15	Includes drywall, shingles, insulation, stucco, asbestos and concrete.
Contaminated Soil	Oil & Gas, Upstream/ Downstream Miscellaneous	6	Contaminated soil types include hydrocarbon, metals and chloride.
Organics/Food Wastes	Food	4	Includes packing house waste and food processing wastes.
Catalyst/Desiccants	Oil & Gas Upstream	4	
Lime Sludge	Water Treatment	4	
Drill Cuttings	Oil & Gas Upstream	3	
Agricultural Organics	Agriculture	2	Includes seed cleaning residues and grain dust.
Animal Wastes	Agriculture	2	Includes chicken manure, chicken offal/feathers and animal carcasses.
Yard Wastes	Miscellaneous	2	Includes sod.
Sulphur Wastes	Oil & Gas Upstream/Downstream	2	
Paint Solids	Paint	2	
Foundry wastes	Foundry	2	Includes iron dust and casting sand.
Absorbents	Miscellaneous	1	
Drums Pails	Miscellaneous	1	
Steel/Metals	Miscellaneous	1	
Asphalt	Transportation/Miscellaneous	1	
Power Pole Butt Ends	Utility	1	
Sawdust	Wood Processing	1	

Table 1 identifies construction/demolition wastes as a primary constituent of waste streams received by the landfills surveyed. While it is important to acknowledge this waste stream it is not considered part of the scope of this project and will not be considered in the evaluation to determine the top waste types. Programs like Alberta Environment's Construction, Renovation and Demolition Waste Reduction web site are currently addressing the five R's (Reduction, Reuse, Recycling, Reclaiming, Recover) of this waste type. Another identified waste type, paint solids, will not be further considered since Alberta Environment is in the process of developing a program to address the wastes produced from the paint industry.

Wastes resulting from upstream and downstream operations of the Oil and Gas (O&G) industry were strongly represented in this research. The primary waste of concern for this industry was contaminated soils. The location of the landfills reporting large quantities of O&G were more closely situated to O&G operations specifically for the upstream sector.

Various organic waste streams from the agricultural and livestock industries were reported. Wastes from the food processing and packaging industries could also be included in this organics waste stream.

Several of the waste streams identified could not be associated with a specific industry, they have multiple potential industrial generators. An example of this would be empty drums/pails. Other waste types mentioned (e.g., power pole butt ends) likely represent a bulk discharge that is not likely to occur on a regular basis.

In addition to the information on the types and quantities of wastes received general comments were recorded from the operators on the challenges they face with respect to some of the identified waste types. A relevant selection of these comments are recorded below:

- *Organics/Paper:*
  - Obvious streams they see that could be diverted include grass and cardboard.
- *Construction/Demolition Debris:*
  - They have tried crushing concrete but have found it cost prohibitive.
  - A private landfill accepts construction/demolition debris at a fraction of the cost of their landfill so they see little of this material.
- *Contaminated Soils:*
  - They have bioremediation pads on site but they are seldom used since it is cheaper to landfill than to treat contaminated soils ($40/tonne for treatment vs. $20/tonne for disposal).
  - There is no economic incentive for oil companies to treat/recycle contaminated soils, it is not expensive to landfill. There is lots of land that isn't expensive and disposal prices are competitive.
  - Contaminated soils provide an excellent source of alternative daily cover while increasing landfill life since clean fill is not used.
  - Upstream contaminated soils are not cost effective to remediate.
- *General Comments:*
  - They have difficulty getting users to place recyclables in the correct area of the site and do not have the resources to sort material as it arrives.
  - Have asked users (the bulk of which are from the Oil and Gas sector) to segregate wastes for better recycling but they do not and the operator does not have the resources to monitor incoming wastes.

A limitation of this telephone survey is that it does not reflect the wastes that are handled or disposed on site by generators. These wastes have been captured in the other research methods that are discussed below.

3.2 Consultations on a Canadian Resource Recovery Strategy

Natural Resources Canada (2002) undertook a consultative process in the spring of 2002 to identify opportunities for resource recovery in Canada. The consultations occurred at seven different locations across Canada and included all interested stakeholders including those from industry, government (all levels) and non-governmental organizations. The Edmonton/Prairie Provinces Consultation was held on April 23, 2002 in Edmonton. Specific objectives of the consultation were to determine:

- resource recovery priorities in urban and rural communities across Canada;
- resource recovery priorities in Canada's north;

- barriers to resource recovery in every region;
- potential resource recovery demonstration projects in industrial, post-consumer and institutional sectors; and
- estimated levels of project funding and co-funding partners.

The resource recovery priorities for industrial wastes that were determined at this consultation are identified in Table 2.

Table 2: Industrial Waste Resource Recovery Priorities – Canadian Resource Recovery Strategy

(NRCan, 2002)

Waste Type	Associated Industry	Comments	Identified in Telephone Survey (Y/N)
Miscellaneous Demolition Wastes	Construction/Demolition/ Renovation	Includes pressure treated lumber	Y
Compostable Organics	Food/Miscellaneous	–	Y
Desiccants (Carbon Recovery)	Oil & Gas Upstream	Assumes carbon recovery refers to desiccants	Y
Fly Ash	Energy Production	–	N
Forest Waste	Forestry	–	N
Animal Wastes	Livestock	–	Y
Fibre Optic Cable	Communications	–	N
Sulphur Wastes	Oil & Gas Upstream/ Downstream	–	Y
Water	Miscellaneous	Not included in the scope of this study	N
Industrial Waste Heat	Miscellaneous	Not included in the scope of this study	N
Railway Ties	Rail/Transportation	–	N
Waste Exchange Leftovers	Miscellaneous	Items not taken in waste exchange programs	N
Paper and Cardboard	Miscellaneous	–	N
Flared Gas	Oil & Gas Upstream/ Downstream	Not included in scope of this study	N
Computers	Miscellaneous	Alberta Environment has a program for this waste stream	N

Some of the noted wastes are not included in the scope of this project. These would include those that are not solid waste (flared gas, water, industrial waste heat), are specifically excluded from the scope (construction, renovation and demolition materials) and those that already have programs either established or being developed (computers, Alberta Environment's Electronic Recycling Program, paper, cardboard). It is important to note the "overlaps" from the telephone survey of landfills/operators. These are highlighted in the last column of Table 2. Some of the overlaps include: organics, desiccants, sulphur wastes, paper and animal wastes.

3.3 Recommendations of Alberta Environment and Team Experts

The list of candidate secondary resources identified in Table 3 was collected through a combination of meetings, telephone conversations and e-mail correspondence with Alberta Environment and team experts.

Table 3: Candidate Wastes Recommended by Alberta Environment and Team Experts

Waste Type	Associated Industry	Identified in Phone Survey (Y/N)	Identified in CCRRS[1] (Y/N)
Miscellaneous Demolition Wastes[2]	Construction/Demolition/Renovation	Y	Y
Compostable Organics	Food/Miscellaneous	Y	Y
Drilling Muds	Oil & Gas Upstream	Y	N
Fly Ash/Coal Ash	Energy Production	N	Y
Animal Wastes	Livestock	Y	Y
Produced Sand	Oil & Gas Upstream/Foundries	N	N
Sulphur Wastes	Oil & Gas Upstream/Downstream	Y	Y
Phosphogypsum	Fertilizer	N	N
Wood Waste	Miscellaneous/Forestry	Y	Y
Lime Sludges	Water Treatment	Y	N
Mine Tailings	Mining	N	N
Cement Kiln Dust	Cement Manufacturing	N	N

[1] CCRRS = Consultation on a Canadian Resource Recovery Strategy
[2] Not included in the scope of this study

Again, this table repeats some waste types that have been previously identified. The right-hand columns of Tables 2 and 3 highlight whether the waste type was identified in the previous research methods.

Demolition wastes, organics, animal wastes, sulphur wastes and wood wastes were identified in all three research methods undertaken.

4.0 SELECTION OF TOP WASTE TYPES FOR REVIEW

Two approaches were used to select the key waste types identified in waste profiling and to identify the top three waste types for conceptual plan development. The first method was a group workshop which gathered team members and key client representatives to evaluate and prioritize the wastes identified in profiling. The second was a systematic review of these prioritized wastes using selection criteria established at the workshop.

4.1 Group Workshop

A group workshop was held at the Edmonton Waste Management Centre of Excellence on October 28, 2005. The workshop attendees included key Alberta Environment staff and project team members. To ensure a common starting point for workshop discussions a review of the project objectives and approach was given. The presentation reported the findings to date and gave attendees the opportunity to add to the list of candidate wastes. Lastly, an overview of the expected barriers to resource management and the potential solutions to the barriers was given. A copy of the workshop slides overview, attendees and findings are provided in Appendix B. After the presentations were completed the floor was opened for group discussions to prioritize the identified waste types.

4.2 List of Waste Types for Evaluation

A list of waste types identified in the preliminary research was provided to the workshop group. This list served as a starting point for the group to add additional waste types to the list that may have been overlooked in the preliminary research. Table 4 details the waste types that were discussed at the workshop.

The workshop discussion of industrial wastes in Alberta generated several new potential waste types for further evaluation.

4.3 Criteria Used to Select Waste Types for Further Study

To evaluate the identified waste types, and their suitability for secondary use, a list of selection criteria was created by workshop attendees. The ability of a waste type to meet these criteria determined whether the waste type should continue to be considered or not. The identified criteria included:

- minimization of time for implementation;
- industries' readiness for change (financial commitment, openness of recognition of waste issue);
- sustainability measurements (environmental, social, financial);
- geographic concerns;
- political acceptance;

Table 4: Candidate Waste Types from Preliminary Research and Workshop Input

Industry	**Waste Types**
Coal	Coal Ash, Fly Ash, *washings/fines*
Transportation	Asphalt
Forestry	Wood debris, sawdust, *tree seedling containers*
Communication	Fibre Optic Cable
Fertilizer	Phosphogypsum (NORM)
Oil & Gas (Upstream)	Sulphur wastes, produced sand, drilling wastes, contaminated soil, absorbents, frac sand, sulphur
Oil & Gas (Downstream)	Contaminated soil, absorbents, *hydrocarbon wastes/sludges (e.g., tank bottoms)*
Pulp and Paper	*Organic Sludges, Bio-solids, de-inking sludge, hog fuel, lime*
Greenhouses	*Coir (?), rooting media*
Hydro-Metallurgy	*Ni-Fe Tailings*
Petrochemical	*Tank bottoms, spent catalyst, petroleum coke, polymers*
Food	Specified Risk Materials (SRM), packing house waste, clay/mud from food processing, *kitchen waste*
Agriculture	Seed hulls, farm mortalities, grain dust, *manure, mushroom waste*
Cement Manufacturing	*Kiln Dust (Calcium Oxide)*
Steel Foundries/Metal Casting	Iron dust, casting sand
Automobile Wrecking	*Shredder Residue (ASR)*
Mining	Tailings
Construction and Demolition	Shingles, insulation, drywall, asbestos, wood, concrete, paint solids, empty paint cans/pails
Wood Processing	Wood debris, sawdust
Landscaping	Wood, leaves, grass clippings
Miscellaneous	Lime sludges/*water treatment sludges*, wood fly ash, road kill, computers/electronics, drums/pails, *organic waste, packaging from misc. industries*

Note: Waste types identified in italics were added to the list at the workshop.

- current cost of disposal;
- volumes generated;
- characterization/complexity of waste;
- potential for opportunities;
- liabilities/risks;
- within scope of this project;
- current pilot projects/historical efforts; and
- economic value/markets ($$).

In considering these criteria the group determined that contaminated soil, organics, phosphogypsum, produced sand, fly ash (coal, wood) and cement kiln dust were the priority waste types. This list represented the best potential resource waste streams given consideration of the preliminary research conducted and the expertise of the collective workshop attendees. Since there were six chosen wastes a more comprehensive evaluation was needed to trim the list to the three required for the project scope.

4.4 Critical Evaluation of Top Identified Waste Types

To trim the waste type listing from six to three waste types a criteria matrix was developed. The criteria matrix summarized the criteria identified in the workshop and gave a weighting to each of the criteria. A weighting of 0-5 was given for each criteria for evaluation with five considered optimal. For example, the existence of technologies to utilize the waste type being evaluated was given a weighting of five while the ability to minimize time for the implementation of a resource management scenario was given a two. While timing is a consideration in the development of a resource management approach, it is not as critical as technology existence. Therefore, the existence of technology was given a greater weighting than timing of implementation. It should also be recognized that timing is a predicted criteria while technology existence is clearly defined.

A second part of the evaluation was to rate each of the top six waste types against the weighted criteria. The scoring again was on a scale of 0-5 with five being optimal. For some of the waste types specific answers could be provided to help gauge the rating. For example, the determination of the volume of waste generated can be determined. Other ratings, like for the opportunity of industry synergies, were based on the project teams current market understanding. It is possible that previously unidentified industry partnerships for secondary resource utilization have potential, but that no group has thought to approach the industries in question about the opportunity.

Both the criteria weightings and the ratings of the waste types against the criteria was determined with the combined experience of the project team. The weightings multiplied by the rating when summed provided a score for each waste type. For an ideal waste the optimal score was calculated to be 200 with the given weightings. Appendix C provides the results for the top six wastes when evaluated against the system described.

The matrix determined that the top wastes for review, in order of priority, were:

1. cement kiln dust;
2. fly ash;
3. phosphogypsum;
4. organics;
5. produced sand; and
6. contaminated soils.

It was interesting to note that the top three wastes were closely grouped together in scoring suggesting that they all are equivalent candidate wastes for resource management. Key areas that either made a waste type more or less appealing were the complexity of the waste (for contaminated soils and organics many different types and levels of constituents were possible), the geographic considerations (the top three waste types have a limited list of generators that are close to economic centres) and the economic value of the end product (contaminated soil once remediated has little economic value).

5.0 ESTABLISHED PROGRAMS FOR SECONDARY RESOURCE MANAGEMENT

There are several secondary resource management programs established in Canada, the US, and internationally, that could be adapted, expanded, adopted, sponsored or supported by the Alberta government to encourage the beneficial use of industrial wastes.

The top three waste types identified (phosphogypsum (PG), fly ash and cement kiln dust (CKD) all have model programs where the use of these materials are promoted as a secondary resource. The bulk of these programs are international which again strongly points to the ease at which Canadian industry has fallen back on it's wealth of natural resources.

In addition to programs that have a specific waste type as the focus there are also general programs that promote the beneficial use of waste. Some programs encourage industry to look for secondary resource opportunities on their own. Industry will attempt a secondary resource management strategy only if it is sustainable and economic. This means the strategy would be appealing to both consumers and industry creating the synergistic structure that will ensure a long term solution. A discussion of example programs is provided in the following sections, while Table 5 lists the programs discussed and their relevancy to this project. Recommendations to Alberta Environment resulting from this review are included in Section 10.0.

Table 5: Established Secondary Resource Programs

Program Name	Specifically Targets Top 3 Waste Type(s)	Overarching Program
Canada Green Building Council – LEED Program		✓
World Business Council for Sustainable Development		✓
National Industrial Symbiosis Programme		✓
Stack Free	✓	
Recycled Materials Resource Centre	✓	✓
Industrial Ecology and Eco-Industrial Parks		✓
US EPA – Coal Combustion Products Partnership	✓	
US EPA – Resource Conservation Challenge	✓	✓
Florida Institute of Phosphate Research	✓	
Association of Canadian Industries Recycling Coal Ash	✓	
European Coal Combustion Products Association	✓	
Clean Calgary and Calgary Materials Exchange Program		✓
Alberta Pacific Forest Industries Inc.	✓	
Weyerhaeuser Canada – Edson Mill	✓	
Ainsworth Lumber Company	✓	
US EPA – Reuse Legislation		✓
Various State-Run Beneficial Use Programs	✓	✓

5.1 Canada Green Building Council – LEED Program

The Canada Green Building Council (CaGBC) exists to accelerate the design and construction of Green Buildings across Canada. The Council is a broad-based inclusive coalition of representatives from different segments of the design and building industry. Their vision is "a transformed built environment, leading to a sustainable future." CaGBC coordinates the Leadership in Energy and Environmental Design (LEED) program in Canada. LEED Certification distinguishes building projects that have demonstrated a commitment to sustainability by meeting higher performance standards in environmental responsibility and energy efficiency. It requires a project to submit detailed documentation of performance standards which are technically reviewed before certification (CaGBC, 2006).

The LEED Canada-NC 1.0 Rating System recognizes leading edge buildings that incorporate design, construction and operational practices that combine healthy, high-quality and high-performance advantages with reduced environmental impacts. They provide a voluntary, consensus-based, market-responsive set of criteria that evaluate project performance from a whole-building, whole-life perspective, providing a common understanding of what constitutes a green building in the Canadian context. This is done by awarding points earned by meeting specific performance criteria, defined in Prerequisites and Credits, that outperform typical standard practice. Improved building performance is certified with ratings—Certified, Silver, Gold or Platinum—based on the total number of points earned by a project. Building occupants, purchasers and lessors are assured of superior building performance by an independent review and audit of the projects' construction documents by experienced design professionals that follow a well-defined and transparent methodology (CaGBC, 2006).

Use of recycled materials or secondary resources such as CKD and fly ash in the building construction add 'points' to the building's design, which in turn help the building reach the LEED rating level specified for the project.

Evidence of the positive impact of this program can be seen in the experience of the Semiahmoo Library & Community Policing Station in Surrey, British Columbia which has achieved LEED v2 Silver status on January 22, 2004. The library is owned by the City of Surrey, and serves the 60,000 residents in the district of South Surrey. The building was designed to combine cost effectiveness, green building design, and functional efficiency for two distinctly different purposes: a community library and the District 5 Station for the Royal Canadian Mounted Police. The Semiahmoo Library & Community Policing Station uses drought tolerant plants in the landscape to minimize the need for irrigation, and within the building, waterless urinals, low flow water closets, and low flow lavatories reduce water use by 41%. Following the LEED protocols the project diverted 88% of materials from the landfill by implementing a construction waste management plan, and to support the regional economy, the project used 62% locally manufactured materials, demonstrating exemplary performance (CaGBC, 2006a).

5.2 The World Business Council for Sustainable Development (WBCSD)

The World Business Council for Sustainable Development (WBCSD) is a coalition of 180 international companies united by a shared commitment to sustainable development via the three pillars of economic growth, ecological balance and social progress. Members are drawn from more than 35 countries and 20 major industrial sectors. WBCSD also benefit from a global network of 50 national and regional business councils and partner organizations involving some 1,000 business leaders globally (WBCSD, 2006).

The WBCSD's activities reflect the belief that the pursuit of sustainable development is good for business and business is good for sustainable development. Their mission is to provide business leadership as a catalyst for change toward sustainable development, and to promote the role of eco-efficiency, innovation and corporate social responsibility. As such, the WBCSD has outlined the following objectives and strategic directions:

- *Business Leadership* – To be the leading business advocate on issues connected with sustainable development;
- *Policy Development* – To participate in policy development in order to create a framework that allows business to contribute effectively to sustainable development;
- *Best Practice* – To demonstrate business progress in environmental and resource management and corporate social responsibility and to share leading-edge practices among our members; and
- *Global Outreach* – To contribute to a sustainable future for developing nations and nations in transition (WBCSD, 2006).

Eco-efficiency is a management strategy that links financial and environmental performance to create more value with less ecological impact. The WBCSD have been pushing for eco-efficiency since 1991 (WBCSD, 2006).

Business is achieving eco-efficiency gains through:

- *Optimized Processes* – Moving from costly end-of-pipe solutions to approaches that prevent pollution in the first place;
- *Waste Recycling* – Using the by-products and wastes of one industry as raw materials and resources for another, thus creating zero waste;
- *Eco-Innovation* – Manufacturing "smarter" by using new knowledge to make old products more resource-efficient to produce and use;
- *New Services* – For instance, leasing products rather than selling them, which changes companies' perceptions, spurring a shift to product durability and recycling; and
- *Networks and Virtual Organizations* – Shared resources increase the effective use of physical assets (WBCSD, 2006).

The WBCSD has worked in recent years to make eco-efficiency more user-friendly for business by developing a framework that provides a common set of definitions, principles, and indicators. It is flexible enough to be widely used and interpreted to fit the needs of individual companies across the business spectrum. They have also gathered case studies on eco-efficiency from all over the world and published them in print and on the web (WBCSD, 2006).

An example of WBCSD policies in action can be found with the L'Oréal factory in Pontyclun, South Wales, UK. At the site, continued efforts are made to reduce waste and conserve energy. The factory now recycles and/or reuses over 75% of all waste generated at the plant. This dramatic improvement in recent years has come about as a result of a group desire to minimize the use of landfill for waste disposal. Plastic, polythene, wood, steel and cardboard are now being re-used and/or recycled, with a large proportion being re-used by site suppliers. This project is in line with L'Oréal's environmental objectives and targets to minimize waste, which reduces their impact on the local community's resources (WBCSD, 2006a).

5.3 National Industrial Symbiosis Programme

NISP is the first industrial symbiosis initiative in the world to be launched on a national scale in the UK and is a business led initiative. It facilitates links between industries from different sectors to create sustainable commercial opportunities and improve resource efficiency (NISP, 2006).

Since April 2005 the program has helped to divert more than 183,636 tonnes of waste from landfill sites and created 98 new jobs. Nationally they have seen a reduction of 273,350 tonnes of CO_2 with an estimated £28,307,311 in cost savings to Industry. More than 222 jobs have been safeguarded across the UK as a direct result of the program and it has also seen £7,246,000 of private capital investment in reprocessing/ recycling with £13,300,125 made in additional sales. This is on top of the achievements made in the last 18 months. NISP is, and aims to remain at, the forefront of industrial symbiosis thinking and practice globally (NISP, 2006).

The first program of its kind to be launched on a national scale in the UK, NISP encourages companies to look outside their own physical and sector boundaries, which are inherently limiting, for additional resource efficiencies and sustainable market opportunities. This business led approach delivers "win - win - win" of economic, environmental and societal benefit. Examples of their efforts that could be relevant to Alberta include:

- animal by-products to fuel cement kilns;
- pallet reuse;
- white goods recycling;
- "Terranova Eco-Bricks", harnessing the elements;
- recovery of silver from waste slim-line batteries;
- reuse of waste from the automotive manufacturing industry;
- production of tailor-made alternative raw materials for cement works;

- utilizing gypsum as a co-product;
- bakery waste to pet food;
- recycling inert waste to produce aggregates and soil;
- exchange of unused chemicals;
- "Bone to Brick", a novel recycling solution for incinerated bone ash;
- auto shredder residue mined for metal reclamation; and
- reuse of catalysts and slag containing vanadium (NISP, 2006).

5.4 Stack Free

“Stack Free” is an international research program that was initiated in May of 2005 with the intention of running until April of 2011. The focus of the program is to be “Stack Free in 53”. This program addresses the concern associated with the global accumulation of phosphogypsum (PG) in storage formations called stacks. The project aims to involve stakeholders worldwide in reviewing the risks and benefits of using PG as a resource instead of storing it in stacks. PG is a by-product of phosphoric acid production in the fertilizer industry. There is currently minimal use of PG in secondary applications. The key concern preventing the use of this material as a resource is the presence of naturally occurring radioactive materials (NORM) along with some metals and fluorides. This program will explore the legitimacy of these concerns and, if justified, mitigation measures. The unique aspect of this program is that it takes a positive attitude toward the problem and assumes a solution can be found and executed in less than 50 years (Stack Free, 2006).

The immediate benefit of this program, while still in its infancy, is the coming together of all stakeholders internationally. Additionally, the program will provide a summary of current problems and the current best management practices in “White Papers” which will be posted on-line for comment.

Given that the program was initiated last spring and is expected to run for another five years no conclusive findings have been published, but this program requires watching given its scope, networking potential and goals. Stack Free is also one of the few programs reviewed that has funding available for studies relating to beneficial use. In this case specifically for PG, the province of Alberta would benefit form utilizing this resource. Research for the project is headed by the Aleff Group based in the United Kingdom and Florida. Numerous regulatory authorities and other stakeholders are being consulted about the project (Stack Free, 2006).

5.5 Recycled Materials Resource Centre (RMRC)

The Recycled Materials Resource Centre (RMRC) is a partnership between the US Federal Highway Administration (FHWA) and the University of New Hampshire. It provides a research and outreach facility for the highway community and acts as a catalyst for the beneficial use of recycled materials. The RMRC has four basic missions:

- to systematically test, evaluate, develop appropriate guidelines for and demonstrate environmentally acceptable increased use of recycled materials in transportation infrastructure construction and maintenance;
- to make information available to State transportation departments, the Federal Highway Administration, the construction industry, and other interested parties;
- to encourage the increased use of recycled materials by using sound science to analyze potential long-term considerations that affect the physical and environmental performance; and
- to work cooperatively with Federal and State officials to reduce the institutional barriers that limit widespread use recycled materials and to ensure that such increased use is consistent with the sustained environmental and physical integrity. The Center has a special interest in the long-term physical and environmental consequences of recycled material use (RMRC, 2006).

On behalf of the FHWA, the RMRC developed a user guideline manual which presents the results of research on the use of waste and by-product materials in pavement construction. This manual would be of interest to highway engineers and materials engineers, as well as waste and by-product producers and others involved in decision-making regarding the use of waste and by-product materials in pavements. It compiles available information on 19 waste and by-product materials (including kiln dust, phosphogypsum and coal fly ash) and guidelines for their use (where appropriate) in six pavement construction applications. General information on evaluating the suitability of a waste or by-product material for use in pavement construction, including engineering evaluation and environmental issues are available from RMRC.

A recent project of the RMRC, “Overcoming the Barriers to Asphalt Shingle Recycling” involved the cooperation of the federal US Department of Transportation, the Minnesota Department of Transportation, and a private consultant. This project addressed the technical, economic and regulatory issues that discourage the recycling of asphalt shingles. These are all aspects that can provide barriers to secondary use of any material. As a consequence of the project a draft specification for shingle use in road construction is currently being reviewed in Minnesota (RMRC, 2006b).

5.6 Industrial Ecology and Eco-Industrial Parks

Industrial ecology provides a method to examine the impact of industry and technology and associated changes in society and the economy on the biophysical environment. It examines local, regional and global uses and flows of materials and energy in products, processes, industrial sectors and economies and focuses on the potential role of industry in reducing environmental burdens throughout the product life cycle (IS4IE, 2006).

Industrial ecology asks us to “understand how the industrial system works, how it is regulated, and its interaction with the biosphere; then, on the basis of what we know about ecosystems, to determine how it could be restructured to make it compatible with the way natural ecosystems function” (IS4IE, 2006).

The field encompasses a variety of related areas of research and practice, including:

- material and energy flow studies ("industrial metabolism");
- dematerialization and decarbonization;
- technological change and the environment;
- life-cycle planning, design and assessment;
- design for the environment ("eco-design");
- extended producer responsibility ("product stewardship");
- eco-industrial parks ("industrial symbiosis");
- product-oriented environmental policy; and
- eco-efficiency (IS4IE, 2006).

As mentioned above, eco-industrial parks (EIPs) are one element of industrial ecology. Hinton’s EIP is one of the more prominent and recent examples in Alberta.

An eco-industrial park or estate is a community of manufacturing and service businesses located together on a common property. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. By working together, the community of businesses seeks a collective benefit that is greater than the sum of individual benefits each company would realize by only optimizing its individual performance (Indigo Development, 2006).

The goal of an EIP is to improve the economic performance of the participating companies while minimizing their environmental impacts. Components of this approach include green design of park infrastructure and plants (new or retrofitted); cleaner production, pollution prevention; energy efficiency; and inter-company partnering. An EIP also seeks benefits for neighboring communities to assure that the net impact of its development is positive (Indigo Development, 2006).

One of the flagship EIPs in operation is located in Kalunborg, Denmark. Incidentally fly ash is one of the waste streams used as a secondary resource in Kalunborg. The site includes a refinery, a power station, some greenhouses, a gyproc plant and a fish farming operation. Products that are exchanged between the plants or are produced as products include, water, steam, sludge, fly ash and heat. Each operation benefits from the other and they are all interdependent (DIEP, 2006).

5.7 US EPA – Coal Combustion Products Partnership (C2P2)

The Coal Combustion Products Partnership (C2P2) program is a cooperative effort between the U.S. Environmental Protection Agency, American Coal Ash Association, Utility Solid Waste Activities Group, U.S. Department of Energy, and U.S. Federal Highway Administration to help promote the beneficial use of Coal Combustion Products (CCPs) and the environmental benefits that result from their use. The C2P2 program will help meet the national waste reduction goals of the Resource Conservation Challenge; an EPA effort to find flexible, yet more protective ways to conserve valuable natural resources through waste reduction, energy recovery, and recycling (C2P2, 2006).

Through the C2P2 program, EPA and its co-sponsors work with all levels of government, as well as industry organizations, to reduce or eliminate legal, institutional, economic, market, informational, and other barriers to the beneficial use of CCPs. Specifically, C2P2 aims for the following goals:

- reduce adverse effects on air and land by increasing the use of coal combustion products to 50% in 2011 from 32% in 2001; and
- increase the use of CCPs as a supplementary cementitious material (SCM) in concrete by 50%, from 12.4 million tons in 2001 to 18.6 million tons in 2011, thereby decreasing greenhouse gas emissions from avoided cement manufacturing by approximately 5 million tons (C2P2, 2006).

The C2P2 program aims to accomplish these goals through the following initiatives:

- *C2P2 Partners* – C2P2 works with organizations to increase the beneficial use of CCPs;
- *Barrier Breaking Activities* – C2P2 undertakes activities such as developing booklets for distribution, publishing case studies, and writing new policies to increase the beneficial use of CCPs; and
- *Utilization Workshops* – EPA and its co-sponsors offer workshops on the beneficial use of CCPs (C2P2, 2006).

C2P2 has recognized the “Chicago 100-Year Road Structure” as an illustration of a coal combustion product application that the Agency believes can be beneficial to the environment. Wacker Drive, is a major two-level viaduct in downtown Chicago, Illinois. The old traditional concrete structure had experienced significant corrosion due to the use of road salts and was not accepted as a suitable design for replacement due to inferior performance in the given conditions. The new viaduct was eventually rebuilt utilizing Class F Fly Ash. This addition has helped to prevent roadway corrosion and deterioration and enhance impermeability. Testing has indicated that this new system will last for 75 to 100 years (FACDC, 2006).

5.8 Resource Conservation Challenge (US EPA)

The Resource Conservation Challenge (RCC) is a national effort to conserve natural resources and energy by managing materials more efficiently. The goals of the RCC are to:

- prevent pollution and promote reuse and recycling;
- reduce priority and toxic chemicals in products and waste; and
- conserve energy and materials (RCC, 2006).

Efficient materials management is one RCC priority. It seeks to have the entities that produce the waste manage it in such a way as to:

- reduce the waste at its source;
- promote recycling of the waste; and
- encourage its beneficial reuse in an environmentally sound manner (RCC, 2006).

Industrial non-hazardous wastes that can be recycled and reused are key to a successful resource conservation program. The RCC is focusing on three industrial non-hazardous wastes:

- *Coal Combustion Products* – Partnership program (C2P2) developed to increase the safe use of coal ash combustion products as a building and manufacturing material.
- *Construction and Demolition Debris* – Waste generated every time a building, road, or bridge is constructed, remodeled, or demolished.
- *Foundry Sand* – Non-hazardous “green sands,” which use clay as binder material and are the molding media most commonly used by foundries (RCC, 2006).

RCC has developed an Action Plan and a Strategic Plan to direct RCC’s efforts in reaching their goals.

5.9 Florida Institute of Phosphate Research

The Florida Institute of Phosphate Research (FIPR) is dedicated to the research and understanding of phosphate issues in the state of Florida. It is funded by the phosphate severance tax and is associated with the University of Florida. Scientists from throughout the world can apply for grants from FIPR to conduct research on phosphate related issues. This of course includes finding a safe and economic use for phosphogypsum. FIPR also serves as a collection centre for phosphate related information in it’s extensive library. The library will provide, free of charge, copies of any research conducted for the institute.

While FIPR is intended to deal with the phosphate concerns within the state the research conducted could have international applications. The state of Florida currently has well over a billion tonnes of PG sitting in stacks with on going production at approximately 30 million tonnes annually. This accumulation dwarfs the PG production and storage in Alberta and helps to put into perspective the level of interest FIPR has in dealing with the problems that can arise from the use of phosphate rock. Any research or pilot projects initiated for the alternative use of

PG should look to FIPR both as a information resource and potential source of funding (FIPR, 2006).

5.10 Association of Canadian Industries Recycling Coal Ash (CIRCA)

CIRCA represents Canadian producers and marketers of coal combustion products (CCPs/ashes) to increase their use as mineral resources instead of wastes. CIRCA brings together generators of CCPs through their association and provide technical support for beneficial fly ash use. This association was initiated in 2001 and promotes the environmentally sound reuse of ashes as well as the reduction of Green House Gas emissions (CIRCA, 2006).

As part of the technical support that CIRCA offers there are, fact sheets, videos, web courses and instructional seminars. Seminars are usually held on an annual basis with the proceedings available to association members. Membership is open to utilities using coal fired generation, marketers of CCPs, government and other agencies (universities/other stakeholders). Ashcor Technologies, Lehigh Inland Cement Ltd., TransAlta Utilities Corporation and Lafarge Canada Inc., all of Alberta, are currently members of the association. In order to take full benefit of services provided by CIRCA all stakeholders should maintain active memberships.

CIRCA has several affiliations with groups in Canada, the United States, the United Kingdom, Europe and Australia. This allows the group to benefit from international research and experience (CIRCA, 2006).

CIRCA members and their representatives work with standard development bodies and brief CIRCA members on developments. In 2001, CIRCA's lobbying efforts were influential in amending Public Works & Government Services Canada's (PWGSC’s) National Master Specification (NMS) to include fly ash in concrete.

CIRCA continues this work to encourage the establishment of a *minimum replacement level* in the NMS and to provide input on PWGSC's proposed "Guideline on the Use of Fly Ash or Slag in Concrete" (CIRCA, 2006a).

5.11 European Coal Combustion Products Association (ECOBA)

The European Coal Combustion Products Association (ECOBA) was founded in 1990 to deal with matters related to the usage of construction raw materials from coal, and consists of 21 members from 13 countries across Europe. ECOBA members represent over 86% of the CCP production in the EU’s 25 countries. ECOBA has associations with other international institutions providing a vast network of contacts and experience. ECOBA has been particularly active in the development of European standards and is represented on a number of committees (ECOBA, 2006).

ECOBA members consider coal combustion products (CCPs), that are combustion residues coal ashes and desulphurization products generated in coal-fired power plants, to be valuable raw and construction materials which can be utilized in various environmentally compatible ways. It is the task of ECOBA to propagate this message especially amongst legislative and standardizing institutions and to communicate the economic and ecological benefits of CCP utilization. The mission of ECOBA is to:

- encourage the development of the technology for the use of all CCPs, both on the industrial and the environmental level, with regard to relevant industrial and environmental demands;
- promote the mutual interests of its members, internationally and particularly within the framework of the European organizations, which are of scientific, technical, ecological and legal nature;
- establish and/or develop necessary legal/regulatory measures for recognition, acceptance and promotion of the use of all CCPs as valuable recoverable resources;
- participate in international activities, including co-operation within the framework of the European organizations, and
- ensure the exchange of information and documentation among the various national and international bodies (ECOBA, 2006).

In order to accomplish these aims, ECOBA maintains and develops close links with all parties interested in the earth's resources, from governments to end users and in construction (ECOBA, 2006).

5.12 Clean Calgary and Calgary Materials Exchange Program

Clean Calgary Association, with assistance from the City of Calgary Waste & Recycling Services, Alberta Environment, industry sponsorship from Allwaste Systems Ltd., Newalta Corporation, Beaver Grinding & Recycling, Calgary Metal, IG Paper, The Plastics Place and industry memberships, administers an innovative program of diverting industrial and commercial waste from Calgary landfills (Clean Calgary, 2006).

This program is designed to bring together industrial neighbours to explore disposal alternatives. The Calgary Materials Exchange aims to educate and provide opportunities for by-product exchanges between businesses in the area. The exchange offers participating businesses the potential benefits of reduced waste disposal costs, reduced raw materials costs, progress towards environmental certification, improved waste management tracking, enhanced community public relations, and reduced industrial "eco-footprint". Other results of the program include energy savings and greenhouse gas reductions (Clean Calgary, 2006).

Exchanges of wood pallets, cardboard, plastic, metal and wood cutoffs, concrete, textiles and glass have already been undertaken. Throughout Calgary, 139 companies are already involved and participate with the Calgary Materials Exchange. The website www.cmex.ca offers an on-line exchange marketplace to list material available or wanted for exchange (Clean Calgary, 2006).

5.13 Alberta Pacific Forest Industries Inc.

Alberta Pacific pulp mill is located in Boyle, Alberta approximately 2.5 hours north of Edmonton by car. This mill produces approximately 560,000 tonnes of pulp a year and is rated the largest of its kind in North America. While quality and quantity of production is important at this mill, the company's environmental policy states it will strive to apply ecologically sustainable forestry practices and it has a commitment to research new and progressive ways of conducting business. Part of Alberta Pacific's current research includes the use of wood ash as a liming agent and soil amendment to improve crop yield (AlPac, 2006).

Alberta Pacific produces a wood fly ash as a residue when burning hog fuel (wood remnants not suitable for pulp, like bark) for energy. They have researched the application of wood ash as both a lime replacement and nutrient supplement for various crops with results showing increased yields from 35 to 113%. The wood ash acts as a liming agent in the soil increasing the pH and making other soil nutrients more readily available for crop utilization. The wood ash also contains potassium, phosphorous and sulfur reducing the need for these nutrients through fertilization. Current tests indicate that 6-12 tonnes of wood ash per hectare of land are required for results to be evident. Tests to date have been in green houses, on mill land and some select farming operations. In addition to the positive yield results recorded there has been no evidence of detrimental impacts due to metal uptake of the crops (AlPac, 2006).

Alberta Pacific has worked with an independent consultant, researchers and the government to advance the use of wood ash as a secondary resource. Many people involved contributed to the development of the Alberta Environment's "Standards and Guidelines for the Use of Wood Ash as a Liming Material for Agricultural Soils". Alberta Pacific is actively looking to expand their wood ash recycling program.

5.14 Weyerhaeuser Canada – Edson Mill

Weyerhaeuser's Edson, Alberta, Structurwood mill generates wood waste by debarking and cutting logs. It maximizes this resource by burning it to create energy that, among other things, warms water and heats the plant. However, burning this fuel creates ash—roughly 2,000 tons per year—which until recently was sent to a landfill (Weyerhaeuser, 2006).

Because the ash is alkaline, it can help correct the pH balance in soil. Where soil is acidic, as in the Edson area, this alkalinity is a welcome soil amendment. Recognizing the potential value of the mill's ash, Weyerhaeuser's Environment, Health and Safety staff began work in 1999 with two Alberta Structurwood mills, the Alberta Forest Products Association, Alberta Environment, and Alberta Agriculture to develop the current provincial guideline for usage of ash in agriculture. Alongside this effort, multiyear scientific field studies performed by Weyerhaeuser and the mills in conjunction with Alberta Agriculture determined there is nothing dangerous in the ash (Weyerhaeuser, 2006).

Subsequent larger-scale trials and ongoing testing have allowed the Edson mill to move to a full-scale application program. The program has been so successful that as of 2004 Edson no longer sends any ash to the landfill.

The program is benefiting those involved financially as well—farmers are getting ash for much less than they'd pay for other soil amendments, such as lime, and Weyerhaeuser is saving on landfill costs. This program is an excellent example of how partnerships between government, industry and industry associations can create a "win-win" situation (Weyerhaeuser, 2006).

5.15 Ainsworth Lumber Company Limited

In 1996, Ainsworth Lumber Company Limited, an oriented strand board producer with a mill located near Grande Prairie, Alberta, began investigating whether the by-products of its operations—sawdust, wood strands, bark and wood ash—could be reduced, reused or recycled. Together with the companies Canadian Forest Products (Canfor) and Manning Diversified Forest Products, Ainsworth approached Fairview College about testing agricultural applications for these by-products. Because the wood residues contain valuable nutrients like potassium and phosphorous, and help retain soil moisture, the idea seemed worth pursuing (NRCAN, 2006).

After experimenting with different by-products and mixtures, researchers found that applications of wood ash immediately increased crop yield on test plots. And because wood ash's high pH helps neutralize the acidic soils of northern Alberta, applying it would save farmers the time and cost of liming their soil for the same result (NRCAN, 2006).

For companies that produce wood ash, diverting the by-product for agricultural use has the environmental benefit of minimizing landfill, the economic benefit of saving the associated costs, and the overall advantage of making fuller, more responsible use of the forest resource. Now Ainsworth and other forest companies are deciding how to distribute and possibly market the product (NRCAN).

5.16 Netherlands, Ministry of Housing Spatial Planning and the Environment

The government of the Netherlands takes an integrated approach to environmental management. The Environmental Management Act, which includes a chapter devoted to waste management, provides the framework for this. The Environmental Management Act is primarily a framework legislation that supports orders in council, provincial environmental ordinances and municipal waste ordinances.

Waste management legislation and decisions are based on the "Lansink's Ladder" of:

- prevention;
- design for prevention and design for beneficial use;
- product recycling (reuse);
- material recycling;
- recovery for use as a fuel;

- disposal by incineration; and
- disposal to landfill.

The top of the ladder, prevention, is considered the ideal with the balance of the waste management options following in order of preference. The ladder was named after the MP who proposed it.

Some of the activities that have been undertaken to support this hierarchy includes:

- developing a tax on waste going to landfill;
- acceptance only of wastes not suitable for other uses in the hierarchy at landfill;
- stricter environmental controls on existing landfills; and
- introducing producer responsibility for the management of waste products.

This approach has been aggressive but produced some astounding results. In 1976 prior to some of these initiatives there were approximately 1000 landfills and other waste dumps in the Netherlands. In 1999 there were 23 sites undergoing closure, 38 operational sites and three in the process of being closed. In addition, the volume of waste going to landfills between 1990 to 1999 has been reduced by more than one half (Netherlands, 2006).

5.17 US Environmental Protection Agency Reuse Legislation

In the US the reuse of PG is allowed under regulation provided it meets specific criteria. Part 61, of the National Emission Standards for Hazardous Air Pollutants Subpart R, regarding the National Emission Standards for Radon Emissions from Phosphogypsum Stacks describes the criteria necessary for reuse. A copy of the Subpart R Rule is included in Appendix D.

The uses directly authorized under this legislation are agricultural or for research and development. Other potential uses require approval by the EPA prior to removal from the stack. A formal request for use other than those identified in Subpart R must be received by the EPA in written form. The request is to be accompanied by a description of the use and a characterization of the PG to be used. For reuse in agriculture the average radium-226 concentration from the stack which the PG is to be removed cannot exceed 10 picocuries per gram (pCi/g)[2] which is equivalent to 370 becquerels per kilogram (Bq/kg).[3] Certification of the radium level is required. The method of radium-226 determination is also prescribed in Subpart R (US EAP, 2006).

While Subpart R provides a framework which identifies acceptable use for PG the criteria it sets is not usually attainable for PG. The only equivalent legislation in Canada is the *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials* (Health Canada, 2000). While this guideline does not specifically identify and regulate secondary usage of

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[2] A unit of radioactivity equivalent to 3.7 x 10^{10} disintegrations per second. Replaced in international usage by the Becquerel.

[3] An SI unit of radioactivity equivalent to one nuclear transformation per second.

PG Table 5-1 of the guidelines lists the unconditional derived release limits for NORM materials, which includes PG. Solid Radium-266, in equilibrium with its progeny, has a limit of 300 Bq/kg listed. This is slightly less than the US limit.

5.18 Various State-Run Beneficial Use Programs

Various states across the United States have developed beneficial use programs for industrial wastes or by-products. While they are different from each other, there is a common structure and operation of the programs. The states that were reviewed for this project include:

- Wisconsin;
- Minnesota;
- Connecticut;
- New Jersey;
- Maine; and
- New York State.

Generally, each state has a list of pre-approved waste types that can be beneficially utilized, and also has a process that can allow industrial companies to apply to approve other waste streams. This process involves a thorough characterization of the waste stream, a detailed proposal about the use of the waste, and it may also involve a human health risk assessment. Whether the company is using a pre-approved or a specially-approved waste stream, they are obligated to do so within the terms and conditions outlined by the State government, but are exempt from the legislation that would apply if the material was treated as a waste sent to disposal. Examples of some successes with these programs include the following.

- *Wisconsin* – Fly ash is identified as a “special waste” that is given approval for use in public works projects. In the year 2000, 72% (WDNR, 2006) of the coal fly ash generated in the state was beneficially used under this program. This compares to a national beneficial use of coal fly ash of only 33%. The positive impact of this program is strongly highlighted with the difference in these percentages.
- *New Jersey* – Department is very interested in supporting and encouraging the beneficial use of materials that would otherwise be waste, in environmentally sound applications. This preserves valuable landfill space for essential disposal uses and helps conserve natural resources by using valuable existing materials. To date, the Department has issued over 290 authorizations for beneficial use of different materials for more than approximately 3.9 million cubic yards of these materials (NJDEP, 2006).
- *New York* – Examples of the industry promoted secondary uses in New York that have taken advantage of their beneficial use legislation include:
    - ❑ dried paper mill sludge as animal bedding;
    - ❑ foundry sand as an aggregate in the production of concrete;
    - ❑ gypsum in the manufacture of wallboard or as a soil amendment; and
    - ❑ tire chips in civil engineering applications such as backfill material (NYSDEC, 2006).

Additionally, some of the states have an advisory group that provides expertise and guidance to industry and the state. For example, the Maine Beneficial Use Advisory Group includes government, academia, industry and other stakeholders. The purpose of the group is to increase the beneficial use of secondary materials in the state, and they receive funding from state agencies and industry to achieve their objectives. The focus of the group is to remove the barriers that exist to beneficial use by utilizing the following tools:

- promotion and outreach;
- regulatory review;
- development of management rules;
- legislative efforts to reduce barriers; and
- research projects by the University of Main Civil Engineering Department.

Incidentally, both Cement Kiln Dust and Fly Ash have been reviewed by the group and have collected and published (on their website) information on:

- CKD sources;
- engineering properties of CKD;
- environmental properties of CKD;
- beneficial uses;
- case studies; and
- local regulatory requirements.

This program provides stakeholders with a central location for information on beneficial use of solid waste as well as an entity that champions beneficial use through the ongoing research and removal of existing barriers (BUSWM, 2006).

6.0 PRODUCTION AND CHARACTERISTICS OF THE TOP THREE SECONDARY RESOURCE TYPES

The following sections detail where and at what rate each of the secondary resource types under consideration are generated as well as the method of generation, and chemical/physical characteristics.

The quantity of secondary resource generated will help determine which secondary use option is most feasible. The proximity of the secondary resource to a potential user will aid in choosing the mode of transport between generator and users and provide information to calculate the costs of transport. The distance between the generator and the user is often a barrier to secondary use.

Knowledge of how a material is generated will help in the understanding of its chemical and physical characteristics. If its characteristics are undesirable it might be possible to alter the generation method to produce a more desirable product for input into another process. Alternately the secondary use process could be changed to handle the undesirable characteristics of the secondary resource. Liability issues regarding the characteristics of a secondary resource may also provide a barrier to secondary use.

6.1 Phosphogypsum

Phosphogypsum (PG) is a by-product of phosphate fertilizer production. Canada currently provides 12% of the world's fertilizer (including non-phosphate fertilizers) contributing approximately 6 billion annually to the Canadian economy (CFI, 2006). The application of fertilizer to the soils that produce crops allow the land to become more efficient which in turn minimizes the land base required to provide a given crop.

PG is currently considered a non-hazardous waste in Alberta.

6.1.1 Production Method and Characteristics

Naturally occurring rock containing phosphorous is the main source of the phosphorous contained in fertilizers. The type of phosphorous in rock is not chemically available to plants in this form. The rock is generally reacted with acid to produce phosphoric acid which can then be used to produce various types of fertilizers. The phosphorous contained in these fertilizers is now chemically available to crops. This reaction also produces PG (chemical formula, $CaSO_4 \bullet 2H_2O$). This reaction results in the production of approximately 4 to 5 tonnes of PG for every tonne of P_2O_5 produced (Ferguson, 1988; Mays and Mortredt, 1986). The produced PG is then deposited to the land in formations called "stacks" which provide long term storage. These stacks cover large tracks of land (up to 740 acres area and 60 metres high) and result in long term management by the producers while making the land unavailable for alternate use.

This ratio of product to waste production has resulted in the accumulation of over 100×10^6 tonnes (Alcordo and Rechcigl, 1993) of PG in Canada alone as of 1993.

The PG generated from the reaction of phosphate rock and acid may contain impurities from the rock. These impurities can include uranium, radium-226, fluoride, phosphorous, and various metals. Once dried out PG is usually a powdery, silt or silty-sand material, gray, green or tan in colour with acidic properties. The level and types of contaminants will vary depending on where the rock was mined.

Some of the impurities in the rock carry with it potential health and/or ecological concerns. The uranium and radium-226 are radio active. This radioactivity is termed "Naturally Occurring Radioactive Material" or NORM radiation since the radiation is from a natural source. Radon-222, a decay product of radium-226 is a gas and can become airborne when diffused into air further spreading the radioactive properties of the PG. While radiation is a carcinogen, it should be noted that NORM radiation is generally below or near background levels of radiation. Trace metal contamination and fluoride content of PG may also be a health concern depending on the PG source and secondary use.

Since the radiation associated with PG is termed NORM it is not regulated under the Canadian Nuclear Safety Commission (CNSC) except for the import, export and transport of the material. The *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)* (Health Canada, 2000) generated by a working group of experts sets out principles and procedures for the detection, classification, handling and material management of NORM in Canada with guidance for compliance with federal transportation regulations.

Appendix E, Material Safety Data Sheets contains an MSDS for the Kapuskasing PG currently being generated at Redwater, Alberta as well as the Florida PG that is in storage at Redwater and Fort Saskatchewan.

6.1.2 Production Rate and Locations

In Alberta two companies have produced PG, Agrium Inc. (Agrium) and Western Cooperative Fertilizers Ltd. (Westco). Of the two only Agrium is still producing PG. Table 6 details the locations, quantities and rock sources of the PG at these sites and well as some general site information.

This table demonstrates the scale of the PG storage problem. This problem is not unique and stacking with subsequent reclamation in place is the current industrial standard for PG.

6.2 Fly Ashes

There are two main sources of fly ash in Alberta, coal fly ash and wood fly ash. Coal fly ash, referred to simply as fly ash, is generated from the pulverization and combustion of coal for power production. Wood fly ash, or more commonly called wood ash, is produced from using wood waste for energy production mainly at pulp and paper mills.

Both types of ash are currently considered non-hazardous waste in Alberta.

Table 6: Phosphogypsum in Alberta

Stack Location	Stack Owner	Production (tonnes/year)	Stack Tonnage	Stack Area (Acres)	Phosphate Rock Source	Other Comments
Medicine Hat	Westco	0	Approx. 10 million tonnes	600 acres	Idaho, USA	• Stack currently being reclaimed • Site operational from 1955-1987 • Total site area is approximately 3,000 acres
Calgary	Westco	0	Approx. 10 million tonnes*	345 acres*	Idaho, USA and Florida, USA	• Site operational from 1966 to 1987 currently serves as a storage and distribution centre for fertilizer produced at other locations • No on site production of fertilizer • Two PG stacks • Total site area is approximately 500 acres
Redwater	Agrium	1.5×10^6 tonnes est.	Approx. 35 million tonnes	325 acres	Florida, USA, Western Africa, Kapuskasing, Ontario	• Believed to be the only operational site for wet process phosphoric acid production in Canada • Started to use Kapuskasing rock in late 1990's • A conceptual closure plan was submitted to AENV as requirement for the stack extension that was recently requested • The projected final area of the stack at closure is expected to be 700 acres and 38 metres high
Fort Saskatchewan	Agrium	0	Approx. 5 million tonnes	87 acres	Florida, USA, Western Africa	• Site is no longer operational, shutdown in the eighties • Stack is covered with soil and vegetated but not officially remediated according to AENV standards

* This represents a total for the two stacks present on the site.

6.2.1 Production Method and Characteristics

For either coal or wood fly ash the production method and facility, as well as the source material characteristics, play an important role in the characteristics of the ash generated. Due to the wide range of feeds and processes used, the resulting ash will vary greatly from each plant. What is consistent is that the ash produced is always a fine, alkaline material.

6.2.1.1 Coal Fly Ash

Alberta is Canada's biggest producer and consumer of coal. Given the abundance of the resource, associated low cost and high demand for power ensures coal will continued to be used. In fact, three key companies in Alberta have already announced plans for new coal fuelled plants. Foregoing dramatic advancements in engineering and technology, the process of coal combustion will inevitably produce by-products such as fly ash, bottom ash, boiler slag, and flue-gas-desulphurization (FGD) material, collectively known as coal combustion products (CCPs). Fly ash makes up approximately 58% of all CCPs (Kalyoncu, 2000) and 80% of total ash generated (Bremner, 2006). Canada produces upwards of 4.8 - 5.1 Mt of fly ash on a yearly basis of which about 2.2 Mt is useable without further processing or beneficiation (Bouzoubaâ, 2006; CIRCA, 2002). Alberta produces around 60% of Canada's fly ash, or 2.6 - 3 Mt per year (AMEC, 2002).

In Alberta coal is the number one source of power generation and is produced by seven facilities across the province. TransAlta Utilities operates Sundance, Wabamun and Keephills, and is a part owner of Sheerness. Taco Electric operates both the Battle River and Sheerness facilities, while Epcor operates Genesee. Maxim Power Corporation owns and operates H.R. Milner. Together the plants produce 5397 MW of power per year, with 2029 MW coming from the Sundance facility alone (NRC, 2004; Maxim, nd). All of these facilities generate CCPs, including fly ash which is captured via electrostatic precipitators or baghouses.

The characteristics of the fly ash captured will depend on the generation source, but in general will be fine spherical (mostly solid, but some hollow) siliceous or siliceous and aluminous, alkaline particles. Fly ash can be further classified according to CSA A3001 into Class F fly ash, Class CI and Class CH fly ash as depicted in Table 7. Alberta does not produce Class CH so the remaining discussion will be focused on Class F and CI. The main differences between the two are that Class F is generally a by-product of bituminous and anthracite coals and contains minimal amounts of lime. Class CI results from the pulverization and combustion of bituminous and lignite coals and is more alkaline than Class F. Both contain varying amounts of calcium oxide, silica and aluminum oxide. Boron, cadmium, cobalt, copper, fluorine, iron, potassium, magnesium, manganese, molybdenum, sodium, nickel, lead, and zinc can also be found in fly ash (EPRI, 2003).

Poor quality fly ash can not be classified as either Class F or Class C and is not suitable as a SCM or Portland Cement replacement. Typically, the failing parameter is an excessive loss on ignition value, which is caused by too high of a carbon content. Other chemical and physical parameters distinguishing poor versus good quality fly ash, such as the moisture content and fineness, are outlined in detail in the ASTM C618-01 and CSA A3000-03 standards.

Table 7: Fly Ash Analysis

Test Description	Units	Specifications				
		ASTM C618-01		CSA A3000-03		
		Class F	Class C	Class F	Class CI	Class CH
Chemical Analysis						
Silicon Dioxide (SiO_2)	%	–	–	–	–	–
Aluminum Oxide (Al_2O_3)	%	–	–	–	–	–
Iron Oxide (Fe_2O_3)	%	–	–	–	–	–
Total (SiO_2)+(Al_2O_3)+Fe_2O_3)	%	70 min.	50 min.	–	–	–
Sulphur Trioxide (SO_3)	%	5 max.	5 max.	5 max.	5 max.	5 max.
Calcium Oxide (CaO)	%	–	–	<8	8-20	>20
Moisture Content	%	3 max.	3 max.	3 max.	3 max.	3 max.
Loss on Ignition	%	6 max.	6 max.	8 max.	6 max.	6 max.
Physical Analysis						
Fineness Retained on 45 µm (No. 325 Sieve)	%	34 max.	34 max.	34 max.	34 max.	34 max.
Strength Activity Index With Cement Percent of Control at 7 Days	%	75 min.	75 min.	–	–	–
Percent of Control at 28 Days	%	75 min.	75 min.	75 min.	75 min.	75 min.
Water Requirement, % of Control	%	105 max.	105 max.	–	–	–
Soundness, Autoclave Expansion	%	0.8 max.	0.8 max.	0.8 max.	0.8 max.	0.8 max.
Density	g/cc	–	–	–	–	–
Increase of Drying Shrinkage @ 28 D	%	0.03 max.	0.03 max.	–	–	–
Quantity of Air Entraining Agent	%	–	–	–	–	–
Control of Alkali (Sil) Agg. Reactivity Mortar Expansion at 14 Days	%	100 max.	100 max.	0.10 max.	0.10 max.	0.10 max.
Sulphate Resistance @ 6 Months	%	Mod Ex. = 0.10 max High Exp. = 0.05 max.	Mod. Exp. = 0.10 max. High Exp. = 0.05 max.	MS = 0.10 max. HS = 0.05 max.	MS = 0.10 max. HS = 0.05 max.	MS = 0.10 max. HS = 0.05 max.
Uniformity Requirements:						
Density, Variation from Ave.	%	5 max.	5 max.	5 max.	5 max.	5 max.
Fineness, 45 µm Sieve, Variation from Ave.	%	5 max.	5 max.	5 max.	5 max.	5 max.
A.E.A., Variation from Ave.	%	±20	±20	±20	±20	±20
Multiple Factor	%	255 max.	–	–	–	–

6.2.1.2 Wood Ash

There are a number of facilities in Alberta with varying processes and products that utilize wood waste (a.k.a. hog fuel) to generate energy. There are over a dozen facilities contributing to the nearly 180,000 tonnes of wood ash generated a year in the province (Patterson, 2004), with the majority coming from Kraft pulp and paper mills, oriented strand board (OSB) mills and chemi-thermomechanical (CTMP) mills.

The characteristics of wood ash will vary depending on the source of generation. Typically, despite the source, the ash will be highly alkaline with pH levels as high as 13.0. Additionally, the wood ash will contain salts, nutrients and some heavy metals. Specific elements include: boron, potassium, arsenic, copper, nickel, cadmium, lead, selenium, cobalt, zinc, chromium, nitrogen and molybdenum. Additionally, wood ash might also contain calcium, magnesium, sulphur, manganese, barium, strontium, titanium and vanadium (Patterson, 2004; Wood Ash Industries, 2003).

6.2.2 Production Rate and Locations

The production rates of coal and wood ash are drastically different, wherein Alberta coal fly ash is generated at a rate of about five times that of wood ash.

6.2.2.1 Coal Fly Ash

In Alberta up to three million tonnes of fly ash is produced annually. Of that, close to 145,000 tonnes of the recycled fly ash is used mostly for concrete products, with some going to blended cement (Bouzoubaâ, 2006). Table 8 summarizes fly ash generation sources and current recycling rates in Alberta.

The locations of the above facilities are better demonstrated in Figure 1.

Figure 1: Location of Coal Fired Power Plants

(Natural Resource Canada, 2004)

Table 8: Coal Fired Power Plants in Alberta

Location	Owner	Plant	Total Capacity*	Comments
Wabamun Lake area (70 km west of Edmonton)	TransAlta Utilities	Sundance	2,029 MW	Good quality ash. Sold about 29% of fly ash generated. Some ash conditioned.
Wabamun Lake area	TransAlta Utilities	Keephills	754 MW	Less than 1% sold.
Wabamun Lake area	TransAlta Utilities	Wabamun	569 MW	Sold about 28% of the fly ash generated.
200 km northeast of Calgary	Atco Utilities	Battle River	735 MW	Sold about 16% for use in cement and oilfield applications.
160 km northeast of Calgary (near Hanna)	Atco Utilities/TransAlta Utilities	Sheerness	766 MW	Amount recycled or sold not available. Some is used in concrete materials.
South of Edmonton	Epcor	Genesee	400 MW	About 30% of the fly ash is used.
100 km south of Grande Prairie	Maxim Power Corporation	H.R. Milner	144 MW	Poor quality ash. None currently recycled.

6.2.2.2 Wood Ash

Table 9 lists the forestry facilities where the majority of wood ash is generated from energy production. In total, about 180,000 tonnes of wood ash is produced annually, upwards of 80% of which is currently being landfilled.

Table 9: Pulp and Paper Facilities in Alberta

Location	Owner	Facility Type	Other Comments
Grande Prairie	Ainsworth Lumber Co. Ltd.	OSB	
Boyle	Alberta Pacific	Kraft	Good quality.
Peace River	Daishowa-Marubeni International Ltd.	Kraft	
Whitecourt	Millar Western Pulp (Whitecourt)	CTMP	
Slave Lake	Slave Lake Pulp Corporation	CTMP	
High Prairie	Tolko Industries Ltd.	OSB	
Hinton	Weldwood of Canada Ltd.	Kraft	
Drayton Valley	Weyerhaeuser Canada Ltd.	OSB	Good quality. Some hog fuel sold to Valley Power.
Edson	Weyerhaeuser Canada Ltd.	OSB	Good quality ash. No longer sends any ash to landfill.
Slave Lake	Weyerhaeuser Canada Ltd.	OSB	
Grande Prairie	Weyerhaeuser Canada Ltd.	Kraft	Due to poor characteristics, all of this ash is landfilled.

Most of the facilities are located in central Alberta, but extend as far north as Peace River, west as far as Grande Prairie and east to Boyle. This dispersion of the facilities allows for easy access to neighboring agricultural land.

6.3 Cement Kiln Dust

Cement kiln dust (CKD) is generated in the manufacture of cement, a main component used in making concrete. Concrete is the most widely used building material in the world and can be found in many diverse applications including bridges, high-rises, driveways and patios. Cement production in Canada alone represents more than 4 billion dollars a year in sales with production at 16 locations across the country, two of which are in Alberta. In the year 2000, 12.6 million tonnes of cement were produced in Canada (Cement Association of Canada, 2006).

Under current Alberta legislation, CKD is not specifically exempted from receiving Hazardous Waste status when going for disposal. The specific characteristics of each CKD would have to be evaluated to make this determination. The characteristic of primary concern in this evaluation would be the high pH (see following section).

6.3.1 Production Method and Characteristics

The raw materials that go into the manufacture of cement include limestone and clay. These primary constituents are usually obtained in their natural state from quarries where they are mined. The raw materials are then crushed and combined in predetermined ratios. This mixture is heated in a rotary kiln where it is oxidized producing “clinker”. Clinker is then combined with gypsum and finely ground producing a basic cement. Special mix cements can have various additives to the basic cement.

Hot combustion gases within the kiln carry off fine particulate matter (raw materials, partially processed feed, and components of the final product) with the flow of the gases to the ambient air. It is important to control this source of particulate matter to ensure acceptable air quality. These particulates are collected in electrostatic precipitators, bag-houses or cyclones and are collectively referred to as cement kiln dust (CKD). The specific raw materials, fuels and manufacturing process for each cement producer determine the quality of CKD generated. (Hawkins et al. 2003)

CKD is generally a fine powdery material similar chemically and physically to Portland cement. The coarser forms of CKD contain free lime while the finer forms will have higher concentrations of sulfates and alkalis. The specific gravity of CKD ranges from 2.6 to 2.8 and the principal constituents of CKD are compounds of lime, silica, alumina, sulphur, potassium, iron, magnesium and sodium. Trace metals can also be found in CKD but the quantities are dependant upon the manufacturing facility. It is important to chemically and physically characterize any CKD proposed for alternate use since some of the trace metals present (e.g., cadmium, lead, selenium) can be toxic at low concentrations. CKD is caustic with a pH of around 12 in a water mixture, this is due to the alkalis content (RMRC, 2006a). An MSDS of CKD can be found in Appendix E, Material Safety Data Sheets.

6.3.2 Production Rate and Locations

The two cement plants located in Alberta are close to the two main population centres of the province, the cities of Calgary and Edmonton.

Lehigh Inland Cement Ltd., located near Edmonton's centre, recently installed a new bag-house collection system. While the focus of the new system was to improve emissions quality it has had the additional benefit of allowing the generated CKD to be re-introduced into the cement manufacturing process. All CKD is now utilized in the manufacture of cement. Prior to this process change CKD was: re-used within the process; sent for alternate use in for road building; and/or sent to landfill.

Lafarge North America's Exshaw operation currently returns a portion of the CKD generated back into the cement making process. Similarly to Lehigh, prior to the installation of the bag-house, it is marketed for secondary use in road building or sent to an on-site landfill.

As a member of the Portland Cement Association, Lafarge has voluntarily adopted the Cement Manufacturing Sustainability Program target of a 60 percent reduction (from 1990 baseline) in the amount of cement kiln dust disposed per tonne of clinker produced by 2020. Hence, CKD recycling has progressively increased at the site beginning in 2003 with a reuse rate of 3%, 19% in 2004 and 47% in 2005. Lafarge is actively pursuing alternate beneficial reuse markets and is aggressively pursuing a zero CKD waste initiative for 2010. Compliance and land management expenses of CKD combined with the economic market potential of beneficial reuse have also combined to promote this change.

The primary market segment for CKD reuse pursued by Lafarge is road base stabilization. However, the company is also pursuing other beneficial reuse market segments. They have repositioned CKD as a by-product and not a waste material and have focused on providing handling and distribution measures to treat it as such.

Table 10 outlines the generation of CKD in Alberta.

Table 10: Cement Kiln Dust Generation in Alberta

Location	Owner	Annual Cement Production	Annual CKD Production	Comments
Edmonton	Lehigh Inland Cement Ltd.	1 x 10^6 tonnes at capacity	0	• In May of 2004 the company invested in a new bag-house system that eliminated the generation of CKD by recycling it back into the process. • Prior to bag-house installation CKD generation was approx. 5,000 tonnes/year.
Exshaw (approx. 60 km west of Calgary)	Lafarge North America	1.3 x 10^6 tonnes	1.2 x 10^5 tonnes*	• Largest supplier of Cement in Canada and the US. • If recycling rate for CKD for 2005 is considered, this would mean approximately 60,000 tonnes of CKD were landfilled in 2005. • Currently has a on-site Class II landfill for CKD that does not yet have an alternative use.

* Note that CKD production is based on 9 tonnes of CKD per 100 tonnes of cement produced (BUSWM, 2006a).

7.0 POTENTIAL USES FOR TOP THREE SECONDARY RESOURCE TYPES

A key criteria for determining the suitability of an existing waste type for further evaluation was the existence of pre-existing technologies for secondary use. Each of the waste types selected have a range of secondary use options. An interesting point to note in the selection of PG, CKD and fly ashes is that they have potential for synergistic use. There are applications for each of them that could also utilize the other. PG and fly ash can be combined and utilized by the cement industry, CKD can be combined with fly ash to create a material with excellent fill properties.

7.1 Phosphogypsum

The chemical and physical characteristics of PG combine to offer many types of potential uses. Some uses that have been encountered during the research for this report include:

- soil conditioner;
- compost conditioner;
- flocculant in mining tailings;
- vitrification for glass and ceramic products;
- roadbeds;
- cement;
- general building materials;
- landfill cover;
- oyster cultch (when combined with fly ash and cement furnishes an underwater location for the attachment and development of oyster spawn);
- wall board;
- roller compacted concrete; and
- fluoridation agent for water.

Of the mentioned uses the ones that have the most support/potential are the use of PG as a soil and compost conditioner, as a building material (specifically road base), in cement, as alternative landfill cover and as a tailings flocculant. The other uses are more controversial, don't have significant research to support their implementation, would require significant start-up costs and/or would not be suitable for applications in Alberta. Each of the alternate uses suitable for Alberta should be investigated. The amount of PG both stockpiled and being generated in Alberta is so vast it is unlikely any one use will make an impact on the volumes available so it is important to pursue all viable options.

In the late 1990's Agrium partnered with Suncor to conduct trials using PG as a flocculant in oilsands mining tailings. PG, when combined with sand and fine tails had the ability to settle out fine tails that would not settle otherwise. Pilot work proved the effectiveness of the material but before a long term use agreement could be reached Suncor's operations began using limestone as a scrubbing agent for their air emission stacks. This process generated their own source of gypsum which was in turn used instead of PG from Agrium. For a short period of time Agrium also provided Syncrude with PG for the same purpose, but Suncor had an excess of gypsum and agreed to supply Syncrude. On an occasional basis, Syncrude has requested supplementary PG from Agrium. This potential use would have required the provision of approximately 80,000 tonnes/year for the Suncor site alone. While these potential consumers of PG are no longer available there could be potential in approaching other oil sands operations.

Agrium has also established the use of PG as a cement additive in oil well casings. While this use of PG does not significantly reduce PG accumulations its ongoing use in this application has the benefit of increasing the awareness, acceptability and potential of PG as a secondary resource. Some Lafarge operations in the US utilize PG for cement-making. This option could be explored at Lafarge's Exshaw plant and at Lehigh.

Marrying the use of PG to the Oil and Gas industry in Alberta would be beneficial since it represents a large and expanding industry in the province, In 2004/2005 revenues to the province from crude oil and natural gas accounted for 34% of Alberta's total revenues. Between the years of 2000 and 2004 oil sands development has grown dramatically, current production is approximately one million barrels a day with a projected increase to 2.6 million barrels a day by the year 2015 (CAPP, 2006).

Agrium has also utilized PG in soil and composting applications. Studies have been conducted that highlight the benefits of these applications. Benefits for composting include:

- a reduction of greenhouse gas emissions from composting of cow manure (Hao *et al.*, 2005); and
- the reduction of nitrogen losses in the composting of feedlot manure (Zvomuya *et al.*, 2005).

The benefits of soil conditioning include:

- an increase plant growth (Al-Oudat *et al.*, 1998); and
- the improvement of the chemical and physical characteristics of sodic (high sodium) soils (Liang *et al.*, 1995) and the remediation of brine spill sites (Liang *et al.*, 1992). Sodic soils are commonly found in southern Alberta (AAFC, 2006).

The papers referenced in the first two points identify the benefits found but also recommend further research to quantify the results and understand the mechanisms at work in producing the given results.

The papers referenced for soil conditioning both indicate an increase in plant growth and, in the case of brine contaminated soils, a reduction in the Sodium Adsorption Ratio (SAR). More study and site-specific evaluations would need to be conducted prior to implementing this reuse option. The addition of a NORM material to sites that may already have NORM contamination (as is often the case for O&G sites) could increase the radiation risk to unacceptable levels.

Alternate uses of PG in and for the Agriculture industry would have the potential to utilize significant quantities of PG. The province of Alberta has 5.93 million head of cattle (Statistics Canada, 2006) and approximately 15% of the province, or 97,300 square kilometers, in crops (Statistics Canada 2001).

A less established use of PG, but with excellent potential, is for daily landfill cover. Studies have indicated that PG would promote faster waste degradation (Shieh, 2004), which would extend landfill life. This year the Florida Institute of Phosphate Research will conduct a study using PG as daily cover on a county municipal landfill. This will provide the practical data required to evaluate this alternative. It is interesting to note that the Westco PG stacks are next door to one of Calgary's three city landfills. Discussions with municipal landfill operators in both Calgary and Edmonton indicated an openness to learning more about the potential of PG as daily cover.

PG has also shown excellent promise as a low-cost highly effective road building material. A road constructed in Florida showed more than a 75% cost savings over traditional road making methods (PG provided at no charge) while providing a road of similar or better quality to one constructed using standard building materials (Chang, 1989). The US based Turner-Fairbank Highway Research Centre evaluates the engineering potential for secondary materials to be utilized for road construction. In their evaluation of PG they indicate that studies show it to be suitable for stabilized and unbound base course installations and in roller compacted concrete mixes, but caution that all uses of PG are still restricted by current Environmental Protection Agency Legislation (TFNRC, 2006) if its radiation level exceeds 10 picocuries per gram. The FIPR has been working towards loosening this restriction which was based on a risk assessment of the following conservative scenario: the road being closed, a house being built on the road site and someone occupying the home 18 hours every day for 70 years.

In order to evaluate the potential reuse opportunities for a given stack the source of the rock used to generate the PG must be taken into consideration to determine the type and levels of impurities present. It is important to test the use of PG for specific uses. It is possible for H_2S gas to be formed if reducing (oxygen deficient) conditions occur.

7.2 Fly Ashes

There are a number of potential and current uses for coal and wood fly ash in Alberta. One example of how either coal or wood fly ash can be recycled is through construction of roadways. Other applications for recycling coal and wood ash are presented in the following sections, respectively.

7.2.1 Coal Fly Ash

Currently in Alberta the majority of fly ash from electricity generation is used for concrete and concrete products, such as ready mix concrete, support footings, precast structures, blocks and bricks, and pipes. Other uses in Canada include:

- portland cement replacement;
- oil and gas well casings;
- hydraulic mine backfill;

- liquid waste stabilization;
- flowable fill; and
- mineral filler.

Additionally, other countries have found uses for coal fly ash in:

- horticultural applications;
- lightweight aggregates;
- highway embankments;
- slabjacking material;
- liquid waste stabilization;
- fillers for composite materials; and
- fillers for paints and plastics.

The benefits of using fly ash for the aforementioned applications ranges from reducing greenhouse gas emissions to production of more technically superior products. Specifically for concrete the key benefits include:

- increased workability;
- enhanced long-term strength;
- permeability reduction;
- increased durability;
- reduced thermal stress and cracking;
- reduced weak zones from bleeding;
- improved resistance to sulphate and other chemicals;
- improved control over alkali-silica reactions;
- improved appearance;
- reduced construction costs; and
- environmentally sound.

Given these benefits and the fact that Canada only recycles about 15-20% (AMEC, 2002; CIRCA, 2002), and considering some European countries like Denmark and the Netherlands are recycling 100% of their coal fly ash (USDOT, 2000), there is obviously room for improvement.

7.2.2 Wood Ash

The following uses have been identified for wood fly ash:

- liming agent for agricultural soils;
- nutrient source for soils/compost amendment;
- road stabilization;
- backfill and milling operations in mining industries;
- rehabilitation of mine-tailings; and
- production of cinder blocks, bricks and particle/cement board.

Other possibilities could consist of:

- bagging wood ash with peat moss;
- mixing wood ash with paper mill biomass;
- pulp effluent processing;
- storage with seeds and nuts;
- absorption of nickel sulfate;
- processing with plastics and geotextiles; and
- oil, gas and acid spill clean up.

The most well-known and utilized use for wood ash is as a liming agent for agricultural soil. In Alberta, several studies have demonstrated substantial increase in yield for crops such as canola and barely. Wheat, beans, alfalfa and other forage crops have also produced an increase of dry matter as a result of wood ash application.

The benefits of using wood ash as a liming material for agricultural purposes include:

- increased yield/productivity;
- improved soil tilth;
- improved soil fertility; and
- weed control.

Given Alberta's acidic soil types, it is a logical concept to use the highly alkaline wood ash to balance the pH to a level more conducive for crop production. The Alberta government has recognized this beneficial relationship and has worked with industry and researchers to approve the use of wood ash for agricultural soil provided it meets the requirements of "Standards and Guidelines for the Use of Wood Ash as a Liming Material for Agricultural Soils" released in July 2002. Some of the key requirements include characterization of both the energy system wood ash and the receiving soil, and using appropriate application rates. Details on acceptable characteristics and methods are described in the standards and guidelines document.

Another use, that is still being investigated, is also as a soil amendment but for the purposes of supplying nutrients. A field study conducted northeast of Edmonton and complimented with a similar greenhouse study, concluded that a single application of wood ash resulted in long-term increases in barley and canola production. A combination of low application rates and proper management can make this secondary use feasible, generating both economic and environmental returns.

Wood ash has also been combined with bottom ash (a.k.a. grate ash) and lime mud for road stabilization.

7.3 Cement Kiln Dust

CKD has a solid record of beneficial use world wide. The Portland Cement Association states that approximately 75% of all CKD generated by it's North American members is reused (PCA, 2006). The ideal of 100% utilization is within the reach of Alberta cement producers. Some uses that have been encountered include:

- soil stabilization;
- waste stabilization/solidification;
- mitigation of acid rock and acid mine drainage;
- portland cement replacement;
- asphalt pavement (mineral filler);
- sorbant to remove SO_2 from cement kiln flue gas;
- mine reclamation;
- controlled low strength material (flowable fill);
- pozzolanic activator;
- lightweight aggregate;
- construction fill;
- agricultural soil amendment;
- alkaline stabilization of biosolids, human and animal waste;
- highway embankments/road works (can be used in conjunction with fly ash); and
- hydraulic barrier in landfill construction.

Most uses identified could be suitable for applications in or near Alberta. Those with the highest profile in Alberta include reuse in the manufacture of Portland cement, road base stabilization materials and the stabilization/solidification (S/S) of wastes. It is important to note that the potential use of CKD is impacted by its weathering, the plant's manufacturing process and the source of raw materials used to generate it. When considering a secondary use for CKD it is important to conduct trials/analysis to determine its suitability.

As mentioned in Section 6.3.2 of this report the cement plants located in Alberta do recycle a large portion of the generated CKD back into the cement manufacturing process. For Lehigh 100% of the generated CKD is recycled.

Lafarge has blended CKD with Portland cement to produce a new product called *Terracem*. This product, marketed for use in road stabilization, has been used in the Municipal District of Rocky View (MDRV) which includes the areas primarily to the north, east and west of the City of Calgary. *Terracem* was blended with coal fly ash to produce approximately 25 km of grid roadways. This work, part of a five year plan for the MDRV, includes the evaluation and study of this new road construction methodology. 2006 represents the third year of the program and includes plans to construct another 16 km of roadways. The performance of the roadways installed to date have been encouraging and have provided momentum to the program.

Additional benefits realized in the use of CKD include, the speed of installation (one day/km vs. one week/km for traditional materials) and reduced costs in both roadway maintenance and construction.

“Solidification” and “stabilization” of a loose solid are often terms used interchangeably to describe discriminate processes that can occur at the same time. Solidification involves a physical change in the properties of the material. In soil stabilization, the creation of a monolithic or soil like structure through improvement of strength and stiffness of the surface or material occurs to improve the handling or engineering integrity. Stabilization refers to chemical processes that reduce the leachability of a waste material by converting the constituents into a less soluble, mobile, or toxic form. CKD, depending upon its physical and chemical composition, can be used in both applications, and is typically mixed in some ratio with Portland cement. According to the Portland Cement Association, the solidification and stabilization of wastes provides one of the largest uses of Portland cement outside the traditional concrete market. Some advantages for this treatment include:

- availability;
- economics;
- volume availability; and
- historical performance data over other reagents(Adaska et al., 1991).

In the US the S/S process represented approximately 30% of the source control treatment technologies selected for Superfund sites (US EPA, 1996). While use of this technology in the US is commonly practiced Canada (and Alberta, specifically) has yet to embrace this treatment method (US EPA, 1996).

8.0 BARRIERS TO SECONDARY RESOURCE MANAGEMENT DEVELOPMENT

For the beneficial use of wastes, the elimination of risk to human health or the environment is key in all assessments of secondary use. Unless solid science to support secondary use is available, proceeding with its use would not be advised, nor likely to occur. There are some things that are common barriers regardless of waste type. Elimination of risk is key in all assessments of secondary use, as well as the development of MSDS's to promote proper handling, storage and use of the new product.

Additional regulatory guidance would also be beneficial for all waste types studied. This would provide clear direction of what is required for both users and generators and provide a framework for implementation of a resource management structure. Some programs identified in Section 5.0 describe where the beneficial use of wastes are regulated in a manner separate from traditional waste handling. These programs could provide the basis for a similar program in Alberta.

8.1 Phosphogypsum

The following barriers to the development of a system for the secondary resource management of PG were given by those interviewed in the development of this report and within the literature researched:

- the impurities present in the PG (specifically the NORM properties);
- public perception and the reluctance of secondary users or suppliers to accept the actual/perceived environmental consequences of PG use;
- lack of regulatory clarity/efficiency;
- lack of contact/knowledge between regulators, industry and potential users;
- transportation cost;
- financial seed money to initiate reuse program (product testing, market research and marketing, infrastructure development etc);
- low cost/risk of long term stack management in place; and
- finding a secondary use that will require large volumes of PG.

While there is documentation to support the secondary use of PG, and in some cases the opportunity to do so, it seldom occurs. Primarily due to it's NORM properties, PG carries with it a negative reputation. The mention of the word radioactive causes great concern. A radiological study of the PG in Agrium's Fort Saskatchewan stack indicates that it exceeds the 300 Bq/kg guideline for radium (at 400-700 Bq/Kg) but that for it's use as a soil amendment, in oil well site reclamation, as an additive in oil sands tailings, as an additive in composting pens and in feedlot manure, the risk of use was below natural background radiation levels and less than 10% of the annual public dose limit. It is critical that PG under consideration for secondary use be characterized with respect to NORM and metals levels/concentrations to evaluate the suitability of the application.

The characterization of PG would include evaluation of the NORM properties as well as other impurities of concern. Depending on the application, a complete radiological survey may need to be conducted at an approximate cost of $20,000-30,000/hundred acre site. This type of survey would give the most complete characterization of the stack. Alternately, if the projected use does not require a detailed survey, it is possible to send individual samples for analysis at a approximate cost of $100/sample, 20-30 samples would be required to characterize a similar area. An analysis for metals, fluoride and any other impurity consistent with the rock used to generate the PG would also need to be conducted. Analytical costs per sample would range up to $300 depending on required detection limits and the parameters of concern for a given rock. These evaluations would help give all stakeholders involved the confidence required to move forward.

Of these identified barriers the education of the public and users is the most critical. This could be addressed through technical assistance/information exchange programs, research and development programs including demonstration sites and industry/consumer education. The Stack Free program discussed in Section 5.0 is developing fact sheets on PG that could provide a basis for educational material to stakeholders. The dissemination of information that identifies actual and perceived risks would help alleviate the gap in understanding that currently exists.

The US currently has legislation that specifically deals with PG use (see Section 5). While the basis for the criteria is restrictive, the document does provide a framework for use and recognizes that it has secondary value. A similar document in Canada, with appropriate guidelines for use would pave the way for alternate use by specifying situations where alternate use is acceptable. This document, which would impact all stakeholders, would help them to understand the needs and restrictions of all involved parties.

The transportation of PG from the source to the user has been estimated at between $13 and $25/tonne[4]. This estimate can vary depending on the distance hauled, long term contracts or back haul potential. Long term stack maintenance costs are low (estimated in the order of tens of thousands of dollars a year for a stack with ten million tonnes) once the stacks have been reclaimed. The market value for the uses discussed has a range of zero (if the user provides the transportation) to up to $50/tonne. This indicates a potential for an economic solution.

While this potential exists there is little incentive for industry to invest the significant up front costs related to testing, developing and promoting secondary use as well as develop the infrastructure required for market delivery. The process to close and monitor stacks is established and accepted internationally. If a secondary use could be established and given regulatory approval, this could change. Regulatory intervention may also be of use to discourage the closure of stacks in place. The requirement of an alternative reuse study prior to consideration for stack closure may alert industry to the options that exist. Annual fees for inactive stacks could be levied. The Stack Free program is promoting the use of all PG stored in stacks in a 50 year timeframe. A prohibition of stacks after this point would certainly motivate industry to look for alternatives.

[4] Based on actual costs for PG movement from historic applications and current trucking costs.

Financing for the activities mentioned would have be obtained from multiple sources. Government and industry would need to contribute to solving this problem. If the motivation exists to invest in a proposal monies from international sources might be available (Stack Free, FIPR programs in Section 5.0). In the US, FIPR receives funding primarily from industry which could also be a source of funding. Transportation incentives might be considered in the early stages of program development to initiate momentum, but care should be taken to make sure it does not create artificial markets and that the program becomes unsustainable at an established boundary or after a period of time. Other financial programs that could provide incentive would be tax relief or relaxed monitoring standards for companies that demonstrate initiative and responsibility in the area of beneficial use.

In order for a company to invest in the infrastructure required to establish PG secondary use there must be demand for volumes of PG that will significantly reduce or eliminate a stack. This would provide the incentive of removing long term responsibility for PG management.

8.2 Fly Ashes

There are financial, perception and regulatory concerns associated with recycling both coal and wood fly ash. How these challenges specifically impact each potential product and additional barriers are addressed in sections 8.2.1 and 8.2.2.

8.2.1 Coal Fly Ash

To encourage recycling of coal fly ash the following issues need to be examined:

- transportation costs;
- marketing;
- regulations;
- engineering specifications and codes;
- infrastructure; and
- safety.

The barriers or concerns preventing increased recycling of fly ash are not mutually exclusive and synergistic solutions should be well thought-out. That said, there are definite barriers that are more critical than others and they should be the drivers for implementation recommendations.

Legislation and engineering specifications can negatively impact the recycling potential of fly ash. Current and potential future pollution prevention and emission control regulations facilitates the use of low or no NO_X burners and activated carbon, which in turn increases the carbon content of the fly ash. Higher carbon content can decrease freeze-thaw characteristics, making it unusable for concrete applications. There are technologies available to reduce potential contaminants such as carbon, ammonia and mercury, but this requires additional investment.

Alberta Infrastructure and Transportation has made changes in the last few years to construction and road specifications to no longer exclude the use of fly ash, however it is still limiting its use. This is in part due to the exposure to freeze-thaw cycles, but also due to a lack of information and knowledge. Regulators and engineers not familiar with the use of secondary resource materials, like fly ash as a supplementary cementing material (SCM), or who have had negative experiences due to the inappropriate use of fly ash may be reluctant to approve or use them in designs. Codes and specifications need to be updated to include and encourage the use of SCMs where appropriate. Additional restrictions are imposed by some engineering firms (AMEC, 2002).

Considering the available markets for fly ash, a common barrier throughout is infrastructure, whether it is regarding the generators, transporters or users. Generators need classifiers, which improve the quality of the fly ash, and load out facilities. Transporters and users could benefit from more trucks, concrete producers need an additional silo, and competent contractors are always in demand. These obstacles, in addition to the fact that many of the power generating facilities are located near their coal mines (where they can use the fly ash as fill material), contribute to fly ash being disposed of instead of recycled.

Other restrictions to coal fly ash recycling in Alberta are related to transportation, resources and costs. There are potential markets in the United States for fly ash, but without sufficient volumes it is not economical to transport it south. In this case the coal-fired power plants, in isolation, are not producing enough (or enough remaining after some is sold to domestic markets) to justify transport to markets. The second problem associated with transportation costs stems from the oil and gas sector, which currently uses nearly half of the recycled fly ash in Alberta. Conversely to a lack of supply, the volume demand for fly ash for well casings is too low to justify the transportation costs. One solution would be to stock pile it near the oil and gas operations, but then there is a problem with storage. Another solution would be to explore backhaul opportunities within or outside of the operation.

Effective marketing and finding economical uses for fly ash has developed to a degree over the last couple of decades, but primarily for the highest quality fly ash. In today's market, supply is greater than demand allowing marketers to be selective. Until a greater demand is created, either through an expanded market or legislation, the majority of the fly ash will continued to be disposed of as wet slurry in lagoons, or dampened and placed in coal excavation pits. If this continues, then there is no incentive for the generators or users to invest in necessary infrastructure, such as on-site handling facilities, off-site storage, and spreading equipment.

Finally, safety can be a concern because of the small particle size of the fly ash material. As with any dust substance, proper handling procedures and safety equipment are needed.

8.2.2 Wood Ash

Using wood ash as a soil amendment, either as a liming agent or nutrient source, appears to be a good fit. However, some barriers to be addressed before the advantages can be maximized include:

- transportation costs;
- public perception;
- regulations; and
- limited research.

Each of the barriers is critical to the success of converting wood ash from a waste to a resource material. The most crucial barriers identified by industry are cost, public perception and buy-in. Without the interest and support of local farmers and land owners, additional research, regulations and transportation fixes, solutions could be fruitless. Barriers preventing a high demand for the product involve initial cost and misperceptions of the material.

Due mainly to high transportation costs it is difficult for farmers to pay for the application. Currently, the suppliers are subsidizing, or in some cases paying for all of the transportation costs. This is not a sustainable business practice for the suppliers and a more amicable and realistic long-term strategy needs to be established to encourage recycling.

Many farmers are aware of the trace metals and elements in wood ash, and are concerned these constituents could be harmful. There is a lack of information easily available or currently being distributed to local farmers and land owners demonstrating there is no need for concern when the wood ash is applied at calculated application rates and under controlled conditions. Also, the benefits of applying wood ash need to be demonstrated to the potential market, the farmers.

The barriers of research and regulations are closely connected. Currently the one standard issued by Alberta Environment isolates application rates from wood ash characteristics. An independent consultant in Alberta suggests there needs to be more flexibility in how amendments are applied. For example, if one of the elements present exceeds the guidelines, instead of being unacceptable, perhaps it could be applied at a lower rate or on specific receiving soils if it is managed properly and performed in an environmentally safe manner. Additionally, the guidelines are very specific to wood ash as a liming material for agricultural soils. This does not apply to the use of wood ash as a nutrient supply and for other applications, like on forest lands. However, applications for approval can be made on a case-by-case basis.

Research has proven wood ash can have beneficial effects when used as a liming agent. However, research on multiple applications and/or long-term research plots could be pursued. Additionally, the use of wood ash to replace lime (or limestone) in the co-disposal of sulfur-containing or sulfur-contaminated waste should be explored.

Each barrier has its own repercussions, but none of them are insurmountable. As with coal ash, these concerns should not be considered independently since the solutions to one barrier may automatically have benefits for another. For example, with additional research, more appropriate standards and guidelines can be implemented, both of which can contribute to public education. With public education comes public understanding and possible acceptance.

8.3 Cement Kiln Dust

The following barriers to the beneficial reuse of CKD were given by those interviewed in the development of this report and subsequent literature search. They include:

- transportation costs;
- education of end-users regarding potential success;
- variation in CKD chemistry and quality; and

- lack of regulatory and agency support.

While the above barriers were identified in literature and by some interviewees, an alternative response by others interviewed saw virtually, “no barriers”.

Lafarge North America has initiated an aggressive program to beneficially reuse 100% of all generated CKD by 2010. This includes the CKD produced at the Alberta Exshaw plant. To achieve this goal, the company has invested time and capital in the study of CKD and the development of CKD beneficial reuse markets. Lafarge conducted and continues a long-term program on CKD chemical and physical characterization at each manufacturing facility and has identified potential beneficial reuse market segments for CKD by-products. The culmination of this work resulted in a strategic business and marketing plan to reposition CKD as a by-product and eliminate its landfill disposal. When interviewed about the motivation to alter disposal practices, concerns of rising operational and monitoring costs of long-term landfill operation and expansion, as well as environmental sustainability were voiced.

The Cement Association of Canada indicated that the S/S of wastes is limited in Alberta due to regulatory process. The use of S/S to conduct remedial work in-situ is not conducive to standard based remediation criteria. To utilize this option a site specific risk assessment is often required. The process for the acceptance of risk assessments for contaminated site remediation requires the approval of multiple regulatory bodies with varying levels of authority. Anecdotal evidence indicates the need for a defined process based on accepted science.

9.0 SECONDARY RESOURCE MANAGEMENT APPROACHES

9.1 Generic Approach

Each of the waste types discussed have varying levels of accepted use in practice, from next to no ongoing programs for PG to the accepted use of coal ash for concrete. The level of acceptance/knowledge for a given use will determine where effort is required. A general approach to the establishment of a secondary resource management scenario could include:

1. *Establishment of a Scientific Basis for Use* – Science for the potential risks associated with use needs to be researched/conducted. This information would be obtained from knowledge of the waste to be used and studies or demonstrations of how it performs in a given use and if that use is acceptable when the risks are identified and evaluated.

2. *Education of Stakeholders* – Information needs to be distributed and explained to all stakeholders. For example, pamphlets could be generated and distributed to stakeholders. This will help identify the market size and location, and allow users to appreciate the benefits that could be realized (financial and/or performance). Government support of secondary resource use would help to authenticate it. If possible, situations where government projects could benefit from secondary waste utilization use should be conducted to serve as evidence of the given information.

3. *Amendments or Additions to Legislation* – Changes to the regulatory environment trigger a response and/or behaviour change from individuals and industry. Relevant legislation should be examined for changes that would either remove barriers or motivate the use of the waste as a resource.

4. *Establish a Support Network* – From the research steps through to program implementation and monitoring, government and the relevant industry(s) requires support to advance the research, ensure the program is sustainable, and make suggestions for continual improvement. This support network should involve representation from all stakeholder groups.

5. *Development of Infrastructure* – The key infrastructure requirement for PG, CKD and ash are transportation and storage systems. Most of the accepted alternate uses recommended do not require the physical alteration of the waste. In some cases blending systems would need to be implemented. It is unlikely that a new process or equipment other than that which is currently used would be required since the alternate uses selected simply replace a raw material with similar characteristics.

6. *Ongoing Monitoring/Reporting* – Once a beneficial use system is in place, the quantities used and where it is used should be reported to AENV.

9.2 Phosphogypsum

The use of PG as a secondary resource is not yet established and would require methodically going through the steps identified above. The quantities of PG available for use demand that multiple opportunities be implemented/investigated. Each of the recommended opportunities will require varying levels of input to satisfy the given steps. Specifics for each alternative will be discussed in brief after a general discussion on the implementation of PG secondary use.

The use of PG needs to be researched and evaluated for potential risks for uses that have not yet been established. Sources for information could include, FIPR, “Stack Free”, academic institutions, international studies or trials/studies conducted with the specific PG intended for use.

Once the data is in order that indicates suitability of a given PG for a given alternative the educational component can be initiated. Each education program would need to involve all stakeholders. A standardized presentation/pamphlet could be developed to highlight the actual vs. the perceived risks of use. It could also identify the researched secondary uses and some of the benefits PG could provide. This pamphlet would require the input of experienced individuals specifically in the area of NORM radiation. Follow up workshops for interested parties would provide an excellent venue for stakeholders specific to a recommended alternate use to learn more about the science behind the use. In this way, they can make an educated decision on PG use. This workshop would also give generators/users and regulators the opportunity to discuss concerns. This type of format could also generate discussion on implementation requirements or challenges.

It would be naive to believe that a single pamphlet or meeting could open the doors to PG use if there is a significant bias to begin with. It is possible that only trials or ongoing education could overcome unfounded bias. This aspect of PG development as a secondary resource could require several iterations.

In the case of PG, where reuse has not been established, the assembly of an Advisory Board to guide these steps would be beneficial. The committee could consist of Albertan representatives from the following stakeholder groups:

- the provincial government;
- engineers;
- generators;
- users;
- the general public;
- industry associations; and
- transporters.

Alberta Environment could be the lead agency but provision should be made for federal involvement/direction.

This type of forum would ensure that the needs and concerns of all affected parties would be considered in the development of PG secondary resource management processes.

Larger volume uses of PG will require changes in infrastructure. At the stack site a loading station with heavy equipment could be established to load the trucks used to transport PG. It is possible a truck scale would also be required. Of the uses mentioned only the soil additive and cement component uses might require a modification of the physical properties of PG. For cement, additional drying of the material may be required to reduce the water content and minimize the impact on feed systems at the cement plant. The distribution of PG over a large area of soil can be accomplished using a standard poultry manure spreader but sometimes this is not ideal. Pellitizing PG would eliminate this concern but add significantly to cost.

The final step of the process, reporting/monitoring, use could become a requirement of an operating approval. If use is tracked and reviewed, AENV will have the ability to see what is/is not working and where intervention might be required.

Specific uses for PG that deserve consideration are as follows.

- *Tailings Flocculant* – This was an established use with the potential for 80,000 tonnes/year per operation. All oil sands properties should be approached to determine if PG would be suitable for their operation. There is currently knowledge of Suncor and Syncrude, Shell Canada Limited, Albian Sands Limited, Canadian Natural Resources Ltd., Encana Corporation, Husky Energy Inc, Imperial Oil Resources Limited and Petro-Canada having, or soon to have, operations. Information could be provided to each company on the benefits of PG as a tailing flocculant and the Suncor/Syncrude experience.
- *Cement Products* – A literature search is required to collect information on this use and identify any gaps if existing. Lafarge would be an excellent resource since PG is used in some of their products in the US. Both Lehigh and Lafarge could be approached once this data has been collected to conduct trials on PG use. Lehigh is located not far from the Agrium stacks and would minimize the required transport while the Lafarge Exshaw plant is close to the Westco stacks in Calgary. Virgin gypsum is available in the south eastern part of BC near Invermere, but costs for this material can range from 4-10 times more than the cost of PG transportation. The manufacture of cement requires the addition of approximately 5% gypsum to the clinker prior to ball mill grinding. If found suitable for operations in Alberta, this use has the potential to require more than 100,000 tonnes of PG/year. The moisture content of PG could provide a challenge for cement manufacturers, as it has the potential to plug current processes. Process modifications might have to be made for this option to succeed, but this can be justified given the price differential for raw gypsum versus PG.
- *Compost/Soil Amendment* – Some literature exists that details PG's performance as a compost additive but more research is required. Of specific interest would be developing a product that could be utilized in the remediation of brine spills. This type of research could be conducted at the EWMCE with the cooperation of Agrium. The current composting operation at the EWMCE would be an ideal location to utilize PG since it is close to the Agrium stacks and has the in-house expertise to both conduct trials and ultimately utilize PG. The potential demand for this type of product could be variable, but tying in the use of PG with the expanding Oil and Gas industry would benefit the

secondary use of PG. Care should be taken in developing this application since some oil & gas sites already have NORM contamination. Further application of a NORM material could increase NORM levels.

Preliminary research done for this report indicates the utilization of PG as a soil amendment is potentially the best option. Gaps in information based on localized use could be addressed with additional research. The potential market for this type of product could be limited since a single application is usually suitable for the improvement of soil characteristics. Agricultural associations could be utilized to help disseminate information on PG's potential.

- *Daily Landfill Cover* – As with the compost amendment alternative there is good potential to utilize the expertise and facilities of the EWMCE. Preliminary work at FIPR has provided promising results but there is still the need for an evaluation in a real world scenario. The FIPR will be conducting such a trial this year on a county landfill in Florida where all parameters, including leachate quality, will be evaluated. The progress of this trial should be followed and combined with any local work to determine the suitability of PG in Alberta for this use.

  If the landfill cover option is supported by these investigations, a list of Alberta landfills could be reviewed to determine those that may benefit from PG as cover and initiate contact to determine interest. Interested parties could then be educated as to the use and benefits of PG in this manner.

  The current cost of landfill cover varies. In some cases material is received free of charge and is a waste that would be going to landfill anyway (e.g., some contaminated soils). The sites where PG use would be economic would be those that pay for cover and have volume concerns that could, in part, be addressed by the ability of PG to accelerate waste decomposition.

  The potential demand for PG as landfill cover is not immediately known. The Shepard landfill in Calgary estimates they use approximately 60 m^3/day when cover is required. This would translate into approximately 150-180 tonnes of PG daily. Regulators will occasionally relax daily cover requirements during the winter. Assuming cover is only required eight months of the year this would translate to 26,000-31,200 tonnes/year of PG for a single site operating five days a week.

- *Road Base* – This option is well researched on the basis of performance but also has not been practiced in Canada. Roadways have been constructed in the US prior to EPA rulings restricting its use. FIPR challenged the basis of the EPA assessment for roadway use and offered the solution of making PG roadways on deed restricted land to avoid a risk assessment based on a house built in the roadway. Progress in this case should be followed since Canada often follows the lead of the US in regulatory matters. Acceptance in the US for PG use in road building could provide evidence for similar use in Canada. The potential volumes required for use in road building would be significant and provide an excellent alternative use.

The potential use of PG as a tailings flocculant, compost amendment or landfill cover has the added benefit of not requiring any further modification to the PG. The only cost associated with its use would be transportation from generator to user.

The question in all of these steps is determining who should take responsibility for the execution of this process. This is one of the primary reasons why secondary use often does not occur, there is no one to take responsibility and champion the process. This is a role best taken on by a neutral third party (not the generator or user). Appointing a provincial lead, and establishing an advisory board in the development of secondary resource management systems would fill this identified gap. Government legislation can also:

- encourage the secondary use through approval requirements;
- establish incentive programs to discourage stacking; and
- encourage reuse and/or reclamation of stacks in place.

The EWMCE can provide research facilities and expertise as well as become a clearing house for a library and knowledge of beneficial use applications. Workshops can be held at the EWMCE to educate stakeholders on opportunities. Industry can do their part by being open to secondary use and contributing to the research required to confirm the suitability of a given use.

9.3 Fly Ashes

Since there are established uses for fly ashes that are accepted in Alberta the key to completely converting fly ash waste to a secondary resource is to build on existing programs and address some of the barriers addressed outlined earlier. The following sections explore steps to be considered for coal fly ash and wood fly ash, respectively.

9.3.1 Coal Fly Ash

Associations , government bodies, researchers and other organizations, such as CIRCA, the Canadian Ready-Mixed Concrete Association, ICON/CANMET, the University of New Brunswick and EcoSmart have forged a path for the recycling of fly ash as a supplementary cementing material in concrete and as a Portland Cement replacement in cement in Canada. This movement has been based on solid science and field demonstrations.

With no indication that the production of fly ash will slow down anytime soon, it would be advantageous to build on the established recycling opportunities in Alberta, primarily for cement replacement and concrete products. Power generating facilities could sell the fly ash for a decent fee (e.g., $4/tonne), but would realize greater economic gains, almost double, from landfill related savings (e.g., landfill space, mine trucking, cat work, etc.). The cement, concrete and oil and gas industries could also benefit from cost savings as well as greater performance. In the cement and concrete industries greenhouse gases can be reduced by using fly ash as a Portland Cement replacement. Not to mention, fly ash can cost up to 30-40% less than Type 10 Portland Cement (AMEC, 2002).

In Canada the use of SCMs can also create a Materials and Resources credit under the LEEDs program as described in Section 5. This is a step in the right direction; however the following discussion describes additional considerations.

Education of the recycling potential of fly ash is gaining momentum. Currently, the Alberta Ready Mix Concrete Association offers programs that include the use of SCMs. The more confident the regulators and engineers are with the capabilities and performance of fly ash, the more widely it can be used. In some cases, it may be appropriate to include quantities or percentages of fly ash in tender specifications. Such quantities can be based on the newly published *Use of Fly Ash and Slag in Concrete: A Best Practice Guide* by the Materials Technology Laboratory and supported by the *Government of Canada Action Plan 2000 on Climate Change*.

Nationally, CIRCA and the Cement Association of Canada are making a valiant effort to promote the benefits and use of fly ash in concrete materials. CIRCA has an elaborate website with many tools and a *Coal Combustion Products (CPPs) Video* Series. The Cement Association of Canada released *Concrete Thinking for a Sustainable Future* in 2004. In addition to these national efforts, a more specific and tailored provincial approach is required. Currently, the main marketers, Lafarge, Lehigh Inland, Aschor and ENX market the ash produced by the four power generators, TransAlta, Epcor, Atco Power, and Maxim Power Corporation. Although this arrangement has been somewhat successful, room for improvement exists.

One possibility to improve the use of fly ash as a secondary resource would be to host a series of focus groups with invitations to the appropriate parties, to provide technical information and examples demonstrating the successful use of fly ash in products such as cement and concrete to engineers, regulators and contractors. Representatives from these focus groups and all stakeholder groups would be candidates for an advisory board that would help “champion” the use of fly ash.

Economic considerations must always be evaluated when trying to grow a market for a product. Education on financial matters, as well as technical merits is important. Transportation costs for recycling fly ash can range from $3 to $12.50 per tonne depending on the transportation distance, volumes and frequency. Combined transportation and handling for disposing of the fly ash has been reported as low as $8 to as much as $12 per tonne. Other costs to consider for recycling fly ash include analytical tests and laboratory costs. For example, fly ash being used for concrete needs to have both chemical and physical analysis. Typical chemistry tests cost between $250 - $460, while the physical tests can run upwards of $900 not including technical reporting, administration and clerical fees. Additionally, special tests such as control of alkali silica reactivity and sulphate resistance performance cost around $595 and $795, respectively. As with transportation costs, analytical costs can vary as well, depending on the amount of testing and length of test programs.

Additional infrastructure is required on the part of the generator and the user. To justify the expense the best solution would be to establish significant markets. This can be done by increasing the application of fly ash, or increasing the quality of the ash by using higher temperatures, making it more appealing to the market. Also, legislation requiring diversion and/or use of waste products would spur the industry to invest in the necessary equipment and infrastructure.

Finally, the use of fly ash as a SCM and Portland Cement replacement should be monitored. This will allow for further field analysis and demonstration of appropriate uses. Additionally, this will provide a means to measure the use with respect to increased awareness and education. If the increase of fly ash use is not significant, then alternative uses should be further explored for applicability in Alberta.

9.3.2 Wood Fly Ash

In Alberta several groups including the forestry industry, Alberta Agriculture, Alberta Environment, educational institutions and independent consultants have worked together to establish the scientific basis of using wood ash as a liming agent for agricultural land. These efforts must be recognized and should be utilized to their full extent. Hence, it is most appropriate to exhaust the established use for wood ash before spending additional time and effort exploring other opportunities. Perhaps the one exception to this would be the possibility of using wood ash as a nutrient replacement for soil since preliminary research has already begun.

Facilities using wood waste for energy production could partner with local colleges and universities to advance research in support of legislation conducive to recycling wood ash as a nutrient replacement in a healthy and environmental safe manner. Research not only goes a long way to help shape legislation, but it can also address public perceptions. To assist with this, another government initiative could be some type of recognition for companies that support recycling wood ash, just as the LEED program does for coal fly ash and other building materials.

Partnerships between institutions, like the University of Alberta, the University of Calgary, the University of Lethbridge and Fairview College, forestry industry companies in Alberta and government branches have worked in the past and should be open to additional cooperation. Additional participation could include the Edmonton Waste Management Center of Excellence and Olds College who are centrally located and could offer a great deal of experience with respect to composting materials and soil amendments. Depending on the success of these relationships, research and education could be extended to exploring other uses, such as road stabilization and the production of cinder blocks and bricks in Alberta. To complement such partnerships and potential programs it would be beneficial to have an organization or committee dedicated to recycling wood ash whose energy could be focused on the advancement of research and education of the potential users (i.e., farmers).

The key to managing wood ash as a resource rather than a waste is to create a demand for the product. To do this the public needs to be educated regarding the benefits of applying wood ash to agricultural land. Local farmers and land owners need to be convinced that the levels of trace elements and metals will not pose environmental or health problems. In an effort to do this there have been programs developed, such as those mentioned earlier.

With respect to the education of stakeholders, costs can play an important role in persuading and gaining peoples attention. The cost to recycle wood ash is quite variable. Typically, the generator pays for the ash and receiving soil to be tested, as well as for the transportation or a portion of the transportation costs. Other expenses to consider include spreading and management costs (e.g., consultant fees to determine application rate). Overall, the cost to use wood ash as a liming replacement for agricultural soils can be divided into 70% for transportation, 15% for spreading and 15% for management. Disposal of wood ash, including transportation and management (e.g., landfill construction, leachate collection and treatment, capping, dozer, haul road construction and maintenance, etc.) has been estimated at $55 per tonne, assuming an average bulk density of 0.45 g/cm^3. However, some facilities can landfill the material for as little as $10 per tonne plus transportation costs, which are roughly estimated at $12.50 per tonne. For reasonable hauling distances, it is more economical to use fly ash as a liming agent than to dispose of it. If transportation distances exceed 30-50 km, then typically the farmer compensates for any additional costs.

The cost of using wood ash not only needs to be compared against landfill costs, but also against its agricultural competitor, lime. The cost of lime ranges from $10.00 per tonne for dry lime kiln reclaim to $31.50 for limestone. As with everything else, transportation costs can increase the price significantly. For example assuming a minimum load of 22 tonnes, it could cost $15.00 per tonne for a 100 km haul and up to $40.00 per tonne for a 500 km haul. Considering there are many more wood ash suppliers than lime suppliers, the transportation costs associated with wood ash are much less than to supply lime. Hence, it is definitely more economical for farmers to use wood ash as opposed to lime.

Financial support would also help lower costs and encourage demand. Years ago there was a freight assistance program that would subsidize up to 60% of the transportation costs to lime agricultural soil in Alberta. This program no longer exists, but many feel that if it was resurrected in some form for wood ash instead of lime it could help with the financial strain on farmers. A similar program for wood ash would likely be less expensive for the government considering the shorter transportation distances. This type of program would also encourage the generators to take a more active role in promoting recycling over disposal. By making recycling an economically sound decision there will be less resistance.

Infrastructure required for this product is minimal, but should still be considered. Basically, existing equipment and machinery can be used with possibly some minor modifications or attachments to control the application rate. For example in the field study conducted northeast of Edmonton, a manure spreader was used to spread the wood ash; another project used potatoe trailers with spinners.

Aside from equipment, the other key infrastructure requirement is storage. For the farmers, the wood ash is typically stored in piles on the side of the field until it can be applied. However, the generators require more storage space given the larger volumes and time required to ensure combustion is complete (i.e., no longer smoldering). Regardless of its destination (recycling or landfill), storage requirements need to be considered.

Since the long term consequences of applying wood ash are not confirmed it would be prudent to monitor the sites using the material, with reporting to Alberta Environment and Alberta Agriculture. It would be best if there was a coordinator or advisory board to collect and collate the data received to identify any commonalities that could either advance the cause or identify necessary changes or modifications.

9.4 Cement Kiln Dust

It is important to recognize that the cement industry is open to both utilizing and producing secondary resources. The cement industry, as evidenced by the Alberta plants' activities, are proactive in seeking out secondary use options.

With the outlook for 100% recycling/reuse of CKD expected to occur in a three year time frame it appears that CKD only requires the final step of monitoring. AENV, through its operating approvals, can request information on the volumes of CKD generated and utilized. Benefit could also be realized if the portion of CKD used for each alternative were recorded. This way AENV could be aware of any slippages from the current goals.

It appears that the cement industry has made a commitment to both the use as secondary resource and creating a secondary resource. Lafarge's environmental policy initiative makes a commitment to "minimize the use of non-renewable resources and, where feasible and safe, replace them with substitute raw materials, alternative fuels or biomass". A similar statement can be found in the Lehigh Cement Groups Environmental Policy, "promoting the reuse and recycling of products". Lafarge's operating approval currently authorizes the use of fly ash, iron millscale, used refractory bricks, glass and grinding aids as alternative raw materials.

10.0 CONCLUSIONS

The research conducted for this report has revealed that significant opportunity exists to move from a waste to resource management system for PG, CKD and coal/wood fly ashes. For each of the top three waste types there exists programs and research for their utilization. The identified barriers can be addressed with a combination of management tools that can include:

- regulatory simplification/additions;
- profit potential identification;
- tax relief programs;
- technical assistance/information exchange programs;
- research and development/demonstration programs;
- financial incentive programs;
- industry partnerships with secondary resource users; and
- industry/consumer education programs.

The bulk of these tools can be implemented by AENV. Industry groups contacted for this report were, in general, very open and interested in the potential for secondary resource management systems. Many groups were proactive with programs and research already being conducted. It is clear that a lead person and/or advisory board is required to collate and evaluate current secondary resource efforts as well as to coordinate future endeavors. AENV has the opportunity to become a leader in these efforts by providing a Beneficial Use Lead with the authority to recommend changes to regulations, operating approvals, fee structures and administrative requirements.

Of the three waste types studied in detail, the one that requires the most intervention is PG. It is the only secondary resource that did not have a significant ongoing and accepted use. Ironically, it also has the greatest accumulation and generation. CKD reuse has basically been managed by industry. The only matter is to monitor progress to ensure that the goal of 100% reuse is achieved and to keep in touch with stakeholders and provide intervention if required.

Fly ash is an established commodity world wide; again AENV can help encourage secondary use of this material through the regulatory tools mentioned. Many of the existing regulations and specifications are based on a lack of information or a previous negative experience where fly ash was inappropriately used. Researchers, especially in the areas of cement and concrete for coal fly ash and agricultural uses for wood fly ash, have demonstrated the benefits of using fly ash and outlined boundaries for their appropriate use. Such information and knowledge needs to be shared with all stakeholders involved and realistic steps taken to encourage recycling of these waste to resource materials.

During the research for this report it was surprising to discover the lack of awareness for some of the options. Finding a way to inform all stakeholders of these options would go a long way to seeing action in the beneficial use of wastes.

11.0 RECOMMENDATIONS

In addition to the review and implementation of the secondary resource management approaches outlined in Section 9.0, the following recommendations are provided:

1. Develop an internal waste tracking system to better understand the quantity, type and management of solid industrial wastes that are being generated in Alberta.

2. Specific actions recommended for the identified top three wastes:
   - monitor both Lafarge and Lehigh operations to ensure the current progress to 100% CKD reuse continues;
   - provide funding/support for:
     - ❑ research on the long term use of wood ash and in multiple applications, and
     - ❑ research on the use of PG as a landfill cover and as a compost and soil amendment; and
   - look to the Stack Free Program (Section 5.4) for funding opportunities for research into the Beneficial Use of PG.

3. Examples of general regulatory activities that could be undertaken to promote secondary uses include:
   - amending approvals to require reporting of secondary resource generation and/or use;
   - amending approvals to require registration/participation in a specific program;
   - the development of a Beneficial Use Regulation with the opportunity of risk based evaluations for alternate use as well as criteria;
   - update/review current legislation to identify/alter situations that constrict the development of beneficial use (e.g., specifications in place for Alberta Infrastructure and Transportation);
   - modification of current regulatory process to discourage land disposal/long term storage and support beneficial use;
   - investigating the feasibility/suitability and possible timing of landfill or stacking bans; and
   - not authorizing projects or processes that do not participate in a given established reuse program.

4. Identify a lead person in AENV to co-ordinate and be accountable for secondary resource activities. This person should be supported by an advisory board (similar to the board operating in the State of Maine) which would also help guide expansion of beneficial use programs to other waste types. Given responsibilities could include:

- *Evaluation of Opportunities:*
  - review of EPEA approval applications to determine potential opportunities for secondary resource development;
  - identify secondary reuse opportunities in the province; and
  - listen to stakeholder needs for the development of beneficial use scenarios and implement process/regulatory changes where justified.
- *Administration/Review of Implementation Strategies:*
  - initiation of a "LEED" type program that recognizes industries efforts to both market and use secondary resources. Points could be given for initiative, volumes used/marketed, implementation of "Industrial Ecology", or for the development of industrial partnerships etc. Expansion of AENV's Envirovista program to include these ideals could be feasible to meet this goal;
  - assess the suitability of additional levies for land disposal or long term waste storage; and
  - administrate/implement transportation incentive programs where required/possible.
- *Education of Stakeholders*:
  - initiate/implement "mutual benefit" workshops to inform stakeholders of both the science and potentials in secondary use, be a liaison between stakeholders where required;
  - educate industry both at the association and local levels of the economic potential of secondary resources;
  - develop an information brochure for secondary use materials;
  - add education fliers in with regular industry correspondence; and
  - educate the public where there are concerns regarding secondary use.
- *Monitor*:
  - monitor the regulatory changes regarding beneficial use occurring on an international level to access suitability/need in Alberta;
  - representing government interests in secondary resource discussions; and
  - monitor data on long-term projects to evaluate trends.

5. Investigate the use of tax relief and regulatory minimization for responsible companies that demonstrate beneficial use.

6. Support the development of a central location for technical information on secondary use. An appropriate industry association or research entity could provide specific data/information when required for regulatory evaluation. This entity could inform AENV of potential funding programs. An annual stipend could be provided to support this service.

7. Become involved in industrial associations to communicate Alberta Environment expectations, and provide and receive educational information. Important associations related to the recommended waste to resource include:
   - Association of Canadian Industries Recycling Coal Ash;
   - Cement Association of Canada;
   - Canadian Ready-Mixed Concrete Association;
   - Alberta Forest Products Association; and
   - Canadian Fertilizer Institute.

These recommendations represent a starting point for strategies to promote the Beneficial use of Waste and utilize some of the tools identified at the Team Workshop held in October of 2005. These strategies may be supplemented by others mentioned at the workshop (Appendix B slides) where additional information indicates the need.

12.0 LIMITATIONS

This report was generated using information that was easily and readily available. Since there is no exhaustive and complete list of waste volumes and types generated in Alberta, it is possible that a waste type with secondary resource use potential was missed.

The ability to remove barriers for the development of a resource management is key to the success of the recommended programs. All barrier removal programs/techniques are based on the best available information and may not respond to all concerns that develop when applied in industrial situations.

Markets for a given secondary use are dynamic. Changes in economy (down turn in oil prices), demand (increased road building) and supply (shortage of virgin materials), events occurring both within and outside of the province (regulatory changes in the US) are only some of the items that can impact the evaluation in this report. The judgments in this report are based on the best available information at the time of writing.

The work performed in this report was carried out in accordance with the Terms of Conditions made part of our contract. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract and proposal.

The report has been prepared in accordance with generally accepted environmental study and/or engineering practices. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our contract and included in this report.

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Appendix A

Landfill Survey/Preliminary Literature Search

Alberta Beneficial Use of Waste Landfill Research

Company	Location	Waste Type	Associated Industry	Source	Annual Quantity Tonnes	Waste specific cells?	Knowledge of Programs? waste reduction/mgmt	Waste Tracking	Other Comments
Canadian Crude Separators	Calgary								
BFI	Calgary Landfill	soil with hydrocarbons	Oil & Gas/Reclamation		200,000 t/yr	no, but jobs are dumped in the same area	can't comment on what happens at the source of waste generation in terms of managament. From the landfill perspective, however,	each individual waste stream is assigned a job specific approval number. Each	None
BFI	Calgary Landfill	soil with metals	Oil & Gas/Reclamation						
BFI	Calgary Landfill	soil with other contaminants	Oil & Gas/Reclamation						
Clean Harbours (Safety Kleen)	Calgary							Manifests with Saf	Safety Kleen was bought out by Clean Harbours. Safety Kleen only provides transportation services, while Clean Harbours' Ryley provides the landfill services. They pick up mostly waste from the auto industry (solvents, paint, oil, coolant, waste oily rags, oil filters, sandblasting sand, paint gun cleaners, etc.) but most of it is recycled. They also transport acid from labs, aresol cans from Wal-Mart, flurorecent lightbulbs for recycling. Sludge from wash sumps at rental car places and bus stations is treated then the solids are landfilled.
Hazco	Calgary	Process solids	Industrial waste processors? Upstream O&G?		5,000 - 50,000 t/yr	most industrial style waste streams are disposed of in designated industrial waste cells, separate from garbage.	cannot comment on management strategies at the generator's site. Scrap steel, tires, wood are handled separately and designated for recycling. Concrete and asphalt (uncontaminated) are recycled. Leachate generated by the landfill is also minimized and treated when possible. Significant investment in infrastructure at the facility level has been undertaken to clean water rather than dispose of it.	they do track specific wastes	Some basic catalyst or desiccant may be recycled or beneficially reused where facilities exist.
Hazco	Calgary	Drill cuttings	Upstream oil and gas exploration and production		0 - 150,000 t/yr	most industrial style waste streams are disposed of in designated industrial waste cells, separate from garbage.			CSS Landfill Services owns/operates the following Class II landfills in AB: Rainbow Lake Landfill, Spirit River Waste Management Facility, La Glace Landfill, Mitsue Landfill, Tower Road (Edson) Waste Management Facility, Fox Creek Landfill, Rocky Mountain House (Area D) Landfill, Bonneyville Landfill
Hazco	Calgary	Sulphur wastes	Industrial waste processors? Upstream O&G?		0 - 100,000 t/yr	most industrial style waste streams are disposed of in designated industrial waste cells, separate from garbage.			They are also involved in the management of the industrial waste disposal business at the following landfills: Newell Regional Solid Waste Management Facility, City of Medicine Hat Landfill, Crownest Pincher Creek Landfill, East Peace Regional Landfill
Hazco	Calgary	Asbestos (by volume)	Asbestos abatement		20 - 500 t/yr	asbestos must be buried and immediately covered			
Hazco	Calgary	Catalyst and desiccants	Industrial waste processors? Upstream O&G?		0 - 1000 t/yr	most industrial style waste streams are disposed of in designated industrial waste cells, separate from garbage.			
Newalta Corporation	Calgary	soil with hydrocarbons	Oil & Gas		unknown	no, only one cell	the soils are recycled/remedia	yes	
	Calgary	soil with chloride	Oil & Gas		unknown				
Paintearth Resource Recovery Centre(operated by Capital Environmental Resource Inc. Ltd.)	Coronation (office in Calgary)								
Byram Industrial Services Inc.	Pembina Area Landfill (Drayton Valley)								

Alberta Beneficial Use of Waste Landfill Research

Company	Location	Waste Type	Associated Industry	Source	Annual Quantity Tonnes	Waste specific cells?	Knowledge of Programs? waste reduction/mgmt	Waste Tracking	Other Comments
Swan Hills Treatment Centre (Operated by Earth Te	Swan Hill								Gordon Godin, Sales Manager, is away this week. Pierre stated they do not landfill at Swan Hills, they only incinerate (both solids and liquids). They use the Kleen Harbours/Ryley landfill.
Waste Management of Canada Corporation (WMCC)	West Edmonton Landfill?	contaminated soil	Oil & Gas		400,000 t (est. avg.)		None	Yes, using waste r	80 - 90% of the waste they receive is contaminated soil from the oil patch. There are no economic reasons to treat/recycle contaminated soil because it is cheap for the oil companies to landfill it. There is a lot of land and a lot of competition, which keeps the prices good for the oil and gas industry.
	West Edmonton Landfill?	lime sludge	Water treatment		1,000 t (est. avg.)				
	West Edmonton Landfill?	absorbents			1,000 t (est. avg.)				
	West Edmonton Landfill?	catalysts			1,000 t (est. avg.)				
WasteCo (now owned by Nealta Co.)	Calgary				1,000 t (est. avg.)				
Calgary Regional Landfill	Calgary								
Edmonton Regional Landfill (cloverdale)	Edmonton	Vermicultie Insulation	Misc	Builder/Demo	375.48				
Edmonton Regional Landfill (cloverdale)	Edmonton	Empty Nickel Sulphate Poly			119.28				
Edmonton Regional Landfill (cloverdale)	Edmonton	Paint solids (flakes)	paint	misc	117.33				
Edmonton Regional Landfill (cloverdale)	Edmonton	Chicken feces, guts, feathers	farming	misc	113.74				
Edmonton Regional Landfill (cloverdale)	Edmonton	Drums/pails	Misc	misc	94.44				
Edmonton Regional Landfill (cloverdale)	Edmonton	Catalyst Cracking fines	O&G	misc	81.18				
Edmonton Regional Landfill (cloverdale)	Edmonton	Food	food	misc	65.19				
Edmonton Regional Landfill (cloverdale)	Edmonton	Stabilized Mixed Sludge			46.19				
Edmonton Regional Landfill (cloverdale)	Edmonton	Empty Paint Cans/pails	Paint/Builders	misc	30.67				
Edmonton Regional Landfill (cloverdale)	Edmonton	Acrylic Stucco	Demo/builders	misc	28.32				
Edmonton Regional Landfill (cloverdale)	Edmonton	Power Pole Butt ends	Utility companies	misc	28.28				
Edmonton Regional Landfill (cloverdale)	Edmonton	Empty waste Catalyst Containers	O&G	misc	46.39				
Lethbridge Regional Landfill	Lethbridge	shingles (2004)	building	misc	3570	clean concrete	US programs/Detroit good CNR model		Open to pilot projects, very keen
Lethbridge Regional Landfill	Lethbridge	iron dust (2004)	foundry		1300	contaminated soil	NE States good programs		CN&R #'s are low, private landfill gets most of it
Lethbridge Regional Landfill	Lethbridge	Paint solids (2004)	Newalta		300				Has a 500 kg/capita goal for 2010-not going to make it on current path
Lethbridge Regional Landfill	Lethbridge	Casting sand (2004)	foundry	same foundry as iron dust	2100				Class II and III Landfills
Lethbridge Regional Landfill	Lethbridge	Clay (process mud) (2004)	food	canbra foods/potato processor	750				
Lethbridge Regional Landfill	Lethbridge	Packing house waste (not rendered) (2004)		misc	1300				
Lethbridge Regional Landfill	Lethbridge	Byproducts (2004)	food	misc	650				

Alberta Beneficial Use of Waste Landfill Research

Company	Location	Waste Type	Associated Industry	Source	Annual Quantity Tonnes	Waste specific cells?	Knowledge of Programs? waste reduction/mgmt	Waste Tracking	Other Comments
Lethbridge Regional Landfill	Lethbridge	Sludge (2004)	Water Treatment, iodized filter cake from Kawneer	City/Kawneer(?)	2700				
Lethbridge Regional Landfill	Lethbridge	Asbestos (2004)	CRD	misc	75				
Lethbridge Regional Landfill	Lethbridge	Demo (2004)	CRD	misc	8000				Represents only a portion of this stream
Lethbridge Regional Landfill	Lethbridge	Contaminated Soil (2004)	O&G	misc upstream	30000				Downstream soils are remediated and used for cover, upstream wastes are not cost effective to remediate
Lethbridge Regional Landfill	Lethbridge	Concrete (2004)	CRD	misc	1300				
Lethbridge Regional Landfill	Lethbridge	Mustard Hulls (2004)	seed cleaning		150				
Lethbridge Regional Landfill	Lethbridge	Grain Dust (2004)	Agricultural	misc	40				Serves Taber, Vulcan, SE BE
Red Deer Waste Management Facility	Red Deer	animals			20	no	Lots of inhouse diversion projects, including composting, chipping of pallets for landscaping, recycing metals and using sawdust for improving secondary roads when muddy	Electronic	
Red Deer Waste Management Facility	Red Deer	Construction/Demo	builders/roofers/developers/drywallers	Misc	7780			Electronic	
Red Deer Waste Management Facility	Red Deer	Asbestos	Misc	Misc	72			Electronic	
Red Deer Waste Management Facility	Red Deer	Saw Dust	Misc	Misc	1487			Electronic	
Red Deer Waste Management Facility	Red Deer	Shingles	Misc	Misc	1386			Electronic	
Red Deer Waste Management Facility	Red Deer	wood	Misc	Misc	781			Electronic	
Red Deer Waste Management Facility	Red Deer	special waste	Misc	Misc	258			Electronic	
Red Deer Waste Management Facility	Red Deer	Concrete (2004)	Misc	Misc	412			Electronic	
Red Deer Waste Management Facility	Red Deer	Sod	Misc	Misc	203			Electronic	
Red Deer Waste Management Facility	Red Deer	Drywall	Misc	Misc	196			Electronic	
Medicine Hat Regional Landfill	Medicine Hat	Biosolids(lime sludge)	Water Treatment	Municipal (MH + one other community)	15000		composted		
Medicine Hat Regional Landfill	Medicine Hat	C&D	Misc	builders/demo/roofer	8000				General - chip clean wood (pallets) to use in composting
Medicine Hat Regional Landfill	Medicine Hat	Yard Waste		residential, park, commercial, industrial	4500		composted		Some still ends up in landfill since that is where some generators put it
Medicine Hat Regional Landfill	Medicine Hat	Puedo Clean fill		municipal and commercial	12000		used as landfill cover		General Comments - Looked at concrete crushing but too expensive
Medicine Hat Regional Landfill	Medicine Hat								
Medicine Hat Regional Landfill	Medicine Hat								
Fort McMurray Regional Landfill	Fort McMurray	ICI (2004)	Misc	Misc	19905				Asked O&G to segregate, but they don't
Fort McMurray Regional Landfill	Fort McMurray	Steel/Metals	Oil & Gas	Misc					Difficult to screen wastes
Fort McMurray Regional Landfill	Fort McMurray	CDR (2004)	Misc	Misc	18700				New Landfill in 2 yrs
Fort McMurray Regional Landfill	Fort McMurray	Drilling Waste	Oil & Gas			Metal & Steel/Construction			They take tires
Ryley (class I)									
Ryley (Regional operated by Canadian Waste)/Beaver Regional Waste Management Services Commission	Ryley								
Drayton Valley Regional Landfill Authority	Drayton Valley							Computerized program from Germany	Private company operating Roseridge/Aspen/Leduc/Drumheller/Hinton/Camrose and Red Deer landfills
East Peace River Regional Landfill Authority	Peace River	Drilling Sump Materials (gel chem, sumpgl)	Oil & Gas	Misc	12480.495	Sulphur cont. Debris only			Remediation of Drill cuttings possible @ $40/tonne but companies choose straight disposal at $20/tonne

Alberta Beneficial Use of Waste Landfill Research

Company	Location	Waste Type	Associated Industry	Source	Annual Quantity Tonnes	Waste specific cells?	Knowledge of Programs? waste reduction/mgmt	Waste Tracking	Other Comments
East Peace River Regional Landfill Authority	Peace River	Drilling Sump Materials (hydrocarbon, sumpin)	Oil & Gas	Misc	799.105				
East Peace River Regional Landfill Authority	Peace River	Catalyst (Sulphur, Catsu)	Oil & Gas	Misc	172.125				
East Peace River Regional Landfill Authority	Peace River	Contaminated Debris & Soil (Crude Oil/Condensate, soilco)	Oil & Gas	Misc	7750.485				
East Peace River Regional Landfill Authority	Peace River	Contaminated Debris & Soil (Produced/Salt Water, Soilpw)	Oil & Gas	Misc	5676.945				
East Peace River Regional Landfill Authority	Peace River	Contaminated Debris & Soil (refined fuels/Oils, soilro)	Oil & Gas	Misc	746.405				
East Peace River Regional Landfill Authority	Peace River	Contaminated Debris & Soil (Sulphur, soilsu)	Oil & Gas	Misc	58.505				
East Peace River Regional Landfill Authority	Peace River	wstnon (?nonspecified waste?)	Oil & Gas	Misc	84.84				
East Peace River Regional Landfill Authority	Peace River	White Asbestos	Misc	misc	8.355				
East Peace River Regional Landfill Authority	Peace River	Asbestos with debris	Misc	misc	47.02				
East Peace River Regional Landfill Authority	Peace River	Asphalt	Misc	misc	4.14				
East Peace River Regional Landfill Authority	Peace River	Bitumen/Gravel mix	Misc	misc	107.85				
East Peace River Regional Landfill Authority	Peace River	Dura Insulation	Misc	misc	6.725				
East Peace River Regional Landfill Authority	Peace River	hydrocarbon contaminated polyliner	Misc	misc	11.13				likely from UST pulls

	Number	Reference	Waste Types Id	Waste Sour	Industry	Research Area Ideas	Web Site Title/Source	Address/Location
SM	1	Landfill Research	Contaminated S	Misc	O&G/Other	O&G Associations/Large Oil Companies		
SM	2	Landfill Research/T	Lime sludge	WW Treatme	Municipal Water Treatment	Other Municipal Waste treatment locations/WW Treatment associations/	Wastewater Treatment Principles and Regu	http://ohioline.osu.edu/aex-fact/0768.html
SM	2	Landfill Research/T	Lime sludge	WW Treatme	Municipal Water Treatment	Other Municipal Waste treatment locations/WW Treatment associations/	The Production of Biosolids/Sludge	http://cwmi.css.cornell.edu/Sludge/Production.pdf
SM	2	Landfill Research/Tony	Lime sludge	WW Treatme	Municipal Water Treatment	Other Municipal Waste treatment locations/WW Treatment associations/	Agricultural utilization of lime treated sludge	http://www.iwaponline.com/wst/04209/wst042090203.htm
SM	2	Landfill Research/Tony	Lime sludge	WW Treatme	Municipal Water Treatment	Other Municipal Waste treatment locations/WW Treatment associations/	Sludge Disposal	http://ewr.cee.vt.edu/environmental/teach/wtprimer/sldg/sldg.html#coag
SM	2	Landfill Research/Tony	Lime sludge	WW Treatme	Municipal Water Treatment	Other Municipal Waste treatment locations/WW Treatment associations/	(1) Municipal Wastewater Services, (2) Bio	http://www.cwwa.ca/faqwastewater_e.asp
SM	3	Landfill Research	Absorbents (hyd	Misc	Misc	O&G Associations/Large Oil Companies/Spill Response Supply Companies	What is Absorbent Recycling?	http://www.ce-nc.com/absorbent.htm
SM	3	Landfill Research	Absorbents (hyd	Misc	Misc	O&G Associations/Large Oil Companies/Spill Response Supply Companies	Storm Water Technology Fact Sheet Sorbent Materials in Storm Water Applications	http://72.14.203.104/search?q=cache:xkMELbTtw9UJ:www.epa.gov/owm/mtb/sorbmat.pdf+hydrocarbon+recycling+absorbent&hl=en
SM	4	Landfill Research/CRRS	Shingles	Misc	Building/roofing/demo	Builder/Roofer Associations/Shingle Manufacturers	Asphalt Roofing Shingles Recycling: Introduction	http://www.ciwmb.ca.gov/ConDemo/Shingles/
SM	4	Landfill Research/CRRS	Shingles	Misc	Building/roofing/demo	Builder/Roofer Associations/Shingle Manufacturers	Roofing Shingles into Roads	http://www.moea.state.mn.us/lc/purchasing/shingles.cfm
SM	4	Landfill Research/CRRS	Shingles	Misc	Building/roofing/demo	Builder/Roofer Associations/Shingle Manufacturers	Markets for Recycling Asphalt Shingles	http://www.shinglerecycling.org/markets.asp
SM	5	Landfill Research/Tony	Iron Dust	Misc	Foundries	Foundry Associations/cement Manufacturers/associations	Recovery Zinc and Iron from EAF dust at Chiba Works	http://www.newsteel.com/features/NS9706F4.HTM
SM	5	Landfill Research/Tony	Iron Dust	Misc	Foundries	Foundry Associations/cement Manufacturers/associations	Ferrous Supplement -- A Second Home for Dust	http://www.recyclingtoday.com/articles/article.asp?Id=4266&SubCatID=42&CatID=11
SM	5	Landfill Research/Tony	Iron Dust	Misc	Foundries	Foundry Associations/cement Manufacturers/associations	Recycling of metallurgical by-products within integrated iron and steelmaking: experimental studies of cold bonded by-product pellets	http://epubl.ltu.se/1402-1757/2004/63/index-en.html
SM	5	Landfill Research/Tony	Iron Dust	Misc	Foundries	Foundry Associations/cement Manufacturers/associations	Recycling Steel Mill Waste, EAF Dust Processing for Low Cost Steel, Zinc and Brick Production	http://www.ceramics.com/cmb/#2
SM	5	Landfill Research/Tony	Iron Dust	Misc	Foundries	Foundry Associations/cement Manufacturers/associations	Recycling of Flue Dust into the Blast Furnace	http://72.14.203.104/search?q=cache:u5c9gZYBUhgJ:www.lkab.se/pdf/pdf_papers/2002_Recycling_of_flue_dust.pdf+recycle+iron+dust&hl=en
SM	6	Landfill Research	Casting Sand	Misc	Foundries	Foundry Associations/	Beneficial Reuse Of Foundry Sand: A Review Of State Practices and Regulations	http://www.epa.gov/sectors/metalcasting/reuse.pdf
SM	6	Landfill Research	Casting Sand	Misc	Foundries	Foundry Associations/	Beneficial Reuse of Spent Foundry Sand (Technical Brief)	http://www.cwc.org/industry/ibp951fs.pdf
SM	6	Landfill Research	Casting Sand	Misc	Foundries	Foundry Associations/	Primary Metals	http://www.p2pays.org/ref/01/text/00778/chapter3.htm
SM	6	Landfill Research	Casting Sand	Misc	Foundries	Foundry Associations/	Recycled Foundry Sand (RFS)	http://www.foundryrecycling.org/
	7	Landfill Research	Packing House Waste	Misc	Food	Meat processor associations/Composters/pet food companies		

	8	Landfill Research	Clay/Mud	Misc	Food	Food Processing Industry Associations/Large processorsj/Composting Programs		
zdr	9	Landfill Research	Asbestos	Misc	Building/Demo	Demo Companies ???		
SM	10	Landfill Research/CRRS	Concrete	Misc	Building/Demo	Cement Manufactures/Associations	Concrete Recycling	http://www.camrose.com/engineer/ConcreteRecycling/concrec.htm
SM	10	Landfill Research/CRRS	Concrete	Misc	Building/Demo	Cement Manufactures/Associations	Concrete recycling takes off: the renewal of Denver's Stapleton Airport showcases concrete's place as a sustainable material	http://www.findarticles.com/p/articles/mi_m0NSY/is_9_22/ai_n6180997
SM	10	Landfill Research/CRRS	Concrete	Misc	Building/Demo	Cement Manufactures/Associations	Concrete Thinking for a Sustainable Future	http://www.cement.ca/cement.nsf/0/6ABDCDE126A87A6C85256D2E005CC53B?OpenDocument#sustainable
SM	10	Landfill Research/CRRS	Concrete	Misc	Building/Demo	Cement Manufactures/Associations	1999 Pollution Prevention Award Recipient Accomplishments	http://sacberc.org/99RecAccomp.html#Livingstons
SM	10	Landfill Research/CRRS	Concrete	Misc	Building/Demo	Cement Manufactures/Associations	Concrete for Bank Stabilization	NSDAF uses
	11	Landfill Research	Seed Hulls	Misc	Seed Cleaning	Seed Industry/Composing Programs		
	12	Landfill Research	Grain Dust	Misc	Agricultural	Agricultural Associations/Farm/Grain Handlers etc		
SM	13	Landfill Research/CRRS	Drywall	Misc	Building/Demo	Builder/Roofer Associations	Wallboard (Drywall) Recycling	http://www.ciwmb.ca.gov/ConDemo/Wallboard/
SM	13	Landfill Research/CRRS	Drywall	Misc	Building/Demo	Builder/Roofer Associations	Gypsum Drywall Recycling	http://gypsumrecycling.com/
SM	13	Landfill Research/CRRS	Drywall	Misc	Building/Demo	Builder/Roofer Associations	Stop Landfilling Drywall: New process saves money and recycles drywall material	http://www.pollutionengineering.com/CDA/ArticleInformation/features/BNP__Features__Item/0,6649,108359,00.html
SM	13	Landfill Research/CRRS	Drywall	Misc	Building/Demo	Builder/Roofer Associations	Information on Recycling Construction and Demolition Debris	http://www.wastecap.org/wastecap/commodities/construction/construction.htm
SM	13	Landfill Research/CRRS	Drywall	Misc	Building/Demo	Builder/Roofer Associations	Creating Markets for Construction and Demolition Debris	http://www.epa.gov/jtr/about/presentations/market.htm
	14	Landfill Research/Tony	Drilling Waste	Misc	O&G	O&G Associations/Large Oil Companies		
SM	15	Landfill Research	Asphalt	Misc	Paving/Demo/Road Mainter	Paving Companies/provincial&federal transport	Asphalt Pavement Recycling	http://www.ciwmb.ca.gov/ConDemo/Roads/default.htm#RAC
SM	15	Landfill Research	Asphalt	Misc	Paving/Demo/Road Mainter	Paving Companies/provincial&federal transport	America's Most Recycled Product	http://www.miasphalt.com/america.html
SM	15	Landfill Research	Asphalt	Misc	Paving/Demo/Road Mainter	Paving Companies/provincial&federal transport	All About Asphalt	http://www.hotmix.org/allaboutasphalt.php
SM	15	Landfill Research	Asphalt	Misc	Paving/Demo/Road Maintenance	Paving Companies/provincial&federal transport	Asphalt In-Place Recycling	http://www.betterroads.com/articles/jul03c.htm
SM	15	Landfill Research	Asphalt	Misc	Paving/Demo/Road Maintenance	Paving Companies/provincial&federal transport	Hot in-place recycling gaining acceptance in Canada	http://rocktoroad.com/hotinplace.html
SM	16	Landfill Research/CRRS	Insulation	Misc	Building/Demo	Builder Associations	Use and Reuse	http://www.naima.org/pages/benefits/environ/use.html
SM	16	Landfill Research/CRRS	Insulation	Misc	Building/Demo	Builder Associations	Shell (UK) Commits To Insulation Recycling Programme	http://www.rockwool.co.uk/sw51829.asp
zdr	17	Landfill Research/Tony/CRRS	Animals (road kill?? Diseased farm animals)	Misc	Farm?	Farming/cattle/provincial parks (RK)		
	18	Landfill Research	Paint Solids	Misc	Paint/renovation	Paint Associations/Chemical companies		
	19	Landfill Research	Drums/Pails	Misc	Misc	????		

20		Landfill Research	Empty Paint cans/pails	Misc	Paint/renovation	Paint Associations/Chemical companies		
21		Tony/CRRS	Fly Ash/Coal Ash	Coal Combustion	Steel Manufacturers?/Cement Manufacturers	Steel/Cement Associations		
22		Tony/Landfill Research	Sulphur Contaminated Wastes	Misc	O&G (mostly)	O&G Associations/Large Oil Companies		
23		Tony	Frac Sand(Lloydminster)	Misc	O&G	O&G Associations/Large Oil Companies		
24		Tony	Mine Tailings	Misc	Mining	Mining Association/Metal Producers		
25		Landfill/Tony/CRRS	WoodWaste (incl. pressure treated lumber, Railway ties)	Misc	Forestry/Landscaping/Lumber Production/other	Forestry industry/Manufacturing companies/Parks etc		
26		CRRS	Flared Gas	Misc	O&G	O&G Associations/Large Oil Companies		
27		CRRS	Computers	Misc	Multiple	Tech Associations		
28		CRRS	Sulphur	Misc	O&G			
29		CRRS	Fibre Optic Cable	Misc	Communication	Utility Companies		
30		CRRS	Water	Misc	Misc	General search for WW usage..(irrigation, other?)		
31		CRRS	Waste Exchange Leftovers	?	?			
32		CRRS	Industrial Waste Heat	Misc	Petro chemical?? Other	Waste Energy Utilization		
Other:	general	web search	Online Exchange	Misc	Misc	Misc	RecycleNet Corporation (NewYork); Recycle World - The Recycler's Exchange	http://www.recycle.net/
	tires	web search	Tire Recycling Alberta		automotive		Recycle tire crumb into durable asphalt	http://www.trma.com/admin/DynomicPage/default.cfm?PageId=118
	tires	web search	Tire Recycling		automotive and larger tires		Ontario Waste Materials Exchange	http://www.owe.org/main.asp?process_name=success_stories#misc
	general	web search	Municipal and Residual Waste	Misc	misc	beneficial uses of municipal and residual wastes	beneficial use permits issued by Central Office of Pennsylvania Department of Environmental Protection	http://www.dep.state.pa.us/dep/deputate/airwaste/wm/MRW/docs/GP_BU_PERMITS.htm

Appendix B

Workshop Documentation

The Beneficial Use of Waste Workshop

Date: Friday, October 28, 2005

Location[1]**:** Edmonton Waste Management Centre of Excellence
Administration Building Classroom
Site 100, 13111 Meridian Street
Edmonton, Alberta

Time: Starting at 10:00 am sharp, the session will run until 2:00 pm, a catered lunch and drinks will be provided

Project Goal: To identify three waste types in Alberta that have the potential to be utilized as a resource and provide recommendations to affect the change from waste to resource utilization

Workshop Objective: To identify and prioritize candidate wastes and management alternatives with the potential for implementation to a secondary resource program

Structure of Workshop

Project Background
- A review of the project team, objectives and proposed methodology

Waste Profiling
- Identified Waste Types
- Discussion to Add/Delete Waste Types Listed

Narrowing Waste Types
- Review Barriers to Waste to Resource Opportunities
- Review Governments Role in helping to affect a Waste to Resource Management System
- Prioritize Waste Types Given the Existing Barriers and Ability to Remove them

Identifying Potential Uses
- Review Identified Technologies/Programs for Top Waste Types
- Discussion on Additional Technologies/Programs for Top Waste Types

Identification of the Top Three Waste to Resource Opportunities

[1] A map to the Centre is also attached with directions from Oxbridge Place

Ministry Attendees

Name	Background/Title
Jodi Tomchyshyn	Waste Reduction Policy, Leaf & Yardwaste, Construction and Demolition
Keith Leggat	Director of Environmental Policy
Walter Ceroici	Environmental Policy Branch, Science and Innovation, Technology
Niel Wandler	Pollution Prevention
Donna Chaw	Waste Composting expert,
Bob Rippon	Land Policy Advisor
Sadiq Unwala	Land Waste Policy Advisor
Brenna McLennan	?
Antonio Fernandes	Environmental Policy Branch, Science and Innovation, Technology

Team Attendance

Wit Siemieniuk	AMEC
Tracy Chambers	AMEC
Zoë Ramdin	AMEC
Bud Latta	City of Edmonton
Salim Abboud	Alberta Research Council
Christian Felske	Alberta Research Council
Richard Johnson	Alberta Research Council
Daryl McCartney	University of Alberta

amec

The Beneficial Use of Waste

A Study Conducted by AMEC Earth & Environmental
and the
Edmonton Waste Management Centre of Excellence

Workshop with the Science and Innovation Section of the Environmental Policy Branch, Alberta Environment

28 October 2005

Structure of Workshop

- Project Background
- Waste Profiling:
  - Identified waste types
  - Discussion to add/delete waste types
- Narrowing Waste Types:
  - Review barriers to waste-to-resource opportunities
  - Review government's role in helping to affect a waste-to-resource management system
  - Prioritize waste types given the existing barriers and ability to remove them
- Identifying Potential Uses:
  - Review identified technologies/programs for selected waste types
  - Discussion on additional technologies/programs for selected waste types
  - Identification of the top three waste-to-resource opportunities



Project Background

Project Goal

- To identify three industrial waste types in Alberta that have the potential to be utilized as a resource and provide recommendations to affect the change from waste to a resource

Introductions

- Project Team:
  - AMEC
  - EWMCE
- Client:
  - Alberta Environment

Project Objectives

- Identify and prioritize the waste types in terms of opportunity for secondary use
- Target techniques and practices that could lead to beneficial use
- Outline a management options framework for the priority waste that will link industry-wide pollution prevention and recycling program initiatives
- Provide an implementation strategy that will generate ideas and information for industry and for government to promote the concept of beneficial use of waste for the identified priority waste streams
- Minimize re-work or re-research that other groups may have done specific to waste to resource

Scope of Project

- Industrial waste only; no municipal
- Wastes that are relevant to Alberta
- Includes solid wastes only
- Includes hazardous and non-hazardous waste
- No construction or demolition waste
- No waste to energy

Project Structure

- Waste Profiling
- Literature Review
- Team Workshop
- Concept Development
- Cost Benefit Analysis and Prioritization
- Implementation Planning

Purpose of Team Workshop

- To brainstorm the results of the waste profiling and literature review exercises to identify and prioritize candidate wastes for secondary resource utilization

Waste Profiling

Methodology

- Lack of a meaningful industrial waste database at a provincial level
- Examined various sources to identify waste types:
  - Tony Fernandes
  - Internal AMEC personnel
  - Disposal sites (e.g., landfill operators, WFER sites)
  - Consultations on a Canadian Resource Recovery Strategy summary of Edmonton/Prairie provinces consultation (April 2002, NRCAN)

Industrial Wastes Identified in Alberta in Significant Quantities

Industry	Waste Types
Oil & Gas	Contaminated soil (hydrocarbons/metals/chloride/ sulphur), absorbents (hydrocarbons), drilling waste, sulphur-contaminated wastes, Frac sand, sulphur, produced sand
Mining	Tailings
Construction & Demolition	Shingles, insulation, drywall, asbestos, wood, concrete, paint solids, empty paint cans/pails
Foundries/Metal Casting	Iron dust, casting sand
Food/Agriculture	Packing house waste, seed hulls, clay/mud from food processing, grain dust, animals (road kill, farm mortalities, veterinary offices), Specified Risk Materials (SRM)
Coal Burning	Coal ash/fly ash

Industrial Wastes Identified in Alberta in Significant Quantities *(cont)*

Industry	Waste Types
Transportation (Demolition)	Asphalt
Forestry/Wood Processing	Wood, sawdust
Landscaping	Wood, leaves, grass clippings
Communication	Fibre optic cable
Fertilizer	NORM gypsum
Miscellaneous	Lime sludge, wood, wood fly ash, computers, drum and pails
Others?	



Barriers

Barriers to Beneficial Use

- There are two types of barriers:
  - Technical
  - Financial

Barriers to Beneficial Use *(cont)*

- Technical:
  - Limited awareness of beneficial use issues at the decision-making level
  - Lack of in-house technical expertise
  - Absence of beneficial use technologies that can be adopted directly
  - Liability
  - Attitude against implementing process change
  - Reluctance to take risks by generators (negative perceptions)
  - Regulatory/legal

Barriers to Beneficial Use *(cont)*

- Financial:
  - Unavailability of capital to affect change even if operating savings are to be realized
  - Less expensive disposal options

Programs to Promote Beneficial Use by Government

- Government plays role of catalyst to encourage beneficial use by:
  - Providing regulatory framework
  - Providing assistance
- Various government program types

Programs to Promote Beneficial Use By Government *(cont)*

- **Regulatory**: Government agencies can contribute to beneficial use by:
    - Encouraging/seeking input from regulated community prior to implementing regulations
    - "Pushing the edge" in product development and manufacturing methods which provides motivation for beneficial use; i.e., regulation gets a generator's attention
    - Providing incentives and assistance to encourage business

Programs to Promote Beneficial Use By Government *(cont)*

- **Assistance:** Government can contribute to beneficial use by:
  - Funding and performing research not covered by private sector
  - Funding and supporting industries willing to perform demo projects and go public with results
  - Encouraging utilization of results from beneficial use research
  - Serving as technical link between industry and stakeholders
  - Serving as focal point for comprehensive multimedia benefit use strategies
  - Compiling and distributing cost effective beneficial use strategies that do not negatively affect process/product performance or production rates

Programs to Promote Beneficial Use By Government *(cont)*

- **Program Types:** Diversity of options for government involvement lead to four broad program types:
  - Voluntary compliance
  - Economic incentives program
  - Mandatory direct regulatory measures
  - Indirect regulatory measures

Programs to Promote Beneficial Use By Government *(cont)*

- Voluntary Compliance Programs:
  - Technical assistance programs
  - Technical information exchange programs
  - Research development and demonstration programs
  - Awards programs
  - Waste exchange programs
  - Industry partnerships

Programs to Promote Beneficial Use By Government *(cont)*

- Technical Assistance Programs:
  - Audits of generator's waste production and management
  - Information on new technologies, source of equipment and engineering expertise
  - Assistance in obtaining financing for new capital investment
  - Coordination of efforts by groups of similar small businesses to improve beneficial use
  - Production of handbooks, education materials, newsletters and seminars
  - Chamber of Commerce/industry trade group joint programs

Programs to Promote Beneficial Use By Government *(cont)*

- Economic Incentives Program for beneficial use:
  - Taxes
  - Subsidies
  - Fines
  - Profit potential identification

Programs to Promote Beneficial Use By Government *(cont)*

- Mandatory direct regulatory measures:
  - Mandatory waste audits and facility plans
  - Bans on certain chemicals, products and management practices
  - Mandatory release reports
  - Mandatory performance standards
  - Regulatory simplification

Programs to Promote Beneficial Use By Government *(cont)*

- Indirect regulatory measures:
  - Controlling and restricting of pollutants released to environment
  - Government influence on treatment and disposal costs

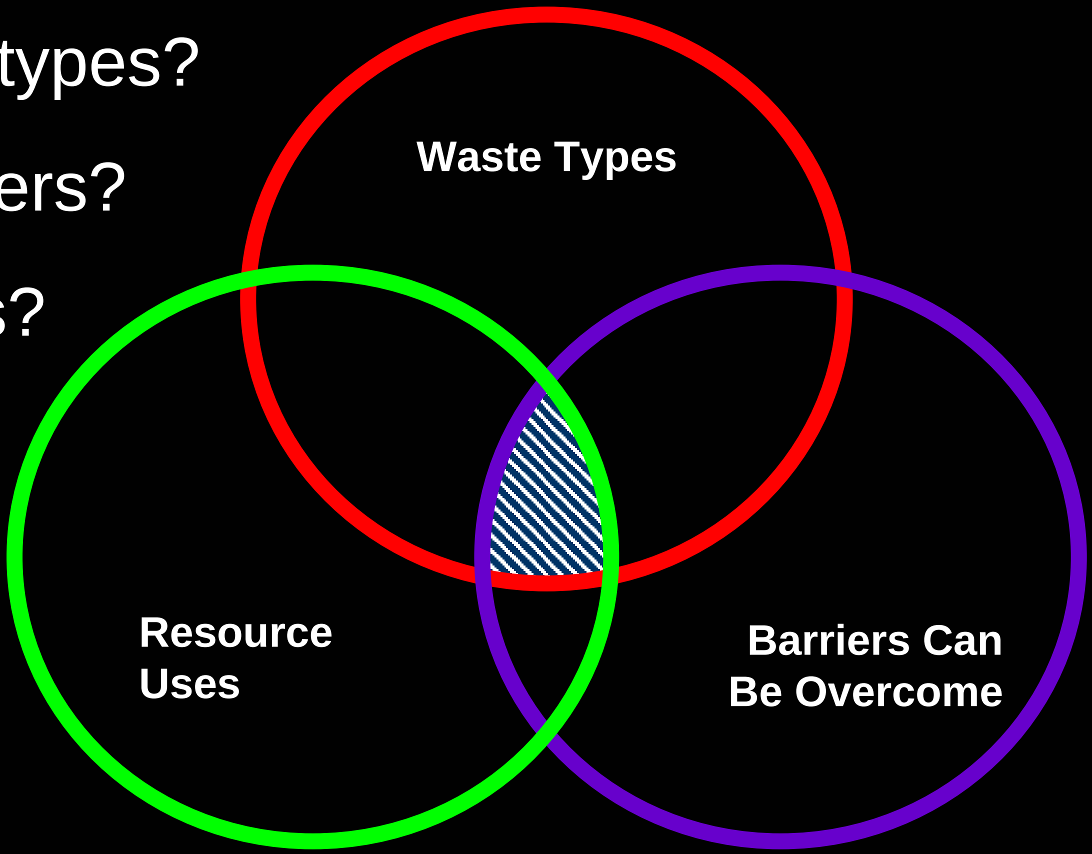
Identifying the Top Three

Discussion

What three waste types?

What are the barriers?

What technologies?



Beneficial Use of Waste
Project CE03316

WORKSHOP FINDINGS
October 28, 2005

Wastes Reviewed[1]:

Industry	**Waste Types**
Coal	Coal Ash, Fly Ash, *washings/fines*
Transportation	Asphalt
Forestry	Wood debris, sawdust, *tree seedling containers*
Communication	Fibre Optic Cable
Fertilizer	Gypsum (NORM)
Oil & Gas (upstream)	Sulphur wastes, produced sand, drilling wastes, contaminated soil, absorbents, frac sand, sulphur
Oil & Gas (downstream)	Contaminated soil, absorbents, *hydrocarbon wastes/sludges (e.g. tank bottoms)*
Pulp & Paper	*Organic Sludges, Bio-solids, de-inking sludge, hog fuel, lime*
Greenhouses	*Coir (?), rooting media*
Hydro-Metallurgy	*Ni-Fe Tailings*
Petrochemical	*Tank bottoms, spent catalyst, petroleum coke, polymers*
Food	Specified Risk Materials (SRM), packing house waste, clay/mud from food processing, *kitchen waste*
Agriculture	Seed hulls, farm mortalities, grain dust, *manure, mushroom waste*
Cement Manufacturing	*Kiln Dust (Calcium Oxide)*
Steel Foundries/Metal Casting	Iron dust, casting sand
Automobile Wrecking	*Shredder Residue (ASR)*
Mining	Tailings
Construction & Demolition	Shingles, insulation, drywall, asbestos, wood, concrete, paint solids, empty paint cans/pails
Wood Processing	Wood debris, sawdust
Landscaping	Wood, leaves, grass clippings
Miscellaneous	Lime sludges/*water treatment sludges*, wood fly ash, road kill, computers/electronics, drums/pails, *organic waste, packaging from misc. industries*

[1] Waste types listed in italics were added to the list at the workshop

Beneficial Use of Waste
Project CE03316

WORKSHOP FINDINGS
October 28, 2005

Ideas for Government to promote Waste to Resource Utilization[2]:

- Government policy that targets beneficial use
- Development of recycling policies
- Regulate acceptable practices
- Simplify confusing regulations
- Programs to:
  - improve public/corporate perception
  - improve waste knowledge transfer on utilization opportunities
- Work to remove overlapping jurisdictions for specific waste types
- Government must lead by example
- Provide funding/funding coordination
- Program to look at “ENVIROVISTA” (rewards industry that exceeds AE expectations)

Criteria used to Select Waste Types for further Study

- Minimize the time for implementation
- Industry readiness for change (financial commitment, openness of recognition of waste issue)
- Sustainability Measurements (environmental, social, financial)
- Diversity and number of generators
- Geographic concerns
- Political Acceptance
- Current cost of disposal
- Volumes generated
- Characterization/Complexity of waste
- Potential for opportunities
- Liabilities/Risks
- Within scope of project
- Current pilot projects/Historical efforts
- Economic Value/Markets ($$)
- Technologies
- Specificity

[2] These ideas were suggested by workshop participants and were in addition to those presented

Beneficial Use of Waste
Project CE03316

WORKSHOP FINDINGS
October 28, 2005

Waste Selected for Advanced Review and Conceptual Design

1. Contaminated Soil

Benefits to Selection for further study:
- LOTS of research
- We have the technology (Richard, Salim as technical contacts)
- Will have support at federal level since it will fit in with Greenhouse gas (GHG) initiatives (GHG now on CEPA toxics list)

Challenges for further study:
- Would be useful to remove from waste stream but value added product not there
- Easy/inexpensive to dispose of, could be addressed by disposal bans/restrictions

2. Organics

Benefits to Selection for further study:
- Lots of technologies (Daryl, Salim, Donna, Bud, Christian)
- Since it will be addressing GHG concerns (see note on Contaminated Soil) there will be $$ available to make it happen
- May have political will to make it happen
- High awareness

Challenges for further study:
- Will require economic incentives since alternatives are less expensive
- Need to develop markets

Additional Information/Ideas
- Bud as contact for CCC info
- Daryl as contact for Federal Protocols

3. Phospho-Gypsum

Benefits to Selection for further study:
- Lots of potential uses (Richard)

Challenges for further study:
- Social perceptions
- NORM risk materials

Additional Information/Ideas:
- Salim (characteristics),
- Look at synergies with other waste types

Beneficial Use of Waste
Project CE03316

WORKSHOP FINDINGS
October 28, 2005

4. Produced Sand

Benefits to Selection for further study:
- EUB has done a lot of work
- HUGE volumes out there
-

Challenges for further study:
- Cheap disposal available
-

Additional Information/Ideas:
- Road construction (Tony)
- Characterization (Sue H.)
- EWMC is already looking at (Bud)

5. Ashes (fly, coal, wood)

Benefits to Selection for further study:
- Lots of technology, uses & research (Richard, Christian)
- Use is established in Alberta (George Armstrong/Salim)
- Cenospheres

Challenges for further study:
- Lack of awareness
- Geographical concerns
- Potential for resistance to change and negative perceptions
- Financial

6. Cement Kiln Dust

Benefits to Selection for further study:
- Lots of research (Daryl)

Challenges for further study:
- Geographical (waste to market)

Additional Information/Ideas:
- Contact manufacturers
- Calcium Oxide
- Construction materials use
- Binders/fillers
- Soil conditioning
- Road work

Appendix C

Selection Criteria Matrix

Selection Criteria for Wastes Selected for Advanced Review/Conceptual Design

WT (0-5)	Criteria	Contaminated Soil	Score (0-5)	Organics	Score (0-5)	Phospho-Gypsum	Score (0-5)	Produced Sand	Score (0-5)	Ashes (fly, coal/wood)	Score (0-5)	Cement Kiln Dust	Score (0-5)
y/n	Other agency/group already 'champion' for programs/ options (y/n)	No	N/A	Yes (composting Council of Canada)	N/A	No	N/A	Yes (EUB, EWMCE)	N/A	Yes (wood ash: Alberta Forest products Assoc/Alberta Agriculture/Alberta Environment)	N/A	Yes	N/A
5	Characterization/complexity of waste/ "specific-enough?" (optimal is very simple, consistent waste from very few sources)	Dependant on source, varies widely, focus only on hydrocarbon contaminated soils	0	Dependant on source, varies widely	2	Metals, fluorides and radionuclides (radon gas)	4	*Frac Sand:* Aluminum silicate beads with crude oil *Foundry Sand:* Metals, formaldehyde, oil & grease; comments: each industries sand could be well characterized but when looking at all produced sands they are very different	3	*Fly Ash:* Si, Al, Ca, Fe. Fine grained made up of spherical, glassy particles. *Wood Ash:* K, Mo, As, B, Cu, Ni, Cd, Pb, Se, Co, Hg, Zn, Cr (consistent if produced under controlled conditions-beehive burners produce inconsistent product)	3	Can depend on source (Haz or Non-haz kiln?) but usually contains some metals and dibenzofurans and dibenzodioxins but since only 2 generators in AB characteristics should be able to be clearly defined once source control is established; K content makes it appealing for a soil amendment	4
4	Current cost of disposal (optimal is high disposal costs)	Depends on level/type of contamination and required transportation($)	2	Disposal is less expensive than any other treatment option	2	Currently "stored" in stacks no disposal options; requires large land base for storage, as land costs go up storage will as well	2	Low?	2	Generally low depending on the location or if company has own landfill	2	Generally low depending on the location or if company has own landfill	2
5	Current pilot projects/historical efforts/technologies available (optimal is lots of background/ history/ technology)	Technology exists for treatment	5	Lots of work related to composting, primary technology used	5	Has been used for plaster board, drywall, bricks, in cement manufacturing, soil amendments, landfill cover, road base	5	*Frac Sand:* Construction fill if separated from crude (but expensive process; reuse has been explored as an option) *Foundry Sand:* Aggregate, pipebedding material, foundation support, road bed material, cement, bricks, composting	2	*Coal Fly Ash:* Commonly used in Europe as a substitute for natural resources in the production of cement & concrete, Cenospheres(?). *Wood Ash:* Alberta Pacific has used it as a soil amendment/backfill, reclamation, reforestation, cinder blocks, interlocking bricks, particle/cement board, oil & gas spill clean up	**5**	Agricultural Applications (liming acidic soils)/waste stabilization & solidification/portland cement replacement/lightweight aggregate/construction fill, metal recovery, building bricks, recycling back into process	5
4	Geographic considerations (optimal is close to market, dense concentration of waste)	Many (i.e., thousands) of sources spread out across province; distance to market varies	1	Many types of sources/industries will produce organic waste	0	Westco Fertilizers Ltd. (Calgary) and Agrium (Redwater) are the main generators	5	Foothills Steel Foundry, M.A. Steel Foundry, Sovereign Castings Ltd., Trojan Industries (Calgary); Lethbridge Iron Works; Alta Steel, Behrends Bronze Inc., Quality Steel Foundries (Edmonton); Wilderness Castings Ltd. (Athabasca); Delburne Foundry Ltd. Also Oilsands locations for Frac Sand	3	*Coal Ash:* Generators are located: Sundance - 80 W of Edmonton; Wabamun - 70 km W of Edmonton; Keepsills - 70 km W of Edmonton; Battle River - 200 km NE of Calgary; and Genesse - W of Edmonton *Wood Ash:* Hinton (Weldwood pulpmill), Grand Prairie (Ainsworth Lumber Company)	4	Two main generators in AB, one near Edmonton the other near Calgary (Inland & Lafarge)	5
3	Economic value/existing markets (optimal is high value, plenty of market demand)	Little to no economic value, often used for landfill cover or fill	1	Requires a strong marketing program to promote worth & acceptance as a product once established product is considered valuable	2	If liability concerns are dealt with significant economic value would be realized due to multiple potential uses with high demand	4	Not much found for frac sand; foundry has more options	3	Variety of uses that have been established locally and internationally with market value	5	Value has been recognized in US programs	4
2	Industry readiness for change (financial commitment, recognition of waste issue) (optimal is proactive industry already looking for options)	Dig/dump is primary method of mgmt since disposal cost are cheap CAPP has many programs/ initiatives; potential for $$ due to GHG concerns	2	Very diverse industry range; potential for program $$ due to GHG concerns	2	International Fertilizer Industry Association has examined options; industry is keen to find a safe use for the waste but use has been hampered by contaminant concerns	4	Little comment on waste handling for foundry operations, some information found for frac sand (Pacific Northwest Pollution Prevention Centre)	2	Use is already established in Alberta & some industry has researched/started alternate use; some European countries boast 100% reuse of coal fly ash & handle it as a resource	4	Lafarge openly advertises on it's website for business partners interested in accepting wastes that traditionally go to landfill	5
4	Liabilities/risks (optimal is no liability or risk involved)	If not properly remediated could contaminate land/water where it is placed	2	If varied organic waste types are accepted for treatment they would have to be closely monitored for contaminants of concern	3	NORM; risk/fluorides/metals	1	Not well known	2	Some contaminants of concern identified in waste but source control can alleviate concerns; established uses well studied; studies in Europe on coal fly ash indicate it can be safely reused	2	Potential for metal leachate (As, Cd, Pb, Tl, Sb, Be, Cr, Ag, Ni, Ba, etc.) depending on metal content; can also contain chlorinated dibenzofurans or dibenzodioxins	2
2	Ability to minimize time for implementation (optimal is near-future implementation)	Would happen quickly if legislation (driver) were in place to restrict disposal or disposal was costly	4	Technology is straight forward & easy to set up for small composing operations, establishing the process (including waste screening, transportation, market) would take more time	3	Physical infrastructure would need to be developed for processing waste; waste is centralized with large volumes in one area and close to potential users; would lend itself well to industrial ecology	3	Given that the generators are diverse and little work has been done for some produced sand it could be longer before a system could be put in place.	2	Implementation should not be difficult since track record/process is well established	4	Given there are only 2 main generators and several options for use (including some for the original generator) implementation time should be minimal	4

WT (0-5)	Criteria	Contaminated Soil	Score (0-5)	Organics	Score (0-5)	Phospho-Gypsum	Score (0-5)	Produced Sand	Score (0-5)	Ashes (fly, coal/wood)	Score (0-5)	Cement Kiln Dust	Score (0-5)
3	Political acceptance (with public and between government agencies) (optimal is the 'easy sell')	Public perceptions post-Lynnview Ridge make it difficult politically	2	Relatively accepted but would still require some education for users and waste producers	4	Would require significant education to adequately answer contaminant concern	2	Not well known	2	Use is already established in Alberta (even more so in Europe) & some industry has researched/ started alternate use	4	May not require public/political acceptance if internally reused; if used as a soil amendment will require more of a sell	3
3	Potential for opportunities/synergies (optimal is high potential, examples exist)	Landfill cover, road construction, fill; i.e., several 'uses'	3	If waste is located near a user good potential would exist	4	High potential for partnerships/ industrial ecology developments	5	Potential for partnerships for foundry sand, frac is more challenging	3	Kalunborg, Denmark Industrial Ecology plant utilizes coal ash in the making of cement roadways	4	Potential exists for the dust to be reused by the company that generates it; it may also be possible for ashes and dust to be utilized together in road construction	4
3	Sustainability measures (environmental/social/financial and indefinitely self-sustaining) (optimal is good triple bottom line and easy to make self sufficient)	Until the value of "clean" soil increases it will be difficult to make this sustainable without considerable incentives	1	Potential exists for sustainability if obstacles of product value & disposal costs are overcome	3	If liability concerns are dealt with and infrastructure developed should be self sustaining	5	Costs would be high to deal with frac sand unless a simple/inexpensive reuse option could be found; transportation down to population centres would prohibit frac sand use to locations near where it was developed; foundry sand has more options	2	Models in Europe currently exist that are sustainable, the only added challenge here might be geography	4	Cement Association of Canada supports sustainable industry; models for use currently exist in the US	4
2	Volumes generated (large/med/small) (optimal is large quantity	Large	5	Large	5	Large (for every kg of fertilizer produced 5 kg of gypsum is produced)	5	Large	5	Large (180K tonnes/yr in AB for pulpmills/sawmills/oriented strand board/fibre board plants only-number from Alberta Gov. Agriculture, Food & Rural Development)	4	Large (9 tonnes for every 100 tonnes of clinker generated)	5
200	**GRAND TOTAL**		**88**		**114**		**149**		**101**		**147**		**154**

Note:

Ratings are 0-5 with 5 optimal
Waste streams are to be within the scope of the BUW project (i.e. industrial solid wastes, non-C&D, etc.)

Appendix D

US Subpart Rule – Phosphogypsum

Subpart R Rule

PART 61-National Emission Standards for Hazardous Air Pollutants
Subpart R: National Emission Standards for Radon Emissions
from Phosphogypsum Stacks

Source: 57 FR 23317, June 3, 1992, unless otherwise noted.

Sec. 61.200 Designation of facilities

The provisions of this subpart apply to each owner or operator of a phosphogypsum stack, and to each person who owns, sells, distributes, or otherwise uses any quantity of phosphogypsum which is produced as a result of wet acid phosphorus production or is removed from any existing phosphogypsum stack.

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Sec. 61.201 Definitions.

As used in this subpart, all terms not defined here have the meaning given them in the Clean Air Act or subpart A of part 61. The following terms shall have the following specific meanings:

(a) Inactive stack means a stack to which no further routine additions of phosphogypsum will be made and which is no longer used for water management associated with the production of phosphogypsum. If a stack has not been used for either purpose for two years, it is presumed to be inactive.

(b) Phosphogypsum is the solid waste by-product which results from the process of wet acid phosphorus production.

(c) Phosphogypsum stacks or stacks are piles of waste resulting from wet acid phosphorus production, including phosphate mines or other sites that are used for the disposal of phosphogypsum. return to: [top] [previous location]

Sec. 61.202 Standard

Each person who generates phosphogypsum shall place all phosphogypsum in stacks. Phosphogypsum may be removed from a phosphogypsum stack only as expressly provided by this subpart. After a phosphogypsum stack has become an inactive stack, the owner or operator shall assure that the stack does not emit more than 20 pCi/m^2-s of radon-222 into the air.

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Sec. 61.203 Radon monitoring and compliance procedures.

(a) Within sixty days following the date on which a stack becomes an inactive stack, or within ninety days after the date on which this subpart first took effect if a stack was already inactive on that date, each owner or operator of an inactive phosphogypsum stack shall test the stack for radon-222 flux in accordance with the procedures described in 40 CFR part 61, appendix B, Method 115. EPA shall be notified at least 30 days prior to each such emissions test so that EPA may, at its option, observe the test. If meteorological conditions are such that a test cannot be properly conducted, then the owner or operator shall notify EPA and test as soon as conditions permit

(b) (1) Within ninety days after the testing is required, the owner or operator shall provide EPA with a report detailing the actions taken and the results of the radon-222 flux testing. Each report shall also include the following information:

- (i) The name and location of the facility;
- (ii) A list of the stacks at the facility including the size and dimensions of each stack;
- (iii) The name of the person responsible for the operation of the facility and the name of the person preparing the report (if different);
- (iv) A description of the control measures taken to decrease the radon flux from the source and any actions taken to insure the long term effectiveness of the control measures; and
- (v) The results of the testing conducted, including the results of each measurement.

(2) Each report shall be signed and dated by a corporate officer in charge of the facility and contain the following declaration immediately above the signature line: "I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment." See, 18 U.S.C. 1001.

(c) If the owner or operator of an inactive stack chooses to conduct measurements over a one year period as permitted by Method 115 in appendix B to part 61, within ninety days after the testing commences the owner or operator shall provide EPA with an initial report, including the results of the first measurement period and a schedule for all subsequent measurements. An additional report containing all the information in Sec.61.203(b) shall be submitted within ninety days after completion of the final measurements.

(d) If at any point an owner or operator of a stack once again uses an inactive stack for the disposal of phosphogypsum or for water management, the stack ceases to be in inactive status and the owner or operator must notify EPA in writing within 45 days. When the owner or operator ceases to use the stack for disposal of phosphogypsum or water management, the stack will once again become inactive and the owner or operator must satisfy again all testing and reporting requirements for inactive stacks.

(e) If an owner or operator removes phosphogypsum from an inactive stack, the owner shall test the stack in accordance with the procedures described in 40 CFR part 61, appendix B,Method 115.The stack shall be tested within ninety days of the date that the owner or operator first removes phosphogypsum from the stack, and the test shall be repeated at least once during each calendar year that the owner or operator removes additional phosphogypsum from the stack. EPA shall be notified at least 30 days prior to an emissions test so that EPA may, at its option, observe the test. If meteorological conditions are such that a test cannot be properly conducted, then the owner shall notify EPA and test as soon as conditions permit. Within ninety days after completion of a test, the owner or operator shall provide EPA with a report detailing the actions taken and the results of the radon-222 flux testing. Each such report shall include all of the information specified by Sec. 61.203 (b).

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Sec. 61.204 Distribution and use of phosphogypsum for agricultural purposes. [64 5574 February 3, 1999]

Phosphogypsum may be lawfully removed from a stack and distributed in commerce for use in agriculture if each of the following requirements is satisfied:

(a) The owner or operator of the stack from which the phosphogypsum is removed shall determine annually the average radium-226 concentration at the location in the stack from which the phosphogypsum will be removed, as provided by Sec. 61.207.

(b) The average radium-226 concentration at the location in the stack from which the phosphogypsum will be removed, as determined pursuant to Sec. 61.207, shall not exceed 10 picocuries per gram (pCi/g).

(c) All phosphogypsum distributed in commerce for use pursuant to this section by the owner or operator of a phosphogypsum stack shall be accompanied by a certification document which conforms to the requirements of Sec. 61.208(a).

(d) Each distributor, retailer, or reseller who distributes phosphogypsum for use pursuant to this section shall prepare certification documents which conform to the requirements of Sec. 61.208(b).

(e) Use of phosphogypsum for indoor research and development in a laboratory must comply with Sec. 61.205.

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Sec. 61.205 Distribution and use of phosphogypsum for research and developmer [64 FR 5574 February 3, 1999]

(a) Phosphogypsum may be lawfully removed from a stack and distributed in commerce for use in indoor research and development activities, provided that it is accompanied at all times by certification documents which conform to the requirements of Sec. 61.208. In addition, before distributing phosphogypsum to any person for use in indoor research and development activities, the owner or operator of a phosphogypsum stack shall obtain from that person written confirmation that the research facility will comply with all of the limitations set forth in Sec. 61.206(b).

(b) Any person who purchases and uses phosphogypsum for indoor research and development purposes shall comply with all of the following limitations. Any use of phosphogypsum for indoor research and development purposes not consistent with the limitations set forth in this section shall be construed as unauthorized distribution of phosphogypsum.

(1) Each quantity of phosphogypsum purchased by a facility for a particular research and development activity shall be accompanied by certification documents which conform to the requirements of Sec. 61.208.

(2) No facility shall purchase or possess more than 7,000 pounds of phosphogypsum for a particular indoor research and development activity. The total quantity of all phosphogypsum at a facility, as determined by summing the individual quantities purchased or possessed for each individual research and development activity conducted by that facility, may exceed 7,000 pounds, provided that no single room in which research and development activities are conducted shall contain more than 7,000 pounds.

(3) Containers of phosphogypsum used in indoor research and development activities shall be labeled with the following warning: Caution: Phosphogypsum Contains Elevated Levels of Naturally Occurring Radioactivity.

(4) For each indoor research and development activity in which phosphogypsum is used, the facility shall maintain records which conform to the requirements of Sec. 61.209(c).

(5) Indoor research and development activities must be performed in a controlled laboratory setting which the general public cannot enter except on an infrequent basis for tours of the facility. Uses of phosphogypsum for outdoor agricultural research and development and agricultural field use must comply with Sec. 61.204.

(c) Phosphogypsum not intended for distribution in commerce may be lawfully removed from a stack by an owner or operator to perform laboratory analyses required by this subpart or any other quality control or quality assurance analyses associated with wet acid phosphorus production.

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Sec. 61.206 Distribution and use of phosphogypsum for other purposes.

(a) Phosphogypsum may not be lawfully removed from a stack and distributed or used for any purpose not expressly specified in Sec. 61.204 or Sec. 61.205 without prior EPA approval.

(b) A request that EPA approve distribution and/or use of phosphogypsum for any other purpose must be submitted in writing and must contain the following information:

(1) The name and address of the person(s) making the request.

(2) A description of the proposed use, including any handling and processing that the phosphogypsum will undergo.

(3) The location of each facility, including suite and/or building number, street, city, county, state, and zip code, where any use, handling, or processing of the phosphogypsum will take place.

(4) The mailing address of each facility where any use, handling, or processing of the phosphogypsum will take place, if different from paragraph (b)(3) of this section.

(5) The quantity of phosphogypsum to be used by each facility.

(6) The average concentration of radium-226 in the phosphogypsum to be used.

(7) A description of any measures which will be taken to prevent the uncontrolled release of phosphogypsum into the environment.

(8) An estimate of the maximum individual risk, risk distribution, and incidence associated with the proposed use, including the ultimate disposition of the phosphogypsum or any product in which the phosphogypsum is incorporated.

(9) A description of the intended disposition of any unused phosphogypsum

(10) Each request shall be signed and dated by a corporate officer or public official in charge of the facility.

(c) The Assistant Administrator for Air and Radiation may decide to grant a request that EPA approve distribution and/or use of phosphogypsum if he determines that the proposed distribution and/or use is at least as protective of public health, in both the short term and the long term, as disposal of phosphogypsum in a stack or a mine.

(d) If the Assistant Administrator for Air and Radiation decides to grant a request that EPA approve distribution and/or use of phosphogypsum for a specified purpose, each of the following requirements shall be satisfied:

(1) The owner or operator of the stack from which the phosphogypsum is removed shall determine annually the average radium-226 concentration at the location in the stack from which the phosphogypsum will be removed, as provided by Sec. 61.207.

(2) All phosphogypsum distributed in commerce by the owner or operator of a phosphogypsum stack, or by a distributor,

retailer, or reseller, or purchased by the end-user, shall be accompanied at all times by certification documents which conform to the requirements Sec. 61.208.

(3) The end-user of the phosphogypsum shall maintain records which conform to the requirements of Sec. 61.209 (c).

(e) If the Assistant Administrator for Air and Radiation decides to grant a request that EPA approve distribution and/or use of phosphogypsum for a specified purpose, the Assistant Administrator may decide to impose additional terms or conditions governing such distribution or use.In appropriate circumstances, the Assistant Administrator may also decide to waive or modify the record keeping requirements established by Sec.61.209(c).

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Sec. 61.207 Radium-226 sampling and measurement procedures. [64 FR 5574 Febı 3, 1999]

(a) Before removing phosphogypsum from a stack for distribution in commerce pursuant to Sec. 61.204, or Sec. 61.206, the owner or operator of a phosphogypsum stack shall measure the average radium-226 concentration at the location in the stack from which phosphogypsum will be removed. Measurements shall be performed for each such location prior to the initial distribution in commerce of phosphogypsum removed from that location and at least once during each calendar year while distribution of phosphogypsum removed from the location continues.

(1) A minimum of 30 phosphogypsum samples shall be taken at regularly spaced intervals across the surface of the location on the stack from which the phosphogypsum will be removed. Let n_1 represent the number of samples taken.

(2) Measure the radium-226 concentration of each of the n_1 samples in accordance with the analytical procedures described in 40 CFR part 61, appendix B, Method 114.

(3) Calculate the mean, $\bar{x}_1$, and the standard deviation, s_1, of the n_1 radium-226 concentrations:

[equation graphic not available]
Where $\bar{x}_1$ and s_1 are expressed in pCi/g.

(4) Calculate the 95th percentile for the distribution, $\bar{x}^*$, using the following equation:

[equation graphic not available]

Where $\bar{x}^*$ is expressed in pCi/g.

(5) If the purpose for removing phosphogypsum from a stack is for distribution to commerce pursuant to Sec. 61.206, the owner or operator of a phosphogypsum stack shall report the mean, standard deviation, 95th percentile and sample size. If the purpose for removing phosphogypsum from a stack is for distribution to commerce pursuant to Sec.

61.204, the additional sampling procedures set forth in paragraphs (b) and (c) of this section shall apply.

(b) Based on the values for $\bar{x}_1$ and $\bar{x}^*$ calculated in paragraphs (a)(3) and (4) of this section, determine which of the following conditions will be met:

(1) If $\bar{x}_1$ is less than 10 pCi/g and $\bar{x}^*$ is less than or equal to10 pCi/g; phosphogypsum may be removed from this area of the stack for distribution in commerce pursuant to Sec. 61.204.

(2) If $\bar{x}_1$ is less than 10 pCi/g and $\bar{x}^*$ is greater than 10 pCi/g, the owner or operator may elect to follow the procedures for further sampling set forth in paragraph (c) of this section:

(3) If $\bar{x}_1$ is greater than 10 pCi/g; phosphogypsum shall not be removed from this area of the stack for distribution in commerce pursuant to Sec. 61.204.

(c) If the owner or operator elects to conduct further sampling to determine if phosphogypsum can be removed from this area of the stack, the following procedure shall apply. The objective of the following procedure is to demonstrate, with a 95% probability, that the phosphogypsum from this area of the stack has a radium-226 concentration no greater than 10 pCi/g. The procedure is iterative, the sample size may have to be increased more than one time; otherwise the phosphogypsum cannot be removed from this area of the stack for distribution to commerce pursuant to Sec. 61.204.

(1) (i) Solve the following equation for the total number of samples required:
[equation graphic not available]

(ii) The sample size n_2 shall be rounded upwards to the next whole number. The number of additional samples needed is $n_A = n_2 - n_1$.

(2) Obtain the necessary number of additional samples, n_A, which shall also be taken at regularly spaced intervals across the surface of the location on the stack from which phosphogypsum will be removed.

(3) Measure the radium-226 concentration of each of the n_A additional samples in accordance with the analytical procedures described in 40 CFR part 61, appendix B, Method 114.

(4) Recalculate the mean and standard deviation of the entire set of n_2 radium-226 concentrations by joining this set of n_A concentrations with the n_1 concentrations previously measured. Use the formulas in paragraph (a)(3) of this section, substituting the entire set of n_2 samples in place of the n_1 samples called for in paragraph (a)(3) of this section, thereby determining the mean, $\bar{x}_2$, and standard deviation, s_2, for the entire set of n_2 concentrations.

(5) Repeat the procedure described in paragraph (a)(4) of this section, substituting the recalculated mean, $\bar{x}_2$, for $\bar{x}_1$, the recalculated standard deviation, s_2, for s_1, and total sample

size, n_2, for n_1.

(6) Repeat the procedure described in paragraph (b) of this section, substituting the recalculated mean, $\bar{x}_2$ for for $\bar{x}_1$.

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Sec. 61.208 Certification requirements

(a) (1) The owner or operator of a stack from which phosphogypsum will be removed and distributed in commerce pursuant to Sec. 61.204, Sec.61.205, or Sec. 61.206 shall prepare a certification document for each quantity of phosphogypsum which is distributed in commerce which includes:

(i) The name and address of the owner or operator;

(ii) The name and address of the purchaser or recipient of the phosphogypsum;

(iii) The quantity (in pounds) of phosphogypsum sold or transferred;

(iv) The date of sale or transfer;

(v) A description of the intended end-use for the phosphogypsum;

(vi) The average radium-226 concentration, in pCi/g, of the phosphogypsum, as determined pursuant to Sec. 61.207; and

(vii) The signature of the person who prepared the certification.

(2) The owner or operator shall retain the certification document for five years from the date of sale or transfer, and shall produce the document for inspection upon request by the Administrator, or his authorized representative. The owner or operator shall also provide a copy of the certification document to the purchaser or recipient.

(b) (1) Each distributor, retailer, or reseller who purchases or receives phosphogypsum for subsequent resale or transfer shall prepare a certification document for each quantity of phosphogypsum which is resold or transferred which includes:

(i) The name and address of the distributor, retailer, or reseller;

(ii) The name and address of the purchaser or recipient of the phosphogypsum;

(iii) The quantity (in pounds) of phosphogypsum resold or transferred;

(iv) The date of resale or transfer;

(v) A description of the intended end-use for the phosphogypsum;

(vi) A copy of each certification document which accompanied the phosphogypsum at the time it was purchased or received by the distributor, retailer, or reseller; and

(vii) The signature of the person who prepared the certification.

(2) The distributor, retailer, or reseller shall retain the certification document for five years from the date of resale or transfer, and shall produce the document for inspection upon request by the Administrator, or his authorized representative. For every resale or transfer of phosphogypsum to a person other than an agricultural end-user, the distributor, retailer, or reseller shall also provide a copy of the certification document to the purchaser or transferee.

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Sec. 61.209 Required records.

(a) Each owner or operator of a phosphogypsum stack must maintain records for each stack documenting the procedure used to verify compliance with the flux standard in Sec. 61.202, including all measurements, calculations, and analytical methods on which input parameters were based. The required documentation shall be sufficient to allow an independent auditor to verify the correctness of the determination made concerning compliance of the stack with flux standard.

(b) Each owner or operator of a phosphogypsum stack must maintain records documenting the procedure used to determine average radium-226 concentration pursuant to Sec. 61.207, including all measurements, calculations, and analytical methods on which input parameters were based. The required documentation shall be sufficient to allow an independent auditor to verify the accuracy of the radium-226 concentration.

(c) Each facility which uses phosphogypsum pursuant to Sec. 61.205 or Sec. 61.206 shall prepare records which include the following information:

(1) The name and address of the person in charge of the activity involving use of phosphogypsum.

(2) A description of each use of phosphogypsum, including the handling and processing that the phosphogypsum underwent.

(3) The location of each site where each use of phosphogypsum occurred, including the suite and/or building number, street, city, county, state, and zip code.

(4) The mailing address of each facility using phosphogypsum, if
different from paragraph (c)(3) of this section.

(5) The date of each use of phosphogypsum.

(6) The quantity of phosphogypsum used.

(7) The certified average concentration of radium-226 for the phosphogypsum which was used.

(8) A description of all measures taken to prevent the uncontrolled release of phosphogypsum into the environment.

(9) A description of the disposition of any unused phosphogypsum.

(d) These records shall be retained by the facility for at least five years from the date of use of the phosphogypsum and shall be produced for inspection upon request by the Administrator, or his authorized representative.

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Sec. 61.210 Exemption from the reporting and testing requirements of 40 CFR 61.1

All facilities designated under this subpart are exempt from the reporting requirements of 40 CFR 61.10.

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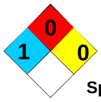
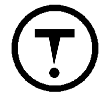
Appendix E

Material Safety Data Sheets

Agrium   Material Safety Data Sheet

NFPA Classification	DOT / TDG Pictograms	WHMIS Classification	PROTECTIVE CLOTHING
Health; Flammability; Reactivity; Specific Hazard 			

Section I. Chemical Product and Company Identification

PRODUCT NAME/ TRADE NAME **Kapuskasing Phosphogypsum**

SYNONYM	Kap Gypsum	**MSDS NUMBER:**	**14236**
CHEMICAL NAME	Calcium sulfate, dihydrate	**REVISION NUMBER**	4.1
CHEMICAL FAMILY	A sulfate salt composed mainly of calcium sulfate with trace amounts of barium sulfate, calcium fluoride and oxides of aluminum and silicon. (Salt.)	**MSDS prepared by the Environment, Health and Safety Department on:**	**January 28, 2006**
CHEMICAL FORMULA	$CaSO_4.2H_2O$		
MATERIAL USES	Experimental use only: Agricultural industry: Soil and compost conditioner. Industrial applications: Retarder for Portland cement. Mining industry: Mine tailings flocculant.		

24 HR EMERGENCY TELEPHONE NUMBER:

Transportation: 1-800-792-8311
Medical: 1-888-670-8123

MANUFACTURER

Agrium
North American Wholesale
13131 Lake Fraser Drive, S.E.
Calgary, Alberta, Canada
T2J 7E8

SUPPLIER

Agrium
North American Wholesale
13131 Lake Fraser Drive, S.E.
Calgary, Alberta, Canada, T2J 7E8

Agrium U.S. Inc.
Suite 1700, 4582 South Ulster St.
Denver, Colorado, U.S.A., 80237

Section II. Hazardous Ingredients

		Exposure Limits (ACGIH)						
NAME	**CAS #**	**TLV-TWA mg/m^3**	**TLV-TWA ppm**	**STEL mg/m^3**	**STEL ppm**	**CEIL mg/m^3**	**CEIL ppm**	**% by Weight**
gypsum (calcium sulfate, dihydrate)	10101-41-4	10 (I)						>90
crystalline silica (quartz)	14808-60-7	0.025 (R)						0.5-1.5
fluorides (as calcium fluoride)	7789-75-5	2.5						0.36 as F
calcium tetrahydrogen phosphate	7758-23-8	10						1.6

ACGIH TLV notations:
---- No assigned TLV
(C) - Ceiling - the concentration not to be exceeded at any time
(I) - measured as the Inhalable fraction of the aerosol
(R) - measured as the Respirable fraction of the aerosol
(T) - measured as the Thoracic fraction of the aerosol

TOXICOLOGICAL DATA ON INGREDIENTS The minimum or maximum tolerated human exposure to this agent has not been delineated.

TOXICITY VALUES - Gypsum
A. DIHYDRATE:
TDLo - (IP) RAT: 450 mg/kg
TCLo - (INHL) HUMAN: 194 g/m^3

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Section III. Hazards Identification.

POTENTIAL ACUTE HEALTH EFFECTS	This product may irritate eyes and skin upon prolonged or repeated contact. Inhaled dust may be irritating to the respiratory tract.
POTENTIAL CHRONIC HEALTH EFFECTS	Contains crystalline silica (quartz). Prolonged or repeated overexposures by inhalation may cause progressive and permanent lung damage. Crystalline silica is classified a human carcinogen by IARC, NTP, NIOSH, and a Suspected Human Carcinogen by ACGIH. Contains trace quantities of naturally occuring radioactive material, including radium. Radium and its decay products are considered to be confirmed human carcinogens. See Section 16, Other Special Considerations for further information.

Section IV. First Aid Measures

EYE CONTACT	May cause eye irritation due to slight residual acidity and mechanical action. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Obtain medical attention if irritation persists.
MINOR SKIN CONTACT	May cause skin irritation. Wash contaminated skin with soap and water. Cover dry or irritated skin with a good quality skin lotion. If irritation persists, seek medical attention.
EXTENSIVE SKIN CONTACT	No additional information.
MINOR INHALATION	Inhalation of dust may produce respiratory tract irritation, characterized by burning, sneezing and coughing. Remove individual to fresh air and allow to rest. Obtain medical assistance if breathing remains laboured.
SEVERE INHALATION	In emergency situations use proper respiratory protection to evacuate affected individuals to a safe area as soon as possible. Loosen tight clothing around the person's neck and waist. Oxygen may be administered if breathing is difficult. If the person is not breathing, perform artificial respiration. Obtain immediate medical attention.
SLIGHT INGESTION	Do not induce vomiting. Low toxicity. May cause digestive tract irritation, with accompanying nausea, vomiting and diarrhea. If spontaneous vomiting does occur, lower the head so that the vomit will not reenter the mouth and throat. If tolerated, give no more than 1 cup of milk or water for adults or 1/2 cup for children to rinse the mouth and throat, dilute the stomach contents, and minimize irritation. Obtain medical attention if irritation persists.
EXTENSIVE INGESTION	No additional information.

Section V. Fire and Explosion Data

THE PRODUCT IS	Non-flammable.
AUTO-IGNITION TEMPERATURE	Not applicable.
FLASH POINT	Not applicable.
FLAMMABILITY LIMITS	Not applicable.
PRODUCTS OF COMBUSTION	Not applicable.
FIRE HAZARD IN THE PRESENCE OF VARIOUS SUBSTANCES	Not applicable.
EXPLOSION HAZARD IN THE PRESENCE OF VARIOUS SUBSTANCES	Does not present any risk of explosion.
FIRE FIGHTING MEDIA AND INSTRUCTIONS	Non-flammable.

Continued on Next Page

SPECIAL REMARKS ON FIRE HAZARDS	When exposed to heat, phosphogypsum looses water of hydration forming calcium sulfate hemihydrate (plaster of paris).
SPECIAL REMARKS ON EXPLOSION HAZARDS	No additional remark.

Section VI. Accidental Release Measures

SMALL SPILL	Use appropriate tools to put the spilled solid in a suitable container for intended use or disposal. Ensure disposal complies with local regulations.
LARGE SPILL	Prevent additional discharge of material, if possible to do so without hazard. Keep spills from entering sewers, wells, watercourses, etc. Product will promote algae growth and may degrade water quality and taste. Notify downstream water users. Sulfate in potable drinking water should be maintained below 500mg/L (Canada). Recover and place in suitable containers for recycle, reuse, or disposal. Ensure disposal complies with local regulations. Will dissolve and disperse in water. Reclaiming material may not be viable.

Section VII. Handling and Storage

PRECAUTIONS	Avoid contact with skin and eyes. Do not breathe dust in concentrations which exceed specified occupational exposure limits. After handling, and prior to eating, drinking or using smoking materials, always wash hands thoroughly with soap and water. Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits.
STORAGE	Keep in a well-ventilated location. Keep out of reach of children.

Section VIII. Exposure Controls/Personal Protection

ENGINEERING CONTROLS	Store and use only in well ventilated areas. If user operations generate dust, supply adequate general ventilation to keep exposure to airborne contaminants below the applicable exposure limits.
PERSONAL PROTECTION	The selection of personal protective equipment varies, depending upon conditions of use. Wear appropriate respiratory protection for dust/mist when ventilation is inadequate. A NIOSH/MSHA approved dust respirator with P-100 filter cartridges may be used under conditions where airborne concentrations exceed occupational exposure limits. Protection provided by air purifying respirators may be limited. A positive pressure supplied air respirator should be used if concentrations are unknown or under any other other circumstances where air purifying respirators may be inadequate. Where skin and eye contact may occur as a result of brief periodic exposures, wear long sleeved clothing, coveralls, chemical resistant gloves, and safety glasses with side shields.
PERSONAL PROTECTION IN CASE OF LARGE RELEASE	No additional remarks.
EXPOSURE LIMITS	ACGIH TLV-TWA: 10 mg/m^3, as calcium sulfate. Federal and Provincial standards may vary by jurisdiction. Consult authorities for local acceptable exposure limits.

Section IX. Physical and Chemical Properties

PHYSICAL STATE AND APPEARANCE	Solid. (Solid crystalline powder.)		
MOLECULAR WEIGHT	136.14	**COLOR**	Light tan to grey.
pH (10% SOLN/WATER)	2.4	**ODOR**	Odorless.
BOILING POINT	Decomposes.	**ODOR THRESHOLD**	Not applicable.
MELTING POINT	1450°C (2642°F)	**TASTE**	Saline. (Slight.)
CRITICAL TEMPERATURE	Not applicable.	**VOLATILITY**	Non-volatile solids, but contains 6 - 12 wt% moisture.

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SPECIFIC GRAVITY g/cc	Not applicable	**SOLUBILITY**	Very slightly soluble in cold water, hot water.
BULK DENSITY kg/m^3 ; lbs/ft^3	Loose: 641 kg/m^3; 40.0 lbs/ft^3	**DISPERSION PROPERTIES**	Easily dispersed in any proportion in cold water and hot water.
VAPOR PRESSURE	Not applicable.	**WATER/OIL DIST. COEFF.**	Not available.
VAPOR DENSITY	Not applicable.		

Section X. Stability and Reactivity Data

STABILITY	The product is stable.
INSTABILITY TEMPERATURE	Not applicable.
CONDITIONS OF INSTABILITY	No additional remark.
INCOMPATABILITY WITH VARIOUS SUBSTANCES	Slightly reactive with metals and alkalis due to residual acidity. Non-reactive with oxidizing agents, reducing agents, combustible materials, organic materials, acids, moisture.
CORROSIVITY	Slightly corrosive to copper, steel, aluminum, zinc. Non-corrosive to fibreglass, stainless steel (304 or316).
SPECIAL REMARKS ON REACTIVITY	No additional remark.
SPECIAL REMARKS ON CORROSIVITY	Slightly corrosive to ferrous metals on prolonged contact. Contact your sales representative or a metallurgical specialist to ensure compatability with system equipment.

Section XI. Toxicological Information

SIGNIFICANT ROUTES OF EXPOSURE	Ingestion. Inhalation.
TOXICITY TO ANIMALS	See Section II.
SPECIAL REMARKS ON TOXICITY TO ANIMALS	No additional remark.
OTHER EFFECTS ON HUMANS	Slightly dangerous in case of eye or skin contact (irritant).
SPECIAL REMARKS ON CHRONIC EFFECTS ON HUMANS	No additional remark.
SPECIAL REMARKS ON OTHER EFFECTS ON HUMANS	ACGIH TLV value for calcium sulfate, based on total dust containing no asbestos and <1% crystalline silica.

Section XII. Ecological Information

ECOTOXICITY	No additional remark.
BOD and COD	Not available.
PRODUCTS OF DEGRADATION	Some metallic oxides.
TOXICITY OF THE PRODUCTS OF DEGRADATION	The products of degradation are less toxic than the product itself.
SPECIAL REMARKS ON THE PRODUCTS OF DEGRADATION	No additional remark.

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Section XIII. Disposal Considerations

WASTE DISPOSAL OR RECYCLING	Recover and place material in a suitable container for intended use or disposal.

Section XIV. Transport Information

DOT / TDG CLASSIFICATION	TDG CLASS 8: Corrosive solid.
PIN and Shipping Name	UN1759 Corrosive solid n.o.s. PG:III
SPECIAL PROVISIONS FOR TRANSPORT	No additional remark.
DOT (U.S.A) (Pictograms)	

Section XV. Other Regulatory Information and Pictograms

OTHER REGULATIONS

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA): This product is on the Domestic Substances List (DSL), and is acceptable for use under the provisions of CEPA.

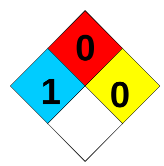
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by the Controlled Products Regulations.

OTHER CLASSIFICATIONS

HCS (U.S.A.)	HCS CLASS: Irritating substance.
DSCL (EEC)	Not available.

National Fire Protection Association (U.S.A.)

Hazards presented under acute emergency conditions only:



TDG (Pictograms - Canada)

DSCL (Europe) (Pictograms)

Not Available
No Disponible
Pas Disponible

ADR (Europe) (Pictograms)

Not Available
No Disponible
Pas Disponible

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Section XVI. Other Information

REFERENCES	- Guidelines for the Handling of Radioactive Materials in Western Canada, 1995, Western Canada NORM Committee - Canadian Guidelines for the Management of Naturally Occurring Radioactive materials (NORM), 1st Ed. January, 2000 -Transportation of Dangerous Goods Act and Clear Language Regulations, current revision. -Canada Gazette Part II, Vol. 122, No. 2 Registration SOR/88-64 31 December, 1987 Hazardous Products Act "Ingredient Disclosure List". -Domestic Substances List, Canadian Environmental Protection Act. -29 CFR Part 1910 -33 CFR Parts 151, 153, 154, 156 -40 CFR Parts 1-799 -46 CFR Part 153 -49 CFR Parts 1-199 -American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances, 2005. -NFPA 704, National Fire Codes Online, National Fire Protection Association, current edition at time of MSDS preparation. -Corrosion Data Survey, Sixth Edition, 1985, National Association of Corrosion Engineers -TOMES® System: Heitland G & Hurlbut KM (Eds) (electronic version): MICROMEDEX, Greenwood Village, Colorado, USA. Available at: http://csi.micromedex.com (2005). The TOMES® System includes MEDITEXT® Medical Management; HAZARDTEXT® Hazard Management; INFOTEXT® Documents; ERG2000 Emergency Response Guidebook Documents; REPROTEXT®: Heitland G & Hurlbut KM (Eds); CHRIS Hazardous Chemical Data: U.S. Department of Transportation, U.S. Coast Guard, Washington, D.C. (2005); HSDB: Hazardous Substances Data Bank. National Library of Medicine, Bethesda, Maryland (2005); IRIS: Integrated Risk Information System. U.S. Environmental Protection Agency, Washington, D.C. (2005); NIOSH: Pocket Guide to Chemical Hazards. National Institute for Occupational Safety and Health, Cincinnati, Ohio (2005); OHM/TADS: Oil and Hazardous Materials Technical Assistance Data System. U.S. Environmental Protection Agency, Washington, D.C. (2005); REPROTOX®: Scialli A.R. Georgetown University Medical Center and Reproductive Toxicology Center, Columbia Hospital for Women Medical Center, Washington, D.C. (2005); RTECS®: Registry of Toxic Effects of Chemical Substances. National Institute for Occupational Safety and Health, Cincinnati, Ohio (2005); and SHEPARDS: Shepard T.H.: Shepard's Catalog of Teratogenic Agents (2005). -The Fertilizer Institute Product Testing Program Results, March 2003
OTHER SPECIAL CONSIDERATIONS	Phosphogypsum from various source rock contains trace but measurable quantities of radioactive substances (typical analyses: uranium-238: 0.1-0.4 Bq/g, radium-226: 0.20-1.4 Bq/g). Currently, phosphogypsum with radium activity of less than 0.37 Bq/g is exempted by the U.S. EPA from regulatory controls. In Canada, similar exemptions are automatic for materials at less than 0.3 Bq/g and may, on a case by case basis be granted for phosphogypsum with concentrations of up to 1.0 Bq/g if the manner in which it is demonstrates no greater risk than material at the exemption limit. One of the radioactive decay products produced is radon gas. This gas may build up in the headspace of closed storage containers or in areas of poor ventilation. Phosphogypsum should be handled and used under good general ventilation conditions (minimum recommended value: 2 air changes per hour).
FOR FURTHER SAFETY, HEALTH, OR ENVIRONMENTAL INFORMATION ON THIS PRODUCT, CONTACT	**AGRIUM** **Wholesale Environment, Health and Safety** **Telephone (780) 998-6906 or Fax (780) 998-6677**

Agrium

Material Safety Data Sheet

NFPA Classification	DOT / TDG Pictograms	WHMIS Classification	PROTECTIVE CLOTHING
Health; Flammability; Reactivity 0; Specific Hazard			

Section I. Chemical Product and Company Identification

PRODUCT NAME/ TRADE NAME **Type 65 - Florida Phosphogypsum**

SYNONYM	Florida Phosphogypsum	**MSDS NUMBER:**	**14060**
CHEMICAL NAME	Calcium sulfate, dihydrate	**REVISION NUMBER**	4.6
CHEMICAL FAMILY	A sulfate salt composed mainly of calcium sulfate with trace amounts of barium sulfate, calcium fluoride and oxides of aluminum and silicon. (Salt.)	**MSDS prepared by the Environment, Health and Safety Department on:**	**July 8, 2003**
CHEMICAL FORMULA	$CaSO_4.2H_2O$		
MATERIAL USES	Agricultural industry: Soil conditioner. Industrial applications: Retarder for Portland cement. Soil neutralizer. Mining industry: Mine tailings flocculant.		

24 HR EMERGENCY TELEPHONE NUMBER:

Transportation: 1-800-792-8311
Medical: 1-888-670-8123

MANUFACTURER

Agrium
North American Wholesale
13131 Lake Fraser Drive, S.E.
Calgary, Alberta, Canada
T2J 7E8

SUPPLIER

Agrium
North American Wholesale
13131 Lake Fraser Drive, S.E.
Calgary, Alberta, Canada, T2J 7E8

Section II. Hazardous Ingredients

		Exposure Limits (ACGIH)						
NAME	**CAS #**	**TLV-TWA mg/m³**	**TLV-TWA ppm**	**STEL mg/m³**	**STEL ppm**	**CEIL mg/m³**	**CEIL ppm**	**% by Weight**
crystalline silica	14808-60-7	0.1						0.24
calcium sulfate, dihydrate	10101-41-4	10						86 - 92
Calcium fluoride	7789-75-5	2.5						0.9

TOXICOLOGICAL DATA ON INGREDIENTS

The minimum or maximum tolerated human exposure to this agent has not been delineated.

The Fertilizer Institute Product Testing Program Results - Health and Environmental Safety Data Summary Document Results:
TOXICITY VALUES - Calcium sulfate
Acute Oral Toxicity, LD_{50}: >5,000 mg/kg bw (Rat); >4,052-4,226mg/kg bw (Mouse)
Chronic toxicity, repeated intratracheal dose, 2 yrs, LOAEL = 10mg (Hamster)

Ecotoxicicty:
Acute toxicity to Fish, 96 hrs, LC_{50}: Pimphales promelas > 1,960 mg/L; Lepomis macrochirus >2,980 mg/L; Gambusia affinis >56,000 mg/L
Chronic toxicity to Fish, 28 days, Salmo irideus, NOEC >3,200 mg/L
Acute toxicity to Aquatic Invertibrates, 48 hrs, Daphnia magna EC_{50} = 1,970 mg/L
Toxicity to Aquatic Plants (Algae), 120 hrs, Nitzschia linearis TL_M= 3,200 mg/L

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Section III. Hazards Identification.

POTENTIAL ACUTE HEALTH EFFECTS	This product may irritate eyes and skin upon prolonged or repeated contact. Inhaled dust may be irritating to the respiratory tract.
POTENTIAL CHRONIC HEALTH EFFECTS	Contains crystalline silica (quartz). Prolonged or repeated overexposures by inhalation may cause progressive and permanent lung damage. Crystalline silica is considered a human carcinogen by IARC, Reasonably anticipated to be Carcinogenic by NTP,and a Suspected Human Carcinogen by ACGIH. Contains trace quantities of naturally occuring radioactive materials (radium-226). Consult Section 16, Other Information, Special Considerations, for futher information on this subject.

Section IV. First Aid Measures

EYE CONTACT	May cause eye irritation due to mechanical action. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Obtain medical attention if irritation persists.
MINOR SKIN CONTACT	May cause skin irritation. Wash contaminated skin with soap and water. Cover dry or irritated skin with a good quality skin lotion. If irritation persists, seek medical attention.
EXTENSIVE SKIN CONTACT	No additional information.
MINOR INHALATION	Inhalation of dust may produce respiratory tract irritation, characterized by burning, sneezing and coughing. Remove individual to fresh air and allow to rest. Obtain medical assistance if breathing remains laboured.
SEVERE INHALATION	In emergency situations use proper respiratory protection to evacuate affected individuals to a safe area as soon as possible. Loosen tight clothing around the person's neck and waist. Oxygen may be administered if breathing is difficult. If the person is not breathing, perform artificial respiration. Obtain immediate medical attention.
SLIGHT INGESTION	Have conscious person drink several glasses of water or milk. Induce vomiting. Lower the head so that the vomit will not reenter the mouth and throat. NEVER give an unconscious person anything to drink. Obtain medical attention.
EXTENSIVE INGESTION	No additional information.

Section V. Fire and Explosion Data

THE PRODUCT IS	Non-flammable.
AUTO-IGNITION TEMPERATURE	Not applicable.
FLASH POINT	Not applicable.
FLAMMABILITY LIMITS	Not applicable.
PRODUCTS OF COMBUSTION	Not applicable.
FIRE HAZARD IN THE PRESENCE OF VARIOUS SUBSTANCES	Not applicable.
EXPLOSION HAZARD IN THE PRESENCE OF VARIOUS SUBSTANCES	Does not present any risk of explosion.
FIRE FIGHTING MEDIA AND INSTRUCTIONS	Non-flammable.
SPECIAL REMARKS ON FIRE HAZARDS	When exposed to heat, phosphogypsum looses water of hydration forming calcium sulfate hemihydrate (plaster of paris).
SPECIAL REMARKS ON EXPLOSION HAZARDS	No additional remark.

Continued on Next Page

Section VI. Accidental Release Measures

SMALL SPILL	Use appropriate tools to put the spilled solid in a suitable container for intended use or disposal. Ensure disposal complies with local regulations.
LARGE SPILL	Prevent additional discharge of material, if possible to do so without hazard. Keep spills from entering sewers, wells, watercourses, etc. Product will promote algae growth and may degrade water quality and taste. Notify downstream water users. Sulfate in potable drinking water should be maintained below 500mg/L (Canada). Recover and place in suitable containers for recycle, reuse, or disposal. Ensure disposal complies with local regulations. Will dissolve and disperse in water. Reclaiming material may not be viable.

Section VII. Handling and Storage

PRECAUTIONS	Avoid contact with skin and eyes. Do not breathe dust in concentrations which exceed specified occupational exposure limits. After handling, and prior to eating, drinking or using smoking materials, always wash hands thoroughly with soap and water. Use process enclosures, local exhaust ventilation, or other engineering controls to keep airbome levels below recommended exposure limits.
STORAGE	Keep in a well-ventilated location. Keep out of reach of children.

Section VIII. Exposure Controls/Personal Protection

ENGINEERING CONTROLS	Store and use only in well ventilated areas. If user operations generate dust, supply adequate general ventilation to keep exposure to airbome contaminants below the applicable exposure limits.
PERSONAL PROTECTION	The selection of personal protective equipment varies, depending upon conditions of use. Wear appropriate respiratory protection for dust/mist when ventilation is inadequate. A NIOSH/MSHA approved dust respirator with P-100 filter cartridges may be used under conditions where airborne concentrations may exceed occupational exposure limits. Protection provided by air purifying respirators may be limited. A positive pressure supplied air respirator should be used if concentrations are unknown or under any other other circumstances where air purifying respirators may be inadequate. Where skin and eye contact may occur as a result of brief periodic exposures, wear long sleeved clothing, coveralls, chemical resistant gloves, and safety glasses with side shields.
PERSONAL PROTECTION IN CASE OF LARGE RELEASE	No additional remarks.
EXPOSURE LIMITS	ACGIH TLV-TWA: 10 mg/m^3 as Inhalable particles, 3 mg/m^3 as Respirable particulates; for Particles (insoluble or poorly soluble) Not Otherwise Specified. Federal, State or Provincial exposure limits may vary by jurisdiction. Consult local authorities for acceptable exposure limits in your area.

Section IX. Physical and Chemical Properties

PHYSICAL STATE AND APPEARANCE	Solid. (Solid crystalline powder.)		
MOLECULAR WEIGHT	136.14	**COLOR**	White to yellowish.
pH (10% SOLN/WATER)	4	**ODOR**	Odorless.
BOILING POINT	Decomposes.	**ODOR THRESHOLD**	Not applicable.
MELTING POINT	1450°C (2642°F)	**TASTE**	Saline. (Slight.)
CRITICAL TEMPERATURE	Not applicable.	**VOLATILITY**	Non-volatile solids, but contains 6 - 12 wt% moisture.
SPECIFIC GRAVITY g/cc	2.96 (Water = 1)	**SOLUBILITY**	Very slightly soluble in cold water, hot water.
BULK DENSITY kg/m^3 ; lbs/ft^3	Loose: 888 kg/m^3; 55.4 lbs/ft^3; Tapped: 1130 kg/m^3; 70.5 lbs/ft^3;	**DISPERSION PROPERTIES**	Easily dispersed in any proportion in cold water and hot water.

Continued on Next Page

VAPOR PRESSURE	Not applicable.	WATER/OIL DIST. COEFF.	Not available.
VAPOR DENSITY	Not applicable.		

Section X. Stability and Reactivity Data

STABILITY	The product is stable.
INSTABILITY TEMPERATURE	Not applicable.
CONDITIONS OF INSTABILITY	No additional remark.
INCOMPATABILITY WITH VARIOUS SUBSTANCES	Very slightly to slightly reactive with metals, alkalis. Non-reactive with oxidizing agents, reducing agents, combustible materials, organic materials, acids, moisture.
CORROSIVITY	Slightly corrosive to copper, steel, aluminum, zinc. Non-corrosive to fibreglass, stainless steel (304 or316).
SPECIAL REMARKS ON REACTIVITY	No additional remark.
SPECIAL REMARKS ON CORROSIVITY	Slightly corrosive to ferrous metals on prolonged contact. Contact your sales representative or a metallurgical specialist to ensure compatability with system equipment.

Section XI. Toxicological Information

SIGNIFICANT ROUTES OF EXPOSURE	Ingestion. Inhalation.
TOXICITY TO ANIMALS	See Section II.
SPECIAL REMARKS ON TOXICITY TO ANIMALS	No additional remark.
OTHER EFFECTS ON HUMANS	Slightly dangerous in case of eye or skin contact (irritant). Dangerous in case of overexposure by ingestion or inhalation.
SPECIAL REMARKS ON CHRONIC EFFECTS ON HUMANS	No additional remark.
SPECIAL REMARKS ON OTHER EFFECTS ON HUMANS	ACGIH TLV value for calcium sulfate, based on total dust containing <1% crystalline silica.

Section XII. Ecological Information

ECOTOXICITY	No additional remark.
BOD and COD	Not available.
PRODUCTS OF DEGRADATION	Some metallic oxides.
TOXICITY OF THE PRODUCTS OF DEGRADATION	The products of degradation are less toxic than the product itself.
SPECIAL REMARKS ON THE PRODUCTS OF DEGRADATION	No additional remark.

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Section XIII. Disposal Considerations

WASTE DISPOSAL OR RECYCLING	Recover and place material in a suitable container for intended use or disposal. Call for assistance on disposal.

Section XIV. Transport Information

DOT / TDG CLASSIFICATION	Not controlled under TDG (Canada).
PIN and Shipping Name	Not applicable.
SPECIAL PROVISIONS FOR TRANSPORT	Not applicable.
DOT (U.S.A) (Pictograms)	

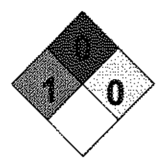
Section XV. Other Regulatory Information and Pictograms

OTHER REGULATIONS	CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA): This product is on the Domestic Substances List (DSL), and is acceptable for use under the provisions of CEPA.	
OTHER CLASSIFICATIONS	**HCS (U.S.A.)**	Not controlled under the HCS (United States).
	DSCL (EEC)	Not controlled under DSCL (Europe).

National Fire Protection Association (U.S.A.)

Hazards presented under acute emergency conditions only:

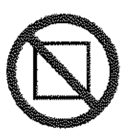
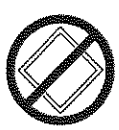
Health



Fire Hazard

Reactivity

Specific Hazard

TDG (Pictograms - Canada)	
DSCL (Europe) (Pictograms)	
ADR (Europe) (Pictograms)	

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Section XVI. Other Information

REFERENCES

- Guidelines for the Handling of Radioactive Materials in Western Canada, 1995, Western Canada NORM Committee
- Canadian Guidelines for the Management of Naturally Occurring Radioactive materials (NORM), 1st Ed. January, 2000
-Transportation of Dangerous Goods Act and Clear Language Regulations.
-Canada Gazette Part II, Vol. 122, No. 2 Registration SOR/88-64 31 December, 1987 Hazardous Products Act "Ingredient Disclosure List".
-Domestic Substances List, Canadian Environmental Protection Act.
-Canadian Centre for Occupational Health and Safety Infodisk Series
-29 CFR Part 1910
-33 CFR Parts 151, 153, 154, 156
-40 CFR Parts 1-799
-46 CFR Part 153
-49 CFR Parts 1-199
-American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances, 2002.
-Fire Protection Guide to Hazardous Materials, (NFPA49, 325M, 491M, and 704), National Fire Protection Association, 10th Ed, 1991
-Corrosion Data Survey, Sixth Edition, 1985, National Association of Corrosion Engineers
-TOMES® System: Heitland G & Hurlbut KM (Eds) (electronic version): MICROMEDEX, Greenwood Village, Colorado, USA. Available at: http://csi.micromedex.com (2002). The TOMES® System includes MEDITEXT® Medical Management; HAZARDTEXT® Hazard Management; INFOTEXT® Documents; ERG2000 Emergency Response Guidebook Documents; REPROTEXT®: Heitland G & Hurlbut KM (Eds); CHRIS Hazardous Chemical Data: U.S. Department of Transportation, U.S. Coast Guard, Washington, D.C. (2002); HSDB: Hazardous Substances Data Bank. National Library of Medicine, Bethesda, Maryland (2002); IRIS: Integrated Risk Information System. U.S. Environmental Protection Agency, Washington, D.C. (2002); NIOSH: Pocket Guide to Chemical Hazards. National Institute for Occupational Safety and Health, Cincinnati, Ohio (2002); OHM/TADS: Oil and Hazardous Materials Technical Assistance Data System. U.S. Environmental Protection Agency, Washington, D.C. (2002); REPROTOX®: Scialli A.R. Georgetown University Medical Center and Reproductive Toxicology Center, Columbia Hospital for Women Medical Center, Washington, D.C. (2002); RTECS®: Registry of Toxic Effects of Chemical Substances. National Institute for Occupational Safety and Health, Cincinnati, Ohio (2002); and SHEPARDS: Shepard T.H.: Shepard's Catalog of Teratogenic Agents (2002).
-The Fertilizer Institute Product Testing Program Results, Calcium Sulfate March 2003

OTHER SPECIAL CONSIDERATIONS

Florida phosphogypsum contains trace but measurable quantities of radioactive substances (typical analyses: uranium-238: 0.14 Bq/g, radium-226: 0.84 Bq/g). The Canadian NORM Working Goup of the Federal Provincial Territorial Radiation Protection Committee, has established an investigation threshold of 0.3 Bq/g for material containing Ra-226. Dose assessments conducted by both the PATHRAE and RESRAD risk assessment methodology indicate that the material meets the criterion for Unrestricted use for soil remediation, tailings flocculation and manure conditioning, based on the latest criterion of the International Commission for Radiological Protection (ICRP). These levels of activity in phosphogypsum are considered exempt by the state of Louisiana, and are acceptable for research purposes by the US EPA.

One of the radioactive decay products produced is radon gas. This gas may build up in the headspace of closed storage containers or in areas of poor ventilation. The handling and use of phosphogypsum should therefore be conducted under good general ventilation conditions (minimum recommended value: 2 air changes per hour). Further information on the safe handling of phosphogypsum may be obtained in the document, Guidelines for the Handling of Radioactive Materials in Western Canada, prepared by Western Canada NORM Committee and available through Alberta Labour Occupational Health and Safety Division, British Columbia Ministry of Health Radiation Protection Service, or Saskatchewan Labour Occupational Health and Safety Branch.

FOR FURTHER SAFETY, HEALTH, OR ENVIRONMENTAL INFORMATION ON THIS PRODUCT, CONTACT

AGRIUM
Environment, Health and Safety Department
Telephone (403) 225-7380 or Fax (403) 225-7608

NOTICE TO READER

Continued on Next Page

Material Safety Data Sheet

Section 1: PRODUCT AND COMPANY INFORMATION

Product Name(s): Cement Kiln Dust

Product Identifiers: Cement Kiln Dust (CKD), Kiln Dust, Cement Lime

Manufacturer:
Lafarge North America Inc.
12950 Worldgate Drive, Suite 500
Herndon, VA 20170

Information Telephone Number:
703-480-3600 (9am to 5pm EST)

Emergency Telephone Number:
1-800-451-8346 (3E Hotline)

Product Use: Kiln dust used in the manufacture of bricks, mortar, cement, concrete, plasters, paving materials, and other construction applications.

Note: This MSDS covers many types of kiln dust. Individual composition of hazardous constituents will vary between types of kiln dust.

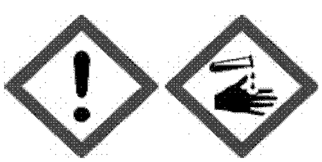
Section 2: COMPOSITION/INFORMATION ON INGREDIENTS

Component	Percent (By Weight)	CAS Number	OSHA PEL -TWA (mg/m^3)	ACGIH TLV-TWA (mg/m^3)	LD_{50} (mouse, intraperitoneal)	LC_{50}
Portland Cement Kiln Dust	100	68475-76-3	NA	NA	NA	NA
Calcium Carbonate*	10-80	1317-65-3	15 (T); 5 (R)	10 (T)	NA	NA
Calcium Oxide	5-30	1305-78-8	5 (T)	2 (T)	3059 mg/kg	NA
Crystalline Silica	0-10	14808-60-7	[(10) / (%SiO_2+2)] (R); [(30) / (%SiO_2+2)] (T)	0.05 (R)	NA	NA
Magnesium Oxide	0-2	1309-48-4	15 (T)	10 (T)	NA	NA

Note: Exposure limits for components noted with an * contain no asbestos and <1% crystalline silica

Cement is made from materials mined from the earth and is processed using energy provided by fuels. Trace amounts of chemicals may be detected during chemical analysis of cement and cement kiln dust. For example, cement kiln dust may contain trace amounts of potassium and sodium sulfate compounds, chromium compounds, nickel compounds, and other trace compounds.

Section 3: HAZARD IDENTIFICATION

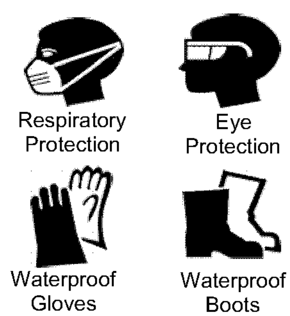


WARNING

Corrosive - Causes severe burns.
Toxic - Harmful by inhalation.
(Contains crystalline silica)

Use proper engineering controls, work practices, and personal protective equipment to prevent exposure to wet or dry product.

Read MSDS for details.



Section 3: HAZARD IDENTIFICATION (continued)

Emergency Overview: Kiln dust is a solid, grey or tan, odorless powder. It is not combustible or explosive. A single, short-term exposure to the dry powder presents little or no hazard. Exposure of sufficient duration to wet kiln dust, or to dry kiln dust on moist areas of the body, can cause serious, potentially irreversible tissue (skin, eye, respiratory tract) damage due to chemical (caustic) burns, including third degree burns.

Potential Health Effects:

Eye Contact: Airborne dust may cause immediate or delayed irritation or inflammation. Eye contact with large amounts of dry powder or with wet kiln dust can cause moderate eye irritation, chemical burns and blindness. Eye exposures require immediate first aid and medical attention to prevent significant damage to the eye.

Skin Contact: Kiln dust may cause dry skin, discomfort, irritation, severe burns, and dermatitis.

Burns: Exposure of sufficient duration to wet kiln dust, or to dry kiln dust on moist areas of the body, can cause serious, potentially irreversible damage to skin, eye, respiratory and digestive tracts due to chemical (caustic) burns, including third degree burns. A skin exposure may be hazardous even if there is no pain or discomfort.

Kiln dust may be shipped or stored hot and can cause thermal burns to unprotected skin.

Dermatitis: Kiln dust is capable of causing dermatitis by irritation and allergy. Skin affected by dermatitis may include symptoms such as, redness, itching, rash, scaling, and cracking.

Irritant dermatitis is caused by the physical properties of kiln dust including alkalinity and abrasion.

Allergic contact dermatitis is caused by sensitization to hexavalent chromium (chromate) present in kiln dust. The reaction can range from a mild rash to severe skin ulcers. Persons already sensitized may react to the first contact with kiln dust. Others may develop allergic dermatitis after years of repeated contact with kiln dust.

Inhalation (acute): Breathing dust may cause nose, throat or lung irritation, including choking, depending on the degree of exposure. Inhalation of high levels of dust can cause chemical burns to the nose, throat and lungs.

Inhalation (chronic): Risk of injury depends on duration and level of exposure.

Silicosis: This product contains crystalline silica. Prolonged or repeated inhalation of respirable crystalline silica from this product can cause silicosis, a seriously disabling and fatal lung disease. See Note to Physicians in Section 4 for further information.

Carcinogenicity: Kiln dust is not listed as a carcinogen by IARC or NTP; however, kiln dust contains trace amounts of crystalline silica and hexavalent chromium which are classified by IARC and NTP as known human carcinogens.

Autoimmune Disease: Some studies show that exposure to respirable crystalline silica (without silicosis) or that the disease silicosis may be associated with the increased incidence of several autoimmune disorders such as scleroderma (thickening of the skin), systemic lupus erythematosus, rheumatoid arthritis and diseases affecting the kidneys.

Section 3: HAZARD IDENTIFICATION (continued)

Tuberculosis: Silicosis increases the risk of tuberculosis.

Renal Disease: Some studies show an increased incidence of chronic kidney disease and end-stage renal disease in workers exposed to respirable crystalline silica.

Ingestion: Do not ingest kiln dust. Although ingestion of small quantities of kiln dust is not known to be harmful, large quantities can cause chemical burns in the mouth, throat, stomach, and digestive tract.

Medical Conditions Aggravated by Exposure: Individuals with lung disease (e.g. bronchitis, emphysema, COPD, pulmonary disease) or sensitivity to hexavalent chromium can be aggravated by exposure.

Section 4: FIRST AID MEASURES

Eye Contact: Rinse eyes thoroughly with water for at least 15 minutes, including under lids, to remove all particles. Seek medical attention for abrasions and burns.

Skin Contact: Wash with cool water and a pH neutral soap or a mild skin detergent. Seek medical attention for rash, burns, irritation, dermatitis, and prolonged unprotected exposures to wet cement or kiln dust, cement mixtures or liquids from wet cement.

Inhalation: Move person to fresh air. Seek medical attention for discomfort or if coughing or other symptoms do not subside.

Ingestion: Do not induce vomiting. If conscious, have person drink plenty of water. Seek medical attention or contact poison control center immediately.

Note to Physician: The three types of silicosis include:

- Simple chronic silicosis – which results from long-term exposure (more than 20 years) to low amounts of respirable crystalline silica. Nodules of chronic inflammation and scarring provoked by the respirable crystalline silica form in the lungs and chest lymph nodes. This disease may feature breathlessness and may resemble chronic obstructive pulmonary disease (COPD).
- Accelerated silicosis – occurs after exposure to larger amounts of respirable crystalline silica over a shorter period of time (5-15 years). Inflammation, scarring, and symptoms progress faster in accelerated silicosis than in simple silicosis.
- Acute silicosis – results from short-term exposure to very large amounts of respirable crystalline silica. The lungs become very inflamed and may fill with fluid, causing severe shortness of breath and low blood oxygen levels.

Progressive massive fibrosis may occur in simple or accelerated silicosis, but is more common in the accelerated form. Progressive massive fibrosis results from severe scarring and leads to the destruction of normal lung structures.

Section 5: FIREFIGHTING MEASURES

Flashpoint & Method: Non-combustible

General Hazard: Avoid breathing dust. Wet kiln dust and cement is caustic.

Extinguishing Media: Use extinguishing media appropriate for surrounding fire.

Firefighting Equipment: Kiln dust poses no fire-related hazard. A SCBA is recommended to limit exposures to combustion products when fighting any fire.

Combustion Products: None.

Section 6: ACCIDENTAL RELEASE MEASURES

General: Place spilled material into a container. Avoid actions that cause the kiln dust to become airborne. Avoid inhalation of kiln dust and contact with skin. Wear appropriate protective equipment as described in Section 8. Scrape wet kiln dust or cement and place in container. Allow material to dry or solidify before disposal. Do not wash kiln dust down sewage and drainage systems or into bodies of water (e.g. streams).

Waste Disposal Method: Dispose of kiln dust according to Federal, State, Provincial and Local regulations.

Section 7: HANDLING AND STORAGE

General: Keep bulk and bagged kiln dust dry until used. Stack bagged material in a secure manner to prevent falling. Bagged kiln dust and cement is heavy and poses risks such as sprains and strains to the back, arms, shoulders and legs during lifting and mixing. Handle with care and use appropriate control measures.

Engulfment hazard. To prevent burial or suffocation, do not enter a confined space, such as a silo, bin, bulk truck, or other storage container or vessel that stores or contains kiln dust. Kiln dust and cement can buildup or adhere to the walls of a confined space. The kiln dust and cement can release, collapse or fall unexpectedly.

Properly ground all pneumatic conveyance systems. The potential exists for static build-up and static discharge when moving cement powders through a plastic, non-conductive, or non-grounded pneumatic conveyance system. The static discharge may result in damage to equipment and injury to workers.

Usage: Cutting, crushing or grinding hardened cement, concrete or other crystalline silica-bearing materials will release respirable crystalline silica. Use all appropriate measures of dust control or suppression, and Personal Protective Equipment (PPE) described in Section 8 below.

Housekeeping: Avoid actions that cause the kiln dust to become airborne during clean-up such as dry sweeping or using compressed air. Use HEPA vacuum or thoroughly wet with water to clean-up dust. Use PPE described in Section 8 below.

Storage Temperature: Unlimited. **Storage Pressure:** Unlimited.

Clothing: Promptly remove and launder clothing that is dusty or wet with kiln dust. Thoroughly wash skin after exposure to dust or wet kiln dust.

Section 8: EXPOSURE CONTROLS AND PERSONAL PROTECTION

Engineering Controls: Use local exhaust or general dilution ventilation or other suppression methods to maintain dust levels below exposure limits.

Personal Protective Equipment (PPE):

Respiratory Protection: Under ordinary conditions no respiratory protection is required. Wear a NIOSH approved respirator that is properly fitted and is in good condition when exposed to dust above exposure limits.

Eye Protection: Wear ANSI approved glasses or safety goggles when handling dust or wet kiln dust to prevent contact with eyes. Wearing contact lenses when using kiln dust, under dusty conditions, is not recommended.

Section 8: EXPOSURE CONTROLS AND PERSONAL PROTECTION (continued)

Skin Protection: Wear gloves, boot covers and protective clothing impervious to water to prevent skin contact. Do not rely on barrier creams, in place of impervious gloves. Remove clothing and protective equipment that becomes saturated with wet kiln dust or cement and immediately wash exposed areas.

Section 9: PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid (powder).	**Evaporation Rate:**	NA.
Appearance:	Gray, tan, or white powder.	**pH (in water):**	10 – 13
Odor:	None.	**Boiling Point:**	>1000° C
Vapor Pressure:	NA.	**Freezing Point:**	None, solid.
Vapor Density:	NA.	**Viscosity:**	None, solid.
Specific Gravity:	2.6-2.8	**Solubility in Water:**	2-20%

Section 10: STABILITY AND REACTIVITY

Stability: Stable. Keep dry until use. Avoid contact with incompatible materials. Kiln dust reacts with water, resulting in a slight release of heat, depending on the amount of lime (Calcium oxide) present.

Incompatibility: Kiln dust and wet cement is alkaline and is incompatible with acids, ammonium salts and aluminum metal. Kiln dust and cement dissolves in hydrofluoric acid, producing corrosive silicon tetrafluoride gas. Kiln dust and cement reacts with water to form silicates and calcium hydroxide. Silicates react with powerful oxidizers such as fluorine, boron trifluoride, chlorine trifluoride, manganese trifluoride, and oxygen difluoride.

Hazardous Polymerization: None. **Hazardous Decomposition:** None.

Section 11 and 12: TOXICOLOGICAL AND ECOLOGICAL INFORMATION

For questions regarding toxicological and ecological information refer to contact information in Section 1.

Section 13: DISPOSAL CONSIDERATIONS

Dispose of waste and containers in compliance with applicable Federal, State, Provincial and Local regulations.

Section 14: TRANSPORT INFORMATION

This product is not classified as a Hazardous Material under U.S. DOT or Canadian TDG regulations.

Section 15: REGULATORY INFORMATION

OSHA/MSHA Hazard Communication: This product is considered by OSHA/MSHA to be a hazardous chemical and should be included in the employer's hazard communication program.

CERCLA/SUPERFUND: This product is not listed as a CERCLA hazardous substance.

EPCRA SARA Title III: This product has been reviewed according to the EPA Hazard Categories promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 and is considered a hazardous chemical and a delayed health hazard.

EPRCA SARA Section 313: This product contains none of the substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

Section 15: REGULATORY INFORMATION (continued)

RCRA: If discarded in its purchased form, this product would not be a hazardous waste either by listing or characteristic. However, under RCRA, it is the responsibility of the product user to determine at the time of disposal, whether a material containing the product or derived from the product should be classified as a hazardous waste.

TSCA: Kiln dust and crystalline silica are exempt from reporting under the inventory update rule.

California Proposition 65: Crystalline silica (airborne particulates of respirable size) and Chromium (hexavalent compounds) are substances known by the State of California to cause cancer.

WHMIS/DSL: Products containing crystalline silica and calcium carbonate are classified as D2A, E and are subject to WHMIS requirements.

Section 16: OTHER INFORMATION

Abbreviations:

>	Greater than	NA	Not Applicable
ACGIH	American Conference of Governmental Industrial Hygienists	NFPA	National Fire Protection Association
CAS No	Chemical Abstract Service number	NIOSH	National Institute for Occupational Safety and Health
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act	NTP	National Toxicology Program
		OSHA	Occupational Safety and Health Administration
CFR	Code for Federal Regulations	PEL	Permissible Exposure Limit
CL	Ceiling Limit	pH	Negative log of hydrogen ion
DOT	U.S. Department of Transportation	PPE	Personal Protective Equipment
EST	Eastern Standard Time	R	Respirable Particulate
HEPA	High-Efficiency Particulate Air	RCRA	Resource Conservation and Recovery Act
HMIS	Hazardous Materials Identification System	SARA	Superfund Amendments and Reauthorization Act
IARC	International Agency for Research on Cancer	T	Total Particulate
		TDG	Transportation of Dangerous Goods
LC_{50}	Lethal Concentration	TLV	Threshold Limit Value
LD_{50}	Lethal Dose	TWA	Time Weighted Average (8 hour)
mg/m^3	Milligrams per cubic meter	WHMIS	Workplace Hazardous Materials Information System
MSHA	Mine Safety and Health Administration		

This MSDS (Sections 1-16) was revised on August 11, 2004.

An electronic version of this MSDS is available at: www.lafarge-na.com under the Products section.

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