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NATIONAL COUNCIL FOR AIR AND STREAM IMPROVEMENT

PROCEEDINGS OF THE NCASI MEETING ON BY-PRODUCTS SYNERGY

SPECIAL REPORT NO. 01-06

DECEMBER 2001

Acknowledgments

NCASI appreciates the interest and contributions of those individuals who participated in the By-Products Synergy Meeting. The meeting was organized by Dr. William Thacker, NCASI Senior Research Engineer. This report was assembled by Anna Aviza.

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serving the environmental research needs of the forest products industry since 1943

PRESIDENT'S NOTE

Different industries have common interests in the management and regulation of non-hazardous industrial by-products. In an effort to promote these interests, NCASI organized a meeting on "by-product synergy," which is a systematic approach to beneficial use. The meeting was intended to (a) initiate a dialog between different industries on the subject of beneficial use; (b) share information on the quantities and characteristics of major industrial by-products; (c) review barriers and aids to beneficial use; and (d) discuss current and potential beneficial use options. Participants represented or were otherwise knowledgeable about the following industries: cement manufacture, power generation, food processing, agriculture, pulp and paper, iron and steel, metal casting, environmental consulting, and waste processing/brokerage. This report contains presentation material from the meeting and summarizes some of the discussion that occurred among the participants.

Ron Yeske

Ronald A. Yeske

December 2001

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ABSTRACT

Industries generate enormous quantities of various non-hazardous wastes that must be managed effectively. Increasingly these wastes or by-products are viewed as a resource, as potential raw material. Cooperation between industries can be valuable with respect to identifying beneficial use opportunities and to improving the regulatory climate surrounding industrial by-products.

This report contains presentation materials from a meeting NCASI held with individuals representing or otherwise familiar with several industries. The purpose of the meeting was to initiate a dialogue on "by-product synergy" (i.e., multi-industry beneficial use). Ample time was allocated at the meeting to informal discussions regarding barriers and aids to beneficial use. These discussions are summarized in the lead article that provides an introduction and overview of the meeting.

KEYWORDS

alternative management, beneficial use, boiler ash, by-product synergy, cement, fly ash, industrial by-products, integrated waste management, pollution prevention, reuse, sludge, solid waste, steel, wastewater residuals

RELATED NCASI PUBLICATIONS

Technical Bulletin No. 806 (May 2000). *Beneficial use of secondary fiber rejects.*

Technical Bulletin No. 798 (February 2000). *Utilizing paper mill by-products as forest soil amendments: forest responses, recommendations, and industry case studies.*

Technical Bulletin No. 793 (September 1999). *Solid waste management practices in the U.S. paper industry – 1995.*

Special Report No. 99-04 (October 1999). *A summary of available data on the chemical composition of forest products industry solid wastes.*

Special Report No. 97-08 (October 1997). *Proceedings of the national bioash utilization conference.*

Special Report No. 95-05 (March 1995). *Solid Waste minimization practices in the forest products industry.*

Technical Bulletin No. 655 (November 1993). *Alternative management of pulp and paper industry solid wastes.*

NCASI BY-PRODUCTS SYNERGY MEETING

FINAL AGENDA
DAY ONE

Tuesday, March 27, 2001

9:00 – 9:10	Welcome and Opening Remarks
9:10 – 9:30	Individual Introductions
9:30 – 10:15	Beneficial Use of Industrial Byproducts – A Perspective Elizabeth Olenbush, EO Associates
10:15 – 10:45	A By-Products Synergy Case Study: The Alberta Project Stuart McCormick, Weyerhaeuser Company
10:45 – 11:00	BREAK
11:00 – 11:30	Utilizing Industrial By-Products in the Cement Industry (Anything Goes?) Dr. Alex Mishulovich, Construction Technology Laboratories
11:30 – 12:00	*Open Discussion:* Regulations, Liabilities/Risks, Public Acceptance, and Related Barriers Surrounding the Beneficial Use of Industrial By-Products
12:00 – 1:00	LUNCH
1:00 – 1:30	Drake's Rule for a Sale and a Case Study: Alum Process Residue as a Primary Feedstock in Cement Manufacture Andy Bettman and David Shively, Marvic Minerals
1:30 – 2:00	The Production & Use of Coal Combustion By-Products from Electric Utilities Dean Golden, Electric Power Research Institute (EPRI)
2:00 – 2:30	Pulp and Paper Industry – Overview of Raw Materials and Waste Products Dr. William Thacker, NCASI
2:30 – 3:00	Screening Process for a Waste Blending Program Doug Hermann, STS Consultants
3:00 – 3:15	BREAK
3:15 – 4:00	*Open Discussion:* Specifications/Performance Standards, By-Product Blending/Enhancement, Technology Development, and Other "Technical" Issues Surrounding the Beneficial Use of Industrial By-Products

NCASI BY-PRODUCTS SYNERGY MEETING

FINAL AGENDA
DAY TWO

Wednesday, March 28, 2001

9:00 – 9:30	Beneficial Use of Short Paper Fiber® (Paper Mill Sludge) For Pollution Prevention in the Mining Industry Joe Laubenstein, BFI
9:30 – 10:15	*Open Discussion:* Internal Advocates, Brokers/Processors, and Marketing Issues Surrounding the Beneficial Use of Industrial By-Products
10:15 – 10:45	Sustainable: Attainable? Ron Vriesman, Environmental Resources Management (ERM)
10:45 – 11:00	BREAK
11:00 – 11:45	*Open Discussion:* Transportation, Competing Outlets, Total Cost Accounting, and Other Economic Issues Surrounding the Beneficial Use of Industrial By-Products
11:45 – 12:45	LUNCH
12:45 – 1:15	Integrated Organic Byproducts Processing in Wisconsin's Fox River Valley Leslie Cooperband, University of Wisconsin
1:15 – 1:45	Food Byproducts Utilization - Challenge and...Opportunity Mike Malecha, Kraft Foods
1:45 – 2:15	Steel Industry Wastes: Types, Synergies and Other Issues Kim Lenti, Heritage Environmental Services
2:15 – 2:30	BREAK
2:30 – 3:30	*Open Discussion:* Communication, Collaboration, and Innovation - Any important waste trades untried? Problems and successes with current beneficial uses? What can we do better? Where do we go from here?

CONTENTS

PROCEEDINGS OF THE NCASI MEETING ON BY-PRODUCTS SYNERGY

INTRODUCTION AND OVERVIEW

"By-product synergy" (BPS) has been defined by the Business Council for Sustainable Development - Gulf of Mexico and the USEPA as "the synergy among diverse industries, agriculture and communities resulting in profitable conversion of by-products and wastes to resources promoting sustainability." In one sense, BPS is the application of the "eco-industrial park" concept to existing facilities. More broadly, it might be viewed as an active and systematic approach to waste exchange.

A two-day BPS meeting was organized by NCASI and held in Chicago in late March 2001. The meeting was intended to (a) initiate a dialog between different industries on the subject of beneficial use; (b) share information on the quantities and characteristics of major industrial by-products; (c) discuss current and potential beneficial use options; and (d) review barriers and aids to beneficial use. Although initially dozens of businesses and other organizations were contacted to gauge interest, there was an objective to limit attendance in the hope of facilitating a comfortable, dynamic atmosphere. Participants represented or were otherwise knowledgeable about the following industries: cement manufacture, power generation, food processing, agriculture, pulp and paper, iron and steel, metal casting, environmental consulting, and waste processing/brokerage. A list of participants is displayed in Table 1.

Table 1. Participants at the By-Products Synergy Meeting

PARTICIPANT	AFFILIATION
Joseph Laubenstein	Allied Waste - BFI Pulp & Paper Group
Alex Mishulovich	Construction Technology Laboratories (CTL)
Dean Golden	Electric Power Research Institute (EPRI)
Ronald Vriesman	Environmental Resources Management (ERM)
Elizabeth Olenbush	EO Associates
Saul Furstein	Georgia-Pacific Corporation
Kim Lenti	Heritage Environmental Services
Michael Malecha	Kraft Foods
Andy Bettman	Marvic Minerals
Reid Miner	NCASI
William Thacker	NCASI
Ann Dougherty	Portland Cement Association
Douglas Hermann	STS Consultants
Marion Bradford	Tate & Lyle - A.E. Staley Manufacturing Co.
Paul Ruesch	USEPA Region 5
Leslie Cooperband	University of Wisconsin, Department of Soil Science
Stuart McCormick	Weyerhaeuser Company

Formal Presentations

Twelve formal presentations were scheduled over the two-day period. The first speaker, Elizabeth Olenbush, reviewed the beneficial use of industrial by-products from a market development perspective, and raised themes that included barriers and opportunities within five "E" categories – environmental, engineering, economics, end users, and education. These themes set the stage for the presentations and discussions that followed.

A specific example of a BPS project, in this case within the Canadian province of Alberta, was described by Stuart McCormick. The facilitated project involved 15 sponsoring organizations and 18 other interested parties and consisted of four phases: raising awareness and recruitment of participants; collection and analysis of data on by-products and their characteristics; implementation in terms of the identification of possible beneficial uses, including top prospects; and evaluation of the project, including an analysis of barriers to beneficial use.

Two presentations addressed the use of by-product materials in cement manufacture. Alex Mishulovich shared information on the U.S. cement industry, the cement manufacturing process, and the use of various by-products (e.g., fly ash, blast furnace slag) as fuels, raw mix ingredients, and cement product additives. The chemical characteristics of cement and of possible by-product ingredients were also reviewed. Andy Bettman introduced a case study on the development of alum processing residue, which is a variable mixture of silica, alumina and titanium dioxide, into a valuable feedstock for cement manufacture. On a more general note, the importance of supply (material characteristics), transportation, and market conditions to the feasibility of a beneficial use project was explained.

Dean Golden described the research and practice on the beneficial use of coal combustion by-products such as fly ash and flue gas desulfurization sludge. About one-third of the fly ash generated in the U.S. is beneficially used, principally in the areas of land application and cement/concrete products. One interesting research area involves the development of aluminum-fly ash composites for the manufacture of automobile parts and similar applications. No paper on this presentation was available for the proceedings.

In his review of raw materials and by-products associated with the pulp and paper industry, William Thacker explained the current management of, and potential alternatives for, the industry's by-products. Particular emphasis was placed on management options for boiler ash, wastewater treatment solids, and causticizing wastes. Causticizing wastes, for instance, are employed as agricultural lime substitutes and as cement kiln feedstocks.

Considerations in the evaluation of beneficial use options were delineated by Douglas Hermann, with a focus on the blending of by-products to produce an improved material. A case study involving the matching of a high-carbon pulp residue with a high-nitrogen pharmaceutical residue for land application was described in detail.

Joseph Laubenstein explained his company's program that employs an engineered soil to cover enormous mine refuse piles, thereby preventing the generation of contaminated water. The soil includes short paper fiber (wastewater treatment solids from the paper industry) as one of its ingredients.

Sustainable business practices were defined and illustrated by Ronald Vriesman. The West Michigan Sustainable Business Forum was offered as an example of an association of businesses promoting recycling and other pollution prevention activities.

Leslie Cooperband described a project in northeast Wisconsin that is investigating the feasibility of combining organic residuals from farms, food processors and possibly other sources at a centralized processing facility and generating one or more products. The initiation of this project was covered in the December 2000 issue of *BioCycle*.

Michael Malecha reported on the types, characteristics, and management of the variety of by-products created by facilities of a major food processing company. The company is focusing efforts on finding uses for by-products that are not land-based. No paper on this presentation was available for the proceedings.

Finally, characteristics of the raw materials, manufacturing processes, and by-products of the iron and steel industry were presented by Kim Lenti. Current beneficial applications for the major by-products were reviewed, with the use of steelmaking slag in asphalt mix recounted in some detail.

Informal Discussion Periods

Discussion periods were scheduled as part of the meeting to allow ample time for informal dialogue regarding various issues surrounding the beneficial use of industrial by-products. These periods were structured along the following interrelated topics: environmental/liability, technical, economic, and markets/advocacy. Much of the discussion centered on barriers to beneficial use.

Significant attention was given to environmental and liability issues. The following were among the observations.

- Classification as a waste creates stigma and regulatory hurdles that virgin materials do not face.
- The traditional command-and-control approach to environmental regulation hinders flexibility and innovation; regulations may not have been designed to promote beneficial use.
- Markets cross state borders, but solid waste regulations, which differ among the states, do not.
- Regulators and generators often are uneasy with the idea of commingling wastes, a step that may greatly enhance a beneficial use option; for generators, there is a concern with establishing a shared liability.
- Regulators and the public can have an excessive fear of trace chemicals.
- Liability/risk concerns may thwart a project, yet liabilities may be more perceived than real.
- Well-designed regulations can reduce uncertainty and concerns with liabilities/risks.

Technical issues that can have a bearing on the feasibility of beneficial use were reviewed as well. The discussion included the comments below.

- Variability in characteristics can eliminate a by-product from consideration; control of by-product quality may need tightening to broaden beneficial use possibilities.
- End-use specifications or performance standards are sometimes unclear or undeveloped.
- Reluctance of potential end users to consider materials of "different" composition can be a hindrance.
- Tech transfer is often haphazard; success stories frequently are not communicated, or not widely communicated.
- Lack of understanding of technical aspects of other industries results in unrecognized opportunities.
- Blending or other processing can improve the utility of residuals.

As with any business enterprise, a beneficial use opportunity must make economic sense. Discussion of economic considerations raised comments that included the ones below.

- A successful project generally requires reduced generator costs, at a minimum.
- Transportation distance is critical to the cost of most projects and is a possible deal breaker.
- Generators are too often unaware of the true cost for their current waste management method.
- Many companies lack capital to make process changes or add a new process that could enhance a beneficial use.

- State taxation and incentive policies can aid the beneficial use of industrial residuals.

Issues related to markets and advocacy, not only reaching possible customers but also gaining support within an organization, were also contemplated. Among the points raised were the following.

- By-product quantity and processor/market demand mismatch (way too little material or way too much) can eliminate potential markets.
- A pessimistic "been there, done that" attitude among generators, from exposure to a number of beneficial use programs that never developed or were short-lived, results in reduced motivation to pursue opportunities.
- Generators and end users are focused typically on normal business activities, and there may be a lack of time to thoroughly investigate potential beneficial uses.
- Waste brokers/facilitators have beneficial use as an area of focus and can be critical to the success of a project.
- State market development agencies can help promote beneficial uses of industrial residuals.

The Future

At the end of the meeting, participants were asked to express any interest and ideas for future activities to promote multi-industry interaction and beneficial use. There was interest by a number of participants in seeing the issue carried forward. It was suggested that state market development officials, state environmental regulators, and additional industries be engaged in future discussions. These "discussions" might take several forms, including publicizing the meeting though the publication of articles. Another route would be to attend or speak at meetings sponsored by certain industries or organizations, such as those related to agriculture, chemical production, and mining.

Subsequent to this BPS meeting, representatives of NCASI and EO Associates attended USEPA's Jobs through Recycling Roundtable where the beneficial use of industrial by-products was discussed with state officials having responsibility for development of recycling markets. NCASI is considering the development of meetings with a regional focus, a by-product-specific emphasis, or with the specific purpose of reviewing by-product characteristics and beneficial use experiences with state regulators. NCASI expects to receive a USEPA grant on beneficial use coordination, and tasks include hosting one or more meetings with state regulators to advance the productive use of industrial by-products.

BENEFICIAL USE OF INDUSTRIAL BY-PRODUCTS - A PERSPECTIVE

Elizabeth Olenbush, EO Associates

Following are copies of the slides used for this presentation.

Beneficial Reuse of Industrial Byproducts - A Perspective

Elizabeth Olenbush
EO Associates

OVERVIEW

- Similar to other market development opportunities
- Goal: Create demand for recycled content products
- Are industrial byproducts really different?
  - Manufacturing process wastes
  - Treated differently than MSW
  - Creates challenges in market development
  - Most larger waste streams are non-hazardous under RCRA
- Do states have a responsibility to help industry?
  - Market/economic developers certainly have experience that can help

Public Policy Impacts Byproduct Generation

- Pulp & paper mill sludges
  - Recycled content mills generate higher proportions of sludges
- Coal ashes
  - Clean Air Act amendments impacting coal ash markets
  - Co-generation creates non-spec ashes
- Foundries, steel mills, smelters
  - Metal producers have highest recycling rates of any industry
  - Impacted by market development activities for plastics
- Biosolids
  - Result from Clean Water technologies

Market Development Issues

- Creating demand for recycled content products
- Developing reliable, quality-controlled sources of supply
- Overcoming barriers: 5 E's
  - Environmental
  - Engineering
  - Economics
  - End Users
  - Education

Environmental Barriers

- Playing field is not level
  - Naturally occurring background levels need to be considered
  - Comparable virgin materials need to be considered
  - Why different regs for different materials?
    - Compost/Biosolids landspreading/Land application of pulp & paper mill sludges/Geotechnical uses for fly ash & foundry sand
- Markets cross state & local borders
  - Different state standards costly for multi-state end users or marketers
  - Industries need to be involved
- Case by case permitting especially costly
  - Often cost prohibitive for smaller generators
- Compliance costs for end users can be deal breakers

Engineering Barriers & Opportunities

- Acceptance of "new" materials tied to technical specifications & performance standards
- Specifications needed for many approved end uses
- Specifications don't accommodate multiple materials
- No centralized technical resources exists
  - Lots of success stories out there
  - Technology transfer mechanism needed
- Transportation Agencies set construction standards
  - UNH Recycled Materials Resource Center
    - Website: http://www.rmrc.unh.edu
  - DOT's lack consistent technology transfer partnerships
- Little coordination of agricultural/soil amendment research

Economic Barriers & Opportunities

- Transportation is the highest cost factor
- Companies want to do the right thing, but often don't have the technical and financial resources
- Lack of capital for technical process changes & processing
- Smaller generators don't have enough material for markets
- Cost of permitting real economic barrier
- Sustainable economies require efficient material management systems; apply principals of industrial ecology
- For smaller quantity generators, commingling and co-processing will be only viable economic model
  - PA's Process Recovery Corp. handles byproduct streams from 40 foundries
  - Centralized processing can provide better environmental accountability

Educational Barriers & Opportunities

- Definition as "waste" concerns end users
- Need dialogue involving both generators & end users
- Educational efforts typically focus on DOT's
  - Most construction isn't DOT controlled
  - Contractors will ultimately determine materials usage in free market
- "Technical Conference on Beneficial Use of By-Product Materials in Construction Applications"
  - November 1999 in Albany, NY
  - Technical proceedings available
- Tech transfer should focus on markets, not materials

End User Barriers & Opportunities

- Lack of knowledge; inertia
- Cost savings/performance benefits
- Perception of Liability due to designation as "waste"
  - Most difficult barrier to overcome
- End users don't want waste hauler/MRF regulation
- Most end user industries organized through regional chapters with educational venues
- Other state agencies communicate with end users
- Procurement programs could have large impact

Other Perspectives on Beneficial Reuse

- US Department of Energy Report to Congress on barriers to coal ash utilization
  - Institutional Barriers:
    - Inadequate Information
    - Inefficient Technology/Information Transfer
    - Lack of Coordination/Leadership
    - Inadequacies of State Programs to Promote Beneficial Reuse
    - Non-existent or Inadequate Specifications for Byproduct Use
    - Existence of Attitudinal Barriers
- New York Pulp/Paper Mill Sludge Report
- Massachusetts Foundry Study

A BY-PRODUCTS SYNERGY CASE STUDY: THE ALBERTA PROJECT

Stuart McCormick, Weyerhaeuser Company

Following are copies of the slides used for this presentation.

A By-Products Synergy Case Study: The Alberta Project

NCASI By-Products Synergy Meeting
Westin O'Hare Hotel
Rosemont, Illinois
March 27-28, 2001

By Stuart McCormick, P. Eng.
Weyerhaeuser Company

Weyerhaeuser
The future is growing

Warning: This was a Canadian project eh?

- Metric Measurements
- Canadian Dollars (Northern Pesos)

Geographical Approach: Who is my neighbour?

Alberta: An Exciting Place to Explore By-Product Synergies

- 3 million people and two of Canada's largest and most vibrant cities.
- more than 60 percent of Canada's proven reserves of conventional crude oil,
- 85 percent of Canada's natural gas,
- 63 percent of Canada's coal,
- ALL of Canada's oilsands reserves,
- one of the world's most productive agricultural economies,
- Alberta's forests cover 58% of the Province and generate over $4 billion dollars of forest products annually, making it the Province's third largest industry.

Project Organization

Applied Sustainability LLC, a private company based in Austin, Texas, supported by the International Institute for Sustainable Development and Hatch Associates, facilitated the process by bringing 15 sponsoring companies and organizations, as well as 18 interested parties, together to identify ways in which the "waste" from one company can be converted into a valuable product for another. Regulatory and technological barriers that stand in the way of successful synergies were also identified and addressed.

Sponsoring Companies and Organizations

The project was funded through a partnership of public and private sector sponsors including the following organizations:

Commission for Environmental Cooperation
Alberta Science and Research Authority
Alberta Research Council

And the following Alberta-based corporations

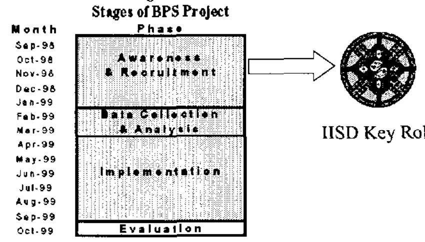
Petro-Canada	Air Liquide
Shell Canada	Alberta's Industrial Heartland Association
Suncor Energy Inc.	Alberta Research Council
Syncrude Canada Ltd	Alberta Science and Research Authority
TransAlta Corporation	Bovar
Trimac	Husky Oil
Wascana Energy Inc.	Marsulex

Other Participants

Alberta Agriculture
CONRAD
Alberta Beverage Container Recycling Corporation
Dalhousie University
Alberta Chamber of Resources
Enersul Inc.
Alberta Energy
Environment Canada
Alberta Environmental Protection
Inland Cement
Alberta Forest Products Association
PL Earth Systems Inc.
AVAC Ltd.
Nolan Cattle
CETAC-WEST
Olds College
City of Calgary
Tynebridge Technologies

Project Stages

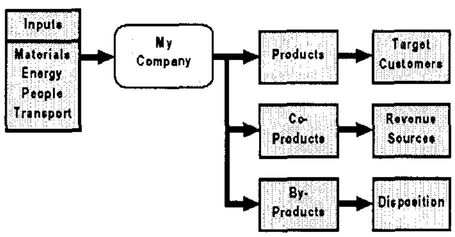
Figure 1
Stages of BPS Project



IISD Key Role

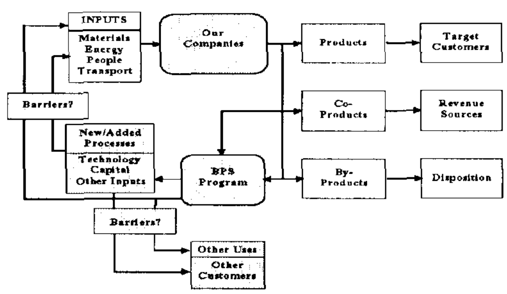
Data Collection and Analysis

The "My Company" View



Implementation

The "Our Companies" View



Implementation - Top Prospects

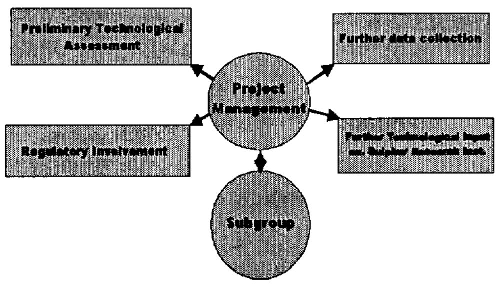
Material	Volume	Degree of Problem	Cost	Opportunity	Flagged Materials
carbon dioxide	high	high	high	high	✓
flue gas	high	high	high	low	
injection wastewater	low	low	low	low	
bottom ash	high	low	low	high	✓
fly ash	high	medium	medium	high	✓
sulphur	high	med-high	medium	high	
sludges	high	low	low	medium (agr, forestry)	
low sulphur coke	high (not captured in data)	low	low	high (done already)	
high sulphur coke	high (not captured in data)	high	high	low	
natural gas	medium	low	low	high	✓
sands	high	low	low	low	
gypsum	high	high	medium	high	✓
wood poles	medium	medium	low	low	
hog fuel	high	high	risk factor	high	✓
waste heat	high	high	high	high	✓
empty transport	high	high	high	high	✓

Subgroups Created to Better Explore Opportunities

Energy
Sulphur and High Sulphur Coke
Inorganics (eg. Fly Ash, Spent Catalysts)
Eco Industrial Parks
Industrial Gases

Implementation Support Structure

Support Structure for Sub-Group Activities



Subgroup Output Example - Energy

Key Opportunities

Co-firing of biomass
Regional electricity and/or co-generation facilities
Biomass and/or oily wastes as fuel for cement kilns
Micro-turbine technology
Ethanol from biomass
Bio-Oil and its derivatives from biomass

Heavy Hitter

Biomass to Energy
(Co-firing, IPP's and Co-generation)

Energy By-Products

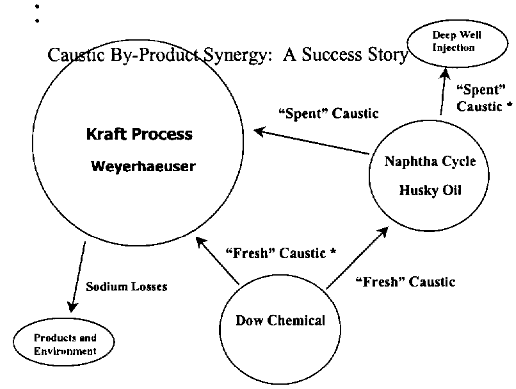
Biomass (agricultural and forestry residues)
Upstream Oil/Gas Field Flared Gases
Heavy Fuel Oil
Butane, Propane, Natural Gas Liquids
Methane (landfills, sludge digestion, etc.)
Used Oil

Barrier Assessment

Barriers to By-Product Synergy

Category	Barrier
➢ Business	➢ lack in continuity of supply
➢ Business	➢ lack of handling facilities (cement kilns for burning tires, other energy sources)
➢ Business	➢ inadequate transportation
➢ Corporate Practice	➢ accounting methods – absence of full cost accounting
➢ Economic	➢ low concentration streams
➢ Economic	➢ low energy costs in AB
➢ Economic/Geographic	➢ lack of critical mass of volume: catalyst, solution gases, geographic concentrations
➢ Economic/Geographic	➢ lack of population
➢ Geographic	➢ geographic distance: sulphur, coke
➢ Geographic	➢ lack of large manufacturing base
➢ Regulatory	➢ regulation (ex. gypsum)
➢ Regulatory	➢ taxation / jurisdictional differences (ex. transportation of hazardous wastes)
➢ Regulatory	➢ deregulation of energy markets
➢ Regulatory/Economic	➢ cost barriers for alternate fuel sources
➢ Risk/Trust/Corporate Practice	➢ mind-set / perceptions

Caustic By-Product Synergy: A Success Story



* eliminated or reduced

Comments on the Process

The truth is not in the numbers.

Regulator participation was an investment.

Facilitation is gold … magic doesn't just happen.

Details are best left to proprietary interests.

Project Legacy

By-Product Synergy community was established.
- Proprietary investigations stimulated.
- Players identified.

Report is a milestone event.
- Barriers identified.
- Priorities indicated.

Money is "in the bank".

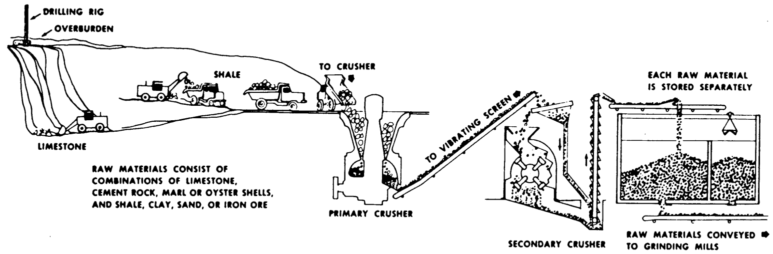
UTILIZING INDUSTRIAL BY-PRODUCTS IN THE CEMENT INDUSTRY (ANYTHING GOES?)

Dr. Alex Mishulovich, Construction Technology Laboratories

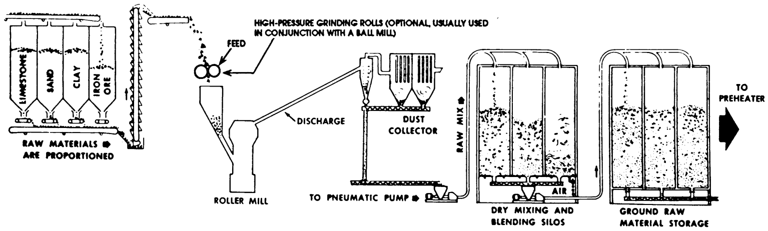
Following are copies of the materials used for this presentation.

CEMENT INDUSTRY DATA SHEET (1999)

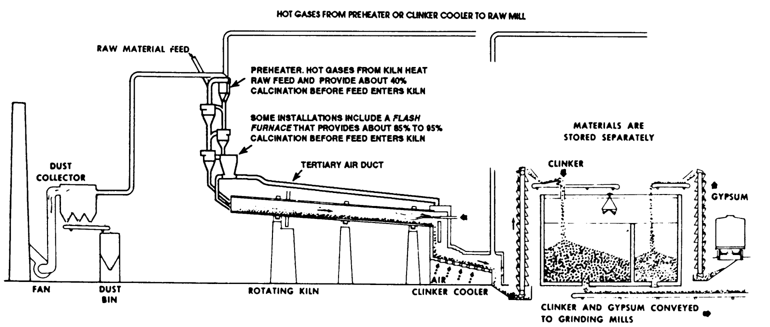
Annual output, thousand metric tons	86,000
Number of cement plants	116
Average plant capacity, thousand ton/year	754
Number of rotary kilns	199
Average kiln capacity, ton/day	1,240
Number of cement-producing states	39
Top 10 cement-producing states	CA, TX, MI, PA, MO, FL, AL, SC, NY, IL



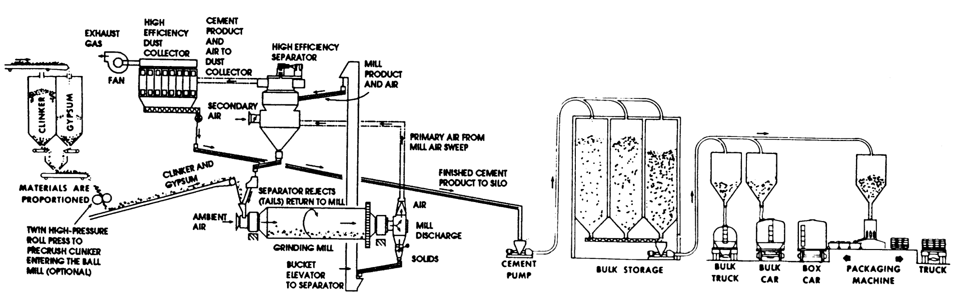
1. Stone is first reduced to 5-in. size, then to ¾ in., and stored.



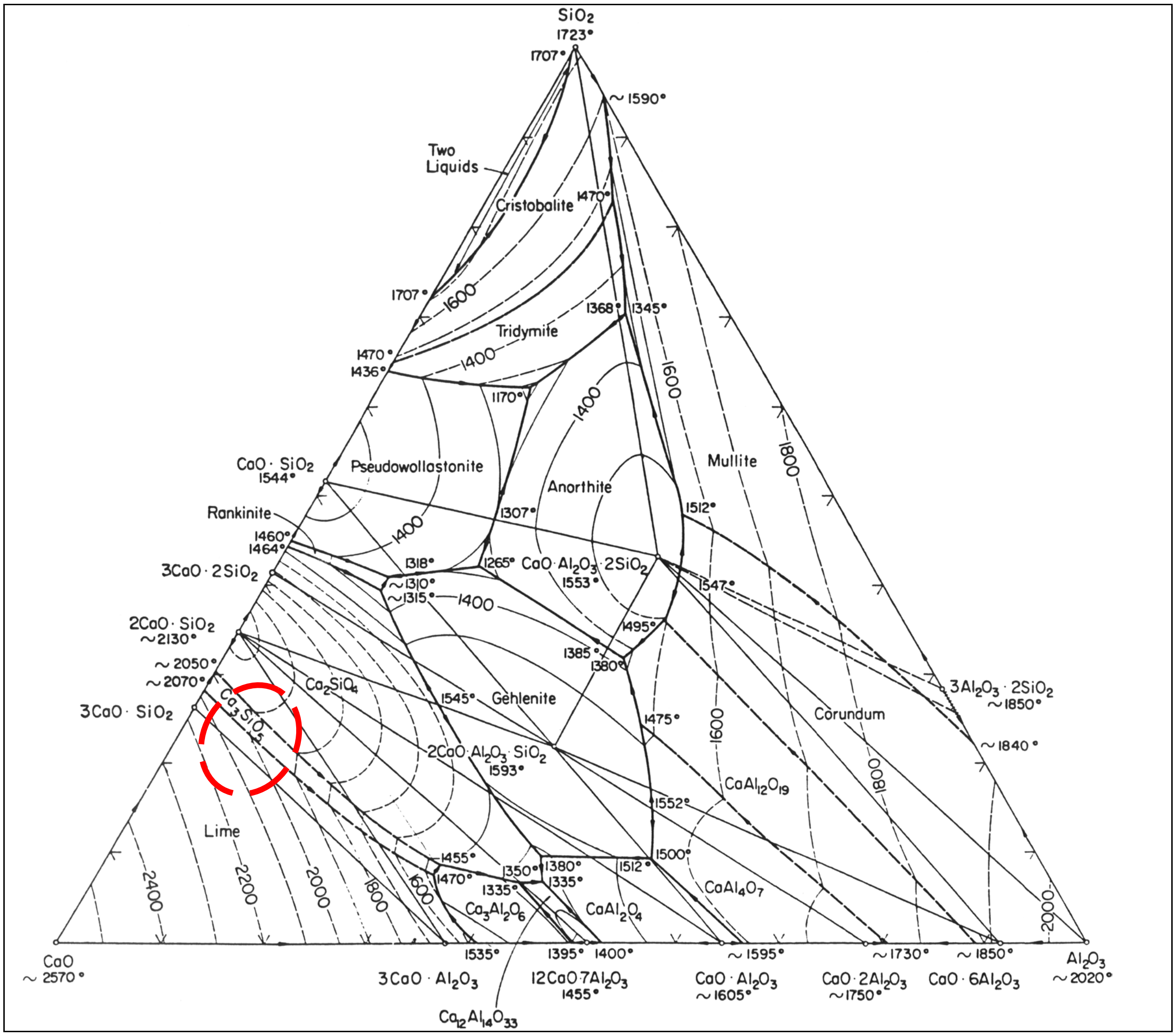
2. Raw materials are ground to powder and blended.

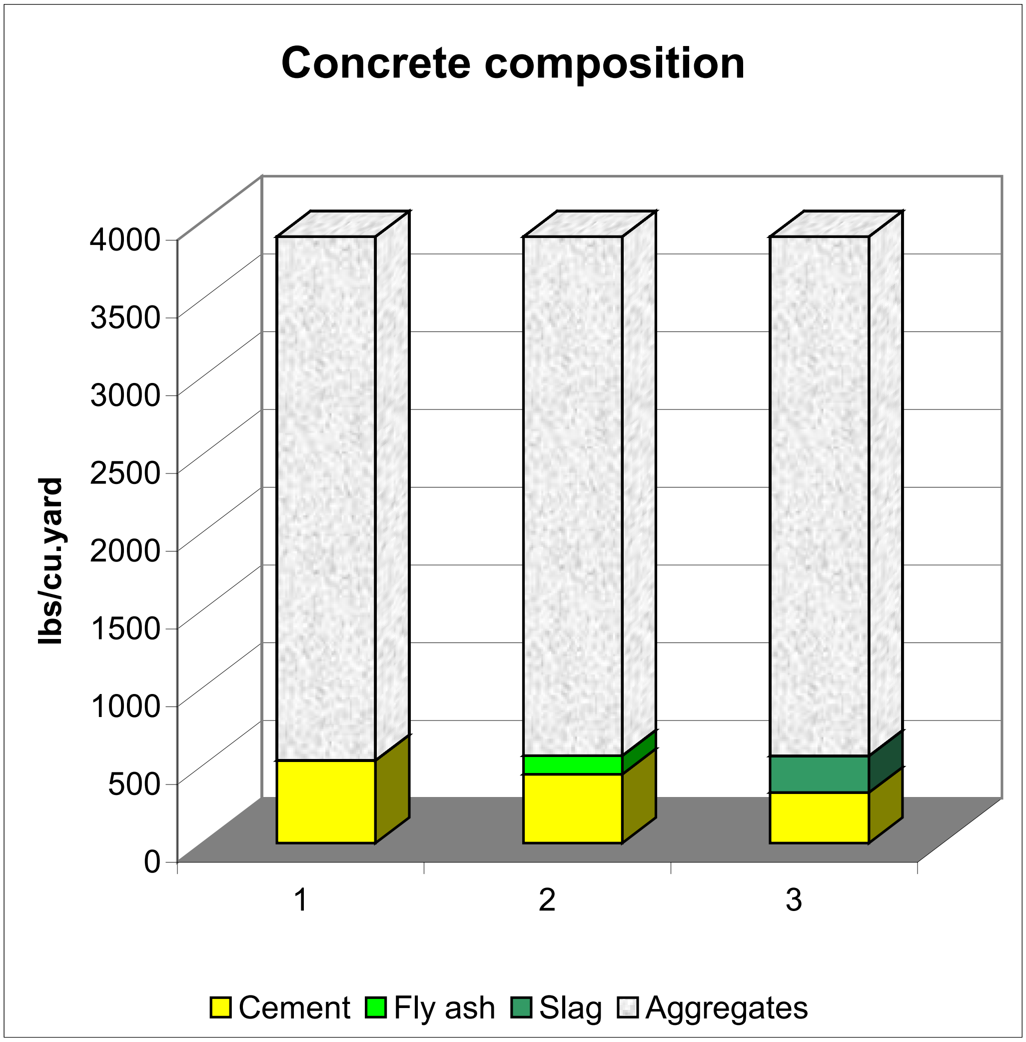


3. Burning changes raw mix chemically into cement clinker.



4. Clinker with gypsum is ground into Portland cement and shipped.


SiO_2
1723°
1707°
~1590°
Two Liquids
Cristobalite
1470°
1707°
1600
Tridymite
1368°
1345°
1470°
1436°
1400
1170°
1600
1400
Mullite
1800
CaO · SiO_2
1544°
Pseudowollastonite
Anorthite
1512°
Rankinite
1307°
1460°
1464°
1400
3CaO · $2SiO_2$
1318°
1265°
CaO · Al_2O_3 · $2SiO_2$
1553°
~1310°
~1315°
1400
1547°
2CaO · SiO_2
~2130°
1495°
1385°
1380°
~2050°
~2070°
Ca_2SiO_4
$3Al_2O_3$ · $2SiO_2$
~1850°
3CaO · SiO_2
Ca_3SiO_5
1545°
Gehlenite
1475°
Corundum
2CaO · Al_2O_3 · SiO_2
1593°
1600
~1840°
1552°
$CaAl_{12}O_{19}$
1800
Lime
1455°
1500°
1470°
1350°
1380°
1512°
$CaAl_4O_7$
2400
2200
2000
1800
1600
1335°
1335°
$Ca_3Al_2O_6$
$CaAl_2O_4$
2000
CaO
~2570°
1535°
1395°
1400°
~1595°
~1730°
~1850°
Al_2O_3
~2020°
3CaO · Al_2O_3
12CaO · $7Al_2O_3$
1455°
CaO · Al_2O_3
~1605°
CaO · $2Al_2O_3$
~1750°
CaO · $6Al_2O_3$
$Ca_{12}Al_{14}O_{33}$


Concrete composition
lbs/cu.yard
4000
3500
3000
2500
2000
1500
1000
500
0
1
2
3
Cement
Fly ash
Slag
Aggregates

BY-PRODUCTS IN CEMENT MANUFACTURING

1. WASTE-DERIVED FUELS

2. RAW MIX INGREDIENTS

3. SUPPLEMENTARY CEMENTITIOUS MATERIALS

USE OF BY-PRODUCTS IN CEMENT KILN FEED

	SiO_2	Al_2O_3	Fe_2O_3	CaO	F^-	Organic matter	Heating value, BTU/lb
Deinking sludge	15	25				50	5,000
Shredder fines	22	6	12	7		12	2,100
Alumina byproduct (1)	44	12		18	13		
Alumina byproduct (2)	23	15		57			
Spent pot liner	11				10	60	7,500
Oily residue	21	19	9	28		86 (as is)	
Food containers	30					52	7,300
Pigment byproduct			55	20			

DRAKE'S RULE FOR A SALE AND A CASE STUDY: ALUM PROCESS RESIDUE AS A PRIMARY FEEDSTOCK IN CEMENT MANUFACTURE

Andy Bettman and David Shively, Marvic Minerals

History

Tri-State Minerals began doing business as a mining company in 1990. During the next 10 years, Tri-State merged or bought several smaller operations throughout the Midwest and near South.

By 1920, they were mining fluorspar, zinc, lead barite, clay, and coal. Consolidations, low recovery rates, and downward business cycles led to Tri-State's eventual transition into industrial minerals with emphasis on construction and cement raw materials.

By 1980, 50% of Tri-State's business has either secondary recovery of spent minerals or byproducts recycling and beneficiation. Recruitment of byproducts was based on the ability to combine these materials with existing product lines in order to achieve lower unit price raw material supplies to customers and as a low cost booster to low grade mined ores.

In 1988, some of the officers and vendors of Tri-State Minerals purchased some of the mineral rights and all the byproduct business of the company and formed Marvic Minerals, Inc., with its primary goal to develop a better strategy and higher end users for its byproducts and waste materials business. By now, there was a burgeoning demand by generators for services that would process and develop beneficial reuse technologies and waste products. Today, 75% of Marvic's market is in beneficial reuse technology.

What is Marvic?

Marvic is a facilitator for waste materials and byproduct market development. This consists of:

Product analysis

- Site analysis
- Logistical analysis
- Market analysis
- Facility analysis—existing facilities processing options
- Like material comparison
- Analysis of shipping options

Processing phase

- Product staging and dewatering
- Material processing, including communition, washing, drying, or calcinization and agglomeration.
- Transporting—hauling and loading on any form of transport
- Shipping and transloading
- Unloading

Marketing/Sales phase

- Off-loading
- Contracting for reuse

- Customer billing
- Collections
- Penalties and carrying charges

Who does Marvic serve?

Consumer—net revenue user

- Makes an end product
- Needs one or more of the constituent minerals contained in raw material
- Can facilitate erratic streams of waste material
- Is and remains in environmental compliance

Generator

- Negative revenue stream—must lower cost of disposal or strive toward a zero or positive revenue stream for byproducts
- Desires to change wastes to useable products through incentive, joint ventures or manufacturing changes

Where does Marvic work?

- Operates on generator's site or nearby
- Utilizes, when possible, fugitive heat sources or additional facilities available to generator
- Operates at port facilities or rail loadout
- Operates on user site

How does Marvic operate?

- Analyzes needs of consumers that could be served by generator's product or combination of products which would include generator's products
- Confirm economic viability of project
- Reclaims and processes generator's wastes to comply with end users needs
- Contracts transportation of wastes or byproduct to end users to assure consistent, timely deliveries
- Can, if necessary, facilitate separate stockpiles and blending at points of origin or discharge to assure product quality and quantity

Anatomy of a Sale

Drake's Rule

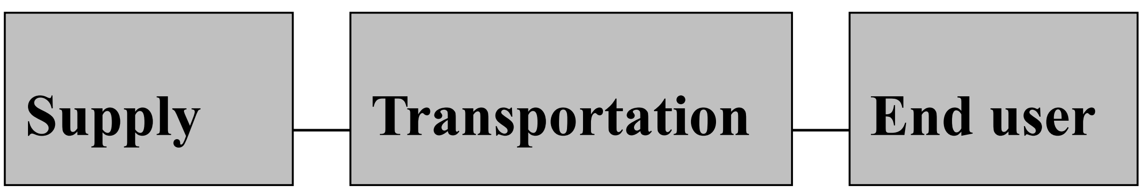
3 Phases of a sale

1. Supply

2. Transportation

3. Market

No sale will ever become a reliable commitment without control of 2 phases of the 3 possible by the seller



Aspects of application for Drakes Rule

Supply

- Quantity
- Quality (consistency)
- Price
- Ease of handling
- Possible value added features
- Customer service

Transportation

- Mode
- Customers' accessibility to multiple modes of transport i.e. barge, rail, truck
- Competitiveness of available modes
- Possible freight combinations i.e. barge to dock, blend—reload rail
- Ownership of vehicles i.e. barge, rail cars
- Contractual relationship with hauler

Market

- Analysis of raw material stream quality and quantities
- Analysis of accessible markets for raw material
- Analysis of available competing raw materials currently serving potential end user and price structure
- Analysis of potential customer long term viability (cyclicality)
- Analysis of costs of beneficiation if necessary for end user including ROIC and analysis of optional disposal costs
- Sale of material to each user

Comparisons of Marketing Entities

Producers	**Facilitators**	**Brokers**
Produces one or more products for sale either by themselves or broker	Can produce some primary raw material for use as blending stock with byproducts	Produces no product Represents producer or facilitator
Maintain possession of raw material until point of sale	Can maintain possession of raw material until point of sale or recycle fee from generator	Takes no possession Makes representation according to producer
Assume all risks	Assumes all risks except residual liabilities inherent in product	Assumes no risk
Can sell direct to end user	Can sell direct to end user	Can only represent former or latter as sales agent
Owns and operates Facility to process	Can own and operate facility Almost always maintains rolling stock for staging material	Office staff only Sometimes owns transportation vessels and storage
Insures for all risks, environmental and liability	Insures for all risks	Limited liability only
N/A	General knowledge of several industries and processes Inclined to find maximum uses of waste material and has capacity to combine his material with others in order to dilute or enhance one or more of the product's constituents	Generally a veteran of a specific industry Specializes in specific needs and acquaintances within that industry

The following is a case history of an actual product we have developed using the aforementioned profile.

Alternative Raw Materials for Use in the Manufacture Of Portland Cement

Alum Process Residue

A Case Study

Background:

Marvic Minerals experience has been about a 50/50 proposition that it finds the "pile" or the "pile" finds Marvic.

In the case of alum process residue (a.k.a. APR), the industrial producer, the one with the "pile", came to Marvic for assistance in developing a viable marketing program. Heretofore, the producer (an expert in aluminum sulfate marketing) had attempted to create a need vis-a-vis internal assessment of where the APR should work, however with limited success they sought expert assistance.

Enter Marvic—byproduct review—targeting a reuse option—testing—contracting
-The rest is history.

What is APR:

Essentially the insoluble fraction from the action of sulfuric acid on a ground and calcined bauxite to produce alum or aluminum sulfate.

Spot Analysis:

SIO2	~67.00%
AL203	12.50
FE203	0.70
CAO	1.50
MGO	0.25
NA20	0.03
K20	0.75
TI02	2.40
SO3	0.06
LOI	11.00
Moisture	23.00
Sieve	90.00 plus 80 mesh

Listed oxides are of major interest to a cement operation and potential positive or negative (based on percentages) impact on clinker quality.

Protocol to Characterize the APR and Potential Reuse Options

Review: What is it? Where is it? How much? How to reuse? What are economics? What are options?

Step 1. What is it?

…A variable mixture of silica/aluminum/titanium dioxide…with the silica being predominately non-crystalline in form.

Step 2. Where is it?

…East St. Louis, IL with rail & river access.

Step 3. How much?

…About 1.5 million tons

Step 4. How to reuse?

…study reveals that some cement operation using a roller mill to crush quartz sand (MOHS 7) can benefit form the softer high silica APR (MOHS 3.5-5.0) i.e. higher thru put and less grinding energy. Also, there is improved in-kiln burnability. Easier grinding & better burning

Step 5. What are economics?

(how to move)…survey determined need for barge movement to optimize freight.

(where to move)…identified plants with processing issues and accessible by barge.

(why to use)…Discuss features and benefits of APR as a silica substitute with key cement managers, with one agreeing to take the lead in testing and champion the project and track:

A. Front end benefits
B. In-kiln advantages
C. Production impact
D. Cost/benefits

(what makes it work)…Explore/negotiate with generator our needs to implement the program:

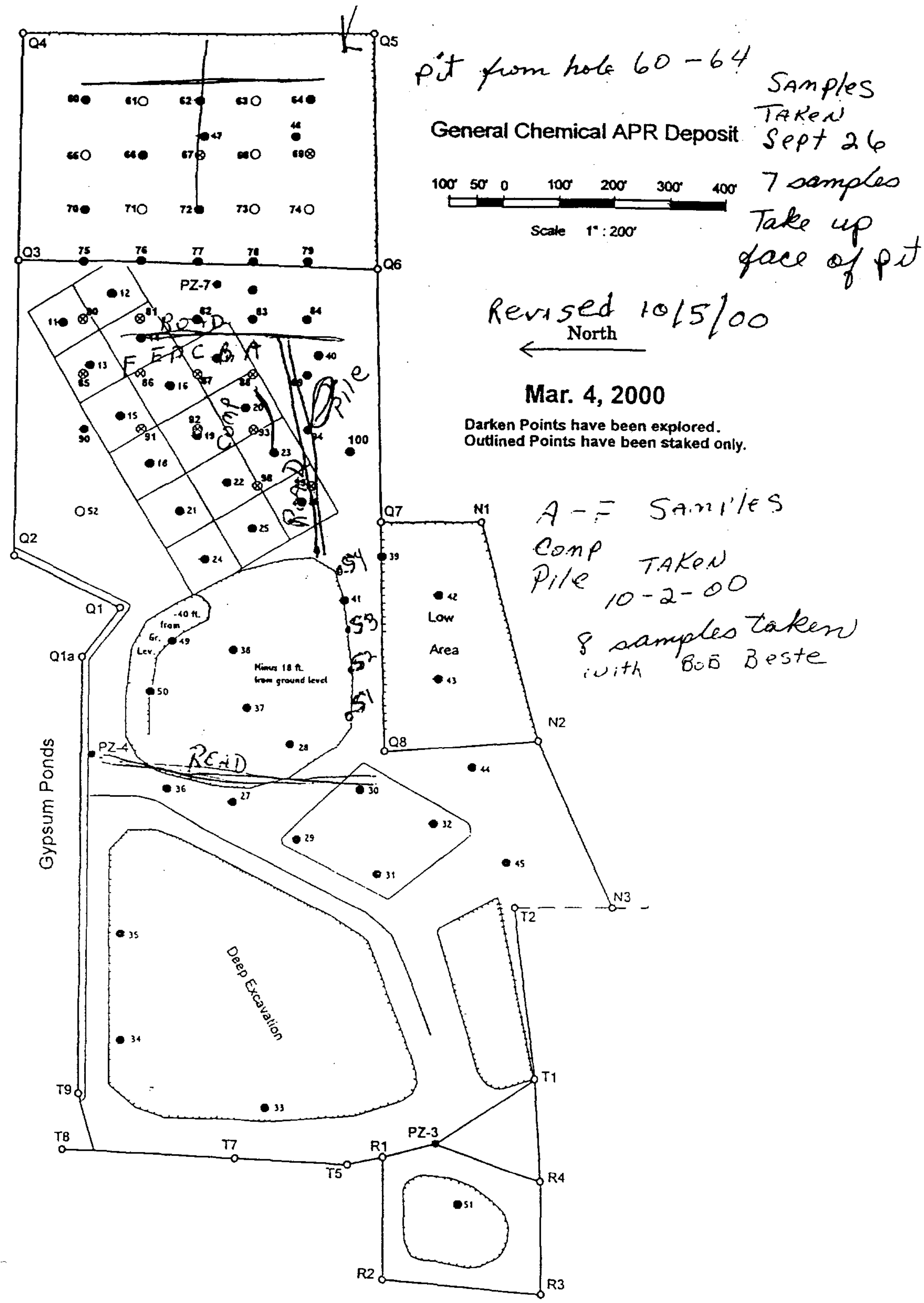
A. Site access
B. Lab availability
C. Environmental issues
D. Subsidies
E. Multiyear contract

Step 6. What are the options?

…with the establishment of the cement plant as the primary consumer of the byproduct it is still necessary (if one is smart) to develop some alternative uses…i.e. a food chain. Find ways to reuse the waste in other industries as secondary, tertiary outlets.

…Marvic allocates some applied research dollars to fully characterize its contract waste streams…e.g. Is it inert, reactive, absorbent, etc? With an understanding of what it is (as-generated) and our broad knowledge of other markets, it may be possible to beneficiate (physical/chemical) the waste… "sow's ear can become the silk purse"?

Thank you for your attention…………Comments?


pit from hole 60 - 64
Samples Taken Sept 26
7 samples
Take up face of pit
General Chemical APR Deposit
100' 50' 0 100' 200' 300' 400'
Scale 1" : 200'
Revised 10/5/00
North
Mar. 4, 2000
Darken Points have been explored.
Outlined Points have been staked only.
A - F Samples
Comp Pile TAKEN 10-2-00
8 samples taken with Bob Beste
Q4
Q5
Q3
Q6
Q7
N1
Q2
Q1
Q1a
Q8
N2
N3
T2
T1
T9
T8
T7
T5
R1
PZ-3
R4
R2
R3
PZ-7
PZ-4
ROAD
Comp Pile
Low Area
-40 ft. from Gr. Lev.
Minus 18 ft. from ground level
Gypsum Ponds
Deep Excavation
100

Holes Samples at General Chemical

Ft.	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6
	Topsoil	Topsoil	Black Topsoil	Topsoil	Topsoil	Topsoil
1	Buff APR w/ some Bricks & Rocks	Gray APR		Gray APR	Buff APR	Pink & Gray APR
2		APR Becoming Pinker with Depth	Buff APR (1Jwa)		Grey Clay	
3				Light to Dark Brown Soil	Buff APR	
4			Gray APR (1Jwb)			
5	Gray Clay		Gr. Clay 1JWc			
6	Pink & Buff APR		Buff Colored APR (1JWd)		Gray & Yellow Clay	
7		APR Becoming Buff Color		Soil	Buff Colored APR	Buff Colored APR
8						
9						
10	APR		APR		APR	APR

Ft.	Hole 7	Hole 8	Hole 9	Hole 10	Hole 11	Hole 12
	Black Topsoil	Topsoil	Topsoil	Topsoil	Topsoil	Topsoil
1	Gray APR	Gray APR (1Kea)	Buff APR	Buff APR	Waste	Buff APR
2	Buff APR				Gray Clay	
3		Buff APR (1Keb)				Rainbow Clay in APR
4	Pink APR			Yellow & Gray Clay	Grey Clay with Waste	
5	Gray Clay					
6	Buff and Pink APR	(1Kec) Thin Gray with Brown Clay Brown Clay increasing to bottom	Yellow & Pink Clay	Buff & Yellow Clay		Waste
7			Buff Colored APR			APR Clay & Waste
8				Buff APR	Grey Clay Waste & APR	
9						
10	APR	Soil	APR	APR	APR	APR

September 26, 2000

Denver Div. # MM777-5
Sample ID: Hole 52 Side & Bottom 9/21/00

CHEMICAL ANALYSIS
WT%, DRY BASIS

Silicon Dioxide, SiO2	69.74
Aluminum Oxide, AL2O3	14.26
Iron Oxide, Fe2O3	0.62
Calcium Oxide, CaO	0.13
Magnesium Oxide, MgO	0.17
Sodium Oxide, Na2O	0.15
Potassium Oxide, K2O	1.00
Total Alkalies as Na2O	0.81
Titanium Dioxide, TiO2	2.82
Manganese Dioxide, MnO2	0.01
Phosphorus Pentoxide, P2O5	0.05
Strontium Oxide, SrO	0.09
Barium Oxide, BaO	0.05
Sulfur Trioxide, SO3	1.28
Loss on Ignition	9.62
Moisture, as Received	17.14

Analysis performed by Wyoming Analytical Laboratories, Inc.

PULP AND PAPER INDUSTRY - OVERVIEW OF RAW MATERIALS AND WASTE PRODUCTS

William E. Thacker, NCASI

Following are copies of the slides used for this presentation.

PULP AND PAPER INDUSTRY

Overview of Raw Materials and Waste Products

William E. Thacker
NCASI

Outline

- Quick introduction to the pulp and paper industry (PPI)
- Quick review of PPI raw materials in terms of fiber, fuel, and chemicals
- Quick review of PPI waste materials with an emphasis on wastewater treatment residuals, boiler ash, and kraft causticizing wastes

U.S. Pulp and Paper Industry

- Approximately 600 mills
- Mostly in: southeast, west coast, northeast, and eastern midwest
- Variety of manufacturing processes, production capacities, raw materials and products

Raw Material Categories

- Fiber
- Fuel
- Chemicals

Fiber

- Standard - wood and recovered paper (wastepaper)
- Specialty - cotton, hemp, kenaf, synthetics
- Ag residues ? - straw, bagasse, corn stalks, cotton stalks, sorghum

Fuels

- Standard - coal, bark/wood, fuel oil, and natural gas
- Other - wastewater treatment residuals (WTR), OCC rejects, non-recyclable paper, tire-derived fuel, used oil, etc.

Pulping & Bleaching Chemicals

Sodium sulfate	Sodium chloride
Calcium carbonate	Sodium hydrosulfite
Sodium carbonate	Oxygen
Sodium hydroxide	Chlorine
Sodium silicate	Sodium hypochlorite
Soaps	Hydrogen peroxide
Fatty Acids	Ozone
Sulfuric acid	FAS

Papermaking & Coating Chemicals

Kaolin clay	Sizing agents
Talc	Retention Aids
Titanium dioxide	Dyes & pigments
Calcium carbonate	Starches
Soy protein	Latexes
Poly vinyl alcohol	Paraffin
Polyethylene	

Mill Cleaning Chemicals

Hydroxides (sodium, potassium)
Acids (sulfuric, hydrochloric, citric)
Ethoxylates (nonylphenol and alcohol)
Glycol ethers
Naptha, other organic solvents
EDTA

Waste Material Types

- Wastewater treatment residuals (WTR) (sludge)
- Bark & wood residues
- Boiler ash
- Causticizing wastes
- Pulping rejects (virgin and secondary)
- Wood yard wastes
- Paper mill rejects
- Broke not recycled in-mill

Wastewater Treatment Residuals

General Characteristics

- 20 - 60% solids content after mechanical dewatering
- Not RCRA hazardous waste
- Low in metals, low to medium in nutrients
- Low in trace organics

Wastewater Treatment Residuals

Amount and Type (proportion) in 1995

~5.8 million dry tons generated in 1995

- Primary WTR (40% of total)
- Secondary WTR (1%)
- Combined (primary & secondary) WTR (54%)
- Dredged WTR (5%)

WTR Management

Technique (proportion in 1995)

- Landfill or lagoon (51%)
- Combustion (26%)
- Land application (12%)
- Reuse in-mill (5.5%)
- Other beneficial use (5.5%)

Primary WTR

General Characteristics

- Ash (inorganic fract.) <10 - 70% dry wt.
- Inorganic fraction - clay, $CaCO_3$, TiO_2, boiler ash, causticizing wastes
- Organic fraction - wood fiber

Primary WTR

Other Beneficial Uses - Actual

Artificial soils	Industrial absorbent
Compost feedstock	Ag chemical carrier
Landfill cover	Fuel pellet ingredient
Landfill cap	Building board
Animal bedding/litter	Roofing felt/tar paper
Cement kiln ingredient	Papermaking fiber
Glass aggregate prod	
Concrete or brick additive	

Primary WTR

Other Beneficial Uses - Potential

Plastics additive	Molded pulp products
Animal feed	Cellulose insulation
Ethanol production	Minerals recovery
Levulinic acid prod.	Fuels from pyrolysis
Other chemical prod.	
Lightweight aggregate	

Power Boiler Ashes

Amount and Type (proportion) in 1995

~2.8 million dry tons generated

- Coal + wood ash (23% of total)
- Wood ash (22%)
- Coal ash (15%)
- WTR + coal &/or wood, etc. (23%)
- Other + coal &/or wood, etc. (17%)

Boiler Ash Management

Technique (proportion in 1995)

- Landfill or lagoon (72%)
- Construction* (12%)
- Land application (11%)
- Other beneficial use (5%)

* Earthen construction such as road beds and berms, not cement or concrete

Wood Ash

General Characteristics

- Function of wood type (e.g., species, bark v. stem wood) & combustion conditions
- Unburned carbon (LOI) <10 - 50%
- Alkaline (high pH) and source of Ca, Mg, K, & P
- Heavy metals generally not a concern

Boiler Ash Management

Other Beneficial Use - Actual or Potential

Compost feedstock
Artificial soils
Landfill daily cover
Cement Manufacture
Concrete Additive
Cattle bedding
Activated carbon manufacture
Soil stabilization
Flowable fill

Kraft Causticizing Wastes

General Characteristics

- Alkaline and high in calcium
- Generally not RCRA hazardous waste
- Low in metals

Kraft Causticizing Wastes

Amount and Type (proportion) in 1995

~1.7 million dry tons generated in 1995

- Excess lime mud (59% of total)
- Green liquor dregs (28%)
- Slaker Grit (14%)

Causticizing Waste Management

Technique and proportion (%), 1995

	LM	GLD	SG
• Landfill or lagoon	70	95	91
• Land application	9	3	5.5
• Reuse in-mill	1	0	3
• Other beneficial use	21	2	1

Causticizing Waste Management

Other Beneficial Use - Actual or Potential

Compost feedstock
Artificial soils
Landfill daily cover
Road dust control
Soil stabilization
Cement manufacture
Clay brick additive
Asphalt additive
WW neutralization
WTR settling aid
WTR dewatering aid
WTR stabilization

SCREENING PROCESS FOR A WASTE BLENDING PROGRAM

Doug Hermann, STS Consultants

Following are copies of the slides used for this presentation.

Screening Process for a Waste Blending Program

by Doug Hermann PE
STS Consultants Ltd.

By-Products Synergy Meeting
Rosemont, IL
March 27 and 28, 2001

Wastestream Characterization Process

- Assess Waste Types
- Assess Waste Volumes
- Assess Current Disposal Costs
- Assess Internal Waste Reduction/Recycling/Reuse Opportunities

Characterization Parameters

- Moisture Content
- Bulk Density
- Viscosity
- BTU/Ash Content
- Transport Characteristics
- Chemical and Mineral Content
- Nutrient Content and Nutrient Balance C:N:P
- Indoor and Outdoor Storage Issues

Characterize Transportation Infrastructure and Logistics

- Marine
- Railroad
- Truck
- Logistics / Costs ($/ton-mile)
- Backhaul Opportunities
- Staging Storage Needs

Evaluate Synergistic and Compatible Waste Industries

- Use Waste Exchanges
- Use Yellow Pages
- Use GIS SIC Code Databases
- Commonly Combined Wastes
  - Mineral, Nutrient and Carbon Wastes to AG
  - Mineral Waste Exchanges between Utility, Cement, Steel/Foundry, and Construction Materials

Evaluate Synergistic and Compatible Waste Industries (Continued)

- High Carbon Wastes with High Nutrient Wastes
- Food Processing Wastes to Other Food Processors
- Ash/Silica Wastes to Mineral-Filled Products
- Dry, High BTU Wastes to Fuel Users

Waste Product Development & Liability

- Produce Reliably Consistent Waste Product
- Match Waste Volume to Opportunity
- Evaluate Transportation Costs
- Evaluate Market Potential
- Evaluate Processing Requirements

Case Examples

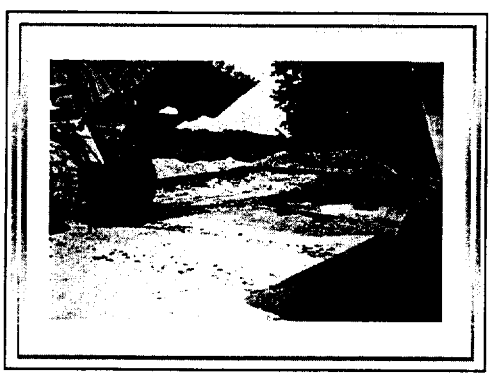
- High Carbon Pulp Residue Matched with High Nutrient Pharmaceutical Residue
- High Carbon Pulp Residue Matched with High Nutrient Animal Manures
- Scrap Tires Matched to Chemically-Durable Aggregate Applications
- High Nutrient and Carbon Wastes Matched to Low Productivity Soils

Case Examples

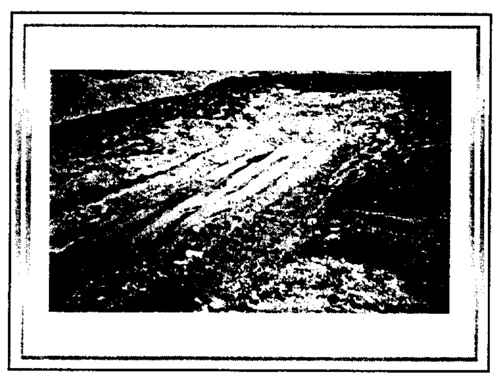
(Continued)

- High Carbon Wastes Formulated for Chemical Carrier/Delivery in Granulated Products
- Colliery Wastes to Fuel Users

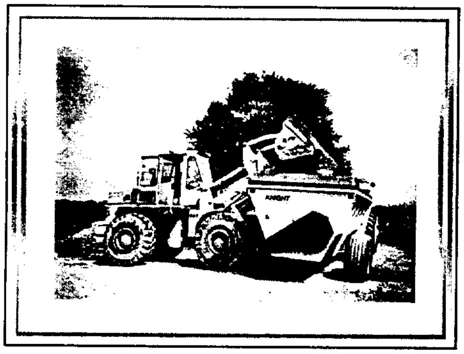
SLIDE 10 - deinking wastewater sludge cake (high C:N ratio) on left; pharmaceutical fermentation sludge cake (low C:N ratio) on right



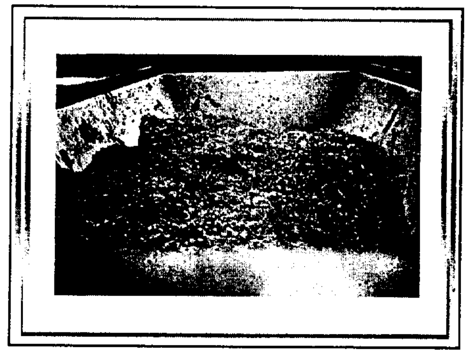
SLIDE 11- Day-old pharmaceutical sludge (to right of loader) slumps badly and attracts insects.



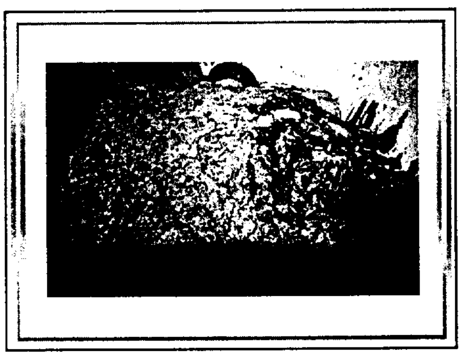
SLIDE 12 - High nutrient pharmaceutical sludge alone was insect breeding substrate.

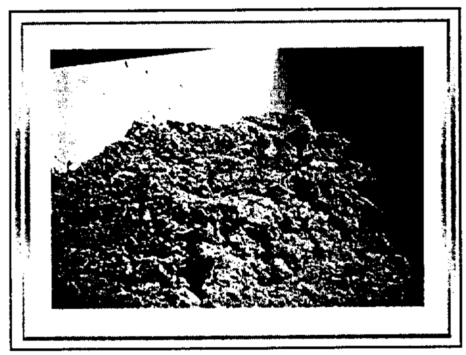


SLIDE 13 - Both sludges were combined and blended with twin auger in spreader box at 1:1 ratio.

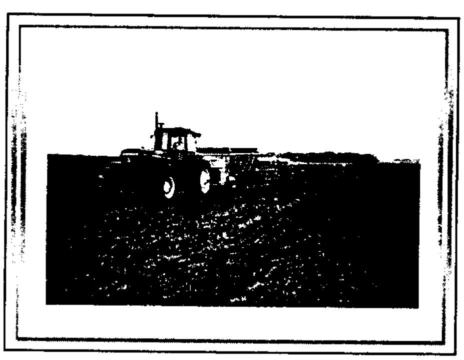


SLIDE 14 - Note the pharmaceutical sludge adhesion to the spreader box wall. This was eliminated after blending.

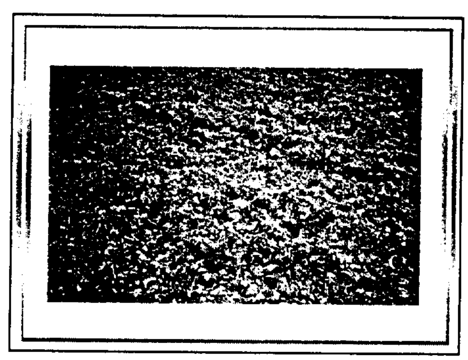




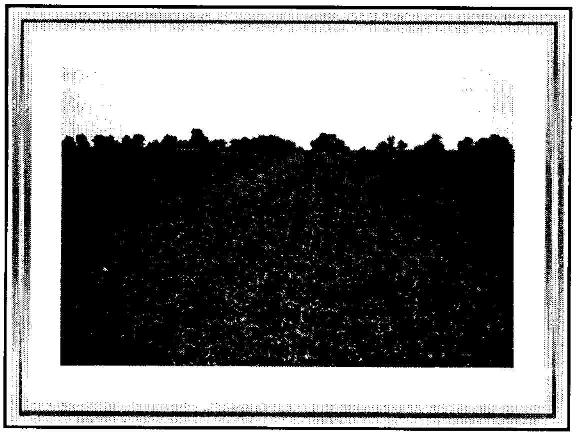
SLIDE 16 - Two minutes of auger blending (about the time to pick up a new load and return to the field) was needed to thoroughly blend the sludges.

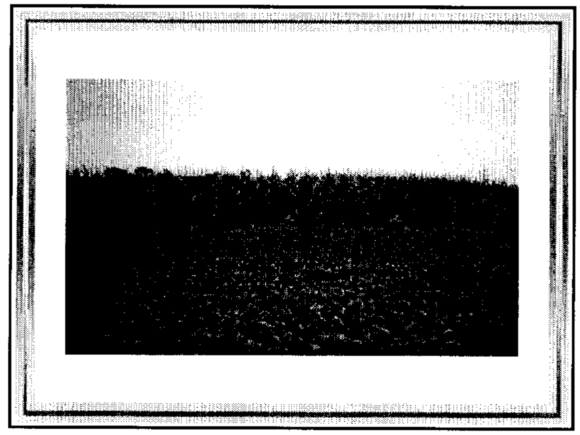


SLIDE 17 - Combined sludges were applied with a side discharge spreader. This was never possible with the wet pharmaceutical sludge.

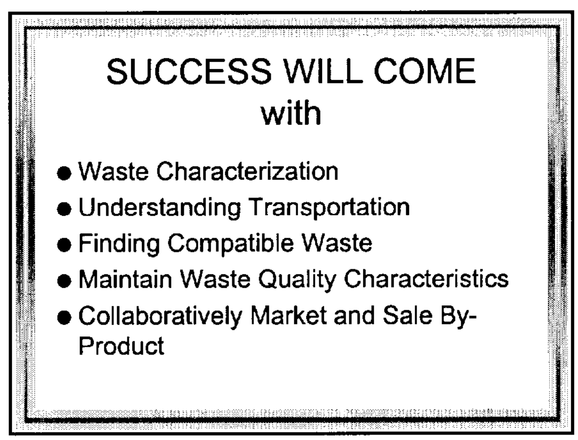


SLIDE 18 - Note uniform application on the ground.





SLIDE 20 - Crop production was well above average and fertilizer application was reduced.



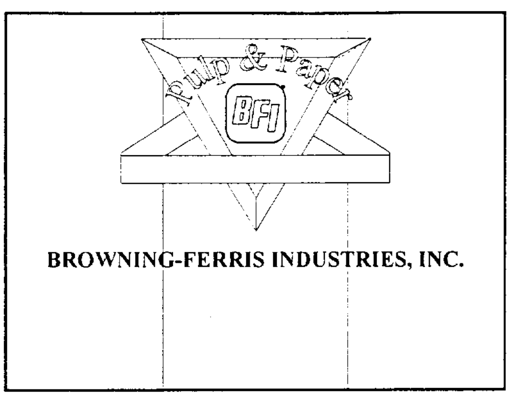
BENEFICIAL USE OF SHORT PAPER FIBER® (PAPER MILL SLUDGE) FOR POLLUTION PREVENTION IN THE MINING INDUSTRY

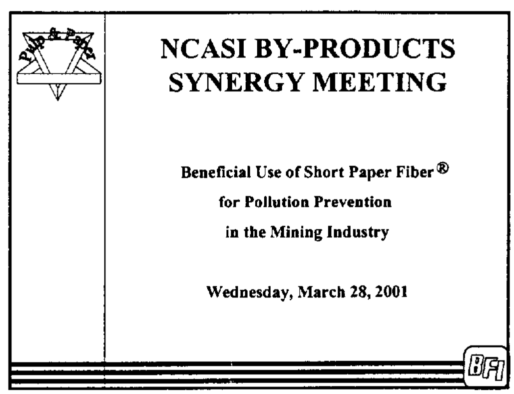
Joseph Laubenstein, BFI

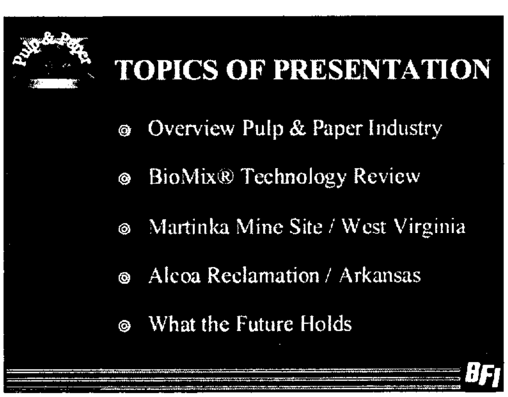
Browning-Ferris Industries (BFI), Inc. has been a service provider to the Pulp & Paper Industry for the past 12 years. Over these past 12 years, BFI has focused on developing beneficial use programs for residuals generated from the papermaking process. The most successful of these programs is the BioMix® Technology. The technology utilizes Short Paper Fiber® (SPF®) which is commonly referred to as paper mill sludge. The program utilizes the SPF® as its raw material to manufacture BioMix® soils which are then sold to the mining and landfill industry to be used as capping materials. Over years of monitoring and performance reviews, this technology has gained acceptance as a means of stopping contamination of rain water flowing through mining refuse piles and landfills alike.

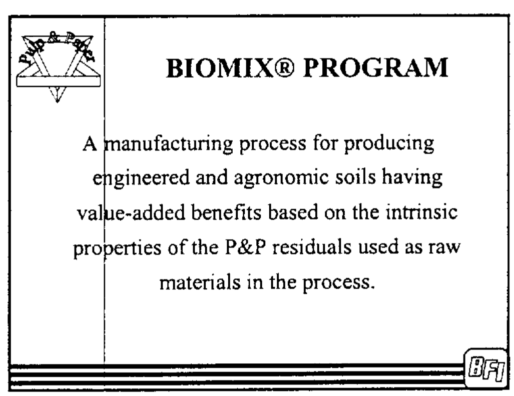
This presentation will focus on the success of working with two industries to fulfill the economical and environmental needs of both industries. By using Short Paper Fiber ® BFI has proven to the mining industry that this product possesses inherent properties that are beneficial to mining operations. Today, BioMix® soils are the preferred product for capping mine refuse piles where water quality issues are of concern

Following are copies of the slides and text used for this presentation.









SLIDE 5 - BioMix® soils have been used in many different applications. This is a listing of some of those applications. The most prominent of these are in the mining and landfill industry where water treatment costs are of major concern.

SLIDE 6 - After investing $5 million of Research and Development funds this is the unit that BFI engineered for the manufacturing of BioMix® soils. This plant has the capacity to manufacture 200 tons of product per hour under a very stringent QA/QC program resulting in a product that can meet any product specifications required. The blending recipes are laboratory-trailed, making certain of the proper mixing ratios, before the manufacturing process is started on a large scale. During production of the product many samples are taken, typically every 5,000 tons of product, assuring the BioMix® meets and many times exceeds the QA/QC program.

SLIDE 7 - One of the most important parts on the manufacturing plant is the preprocessing unit. Shown above is the rototiller assembly which can also be switched out with a hammer mill unit for more difficult SPF® materials. This unit preprocesses the SPF® down to particle size of 3/8 of an inch or less. This is very important in the manufacturing process. Many product specifications require a large surface area so microorganisms can readily get to the carbon source that is available in the SPF®. Allowing the SPF® to stay in a “slug” form, which is the way it is mostly received from the paper mills, results in soil matrixes that do not perform satisfactorily in the field. Another important attribute of the preprocessor is it transforms the SPF® into a raw material resulting in a very homogeneous BioMix® soil.

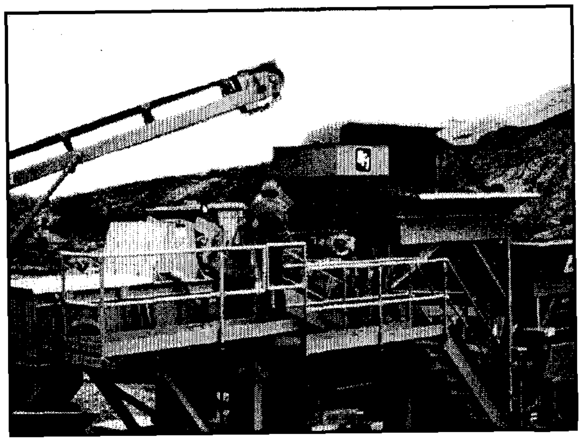
SLIDE 8 - This is the unit that feeds our proprietary fertilizers and pH adjusting compounds into the mixes. This is especially critical when we are manufacturing agronomic soils. Agronomic soils are manufactured based on their moisture holding capacities and their abilities to grow vegetative plants having the highest evapotranspiration properties achievable. This is the most beneficial property of these soils for in many instances the hydraulic barrier layer can be eliminated from the closure process.

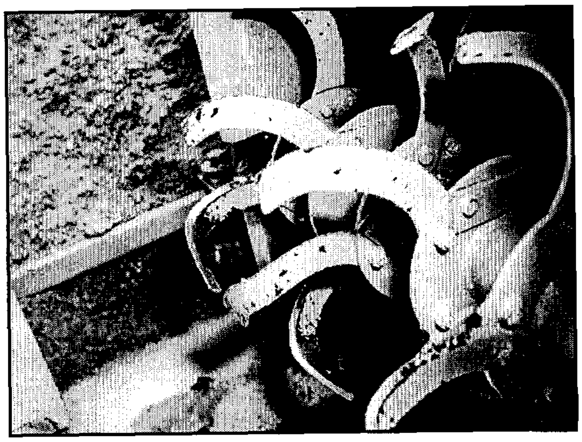
SLIDE 9 - You are looking down the throat of the pug mill mixing component. This is where all the ingredients are mixed together resulting in the proper BioMix® soil. The mixing chamber has a retention time of only a few seconds up to 20 seconds depending on the mixing requirements to obtain a soil matrix needed to meet the QA/QC requirements of the project. The paddles are made of ¾-inch tempered steel able to withstand the most difficult materials (granite, shale, and other hardened materials) which are used sometimes to manufacture BioMix® soils.

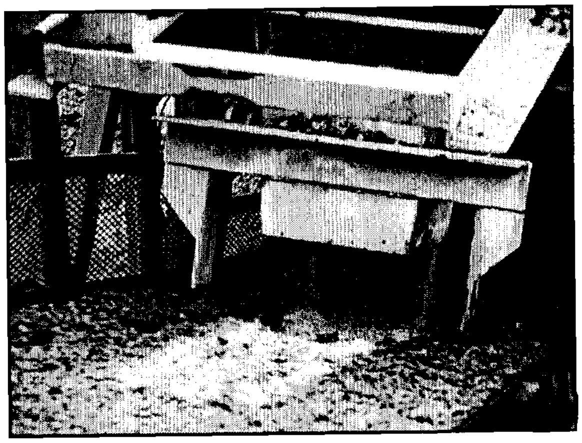
SLIDE 10 - The hand on the right holds Short Paper Fiber® or SPF® as it is commonly received from a paper mill. The hand on the left holds SPF® after it has gone through the preprocessing unit. Notice how the particle size is much smaller, resulting in larger surface areas for the microorganisms.

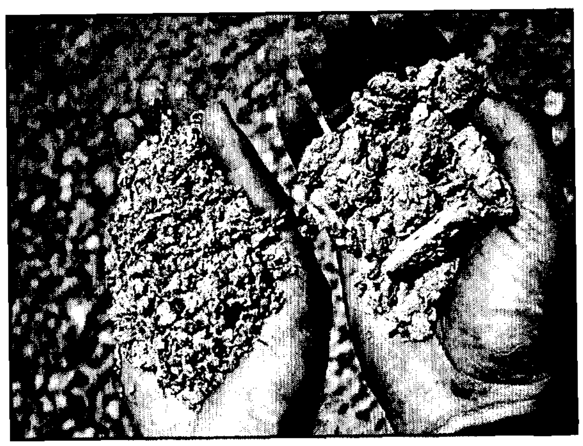
UTILIZATION SITES OF BIOMIX® SOILS

- Golf Courses
- City Parks
- Mine Reclamation - *coal, bauxite & phosphate*
- Landfill Closures - *Over 100*
- Operating Landfills - *daily cover, intermediate cover, grading material, and base of service roads.*









SLIDE 11 - The hand on the right is holding SPF® after being processed through the preprocessing unit. The hand on the left is holding a BioMix® soil matrix. Notice the BioMix® soil has a dark brown color as compared to the SPF® on its own. This is a very important feature of our soils for we try to mask the presence of the SPF® material in our soils. This is accomplished through mixing the SPF® with on-site native soils that may contain humus material or at times we even spray the BioMix® soils with environmentally friendly color enhancers that turn the soils a deeper earthen brown color. Not only are the soils more accepted by the end users but it also results in soils that germinate plants quicker and in the Northern climates longer into the fall months due to their solar absorption properties.

SLIDE 12 - Here you are looking at a stockpile of BioMix® soil. It is hard to see from this picture but the tip of the pen is pointing to an aqua colored fertilizer particle. The fertilizer particles that we purchase are actually sprayed this color so we can visually see the distribution of the fertilizer throughout the product. Also, when we go back to projects that have had our soils in place for a period of time we are able to easily locate the fertilizer particles to evaluate their breakdown and remaining nutrient values. This practice is only done today on those projects requiring close scrutiny.

SLIDE 13 - These are two different mining operations where we have successfully employed the BioMix® Technology. The Martinka Mine site is a 135-acre coal refuse pile over 300 feet high in Tygart River, West Virginia.

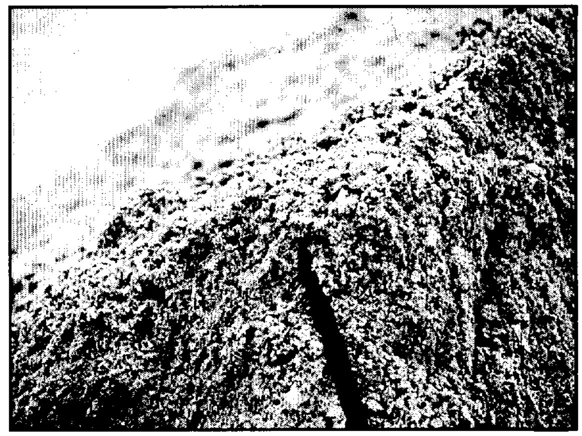
The Alcoa mining site is located in Bauxite, Arkansas. This site encompasses 7,000 acres; all of the rainwater falling on this site is treated through a water treatment process to remove acid mine drainage commonly referred to as AMD.

SLIDE 14 - This is what streams look like that receive Acid Mine Drainage (AMD) from many of the inactive mine sites through out the Appalachian Mountains. The water coming from the small stream in the middle of this picture contains the AMD from an abandoned mining site. The pH of this water is in the range of 2.3 to 2.5. As it flows into the larger receiving stream the pH is quickly raised by the dilution of the larger receiving stream resulting in the precipitation of the iron and manganese. One can see the settling of the red precipitate around the rocks in the stream. Hundreds of miles of streams are void of life due to the effects of AMD.

SLIDE 15 - This is an aerial photo of the Martinka Mine site located in Tygart River, West Virginia. Active mining of coal stopped at this site in 1993. You are looking down on the coal refuse piles that were constructed over the past 50 years while the mine was in operation. The combined area of the two refuse piles is 135 acres. The piles rise to a height of 300 feet from toe to top, having slopes of 2:1. Reclamation on the refuse pile on the left side of this slide was started in 1995 and completed in 1999. The refuse pile to the right is in the process of receiving BioMix® soils and is scheduled for completion in summer of 2001. Upon completion, over 700,000 tons of Short Paper Fiber® will be used on this site to cure the AMD problem.

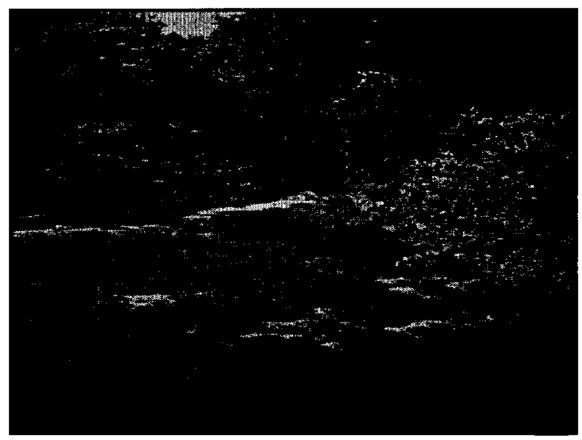
One can see all the collection ponds around the site that collect all the rain water that percolates through the pile. In the center of the slide, or the area between the two refuse piles, is where the water is treated before being discharged into the Tygart River.

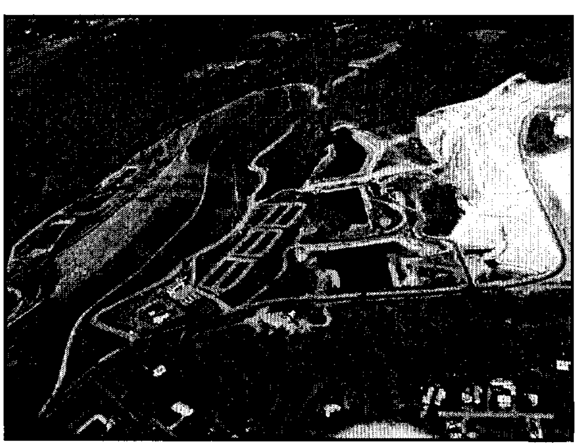
SLIDE 16 - This is one of the treatment ponds that the AMD is pumped up to. Notice the dark red color of the water which is characteristic of AMD water.



MINE RECLAMATION

- Martinka Mine Site - Coal Mine
- Alcoa Corporation - Bauxite Mine





SLIDE 17 - This is one of our permitted blending areas in the state of West Virginia. The Short Paper Fiber® is trucked from the mill to this site where it is blended with native soils, fertilizers, and pH adjustments in the manufacturing of BioMix® soils. This is a 5-acre site that is permitted to handle 60,000 tons of product at any one time. From here the BioMix® soil is trucked to the mining site where it is placed on the refuse piles.

SLIDE 18 - This is a 5,000 square foot test pad to get the proper permeability to get the right placement methodology which is required for developing our QA/QC program. Shelby tubes are extracted from the test pad area and sent to a laboratory to determine the permeability of the material. Once the proper methodology is determined, number and depths of lifts plus number of passes needed to be made by the compacting piece of equipment, the specifications are implemented into the field placement and become the major part of the QA/QC program. When placed in the field Shelby tubes are taken every acre to confirm the proper permeability for the project is met.

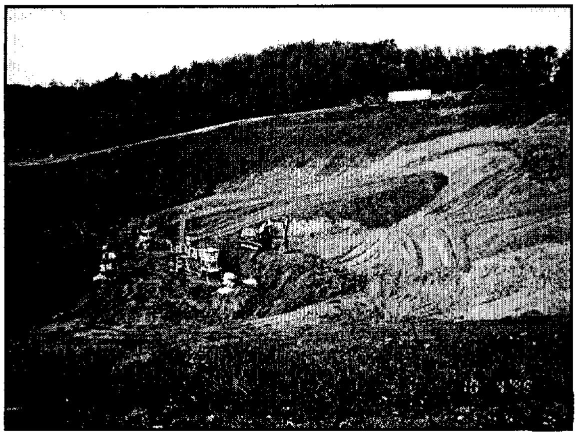
SLIDE 19 - These are the permeability results from the 5,000 square foot test pad used at the Martinka project. One can see from this table that this SPF® has great permeability properties resulting in a barrier layer that will stop both water and oxygen from entering into the coal refuse piles. Without the presence of water and oxygen together, Acid Mine Drainage (AMD) cannot be generated.

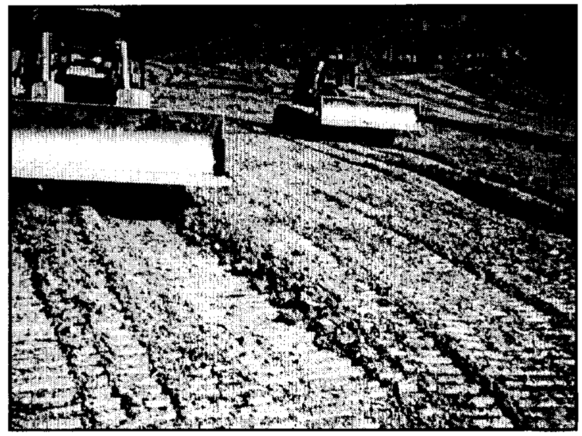
SLIDE 20 - This is placement of the SPF® for barrier layer on the slide slopes of the coal refuse pile. Notice the steepness of the slopes.

SLIDE 21 - The placement equipment must be able to move both up and down the slopes to properly and economically place material. For this project a wide track D-6 low ground pressure dozer is used.

Notice in the background the refuse pile on the other side of the valley which was capped from 1999 through 2001.

SLIDE 22 - Notice the Acid Mine Drainage (AMD) which is seeping out from the refuse pile where the bench is constructed for support of the height of the pile. This did cause problems during placement of SPF® and BioMix® on the slopes of the refuse piles. Each bench was graded so that all the AMD would flow by gravity to the collection ponds.

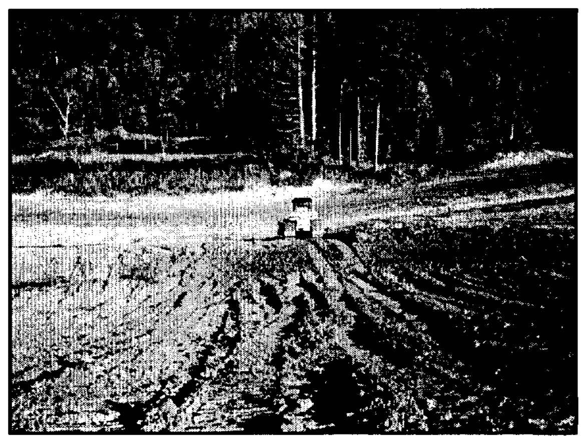


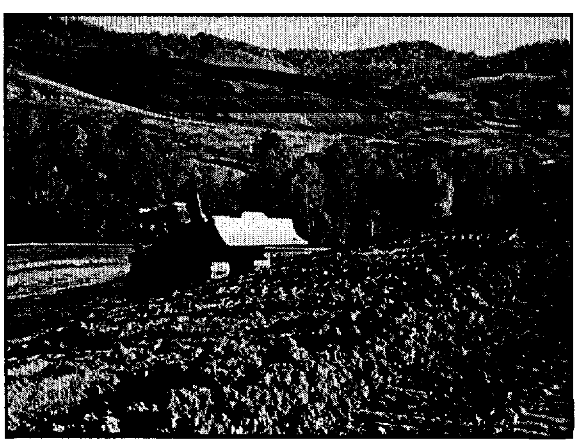


PERMEABILITY TEST

•Client project: Martinka Capping Test Pad - April 1997

Sample	Average Permeability cm/sec @20C
ST - 1	9.50E-08
ST - 2	2.10E-08
ST - 3	8.70E-08
ST - 4	6.40E-08
ST - 5	2.30E-07
ST - 6	5.50E-08





SLIDE 23 - Once the final vegetative layer is placed on the refuse piles the areas are seeded. The preferred method of seeding BioMix® is drill seeding. On slopes too steep for this method, seeding is accomplished by standard hydroseeding methods.

SLIDE 24 - One truly gets the feeling of the steepness of the slopes from this slide. One major advantage of BioMix® soils is its ability to stick on steep slopes with little to no erosion. This ability is achieved from the interlocking mechanism of the fibers in the product. Each fiber interlocks with an adjoining fiber resulting in a matted effect which resists erosion. It takes tremendous energy from a violent downpour to overcome this interlocking phenomenon; thus the product is virtually non-erodible.

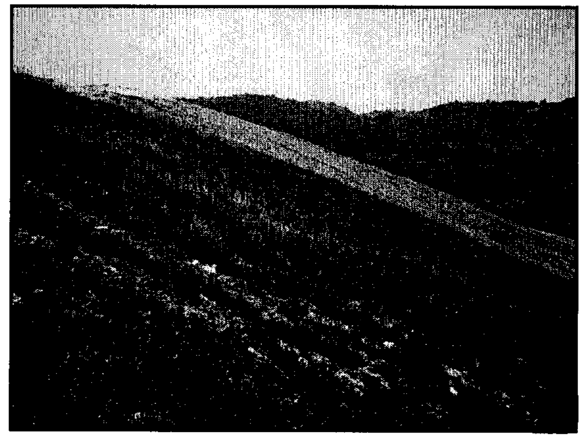
SLIDE 25 - Once the turf plants become established, usually within 6 months, the entire slide slopes become secured and chances of slope failures are nonexistent.

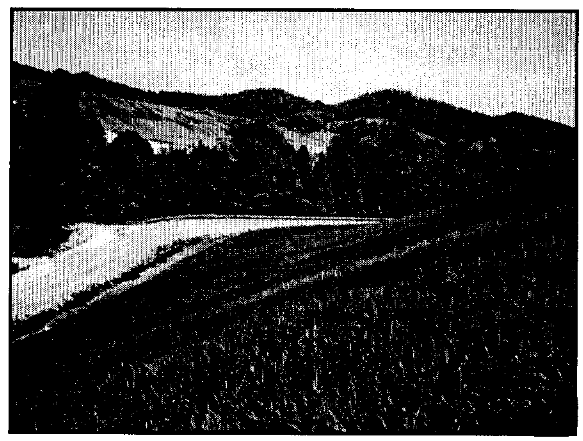
SLIDE 26 - From this slide, one can notice the uniformity of the grass cover. The cover is the most important part of the closure; each grass plant acts as a pump in removing water from the refuse pile. The grass varieties are chosen based on their evapotranspiration rates. Another characteristic of the grass species chosen is winter hardiness along with tolerance to heat stress.

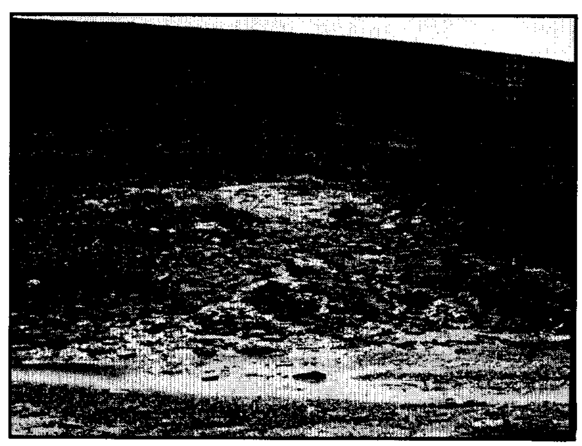
It is extremely important that these capping systems are functional for the majority of the calendar year. Winter and summer dormancy of the plants is kept to a minimum by the selection process. In some climatic regions dormancy cannot be overcome. In these areas the capping layers are increased in depth allowing for a larger reservoir capacity for water in the soils. Once the turf plants come out of dormancy the excess moisture held in the BioMix® soils is extracted and vacated out of the soil. Once again the systems are restored to 100% of their holding capacity.

SLIDE 27 - This close-up of the grass cover shows some of the plants going to maturity and starting to form seed heads. Upon maturity these seeds will fall to the ground where many of them will germinate, resulting in young new plants. This is also important to the cap performance for younger grass plants have a higher evapotranspiration rate than older more mature plants.

SLIDE 28 - This is an area where acid mine drainage (AMD) is seeping from the refuse pile even after the BioMix® cap has been placed over it. This is due to the fact that there are extremely large quantities of water in these piles for they have been open to the environment for years. This area is one where the water pressure within the pile is being relieved both by hydraulic pressure within the pile and gravitational forces. Since the pile has been capped off, water no longer is able to penetrate the refuse pile; over time the flow will become less and less until it stops altogether.







SLIDE 29 - Historically, the normal practice of the reclamation industry was to install seep drains into these refuse piles to release the water to collection areas for treatment. The soils used to cap the piles where very porous, allowing rainwater to move freely into the piles. It's not uncommon to see seep drains every 20 to 50 feet around the entire toe area. These drains also were important to relieve the internal water pressure at the toe of the pile that resulted in many slope failures on these enormous piles. With the use of BioMix® soils rainwater is held in the top 24" where it is used by the grass and not allowed into the refuse pile. With the use of this technology not only is water treatment eliminated but also the need to install and maintain these seep drains. Also, the engineered integrity of the refuse pile stays intact eliminating the danger of slope failures.

SLIDE 30 - This is the same area that was shown two slides back. This was taken two years after the BioMix® cover was placed on the refuse pile. Notice that the flow has been reduced to a trickle and the grass is creeping in. Once the seep slows the grasses grow in due to their tilling and reseeding properties. Today this entire area is completely grassed and this seep is non-existent.

SLIDE 31 - This picture was taken half-way up the refuse pile showing one of the collection ditches located on every bench. There is still some flow of AMD as the BioMix® has only been in place on this area just under one year.

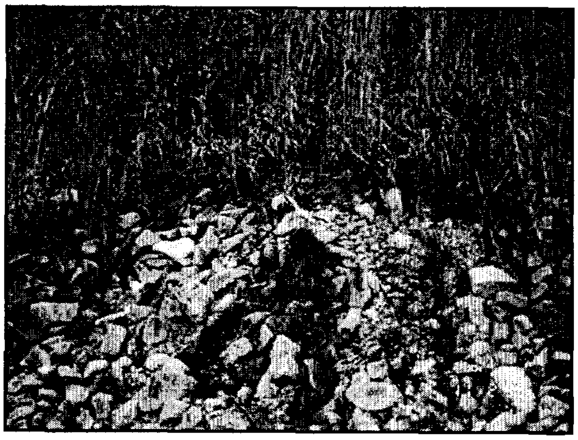
SLIDE 32 - This is one of collection ponds for the AMD being generated from the refuse pile. Notice the dark red coloring of the water which is characteristic of AMD. More importantly, notice how the level of water in this pond has been reduced some 18 to 20 feet. At one time the water level was up to the lower bench area of this pile. From this slide one can also see that the grass cover has not matured yet so the full performance of the BioMix® cap has not even been achieved at this time.

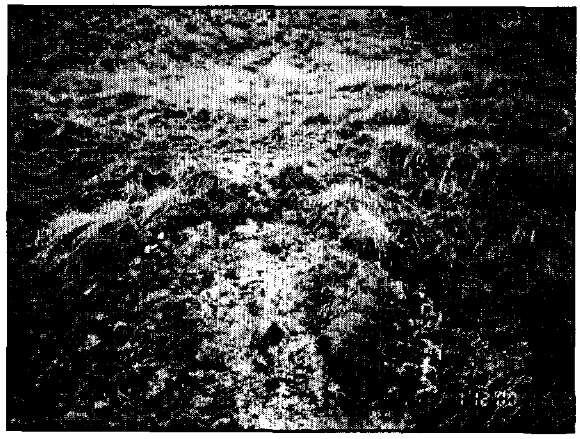
SLIDE 33 - This picture was taken later of the same collection pond as the previous slide. Notice once again that the level of AMD water has dropped another 10 to 12 feet and the grass is maturing with the dark green color which is characteristic of plants growing on BioMix® soils. This dark green coloring is due to the beneficial inherent properties from the Short Paper Fibers® used in the manufacturing process of BioMix®.

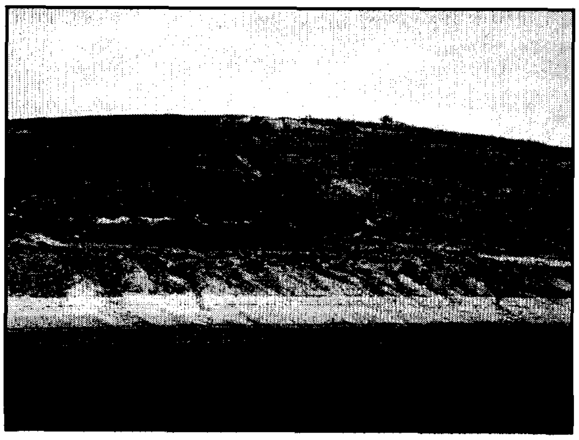
The right side of this slide was not reclaimed with BioMix® soils but with native soils that came from the site. The BioMix® side, the left side of the slide, was seeded approximately a year prior to this picture.

SLIDE 34 - This is where one really begins to appreciate the impact BioMix® soils have on reducing the generation of AMD. Notice from this slide that the water level has been lowered some 20+ feet in the collection pond. More importantly this slide was taken in mid-January when the evapotranspiration rate of the cap is at its lowest and still very small volumes of water are coming from the refuse pile. This truly shows how well these caps work even during the most demanding times of the year.

Also notice the green color of the grass on the slope of the refuse pile to the right of the slide. This shows the importance of the selection process of the proper varieties of grasses based on their winter hardiness characteristics.







SLIDE 35 - This is a different view of the same holding pond from the previous slide. Once again notice the depth that the water level has been reduced to and also what little flow is contributing to the pond during this most critical time of the year.

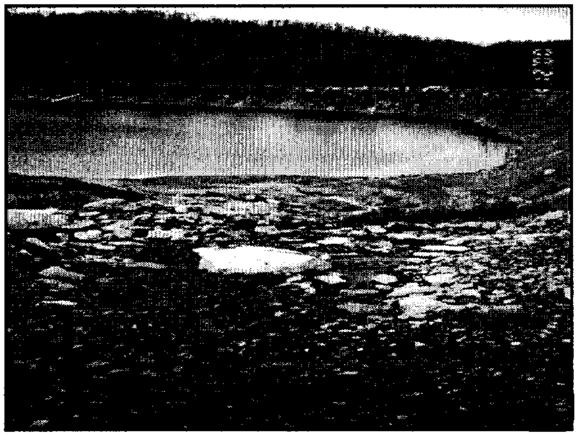
SLIDE 36 - Looking down into the holding pond, one notices the characteristic dark red color of the AMD is gone. This water is clear, as can be seen along the edge of the pond, and the water quality is excellent. The pH of this water is 7.2 while the iron and manganese levels are in the range of 2 to 5 ppm. This is additional validation of the beneficial effects BioMix® soils have on curing and eliminating the generation of AMD from coal refuse piles.

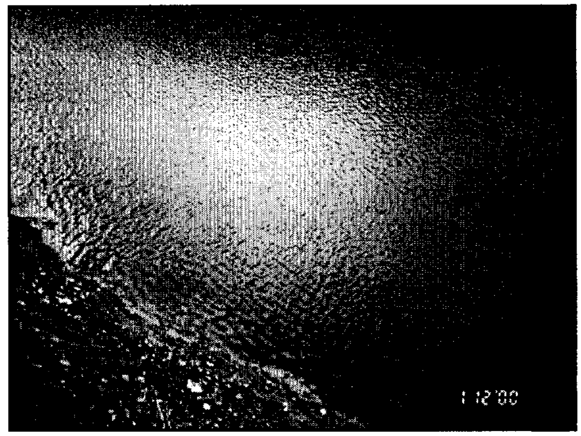
SLIDE 37 - This slide shows the difference in water quality after reclaiming the coal refuse pile using BioMix® soils.

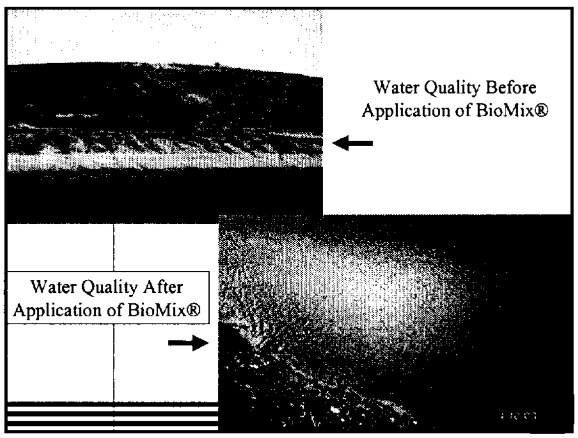
SLIDE 38 - Looking at the refuse pile on the left side, one will notice that the backside of the pile has no turf cover. This area was reclaimed with a mixture of coal fly ash, soils, and fertilizer.

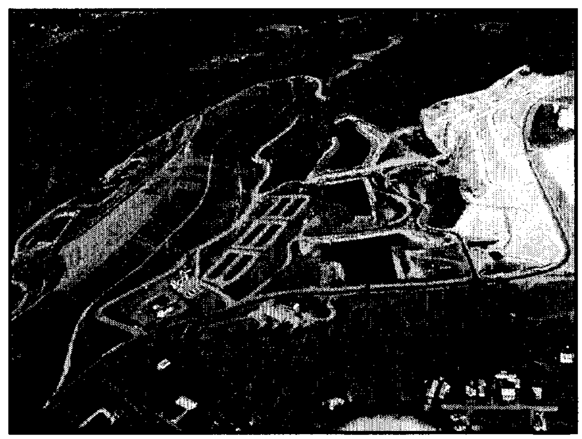
SLIDE 39 - A close-up of this area reclaimed with the fly ash product reveals severe erosion and a turf cover that is not uniform.

SLIDE 40 - A closer view of these washout gullies reveals that the topsoil layers have been completely eroded and the refuse coal is exposed to the elements. This results in rainwater infiltrating into the pile resulting in additional AMD generation.






Water Quality Before
Application of BioMix®
Water Quality After
Application of BioMix®



SLIDE 41 - This is a slide showing the coal refuse pile that has been under reclamation for the past three years. This picture was taken in 1997, a year prior to reclaiming this pile.

One can get a sense of the magnitude of the pile by looking at the Euclid truck in the middle of the picture. This truck is large enough to hold 60 tons of coal.

SLIDE 42 - This aerial photo was taken in 2000 showing the amount of the refuse pile that has been reclaimed. All of the steep slopes are completed on the front face of the pile. The arrow is pointed to where the turf cover is starting to establish on the right hand side of the pile.

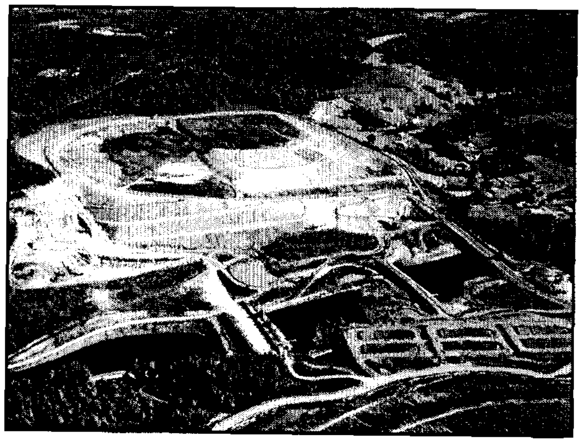
SLIDE 43 - The Alcoa site encompasses some 7,000 acres located in Bauxite, Arkansas just 15 miles south of Little Rock. This is a closed site where bauxite ore at one time was mined for manufacturing aluminum products. All rainwater falling on this site is treated due to the generation of acid mine drainage (AMD) also.

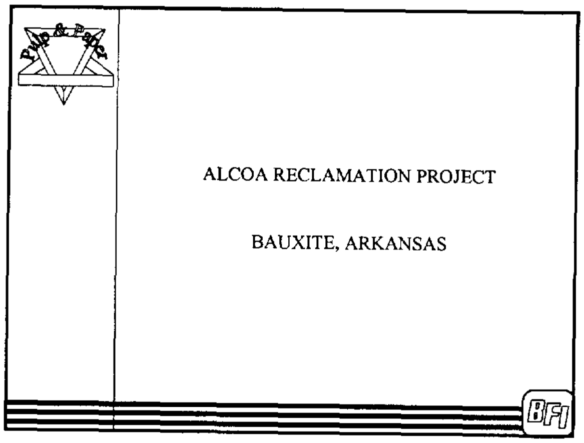
SLIDE 44 - This is a massive site. As far as the eye can see the land has been disturbed to mine the bauxite.

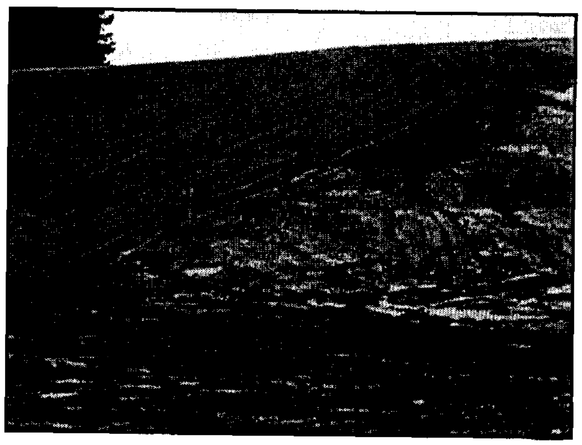
SLIDE 45 - This slide shows a ten-acre area that was reclaimed using BioMix® soils. The entire area to the left of the arrow and the area in the middle of this picture received BioMix® soils. The light area to the right of the arrow was reclaimed under the normal operating procedures for reclamation.

Immediately after this area was seeded the site received 5.2 inches of rain in a 6-hour period. One can actually see the water flowing in the tracks left from the tractor seeding.

SLIDE 46 - The arrows show the line of demarcation delineating between the BioMix® soils above the arrows and the native soils below the arrows. What is so noticeable in this picture is all the erosion of the native soils and no erosion whatsoever of the BioMix® soils. Even where the tracks from the tractor ran straight up and down the slope there was no movement of the BioMix® soil.




Pulp & Paper
ALCOA RECLAMATION PROJECT
BAUXITE, ARKANSAS
BFI



SLIDE 47 - This is a later picture taken of the same area as the previous slide. Notice to the left of the arrow the uniform dense crop of turf established. The native soils have patches of turf while erosion continues to move soils off of the site into the retention ditches below.

SLIDE 48 - Moisture-Point® Technology was deployed for all the reasons mentioned above.

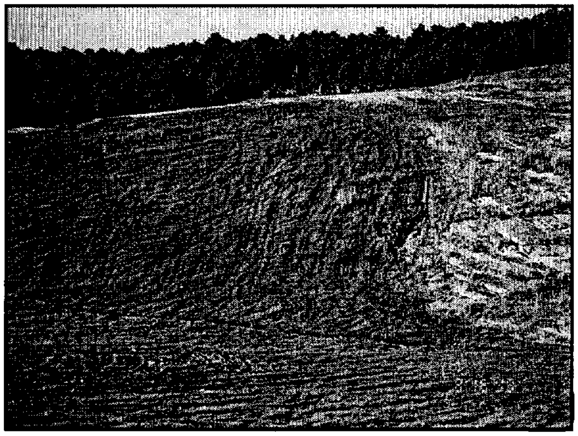
SLIDE 49 - These listed companies along with Texas A&M are instrumental in the development of this technology.

SLIDE 50 - Moisture-Point® Technology is a methodology for monitoring and calculating moisture-holding capacities of soils on a real time basis. In the past, evapotranspiration rates could only be projected by using theoretical models and one could only project based on the assumptions used in the model. This is not the case with Moisture-Point® Technology which gives one live data from the site based on the actual live time performance of the turf cover and soil.

Probes are placed in the soil profile at predetermined depths. Through the process of electric diodes within the probe one is able to get readings of soil moisture at each diode depth. If one wanted to, the soil profile could be dissected into 1-inch slaps, monitoring the performance of the soil based on the readings for every one-inch layer of soil. The system has the capabilities of taking readings every three (3) minutes. By knowing the moisture holding capacity of the soil from a simple laboratory test, one can calculate the moisture holding capacity of the soil at anytime by subtracting the current moisture in the soil from the available capacity of the soil.

SLIDE 51 - This shows a technician installing a probe in the field at the Alcoa site in Bauxite, Arkansas. The probe is driven into the ground with a special tool resulting in 100% soil to probe contact which is necessary to get readings of the moisture in the soil.

SLIDE 52 - Once the probes are installed at the proper depth in the soil they are hardwired back to a data logger. The data logger not only sends out the electrical impulse to the probe but records the data as to the moisture content in the soil at that given depth.



MOISTURE-POINT® TECHNOLOGY

- Substantiate BFI's claims of the superiority properties relating to BioMix® soils
- Development of Landfill Closure Caps for the next millenium
- Further differentiate BFI from competitors "Market Protection"
- Booster BFI's position for patent rights
- Online monitoring of sites for cap performance

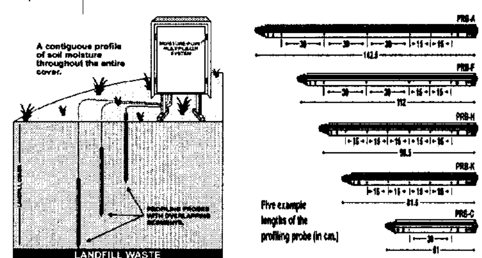
BFI

ENTITIES INVOLVED IN PROJECT

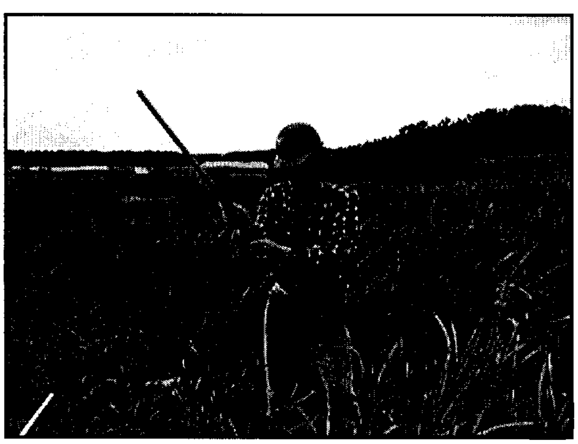
- BFI Developer/Owner
- Environmental Sensors, Inc.
  - Moisture-Point® Technology
- Sutron Corporation
  - Weather Stations, Water Quality Monitoring
- Orcom Corporation
  - Satellite Transmission of Field Data
- Texas A&M
  - Proprietary Research Studies

BFI

MOISTURE-POINT® TECHNOLOGY



BFI



SLIDE 53 -At the Alcoa site a complete weather station was installed to record all the local weather conditions right at the site. All these data were collected into the data logger. From the data logger the data were retrieved via satellite transmission to a receiving station in Virginia then back to BFI offices via the Internet in Houston. We set up the system to take readings every hour, with 58 different data points monitored.

SLIDE 54 - This is a picture of the 10-acre reclamation area one (1) year after planting. The Moisture-Point® equipment with weather station is at the tip of the arrow. The area behind the equipment is the area reclaimed with native soils that also has been monitored with probes to compare the performance of the BioMix® soils to native soils.

SLIDE 55 - These last six (6) slides are an artistic rendering of how the BioMix® soils actually work as compared to native soils. We will only concern ourselves with the final topsoil layer which is the most important layer for landfill closures and mine reclamation.

On typical closure and reclamation projects the topsoils used are very coarse in structure and usually void of any organic matter, resulting in a growing medium that has little moisture holding capacity. The void spaces between soil particles are very large and mostly filled with sand particles or just air.

In BioMix® soils the organic matter content is very high resulting from the Short Paper Fibers® filling the voids between the soil particles. The proper ratio of soil to SPF® is critical for the proper performance of the soil. Each fiber must be in contact with a neighboring fiber which allows for a wicking process which is why these soils are superior growing mediums over native soils used on these projects.

SLIDE 56 - As a rain event occurs water moves quickly into the native soils and many times on sloped areas the water moves over the surface of native soils which is the cause of erosion. The water entering the soil matrix on native soils moves quickly down through the soil due to the large void spaces and little if any is captured since there is little to no organic matter to absorb the water.

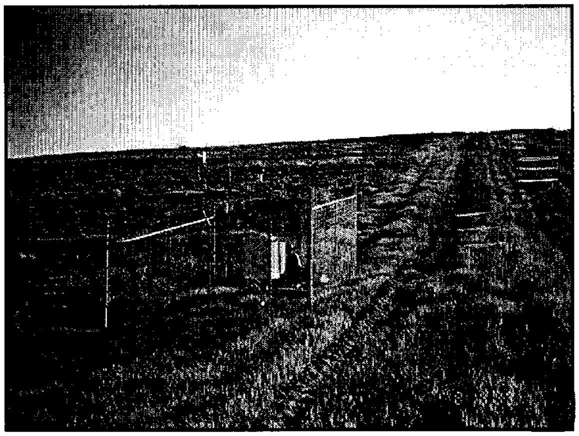
The BioMix® soils act just in reverse of native soils. First, due to the high organic matter and lush vegetative covers achieved, minimal water moves across the surface even on the steepest slopes 2:1. Water is pulled into the soil matrix based on the inherent properties of the fibers making the medium act as a sponge. Once the water is in the matrix it moves slowly downwards from fiber to fiber resulting in uniform wetting across the entire soil profile. The upper soil layers achieve maximum moisture holding capacity before the lower soil areas start to take on water. In the native soils just the opposite takes place. Water moves quickly down to lower soil strata by short-circuiting through the voids which are present throughout the soil matrix. This can result in areas within the soil completely dry just hours after a major rain event occurs.

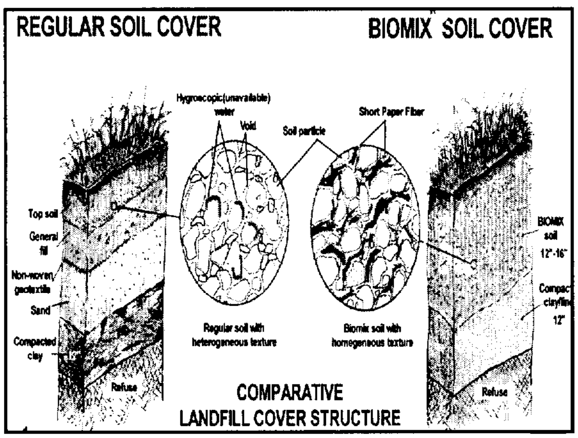
SLIDE 57 - Once the rain event stops, water moves very quickly out of the growing zone into layers below on native soils. Once water leaves the top six (6) inches of the growing medium it can not be used by the growing plants. This water moves down into the refuse pile where it becomes acid mine drainage (AMD) which needs to be treated as contaminated water when it exits the refuse pile.

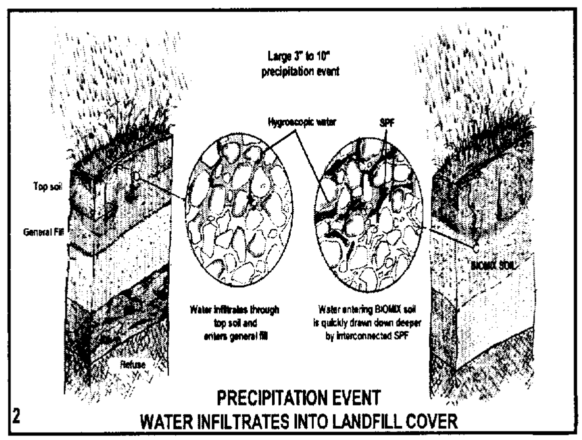
BioMix® soils have moisture-holding capacities exceeding 200 to 300 % compared to native soils. This impressive moisture holding capacity is due to the properties of the fiber. Once the rainwater comes into contact with the fiber it is immediately drawn into the fiber. As the water enters, the fiber swells giving it the ability to hold 10 to 20 times its weight in water. It has been shown that a 12-inch layer of a properly blended matrix of BioMix® soil can hold 16 inches of water before releasing water to the layer below.

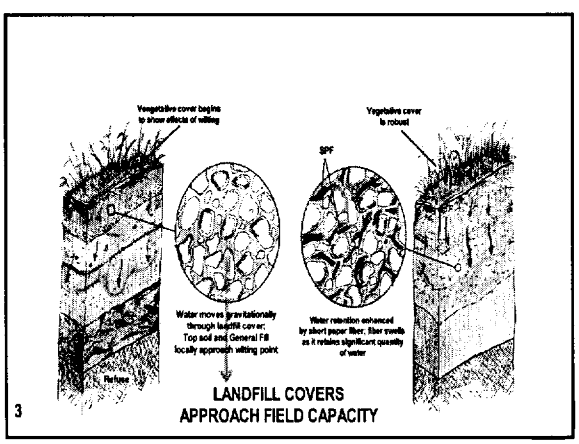
SLIDE 58 - Since the native soils have a very low moisture-holding capacity the turf covers become stressed and go into dormancy for survival. This further adds to the deterioration of the cap for once the turf begins to die back and thin it further exposes the native topsoil layer to erosion.

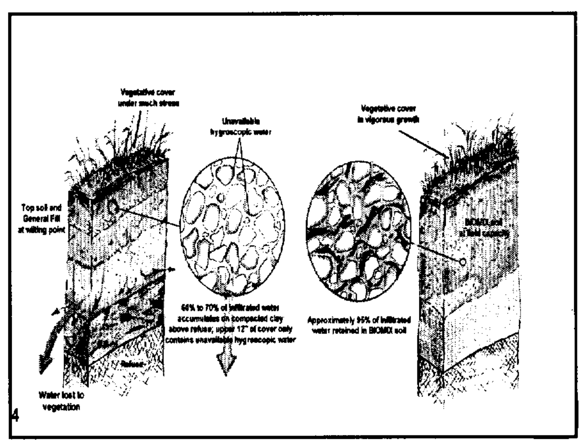
The BioMix® soils sustain a rich vibrant vegetative cover for the grass plants have a reservoir of water available. All of the water that is held in the topsoil layer is available to the turf plants for growth.

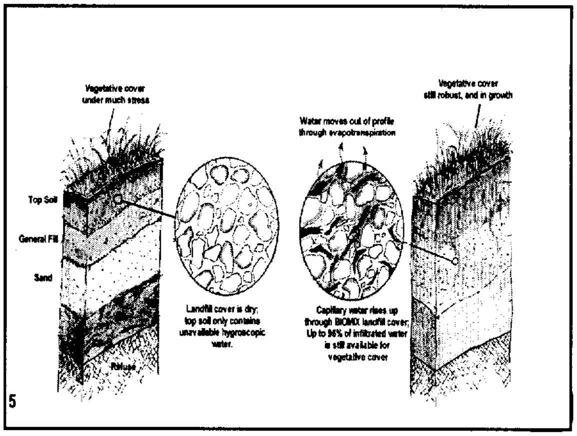



REGULAR SOIL COVER
BIOMIX SOIL COVER
Hygroscopic(unavailable) water
Void
Soil particle
Short Paper Fiber
Top soil
General fill
Non-woven geotextile
Sand
Compacted clay
Refuse
BIOMIX soil 12"-16"
Regular soil with heterogeneous texture
Biomix soil with homogeneous texture
Refuse
COMPARATIVE
LANDFILL COVER STRUCTURE


Large 3" to 10" precipitation event
Hygroscopic water
SPF
Top soil
General Fill
BIOMIX SOIL
Water infiltrates through top soil and enters general fill
Water entering BIOMIX soil is quickly drawn down deeper by interconnected SPF
Refuse
PRECIPITATION EVENT
2
WATER INFILTRATES INTO LANDFILL COVER

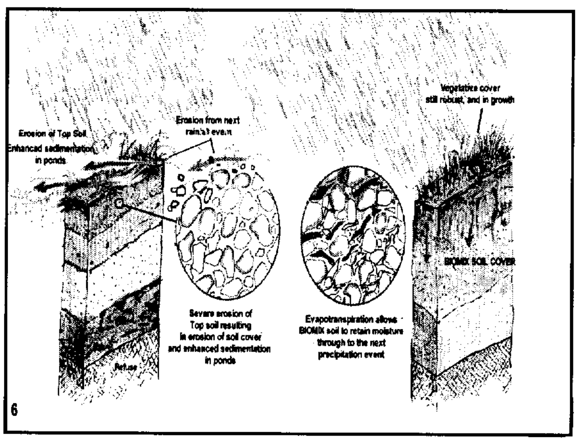

Vegetative cover begins to show effects of wilting
Vegetative cover is robust
SPF
Water moves gravitationally through landfill cover; Top soil and General Fill locally approach wilting point
Water retention enhanced by short paper fiber; fiber swells as it retains significant quantity of water
Refuse
LANDFILL COVERS
APPROACH FIELD CAPACITY
3


Vegetative cover under much stress
Unavailable hygroscopic water
Vegetative cover in vigorous growth
Top soil and General Fill at wilting point
Approximately 95% of infiltrated water retained in BIOMIX soil
Water lost to vegetation
4



SLIDE 59 - This is the most **important** property of BioMix® soils. When blended properly, these soils develop wicking properties allowing water molecules that are below the root depth layer, typically 6" or less, to move back up into the rooting zone by traveling from fiber to fiber. This unique characteristic allows the grass plants access to water during drought conditions. By doing this, the available moisture holding capacity of the soil is restored as the plants utilize the water from the reservoir.

On native soils there is no water reservoir for the turf. Under summer stress conditions the turf covers typically go dormant and in many cases dormancy leads to death of the cover.



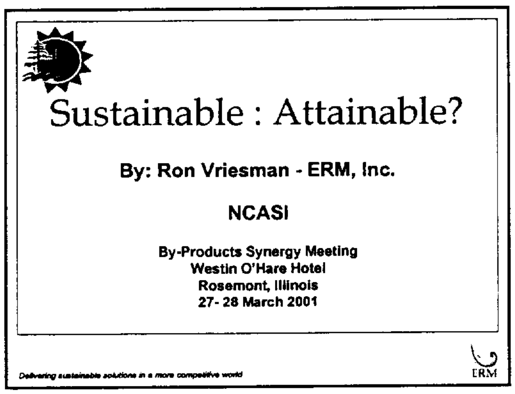
SLIDE 60 - By keeping a dense cover of turf on these steep refuse pile slopes erosion becomes non-existent. Erosion not only leads to water getting into the refuse pile resulting in AMD, but also increases maintenance costs for many of the surface ditches need to be excavated of the soils that have moved off the slopes into these ditches.

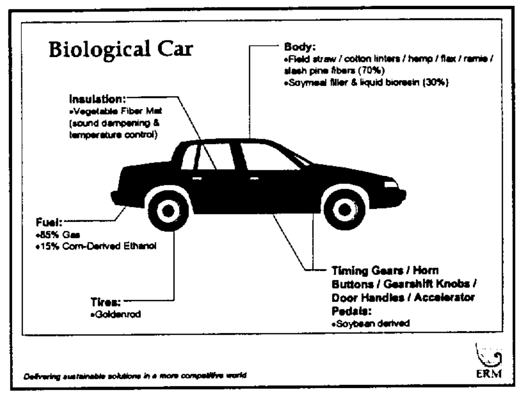
Not only are the water treatment costs reduced dramatically on sites using BioMix® soils, but also their post-closure maintenance costs are substantially reduced.

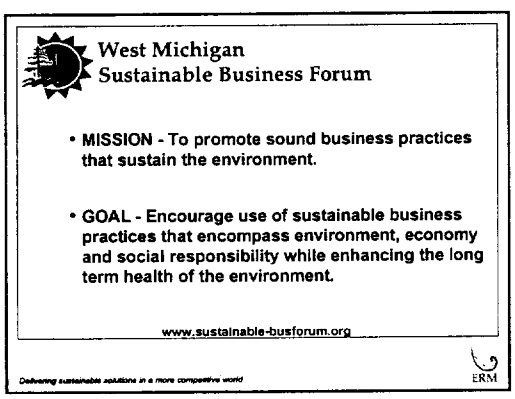
SUSTAINABLE: ATTAINABLE?

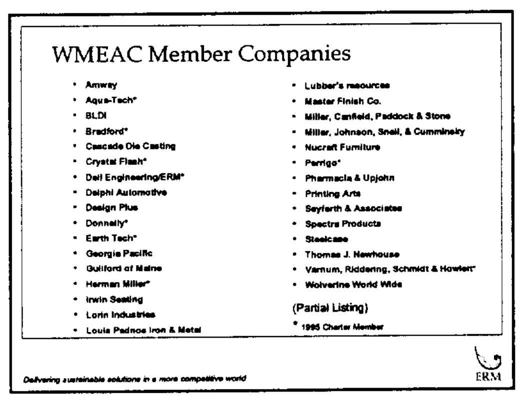
Ron Vriesman, Environmental Resources Management (ERM)

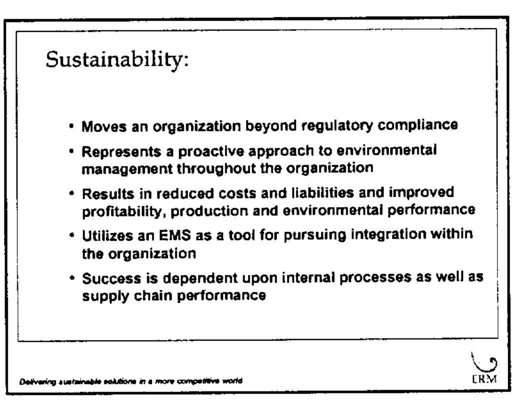
Following are copies of the slides used for this presentation.

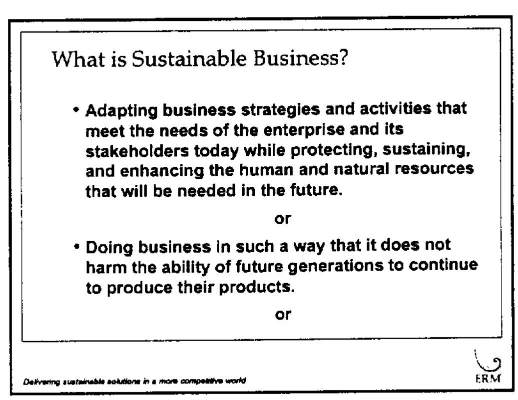












What is Sustainable Business? -continued

- **A profitable company!**
- **A company focused on reducing their labor costs.**
- **A company focused on reducing material costs.**
- **A company focused on reducing wastes.**
- **A company which recognizes that the environment needs to be protected to protect future profits.**

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CORPORATE EFFORTS TOWARD SUSTAINABILITY

COMPLIANCE (Meeting Requirements)	SUPER-COMPLIANCE (Setting New Standards)	ECO-EFFICIENCY (Reducing Resource Intensity)	"MACRO" SUSTAINABLE DEVELOPMENT (Creating New Global Value)	"LOCAL" SUSTAINABLE DEVELOPMENT (Creating Sustainable Communities)

Sustainability Continuum ***"Thinking outside the box" and going beyond compliance.***

Compliance: Doing only what is required by regulatory agencies. The starting point for all companies

Super-Compliance: Becoming proactive How do you begin to set the standards for environment beyond what is required? Monsanto made a commitment in 1988 to reduce air emissions by 1992.

Eco-Efficiency: Assessing how to maximize value while minimizing cost. This is where a company begins to look not only at resources with a price tag but at those that are "free," such as water and unaccounted cost of energy (CO_2 output, for example). This is a more comprehensive view of what material cost really includes

"Macro" Sustainable Development: Looking beyond one's own business or competitive environment to note the important trends, and applying that thinking in terms of how the company can begin to benefit by anticipating trends as it would anticipate a technological breakthrough, demo patterns and consumer trends. Companies that make intelligent, risky decisions in face of these rapidly changing parameters are the ones that survive.

"Local" Sustainable Development: Meeting local demands in both the developed world and developing economies. Today, primarily economic activity concerns about one-sixth of the world's population. China, India, Latin America and Southeast Asia are growing as rapidly as possible, creating huge potential for both markets and crises. Companies need to try to design offerings to meet growing demands in a way that supports communities and local development, as well as ecological sustainability.

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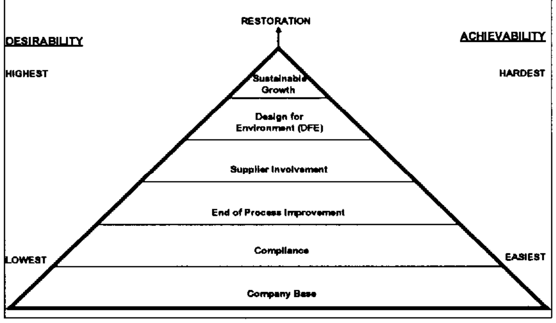
Environment Management Hierarchy*



* "Sustainable Growth Through Environmental Management", Paul Murray (Herman Miller, Inc.), World Workplace 95' Proceedings, September 17-20, 1995, Miami Beach, Florida.

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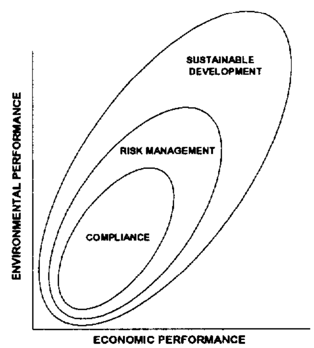

Business Performance as a Function of Sustainability

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Project Objectives

- **Utilize Secondary Resources to Manufacture Counterweight Components**
- **Reduce Environmental Impact from Products and Operations**
- **Demonstrate Commitment to Environmental Sustainability**
- **Simplify Counterweight Design and Reduce Assembly Effort**
- **Develop Returnable Counterweights Remanufactured into New Product**
- **Minimize Types, Sizes and Fastening Methods of Existing Counterweights**
- **Satisfy Emerging Customer Needs for Environmentally Friendly Products**
- **Become Less Reliant on Secondary Markets for Resources**

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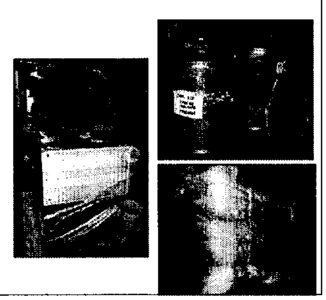
Secondary Resource Materials

- **Various metal products**
  - Painted, non-painted
  - Punch-outs
  - NCM assemblies
- **3 barrels of powder paint**
- **Bale of various plastics**



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Conclusions (Incoming Materials)

- **Current secondary resources include powder paint, plastic in various forms, metal in various forms**
- **Plastic received contained non-plastic materials (i.e. cardboard, tape, paper)**
- **Removing foam wrap and bubble wrap improved pressing performance**
- **Metal can be successfully shredded**

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Conclusions (Pressing Procedure)

- **Paint bonds to shredded metal and metal dies easily**
- **6"x 6" coupons can be pressed consistently to a density of ~ 3.1g/cc**
- **Impact testing of 6" x 6" coupons shows better response than ½" plywood**
- **Concrete counterweight style prototypes can be pressed to at least 3.0g/cc**

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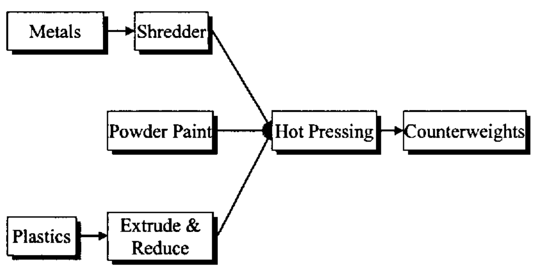
Process Flow Sheet



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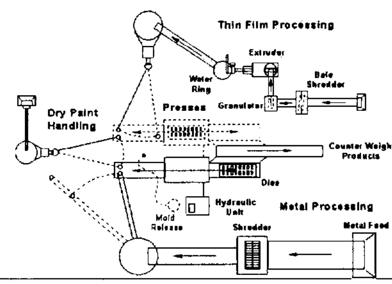
Preliminary Layout



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Unresolved Issues

- **Metal Processing**
  - Feeding metal to shredder
  - Shredder configuration – cascading multiple shredders, size, staging requirements, sorting/recycling phase design
  - Discharge of shredded metal from storage bin
    - live bin bottom + narrow drag could work – needs testing
- **Dry Paint Handling**
  - Delivery system needs testing
  - Dust collection for delivery system

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Unresolved Issues

- **Thin Film Processing**
  - Bale shredder size
  - Capital expense
  - Large throughput required for economic viability
  - Outside processing may be necessary
  - Technical feasibility has not been demonstrated
- **Presses**
  - Size of press
  - Quantity of counterweights pressed vs. cycle time
  - Mold release practices

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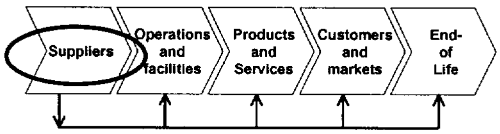
Sample Supply Chain



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Drivers

- **Supplier performance needed to meet corporate business goals**
  - costs
  - cycle time
  - quality
  - reliability
- **External perception**
  - accountability for supplier performance
  - GRI guidelines, socially responsible investors, etc.

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Opportunities and Benefits

- **Environmental improvements**
- **Cost reductions**
- **Quality assurance**
- **Risk management**
- **Product improvements**

Business Case: uninterrupted, dependable, cost-effective supply chain

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Opportunities to Affect Supplier Environmental Performance

- **Purchasing**
  - Training and awareness on selecting suppliers
    - Cost vs. price
- **On-site assessments**
  - Company or 3rd party led
  - Integrated into existing quality audits
- **Motivating performance**
  - Awards and recognition
- **Product innovation**
  - Design for environment, problem-solving, etc.

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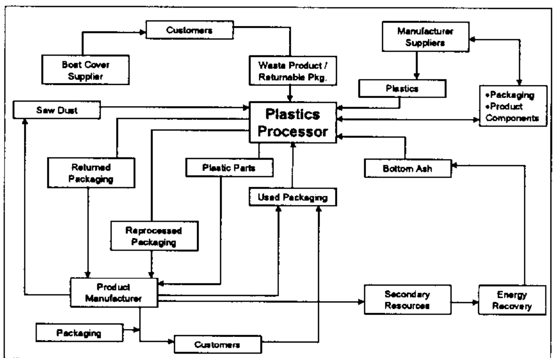
ERM



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Sustainable Purchasing:

- **Represents an area of business operations which can positively influence an organizations future sustainability and success**
- **Handbook has been developed by the West Michigan Sustainable Business Forum; This Handbook:**
  - ...is a tool to improve corporate profitability while enhancing environmental health
  - ...must be communicated internally to achieve successful sustainable purchasing practices
  - ...identifies a means to monitor and measure success
  - ...provides access to numerous other resources including case studies from other leadership companies
- **Is a step toward "greening" of the organization and ensuring continued access to existing customers and markets**

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Sustainable Purchasing
Goals/Objectives

- Educate Organizations on Environmental Sustainability Purchasing Elements
- Promote Adoption and Implementation of Environmental Sustainability Purchasing Practices
- Utilize Supplier Development Activities to Promote Sustainable Purchasing Opportunities
- Monitor and Measure Sustainable Purchasing Efforts

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Sustainable Purchasing
Goals/Objectives

- Compliment Existing Sustainable Purchasing Guidance and Standards
- Apply New Methodology to Promote Sustainable Purchasing
- Improve Corporate Profitability While Enhancing Environmental Health
- Communicate Successful Sustainable Purchasing Practices

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Establishment of Purchasing Requirements
Process Assessment

a) Does Environmental Policy Statement support pollution prevention and sustainability throughout the organization?

b) Do purchasing procedures incorporate sustainability aspects and support the Environmental Policy Statement?

c) Has a green material checklist been developed?

d) Have recycled content/sustainability specifications been established?

Scale: N/A 1 2 3 4 5

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Identification of Material Needs
Process Assessment

a) Have environmental aspects of product manufacturing/service delivery been considered?

b) Are employees within all business operations knowledgeable on sustainability?

c) Have product sharing or short-term rentals been considered?

d) Do material specifications incorporate sustainability opportunities?

Scale: N/A 1 2 3 4 5

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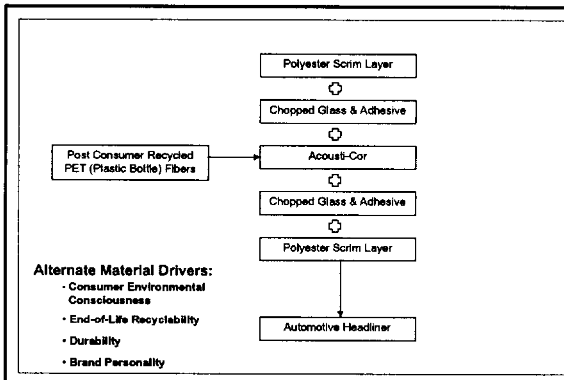

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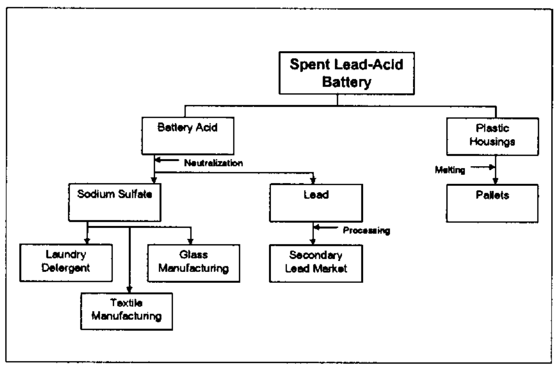

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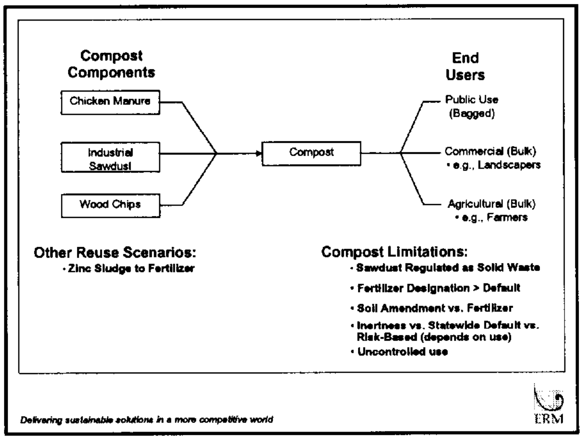


INTEGRATED ORGANIC BYPRODUCTS PROCESSING IN WISCONSIN'S FOX RIVER VALLEY

Leslie Cooperband, University of Wisconsin, Madison

(Reprinted with permission from the December 2000 *BioCycle*, Journal of Composting and Organics Recycling, Emmaus, PA; www.biocycle.net.)

MANAGING FAST GROWTH AND RESIDUALS IN FOX VALLEY

New project will help waste generators in Northeast Wisconsin find alternatives to direct land spreading and landfilling of organic residuals.

Northeast Wisconsin - particularly the Fox River Valley - is faced with increasing obstacles to land spreading or landfilling organic residuals. The region is home to food processors (canneries, cheese manufacturers), municipal wastewater treatment and solid waste facilities (biosolids and yard trimmings), paper mills, wood product manufacturers and livestock producers. Dairy herd expansion is progressing at one of the highest rates in NE Wisconsin. In addition, the region represents one of the fastest growing urbanizing populations in the state. Because of increasing competition for land available for land spreading, rising landfill costs, increasingly restrictive regulations on spreading of organics and loss of agricultural land to urban/suburban development, farmers and industries in the Fox Valley are looking for alternatives to direct land spreading and/or landfilling of raw wastes.

The University of Wisconsin's "University-Industry Relations" Program has given a one-year grant to the Department of Soil Science to conduct a feasibility study of organic waste management in the Fox River Valley. The main objective of the project is to evaluate the economic, technical, organizational and regulatory feasibility of combining organic residuals in a centralized processing facility. The facility would collect the organics, process them into soil amendments using appropriate technologies (anaerobic digestion, composting, dehydration) and market the finished products (fertilizers, composts, soil blends) to landscapers, horticultural enterprises, state departments of transportation, golf courses, land reclamation projects, etc.

Specifically, a feasibility study of a pilot scale processing facility in the Fox River Valley is being conducted. This study includes 1) Demographics of "waste generators" (geographic location, company size, volumes and timing of wastes generated); 2) Chemical and physical characteristics of each waste stream as well as combinations of wastes; 3) Economics of transporting wastes to a centralized processing facility; 4) Suitability of processing technologies for production of soil amendments; e.g., fertilizers and or compost; 5) Costs of building a processing facility and managing it; 6) Market opportunities for finished products; 7) Business structure of processing facility, e.g., a cooperative structure vs. other types of structures; 8) Existing regulatory and political climate for such a project and changes that might be needed to provide incentives for this type of project and 9) Potential location of centralized processing facility and sources of financing.

GENERATORS AND INTEGRATORS

We have identified several "waste generators" (industries, livestock farmers, municipalities) and a waste "integrator" (public sector agency or private sector company or entrepreneur, responsible for waste collection, processing and marketing/distribution) who might participate in a pilot-scale centralized waste processing project. We anticipate that at least one food processor, several large dairies, Appleton Wastewater and Department of Public Works (yard trimmings), a paper mill and a wood products processor (pallet company, lumber mill) will be the major generators. We also expect Agriliance (formerly Cenex Land O'Lakes) to play a major role as either waste processor/integrator or product marketer and distributor. These key players will participate in the feasibility study by providing information about the demographics of their waste streams (amounts, timing, current fates) and chemical, physical and biological characteristics. Cenex Land O'Lakes will provide knowledge and expertise in product marketing and distribution. All key players will participate in discussions about the structure of their business partnership. We will explore the feasibility of a cooperative structure for bringing industries, farmers and municipal agencies together. The University of Wisconsin's Center for Cooperatives and Cooperative Development Services (a consulting agency) are assisting with this part of the feasibility study. We will also identify and evaluate appropriate processing technologies and potential markets. We will also develop a plan for securing private investments and grants for the construction and operation of the pilot processing facility.

A number of operational projects will be studied by the steering committee members to assemble feasibility data. These project include: A-1 Organics, Inc. in Colorado which composts diverse feedstocks into marketable soil amendment blends; Chamness Technologies in Iowa which also composts varied organic residuals; and Pheasant Run near Kenosha, Wisconsin that blends and composts duck manure, cranberry processing residuals, wood shavings and other feedstocks. Regulatory agency policies will also be reviewed carefully. Two specific public agencies and their positive incentives for creative management projects include the California Integrated Waste Management Board and the Iowa Department of Natural Resources Solid Waste Management Initiative.

FROM STUDY TO FACILITY

As industry representatives, farmers and municipal government officials will be involved continuously and actively in the feasibility study, they will receive information about the economic and technical feasibility of a pilot-scale processing plant as it unfolds. We have formed a steering committee of several key players and an advisory group consisting of by-product generators, extension agents and state agency personnel. The steering committee will provide advice and guidance on technical, organizational and financial issues. The advisory group will provide feedback on the study as it progresses. We will test and demonstrate appropriate processing technologies on-farm and at the Appleton Waste water Division waste treatment facility. We anticipate development of clear guidelines for use of optimal waste streams, processing technologies, business structures, and marketing/distribution opportunities for the soil amendments generated at a centralized processing facility. The feasibility study will be completed in 12 months, and it will serve as document for securing funds for a pilot-scale waste processing facility in the Fox River Valley. We will hold public and private presentations for potential financiers of the pilot-scale processing plant, including state and federal agency personnel, private investors and private foundation representatives.

If successful, this project could have a significant short- to long-term economic impact in Northeast Wisconsin. It should reduce waste handling costs for most of the industries, farms and municipal agencies participating in the project. It should also generate revenue from the sale of the soil amendment products. It may also alleviate regulatory oversight and lower liability costs associated with waste handling and disposal. It should facilitate industry compliance with ISO 14,000 environmental management standards. Overall, the project should have a beneficial economic and environmental impact in the region by converting wastes to resources, reducing over application of nutrients (nitrogen and phosphorus) on agricultural lands and redistributing organic matter to soils where it is most needed.

STEEL INDUSTRY WASTES: TYPES, SYNERGIES, AND OTHER ISSUES

Kim Lenti, Heritage Environmental Services

Following are copies of the slides used for this presentation.

Steel Industry Wastes

Types, Synergies & Other Issues

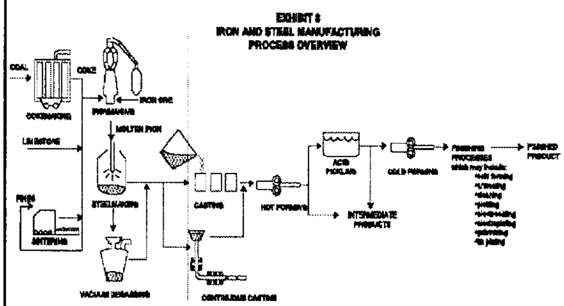
for
NCASI By-Products Synergy Meeting
3/28/01

Kim Lenti
HERITAGE

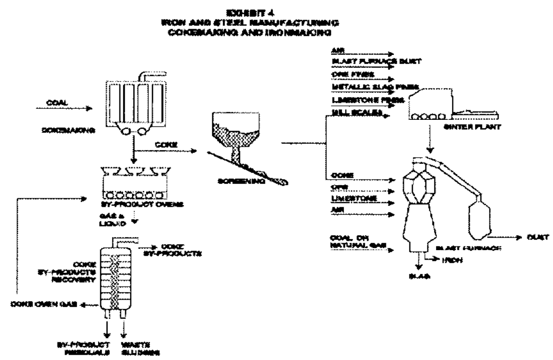
Outline

- 1 Minute Steelmaking Course
- Wastes Generated
- Raw Materials Used
- Current Synergies
- Other Heritage Synergy Work

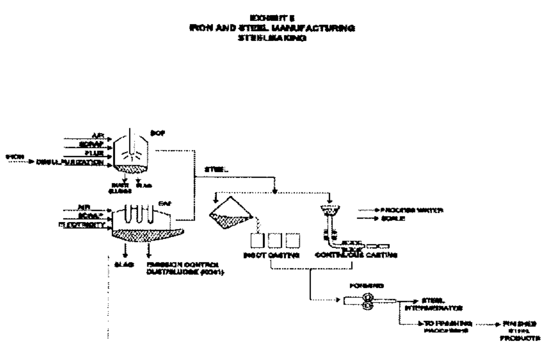
1 Minute Steelmaking Course



1 Minute Steelmaking Course



1 Minute Steelmaking Course



Major By-Products/Wastes

IRONMAKING — Blast Furnace

SLAG
15-35% of HM Production
Oxides of Si, Al, Ca, Mg, <5% Iron
Most is sold or used in land reclamation, landfill construction and aggregate

FLUE DUST
1-2% of HM Production
10 to 35% Iron
30 to 75% Carbon
Ca, Si, Mg, Mn, Al
Normally recycled to sinter plants.
Barriers: Size

SLUDGE
2-3% of HM Production
15 to 48% Iron
20 to 65% Carbon
Ca, Si, Mg, Mn, Al
Barriers: Size, moisture & chemistry

STEELMAKING — Basic Oxygen Furnace

SLAG
100-440 lbs/ ton of Steel
20 to 25% Fe, Ca_2SiO_2,Al,Mn,Mg
About 50% of iron is recovered.
Barriers: Chemistry (Lime)

DUST
8-12 lbs/ ton steel
60 to 67% Fe
Barriers: Size & chemistry

SLUDGE
20-55 lbs/ton steel
50 to 63% Fe
Barriers: Size, moisture, & chemistry (Zn)

Electric Arc Furnace

EAF SLAG
230 lbs/ton steel
20 to 25% Fe, Ca_2SiO_2,Al,Mg,Mn
About 50% of iron is recovered.
Barriers: Chemistry

EAF DUST
35lbs/ton steel
20 to 40% Fe, 10-40% ZnO, PbO
Most is recycled for zinc recovery.
Barriers: Expense of zinc recovery

ROLLING & FINISHING

MILL SCALE
10-80 lbs/ton steel
60 to 74% Fe
Normally recycled to sinter plant or blast furnace or sold (cement)
Barriers: % Oil

SLUDGE
4-60 lbs/ton steel
30 to 74% Fe, oil, grease
Barriers: Size, % oil (30%), moisture (20-50%), & chemistry

PICKLE LIQUOR
1.5 B gpy
1.5 lb Fe/gal 1-2% HCl
Most is regenerated, neutralized, disposed, or sold for WWT
Barriers to recycling Fe_2O_3: Size & chemistry(Si, Na, Cr, Zn,Cl)

AISI Steel Technology Roadmap

Raw Materials

IRONMAKING — Blast Furnace

FUEL
•Coke, Coal, Oil
Limits: S, P,

FLUX
•Limestone, dolomite
Limits:

IRON
•Iron Ore, Sinter, Pellets, Small Scrap
Limits: Zn, Pb, Cu, Ni, Cr, Mo

OTHER
•Bauxite
•Titanium(refractories)
Limits: P,

HOT AIR

STEELMAKING — Basic Oxygen Furnace

IRON
•Scrap, Hot Metal, DRI
Limits: Cu, Ni, S, P

ALLOYS
•Aluminum
•Manganese
Limits:

FLUX
•Flourspar
•Dolomite
Limits:

OXYGEN
Limits:

CARBON
Limits:

Electric Arc Furnace

IRON
•Scrap, DRI
Limits:

FLUXES
•Flourspar
•Dolomite
Limits:

ALLOYS
Limits:

OXYGEN

ELECTRICITY

ROLLING & FINISHING

ACID
•HCl
•H_2SO_4
Limits:

ALKALINE CLEA
Limits:

ZINC
Limits:

OILS
Limits:

Current Steel Synergies

BF Slag	→	Roads
Steelmaking Slag	→	Asphalt
BOF Sludge	→	Concrete
EAF Dust	→	Zinc
Pickle Liquor	→	Magnetics Ind. WWT
Oil	→	Fuel

Steel Slag

Steel Slag in Asphalt Pavements

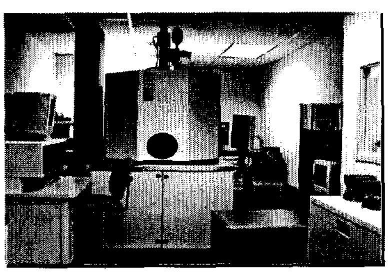
Steel Slag

- Heritage has been evaluating steel slag as an aggregate in hot mix asphalt since 1993

Steel Slag Research

- Studies conducted in the 1990's found that Steel Slag Asphalt Mixtures are much stronger than conventional asphalt pavements

Superpave Shear Tester

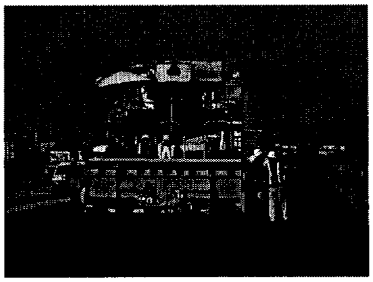


Used to determine Rut Resistance of Pavements

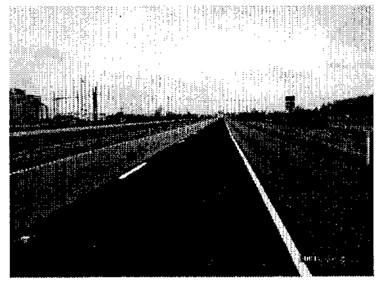
INDOT Research

- INDOT found Steel Slag Asphalt Surfaces have excellent long term friction
- INDOT Specifications include Steel Slag as an option for its highest traveled pavement surfaces where long term friction is critical

Steel Slag on I-74 (1999)

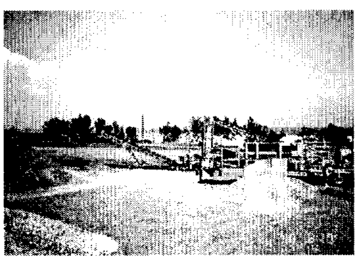


Steel Slag on I-74 (2001)



U.S. Aggregates - Gary Operations

Steel Slag Aggregate Production



Steel Slag Production

- Involves Crushing
- Destruction of Deleterious
- Removal of Metal
- Screening to Size

Steel Slag Finished Product

Steel Slag Advantages

- Better Rut resistance in pavements
- Better and longer lasting wet friction
- Better Durability
- Produces a Quieter Pavement
- Completely Recyclable

Steel Slag is not a waste!

- Steel Slag is a valuable resource for Indiana Roads
- Steel Slag is currently being used to make Indiana Highways safer and longer lasting
- Steel Slag is a premium product and is expected to be in short supply within 5 years

Other Heritage Successes

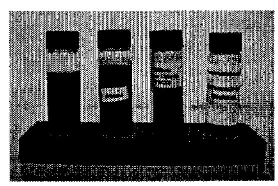
MICRONUTRIENTS:

Printed Circuit Board
Animal Micronutrient

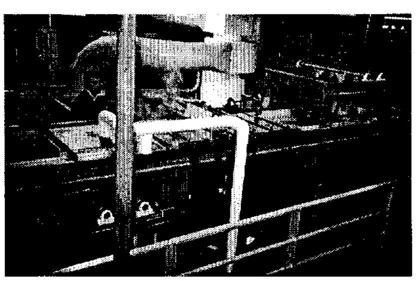
Micronutrients

Micronutrients produces TriBasic Copper Chloride (TBCC)

from Acid and Base Spent Etchants from Printed Circuit Board Industry which are converted into TBCC and Recycled Etch (no waste products)



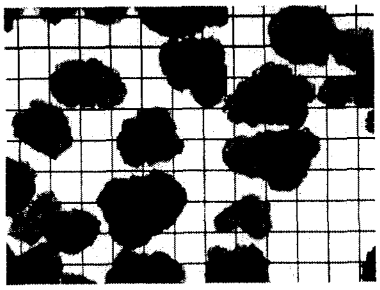
TBCC Production ISO 9002



TBCC QC Laboratory

An improved and proven source of copper for animal feed

TriBasic Copper Chloride

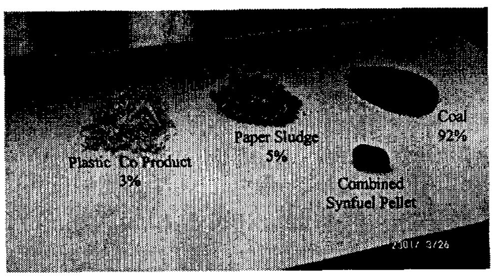


Zinc Basic Chloride

The Next Product from Micronutrients

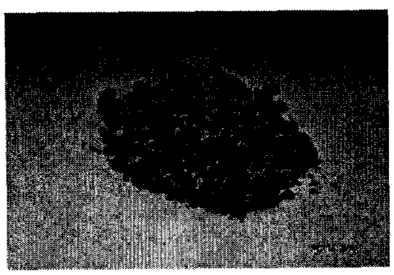
Produced from zinc rich co-products such as EAF dust

Biomass in Coal



Heritage is working with CQ, Inc. to make Biomass Synfuel from paper sludge and plastic by-products for Stoker Coal

Paper Sludge (60% Water)



Nearing
Full-Scale
Production