SIXTH INTERNATIONAL SYMPOSIUM ON ENVIRONMENTAL ISSUES AND WASTE M ANAGEMENT IN ENERGY AND MINERAL PRODUCTION (SWEMP)

MAY 30 – JUNE 2, 2000

HELD AT CALGARY, ALBERTA
CANADA

REPORT BY:

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ABSTRACT

Recognizing the importance of national and international conferences and symposia, GENCAPD provided support for participation in the Sixth Symposium on Environmental Issues and Waste Management in Mineral and Energy Production (SWEMP), held from May 30th to June 2nd, 2000 in Calgary Alberta, Canada.

The aim of the SWEMP was to contribute to the development of methods and technologies for assessing, minimizing and preventing environmental problems connected with mineral and energy production. Some of the main topics covered were: Environmental Impact Assessment, Permitting and Management, Waste management practices, Environmental issues related to mining, Emerging technologies, Mine site closure and tailings disposal-rehabilitation.

Mrs. Karen Livan, Environmental Manager of GGMC, as part of the GENCAPD mining project, presented a paper entitled 'The challenge of sustainable Small and Medium Scale Mining in Guyana", summarizing the Guyanese situation and challenges associated with the mining methods employed, mineral recovery, and management of tailings wastes. SWEMP 2000 was an excellent forum for obtaining information and exposure on current, topical and pressing issues in Waste and Environmental Management in Mineral and Petroleum Production, and to meet and exchange ideas with practitioners from industry and academia involved in working on these issues.

ACKNOWLEDGMENT

It was indeed a double privilege to participate in SWEMP 2000, and to make a presentation. My thanks are extended to Guyana Geology and Mines Commission and CIDA Guyana Environmental capacity Development (GENCAPD) Mining Project for supporting my attendance.

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1.0 OBJECTIVES

The basic aim of the SWEMP series of symposia is to contribute to the development of methods and technologies for assessing, minimizing and preventing environmental problems connected with mineral and energy production. Notable at SWEMP 2000 was the close interrelationship between Industry and Academia, in working together to solve the problems and challenges in environmental and waste management in mineral and energy production.

2.0 OPENING PLENARY SESSION

The commencing Plenary Session on Tuesday May 30, 2000, set the stage for SWEMP 2000. The four plenary presentations were:

- Environmental Management, who owns it? By John Popowich, V.P., Fording Coal Limited, Calgary, Alberta, Canada.
- Sustainable Development at Work in Trans Alta Energy Corporation of Calgary, by Paul Clarke, Director, Fuel Supply.
- A blot on the landscape? By Patrick Reid, President, Ontario Mining Association.
- Underground Waste Disposal in Germany - Facts, Figures, Future by Professor Per Nicolai Martens, Technical University of Aachen in Germany.

These presentations effectively captured the challenges and issues currently facing the Mining and Petroleum Industries in waste management and environmental protection. Some of these issues are: Multiple perceived 'owners' of Environmental Management - politicians, bureaucrats, Environmental NGO's, Industry - resulting in multiple laws and rules, often conflicting, which can lead to confusion.

It was stressed that in order to successfully manage these issues, they must be clearly defined, understood, and communicated, and that the purpose of rules must be to assist in Environmental Management. Environmental Management Systems (EMS), it was posited, assigns ownership for Environmental Management, and integrates Environmental Management with business, safety, etc, as part of doing the job well. The Board of Directors and Corporate Management both have responsibility for Environmental Management.

Sustainable development at TransAlta involves alternative mine rehabilitation projects, use of high efficiency turbines, and helping the Edmonton municipality in the treatment of waste to create compost, a valuable product, from about 50% of the municipal waste stream. It also incorporates development of secondary product uses for the byproduct of energy production from coal- bottom ash for road construction, fly ash for admixtures in concrete, and gypsum for use in the building industry, and by research, innovation and continuous improvement, continues reduction of other emissions while working towards zero emission in its operations by 2024. Ever mindful that Alberta currently accounts for 6% of Canada's greenhouse gas emissions, Trans Alta works to protect Alberta's competitive advantage.

The telling title *"A blot on the landscape"* lamented the very poor opinion of mining in the public eye worldwide, and the need for the Industry to balance environmental protection with economic development. This can be facilitated by adopting the new, expanded concept of "Triple Bottom Line", which includes Environmental and Community/Social concerns with Financial returns for Shareholders, as the three guiding principles for Mining Companies.

The presenter noted that the negative visual impact of abandoned mines, and pollution resulting from their wastes, such as acid rock drainage causing the release of heavy metals, which are killing fish, is contributing in large measure to the negative public opinion of the mining industry today. NGO's are using pictures of abandoned mine sites as a weapon against the mining

industry. Since the requirement for reclamation after shutdown, has only been introduced over the last twenty years, there are many abandoned mine sites: 600 are in Ontario, including fifteen major ones.

Although it is the public perception that government should be reclaiming these sites, even in Canada, government lacks the money and the willingness to clean up abandoned mine sites. The presenter therefore proposed that Industry should take a proactive approach, such as its collaboration with government in the MEND program in Canada which was run for the last ten years, and its participation in the international INAP programme which will share the information generated by the MEND project, and contacts for avoiding, and dealing with acid rock drainage.

It was posited that Industry should actively participate in the cleaning up of abandoned mine sites - as has happened in the US, using funds from National Geographic and Conservation activities. Reference was made to the Global Mining Initiative, which will produce a report in 2001 ($3 million has been made available for this purpose), and this will lead to a Conference in 2002 of NGO's, Communities, Mining Experts and Governments to try and build better relationships and agree on procedures for the Mining Sector.

The presenter proposed steps that practitioners can take, beginning with Closure Plans and Financial Requirements for Closure, to steps taken during mining, with closure in mind, to ensure that the land will be left as best as practicable for alternative uses. In addition, Industry can help identify problem areas, share and cooperate with native groups, provide technical expertise and services to government agencies with responsibility for cleaning up, and monitor areas near present operations.

The final keynote presentation outlined the requirements and advantages of disposing non-mining waste underground in Germany. Underground repositories are confined to salt rock formation, where they are prevented from interacting with the biosphere. Two safety concepts are applicable to these repositories - neutral emission and complete enclosure, which requires multiple barriers, which must be specially monitored.

Sixteen percent of hazardous waste in Germany, including mercury and residues containing cyanide, nitrites, products containing PCB and mixed wastes from treatment plants are disposed of underground. The containment concept applies strictly for hazardous wastes. Cost of underground waste disposal in Germany compares favourable with the higher priced range for surface disposal, as follows:

Underground disposal -	US$200-300/tonne
Surface disposal -	US$100-300/tonne

There is a trend, noted the presenter, towards reducing waste, and developing useful economic products from waste. From the European perspective, it is recognized that future decisions concerning waste disposal in mining sector operations will be determined less by scientific progress than by political decisions and public opinion.

3.0 ORGANIZATION OF SYMPOSIUM

The Symposium was organised into three sessions per day where three parallel groups of presentations were made, under the following nine subject headings:

- Managing Environmental Impact Assessment, Permitting and Management
- Waste Management Practices
- Environmental Issues in Open Pit and Underground Mining
- Emerging Technologies for Environmental Protection
- Mine Site Closure, Tailings Disposal and Rehabilitation
- Mine Site Closure, Acid Mine Drainage
- Environmental Impact - National Reports.
- Computer Modelling and Applications
- Waste Characterisation and Modelling.

It is estimated that there were over 100 presentations. The proceedings, which were distributed at the symposium, contain 118 presentations. The author's presentation, "The challenge of sustainable small and medium scale mining in Guyana," was presented under the subject head "Environmental impact - National Reports." Presenters were drawn from Ghana, Guyana, Brazil, Canada, Sweden Poland, Germany, France, Spain, Ukraine, Russia, Japan, Estonia, United Kingdom, Australia, Italy, Turkey, Romania, Austria, China, Belarus, Jordan and Tunisia.

It is of note that except for the author's presentation, there was no other presentation dealing with small-scale gold mining or environmental issues relating to mercury from small-scale gold mining operations. Notwithstanding, the wide range of topics discussed are all relevant to the ongoing development of environmental management practices in mining in the small, medium and large scale sectors of the Mineral Industry of Guyana.

A list of papers of special interest is presented in the Appendix A while the Appendix B presents the list of useful contacts from that conference.

4.0 HIGHLIGHTS OF PRESENTATIONS

There were many highlights from the presentations, which are listed in this section.

Tips for mining with closure in mind:

Closure plans and financial requirements should be in place, to avoid having abandoned mines.

Site should be as small as possible.

- Clumps of trees - green space - should be left.
- Roads should be curbed.
- Structures should be erected with a view to their removal.
- Chemical waste should be stored separately from others.
- Sites should be planned so they could be used for other purposes.
- Land should be left as best as possible for other purposes.

Sufficient financial and human resources and organizational structures should be deployed for environmental management. *A comprehensive, integrated and multi-disciplinary approach is needed.*

Ongoing, long-term research is needed to understand the complex physical/chemical and biological nature and interactions, resulting from mining, and to guide techniques for the mitigation/reduction of environmental effects.

Mining Companies should take responsibility for Environmental Management. The Company's goals should be to reduce cost, improve productivity, stay in production, and employ environmental management.

There should be a focused response for compliance. Key questions to be addressed are: what is to be done and how should it be done, what needs to be managed, how should it be managed, and actual management. Training should be provided to employees for compliance enforcement.

The Company should ensure that employees understand the issues relating to environmental management. *Managing environmental issues* is key, since skills and techniques for addressing technical issues are available and well known in the industry. It is poor management of the issues that often leads to environmental accidents, which have a long residual negative effect internationally.

It is ironic that people with no schools, no jobs and no medical care are turning down economic mining opportunities because of perceptions of environmental damage.

The Mining Industry does not communicate what it does to the public - communication occurs within the Industry. For example, Elliot Lake is cited represents an excellent job of mine reclamation: one would not know that a mine was there.

5.0 OVERVIEW OF SELECTED CONFERENCE PAPERS

Collaboration between Universities/Research Institutions and Industry
By capturing the close collaboration between universities/research institutions and the Mining Industry, SWEMP 2000 has proven to be a useful forum for highlighting trends and technological developments relating to environmental issues and waste management in Energy and Mineral Production, as well as current thinking and practices within these sectors.

Stricter Environmental Practices Demanded Worldwide
Country presentations highlighted the worldwide trend towards increasingly stringent demands and application of environmental regulations, standards and practices, driven in part by the requirement of multilateral financing institutions for privatization of former state-owned mining sector operations in Eastern Europe and around the world.

Mining Industry Response - Closure Plans, Clean-up, Monitoring, Environmental Management
The Mining Industry in turn is encouraging higher standards for environmental practices among its practitioners, as a response to the very strong negative public image of mining, deemed a 'blot' on the industrial landscape. This image is reinforced by recent and recurrent tailings dam failures, which attract high profile reporting and worldwide publicity, with spectacular verbal and visual images that linger in the public consciousness, and the large number of abandoned mine sites some of which are causing significant Acid Mine Drainage (AMD).

The industry is demanding a more proactive approach in preventing abandoned mine sites by the application Closure Plans early in the life cycle of a mine, for which provisions for financing are put in place. Industry is further recommending that practitioners should assist in cleaning up abandoned mine sites and monitoring areas near to their operations.

It was acknowledged that the mining industry possesses the technology, skills and competence to successfully operate tailings impoundment facilities. A review of recent spectacular accidents at tailings facilities, sometimes resulting in loss of human life, indicated that in most cases, *the root cause of the failure lay in poor management of construction and environmental aspects of the operations*. One contributory cause is that contrary to the practice governing the construction of hydroelectric dams, tailings dams are raised incrementally over the active life of the facility, and moreover, they are often designed and initiated by one engineering group, while the bulk of the structure is built and maintained by the mine staff. In addition, the Mine Manager, usually a Mineral Processing Engineer, is usually responsible for the Tailings Impoundment Facility.

Environmental Management Systems (EMS), mainly ISO 14000, increasingly embraced
To correct management deficiencies that can easily result from these practices, Environmental Management Systems, linked to the Environmental Impact Assessment (EIA) process, including regulatory requirements, monitoring, verification of predictions of the monitoring adaptation of the goals and program and documentation, are being proposed as an effective tool for environmental management.
These systems, of which the ISO14001 part of the ISO 14000 Standard on Environmental Management System, is growing in popularity, stress documentation, ownership of

environmental management, education throughout the Company, involvement and commitment backed by adequate funding, continuous improvement, and details as to what needs to be managed, how and by whom. A typical EMS document describes the plan and do actions, check and review components. The check and review components are the subject of an annual environmental report available to the public for comment and critique. The EMS ensures that any new concerns are factored into plans for future actions and review, and that financial resources are set-aside for Environmental Management. It is in the content of the EMS structure that the Mining Association of Canada (MAC) has drawn up and published a "Guide to Management of Tailings Facilities."

The increasing adoption of the ISO 14001 Standard attests to its growing recognition and importance. The use of this standard, and the multi-disciplinary approach that is necessary for environmental and social evaluation and management are being captured by universities, which are well placed to undertake such research programs to provide technical information. Through analysis and synthesis, the data and information are applied to develop frameworks and models, to be used as tools to support sustainable development based on decision-making.

Among others, such tools for data management and decision-making are being developed for the Bauxite Mining Sector worldwide by the Collaborative Research Centre 525 (CRC 525) of Aachen University of Technology, by the World Bank in the context of the proposed National Protected.

Areas for Guyana, NPAS, to facilitate decisions to allow mining in Guyana to participate in sustainable practices, while maximizing both mining options and addressing conservation needs (Dimitrakopoulos *et al.*); and by the application of GIS based models.

Combining EMS, Multi-Disciplinary Approach in Tertiary Level Training

The importance of the ISO 14001 Standard and the multi-disciplinary approach are the underlying principles for a new B.Sc course to be introduced in 2001 at the University of Technology, Lulea Sweden. This course expands on the successful integration of ISO 14001 principles into the University's annual short term international course for Mining and the Environment for professionals active in the mining sector. The B.Sc Degree Course will have a natural resources science base, but will also have an integrated perspective on social sciences, e.g. management, communications conflict resolution, jurisprudence, economics etc.

Universities and other research institutions are also making valuable contributions to the understanding and application of environmental management technologies through long term applied research projects, for example in revegetation of mine waste and tailings, and amelioration of Acid Rock Drainage.

Triple Bottom Line -Highlighting Economic, Environmental, and Social Well-Being

Together with Economic issues, Environmental and Social issues are now incorporated into the new principle of 'Triple Bottom Line' to guide mining companies mode of operation. Social skills are now being recognized as being necessary in mine planning, development and operations. Environment management has to continue after mine closure, and indeed into perpetuity, where polluting conditions persist, and funds have to be provided for this. Hence,

Mine Closure Plans are becoming more important and are incorporated from the earliest part of the mine cycle. The aim of the closure plan is to ensure that decommissioning and reclamation of the site can be successfully achieved while satisfying objectives of sustainable post mining use of the site acceptable to all stakeholders, protection of public health and safety, alleviation or elimination of valuable attributes, and minimization of socio-economic impacts, and meeting statutory requirements.

Progressive mine site rehabilitation for closure initiated during mining also serves to reduce the cost of reclamation/rehabilitation after closure for the mine operator and government, reducing environmental liability and improving the image of the mining operation. In spite of the prevailing negative image, there are success stories in mine rehabilitation. Elliot Lake is one such shining example. It was felt that the industry needs to educate the public regarding aggressive environmental management strategies that are being adopted and its success stories.

National Approaches

Brazil

The Symposium reviewed the effectiveness of the implementation of EIS in Brazil, and self-regulation in environmental management in large scale mining in Zimbabwe. A study of the implementation of EIS in sand, and crushed stone operations in Brazil exposed weaknesses, stemming mainly from vagueness or impracticality of the conditions of the Environmental Licenses, loss of comprehensiveness as a project progressed through the five stages and associated agencies involved in the licensing process, and implementation by the pollution control agency which has little knowledge of the details, and was not previously involved in the process discussion and review of mining projects. As a result, in the five operations visited, operators only paid token regard to the implementation conditions in their Environmental Licenses.

Zimbabwe

Collaboration between government and mining companies in improving environmental management systems in Zimbabwe has been recommended. It was further recommended that industry in Zimbabwe, which does not commonly apply a self-regulatory approach, should become more proactive, moving from the level of seeking to meet minimum acceptable levels, to reaching for improvement and surpassing minimum levels, consistent with the philosophy and practice of EMS.

India

Environmental practices in other countries, notably in Eastern Europe and India were also reviewed, and it was generally found that there is need for much 'catching up' in matters of environmental management, which previously was not subject to any stringency. Again, the need for data gathering, improved mining and processing techniques and remediation is apparent in all cases, and the current environmental regional assessment program in India started in 1997 and undertaken by the Indian Bureau of Mines with Technical Assistance from BRGM of France, aims at undertaking a Regional Impact Assessment (REA) of existing and potential environmental impacts of mining operations, characterize the risks for human health and the

environment based on a source-pathways-targets approach, and develop an Environmental Management Plan for the region incorporating regional and mine-site specific solutions in terms of both environmental management and technical improvement. These objectives are mirrored by GGMC and GENCAPD, as we seek to improve environmental management practices and build capacity for Environmental management in the Mining Sector in Guyana.

The North Goa iron ore mines and the Sukinda valley chromite mines study area present two environmental problems. Large volumes of mining waste is generated from the high overburden to ore ratio (about 3:1) in the iron ore mines causing major problems in land use management, and also contribute to erosion/sediment loading in the water courses, especially during the monsoon season. In the Sukinda valley, there is chemical pollution of waters, soils and sediments by chromium and to a lesser extent, nickel, resulting from mine water discharge, the release of beneficiation plant effluents and slurries into the environment.

Elevated mercury levels result from agricultural practices of using seed coated with a mercury bearing fungicide and leaching of waste dumps and ore stockpiles. The mines generally occur upstream from paddy fields in the vicinity of farming villages, and most wells and watercourses in the central part of the valley are contaminated by Cr^{+6} and in a few places by nickel, with concentrations exceeding the Indian guidelines for drinking water, surface water, and agricultural soils. However, elevated Cr^{+6} content in groundwater could correspond to the regional and geochemical background prevailing naturally before mining occurred, and any solution has to take this factor into consideration. In response, the EMP must address the most urgent concerns related to the presence of high chromium content in the environment and its bioaccumulation in the food chain.

Argentina

A presentation from Argentina demonstrated the usefulness of the compilation of existing data sets into an environmental baseline map composed of several themes, the most important being lithology (including information on rock permeability/porosity), geomorphology, soils, climate, vegetation, land use and national and cultural patrimony.

Sardinia, Italy

Experiences in the use of cyanidation in small-scale mining in Sardinia in Italy, and in tailings facilities management at the Bogosa Gold Mine near Tarkwa in Ghana, are instructive. In the Sardinian experience, a 270,000 tons per year operation commenced in 1997, where gold is produced from an open pit mine utilizing a CIP plant for gold and silver recovery. Total ore reserves are 2.15 million tons at a grade of 2.82gm/ton. The water from the tailings pond is recycled and cyanide is recovered. The area was extensively worked for kaolin previously. The area is populated and hosts' important water sources. The Earth Sciences Department, University of Cagliari, Italy, undertook a study.

The hydrogeology is mainly controlled by the altered volcanic rock: fractures and vuggy silica zones allow the groundwater flow and sulfide minerals to persist near the surface. The shallow groundwater level fluctuates, and when it rises, there is admixing with the water from the tailings pond, causing a reduction in pH and concomitant volatilization of HCN.

Levels of free cyanide CN (200mg/l), Hg and Ag in the tailings pond are high but the chemical composition of the water downstream from the tailings basin has not changed over the three years of exploitation. However, when the water level rises and the hydrostatic pressure in the impoundment increase significantly, such as happened in February 1998, seepage occurs downstream of the tailings pond. The plume was found to contain high levels of cyanide 120 µg/L, 2.5 µg /L Hg and 2 µg /L Ag at sampling point F25, the first sampling point downstream of the tailings basin. The contaminated water was pumped back into the pond to prevent the plume from spreading. About 50m downstream, CN in water had decreased, and was close to background 300m downstream. Sampling a week later showed a similar situation.

Cyanide concentrations at sampling point F25 was monitored weekly. From February 1998 to March 1999 it showed marked variations (0.1-2 mg/L) and then increased from 3mg/L to 12mg/L. At the other sites, all downstream from F25, CN was only occasionally detected (up to 23 µg /L) being mostly below the detection limit of 10 µg /L.

It was concluded from the results of the monitoring program that despite the recycling of the supernatant tailings water and recovery of cyanide, high CN, Hg and As contents in the impoundment might represent a potential hazard in the future. Since long periods of dry weather and high temperatures during the summer causes increase in CN concentrations in the impoundment due to evaporation, a more contaminated plume was observed in 1999.

Ghana

The situation at Bogosa Gold Mine in Ghana, with similarities and differences with Omai Gold Mines was more positive with respect to the management of the supernatant tailings water. The open pit operations started in 1990, and the oxide ore is processed by CIP to produce 100-110,000 oz/yr. The tailings impoundment currently consists of a series of embankments and saddle dams around the periphery of a storage basin. Approximately 10 million tonnes of tailings were deposited by the end of 1997 at a deposited tailings density of 1.45 t/m^3.

The main tailings dam is constructed upstream using a laterite fill, compacted in 150mm thick layers to 95% standard compaction dry density. A longitudinal drain constructed at the foundation level and connected to a series of transverse drains that daylight at the downstream toe have been incorporated within the design to reduce pore pressures throughout the embankment and to provide a path for seepage to migrate to a down stream collection sump.

Tailings deposition is at a rate of approximately 180,000 tonnes/mth. Tailings are spigotted on a rotational basis from five operational embankment areas. Rotational spigotting practices aim to maintain the supernatant pond within a small area and prevent encroachment within 100 metres of the dry embankment walls. Excess water commonly accumulates during the heavy rainfall (monsoon) and is discharged into a constructed wetland area.

Seepage collection pumps established below the south and southeast walls of the embankment pump where the water collected in these sumps back into the pond on a daily basis. Sewage is also pumped into the pond to promote bacteriological breakdown of residual free cyanides.

The current tailings impoundment is expected to remain in use until the end of 2001 when a new facility will be constructed for sulphide ore production. Food crop trials are ongoing on the oxide tails to determine the likely metal uptake in the root crops planted on the decommissioned tailings surface, and results of the study will be used to determine the need if any for final capping of the tailings dam.

A study of the viability of citronella grass plantations and local oil extraction facilities is being evaluated in line with corporate sustainable development objectives. Design of a final spillway and passive treatment options for seepage water chemistry are currently under review in the line of long term closure planning.

Precautio ns are taken during mining to ensure that mining of the oxide ore does not penetrate the transitional zone, in an effort to avoid acid rock generation.

6.0 THE GLOBAL PICTURE

While at the level of the individual mine, (i) the triple bottom line with emphasis on economic environmental, and social well-being during and after mining operations, (ii) adoption of Environmental Management Systems with a focus on available financial resources and continuous improvement, (iii) implementation of Closure Plans linked to sustainable utilization of the mine site after closure; and responsibility for pollution abatement after closure; and (iv) proactively participating and making skills, services and funding available for clean-up of abandoned mine sites are being pursued as key strategies for improving environmental performance of the Mining Industry, at the global level industry leaders are participating in the Global Mining Initiative, where the Industry, governments, NGO's, native groups are working together to define the way forward for the industry in the 21st century.

In Waste Management, there is a trend towards reducing waste and developing useful economic products from waste. From the European perspective, it is recognized that in the future decisions concerning mining sector operations with respect to waste disposal, will be determined less by scientific progress than by political decisions and opinions of society. Since waste disposal - tailings, waste rock, hazardous materials - is a major part of mining operations, it is to be expected that this trend, towards growing influence of the political directorate and public opinion, already apparent, will govern the development of the mining and petroleum industries in the future worldwide. *In the true spirit of globalization, the Mining Sector in Guyana will not be exempted from these global trends within the Industry*.

7.0 CONCLUSION

SWEMP 2000 was an excellent forum for obtaining information and exposure on current, topical and pressing issues in Waste and Environmental Management in Mineral and Petroleum Production, and to meet and exchange ideas with practitioners from industry and academia involved in working on these issues.

Guyana will not be isolated from the worldwide trends in environmental management in mining, which will be highlighted by ongoing global processes such as the Global Mining Initiative, a meeting of minds from industry, governments, NGO's, communities, to try and build better relationships and agree on procedures for the mining sector.

Combined with the universal demand for stricter environmental monitoring and performance, public opinion, at least in the developed world, will play an increasingly strong role. Therefore, trends in Waste and Environmental Management in Mineral Production evinced by the Symposium serve to reinforce the current thrust in Guyana, stressing information/data gathering through Environmental Studies, including desktop studies, and Surveys and desktop studies; building awareness and important skills in public sector institutions and among miners, for enhanced environmental management; and working towards greater efficiencies and cost effectiveness in mining, processing and reclamation, with emphasis on sustainability, during and after mining.

Miners should be encouraged to work towards sustainability, and to conceptualize early in a mining project about how the area should be left at the end of the operation. Even where an Environmental Management System cannot be fully adopted, miners should be encouraged to adopt in part the main principles and approaches of EMS, since awareness and management of environmental issues have proven to be as important as the skills for safe, environmentally friendly practices. Moreover, the EMS goal of continuous incremental improvement is expected to yield economic benefits with such improvement.

APPENDIX A

Papers of Special Interest

PAPERS OF SPECIAL INTERESTS

1. Bauxite mining and its effects by P.N. Martens et al, Aachen University of Technology, Germany.

2. Using Environmental Management Systems to systematically improve operational performance and environmental protection by Tony Dzwilski, Marshall University, West Virginia, USA.

3. The tailings pond failure at the Aznacóllar mine, Spain by N. Erickson of Boliden and P. Adamek of Spain.

4. Regional Environmental Assessment and Management of Mines in India by T. Biswas et al, Bureau of Mines, India F. Cottard et al, BRGM and C. Jucker, ANTEA International, France.

5. Using ISO 14001 as a structure for integrated environmental training by J.O. Berman, Lulea University of Technology and S.E. Osterlund of CENTEK, Lulea, Sweden.

6. Use of "A guide to the management of tailings facilities at Syncrude" by J.G. Matthews of Syncrude Canada Limited et al.

7. Tailings Disposal and Management Practice at Bogosa Limited Ghana, by Samuel Ndur et al, University of Science and Technology, School of Mines, Tarkwa, Ghana and Morris et al, of Bogosa Gold Limited, Ghana

8. Design of safety channels in mining for small drainage basins by E. Orche, Department of Natural Resource Engineering, and University of Vigo, Spain.

9. Design, construction and rehabilitation of spoil dumps - A case study by Y.V. Rao et al, Department of Mining Engineering, and K.R.E.C, INDIA.

10. Air particulate mining in a major Ghanian mining town - the case study of Tarkwa by N. Amegbey and S. Ndur, School of Mines, University of Science and Technology, Tarkwa, Ghana.

11. A multi-criteria geographical approach for the environmental impact assessment of open pit quarries by P. Berry et al, Department of Chemical, Mining and Environmental Engineering, University of Bologna, Italy.

12. Natural regeneration of vegetation on mining waste sites by C. Biro et al, Department of Mining, University of Petrosani, Romania.

13. Environmental planning considerations for the decommissioning, closure and reclamation at a mine site by D.M. Mchaina Bolidern Limited, Etobicoke, Ontario, Canada.

14. Tailings revegetation - On non-ameliorated substrate, by J.M. Osborne School of Environmental Biology, Curtin University of Technology, Perth W.A., Australia.

15. Completion Criteria - Case studies considering bond relinquishment and mine decommissioning - J.M. Osborne and D.R. Bearley, School of Environmental Biology, Curtin University of Technology, Perth W.A., Australia.

16. The Brazilian program of high-pressure water jet to cut ornamental rocks by C.T. Lauand of University of Sao Paulo, Brazil and R. Ciccu of University of Cagliari, Italy.

17. An approach to the Environmental baseline chart in Argentina by J.C. Avila, Tucuman University, Argentina.

APPENDIX B

USEFUL CONTACTS

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1. Prof. Dr. Ing Amegbey – Environment, Human Factor and Safety, School of Mines, Tarkwah, Ghana.

2. Dr. Elizabeth Quarshie – Board Member, National Energy Board, Calagary, Alberta.

3. Dr. Samuel Frimpong – Assistant Professor of Mining Engineering, University of Alberta.

4. Mr. Oral Rainford – Director, Minerals Development, Ministry of Mining and Energy, Jamaica.

5. Ms. Elvira Dias – Mining Engineering Department, University of Sao Paulo.

6. Mr. Sven-Erik Osterlund – Assistant Managing Director, Co-coordinator, International Programmes, CENTEK, Lulea, Sweden.

7. Dr. David Mchaira – Manager, Environmental Affairs, Americas, Bolidern Lt. Toronto.

8. Joan Osborne – Associated Professor, Mine Rehabilitation Group, Coordinator of Undergraduate Studies, School of Environmental Biology, Curtin University of Technology, Western Australia.

9. Dr. Lidia Gawlik – Polish Academy of Sciences, Mineral and Energy Economy Research Institute, Gracon, Poland.

10. Dr. Hilary Inyang – University Professor and Director, Centre for Environmental Engineering Science and Technology (CFEST) University of Massachussetts, USA.