Plenary Lecture

Mining and the environment

by

J.M. Whiting† and K.G. Crane‡‡

ABSTRACT

This paper discusses the evolution of public concern about man's impact on the environment and legislation enacted by democratically-elected representatives to limit it. After a decade of increasing awareness about Planet Earth's inherent limitations, especially its ability to benignly absorb man-made pollutants, the National Environmental Protection Act (NEPA) was passed by the U.S. Congress, and the Fisheries Act was passed by the Canadian Parliament near the beginning of the 1970's. Both Acts carried a very broad mandate with extensive implications — "Thou Shalt Not Pollute" — and both were vague. Details were missing, of course, because no one had a clear idea of exactly what was to be done, nor how it would be accomplished. In essence, however, an environmental crusade was ordered, and everyone was expected to participate in it. Subsequently, very many additional rules and regulations were created by all levels of government during the past 20-plus years to clarify and implement the intent of the initial legislation, and the process is still going on.

Nevertheless, the people who find, develop and operate energy and mineral producing enterprises in Canada and the United States have proved they are capable of dealing effectively with a very wide variety of environmental and regulatory challenges, and in minimizing the adverse impacts of the instabilities (usually temporary ones) caused by extracting resources from the earth. They have been aided in this accomplishment, in most instance, by working with professional people in regulatory agencies who can also learn and understand the constraints imposed by the laws of nature and economics, and can work together to turn legislators' dreams into practical achievements. Two coal mining operations of Luscar Ltd. in western Alberta, Canada, are described as examples where experimentation and innovation to effect solutions to environmental problems have been used throughout their history to achieve award-winning results.

The writers briefly mention longer-term environmental issues which have wide-ranging implications to the future of energy and mineral development in North America. In closing, they observe that major expenditures for environmental protection, proposed or implemented to attain long-term incremental reduction of hazards to human life and other organisms, and not supported by rigorous cost-benefit analyses, nor based on experience or science/engineering-supportable documented facts, are speculation as contrasted to investment.
These type of expenditures are likely to create the same end result as other speculations, such as penny mining stocks, lotteries and roulette: A few people will reap large rewards, because many will pay.

1. INTRODUCTION

The purpose of this paper is to outline some of the considerations which led to a rapid expansion of environmental legislation United States and Canada starting in the late 1960's and early 1970's, and to comment on how the energy and mineral extraction industries have dealt with several facets of the public's concerns about protecting the environment. It provides examples of how these concerns are dealt with in the planning and daily operation of thermal and metallurgical coal mines in Western Canada where land reclamation regulations are stringent. The objectives of environmental work at these operations are discussed, as well as the steps taken to accomplish them. The paper also touches upon long-term, unresolved environmental issues which have wide-ranging implications relative to future mineral and energy development in North America.

2. BACKGROUND OF ENVIRONMENTAL CONCERNS RELATED TO MINING

One of the writers (JW) spent much of his childhood in mountainous regions north of Spokane, Washington, U.S.A, just south of the U.S.-Canadian border. Many people in this sparsely-populated area were engaged in logging, mining and farming. They were very closely associated with nature, flora, fauna and weather. They survived, with the help of nature, and often they were harmed by natural events, such as floods, high winds, severe winters, and occasional losses from predators.

Almost everyone was taught from earliest childhood to respect "natural" conditions, as well as all of the creatures that lived in the ecosystem with them. Very few people were careless; and such people were usually subjected to criticism or scorn. Most of these "slow-learners" became more respectful of the earth, the creatures and their fellow men as they matured. No one believed it was his or her God-given right to harm or destroy natural things, nor to damage the planet or its inhabitants.

Nevertheless, steady population growth, along with everyone's desire to enjoy the benefits associated with increasing disposable income and affluence — these accelerated greatly after World War II — led to rapidly-increasing materials and energy consumption. These obvious trends began to worry some scholars that man was making an important adverse impact on the environment, especially in certain regions where raw materials were recovered or processed, or where people disposed of wastes.

The scholars' concerns were passed on to some of the public. In the 1960's, however, people in North America believed that it was possible to do anything and everything at the same time. During the 30-year period of unparalleled growth of the economies of the United States and Canada (1940-1970), it seemed possible and beneficial to send to the moon, defend the world from the advance of communism, eliminate poverty, educate everyone, and to supply increasing mineral and energy demands at high annual growth rates of five to six percent. A relatively few people who were more cautious, and sometimes more concerned about man's impact on nature, or who opposed
increasing consumption (demand growth) because of a variety of personal beliefs, began to communicate their concerns in an empathetic popular media.

One book in 1962, “Silent Spring,” by Rachel Carson, seemed to be particularly effective in expanding concerns that the growing use of powerful insecticides was decreasing the thickness of the shells of wild bird eggs, and ultimately causing the death of many birds. This type of pollution seemed especially insidious, pervasive, discouraging — and believable.

Other credible researchers and effective communicators decried water, air and land pollution. In fact, many important and costly steps were taken to control adverse impacts, and many people and corporations behaved in a responsible manner under regulations existing at that time. However, highly-competitive market forces were not in favor of adding costs to a product in order to achieve some intangible, unprovable “good.” Therefore, the actual steps taken to reduce pollution were based less on anyone’s moralistic desire to protect nature, and more on practical reasons to cut costs, increase profits, and to avoid public relations damage or lawsuits.

3. THE UNITED STATES’ GOVERNMENT ENACTS N.E.P.A.

By the end of the 1960’s, the U.S. Congress had received enough stimuli to pass a simple-worded, and — at first glance — innocuous piece of legislation called the National Environmental Protection Act (NEPA). Simply paraphrased NEPA said: “Pollution must be controlled and reduced.” This piece of legislation was barely noticed most people in the mining and energy industries, and they essentially ignored its implications.

At that time, it seemed obvious to one regularly involved with resource development that two factors catalyzed the creation of national legislation to protect the environment in the late 1960’s. First, many people were deeply concerned about the seemingly staggering requirements estimated as necessary to create future energy-producing facilities in terms of land use, processing plants and capital investment, especially in regions where such activities would be new and less immediately-acceptable than in already-impacted industrial regions. The relatively pristine States of Colorado, Wyoming, Montana, Utah, Arizona and New Mexico were believed to be positioned for unprecedented coal, oil shale, uranium, and crude oil and natural gas development, especially to achieve some measure of greater energy self-sufficiency. Secondly, national leadership was seeking new means to stimulate employment. Environmental protection was viewed as a new growth industry from its official NEPA beginning, and it is still viewed as such by many.

In the U.S., during the late 60’s and early 70’s, it became progressively difficult for a corporation or individual to obtain a Federal coal exploration permit, or to obtain a “preferential lease” of Federal coal lands after making valid discovery and starting diligent development of a new economic coal deposit (i.e., an “orebody”) on public (Federal government-controlled) lands. However, the law regarding coal leasing had not been changed by legislation. Rather, the executive branch of the Federal government decided to delay, and finally to suspend, leasing of new coal properties on Federal land, the location of most of the undeveloped U.S. coal resources. This happened, in large part, because preferential coal leasing, based on a valid discovery, was viewed increasingly by some of the public and empathetic Federal bureaucrats as a “give-away” of valuable resources. They believed that closer control of energy development by the Federal government was desirable, and evolutionary, and inevitable.
A coal development "boom" of great extent was expected, and the imagined environmental impact of developing multiple, large operations in the Western and Southwestern United States (for electrical power generation, coal gasification, and, eventually, coal liquefaction) was extremely worrisome to many non-developers. The "suspension" of preferential coal leasing was the first crystal-clear indication that Federal government control of exploration and development activities of mined energy materials was going to increase very significantly to help satisfy the demands of activists who wanted a slow-down in the growth of domestic energy production.

During this period, the writers witnessed the invention of the Environmental Impact Statement (EIS). At first, those responsible for resource development and extraction, as well as those responsible for regulating them, were uncertain about what was to go into such a "statement." However, engineering consultants who were familiar with the site-permit requirements of electric power generating stations (particularly nuclear plants), and other major regulated projects, were prepared to guide mining and energy companies, and newly-hired environmental planning/permitting people in government, to produce Environmental Impact Statements that three feet (or more) in thickness. These reports recorded every conceivable thought about how a new resource operation would be created, operated, shut down and restored to an acceptable condition. They required great effort, time, money and people resources to create, review, modify and approve. In the United States, it was required that complete copies of EIS's be made available to any person upon request.

Creating a successful EIS could be a very costly and intellectually-challenging process. However, the costs of the EIS and all associated planning and environmental studies usually turned out to be a secondary consideration compared to experiencing any significant delay in the start of a venture's production and positive cash flow, and thereby not recovering the venture's capital investment in the shortest possible time. The latter remains a principal concern to this time.

4. CANADA'S SIMILAR PATH

Peoples' thinking about environmental protection developed along similar lines in Canada. In the writers' resident Province of Alberta, the center development and production for Canada, environmental concerns were focused on anticipated rapid expansion of coal and oil sands mines and processing facilities, and increased production from known crude oil and natural gas fields, as well as bountiful new discoveries envisioned by government and corporate energy planners in remote regions such as the Arctic and the continental shelf.

The Fisheries Act was passed by the Canadian Parliament near the beginning of the 1970's. Both NEPA in the U.S. and the Fisheries Act in Canada carried very broad mandates amounting to "Thou Shalt Not Pollute," and therefore carried extensive, pervasive and costly implications. Both acts were vague, generalized and simple; details were missing. No one, even among experts, had a clear idea of exactly what was to be done, how it was to be done, nor who was ultimately responsible for doing it. In essence, an environmental crusade was ordered, and everyone was expected to participate in it.

In Alberta, Canada, the Environment Conservation Authority was created in 1971. During 1971-72, it held public hearings throughout the Province on the "impact on the environment of surface mining in Alberta". Recommendations from these hearings were translated directly into new legislation and government policy.
During 1973 and 1974, the Alberta government issued new legislation regulating coal mining, including the Coal Conservation Act, the Land Surface Conservation and Reclamation Act, and the Regulated Coal Surface Operations Regulations.

In 1973, the so-called “oil embargo” of the United States by OPEC members took place, and prices for all energy commodities were upward drastically, and permanently. This event and its results started or accelerated many profound changes in resource development regulations, planning and procedures in both countries.

5. EVOLUTION OF LEGISLATION AND REGULATION IN ALBERTA, CANADA

During the remaining 1970’s and throughout the 1980’s, Alberta was typical of many government jurisdictions, whether they were at the Federal, Provincial or State level, both in Canada and the United States: Many regulations were passed that affected the planning, ultimate configuration and operation of a resource extraction venture. A few examples are cited below to provide more of an understanding of how we got to where we are:

In 1975, Alberta followed the U.S. precedent, and placed a “moratorium” on coal exploration in the Province. The government adopted a policy of Integrated Resource Planning (IRP) which attracted little attention or understanding by the public, but the concept would have a considerable future impact on energy producers.

A Coal Development Policy for Alberta was issued in June 1976. This comprehensive document covered all aspects of coal leasing, exploration, zoning, development, marketing, and environmental planning protection. It quickly was followed by an Eastern Slopes Policy. (“Eastern slopes” refers to the eastern side of the Rocky Mountains, a region known for both exceptional natural beauty and vast metallurgical coal deposits.) This was another environmental document that defined eight zones of land-use, such as protected areas, areas for development, recreation, forestry, oil and gas, etc.

In June 1984, the CAC submitted a comprehensive statement about regulatory reform for the coal industry. The Eastern Slopes Policy was revised to accommodate IRP for zoning purposes.

An agreement was reached in 1987 between the Provincial government and the CAC on how IRP could be applied to coal in a manner that would be fair to developers. There were still some problems, but the result was a major improvement, and a new Coal Policy (eight pages) seemed imminent. However, in late 1987, the government announced the elimination of its Resource Evaluation and Planning Branch, and the IRP function was reorganized and spread through the Province’s Forestry, Lands and Wildlife Department (mainly the Public Lands Division).

The result is that the original 1976 Coal Policy is still in effect, as are the Integrated Resource Plans developed for the public land areas of the Province. In some areas, the IRP and the Coal Policy are consistent, and in other areas they are not. Further, the Department of Alberta Environmental Protection passed wide-ranging legislation (EPEA) in 1993, requiring significantly more public involvement, and substantially increasing fines and penalties. The Federal government is currently in the process of enacting new Federal legislation (the Canadian Environmental Assessment Act).
6. PEOPLE HAVE LEARNED HOW TO SOLVE ENVIRONMENTAL PROBLEMS

The foregoing details illustrate many general features about the evolution and development of environmental regulations in democratic, free-enterprise, U.S. and Canadian societies during the 1970's and 1980's. For several reasons, activists — and please note that no negative biases are connected with this word — were able to cause or accelerate the passage of legislation which significantly affected business practices, while a great many more people were indifferent, or even opposed, to the often poorly-defined goals of the legislation. At first, those directing business enterprises — including both management and technical staff — were not concerned nor well-informed about the ultimate implications of the proposed or recently-enacted legislation. In many cases, even those in government who were made responsible for administering the new regulations were uncertain about how to carry out the mandates. As problems arose they were solved — often with considerable expense and delay but people learned, and the process became more efficient rather quickly. Government and business professionals regularly worked together to interpret ambiguities in a manner that made the best use of existing scientific knowledge and technologies, and, in essence, defined the missing details of the legislation as they went along. As the long and very large wave of excitement about proposed extensive new domestic energy projects to achieve greater domestic self-sufficiency faded in the light of realities about adequate crude and natural gas supplies, plus effective energy conservation practices, priorities to accelerate control of energy development also faded. This phase with demonstration by industry and government scientists and engineers that practical solutions could be applied to very esoteric environmental problems.

This brings us to the present status of the energy resource extraction and processing industries. Although much uncertainty always has been present, considerable work has been done — at great cost — to lessen the “impact” on the environment from mining and processing operations. Significant penalties can be imposed for non-compliance with environmental regulations, and the responsibilities of the directors of companies whose actions might cause adverse effects on the environment must be taken very seriously. Furthermore, private and governmental activities are still underway to create new legislation and additional rules and guidelines which stand to affect mineral and energy resource operations.

Nevertheless, the people who find, develop and operate energy and mineral producing enterprises in Canada and the United States have proved they are capable of dealing effectively with a very wide variety of environmental and regulatory challenges, and in minimizing the adverse impacts of the instabilities (usually temporary ones) caused by extracting resources from the earth. They have been aided in this accomplishment, in most instances, by working with professional people in regulatory agencies who can also learn and understand the constraints imposed by the laws of nature and economics, and can work together to turn legislators' dreams into practical achievements.

Those who oppose resource development without carefully building their opposition on a base of facts are likely to only disrupt procedures for a limited period of time. The valid elements of their concerns can be dealt with; the smoke and noise they produce are absorbed by other public interests and greater knowledge, given the passage of time.
7. LUSCAR LIMITED’S MINING OPERATIONS

Mine reclamation regulations were first introduced in Alberta in the early 1960’s. At that time, reclamation standards called for simple levelling waste-rock spoil piles, and attempting to re-establish a vegetation cover. Legislation in the 1970’s (mentioned above) placed a greater emphasis on reclamation planning, with particular emphasis on soil conservation — the essence of reclamation. In 1976, the Alberta Coal Policy was issued which set the reclamation standard for Alberta: *To return mined land to a condition “equal to or better than” that which prevailed before mining.*

Reclamation requirements in the adjoining Province of Saskatchewan were first defined under the Mines Regulation Act in 1971. Reclamation plans were to be submitted to the Department of Mines and Minerals with the goal of returning a land use compatible with the land use activities surrounding the minesite. Some years later, area-specific reclamation guidelines were issued for two areas containing Luscar coal mines. These guidelines set specific requirements for salvaging soil materials, and define levelling criteria.

Luscar Ltd. has seven coal mining operations: Four are in Alberta, and three are in Saskatchewan. One mine produces metallurgical coal, and seven produce thermal coal. The primary environmental impact caused by these operations is temporarily disturbing the land surface, flora and fauna. Many steps must be taken to minimize permanent impacts on the effected environment, but it is worth noting at this point that a variety of problems connected with some other types of mining are not present. For example, problems related to destabilizing mineral deposits containing heavy-metal ions, or exposing sulfide deposits that oxidize and produce low-pH runoff or gaseous effluents are not present. Also, Luscar has no metallurgical operations to produce a variety of chemically-active effluents.

Luscar’s mines are situated in three distinct physiographic regions — Prairies, Foothills and Mountains. For each region, specific land uses, both natural and man-centered, must be considered in land reclamation planning, for example:

<table>
<thead>
<tr>
<th>Region</th>
<th>Land Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prairies</td>
<td>agriculture, recreation, native flora and fauna</td>
</tr>
<tr>
<td>Foothills</td>
<td>natural forest and varied vegetation, fish and wildlife habitat, commercial timber, recreation, watershed protection</td>
</tr>
<tr>
<td>Mountains</td>
<td>fish and wildlife habitat, native vegetation, recreation, watershed protection</td>
</tr>
</tbody>
</table>
All seven of Luscar's operations require-specific, carefully-planned and executed environmental programs to prevent pollution and restore mining areas to desirable conditions, and to meet regulatory guidelines. The fact that Luscar has been very successful in meeting people's expectations is evidenced by the results which are obvious to anyone who visits the company's operations, and examines restored areas, and by several awards from agencies whose mission is to help advance environmental protection.

Environmental factors influencing reclamation can be summarized by the relationship: \( \text{vs} = f(\text{groct}) \), where vegetation and soils are a function of geology, relief, organisms, time and climate. Reclamation planners must measure and evaluate all of the factors contained in the relationship, and they must record all \textit{baseline environmental information} and interpretations in formal \textit{Environmental Impact Assessments} that are reviewed and approved by appropriate government experts.

Reclamation is also highly influenced by human factors, primarily in determining desirable end uses of land. In natural or forested areas, for example, people expect to see recreational pursuits. In agricultural areas, landowners and rural municipalities usually want mined areas to be returned to agricultural production. Fortunately, all of these end uses can be achieved successfully and satisfactorily.

Reclamation programs at two very different mines are outlined below. These operations illustrate the type of considerations which Luscar deals with routinely in order to stay in business.

8. PAINEARTH MINE—A PRAIRIE THERMAL COAL MINE

The Paintearth thermal coal mine is located in central Alberta, approximately 200km southeast of Edmonton. The mine's capacity is 2.0 million tonnes of subbituminous coal annually. All of the coal mined is delivered to Alberta Power Ltd's Battle River generating station.

Motor scrapers first remove the topsoil and subsoil above the scheduled mining area, and move it to an identified storage area from where it cannot be misused or misplaced. Conventional dragline mining employs a huge dragline (bucket) to remove all of the rock overburden above the coal seam(s) in long, narrow, sequential "strips." The coal is loaded by large power-shovels or front-end loaders, and trucked out of the "strip" to the generating station. When all of the coal is recovered from a strip, the dragline refills the strip with the rock overburden by dumping it in a series of overlapping "spoil piles." Bulldozers and scrapers, basic earth-moving tools, are used to contour the spoil piles as desired, and to carefully replace the subsoil and topsoil.

The Paintearth mine is in a prairie region characterized by expansive, gently-rolling terrain. Long, cold winters and relatively short, warm summers are normal. Average annual precipitation is 42 cm, with an annual water deficiency of 13 to 15 cm. Most soils in the area are rated as Class 3 under the Canada Land Inventory, i.e., soils having moderately-severe limitations that restrict the range of crops, or require special management practices. Some less-productive Class 4 and 5 soils also exist within the mine area.

Reclamation criteria call for saving all suitable soil materials up to a depth of 1.5 m, where such quantities exist. Topsoil and subsoil are handled carefully and selectively. A unique step in the Paintearth mine's reclamation program is the simulation of deep ploughing techniques when handling solonetze soils. For example, topsoil is separately removed, and then the subsoil layers,
comprised of a sodium-rich hardpan (dried-clay) horizon and a calcium-rich soil horizon, are mixed to improve the crop-production capabilities. Over nine years of monitoring, the mixed soils have produced forage yields 1.5 times that of similarly-managed, unmodified reference areas.

Overburden materials are bulldozed to contours which approximate the original terrain. Care is taken to ensure positive drainage.

Agriculture is important to the area; consequently, reclamation practices return all of the agricultural capabilities which existed prior to mining. This allows growing the full range of cereal and forage crops, namely wheat, barley, canola, and hay. Yields on reclaimed lands are comparable to those obtained from adjacent unmined fields.

Luscar operated the Diplomat mine, approximately 10 km north of the Paintearth operation, from 1950 to 1985. The minesite (over 1000 hectares) is now used for agricultural production. Because of the extensive period of operation, different regulatory standards were in effect at different points in time. Pre-standard lands were reclaimed to a rolling topography, and are used for pasture and forage production. Present-standard lands were leveled, and now support cereal crops. The property also has a seven-hectare recreational lake which is annually stocked with rainbow trout. The lake has proven to be a popular recreational retreat in summer and winter for local residents.

9. LUSCAR MINE—A MOUNTAIN METALLURGICAL COAL MINE

The Luscar mine is immediately adjacent to the scenic front ranges of the Rocky Mountains along the Eastern Slopes of Alberta, about 330 km west of Edmonton, Alberta. The operation has an annual capacity of 2.5 million clean tonnes of bituminous coking coal. Coal production is shipped through Neptune Terminals in Vancouver, mainly to steel mills in Japan.

Most of the minesite lies in the subalpine eco-region at elevations ranging from 1615 m to 1800 m above sea level. It is a beautiful region 60 km south of Hinton, Alberta, and relatively near the town of Jasper, an internationally-known center for those who want to enjoy the visual and other delights of driving, walking or camping in the high, rugged, glacier-formed mountains.

Truck-and-shovel mining is employed. Mining procedures are very similar to hard-rock, open-pit metal mines. The geological forces that pushed up the great mountains also severely distorted and metamorphosed coal beds to provide an unusual variety of coal deposits in shape, attitude and thickness. First, commercial deposits must be discovered by geological studies and exploration drilling, and then each is removed by “custom-tailored” production drilling, blasting, loading and hauling practices. No two deposits are the same. When a maximum ratio of overburden-to-coal is encountered, mining stops, and the pit is filled in with rock, leaving a highwall above the practical limiting elevation of the rock fill.

Minesite precipitation averages 73 cm, with 70 percent falling as rain from June to September. Snowfall can occur during any month of the year. Snowpack lasts for 160 to 180 days, with the greatest snowpack occurring between February and March.

Soils encountered are mainly of the Luvisolic order. Various soil salvage programs have been implemented at the minesite over the years. Mining equipment is used to salvage regolith (i.e., the
unconsolidated material overlying bedrock), and soil materials are salvaged utilizing scrapers, or, in
the case of wet areas, by using backhoes loading standard-size gravel trucks. Depending upon the recl-
amation plan and final land use, reclamation materials are replaced in depths ranging from 15 to 30
cm.

Overburden is evened-out to a maximum 27-degree slope, and varied topographical relief is con-
structed on the tops of dumps and backfill areas to provide micro-site diversity.

However, the main objective of the environmental program at the Luscar mine is the re-
establishment and concurrent maintenance of wildlife habitat, with special attention paid to Big
Horn sheep. Recreation and forestry are also important components of the program.

A habitat suitable for Big Horn sheep must provide range or grasslands in close proximity to es-
cape terrain (steep or rocky slopes). Truck-shovel mining operations conducted at the Luscar mine
can provide such conditions. Dumps are sloped to varying angles up to a maximum of 27 degrees,
and mine pits are backfilled; however, to provide the necessary travel corridors and escape terrain,
key parts of highwalls or steep faces are left in place. Benches on highwalls also serve as lambing
areas for the ewes, and as “hospital sites” for sick or injured animals.

“Remarkable” is the word to describe the success of the reclamation program at this Luscar
mine. Starting with an initial herd of 25 to 30 animals, site now boasts a total population in excess
of 300 animals. Government agencies have used the site as a source of sheep for transplanting ani-
mals into areas with declining populations. (In 1992, 30 animals were captured and transported to
Nevada as part of a co-operative program.)

Another excellent example of “mining and the environment” is the creation of a high alpine lake
in an abandoned pit at the Luscar mine. It is fed by a natural creek which enters the lake as a water-
fall, and then falls from the lake into its original stream channel, which was dry during pit opera-
tions. The stream was enhanced for trout by creating pool and riffle areas, and by placing spawn-
ing gravels in the stream bed and littoral zone of the lake. One hundred pairs of spawning rainbow
tROUT were observed using the area in the spring of 1991.

The Luscar mine earned the Order of the Big Horn Award from the Forestry, Lands and
Wildlife Department of the Alberta Government in recognition of its accomplishments in reclama-
tion.

The foregoing provides only brief examples of reclamation planning and implementation at
Luscar’s operations. Nevertheless, they can serve to demonstrate that coal mining today is truly a
temporary land use, and that it fits within the concept of sustainable development, that is, “develop-
ment which meets the needs of the present generation, without compromising the ability of future gen-
gerations to meet their own needs.”

The writers are aware of many other complex environmental matters that have been handled suc-
cessfully by mining, metallurgical and energy companies in Canada and the United States. In fact,
it is accurate to state that resource and processing companies are leaders in developing knowledge
and technological solutions to make industrial development much more tolerable to the environment,
and responsive to the needs and desires of people and future generations of people.

Many of the desirable results can be achieved efficiently through careful, forward-looking plan-
ing, along with very diligent implementation, but many actions are not without considerable cost.
At each fork in the decision tree, leaders of environmental awareness, government, and energy/mineral extraction companies must review priorities, inform the public of the real cost of future objectives, and communicate sufficiently to enable truly-informed choices in the democratic process.

10. UNRESOLVED ENVIRONMENTAL ISSUES RELATED TO MINING

Reclamation of mined lands is an important part of maintaining a high-quality environment. However, mining is also connected to other environmental concerns, and future opportunities and directions will be determined in large part by how these concerns are resolved. To a considerable degree, the question is: Will increasing knowledge create increasing fear of hazards, which we then try to eliminate completely with ever-increasing regulations and protective systems, or will we try to work with nature and man-made systems to reduce hazards to lower levels while maintaining our freedom to choose from many options?

Atmospheric warming — the “Greenhouse Effect”

Carbon-dioxide is produced by combustion of hydrocarbon fuels. Some scientists and some non-scientists interpret increases in carbon-dioxide concentration in the atmosphere as a result of man’s increasing use of energy to sustain the growth of manufacturing, transportation, and consumption.

So-called “greenhouse gases,” mainly carbon-dioxide (CO₂), methane (natural gas, CH₄) and chlorofluorocarbons (CFC’s) are viewed by some as hazardous to the long-term maintenance of climates and ecosystems that humans have experienced during their relatively recent history. Despite the scientific uncertainties surrounding enhanced global warming, activists argue that very significant steps should be taken, immediately, to lower the amount of carbon dioxide and unburned hydrocarbons which enter the atmosphere.

However, much of the world’s energy supply, present and future, consists of coal, crude oil and natural gas. Enormous deposits of untapped heavy oil, oil sands, and oil shale deposits exist that might have a critical role to play in bridging any gap between our dependence upon hydrocarbon fuels and some future energy source such as nuclear fusion. There is little doubt that to maintain the basic needs of societies throughout the world, greater quantities of hydrocarbon fuels will be extracted from the earth by mining and petroleum engineering technologies, processed and burned to produce carbon dioxide.

Acid rain and acidic runoff

Sulfur is almost always present in hydrocarbon deposits, and in a wide variety of mineral and metallic deposits. The depositional environment associated with coal, crude oil and natural gas deposits was of a reducing nature, and this contributed to concentrating sulfur along with the hydrocarbon components. The same was true for phosphate rock, oil sands, oil shale and heavy oil deposits. Many important metalliferrous deposits contain sulfides of lead, zinc, copper, and iron.

Mining, metallurgical and combustion processes can recover much of the sulfur, and use it for making sulfuric acid, phosphate fertilizers and wide variety of chemicals, but inevitably, something escapes from even the finest barrier, or from an unstable mining area.
Once again, priorities must be examined closely in the light of facts. How much can society afford to pay for removing low concentrations of sulfur compounds from process effluents, or bloking them from contact with "natural" air or water streams? The answer is "something," maybe it is "a lot;" however, it is not "whatever it takes," because the latter answer implies there is no cost limit.

Metals and metal ions

Several metals and their ions have well-earned reputations as health hazards: Examples are arsenic, mercury, lead, manganese, beryllium, chromium and nickel. Great progress has been made in controlling the release of these ions (and others) into streams, oceans, the atmosphere and land surfaces. Nevertheless, any goal of zero concentration is likely to be unobtainable, even at great cost. Any portion of our "natural" environment contains some concentration of almost every element.

As science and technology advance, it is possible to more clearly recognize real and potential health hazards, and to detail real or probable ailments or deaths that might befall people who are exposed to them. Furthermore, our abilities to detect ever-lower concentrations of substances, to examine molecular patterns - to "see" atoms - are growing greater and becoming more refined every year. Our new knowledge doesn't make us more comfortable. Increasingly we are aware that we are constantly walking, breathing and sleeping in a "soup" of inorganic and organic "contaminants."

At the same time, we need to reflect on the fact that humans have survived and evolved over a long period, and our bodies' systems have learned how to cope with "tolerable" concentrations of nearly everything. In fact, some have suggested that we are the way we are, good or bad, in part because we have ingested a variety of "contaminants" over tens of thousands of years.

Once again, we need to establish or refine well-documented guidelines and objectives, and proceed to remove truly harmful substances, or to reduce truly harmful concentrations in a practical, economic manner that helps to maintain our freedom of choice.

11. CLOSING COMMENT

The writers' have observed that those proposed solutions to environmental concerns which are first prioritized by rigorous investigations, including risk assessments and economic evaluations, and then preferentially implemented to achieve the greatest measurable benefit per unit cost, usually are readily identifiable as worthwhile by all stakeholders. Such work has a high probability of being "affordable," and sometimes "profitable." The most capable, well-managed companies proceed in this manner, often well in advance of legislated requirements.

In some cases, enough facts are not available to provide a basis for the thorough analysis indicated above. Consequently, people must proceed to experiment, innovate and otherwise work towards solutions while building a database for analysis and improvement. This has often been the approach required for success in developing methods to mitigate the impact of resource extraction and processing operations. The two coal mining operations of Luscar Ltd. that are cited in the text of this paper employed experimentation and innovation to effect solutions to environmental
problems throughout their history.

However, major expenditures for environmental protection, proposed or implemented to attain long-term incremental reduction of hazards to human life and other organisms, and not supported by rigorous cost-benefit analyses, nor based on science/engineering-supportable, documented facts, are *speculation* as contrasted to *investment*. These type of expenditures are likely to create the same end result as other speculations, such as penny mining stocks, lotteries and roulette: A few people will reap large rewards, because many will pay.

12. A FEW REFERENCES


Maxey, Margaret N., *Engineering & environmentalism: Is there an ethical connection?*, The University of Texas at Austin, Austin, Texas, USA, October 1991, 17 pp. (For a copy of this paper, write to Dr. Margaret Maxey, Professor, Biomedical Engineering Program, Petroleum / CPE 3.168, The University of Texas at Austin, TX, 78712, USA.)

