TECHNICAL SUPPORT DOCUMENT FOR THE REGULATORY IMPACT ANALYSIS FOR AIR QUALITY REGULATIONS DEVELOPED BY THE NATIONAL ENVIRONMENT AND PLANNING AGENCY

Prepared for

National Environment and Planning Agency (NEPA)

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Background to Regulatory Impact Analysis Statement (RIAS)

In Jamaica, each bill that passes through parliament usually includes a separate note that describes the need for the bill and its impact. A RIAS is an expanded version of that statement. The RIAS being prepared for the Air Quality Regulations is the first such document prepared for a regulation in Jamaica.

A RIAS is a document to communicate the basis for a new regulation to be enacted by the national government. The document allows the regulator to show:

- What problem or risk exists, and why action is necessary
- Which alternatives were considered and how the regulations deal with the problem
- How stakeholders were consulted
- What costs and benefits arise from the regulation
- How the regulations will be implemented and evaluated.

A RIAS should demonstrate positive net benefits of the regulations to the country, that any adverse impacts on the capacity of the economy to generate wealth and employment are minimized and that no unnecessary regulatory burden is imposed.

The Air Quality Regulations - The Problem and Why Action is Necessary

The deterioration of air quality especially in the Kingston area and in the vicinities of industrial facilities, is evident from reduced visibility and frequent complaints about dust emissions from industrial facilities (cement, alumina, bauxite). Limited measurements of ambient air quality in urban areas have shown that dust levels (measured as total suspended particulate matter or TSP) have exceeded the National Ambient Air Quality Standard for TSP at several urban locations. More extensive measurements near bauxite and alumina plants show very few exceedances of the TSP ambient air quality standard. There are also frequent complaints about odour from sewage treatment plants, agricultural operations and alumina operations.

The main sources that contribute to poor air quality in Jamaica are emissions from industrial sources, motor vehicles and open burning of sugar cane fields, dumps and trash. The main air pollutants and their sources are listed in Table 1. The sources that contribute to emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_2) and particulate matter (PM) are shown in Figures 1, 2 and 3.

Industrial sources in 1994 accounted for 65% and 35% respectively of SO_2 and NOx emissions (see Figures 1 and 2). Electricity generation accounted for an additional 29% and 18% respectively of SO_2 and NOx. The regulations will apply to industrial sources that account for at least 94% of SO_2 emissions and 53% of NOx emissions. Preliminary estimates of PM emissions for 2000 (Figure 3) show that industrial point sources and fugitive sources in the cement industry account for up to 86% of PM emissions. PM emissions from motor vehicles and sugar cane burning account for the remaining 14%. PM emissions from fugitive sources such as burning of agricultural and yard waste and from mining, quarrying and shipping of alumina are not included in the estimate.

Between 1989 and 1999, sugar cane, cement production and petroleum refining remained relatively unchanged but alumina production increased by 61%, the amount of electricity sold increased by over 50% and the number of motor vehicles doubled. These increases mean that the amounts of air pollutants emitted will also have increased.

Further increases in population, alumina production, per capita consumption of electricity and growth in the motor vehicle fleet will cause further increases in air pollution.

Table 1 **Main Air Pollutants and Their Sources**

Pollutants	Main Sources
Particulate matter Total suspended particulate matter or TSP – commonly called dust Particulate matter with particles less than 10 x 10^{-6} m in diameter or PM_{10}	Fuel combustion (electricity, bauxite, alumina, lime processing, sugar production, manufacturing) Industrial facilities (bauxite, alumina, lime, cement plants) Fugitive dust (industrial storage piles, mining, quarrying, haul roads etc.) Open burning (sugar cane fields, trash/backyard burning, dumps sites) Roadway dust from motor vehicles and other mobile sources
Sulphur dioxide	Fuel combustion – mainly heavy fuel oil with up to 3% sulphur. Other fuels such as diesel (<0/5%) and gasoline (<).013%) have less sulphur Sulphuric acid manufacture
Nitrogen oxides	Tailpipe emissions from motor vehicle and other mobile sources, fuel combustion
Volatile organic compounds	Tailpipe and evaporative emissions from motor vehicles, petroleum storage, petroleum refining

Figure 1 **Jamaica's SO_2 Emissions (1994)**

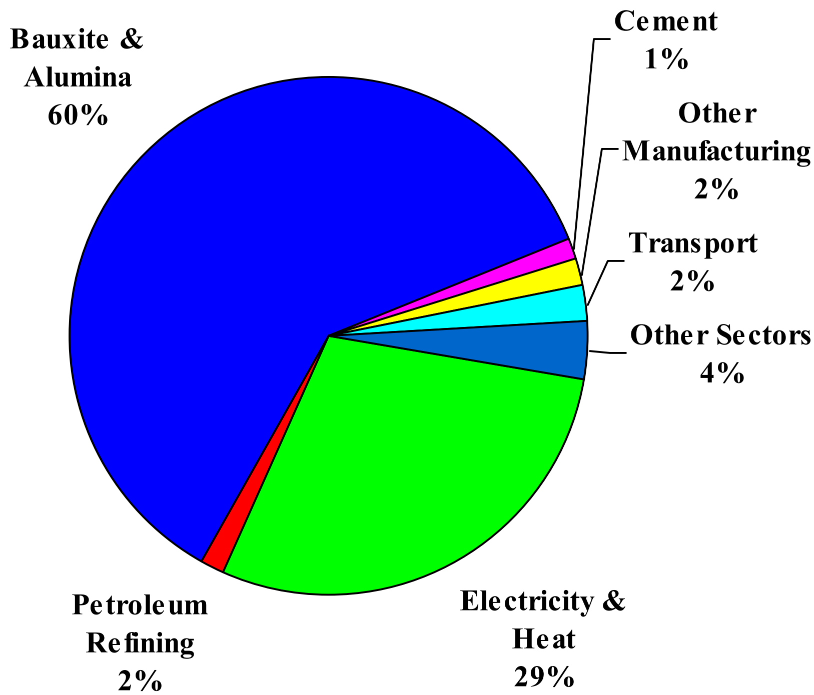


Figure 2 Jamaica's NOx Emissions (1994)

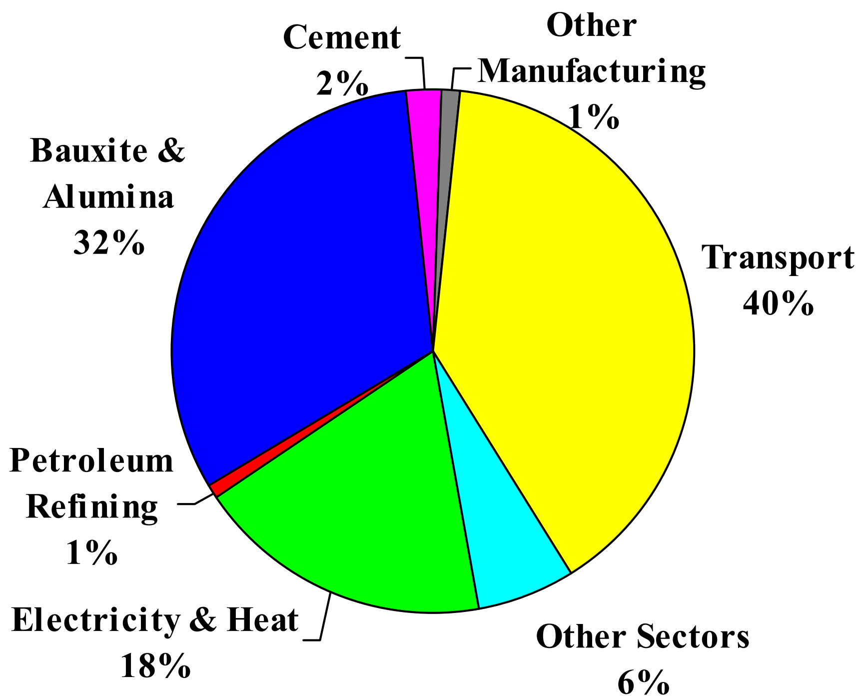
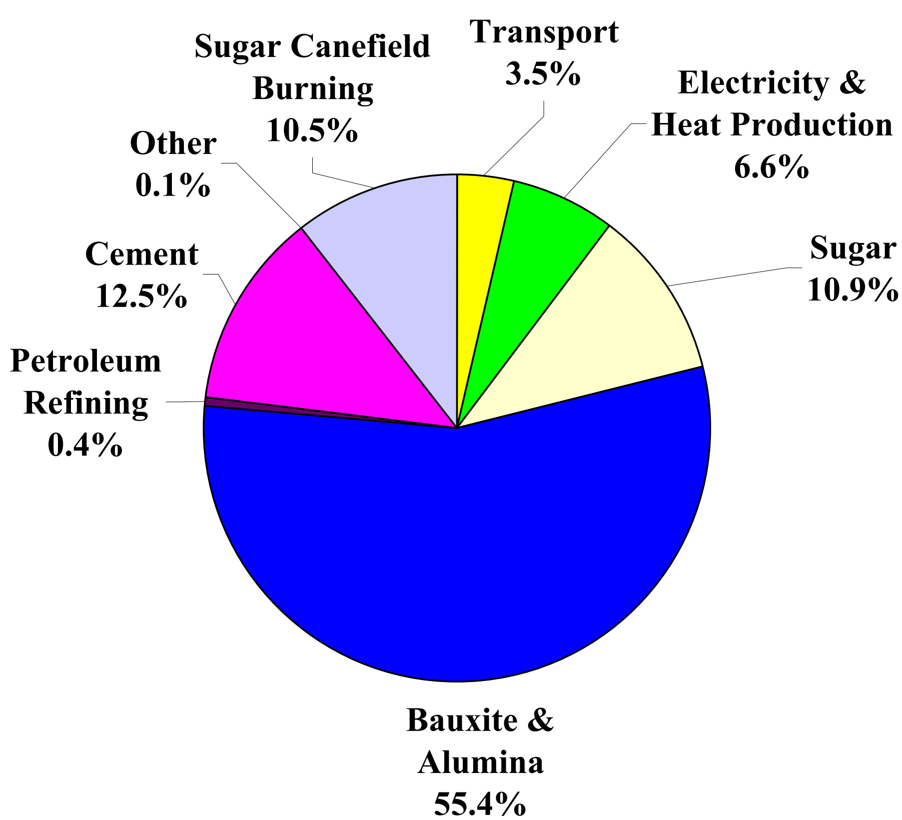


Figure 3 Jamaica's Total Particulate Matter Emissions (2000) (Preliminary)



Air pollutants have a wide range of impacts including human health effects, damage to crops and materials, reduced visibility and nuisance odours.

Health data for Jamaica show that the rate of respiratory and cardiovascular disease increased between 1996 and 1999 and decreased slightly in 2000. Some of these outcomes are attributable to air pollution. In 1996 chronic and acute respiratory care were, respectively, the sixth and ninth leading causes of discharges from public hospitals. Overall respiratory disease accounted for 11.6% of admissions (excluding obstetric admissions). Asthma, the leading cause of chronic respiratory disease, accounted for 25% of the respiratory tract infection discharges from government hospitals in 1999.

The costs for respiratory care accounted for J$177 Million or 6.3% of costs in Jamaican government hospitals in 1996. The total national costs for respiratory care in 1996 would be considerably larger since the government hospitals accounted for only an average of 36% of out-patient and doctors' visits (but ~89% of hospitalization). Cardiovascular disease and respiratory disease were respectively the fourth and sixth highest categories of government hospital care costs in 1996.

The existing regulations (the Clean Air Act of 1964 and the Public Health Act of 1985) are inadequate as legislative means to manage and control industrial sources in a manner that will address existing and future air quality issues. Other non-legislative means such as the promotion of environmental management systems, existing arrangements for environmental management for the bauxite and alumina industry lack legislative support and have not been sufficiently effective.

These regulations only address industrial sources and will complement and reinforce existing and planned non-legislative initiatives. The regulations however, provide the framework for the management of all air pollution sources. Separate measures are being developed to address motor vehicle emissions and open burning of sugar cane fields. The regulations will support and complement those measures.

Analysis of Alternatives

During the development of the regulations, the Natural Resources Conservation Authority (NRCA) as NEPA was then, did not formally analyse alternatives as would be done in a typical RIA. The RIA process only commenced towards the end of the regulation development process for these regulations. Future regulations will formally identify and analyse alternatives.

Alternatives to regulations include measures such as promotion of environmental management systems, industry-specific codes of practice or voluntary agreements and economic incentives or instruments. In most jurisdictions, such non-regulatory measures are used in addition to legislation that provides the means to integrate various measures and to provide sanctions and penalties for non-compliance. In the absence of suitable legislation, the need for the air quality regulations is self-evident.

The different approaches that can be employed in the regulations were also not formally analysed during the formal consultation process but they were addressed during the RIA.

It should be noted that the air quality regulations are based on two key principles, namely, the ***polluter pays principle*** and on the ***environmental stewardship principles***.

Under the ***Polluter Pays Principle*** the polluter pays for environmental impacts created. This principle was stated in the government's Industrial Policy and is closely related to the application of user fees whereby those who use or are beneficiaries of services or amenities pay fees for their use. The polluter pays principle is used as the most equitable means for allocating costs among licensees.

The ***Environmental Stewardship Principle*** recognises the roles and responsibilities that companies, institutions and government departments have for knowing their environmental impact, taking action to reduce these impacts and attributing accountability for reaching social, environmental and economic goals.

Description of the Regulations:

The main features of the Air Quality Regulations are as follows:

- Establish emission standards for new sources (those constructed after the regulations come into force)
- Establish emission targets for existing facilities

  New facilities must meet standards immediately. Existing facilities will be given up to seven years to meet targets or up to ten years when large capital expenditures for pollution control equipment (more than US $0.5 million) are required. NEPA, at its sole discretion, may also allow the time limits (seven or ten years as the case may be) to be exceeded.

- An air pollution discharge licensing system for "***major***" and ***"significant"*** facilities. Licences are renewable every five years

Major facilities are those that emit more than 100 tonnes/year (tonnes/y) of any one or more of the common pollutants (SO_2, NO_2, PM or carbon monoxide (CO)) or five or more tonnes/y lead; or ten or more tonnes/y of any single priority air pollutant excepting greenhouse gases; or twenty-five or more tonnes/y of any combination of priority air pollutants excepting greenhouse gases.

Significant facilities are those that emit between 25 and 100 tonnes/y of any one or more of the common pollutants or one to five or more tonnes/y lead; or one to ten or more tonnes/y of any single priority air pollutant excepting greenhouse gases; or five to twenty-five or more tonnes/y of any combination of priority air pollutants excepting greenhouse gases.

- The licensing of facilities will be phased in over two years (major facilities in 2004 and significant facilities in 2005)
- Licensed facilities will be charged an annual discharge fee of J$100/tonne for each of the common air pollutants (TSP, SO_2 and NOx) and J$200/tonne for each priority air pollutant excepting greenhouse gases) based on actual emissions.
- Require facilities to file annual reports and significant pollution related incidents
- Progressively punitive sanctions (warnings, control orders, administrative penalties, prosecution)
- Industry self monitoring with NEPA prescribing monitoring methods and protocols. NEPA will audit the facilities' monitoring activities and also has the right to conduct its own monitoring.
- NEPA is required to compile the reports each year and the Minister is required to present result in parliament at least every three years.

Consultation

Parties potentially affected by the regulations (stakeholders) were identified by NEPA. Stakeholders consisted of industrial facilities, government agencies, environmental groups, non-government organizations and academic institutions. Formal consultation with stakeholders took place between March 1998 and June 1999.

Throughout the consultation process, written answers and reasons for the answers were provided for all written comments and also to comments and questions raised at the public meetings.

A public meeting was held in November 1998 to discuss the revised draft regulations which took all comments into consideration together with answers to each comment and whether or not and if not why the comment was addressed in the revised draft.

At the end of the consultation process, three issues remained. They were: Discharge Fees / Major Modification definition / Compliance plans with respect to plant age.

During the latter part of 2001, interventions from bauxite and alumina companies and with support from the Jamaica Bauxite Institute led to the conduct of a Regulatory Impact Analysis project that was initially intended to address air quality as well as the proposed trade effluent and sewage effluent regulations. In view of the advanced state of the air quality regulations, the RIA process was eventually limited to the air quality regulations.

In May 2002, NEPA provided stakeholders with a draft of the regulations as received from the Chief Parliamentary Counsel and requested comments at the end of a 30-day review period.

Based on the responses received during the comment period, a number of changes were made to the draft regulations. These include:

- Elimination of the granting of a provisional license on application and replacing it with a full licence.
- Inclusion of “Lifetime Compliance Plan” provision for plants required to spend more than US $0.5 million for pollution control equipment.
- Modification of the existing Compliance Plan and the Lifetime Compliance Plan to extend the maximum period for compliance (7 or 10 years) at NEPA’s sole discretion.
- Removal of a requirement for facilities to provide the public with information at their sites
- Various changes to definitions and text to correct errors or to clarify the regulations
- Addition of emission targets for particulate matter from fuel combustion sources. Previously there was only a target for opacity.

Since the end of the formal consultation process in June 1999, several issues have been raised by bauxite and alumina companies and others. The main issues raised by bauxite and alumina companies are how the regulations affect competitiveness, the issue of discharge fees and grandfathering.

With regard to the competitiveness issue the following points are noted. Production costs for Jamaican alumina plants are in the second (one plant) and third quartile (three plants) of the world industry cost curve. The bauxite levy which is being eliminated, accounted for about 10% of gross earnings from bauxite and alumina between 1988 and 2001. Since production costs are calculated including the levy, its removal will effectively lower production costs.

The component production costs for alumina are typically broken down into bauxite, caustic/lime, energy, labour and other. Environmental costs would be included in the “Other” category together with a small component of the labour costs (for environmental staff). No industry-wide information on the environmental costs for the industry was available so other means were used to infer the effect of the regulations on competitiveness.

Comparisons of ambient air quality standards, stack emission limits, discharge fees, monitoring and reporting requirements in Jamaica and in other jurisdictions were made to infer the impact of the regulations on competitiveness. The comparisons show that by and large and especially for bauxite producing countries such as Australia, Canada, Ireland and U.S., the added regulatory burden will be less in Jamaica than in these countries. The discharge fees are less in Jamaica (approximately US $2/tonne compared to US $4.44 to US$32.65 for PM).

Reporting requirements (annual reporting) are similar in most countries with alumina plants. The planned introduction of a pollution register is intended to provide added impetus for companies to reduce air emissions and to demonstrate pollution prevention and energy efficiency improvement measures. Experience in other countries that have discharge fees show that best results are obtained when the discharge fees are high enough so that it is less costly to install pollution control equipment or other means to reduce emissions than to pay discharge fees. On this basis, the fees in Jamaica appear to be too low. However, payment of discharge fees together with publication of the pollution register should provide sufficient incentive for facilities to reduce emissions to meet emission targets in a timely manner.

Benefit Cost Analysis

For the first time in Jamaica, the benefits and costs for implementing regulations have been estimated. The costs and benefits are based on the requirements to meet the regulatory requirements and the associated avoided environmental and health outcomes.

Ambient environmental standards have been set to protect the general population or most receptors. The levels at which standards were set assumed that human health or environmental effects do not occur at exposures below the environmental standard. Over the past 10 to 15 years, it has become increasingly clear that contaminants such as particulate matter (PM_{10} or $PM_{2.5}$) and ozone have no threshold below which effects do not occur. Therefore, health effects occur at all concentrations above background levels. For other pollutants such as SO_2, CO and NO_2, there are quantifiable health effects at levels below the ambient standards. Understandably, at concentrations close to background levels there is more uncertainty in the relationships between the exposure and the amount of the effect.

The regulations will require licensed facilities to incur costs for the initial assessment of their facilities' emissions and impacts, staff training and for ongoing reporting. Facilities with sources that exceed emission targets may need to incur capital costs to install or repair pollution control equipment or take other steps to meet the emission targets. The capital costs for pollution control equipment and ongoing costs for ambient and stack monitoring and for maintenance of pollution control equipment are included in the costs to society. Government will also incur costs for administration and enforcement of the regulations.

The main features of the cost benefit analysis are summarized in the text box. The costs were estimated for a 30-year period starting in 1996. The start year was selected to recognise the expenditures made by companies for ambient monitoring and pollution control equipment since NRCA announced its intention (in 1996) to develop air quality regulations. The 30-year period was used because it reflects the lifetime for major capital investments.

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[1] Requests made to local bauxite and alumina companies for information on the environmental portion of the "other" component costs at Jamaican and foreign alumina plants operated by owners of Jamaican plants did not yield information in time to be included in this report.

Key Features of Benefit Costs Computations

Pollutants	Control costs for PM and volatile organic compounds (VOC). Avoided health outcomes are estimated only for PM_{10}.
Time horizon	30 years (1996-2025). Capital and ambient monitoring expenditures by industry commenced in 1996 based on notification by NRCA that regulations would follow promulgation of National Ambient Air Quality Standards (NAAQS).
Discount rate	10%.
Residual value	Capital was assumed to have no residual value in 2025.
Exposure reduction	Control measures were assumed to reduce PM_{10} exposure by at least 10 $\mu g\ m^{-3}$ based on measured ambient PM_{10} concentrations and estimates of PM emissions reductions at major facilities. PM exposure assumed to be reduced by 10% (of 10 $\mu g\ m^{-3}$) from 1997 to 2002, 20% in 2003 and increasing by 10% each year to 2011.
COSTS	Startup (assessment, screening modelling) for ~150 significant facilities and 50% (~25) of major facilities; assessment, stack testing, detailed modelling 50% (25) of major facilities).
	Incremental environmental staff and initial training for staff.
	Capital for pollution control and monitoring equipment for PM from four major facilities.
	Ambient gas monitoring equipment replaced every 10 years.
	Annual operating costs for pollution control and ambient monitoring equipment, fugitive dust control, fugitive VOC control.
	Public sector (NEPA, JBI) costs (assessment, reviews, visits to facilities, training).
	Secondary economic impacts (employment, prices) assumed negligible.
BENEFITS	Avoided total mortality and morbidity (hospital admissions and emergency room (ER) visits for respiratory tract infection (RTI) and cardiovascular disease (CV) and associated lost workdays for ER visits). Literature dose response functions and Jamaican health care statistics and costs for RTI, CV and emergency room visits for RTI.
	Avoided mortality valuation based on the value of statistical life (VSL) for U.S. multiplied by the ratio of per capita gross domestic product for Jamaica over that for the U.S. The ratio was also adjusted by an elasticity factor. The recommended VSL is the unadjusted value (US $1.96 million). The elasticity adjusted value (US $0.526 million) was used for sensitivity analysis.
	Damages for visibility not included; damages for corrosion neglected since impact due to SO_2 emissions expected to be small.
	Health care costs (for RTI and CV admissions, average national wage rates and ER visits) based on Jamaican data for 1996.

The benefits to society brought about by the regulations include:

- Public benefits (reduced health impacts, reduced material and crop damage, improved quality of life e.g., visibility, avoided cleanup and remediation costs)
- Private benefits (revenue from the recovery of materials from pollution control devices, reduced production costs and improved public relations due to better environmental performance)
- Local or regional economic activity and employment

Many of these benefits are difficult to quantify or are small and the only benefits considered were the human health benefits.

Since the benefits and costs take place at different times over the 30-year period, they are expressed as the net present value in 1996 dollars. A discount rate is used to calculate the present (1996) value. The discount rate accounts for the willingness of people to accept less money now rather than in the future.

The discount rate used in this type of analysis is not the same as is used for ordinary financial transactions. The discount rate used represents a "social interest rate" which compensates society as a whole for the foregone benefits from spending a dollar today.

The discount rate used is close to a risk free investment. Such risk free investment would be the long-term interest rate on government bonds and securities. Similar benefit cost analyses for RIAs in Canada and the U.S. used discount rates of 4% or 5%. A discount rate of 10% is used here since rates of return used for public sector funded projects and Treasury Bill rates in Jamaica are higher relative to similar rates in the U.S. As is done in similar studies, a range of rates (6% and 14%) is used to examine the sensitivity of the analysis to the discount rate.

The requirement to install pollution control devices and the incentive to pay the least amount of discharges fees will serve to reduce emissions. Reduced emissions will lead to lower ambient air quality levels. Numerous studies in different countries in the world have shown that there are quantitative relationships (dose response relationships) between ambient dust levels (measured as TSP or PM_{10}) and death due to respiratory tract infection (RTI) and cardiovascular disease (CV). Similarly, there are also quantitative relationships between PM_{10} levels and hospital admissions and emergency room visits for RTI and CV. Visits to health clinics and private doctors' offices which account for considerably more cases than admissions or emergency room visits, were not estimated since there are no suitable dose response relationships that could be used.

The number of shortened lives estimated for Jamaica compared favourably with similar data for Toronto and Jakarta when account is taken of the differences in population and the reduction in PM_{10} and mortality rates. Several factors such as accessibility to health care, cultural patterns that determine whether or not medical attention is sought etc. can account for small discrepancies but the results for the three locations appear reasonably consistent with what one may expect.

The costs for various types of medical services in Jamaica including various types of treatment in hospital, emergency room treatment and doctor's visits have been estimated for 1996. Hospital admission benefits also took into account the lost wages based on the average length of stay in hospital and the national average wage rate.

The valuation of shortened human lives avoided is more contentious. Similar RIAs done in Europe, U.S. and Canada have estimated the value of a human life for use in studies of this type. The recommended approach for developing countries is to adjust the value for a developed country, say in the U.S., by the ratio of the per capita income in the developing country and that in the U.S. On this basis, the value for a statistical life (VSL) for Jamaica is US$1.966 million based on US$5 million for the U.S. An alternate calculation uses the per capita income ratio raised to an exponent called the elasticity which is intended to account for the fact that someone's willingness to pay for better air quality is likely to be lower in a low income country, but not necessarily in proportion to one's personal spending income. This yields a lower VSL when the exponent is less than one. We also used the lower value for the VSL (US$0.526 million) with all combinations of the discount rate as part of the sensitivity analysis.

As is often the case, several health and other outcomes (e.g., private doctors' visits, soiling, corrosion, visibility reduction) were not considered and thus benefits are underestimated.

The comparison of benefits and costs is shown in Table 2. Since local labour costs (e.g., for assessments and additional staff) are low relative to that for capital equipment, the costs are dominated by the capital costs for pollution control and monitoring equipment. Capital equipment and maintenance costs are determined by U.S. or other external market prices. Typically, the capital costs in Jamaica are even higher than they would be in countries where the capital goods are produced because of additional transportation costs for example.

Table 3 Summary Comparison of Costs and Benefits (US $ million 1996$)

Discount Rate	10%
COSTS	152.66
BENEFITS	768.24
NET BENEFITS	615.58
Benefit/Cost Ratio	5.0

For a discount rate of 10% and the VSL of US $1.966 million, the benefits will be five times greater than the costs. The benefit to cost ratio (3.5) is still favourable at a discount rate of 14%. The benefits and costs are similar (benefit cost ratio of 0.96) only when the discount rate is 14% and the VSL is US $0.526 million.

Benefits are dominated by the valuation for mortality as determined by the value of a statistical life (VSL). Since the VSL for Jamaica is adjusted downwards by the relative purchasing power, the "devalued" benefits will be stacked against costs that are the same if not higher than they would be in a developed country. These factors effectively skew the costs to higher values and the benefits to lower values in developing countries. Together these factors will make it much more difficult for a regulatory measure to show a positive net of benefits over costs.

Implementation and Evaluation

To ensure a minimum impact on the economic base of affected companies, the regulations will be phased in first for major facilities and afterwards for significant facilities. Since the smaller industrial facilities (the so called significant facilities) will fall under the regulations two years after promulgation it will allow time for facilities to gear up to meet the largely reporting requirements in the regulations. This will allow time for NEPA and government agencies to build capacity (additional staff and training of staff) and be better able to implement and enforce the regulations.

Although the air quality regulations only directly manage and control industrial sources, the regulations provide the basis for NEPA to compile information on all types of sources and to track the progress and effectiveness of these and other regulations and policies.

The regulations require NEPA to compile and report periodically on the emissions (an emissions inventory). The regulations also will allow Jamaica to fulfill some of its international obligations since it has signed conventions such as the climate change and persistent organic pollutant conventions.

Implications for Jamaica of RIA Process and Next Steps

Although the RIA process started near the end of the regulation development process, it clarified the basis for environmental policies, benchmarked the technical standards and clarified administrative issues faced by industry and NEPA. The data gathered in the process can be applied to future regulations and will improve the capacity of NEPA to develop regulations in consultation with stakeholders. The project has allowed NEPA to modify its regulation development processes to include cost benefit analysis, formal examination of alternatives and to increase consultations (for example by including a 30 day comment period on the drafting instructions). These processes will be applied in the Sewage Effluent Regulations and the Trade Effluent Regulations. A RIA Manual is being prepared to guide the conduct of these and future RIA activities.

1 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to provide technical details and supporting information for the Regulatory Impact Analysis Statement (RIAS) for the Air Quality Regulations developed by the National Environment and Planning Agency (NEPA).

1.2 BACKGROUND

The Air Quality Regulations have been in development since 1996 when National Ambient Air Quality Standards (NAAQS) were gazetted. Formal consultation with stakeholders about the air quality regulations started in March 1998. By June 1999, the consultation process yielded four regulations. NEPA (formerly the Natural Resources Conservation Authority (NRCA)) also documented the consultation process, determined public sector costs and resource needs and developed a framework to monitor and measure the effectiveness of the air quality regulations[1]. The previous documentation:

- had limited information on problem identification and formal characterization of the problem;
- did not include any formal analysis of alternatives to regulations nor of how regulations may affect industrial competitiveness, and;
- did not include costs to industry and societal benefits.

The Regulatory Impact Analysis (RIA) project was the result of interventions by the bauxite and alumina industry. These interventions sought to influence the final air quality, trade effluent and sewage effluent regulations, to scrutinize the principles upon which these regulations are based and to present alternatives.

The RIA project started in January 2002 - towards the end of the regulatory development process for air quality regulations. Since the air quality regulations were in advanced stages (i.e., regulations were at the drafting stage with Chief Parliamentary Counsel in January 2002) while the sewage effluent regulations were entering the consultation phase and the trade effluent regulations had not yet been drafted, the focus of the current RIA is on the air quality regulations. It should also be noted that trade effluent standards and national ambient water quality standards were prepared (but not promulgated) in 1995 and that sewage effluent standards are incorporated into the sewage effluent regulations.

The Environmental Action Program (ENACT) contracted Claude Davis & Associates and Kaizen Training and Management Consultants Ltd. to conduct the project. The RIA project was conducted in two phases. Phase I entailed meetings and discussions with the bauxite and alumina sector and Phase 2 addressed the remaining sectors. The Terms of Reference are given in Appendix 1 but it must be noted that the tasks actually performed deviated considerably from the work statement. The most significant deviation was to focus exclusively on the air quality regulations. Therefore, the report contains few references to the trade effluent and sewage effluent regulations. The deviations were documented in minutes of various meetings held during the project.

The key objectives of the project are to:

- Apply, as far as practicable, a RIA process to any outstanding elements in the development of three regulations: draft air quality, sewage effluent and trade effluent regulations. The project was limited to the air quality regulations and was conducted in two phases. The first phase was limited to the bauxite and alumina companies and second phase addressed facilities in other sectors.
- Address outstanding issues regarding the proposed air quality regulations and draft ambient water quality and draft trade effluent standards.

- Provide a RIA manual that includes a "primer" with descriptions of principles, strategies and approaches typically used in the regulations and which would guide NEPA in developing future regulations. The manual and primer will also inform the discussion on the philosophical (principles and strategies employed) and some technical issues in the air quality regulations especially where there are substantive concerns about the content or process used in developing the regulations.
- Promote the use of the RIA manual and primer as a template for NEPA in developing future regulations.

Some of these outstanding elements and analyses in the RIA process are addressed in this report to the extent feasible, given limitations in resources and time and the fact that the RIA process started nearly four years after the stakeholder consultation process began. The outstanding steps that are addressed are:

- Provide additional information on problem identification/characterisation
- Enhance the benefit cost analysis to include both public and private sector costs and societal benefits
- Include a discussion on the potential impact of the regulations on industrial competitiveness
- Discuss some of the principles and issues raised by industry and provide alternative approaches for consideration in modifying the regulations

The RIA process also allowed further discussion of issues that were unresolved after the consultation process and entertained new issues raised. The documented product of the RIA process, the RIAS, is intended to provide relevant information to support decisions taken in the regulation. It is also used as a communication tool to inform decision makers, stakeholders and the public.

All of the steps in a typical RIA were included in the RIA for the air quality regulations. The reader must always bear in mind that since the RIA for the air quality regulations started towards the end of the regulation development process, some of the steps and analyses were done retrospectively and out of logical sequence (see the following section for a description of a RIA). Because of this, the sequence of steps used in the RIA for the Air Quality Regulations must NOT be used as a precedent or example in developing future regulations. It should be noted also that many of the steps in the RIA process are included in the regulatory development process used in the Ministry of Land and Environment[2].

1.3 WHAT IS REGULATORY IMPACT ANALYSIS (RIA)?

Since the RIA process is relatively new to Jamaica, a brief description is presented here. Regulatory impact analysis (RIA) is one of the tools that governments in some developed countries use for regulatory reform and development. The RIA process forces regulators to think in a structured way before they act and increases the accountability of regulatory departments.

The RIA is the process or series of steps taken in developing regulations according to a predetermined framework established for the RIA process. The RIAS is the document that describes the process followed in the RIA.

The key steps in the RIA are:

- definition and characterisation of the problem and its risks;
- analysing alternatives to determine if a regulation is the most appropriate course of action;
- consultation with stakeholders;
- benefit cost and competitiveness analyses;
- determination of the government's resource needs for implementation; and

- ***although not typically required for RIAs, we recommend including a discussion on mechanisms for assessment of the effectiveness of the regulation.***

The framework requires regulators to show that:

- a problem or risk exists;
- government intervention is justified;
- regulation is the best alternative;
- stakeholders are consulted and have an opportunity to participate in developing or modifying regulations and regulatory programs;
- the benefits outweigh the costs to citizens, their governments and businesses;
- adverse impacts on the capacity of the economy to generate wealth and employment are minimized and no unnecessary regulatory burden is imposed; and
- regulatory authorities ensure that:
    - information and administrative requirements are limited to what is absolutely necessary;
    - the special circumstances of small businesses are addressed;
    - parties proposing equivalent means to conform with regulatory requirements are given positive consideration;
    - full advantage is taken of opportunities for coordination with other levels of government and with government agencies; and
    - systems are in place to manage regulatory resources effectively. In particular, regulatory authorities must ensure that:
        - compliance and enforcement policies are articulated, as appropriate; and
        - resources have been approved and are adequate to discharge enforcement responsibilities effectively and to ensure compliance where the regulation binds government.

The RIAS summarizes the basic information required by the government or its authorised agent (e.g., ministers) to reach a decision on proposed regulations. It also provides the public with information on regulatory proposals. The RIAS is typically published to give the public additional opportunity to make final comments about specific aspects of the regulations. The comments are also taken into account in the decision.

The RIAS in various countries have prescribed formats and content. The Canadian Federal Government's RIAS for example is designed to have six sections as follows:

1. ***Description -*** outlines the regulations, defines the problem and shows why action is necessary.
2. ***Alternatives -*** lists options besides regulation and other types of regulation.
3. ***Benefits and Costs -*** quantifies the impact.
4. ***Consultation -*** shows who was conferred with and the results.
5. ***Compliance and Enforcement -*** explains the policy on conforming to the regulations and tools to ensure it is respected.
6. ***Contact Person -*** the individual best able to answer questions from RIAS readers.

The writing of the formal RIAS occurs toward the end of the regulation-making process when most of the evaluation should have already been completed. In some cases, such as budgetary regulations, the requirements stipulate (for obvious reasons) that the RIAS must be done after the regulations are enacted.

1.3.1 Which Jurisdictions Use RIA’s?

Jurisdictions that use RIAS are largely limited to Federal governments in Canada, United States (U.S.), Australia and various levels of governments in the Canada, U.S., United Kingdom and other Organisation for Economic Cooperation and Development (OECD) countries. The Ontario Provincial Government conducts an equivalent analysis called the Less Paper/More Jobs Test and some provincial governments in Australia also conduct RIAs. Several states in the U.S. (e.g., Louisiana) require RIA.

Examples of Guidance Documents that describe the procedures for some of these jurisdictions are available and are described in Appendix 2.

1.3.2 What Has Been the Experience in Using RIA’s?

Despite shortcomings in nearly all regulatory impact analyses, anecdotal evidence indicates that RIA has:

- helped develop short-lists of preferred policy tools;
- identified design changes that were built into regulations;
- identified instances in which more stringent standards would yield higher net benefits;
- raised enough warning signs that some regulations have been sent back for further analysis and verification; and
- helped overcome industry opposition to the proposal by allaying fears of adverse impacts.

1.4 OUTLINE OF THIS REPORT

This report provides the following:

- An overview of the existing processes for developing regulations in NEPA and the Ministry of Land and Environment and a retrospective analysis of alternatives to the air quality regulations (Section 2);
- A brief retrospective analysis of alternatives (Section 3);
- A summary of the main features of the air quality regulations (Section 4);
- Problem definition – sources, available air quality data and information, indicators of air pollution impacts, prognosis (section 5);
- A summary of some of the relevant principles used in the air quality regulations (Section 6);
- Benefit cost analysis (Section 7);
- A summary of the consultation process focussing on concerns raised in the consultation process and an analysis of the how the regulations may affect industrial competitiveness (Section 8); and
- A summary of compliance, enforcement issues and means to evaluate the effectiveness of the regulations (Section 9).

2. JAMAICA'S REGULATORY DEVELOPMENT PROCESS

There are existing policies, directives, processes and customs together with institutional arrangements that guide the development and enactment of legislation in Jamaica. The legislation development process, which requires parliamentary approval, involves similar steps as indicated in the 1974 directive (Circular 4, File #626/07) from the Deputy Prime Minister and Minister of Finance.

The enactment of regulations under specific acts such as the Natural Resources Conservation Act, do not require parliamentary approval but require Ministerial and Cabinet approval once there are appropriate provisions in the specific acts.

In the case of the Ministry of Land and Environment (MLE) under which NEPA falls, MLE's priorities and NEPA's corporate plans determine the context in which regulations are developed. These priorities and plans define the *status quo* in terms of which regulations are developed and how these regulations are developed. The priorities are expressed as needed in the legislative agenda for the Ministry and become part of the national legislative agenda. It should be noted however that the legislative agenda focuses on activities which require parliamentary approval.

2.1 THE REGULATION DEVELOPMENT PROCESS

The process for the development of regulations under the NRCA and other Acts is outlined in a Ministry of Land and Environment Directive which is summarised in Table 2-1.

The regulations and other instruments that NEPA plans to develop are usually well documented and are included in NEPA's corporate plan. When regulations are required the involvement of Chief Parliamentary Counsel (CPC) will be necessary and we recommend that NEPA through MLE develop a regulatory agenda (distinct from the ministry's or the national legislative agenda) that will help to streamline and coordinate the development of regulations (requiring Ministerial approval).

2.1.1 Current Status of Various Regulations Relevant to Air Quality, Trade Effluent and Sewage Effluent Regulations

The process that NEPA follows to develop regulations is as follows. The description will include reference to other regulations to provide the reader with a better idea of the context within which the air quality regulations have been developed.

The Interagency Environmental Standards Technical Committee was established in 1991 to develop environmental standards. Two sub-committees, the Air Quality Standards Subcommittee and the Water Quality Standards Subcommittee, were set up to develop respectively air quality and water quality standards and regulations. To date, these subcommittees have developed national standards for Ambient Air Quality, Trade Effluent, Ambient Water Quality and Sewage Effluent. National ambient air quality standards were gazetted in 1996 as the *Natural Resources Conservation (Ambient Air Quality Standards) Regulations, 1996.*[3] When air quality standards were gazetted, the Natural Resources Conservation Authority (NRCA) indicated that air quality regulations would be developed and a stakeholder consultation process was initiated in March 1998. Draft stack emission standards were also developed in 1997 and were provided to stakeholders for review. The draft stack emission standards have been incorporated in the draft air quality regulations. Stakeholders were intimately involved in formal, extensive consultation that influenced the development of the draft air quality regulations between March 1998 and June 1999. Additional discussions on the air quality regulations have taken place since June 1999 and include discussions during the RIA project.

Table 2-1 Preparation of Regulations under Natural Resources Conservation Authority (NRCA) and Other Acts

Steps to be Taken	Responsibility and How Step is Done
1. Schedule of regulations to be prepared (a) Regulations referred to in the Act (b) Regulations to address a specific need (e.g. to implement an international convention)	NRCA/Ministry An annual list of proposed Regulations and time table to be sent to the Authority and the Minister for review
2. Proposed schedule to be discussed with the Office of the Parliamentary Counsel (OPC)	Ministry/NRCA Discussion with OPC
3. Drafting instructions to be developed according to priority list (a) technical matters requiring the development of standards, guidelines (b) administrative / non-technical regulations	NRCA NRCA to consult with experts, NGOs relevant agencies; Ministry to collaborate with NRCA, obtain similar legislation from other countries, etc. The consultation process may involve meetings with various Government and non-governmental agencies; consideration by the legal subcommittee of the NRCA and other technical subcommittee of the Authority
4. Drafting instructions to be issued to (a) Office of the Parliamentary Counsel (b) lawyer contracted privately (with the approval of Parliamentary Counsel)	 The Ministry: It is preferred that the OPC prepares the regulations. The drafting of regulations by lawyers not trained in legal drafting can delay the process NRCA through the Ministry. The draft and drafting instructions must be sent to OPC.
5. Preparation of Draft Regulations	OPC and sent to the Ministry
6. Comments on draft regulations to be obtained from a) Relevant government organizations b) NGOs c) Relevant professional organizations	NRCA or Ministry may collate and review comments Legal Sub-Committee to consider draft regulations Ministry to examine draft
7. If amendments to the draft are proposed, further drafting instructions to be issued to the OPC	Ministry to refer proposed amendments to Minister and to CPC with further instructions
8. Final draft to be approved, the Authority informed and the regulations gazetted	Ministry to get regulations approved and signed by the Minister and sent for printing to Jamaica Printing Services
9. The printed regulations to be circulated widely	Ministry/NRCA to ensure that the relevant agencies, NGOs, persons are informed of the regulations

A document titled "National Trade Effluent Standards" has been circulated to stakeholders since 1995. The process for developing standards and regulations was outlined in the document and to date there has been no formal public consultation. Draft Trade Effluent Regulations are being developed and NEPA will undertake stakeholder consultation when the draft is completed. Stakeholder comments have been invited on the Ambient Water Quality Standards for Jamaica since 1998. It should be noted that the bauxite and alumina industry have concerns about the ambient water quality and trade effluent standards but such concerns should be addressed separately and are not discussed further in this report.

The draft sewage effluent standards have been circulated since 1999 and draft regulations for sewage effluent have been prepared. As of April 2002, the draft Sewage Effluent Regulations is currently available to stakeholders and the formal consultation process is under way.

2.1.2 Implications of the Current Status of Regulations for Regulatory Impact Analysis

In view of the varying stages of development of these regulations, it was agreed to separate the RIA project into three components that would provide separate regulatory impact analyses for each of the three regulations. In each case it is feasible only to apply RIA process (as may be deemed appropriate for Jamaica) only to those stages of regulation development that remain to be completed.

The separation of the project will allow attention to be focussed on the most advanced regulations - the draft air quality regulations. One of the outputs of the RIA for the air quality regulations is a manual or primer that would include a general discussion on principles and strategies that can be used in developing regulations and recommendations for a RIA template. This template would be used by NEPA (and potentially other agencies) in developing regulations. The manual is provided as a separate internal NEPA document.

3. RETROSPECTIVE ANALYSIS OF ALTERNATIVES

This section provides a retrospective analysis of alternatives to regulations. It is based on an examination of current air quality management legislative and non-legislative instruments that are available or are employed by NEPA.

Governments use a mix of strategies such as regulations, guidelines, promotion or acquiescence to voluntary agreements or self regulation, administrative procedures, judicial precedents, standards, policy statements, etc. for environmental protection. The desired environmental protection – e.g., to improve or protect air quality by reducing air pollutant emissions - may be required to correct an existing problem or to prevent a future one from arising or worsening because of existing or future activities.

In the case of the protection of air quality, the strategies invariably consist of one or more of:

- setting ambient air quality standards and/or discharge/emission limits;
- monitoring emissions and ambient air quality;
- applying implementation incentives and/or sanctions (i.e., prosecutions, fines, user charges, discharge fees, subsidies and other forms of financial assistance to offset compliance costs) that will induce facilities to comply with standards and other requirements;
- promotion and encouragement of voluntary and self regulatory measures such as Codes of Practice, industry-specific agreements, promotion of environmental management systems; and
- legal instruments that codify the strategies (e.g., methods to monitor, verify and report), and specify rights and obligations of various stakeholders.

The strategies may also include research and the promotion of research to develop pollution prevention and abatement technologies.

It is important to note that the above strategies are not exclusive alternatives. Jurisdictions invariably use several of the strategies for environmental protection. Regardless of the mix of strategies, in the case of air quality, the desired environmental effect is invariably based on achieving an ambient environmental "quality" or "standard" or a certain level of emissions. The emissions level or emission limit may be facility- or source-specific or it may entail setting a desired level of reduction in emissions for an entire country or region of a country. Both types of standard setting have limitations.

It was previously noted that NEPA did not undertake a formal analysis of alternatives that led to a decision that regulations are needed. In the absence of suitable legislation it was the obvious course of action and the decision will be taken as given and justified without further analysis.

Since the strategy in the current case entails the development of regulations (which are taken as given) it is instructive to state the legislative basis for the regulations and to determine the extent to which the proposed regulations overlap with existing legislation and regulations.

The NRCA Act of 1991 provides a comprehensive legislative basis for the management, conservation and protection of Jamaica's natural resources. The Act includes provisions for the Minister to make regulations that (among other things) establish standards and codes of practice; specify the concentrations, amounts or conditions of substances that may be released into the environment; and the fees payable in relation to the discharge of waste. To date, the Permits and Licences Regulations (1996) and the Ambient Air Quality Standards Regulations (1996) have been promulgated as regulations under the NRCA Act.

Other Jamaican Acts and/or their associated regulations that are relevant to air quality management are the:

- Clean Air Act of 1964;
- Public Health Act of 1985;
- Petroleum Quality Act of 1990 and the Petroleum Quality Regulations of 1999;
- Country Fires Act of 1955 (amended); and
- Fire Brigade Act.

The provisions of the Clean Air Act include the requirement that owners allow access by inspectors to their premises and to use the best practicable means to prevent the escape of noxious or offensive gases or to render such releases harmless or inoffensive. These provisions (developed in 1964) are not appropriate and are inadequate in today's technological and industrial environment given current knowledge of the effects of air pollutants, available pollution prevention and pollution control technology and practices in several jurisdictions.

The Public Health (Nuisance) regulations of 1995 made under the Public Health Act include "dust, smoke, fumes, gases or effluvia" among the nuisances that persons are prohibited from causing or permitted to be caused. The regulations also empower a Medical Officer (Health), a public inspector or person authorised by the Minister (of Health) to require owners to abate the nuisance "within a reasonable time not being more than three days as may be specified in the notice". These regulations are inadequate in today's industrial environment and although odour is not specifically mentioned, it is likely that it could be included as a nuisance.

The Country Fires Act of 1995 has a provision that allows the Minister (of Agriculture) to prohibit setting of fire to any trash in any part of the island without a permit. The only crop allowed to be burned is sugar cane (with a permit). The act does not apply to the urban and suburban districts of the Corporate Area and to towns or districts subject to the Fire Brigade Act. In principle, such prohibition (of trash burning) and abandoning the practice of burning sugar cane fields before harvesting would together with the air quality regulations address the control of nearly all of the man made air emissions of particulate matter.

Other policies and initiatives that are currently in use or planned to be used by NEPA are:

- Use of Section 17 of the NRCA Act to collect information
- A Memorandum of Understanding between NRCA and the Jamaica Bauxite Institute (JBI) in which NRCA delegated responsibility to the JBI for the environmental management of the bauxite/alumina industry
- Development of Environmental Codes of Practice
- A Green Paper on a National Policy and Strategy on Environmental Management Systems
- Public reporting using a Pollutant Release and Transfer Register

The use of Section 17 only provides for the collection of information about environmental releases (including but not limited to air releases) from industrial facilities but it does not indicate how facilities should improve performance or specify what level of performance is required. The current reporting provisions are inadequate as indicated in a recent report on a pilot Pollutant Release and Transfer Register for Jamaica[4]. NEPA has signalled its intent to phase out the use of Section 17 reporting by facilities that are required to have air pollutant discharge, trade effluent and sewage effluent licences, once the air quality and other regulations are enacted.

The *Permits and Licences Regulations* are applicable only to new projects at existing or new facilities and do not address existing facilities that do not undertake a new project such as an expansion. These regulations do not provide guidance (e.g. monitoring methods) as to how permit or licence conditions should be met. The system is being used in the interim to specify some (but not all) of the operating and reporting conditions and requirements that are envisioned in the air pollutant discharge licences.

In the 1994 Memorandum of Understanding (MOU) between NRCA and the Jamaica Bauxite Institute (JBI), NRCA delegated to the JBI responsibility for environmental management of the bauxite and alumina industry and mitigation of the industry's environmental impact. NRCA however, has overall ultimate legislative authority. The MOU addresses only the bauxite and alumina sector. There are no similar MOUs or arrangements for other sectors such as the cement and lime industry, electricity generation, sugar industry and the manufacturing sector. While the NRCA/JBI MOU provides a framework for environmental management in the industry there are no supporting regulations or documented protocols for monitoring and reporting nor are there legally binding sanctions. The performance and or effectiveness of the MOU should be reviewed and assessed in light of the new regime that will apply when the air quality regulations are promulgated.

The National Policy and Strategy on Environmental Management Systems (EMS)[5] is an important initiative that articulates government's commitment and policy framework for sustainable development. The policy goals include strengthening the legal and economic framework to facilitate promotion and implementation of EMS's. NEPA wants to encourage voluntary compliance with environmental standards by promoting the establishment of environmental management systems by private sector and government entities. In addition NEPA is promoting other initiatives that will enhance and promote sustainable development. All strategies are being considered and used to further encourage compliance.

Together, these instruments are not sufficient for responsible and adequate air quality management hence air quality regulations are required. The use of air quality regulations is typical in jurisdictions that also have a similar mix of instruments and therefore Jamaica's decision to implement regulations will be consistent with established practice. The provisions in the air quality regulations are described in Section 4.

4. FEATURES OF THE AIR QUALITY REGULATIONS

In order to allow informed discussion on the issues that remained unresolved after the consultation process and to provide the bases for discussion of benefit cost analysis, the main features of the air quality regulations are summarised below. The regulations:

- Employ the "polluter pays principle" in the discharges of air pollutants to induce licensees to minimize their emissions.
- Establish incentives for industries or facilities to use renewable fuels (bagasse, landfill gas, energy recovery from municipal waste) by waiving discharge fees for emissions from such fuels.
- Specify monitoring methods but with flexibility to use alternate methods that are demonstrated to be equivalent or better and allow for new methods as they become available.
- Make provisions for warnings, Control Orders, Administrative Penalties, revisions or addenda to licences, termination of licences, denial of a licence renewal and prosecution for offences.
- Establish an air pollution discharge licensing system.
- Establish stack emission standards for new sources and stack emission targets for existing sources and limits on the sulphur content of fuel in order to control releases from point sources.
- Make provisions for existing facilities to develop compliance plans subject to agency approval.
- Complement existing ambient air quality standards for common air contaminants by defining and specifying ambient guideline concentrations for the most toxic and potentially harmful air contaminants.
- Include measures to address the problems of odour and fugitive dust.
- Specify the air quality assessment requirements (monitoring, dispersion modeling, reporting) for environmental impact assessments and applications for air pollution discharge licences.

The air quality regulations provide the legislative basis for the National Environment and Planning Agency (NEPA) to effectively manage air quality in Jamaica.

5. JAMAICAN CONTEXT AND STATEMENT OF THE PROBLEM - WHY ACTION IS NECESSARY

5.1 JAMAICAN CONTEXT

Jamaica is an island with a delicate and intricate ecosystem. It is highly dependent on tourism, which can generate release to the environment and is itself susceptible to adverse environmental impacts from their own and others' releases. Preservation of the environment is not only an economic issue but an imperative that will ensure sustainable development and preservation of an acceptable quality of life for every citizen of Jamaica whether in rural or urban areas. Notwithstanding the necessity to protect the environment, the principles that guide environmental actions in developed countries have to be adapted with due consideration to the limitations that exist in under-developed economies like Jamaica's. It is critical to establish and maintain an appropriate balance between use of resources by industries that have the potential to harm the environment and the profitable and sustained use of natural resources by both industries and the Jamaican people. Such a balance requires a framework in which all stakeholders can take appropriate actions (monitoring, pollution prevention and control, reporting, participating in decision making etc.) based on reliable information.

5.2 WHY ACTION IS NECESSARY

The "problem" that requires air quality regulations can be summarised as follows and are elaborated following the summary:

- There are currently no effective legislative means to manage industrial air pollution sources nor is there a framework with procedures and protocols for ambient or source monitoring and reporting.
- The main pollutants of concern are suspended particulate matter (total or smaller size fractions – PM_{10} and $PM_{2.5}$), sulphur dioxide and nitrogen oxides.
- The limited ambient air quality measurements show exceedances of the national ambient air quality standards for total suspended particulate matter in some urban areas and in the vicinities of some industrial sources.
- There have been several complaints about air pollution (about dusting from some industrial facilities and odours from various industrial and waste water treatment facilities, motor vehicle exhaust). The complaints documented by NEPA have increased in the past 3 years.
- Ambient air quality modelling of sulphur dioxide released from some existing electric utility and industrial facilities predict that the NAAQS would be exceeded
- The tracking of greenhouse gas (GHGs) emissions is important since it will facilitate Jamaica benefiting from international trading in carbon dioxide emissions and will satisfy local objectives (optimal use of renewable energy sources) and international obligations (reporting emissions to the United Nations Framework Convention on Climate Change (UNFCCC).
- Although there are no reliable data for releases from the largest industrial sources in the Kingston area (cement plant, petroleum refinery, power stations) particulate releases from these and other sources contribute to poor visibility that is observed in the Kingston area.
- Over the past 10 years the number of motor vehicles has increased by 126%. This remarkable increase will contribute to increased releases of nitrogen oxides (NOx), volatile organic compounds (VOCs) and particulate matter and hence to noticeable deterioration in air quality especially in the Greater Kingston Metropolitan area

- The main health effects of air pollution are respiratory and cardiovascular disease. Table 5-1 lists the World Health Organisation (WHO) Guideline concentrations for classical air pollutants. Epidemiological data for Jamaica show that there has been an increase in the rate of respiratory and cardiovascular morbidity and mortality between 1996 and 2000. Some of these outcomes are likely attributable to air pollution.
- In 1996 chronic and acute respiratory care were, respectively, the sixth and ninth leading causes of discharges from public hospitals; overall respiratory disease accounted for 11.6% of admissions (excluding obstetric admissions)[6]. Asthma, the leading cause of chronic respiratory disease, accounted for 25% of the RTI discharges from government hospitals in 1999. The costs for respiratory care accounted for J$177 Million or 6.3% of costs in Jamaican government hospitals. The total national costs for respiratory care will be considerably larger since the government hospitals account for only an average of 36% of out-patient and doctors' visits (but ~89% of hospitalization). Air pollution will account for a portion of these costs.
- Air pollutants (sulphur dioxide and particulate matter) cause corrosion to building materials and soiling of personal property and can cause damage to crops. Residents in the vicinities of some industrial sources (bauxite and alumina plants, cement and sulphuric acid manufacture) have claimed they have been affected by such impacts.
- Open burning of yard wastes, sugar cane fields and dump sites has adversely affected visibility and contributed to complaints of soiling of property.

Although the air quality regulations do not address all of the potential sources of the problem (the control of motor vehicle emissions and open burning are the areas not addressed), they do provide a comprehensive and complete context for characterising the extent of all air quality issues and require NEPA to report on the relative contribution of **all** air pollution sources.

5.3 AIR POLLUTION SOURCES IN JAMAICA

The main air pollution sources in Jamaica are summarized in Table 5-2. The most recent year for which data are available[7] is 1994. This points to the urgent need for the ability to compile emission inventories in a timely manner.

Industrial sources in 1994 accounted for 65% and 35% respectively of SO_2 and NOx emissions[7] (see Figures 5-1 to 5-2). Electricity generation accounted for an additional 29% and 18% respectively of SO_2 and NOx. The regulations therefore will address up to 94% of SO_2 emissions and 53% of NOx emissions. The air quality regulations do not address motor vehicle emissions but they do establish the framework for assessments of the emissions and for tracking the absolute and relative contributions of all air pollutant emissions. Other instruments that are not under NEPA's jurisdiction (i.e., motor vehicle emission inspection and maintenance that would include tailpipe tests and limits) will be used to control motor vehicle emissions.

Published data for particulate emissions are not available. Since PM is the pollutant of major concern it is useful to estimate "how much of the PM problem" is addressed by the regulations (see Figure 5-3).

Data collected during this study show that preliminary estimates of PM emissions from major industrial facilities (point sources at bauxite, alumina, lime, cement and electricity generation facilities and sugar factories and fugitive sources at the cement plant) are ~42,300 tonnes in 2000. PM emissions from fugitive sources at mining, quarrying and other large industrial facilities other than the cement plant and from smaller facilities are not included in the estimate.

Table 5-1 WHO guideline values for the "classical" air pollutants (WHO 1999a)

Compound	Annual Ambient Air Concentration [μg/m^3]	Health Endpoint	Observed Effect Level [μg/m^3]	Uncertainty Factor	Guideline Value [μg/m^3]	Averaging Time
Carbon monoxide	500-7000	Critical level of COHb < 2.5%	n.a	n.a.	100 000 60 000 30 000 10 000	15 minutes 30 minutes 1 hour 8 hours
Lead	0.01-2	Critical level of Pb in blood < 100-150 μg Pb/l	n.a.	n.a.	0.5	1 year
Nitrogen dioxide	10-150	Slight changes in lung function in asthmatics	365-565	0.5	200 40	1 hour 1 year
Ozone	10-100	Respiratory function responses	n.a.	n.a.	120	8 hours
Sulphur dioxide	5-400	Changes in lung function in asthmatics Exacerbations of respiratory symptoms in sensitive individuals	1000 250 100	2 2 2	500 125 50	10 minutes 24 hours 1 year

n.a. Not applicable

Table 5-2 Estimates of Pollutant Emissions (ktonne) in Jamaica (1994)[7]

GREENHOUSE GAS SOURCE CATEGORIES	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
Total Energy	**8182**	**0.67**	**0.113**	**30.90**	**173**	**29.10**	**98.90**
Fuel Combustion Activities (Sectoral Approach)	8182	0.67	0.113	30.90	173	27.40	98.90
Energy Industries	*2245*	*0.09*	*0.02*	*5.94*	*0.45*	*0.15*	*30.10*
Public Electricity and Heat Production	2141	0.09	0.02	5.66	0.43	0.14	28.50
Petroleum Refining	105	0.00	0.00	0.28	0.02	0.00	1.62
Manufacturing Industries & Construction	*4111*	*0.12*	*0.03*	*10.80*	*0.70*	*0.29*	*63.00*
Bauxite	3749	0.10	0.03	9.81	0.49	0.25	60.10
Cement	235	0.00	0.00	0.69	0.19	0.032	1.42
Other Manufacturing	127	0.02	0.00	0.34	0.02	0.00	1.52
Transport	*1257*	*0.39*	*0.01*	*12.20*	*106*	*20*	*2.10*
Civil Aviation	7.89	0.12	0.00	0.00	0.011	0.00	0.01
Road Transportation	1208	0.00	0.01	11.30	105.90	19.90	1.65
Railways	0.10	0.28	0.00	0.00	0.00	0.000	0.000
Navigation	41.20	0.00	0.00	0.83	0.55	0.11	0.44
Other Sectors	*586*	*0.07*	*0.05*	*1.91*	*65.70*	*6.97*	*3.58*
Commercial/Institutional	119	0.00	0.00	0.16	0.03	0.00	0.81
Residential	316	0.02	0.02	0.96	26.90	2.30	0.68
Agriculture/Forestry/Fishing	151	0.05	0.03	0.79	38.80	4.66	2.10
Fugitive Emissions from Fuels	0.00	0.02	0.00	0.04	0.06	1.63	0.61
Oil and Natural Gas	0.00	0.02	0.00	0.04	0.06	1.63	0.61
Oil	0.00	0.02	0.00	0.04	0.06	1.63	0.61
Total Industrial Processes	**379**	**0.00**	**0.00**	**0.00**	**0.00**	**5.84**	**0.24**
Mineral Products	*379*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Cement Production	226	0.00	0.00	0.00	0.00	0.00	0.00
Lime Production	153	0.00	0.00	0.00	0.00	0.00	0.00
Glass Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical Industry	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.24*
Sulphuric Acid	0.00	0.00	0.00	0.00	0.00	0.00	0.24
Total Other Production	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*5.83*	*0.00*
Food and Drink	0.00	0.00	0.00	0.00	0.00	5.83	0.00

Figure 5-1 Jamaica's SO_2 Emissions (1994)

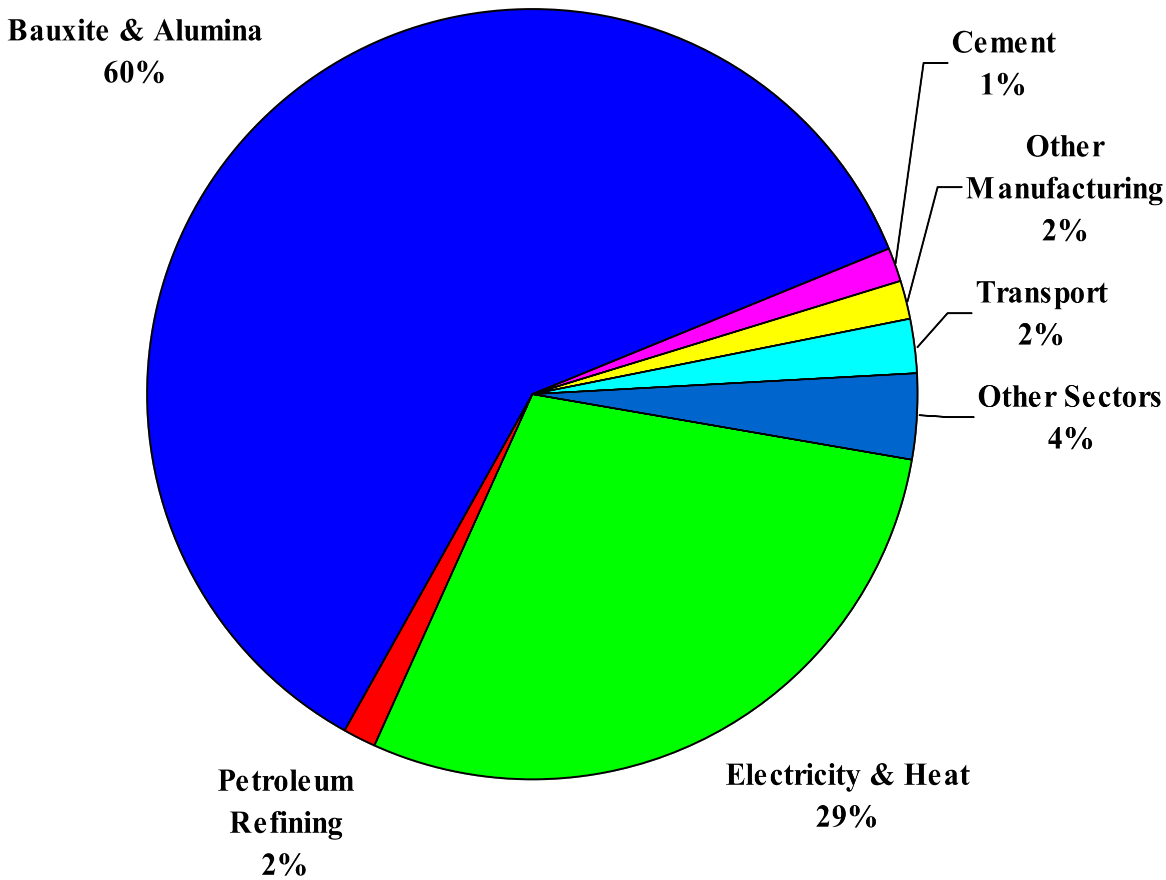


Figure 5-2 Jamaica's NOx Emissions (1994)

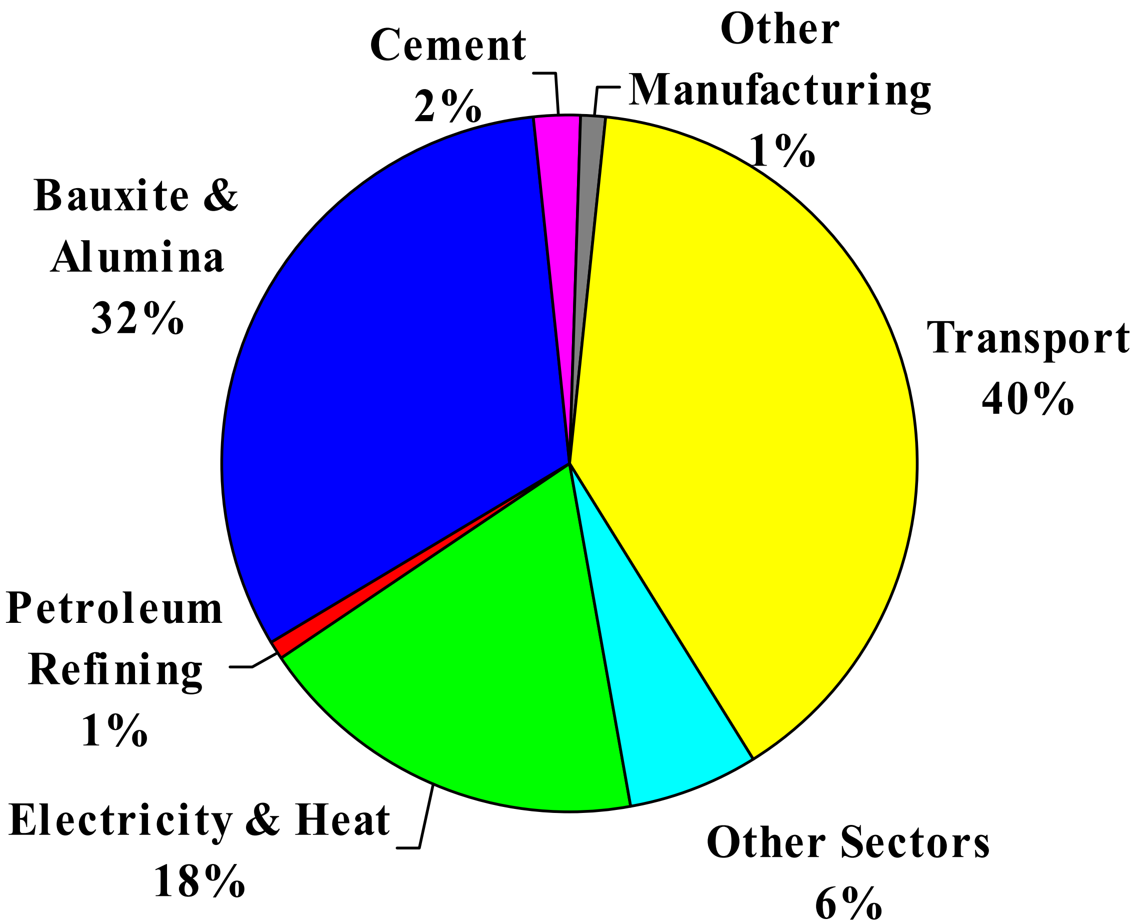
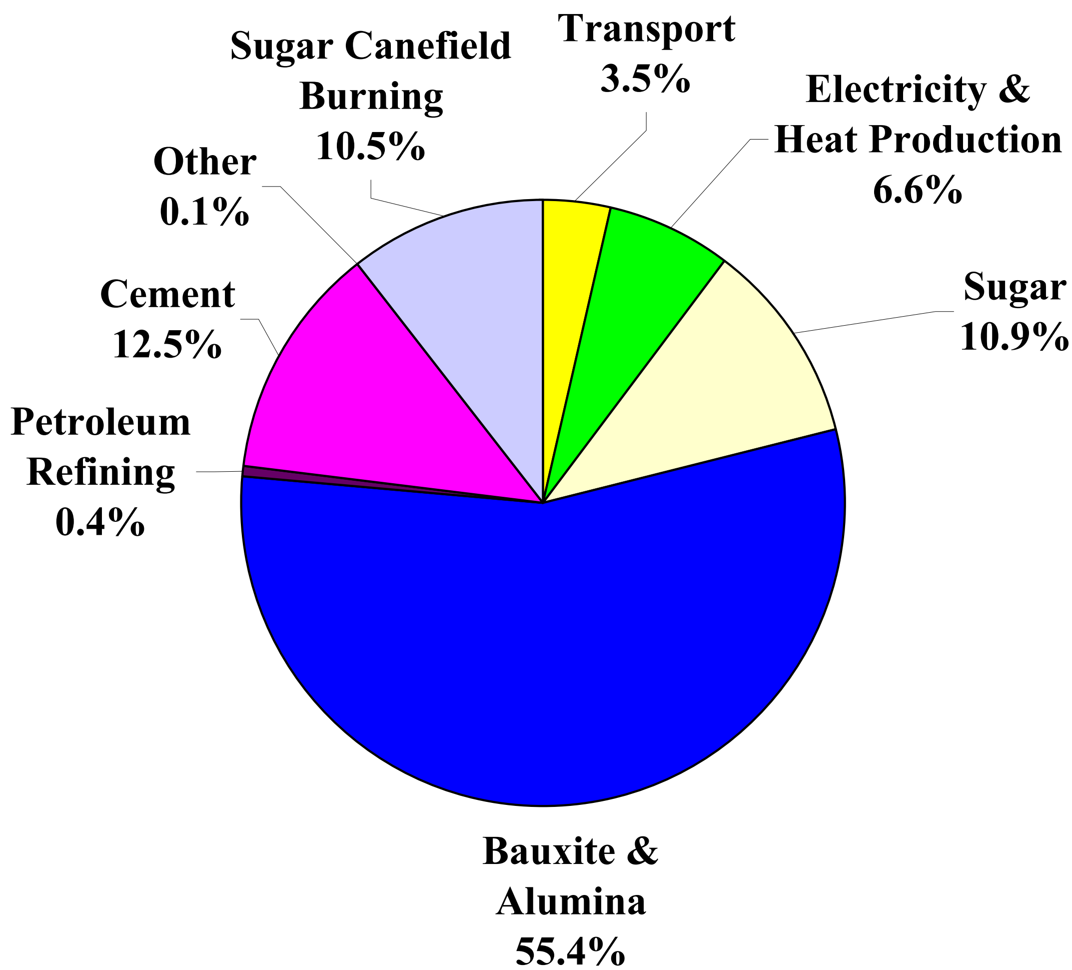


Figure 5-3 Preliminary Estimate of Jamaica's PM Emissions in 2000



PM emissions from the open burning of sugar cane fields are approximately 4,500 tonne/y. This estimate is based on emission factors for sugar cane burning[8] and conservatively (to obtain the highest estimate) assumes that all of the sugar cane crop (~40,000 hectares) is burnt before harvesting.

PM emissions from motor vehicles (exhaust, brake and tyre wear and road dust) were estimated at 790 tonnes in 1993[9] and could be double that or ~1,600 tonnes in 2000.

Mining activities and agricultural operations and the burning of dumpsites and household/yard waste are also potential sources of fugitive PM emissions. Mining and other non-combustion PM sources typically have particle sizes that are larger than those from combustion related sources. The effects of fugitive dust from the fugitive sources will occur over a smaller area than those from combustion related sources which emit smaller particles which can be dispersed over a wider area.

The conversion of the Riverton City dumpsite to a managed landfill facility has dramatically reduced open burning at the site. PM emissions from fires at the Riverton City site can now be neglected. The amount of yard waste that is burned is difficult to determine and hence PM emissions from this source are difficult to estimate. As the collection of garbage and yard waste improves the amount of open burning of yard waste should decrease.

The air quality regulations will apply to facilities that account for at least 85% of man-made PM emissions (i.e., all sources in Figure 5-3 except motor vehicles and cane field burning). It should be noted that this percentage does not account for emissions from the burning of household/yard waste, wind blown dust from agricultural operations and fugitive emissions from mining and other industrial sources other than the cement plant.

5.3.1 Available Ambient Air Quality Measurements

The limited air quality information available for Jamaica indicates the following:

> Measurements of total suspended particulate matter (3 times per week for one month at each of 23 sites) in Jamaica exceeded the national ambient air quality standard (NAAQS) for the 24-h average concentration (150 $\mu g/m^3$) at two sites[10]. The mean total suspended particulate (TSP) levels at the stations ranged from 15 to 114 $\mu g\ m^{-3}$ with a maximum station mean of 114 $\mu g\ m^{-3}$.
>
> In another study[11], the maximum reported PM_{10} levels exceeded the NAAQS 24-h average concentration (110 $\mu g/m^3$) at 9 of 19 monitoring locations even though measurements were made over a very limited period (daily measurements over different 10 to 14 day periods). The daily average PM_{10} concentrations ranged from 30 to 106 $\mu g\ m^{-3}$ with a mean value (all data) of 69 $\mu g\ m^{-3}$.
>
> Bauxite and alumina companies have measured ambient concentrations of TSP, PM_{10}, dustfall, sulphur dioxide, nitrogen dioxide, carbon monoxide and ozone at locations in the vicinities of bauxite and alumina plants since about 1994. The number of monitoring stations and period over which data are available are listed in Table 5-3. Between 1994 and 2001, the numbers of exceedances of NAAQS were as follows:

NO_2	0	
PM_{10}	0	
SO_2	1	
TSP	85	[53 of these exceedances occurred at one station]

> The dustfall measurements when compared with WHO guidelines for dustfall show that 56% of the measurements exceeded the guideline.

Table 5-3 Summary of the Numbers of Ambient Monitoring Stations Near Bauxite and Alumina Facilities: 1994 to 2001

Pollutant	Company/Area	Number of Stations							
		1994	1995	1996	1997	1998	1999	2000	2001
CO	Alpart	1	1	1	1	1	1	1	1
	Ewarton								1
	Kirkvine								1
Dustfall	Alpart Essex Valley			20	10	8	8	8	
	Alpart Manchester Plateau			18	10	10	9	9	
	Ewarton			32	19	20	18	18	18
	Jamalco			7	8				
	KJBC			12	17	17	14	16	17
	KJBC Mines			5	16	14	16	10	9
	Kirkvine			32	22	20	21	21	13
	Kirkvine Mines			14	14	13	14	14	6
	Port Esquivel			0	5	5	5	5	5
NO_2	Alpart	1	1	1	2	2	2	2	2
	Ewarton								1
	Kirkvine								2
NOx	Alpart				2	2	2	2	2
Opacity	Ewarton			5	5	5	5	5	5
	Kirkvine			5	5	5	5	5	5
Ozone	Ewarton								1
	Alpart	1	1	1	1	1	1	1	1
	Kirkvine								1
PM_{10}	Alpart	1	1	2	2	2	2	5	5
	Ewarton						1	3	3
	KJBC							1	1
	Kirkvine							2	3
SO_2	Alpart	1	1	1	2	2	2	2	2
	Ewarton			2	2	2	2	2	2
	Jamalco	2	2						2
	Kirkvine								2
TSP	Alpart	2	2	3	4	7	7	7	7
	Ewarton							3	3
	Jamalco	4	4	7	7	7	7	7	7
	KJBC					3	3	3	3
	Kirkvine							2	3

Measurements of TSP in the vicinity of the one plant's facilities (plant, mines and port) show distinct downward trends in the annual average concentrations from up to 92 $\mu g\ m^{-3}$ to between 6 and 22 $\mu g\ m^{-3}$. Annual average TSP levels at other facilities show little trends and generally range from 31 to 85 $\mu g\ m^{-3}$ with one station at a port with a relatively high concentration (154 – 165 $\mu g\ m^{-3}$). The current (2001) TSP levels at one plant (6 – 21 $\mu g\ m^{-3}$) are between 18 and 70 $\mu g\ m^{-3}$ lower than in 1996. They are also 20 to 40 $\mu g\ m^{-3}$ lower than those at other alumina plants (42-67 $\mu g\ m^{-3}$). TSP levels in 1996 (or the year closest to 1996) at three different bauxite and alumina facilities ranged from 25 to 70 $\mu g\ m^{-3}$, 57 to 85 $\mu g\ m^{-3}$ (1997 data); and 43 to 64 $\mu g\ m^{-3}$ (1997 data).

The (limited) air quality data show that annual average TSP levels in Jamaica range from 6 to 114 $\mu g\ m^{-3}$ with higher concentrations in urban areas. The majority of TSP concentrations in the vicinity of bauxite and alumina companies (6 to 85 $\mu g\ m^{-3}$) are in the middle to third quartile of the range of concentrations. The high values at a port facility are excluded.

Other indicators of ambient air quality are complaint data. Between 1997 and 1999, 72 of the 136 complaints (53%) received and documented by NEPA were concerned with air quality. The majority of complaints about air quality were about odours from a variety of sources (sewage treatment plants and other industrial facilities. None of the complaints documented by NEPA during this period were concerned with bauxite and alumina plants. One bauxite and alumina facility reported over 50 complaints about excessive dust levels in 2000. There have been periodic complaints about SO_2 and odour from the mud lake, sulphide rail cars and from the plant.

5.3.2 Available Source Measurements

Opacity measurements have been made and reported on a routine basis for a number of years by one bauxite and alumina company. Measurement of opacity in stack emissions using a visual observation method at these two alumina plants show that opacity limits proposed in the regulations were exceeded in 46% of the measurements.

Since the introduction of the Permit and Licence Regulations, source measurements have been required (for new facilities only) as conditions of such licences. Alumina plants have conducted some emission tests at their facilities – some more often than others. Jamaica Public Service Company (JPSCo) have recently made measurements of most of their stacks prompted by the development of the regulations.

The stack measurements required as conditions of licences at electric power generating facilities have been in compliance with licence conditions. Emission from some alumina kilns exceed the emission targets for particulate matter.

The lack of routinely measured and reported stack emissions, especially of particulate matter at major facilities, is a critical shortcoming of the present situation which the regulations need to address.

5.3.3 Dispersion Modelling Studies

Dispersion modelling studies can be used for estimating changes in ambient concentrations when emissions change (all other things being equal). Dispersion modelling studies at bauxite and alumina plants have been made by bauxite and alumina companies. These include studies for the Alpart plant (1991 report), Ewarton (1999 report) and the Jamalco and Kirkvine plants. The 1991 Alpart study was based on on-site surface meteorological data but upper air data were not coincident. The other two studies were based on surface meteorological data for Norman Manley International Airport. Since the terrain in the vicinity of these plants is complex it is essential that on-site data be used. All bauxite and alumina companies now have on-site surface meteorological stations.

The Alpart study was used to determine the optimum location of ambient monitoring stations. The Jamalco report was for assessment in connection with the construction of a temporary stack. The

Kirkvine report was used to indicate changes in SO_2 concentrations when stack heights were changed while the Ewarton study was for general air quality assessment.

It was hoped that the modelling studies together with changes in emissions that result from installation of pollution control equipment since 1996 could be used to provide definitive estimates of the resultant changes in ambient concentrations as emissions change. The information from these reports are of limited value for this study since there are few reliable emission rates for particulate matter that could be used to estimate changes in ambient concentrations. Reliable information is lacking on the changes in emissions that would result from installation of particulate matter pollution control devices. This lack of information impinges directly on the benefit cost analysis as the costs of pollution control devices is normally expected to have quantifiable resultant benefits in terms of reduction of emissions.

There are few detailed dispersion modelling studies of other Jamaican airsheds that take into account all or most of the sources in the airshed. A study of the Hunts Bay power station[12] showed that ambient SO_2 concentrations for the existing sources (at that time) were predicted to exceed the 24-h average NAAQS and would also exceed the 1-h average NAAQS. Model predictions for the Kingston airshed[13] provided extensive information on all sources in the Kingston airshed but predictions focussed on the oil refinery. The model results showed predicted exceedances of the 1-h average NAAQS for SO_2 and NO_2 in the vicinities of the oil refinery and power station.

5.3.4 Health Related Impacts

Relationships between air pollution and health effects are well established. Since the main health outcomes related to air pollution are respiratory and cardiovascular disease it is instructive to present available information on these health outcomes in Jamaica.

Health related statistics compiled by the Ministry of Health include data on the number and diagnosed causes of death (mortality) or illness (morbidity) for patients in public hospitals and clinics. Similar data for privately provided health care are not available. Between 1996 and 2000, Government health care facilities accounted for an average of 89% of the hospital admissions (in-patient care) and only 36% of the outpatient visits[14].

5.3.4.1 Mortality Data

Data for 1990 and 1996 to 1999 (Table 5-4) show an increasing trend in the mortality rate due to respiratory tract infections for government hospitals. The rate decreased in 2000. Deaths in hospitals account for 36% to 41% of registered deaths in Jamaica and acute and chronic respiratory tract deaths were respectively the 9th and 10th leading causes of deaths in Jamaican hospitals in 1998.

Mortality data (for patients in government hospitals) for 1992 to 1995 are available but did not include all hospitals: data from Victoria Jubilee Hospital were included in 1993 to 1995 and from Bellevue and the National Chest Hospitals were added in 1995. Data from the University of the West Indies (UWI) hospital were included as of 1996. Furthermore, the cause of death can be determined in an average of 65% of cases. For these reasons hospital mortality data for 1990 to 1995 may be low and/or unreliable.

5.3.4.2 Morbidity Data – Outpatient Care

Visits to public primary health care facilities decreased from 1990 to 1994 and then increased to 1999 and decreased in 2000 relative to 1999 (see Table 5-5). The decreasing trend probably reflects the increased availability and use of private outpatient medical care – or that there are fewer persons reporting illness and seeking care. Visits by patients diagnosed with respiratory tract infection (RTI) increased steadily from 1995 to 1999 and decreased marginally in 2000. When visits for pregnancy and dressings are excluded, RTI ranked second in all years except in 2000 when it was the leading cause of visits. It must be noted that care at private hospitals are excluded from the estimation of health benefits.

Table 5-4 Mortality Data for Patients in Jamaican Public Hospitals[15]

Year	Population*	All Deaths	Rate/10,000 All Deaths		Rate/10,000 due to RTI
1990[16]	2,378,100	4,424	18.6		1.10
1991	2,398,800				1.2
1992	2,423,700				NA
1993	2,445,900				0.9
1994	2,472,960				0.8
1995	2,502,030				0.9
1996	2,527,453	6,078	15.1		1.64
1997	2,553,102	6,229	15.1		1.70
1998	2,576,256	6,187	16.3		1.90
1999	2,588,928	6,372	19.3		2.20
2000#	2,605,787	6,446	17.6		1.90

Preliminary data
* Population data from Economic and Social Survey Jamaica 2000 and 1996.

Table 5-5 Major Causes of Curative Visits to Primary Health Care Facilities*

Year	Total Curative visits	Hypertension	Rate/10,000#	Respiratory Tract Infections (RTI)	Rate/10,000#
1990	1,040,192	135,630 (1)	570.3	79,324 (2)	333.6
1991	1,040,553	131,380 (1)	547.7	81,052 (2)	337.9
1992	1,005,126	120,581 (1)	497.5	68,820 (2)	283.9
1993	900,044	111,806 (1)	457.1	65,489 (2)	267.8
1994	743,495	111,037 (1)	449.0	62,795 (2)	253.9
1995	780,520	112,001 (1)	447.6	82,863 (2)	331.2
1996	809,824	123,090 (1)	487.0	89,733 (2)	355.0
1997	831,527	136,488 (1)	534.6	99,831 (2)	391.0
1998	899,287	142,147 (1)	551.8	109,533 (2)	425.2
1999	883,904	148,202 (1)	572.4	117,275 (2)	453.0
2000	738,311	106,601 (2)	409.1	116,900 (1)	448.6

#Based on population data in Table 5-4.
* Ministry of Health Jamaica Annual Report 2000 (Table 35) for 1996 to 2000 and ESSJ publications 1994 and 1996 Table 22.5
Values in parentheses are ranks excluding dressings

Emergency room visits between 1999 and 2000 (see Table 5-6) show that respiratory disease (asthma, upper respiratory tract infection (URTI) and lower respiratory tract infection (LRTI) account for 11.7% of emergency room visits. Visits for asthma increased consistently between 1996 and 2000.

5.3.4.3 Morbidity Data - In Patient Care

Hospital admissions (in-patient care) between 1990 and 2000 are summarised in Table 5-7. Data for 1990 to 1995 are incomplete since not all hospitals were included in the reporting as noted previously for mortality data. Hospital admissions for respiratory tract diseases (first listed diagnoses) increased between 1996 and 1999 with relatively sharp increases from 1997 to 1998. The rate per 10,000 for RTI decreased slightly in 2000 relative to 1999.

5.3.4.4 Public Sector Health Care Costs

Respiratory tract infection and cardiovascular disease remain major causes of morbidity and mortality in Jamaica. Costs for providing hospital care for RTI in 1996 was estimated at J$176.8 million or 6.5% of the <u>hospital</u> based care costs[17] and costs for cardiovascular <u>hospital</u> care adds another J$218 million (see Table 5-8). When the costs for visits to government <u>clinics</u> are included the total RTI costs in 1996 are closer to $J213 million. Costs for visits to private health care facilities would add another J$107 million – assuming similar proportions of RTI visits as in government hospitals and using costs for private doctors visits[18]. Of all categories of hospital care (including psychiatric, accidents and injuries and obstetrics), cardiovascular disease and respiratory disease were respectively the fourth and sixth highest categories of government hospital care costs in 1996[17].

Only a small percentage of the respiratory and cardiovascular illnesses and associated costs are due to air pollution and the estimates of these costs will be provided in the benefit cost section of this report.

Table 5-6 Respiratory Tract Infection Emergency Room Visits

Year	A&E Visits	Asthma	URTI*	LRTI*	Total RTI	%RTI
1996	546,933	29,021	NA	NA	-	
1997	598,004	25,957	NA	NA	-	
1998	634,792	25,000	NA	NA	-	
1999	654,746	37,133	27,223	12,117	76,473	11.7
2000	643,101	40,237	24,834	9,887	74,958	11.7

URTI Upper respiratory tract infection; LRTI Lower respiratory tract infection.
NA – URTI and LRTI data were not collected before 1999.

Table 5-7 Inpatients Discharged from Public Hospitals and Rates per 10,000 Population

Year	Population	All Discharges	All Discharges Rate/10,000	Diseases of the Circulatory System	ALOS (days)	Respiratory Disease Discharges Rate/10,000	ALOS
1990	2,378,100	114,475	409.8	31.3		31.6	
1991	2,398,800	137,155	571.8	24.4		28.3	
1992	2,423,700	129,581	534.6				
1993 (a)	2,445,900	134,726	550.8	25.4		21.2	
1994	2,472,900	127,573	515.9	42.6		43.4	
1995	2,503,300	142,077	567.8	40.2		36.5	
1996	2,527,453	145,656	468.8	27.8	9.6	32.3	6.1
1997	2,553,102	153,101	474.7	28.3	10.6	32.5	6.8
1998	2,576,256	158,851	514.8	35.2	8.5	36.3	5.3
1999	2,588,928	163,714	558.5	40.8	7.8	43.9	4.9
2000	2,605,787	173,700	555.6	35.8	13.0	42.8	7.2

ALOS Average Length of Stay
Health data for 1996 to 2000 from Ministry of Health Jamaica Annual Report 2000 Appendix XXVI. Data for 1990 to 1995 from annual MOH reports
Population data from ESSJ 2000

Table 5-8 Public Sector Health Care Costs 1996

Item	**J$million**	**% of National Budget**	**% of MOH Budget**	**% of Hospital Based Care Costs**
National Budget	65,097	100		
Ministry of Health Budget (recurrent)	5,468	8.40	100	
Hospital Based Care	2,739	4.21	50.1	100
Respiratory Hospital Care	177	0.27	3.2	6.5
Cardiovascular Hospital Care	218	0.33	4.0	1.9

5.4 EXPECTED EVOLUTION OF THE POLLUTION PROBLEM OVER TIME

Population growth, greater per capita use of electricity and industrial expansion will result in increases in fuel consumption, the motor vehicle fleet and non-fuel related air pollutant emissions. Increased fuel consumption for the motor vehicle fleet, domestic cooking, electricity generation and industrial use will result in increases in emissions of carbon, nitrogen and sulphur oxides, volatile organic compounds (VOCs) and particulate matter (PM). Complementary control measures (e.g., motor vehicle emission standards, inspection and maintenance programs and associated enforcement programs) to the air quality regulations are needed to address the increases of emissions from motor vehicles.

There are limited data on the historical changes in air pollutant emissions (a deficiency that the air quality regulations will resolve). Instead it is instructive to look at the changes in fuel consumption and the motor vehicle fleet as indicative of changes in air pollutant releases. Figure 5-4 shows a plot of gasoline consumption and the number of vehicles passing certificates of fitness (excluding trailers) from 1988 to 2000. There was a rapid increase in the number of vehicles. Between 1988 and 2000, the motor vehicle fleet and the gasoline consumption increased by factors of about 2.5 (see Figure 5-4). It has been noted[21,22] that the reported number of vehicles passing fitness tests underestimates the on-road fleet by approximately 20%. Continued increases in the motor vehicle fleet will have significant impact on NOx, CO, PM and VOC emissions in motor vehicle exhaust and on PM emissions from road entrained dust.

The consumption of imported fuels between 1990 and 2000 increased by 34% (see Figure 5-5). The largest average percentage increases in consumption between 1990 and 2000 were for transportation (205%), electricity generation (32%), cooking and lighting (16%) and bauxite and alumina processing (24%).

Estimates of projected primary energy supplies (which include wood/charcoal, hydro, bagasse, biogas and proposed wind energy) for the period 1994 to 2030 were made for a base case, moderate and aggressive growth scenarios and are presented in Figures 5-6 to 5-8[23]. The base case assumed 2% gross domestic product (GDP) growth, and bauxite and alumina production remaining flat after 2001 at 4 million tonnes/y each. The moderate growth scenario assumed a GDP growth rate of 4% and an increase of 1.5 million tonnes in alumina production between 2003 and 2015 relative to the base case. The aggressive growth scenario assumed a 6% GDP growth rate, a 1-million tonne/y increase in alumina production in 2015 beyond that in the moderate growth scenario, *natural gas used for 50% of alumina industry's kiln and boiler energy needs as of 2015* and Petrojam Refinery expansion from 35,000 bpd to 50,000 bpd and includes a petroleum coke plant. The coke plant would provide fuel for an associated 120 MW power station. The scenarios include increasing use of coal which, at the time the report was prepared, was the fuel of choice for the majority of new electricity generating capacity.

The increases in fuel oil consumption under all scenarios will translate into an increasing trend in air pollutant emissions but because of the mix of fuels and end uses, the increases in air emissions will not be proportional to fuel use. In the absence of limiting emissions from new sources and taking measures to reduce emissions from existing sources, the increased fuel consumption and industrial expansion would clearly worsen air quality.

Figure 5-4 Jamaica's Motor Vehicle Fleet and Gasoline Consumption: 1988 – 2000

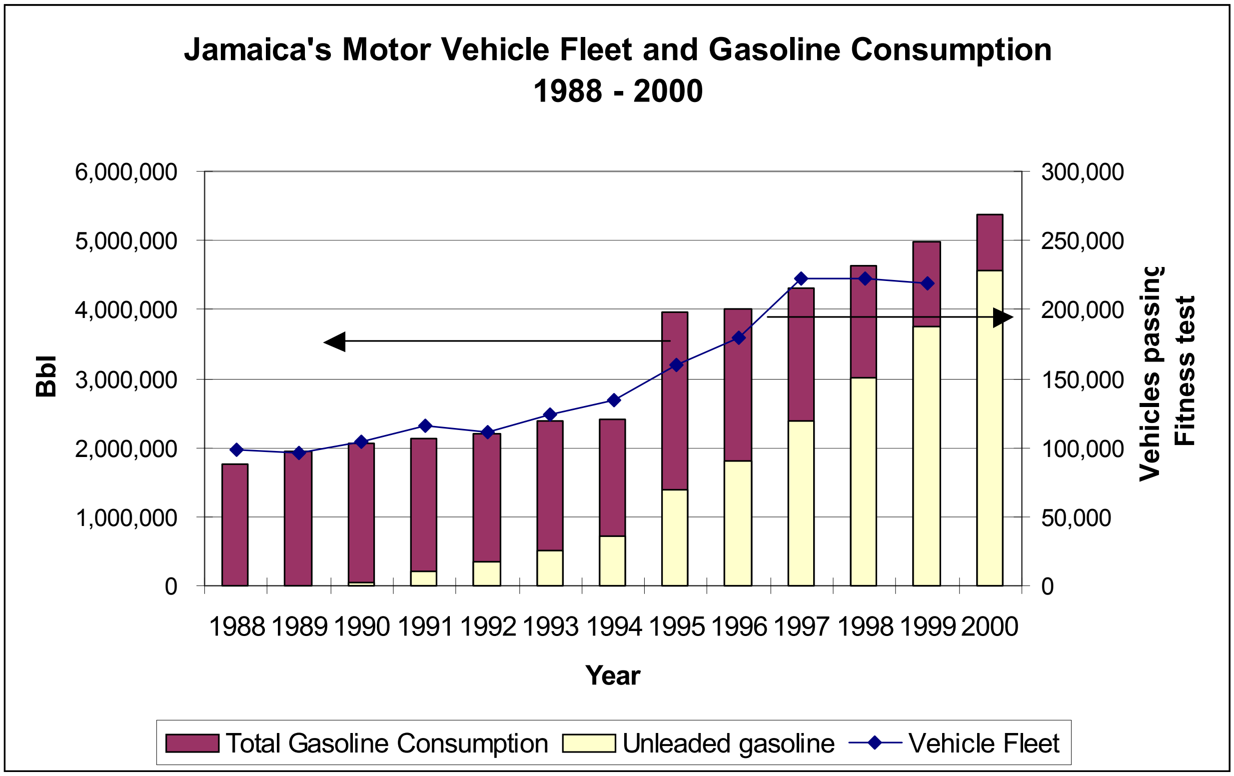


Figure 5-5 Jamaica's Fuel Oil Consumption By End Use: 1990 to 2000

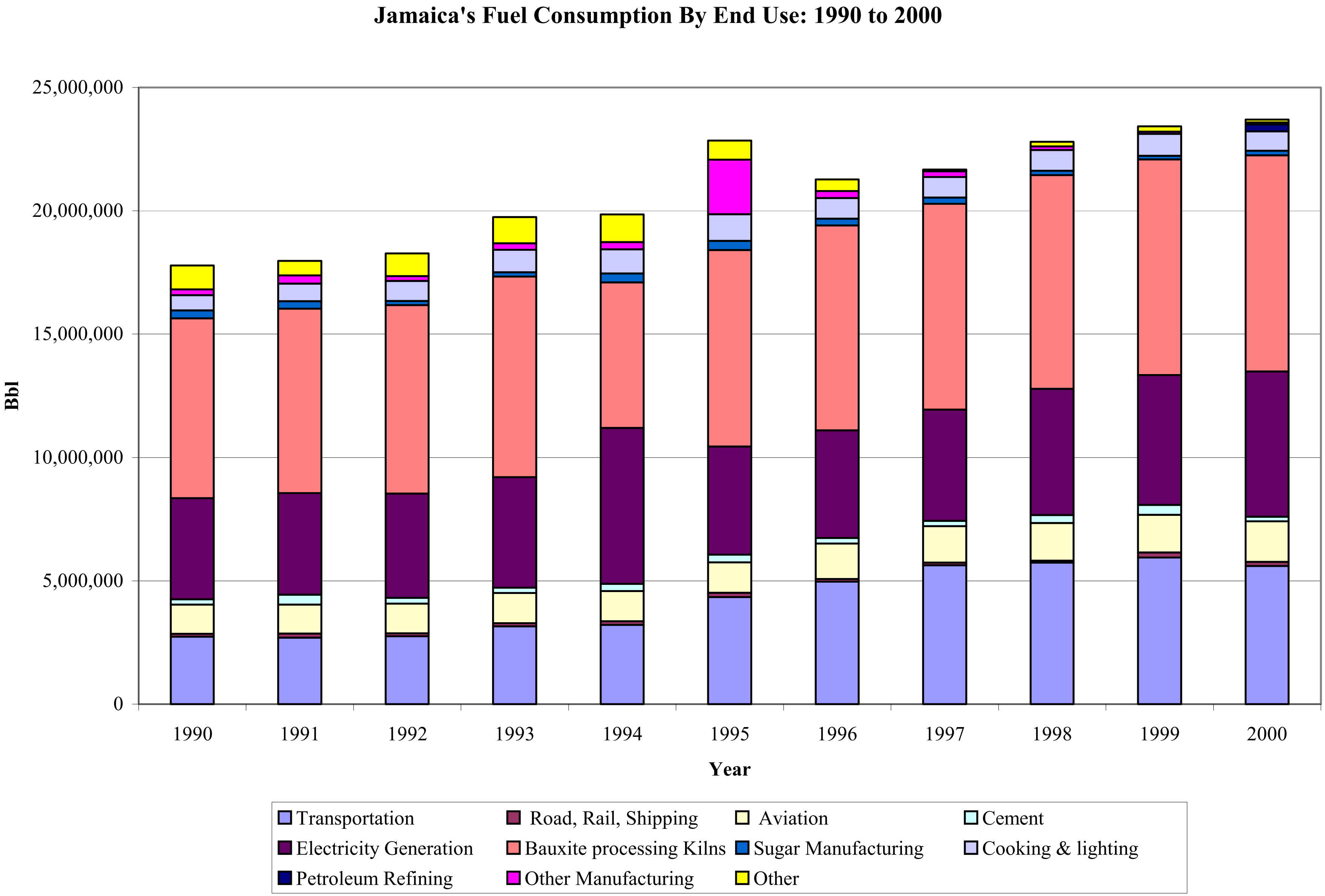


Figure 5-6 Jamaica's Energy Demand By Fuel (Bbl Oil EQ), 1994 – 2030: Base Case

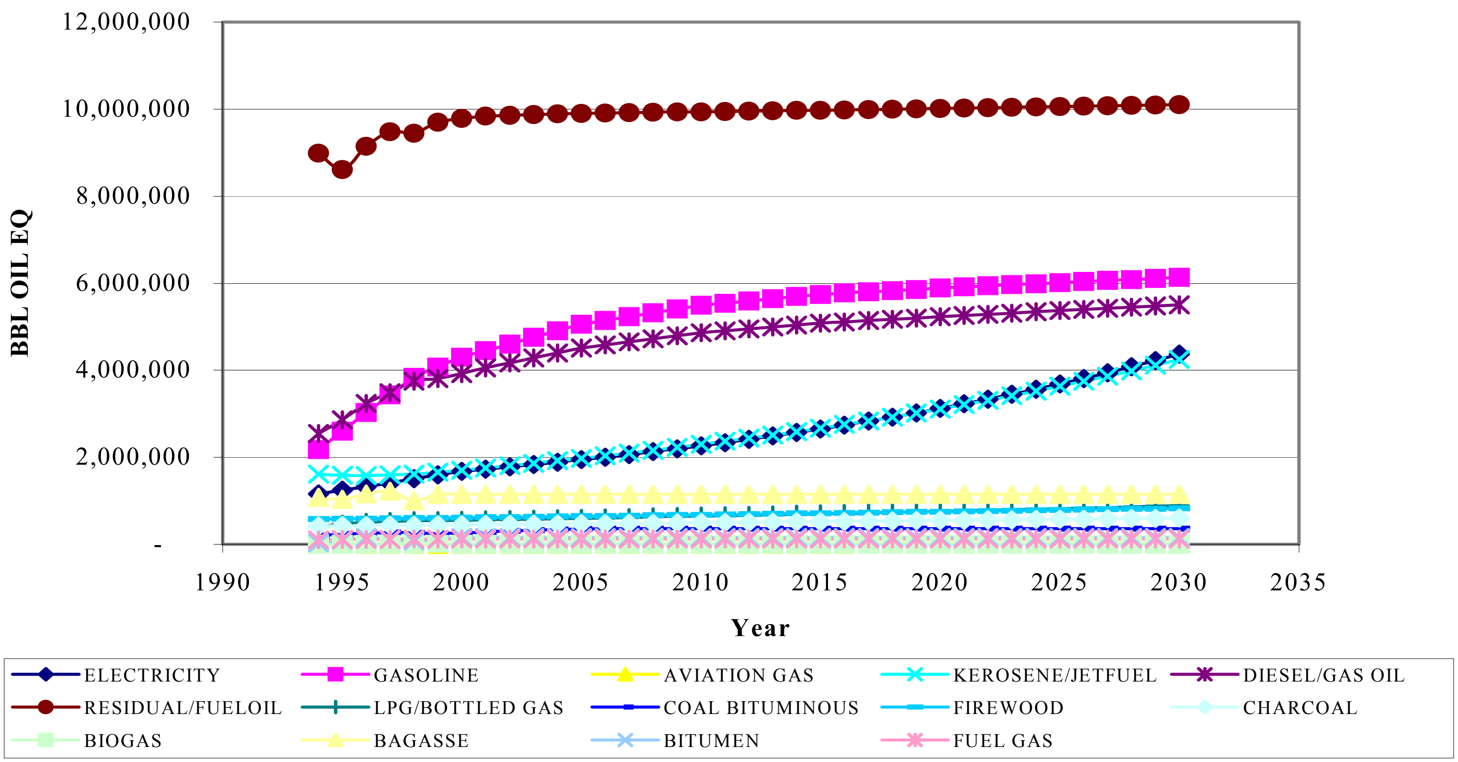


Figure 5-7 Energy Demand By Energy End Use Fuel: Moderate Growth Gate Scenario

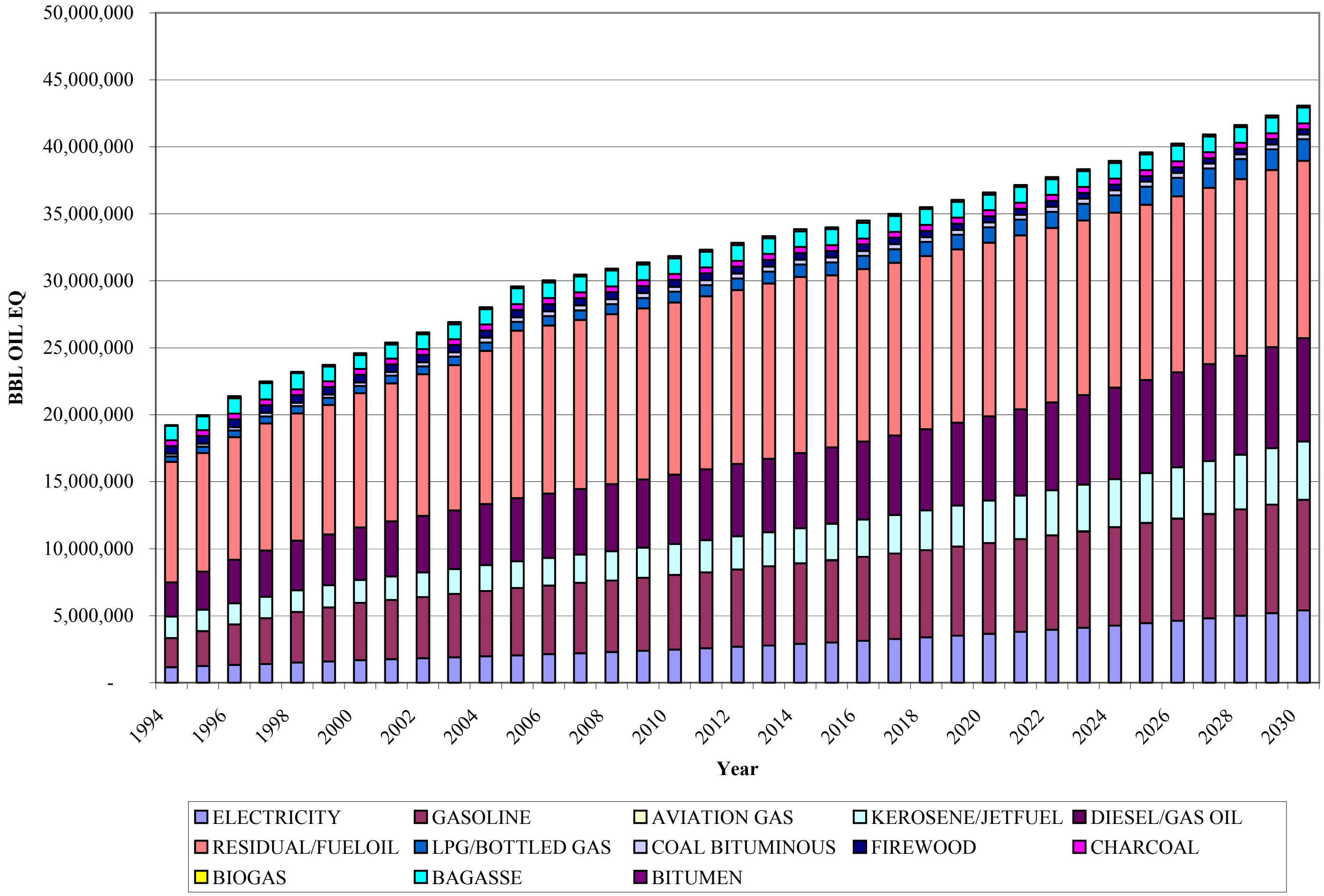
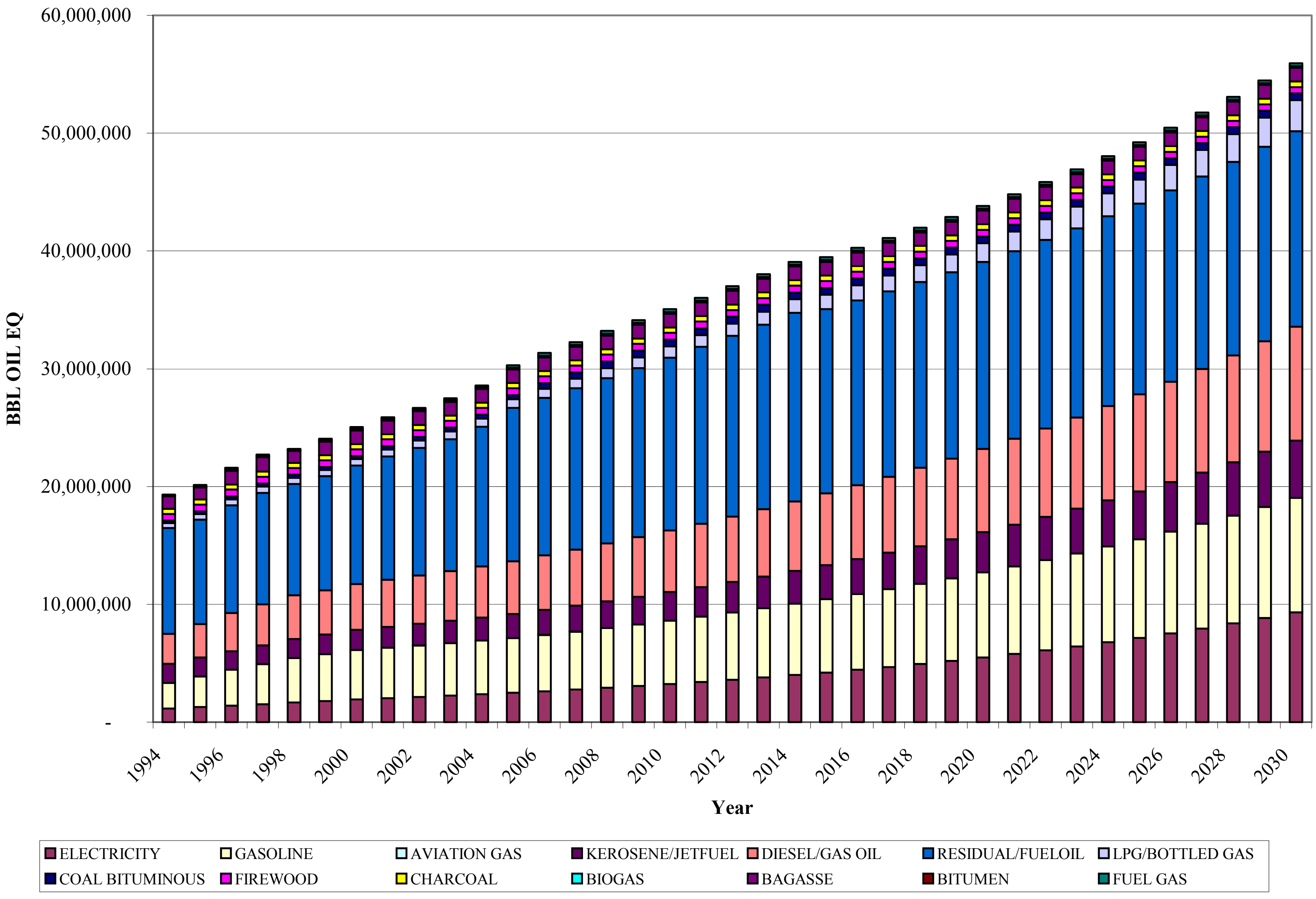


Figure 5-8 Energy Demand By Fuel, 1994-2030: Aggressive Growth Rate



5.5 CURRENT CONTROL AND MITIGATION TECHNIQUES

The regulatory system that is currently in place to control industrial air pollutant releases relies on the Permits and Licences Regulations. These regulations only apply to new facilities or existing facilities that undertook new construction or expansion since the regulations were promulgated on January 1, 1997. Although these regulations enable NEPA to require stack testing (and ambient monitoring) as conditions under the licence to operate, the regulations do not provide any guidance or instructions for stack testing (and ambient monitoring) methods nor do they specify reporting requirements. The Permits and Licences Regulations do not address existing industrial facilities unless they undertook new construction. Facilities with recently obtained permits are limited to using a maximum of 2.2% sulphur in heavy fuel oil (as restated in the Air Quality Regulations for new facilities or existing facilities that undertake major modifications). Air quality initiatives by some industries particularly the bauxite and alumina and some facilities in the electric utility industries, have resulted in some ambient monitoring and stack testing programs.

NEPA has no suitable means to obtain accurate and reliable information on emission control equipment (e.g., type, specification/adequacy, location/process served, performance, maintenance) at facilities since current regulations or mechanisms to compile such information (e.g. Section 17 notices or licence conditions under the Permits and Licences Regulations) are inadequate. Anecdotal information indicates that emission control equipment is limited to the control of particulate emissions. Information on the adequacy (suitability of equipment for the application), performance and maintenance of the equipment is not known. The particulate emission control equipment includes baghouses (cement), cyclones (several industries), electrostatic precipitators (cement, alumina kilns) and a wet scrubber (bauxite kiln). In some cases, monitoring data (stack test, opacity tests) and in other cases visual observation and/or measurements indicate sources would be/are out of compliance with particulate emission targets.

The lack of information on emission control equipment at industrial facilities is another serious limitation of the present situation.

5.6 THE AMOUNT OR PROPORTION OF THE AIR QUALITY PROBLEMS LIKELY TO BE CORRECTED BY REGULATIONS

Since the regulations address industrial sources they will only directly affect air quality related to these sources. The other important air pollution sources – mobile sources, sugar cane and trash burning and natural sources are not addressed by these regulations but the regulations provide a framework (through emission inventories that would include motor vehicle emissions and specification of ambient air quality monitoring methods) for assessment of all facilities (licensed industrial facilities, mobile and other area sources not required to obtain a licence). It should be noted that it is estimated that the facilities that would be required to obtain air pollution licences would account for over 90% of fuel combustion emissions.

5.7 PROFILE OF INDUSTRIES AFFECTED BY REGULATIONS

A profile of industries affected by the regulations is needed to identify the relevant economic and financial characteristics and trends for the industries affected and to compile data necessary to define a baseline for the benefit cost analysis.

The industry profiles are limited to that for the mineral processing (bauxite and alumina, cement and lime), electric utility, petroleum refining and the sugar industries and are summarised in Appendix 3. A list of the Major Facilities is given in Table 5-9. The number of Significant Facilities is estimated at 150.

Table 5-9 Estimate of the Number of Air Pollutant Facilities in Jamaica that are Likely Classified as Major Facilities

Plant Type	Number of Facilities	Name/Description
Alumina plants	4	Windalco Kirkvine, Windalco Ewarton, Jamalco, Alpart
Bauxite drying plant	1	Kaiser
JPS Electricity generating plants	4	Hunts Bay, Rockfort, Old Harbour, Bogue
Engine driven electricity generating plants	2	Jamaica Energy Partners, Jamaica Private Power Company
Petroleum refinery	1	Petrojam
Sugar factories	8	Appleton, Bernard Lodge, Frome, Hampden, Long Pond, Monymusk, St. Thomas Sugar, Worthy Park
Cement	2	Caribbean Cement Company Ltd, Western Cement
Sulphuric acid factory	1	Industrial Chemicals Ltd
Distilleries	4	Appleton, Hampden, Long Pond, Monymusk
Bauxite mining	4	Windalco Kirkvine, Windalco Ewarton, Joint Mining Venture, Alpart, Kaiser
Bauxite/Alumina Shipping	4	Port Esquivel, Port Kaiser, Rocky Point, Port Rhoades
Ethanol plants	2	Jamaica Ethanol Co, Jamaica Alcohol Co.
Cogeneration plants	2	Jamaica Broilers, Braco
Facilities with larger boilers or furnaces	6	Various
Total	45	

6. ANALYSIS OF PRINCIPLES AND APPROACHES USED IN THE AIR QUALITY REGULATIONS

In this section of the typical RIAS, the analysis of alternatives would be documented. NEPA did not use a formal process that led to selecting the regulations as the preferred alternative. Several of NEPA's policies and regulations rely on principles which in some cases are explicit national policy or by virtue of the Jamaican Government being a signatory to international conventions or protocols as well as by expressed policy of the Authority. These include the *polluter pays* principle, the *precautionary* principle and the *environmental stewardship* principle. The "polluter pays" and "user pays" principles are the stated national environmental policy as indicated in the National Industrial Policy[24]. These principles as well various regulatory and non-regulatory approaches are discussed with reference to how they are used or applied in the air quality regulations or policies in Section 8. General discussions of principles and various regulatory and non-regulatory strategies used in regulations are provided in a separate document or primer that is intended to be generic.

7. BENEFIT COST ANALYSIS

In this section we provide an analysis of the benefits and costs for implementing the air quality regulations. The regulations employ a mix of strategies based on ambient air quality standards and emission limits - targets for existing sources and standards for new sources - and on monitoring and reporting on performance relative to the standards. The benefits and costs are based on the requirements to meet the ambient air quality standards and emission limits and also to comply with monitoring and reporting requirements.

Historically, most ambient environmental standards were set to protect the normal population or receptors and were based on no-effects thresholds which assume that human health or environmental effects do not occur at exposures below the environmental standard. Over the past 10 to 15 years, it has become increasingly clear that contaminants such as particulate matter (PM_{10} or $PM_{2.5}$) and ozone have no threshold below which effects do not occur and thus health effects do occur at all concentrations above background. For other pollutants such as SO_2, CO and NO_2, there are quantifiable health effects at levels below the ambient standards. Understandably, at low concentrations there is relatively more uncertainty in the relationship between the exposure and the amount of the effect. Historically, establishment of ambient standards took little account of costs to achieve them but recently, benefit cost has been considered in setting ambient air quality standards as well as in regulation and policy development.

Emission limits require determination of the emission levels achievable by pollution abatement or pollution prevention technologies (often called "best available") and require definition or qualification of “best”. The qualification of best may be expressed in different ways and as technology advances the limits require frequent revisions. What is best in terms of removal efficiency may be unreliable or expensive (or not cost effective). The most serious limitation of emission/discharge limits is that they focus on technologies and their costs and financial consequences but they take no account of environmental effects and the benefits.

Benefit cost analysis allows consideration of both costs and benefits whether there is a single strategy or a mix of strategies. The benefit cost assessment is designed to determine whether specific initiatives such as regulations or a mix of initiatives are economically justified. When the value of the potential benefits to implement the initiative is greater than the value of the potential costs to implement the initiative, for example a regulation, the proposed initiative is deemed economically feasible and justified.

While we can readily estimate the costs to implement regulations, the environmental benefits are difficult to quantify and value. For example, people will want “cleaner air” or improved visibility or to be able to enjoy unpolluted waters in which to swim. While it is feasible to measure air or water quality it is more challenging to place a value on the increase in enjoyment afforded by cleaner air or water.

The level of effort and detail of analysis of benefits and costs for regulations are generally based on the significance and impact of the regulation. The benefit cost analysis for this project (limited in this report to air quality regulations) was constrained by:

a) the limited time to conduct the analysis
b) the limited amount of cost effectiveness information for pollution control equipment specific to Jamaican industry (especially the bauxite and alumina industry)

As a result, only readily available information from published studies could be included.

Bearing in mind the above constraints, the approach (damage function approach) adopted in this analysis is to base the benefits of reduced air pollution or cleaner air on the avoided costs for the effects on human health, materials and other response categories. Costs are based on the capital and operational costs for the regulated community to comply and for the regulator (government) to enforce the regulations. No consideration will be given to changes in employment or consumer behaviour since the regulations will not directly affect employment levels or consumer choices.

The air quality regulations are considered as having major cost implications for facilities that would need to install and maintain emission control equipment and therefore warrant a full benefit cost analysis. In general much but not all of the information on emission control equipment costs was sought only from industries with major facilities that would require emission control equipment. Cost information for industries whose costs did not include emission control equipment was estimated based on typical costs based on the consultants' experience.

The air quality regulations will require facilities that are licensed to conduct air quality assessments (to determine likely compliance) and to make annual reports of releases and other activities. Based on the air quality assessments, it may be necessary for some facilities to monitor either or both of (some) pollutant releases and ambient pollutant concentrations. In cases where there is non-compliance with emission targets, strategies will need to be employed to reduce emissions. The strategies may range from pollution control equipment to process or other changes in a facility's operations. The benefit cost analysis assumes the use of pollution control equipment for existing sources that are not in compliance with targets. Note that benefit cost analyses do not include compliance costs for facilities with new sources since their number is unknown and such facilities will enter a regime that has established standards (for new sources). New facilities are as defined in the regulations and include existing sources that undertake major modifications.

The use of pollution control equipment will lead to emissions reductions that will result in improvements in ambient air quality which in turn will lead to reduced environmental effects e.g., damages to receptors (humans/human health and property enjoyment, crops, buildings etc.) affected by air quality. The reduced damages are estimated by dose response relationships that translate a change in air quality into a change in the effect or damage (e.g., a certain change in air quality will lead to a change in hospital admissions or number of people that may die as a result of exposure to air pollution). Such changes in the effect are valued or monetised.

7.1 TIME HORIZON - BASE YEAR AND PERIOD FOR EVALUATION

In estimating costs and benefits it is necessary to determine the starting point and the duration over which the evaluation is to be made. The typical starting point is when the regulations take effect. In the case of air quality regulations NRCA, (as NEPA was then), indicated its intention to develop air quality regulations shortly after the National Ambient Air Quality Standards and the Permits and Licences Regulations were both promulgated in 1996. Since 1996, facilities that required permits and licences under the latter regulations were required as part of the operating conditions to use heavy fuel oil with no more than 2.2% sulphur – the same as included in the air quality regulations for new sources. Also, bauxite and alumina companies indicated they stepped up implementing ambient monitoring and other environmental activities in response to the 1996 regulations. Based on these factors, 1996 was selected as the base year.

The duration of the evaluation period is typically based on the lifetime of investments that would be required as a result of the regulations as well as to allow a reasonable time for benefits to take effect. This period is not normally more than 30 years and is selected in this case. Only capital investments made as of 1996 and their associated maintenance costs will be included in the analysis. Capital costs made before 1996 and their associated maintenance costs are excluded. Only the net changes in capital and operating costs due to the regulation are considered.

7.2 DISCOUNT RATE

Benefits and costs which occur at different points in time must be added together and the discount rate is the means of converting impacts arising over time into a common "present value". The regulations will entail large investments in emission control technology soon after the regulations come into force and ongoing operational and maintenance costs. The health benefits will accrue following the implementation of control technology until the end of the evaluation period. The higher the discount rate the less account is given to the future environmental benefits and costs.

The choice of discount rate for benefit cost analyses is often contentious since it is a significant factor in determining the net benefits.. A discount rate is an interest rate used to estimate the value of current payments instead of waiting until some time in the future. The interest rate charged by lending institutions is called the nominal interest rate and such rates include a factor to account for anticipated changes in the general level of prices (inflation). The real rate of interest – the actual cost of borrowing – is the nominal interest rate minus the inflation rate. Nominal interest rates generally vary across industries, sectors and of course countries for a wide variety of reasons.

The discount rates typically used in benefit cost analyses is the social discount rate. The social discount rate like nominal and real interest rate, also compensates society for the foregone benefits associated with spending a dollar today since society has a collective rate of time preference that equates the value of future benefits with an equivalent level of benefits enjoyed now. The foregone social benefits associated with an investment remain the same across industries.

The social discount rate is also adjusted for inflation. The social discount rate is typically considered to be the same as that for a completely riskless investment. Riskless investments are represented by the long-term interest rate on government bonds and securities. When determined in this manner, the social rate of discounting should be appropriate for the evaluation of social projects.

U.S. Office of Management and Budget (OMB) guidance[25] on discount rates is to use the rate of return on private investments namely seven percent (7%). However, recent benefit cost analyses used discount rates of 5% (U.S. EPA Clean Air Act Benefit Cost Analysis; Tier II motor vehicle emission standards; Development of Canada-Wide Standards for Particulate Matter and Ozone) and 4% (Ontario). The EPA and Canada Wide Standards studies also included sensitivity analyses by using with higher (7.5% or 7%) and lower (2% and 3%) discount rates. The lower discount rates are more appropriate for century long periods over which benefits (from measures to reduce stratospheric ozone) occur.

A discount rate of 10% is assumed for the present study to reflect generally higher private rates of return for private capital and higher Treasury Bill rates in Jamaica relative to the U.S. Jamaican Treasury Bills represent the lowest risks for Jamaican based investments. Since consensus on a preferred discount rate to be used in this analysis is extremely unlikely, we use a broader range of rates than that used in other studies namely, 6% and 14%, to examine the sensitivity of the analysis with respect to discount rate.

7.3 COSTS TO SOCIETY

7.3.1 Estimation Procedures

The costs to society include:

- One-time compliance assessment, consulting and start up costs;
- Capital costs for pollution control and monitoring equipment and structures; and
- Ongoing operational costs to industry and administrative and enforcement costs to government.

The initial assessment costs are estimated for all sectors while capital and operational costs are limited to the sectors that need to install pollution control equipment. The capital and operational costs are broken down into those associated with monitoring, stack testing and emission control costs.

The continuous analysers used in ambient monitoring equipment are assumed to have a lifetime of 10 years while particulate samplers are assumed to last 30 years. The latter assumption is based on the ongoing replacement of motors that are included in maintenance costs. The lifetime for major capital equipment is assumed to be 30 years which would likely correspond to the time period over which bauxite resources are depleted and is also based on experience of existing plant equipment.

The costs for ambient monitoring and pollution control equipment were obtained from industry sources (bauxite and alumina companies, JPSCo, CCCL) and were compared with typical monitoring equipment costs. Pollution control equipment costs were also compared with typical industry data.

7.3.1.1 One-Time Compliance Assessment, Consulting and Startup Costs

All licensed facilities will be required to conduct assessments to determine their emissions and potential impact on ambient air quality. The majority of facilities that are categorised as Significant Facilities will invariably have emissions that arise from fuel combustion, namely, boilers. The effort required by Significant Facilities will be less than that for Major Facilities. Outreach to Significant (especially) and Major Facilities by NEPA should be used to clarify regulations and clear up any misperceptions.

For the Significant Facilities, estimation of emissions and running a simple (screening) dispersion model is estimated to cost an average of J$160,000 (US$3,500).

It is estimated that about one-half (25) of the facilities classified as Major Facilities will be required to conduct only screening modelling while the other half would need detailed dispersion modelling and stack testing. The costs for detailed modelling and assessment are estimated at a minimum of J$300,000 (US $6,250). These costs will increase depending on the complexity of the buildings on the site, the number of source/pollutant combinations and the availability of quality assured meteorological data. Estimated costs for stack testing are US$10,000 per stack with a minimum of about US$20,000 per facility. It is assumed that point sources in the bauxite and alumina companies, electricity generating stations, refinery and lime plants will require stack testing. Actual incurred costs for stack testing and modelling between 1996 and 2001 were used if they were provided.

7.3.1.2 Capital Costs For Monitoring and Pollution Control Equipment

Ambient and Stack Emission Monitoring Equipment

The regulations include requirements for meeting emission targets and ambient air quality standards. In some cases, ambient monitoring and stack testing are required. The regulations call for ambient monitoring (TSP or PM_{10}, SO_2, NOx) where modelling predicts concentrations are greater than 75% of the ambient air quality standard. The only likely ambient monitoring that will be required by licensees is for particulate matter (TSP or PM_{10}), nitrogen oxides and sulphur dioxide. No monitoring by licensees will be required for ozone (since it is not a pollutant emitted by facilities). It is extremely unlikely that monitoring for lead and carbon monoxide would be required. Some companies have installed ozone and CO monitors – presumably for reasons other than to meet the regulations. NEPA or its designees (JBI) will be required to conduct ambient monitoring (e.g., for CO, O_3, SO_2, NO_X) in urban areas as well as for auditing and other compliance related purposes. These costs are included.

Maintenance costs for ambient monitors are estimated at US$500/year for PM_{10} and TSP monitors (including replacement motors) and US$1,000/year for gas analyzers (SO_2 and NO_2). Gas analyzers (SO_2 and NO_2) are assumed to have a lifetime of 10 years while TSP and PM_{10} instruments are assumed to last 30 years (since the motors are included in annual operating costs).

The regulations will require continuous emission monitoring (CEM) for stacks whose uncontrolled emissions would exceed the emission standard or target. Thus stacks with ESPs and baghouses for example would require CEMs. Affected stacks would be all alumina, lime and cement kilns. Costs for each CEMs are estimated at US $250,000 where actual costs were not provided.

Pollution Control Equipment

Capital costs for pollution control equipment will be required when stack emissions are greater than emission targets **and** the overall allowable facility emissions for the pollutant are exceeded. Equipment for the control of particulate emissions or to meet opacity standards could be required. Capital costs for pollution control equipment installed since 1996 were provided by bauxite and alumina companies.

Based on information provided by companies, the status of emissions relative to targets and the control equipment requirements are as follows:

> One of the four bauxite and alumina facilities may not need pollution control equipment changes to meet PM emission targets on alumina kilns. At this facility one of three kilns may not meet the PM emission target targets but the entire facility will likely meet the bubble limit for PM. At the other three alumina facilities, seven of eleven kilns are currently likely to exceed the PM emission target. Opacity targets for boilers at three facilities regularly exceed the emission target for opacity.
>
> Emissions from ship loading are the most likely cause for exceedances of ambient air quality standards for TSP near the port.
>
> Just under US $10 million were spent to upgrade pollution control equipment for kilns, storage silos, bauxite drying and ship loading facilities. Expenditures for ship loading pollution control equipment were assumed to have a payback period of 10 years.
>
> Bauxite and alumina companies provided estimates of the expenditures required to meet emission targets. The estimates are as follows.

- Approximately US$3 million are required to upgrade electrostatic precipitators (ESPs) on kilns but the expenditure may only achieve PM rates less than 300 mg m^{-3} (the emission target is 100 mg m^{-3}).
- Approximately US $10 million to upgrade ESPs.
- Total capital expenditures of ~US$70 million would be required to install two new kilns at one facility. The new kilns would employ current technology with increased energy efficiency (relative to the existing kilns) and the costs are based on increased alumina production capacity to satisfy planned plant expansion. The portion of the total expenditures attributable to emission control equipment (ESPs) was not provided. The total capital expenditure would be offset by the private benefits from improved energy efficiency and the residual value of the rotary kilns that are displaced.

  If the expansion qualifies as a major modification, the new kilns would be treated as a new source and thus pollution control costs would not be applicable in the benefit cost analysis.

  In the absence of additional information, two expenditure scenarios are considered for use in the benefit cost analysis:

  a) US $3 million for maintenance to achieve 300 mg m^{-3} on kilns (pending compliance plan approval from NEPA since it would not meet the target)

  b) Expenditures of US$10 million to upgrade the current ESPs to meet the target of 100 mg m^{-3} without any increase in plant capacity.
- The higher cost (US $10 million) in scenario b) was used in the analysis. The estimated annual emissions reductions from these expenditures are over 16,500 tonne/y from kilns.

- Additional US $4 million in 2004/2005 for in-haul and ship loading controls.
- US$5.15 million in 2003 to rebuild ESPs and to review operational practices
- US$3 million in 2006 to install a dust collector system on a lime kiln.
- US$1.5 million in 2004 for an in-haul alumina dust suppressor system, to review operating SPI and to improve housekeeping practices

The situation at other mineral processing industries is as follows.

- Emissions from a stack likely exceed emission target for PM due to failure of the ESP and possibly preheater cyclone components although no measurements are available. Ongoing studies are being conducted to assess the full requirements. A very preliminary estimate is US $0.750 million to upgrade an ESP and a cascade cyclone .

7.3.2 Summary of Costs

The startup costs, ongoing ambient and stack monitoring costs and emission control costs together with the emission reductions are summarised in Table 7-1.

Table 7-1 Summary of Startup and Annual Monitoring Costs

Item	Comment	Cost (US $)
Startup and One-time Costs		
Air quality assessment	Stack tests, modelling, assessment	1,774,468
Monitoring equipment		996,887
Staff training	One time training costs	396,000
Capital pollution control equipment costs*	Includes 1996-2000 costs and future ESP, baghouse and CEM costs	35,172,000
Fugitive VOC control costs		50,000
Total One-time costs		38,339,355
Ongoing Annual Costs		
Incremental Staff	Major and Significant facilities	305,000
Ambient Monitoring (maintenance)		39,500
Maintenance Pollution control equipment	All ESPs, baghouses, boiler maintenance	8,805,000
Fugitive dust control costs	Bauxite & alumina industry, cement	735,000
Total Annual Costs		9,934,500

* Lower of two control cost scenarios for one alumina plant. An additional US $10 million for scenario with control costs to meet currently proposed target.

7.4 BENEFITS TO SOCIETY

Societal benefits include:

- Public benefits
- Private benefits
- Local or regional economic activity and employment

Public benefits include actual and perceived increases in welfare and quality of life because of reduced health impacts, extended life, reduced mortality, increased productivity, reduced material damage, avoided cleanup and remediation costs. Some of these will be considered in this study.

Private benefits include revenues from the recovery of product or sale of secondary materials recovered from pollution control processes and reduced production costs. They also include benefits such as enhanced public relations and recognition of products or of the company as "green". The only private benefits included in this analysis are the recovery of alumina from ship loading controls and the recovery of material from ESPs at one facility. The benefits were based on a payback period of ten years for the ship loading controls and, in the case of ESP repairs, on the average price per tonne of alumina derived from foreign exchange earnings over the past five years (US $181).

Private benefits such as improved goodwill due to improved environmental performance, better public relations and public recognition are not easily quantified and are ignored.

Indirect economic activity and employment can be generated from the expenditures by licensees and government in complying with or implementing the regulations. Little of any such activity is expected from the regulations and this indirect activity was assumed to be negligible and was ignored.

7.4.1 Public Benefits

Emission reductions will lead to lower ambient air concentrations, which in turn will yield improved human health and reduced materials and vegetation damage. These benefits are expressed in monetary terms as avoided health care costs, the monetary value of a shortened life, avoided crop losses, avoided damage to materials and avoided expenditures for protection or replacement of materials.

Only emissions reductions of particulate matter are considered since the reductions in SO_2 and NOx emissions are expected to be small. Consequently the only societal benefits considered will be due to avoided human health effects of particulate matter.

Current evidence indicates that air quality standards or guidelines are not low enough to safeguard against adverse health effects and that there may be no concentration that is low enough to safeguard against harmful health effects. Mortality and morbidity endpoints have been observed at levels below the ambient air quality standards especially for particulate matter and ozone. This means that air pollution related health effects increase with increasing concentrations of PM and/or ozone and are more discernible at higher exposure levels. The consensus is that there is no threshold below which there are no effects from PM or ozone. For PM, the relationship is linear up to about 200 $\mu g\ m^{-3}$. Above this concentration, the slope is flatter at higher ambient concentrations. In line with these observations, the World Health Organization (WHO) has set no ambient guideline concentration for PM, but rather has developed exposure response curves to guide policy makers[26]. The evidence on the adverse health effects of fine particles is compelling. Numerous studies in several countries world wide, including developing countries, have shown generally consistent quantitative relationships between PM and mortality and morbidity[27]. Some of the recent reviews and use of dose response relationships to estimate costs of air pollution are U.S. EPA retrospective and prospective benefit-cost assessments of the Clean Air Act[28], and the Health Canada-Environment Canada Science Assessment Document for particulate matter[29].

The most common health end points for PM exposure are total mortality, respiratory mortality, cardiovascular mortality, mortality from chronic obstructive pulmonary disease (COPD), and pulmonary heart disease (PHD). The quantitative relationships between mortality and PM concentrations are summarized in Figures 7-1 (mortality), 7-2 (hospital admissions) and 7-3 (selected morbidity endpoints). The relationships were developed from studies in several developed and developing countries for daily average PM_{10} concentration between 20 and 200 µg m^{-3}. The PM_{10} concentrations measured in Jamaica (other than near bauxite and alumina plants) are limited but daily values ranged from 30 to 110 µg m^{-3}. PM_{10} measurements near bauxite and alumina plants ranged from 9 to 120 µg m^{-3} and annual mean values ranged from 23 to 41 µg m^{-3}.

For comparison, between 1984 to 1995[30], mean PM_{10} concentrations at the urban (downtown) sites in Ontario ranged from 21 µg m^{-3} in Ottawa, 26 to 28 µg m^{-3} in Toronto to 31 µg m^{-3} in both Hamilton and Windsor. A rural site, Egbert, recorded a mean concentration of 17 µg m^{-3}.

The measurements in Jamaica are well within the range over which dose response relationships are applicable.

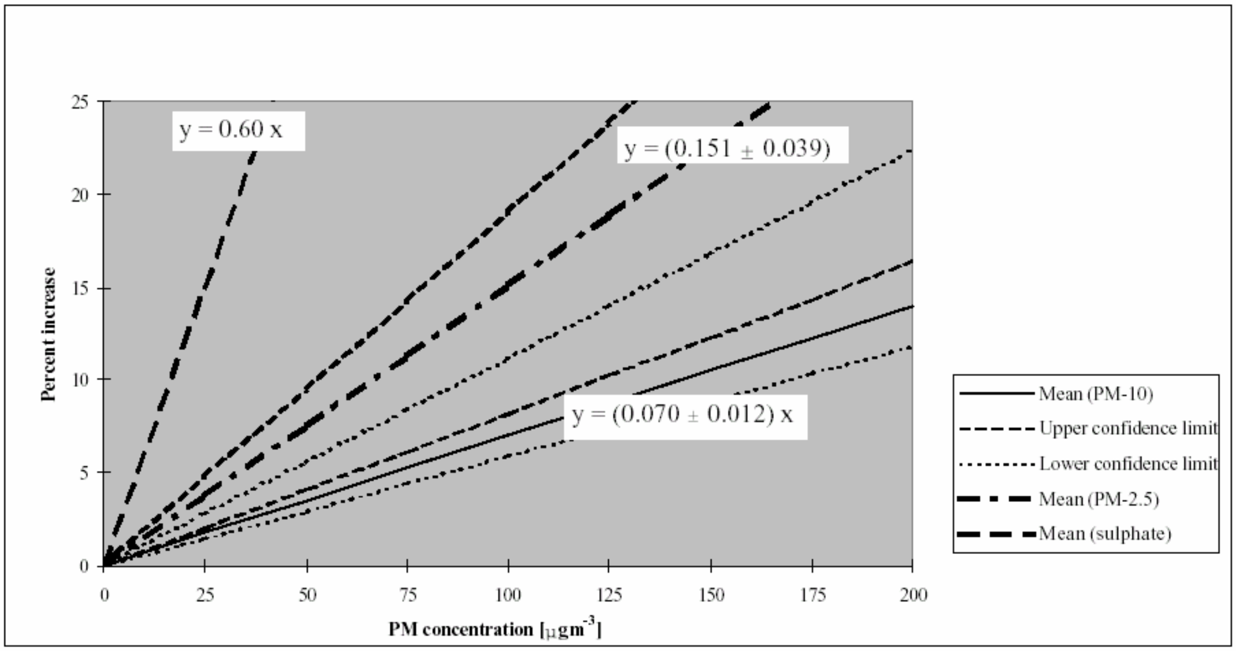
The choice of concentration–response to be used in this study was dictated by the availability of health outcome statistics for Jamaica. The relevant outcomes for PM exposure and the available data for Jamaica are summarised below. Availability of information is based on previously published or readily available statistics from Ministry of Health and other sources.

The outcomes used in this study (as in several others) are the relatively less frequent but more serious outcomes (death, hospital admissions, emergency room visits) and do not include the considerably larger number of less serious outcomes such as outpatient and doctor's visits, respiratory infections not requiring doctor's visits and any associated absences from work or school. Table 7-2 summarises the health and other outcomes associated with PM exposure and indicates those used in the analysis.

It must be noted that there are claims of corrosion damage due to alumina plant emissions. Bauxite and alumina companies have compensated residents near their facilities for replacement of zinc roofs. Since the regulations are not likely to result in large reductions in SO_2 emissions, there would be no expected changes in ambient SO_2 concentrations which could influence corrosion rates. Because of this no cost estimates for avoided corrosion impacts (benefits) are included.

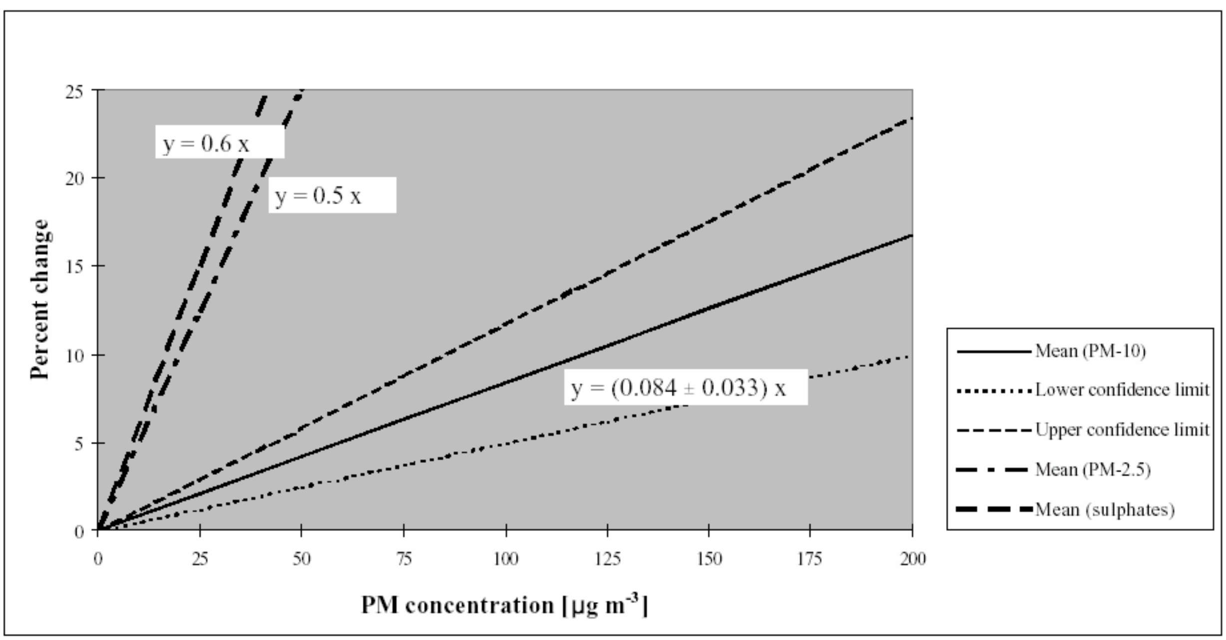
Future plant expansions that qualify as major modifications will be required to use heavy fuel oil with no more than 2.2% sulphur in the new sources. The SO_2 emissions from the new sources will be lower by up to 26.7% (3 - 2.2)/3x100) than had the regulations not been in place and thus corrosion impacts would be reduced. As a practical matter, facilities with a mix of existing and new sources would be licensed to use a single heavy fuel oil with sulphur content between 3 and 2.2%, depending on the relative amounts of fuel used in the existing and new sources.

Figure 7-1 Increase in Daily Mortality as a Function of PM Concentration



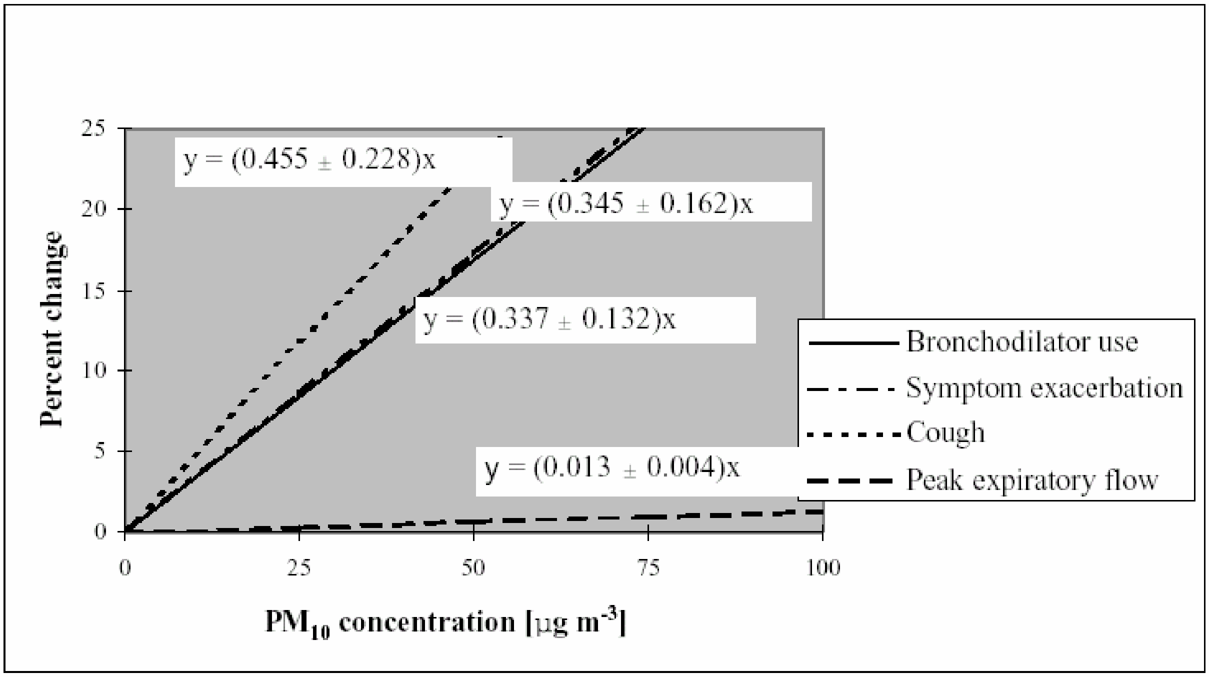
From WHO, 2000

Figure 7-2 Percent Change in Hospital Admissions Assigned to PM_{10}, $PM_{2.5}$ and Sulphates



From WHO, 2000

Figure 7-3 Change in Health Endpoints as a Function of PM_{10} Concentration



From WHO, 2000

Table 7-2 PM Health and Other Outcomes and Those Used in Benefit Cost Analysis

Outcome	Applicable	Jamaican Data Available	Used in Analysis	C-R Value % Change/µg m^{-3} in PM_{10}
Mortality				
Total (all causes)	Y	Y	Y	0.070 [a]
Cardiovascular	Y	Y	N	0.34 [b]
Respiratory	Y	Y	N	0.14 [b]
Morbidity				
Respiratory hospital admissions	Y	Y	Y	0.17 [c]
Cardiac hospital admissions	Y	Y	Y	0.23 [d]
Asthma, upper, lower respiratory tract infection admissions	Y	Y	N	
Emergency room visits	Y	Y	Y	3.66×10^{-8}
Chronic bronchitis cases	Y		N	
Asthma symptom days	Y		N	
Restricted activity days	Y		N	
Acute respiratory symptom days	Y		N	
Child bronchitis	Y		N	
Lost wages/Value of time	Y	Y	Y	*
Production/consumption				
Crops	N			
Forests	N			
Economic Assets				
Materials (corrosion, soiling)	Y	Y	N	
Property values	Y	N	N	
Environmental Assets				
Use	Y	N	N	
Recreation	Y	N	N	
Visibility, aesthetics	Y	N	N	
Passive use (nonuse) and/or Total values for other impacts to vegetation, wildlife, and other ecologic resources	N		N	

[a] WHO 2000. Guidelines for Air Quality, WHO, Geneva.
b Dockery and Pope, (1994)
[c] Median value used on CEPA/FPAC study
[d] Burnett, R.T., S. Cakmak, J.R. Brook and D. Krewski (1997c). The role of particulate size and chemistry in the association between summertime ambient air pollution and hospitalization for cardiorespiratory diseases. *Environ. Health Perspect.* 105: 614-620.

* Based on average earnings per week of J2,214 in 1996.

The dose response data are for PM_{10} and several studies have assumed relationships between TSP and PM_{10} (typically PM_{10} is assumed to be 55% of TSP levels) in order to use the available TSP data. There are limited PM_{10} data measured in Jamaica and the same relationship between TSP and PM_{10} found elsewhere is assumed. The extremely limited co-located TSP and PM_{10} measurements made in Jamaica[31] are consistent with this ratio.

The change in number of health outcomes of a particular type i, ΔH_i due to a change in PM_{10} concentration ΔC, is estimated by multiplying the slope of the concentration–response curve *b*, by the change in concentration and the population, P.

$\Delta H_i = b \times P \times \Delta C$

One way of expressing the concentration-response curve (to define the slope b) is as the percentage change in outcome per unit change in concentration. It is necessary to know the base rate that is changing to use this form of the concentration response curve. For example, if the number of non-traumatic (all causes except trauma) deaths in a population of 2 million is 11,344 (a mortality rate of 0.00567 per person), and there is a 0.07% change in non-traumatic deaths for each $\mu g\ m^{-3}$ reduction in PM_{10} concentration, then the number of nontraumatic deaths avoided will be the 0.00567 x 2,000,000 x 0.07/100 or 7.94 persons. If the change in PM_{10} is 10 $\mu g\ m^{-3}$ then the number of deaths avoided would be ten times greater or 79 deaths.

7.4.2 Reductions in TSP and PM_{10} Concentrations

In order to make the estimates of health outcomes we need to know the reduction in PM_{10} concentrations that would occur when facilities comply with the regulations. Facilities that currently exceed targets would be required to reduce emissions so that they meet the emission target.

Stack emission targets for PM are exceeded in 7 of the 14 alumina kilns at the alumina plants. Significant emission reductions will be required at three of the four alumina plants. PM emissions from the cement plant have not been characterised recently but based on a recent audit of the plant it is very likely that the emissions from one of the kilns will exceed the target while those from the other are likely to meet the target.

PM emissions from boilers at alumina plants are apparently not always well characterised. Opacity measurements have been made on a routine basis at two facilities. The opacity target is often exceeded at the boilers at one of these facilities. PM emission targets are likely exceeded at most (7 of 11) of the kilns at alumina plants. PM emissions from boilers used on five steam fired units are likely nearly double the PM target being considered. Emissions from one of the three engine driven generating stations exceed the PM target. PM emissions from sugar factories will likely benefit from boiler improvement as part of the combustion efficiency program that the regulations will require.

Estimates of the effectiveness of emission controls implemented by companies since 1996 were not available except for one Lurgi kiln at one plant. Future emission controls were assumed to meet the PM target.

Annual mean TSP concentrations measured at monitoring stations one alumina plant decreased by 35 $\mu g\ m^{-3}$ between 1996 and 2001. If PM_{10} concentrations are about 55% of TSP concentrations, the reduction in PM_{10} concentrations over the same time period would be about 19 $\mu g\ m^{-3}$.

For another alumina plant, a 1991 dispersion modelling study predicted annual mean TSP concentrations of 17-19 $\mu g\ m^{-3}$. The total TSP emission rate was 131 g/s from 4 boilers, three alumina kilns and one lime kiln and were based on AP42 emission factors. Stack test data at this plant since 1996 were extremely variable – ranging from 32 to over 4,300 $mg\ m^{-3}$ for the three rotary kilns and 25 to over 2,000 $mg\ m^{-3}$ for the Lurgi kilns. Based on the average PM emission rates from stack tests since 1996 for two Lurgi kilns and three alumina kilns, the TSP emission rate from these sources alone could be ~265 g/s. This emission rate is more than two times that used in the modelling study and based on an albeit an extremely crude prorating, the annual mean predicted TSP concentration could be at least two times higher than the 1991 estimate. Emission controls could therefore reduce TSP concentrations by over 30 $\mu g\ m^{-3}$. A PM_{10} reduction of 10 to 20 $\mu g\ m^{-3}$ (assuming PM_{10} to be about 55% of TSP concentrations) at this facility is therefore feasible.

Given the fact that PM targets are exceeded by the other two alumina plants, the cement and at steam fired power stations, the controls required by the regulations will be assumed to reduce PM_{10} concentrations by between 10 and 20 $\mu g\ m^{-3}$.

Health outcome and estimates of associated benefits data are based on a 10 $\mu g\ m^{-3}$ reduction in PM_{10} concentration.

7.4.3 Estimates of Avoided Health Outcomes

Estimates of avoided respiratory tract infections and cardiovascular disease health outcomes are made for total mortality, hospital admissions and emergency room visits for the period 1996 to 2025.

Cost information is as follows:

Value of a statistical life [a]	0.526 to 1.966 (US $Million)
Daily costs of hospital stay[b]	
Respiratory	J$2,931
Cardiovascular	J$3,039
Average length of stay[c]	
Respiratory	6.06 days
Cardiovascular	9.09 days
Cost for emergency room visit [d]	J$750
Average earnings per week[e]	J$2,214

[a] See below.
[b] Data from Ward (2002). A review of Hospital Care: Outlining Morbidity and Mortality Patterns, Costs of Care and Resource Inputs, Jamaica, 1996.
[c] Also from reference in a but the values are averages for 1996 to 2000.
[d] E. Ward, personal communication. Emergency room visits costs are the same as outpatient cost/visit.
[e] STATIN data for 1996. Compensation of employees at current prices divided by the labour force.

The costs are estimated in 1996 $ using discount rates of 6%, 10% and 14%.

The choice of the value for a shortened life has been the most controversial aspect in the valuation of the health benefits of environmental initiatives.

Estimates of the value of a shortened life have been made in several studies using different methodologies. No such empirical estimates have been made for Jamaica. Most of the empirical studies have been in the United States, Canada and Europe but others have been made in Thailand and Chile. The estimates for the U.S. range from 0.6 million to 13.5 million (1990 $)[32]. Recent benefit cost studies used CAN$3 million (Vancouver)[33], US $4.8 million (U.S.)[24], CAN$4 million (Ontario)[34], US $2.87 million in 1990$ (Canada)[35], US $3.03 million (Europe)[36] and US$1.62 million (1990 $) (base rate used for six cities worldwide)[37].

One approach for estimating the value of a shortened life in a developing country is to scale the developed country values by the ratio of Parity Purchasing Power GDP (PPPGDP) per capita of the developing country (e.g., Jamaica, US $2,319 per person) and the reference case (U.S.) study. The relationship for the adjustment is:

$$\frac{V_k}{V_{US}} = \left[\frac{Y_k}{Y_{US}}\right]^{\gamma}$$

where Y_k and Y_{US} are the per capita incomes of country k and the U.S.; V_k and V_{US} are the monetary values for the health end points in country k (Jamaica in this case) and in the U.S. and γ is the income elasticity. The income elasticity factor, γ, is a measure of the percentage by which the willingness to pay for a particular benefit declines for each percentage fall in the real income of the person concerned. The elasticity accounts for the fact that someone's willingness to pay for better air quality is likely to be lower in a low income country, but not necessarily in proportion to one's personal spending income. The value of V_k is very sensitive to γ. Estimates for γ vary widely with most less than 1 (often about 0.5) but values larger than 1 are suggested[29,38]. Recent studies[29,30] preferred using a conservative value of 1 for γ rather than an "average" elasticity value.

Transferring values from one country to another implicitly assumes that the two risk groups are sufficiently alike so they would have similar personal preference choices and attitudes towards improving air quality standards. These and other limitations and qualifiers in the approach are discussed below.

Annual avoided health outcomes were estimated based on full implementation of control measures by 2011. Between 1996 and 2009, the degree of implementation was assumed to be 10% 1997 to 2001; 20% for 2000 to 2003 and increasing by 10% each year to 2011. Costs were based on 1996 unit costs for hospital stays, population in 2010 and 1995 value of a statistical life (VSL) for mortality (US $1,966,000). Use of the lower value for VSL (US $526,000) would of course result in lower mortality costs. The number of outcomes and the associated benefits for 2011 are shown in Table 7-3 based on a 10 $\mu g\ m^{-3}$ reduction in the PM_{10} concentration.

Table 7-3 Summary of Health Impacts for PM_{10} in 2011

Outcome	Avoided Outcomes in 2011	Annual benefit (US $million) (2011)
Total Non-Trauma Mortality VSL US$1.966 million VSL US$0.526 million	105	 55.05 169.7
Respiratory Hospital Admissions (RHA)	168	0.077
Cardiac Hospital Admissions (CVA)	204	0.159
Emergency room visits	5,950	0.194

The results for the PM_{10} outcomes can be compared with studies for Toronto and Jakarta (see Table 7-4). Toronto has a similar population and PM_{10} levels while Jakarta's population is 8 million and PM_{10} levels were higher. Toronto has a similar mortality rate to Jamaica while that for Jakarta is higher. Jakarta's population is about three times that of Jamaica and the average reduction in ambient PM_{10} levels was about 22 $\mu g\ m^{-3}$ or about twice that used for Jamaica. The differences in population and reduction in ambient PM_{10} levels are consistent with the nearly six-fold number of shortened lives in Jakarta compared to Jamaica. Several factors such as differences in accessibility to health care, cultural patterns that determine whether or not medical attention is sought etc. can confound the results but the results for the three locations appear reasonably consistent.

Table 7-4 Comparison of Annual PM_{10} Outcomes

Study Area	Population	Shortened lives	RHA	CVA
Jamaica	2,625,200	103	168	203
Toronto	2,367,146	226	555	812
Jakarta	8,200,000	1200	2000	

7.5 QUALIFICATION OF ESTIMATES OF BENEFITS AND COSTS

The estimates for avoided morbidity and mortality outcomes rely on two main factors – the dose response relationship and the monetary value of the avoided outcome. In the absence of Jamaican data for the dose response, there is little choice but to use values derived in other studies. This raises the question of the transferability of the dose response functions to the Jamaican population. Some of the factors that could cause dose response functions to be different for the Jamaican population are differences in:

- the age distribution of population (developing countries have younger populations – sensitivity to exposure differs with age);
- composition of particulate matter; and
- exposure regime (amount of time spent indoors/outdoors).

The central estimates of the dose response functions cited for example in the WHO report cover a wide range of populations that are likely to include characteristics of the Jamaican population and it is feasible to presume that the dose response for the Jamaican population will be within the error bounds cited in the WHO report.

The monetary values for morbidity outcomes included in this study are based entirely on Jamaican health care cost data and are therefore not subject to some of the challenges that accompany studies where local health care costs are not available. It must be noted however, that not all of the health care outcomes are included and thus morbidity estimates will be underestimated.

The monetary value for mortality used here is an adjusted value of a statistical life (VSL).

The benefits are dominated by the mortality values which and are based on a VSL for a developed country but adjusted to account for relative earning capacity in Jamaica. The morbidity costs for Jamaica are very low compared to those in developed countries. For example, the cost per emergency room visit was assumed to be J$750 or US $20 in this study (1996$) compared to values of CAN$1450 or US $1,000 in the GVRD study; hospital admission costs were J$3,000 or US $80/day here compared to CAN $600/day or US $420 in the GVRD study[25]. In contrast, the costs are dominated by pollution control costs that are the same and in many cases higher in a developing country than in a developed country. In the present instance as is often the case, several health and other outcomes (e.g., soiling, visibility reduction) were not considered and/or monetised and thus benefits are underestimated. These factors effectively skew the costs to higher values and the benefits to lower values in developing countries. These relationships between costs and benefits effectively set a higher standard for regulatory acceptability (when based on benefit cost analysis) in developing countries than in developed countries.

Since the estimation of avoided health benefits is based on the reduction in PM emissions, it is useful to examine the location of industrial facilities (that will reduce PM emissions) in relation to the population centres. The reductions in PM emissions will arise mainly from cement and bauxite and alumina industries because of refurbished or replaced emission control equipment. Smaller reductions are expected from oil fired utility facilities and sugar factories through improved operational practices and a required boiler efficiency program. The effort to minimise discharge fees will also encourage fuel efficiency and improve emission controls especially of fugitive sources.

The parishes (Kingston & St. Andrew, Clarendon, Manchester and St Catherine) in which the cement and alumina industries are located account for 65% of Jamaica's population in 2000. Most of the oil fired electric utility facilities are also located in these parishes (Kingston & St. Andrew and St. Catherine). Sugar factories are located in several parishes (St. Thomas, St. Catherine, Clarendon, Westmoreland, Trelawny). It should also be noted that detailed health statistics are not readily available at the parish level. Very preliminary and as yet incomplete analysis of regional health data indicate the morbidity and mortality rates show some variation among the four regions for which data are available[39]. More detailed spatial analysis could, for example, entail using dispersion modelling to quantify exposure in specific grids for which population and health data are available and using these data to estimate health outcomes. This type of analysis would pinpoint individual facilities' contributions to health outcomes. Such analysis is not warranted given the available information on emission reductions and the additional level of effort that would be needed for such a study.

7.6 COMPARISON OF BENEFITS AND COSTS

Potential costs and benefits are compared below for three discount rates and two VSL values. The key features of the computations and assumptions are also summarised (see text box). The comparison of benefits and costs is shown in Table 7-5.

The estimates were made for three discount rates (6%, 10% and 14%) using the VSL purchasing power adjusted rate uncorrected (γ = 1) and corrected for income elasticity (γ=0.7). The preferred value for is γ is 1 which leads to a VSL of US $1.966 million. The "preferred" discount rate is less obvious. Although similar studies in the U.S. and Canada used preferred discount rates near 5%, the choice of discount rate is less obvious for Jamaica and a value of 10% is assumed.

The situation in Jamaica is complicated by the fact that costs are dominated by capital equipment whose cost is determined by U.S. or other external market prices. Typically the capital costs are higher than they would be in countries where the capital goods are produced. The relatively small local labour component for costs to industry (due to the regulations) will mean that the costs are dominated by the capital costs for pollution control and monitoring equipment.

Benefits are dominated by the monetised mortality value determined by the VSL. Since the VSL is adjusted downwards by the relative purchasing power the "devalued" benefits will be stacked against costs that are the same if not higher than they would be in a developed country. Together these factors will make it much more difficult for a regulatory measure to show a positive benefit cost.

If we assume that the preferred discount rate and VSL are respectively 10% and US $1.966 million, the regulations will have a net benefit with a benefit cost ratio of just over 5. The benefit/cost ratio is still favourable at a discount rate of 14%. The extreme conditions of a 14% discount rate and a VSL adjusted for income elasticity yields a break even i.e., similar costs and benefits (see Table 7.4). The net present values for costs are indicated in Table 7-6. The costs are dominated by capital equipment and operation and maintenance costs. Capital costs for pollution control equipment were provided by bauxite and alumina companies and were estimated for the cement plant (company provided estimates were not yet available). The estimates for maintenance of pollution control equipment provided by bauxite and alumina companies were extremely low so the costs were based on US $7.50/cfm/year for electrostatic precipitators.

Key Features of Benefit Costs Computations	
Pollutants	Control costs for PM and VOC; avoided health outcomes are estimated only for PM_{10}
Time horizon	30 years (1996-2025). Capital and ambient monitoring expenditures by industry commenced in 1996 based on notification by NRCA that regulations would follow promulgation of National Ambient Air Quality Standards (NAAQS)
Discount rate	10%. Rates of 6% and 14% included for sensitivity analysis
Residual value	Capital was assumed to have no residual value in 2025.
Exposure reduction	Control measures and incentives assumed to reduce PM_{10} exposure by at least 10 $\mu g\ m^{-3}$. Assumption based on measured ambient PM_{10} concentrations and estimates of PM emissions reductions at major facilities. PM exposure assumed to be reduced by 10% (of 10 $\mu g\ m^{-3}$) from 1997 to 2002, 20% in 2003 and increasing by 10% each year to 2011.
COSTS	Startup (assessment, screening modelling) for ~150 significant facilities and 50% (25) of major facilities; assessment, stack testing, detailed modelling 50% (25) of major facilities) Incremental environmental staff and initial training for staff Capital Ambient monitoring (gas monitoring equipment replaced every 10 years), pollution control equipment for PM at 4 major facilities, Annual operating costs for pollution control and ambient monitoring equipment, fugitive dust control, fugitive VOC control Public sector (NEPA, JBI) costs (assessment, enforcement, reviews, visits to facilities, training) Secondary economic impacts (employment, prices) assumed negligible
BENEFITS	Avoided total mortality and morbidity (hospital admissions and emergency room visits for respiratory tract infection (RTI) and cardiovascular disease (CV)) and associated lost work days for hospital admissions for RTI and CV.. Literature dose response functions and Jamaican health care statistics for RTI, CV and emergency room (ER) visits for RTI Mortality valuation was based on the value of statistical life (VSL) for U.S. adjusted by purchasing power based on elasticity adjusted and unadjusted by purchasing power parity for Jamaica relative to U.S. The recommended VSL is the unadjusted value (US $1.96 million). The elasticity adjusted value (US $0.526 million) used for sensitivity analysis. Damages for visibility not included; damages for corrosion neglected since impact due to SO_2 emissions expected to be small Health care costs (for RTI and CV admissions, average national wage rates and ER visits) based on Jamaican data for 1996 Avoided outpatient visits not included

Table 7-5 Summary Comparison of Costs and Benefits (US $ million 1996$)

Discount Rate	14%	**10%**	6%
VOSL = US $526,000			
COSTS	128.01	152.66	190.88
BENEFITS	122.38	207.18	381.62
NET BENEFITS	(5.63)	54.52	190.74
Benefit/Cost Ratio	0.96	**1.4**	2.0
VOSL = US $1,966,000			
BENEFITS	452.11	768.24	1,418.80
NET BENEFITS	324.10	615.58	1,227.92
Benefit/Cost Ratio	3.5	5.0	7.4

Table 7-6 Summary of Costs (US $ million 1996$) for Implementing Air Quality Regulations

Discount Rate	14%		10%		6%	
COSTS	123.83		147.12		183.37	
Start-up		4.38		4.80		5.28
Monitoring equipment		1.49		1.69		1.98
Ambient Monitoring Maintenance		0.23		0.32		0.48
Incremental Air Quality staff		1.97		2.70		3.83
Pollution Control & CEM		49.31		50.90		51.95
Fugitive Controls		5.04		6.57		9.09
Staff Training (one time costs)		0.35		0.36		0.37
Pollution Control equipment maintenance		59.80		78.22		108.33
Public Sector		1.27		1.57		2.04

8. CONSULTATION

8.1 OVERVIEW

The regulations were developed after extensive consultation with stakeholders. Formal consultation on the air quality regulations occurred between March 1998 and June 1999. In the latter months of 2000 and early in 2001, bauxite and alumina companies engaged JBI in discussions that eventually led to a proposal to conduct a regulatory impact analysis for three regulations including the air quality regulations. In the course of the RIA process, outstanding issues were revisited and new issues raised; some were resolved.

Invitations to participate in the consultation were sent to all stakeholders in the public, industrial, non-government organizations (NGO), academia and consulting sectors. During the formal consultation process, stakeholders undertook reviews of the draft regulations by local technical and in some cases legal staff, external consultants and/or overseas corporate/head office staff. Throughout the consultation process, NRCA provided written responses to all written comments and all oral comments made at public meetings. Stakeholders that provided extensive written comments were bauxite and alumina companies (individually and collectively), Jamaica Public Service Company, Office of Utility Regulations, Jamaica Private Power Company, Air Quality Technical Standards Subcommittee and Industrial Chemical Company. The two public meetings were attended by stakeholders from all of the major industrial sectors (sugar, bauxite/alumina and cement, petroleum, chemical, electricity generation), the public sector, academia and consulting companies.

It should also be noted that public comment was invited and received on the Draft Stack Emission Standards which are incorporated in the Air Quality Regulations. Written comments on the stack emission standards and targets were obtained from bauxite and alumina companies, one consulting company, Jamaica Energy Partners, Jamaica Public Service Company, Office of Utility Regulations and the NRCA Air Quality Technical Subcommittee.

8.2 FORMAL CONSULTATION FOR AIR QUALITY REGULATIONS

Initial consultation meetings on the proposed air quality regulations were held in March/April 1998 with industry, government and non-government organisation stakeholders to outline the proposed features of the regulations and to invite input. Written summaries of the issues discussed at the stakeholder meetings were circulated to stakeholders that attended.

A First Draft of the regulations was provided for public review and comment in May 1998. Written comments on the regulations were requested by September 30, 1998 and upon request by some stakeholders, this was extended to October 30, 1998. A public meeting to discuss the regulations and to indicate how comments received were addressed was held on November 17, 1998. It was the consensus of the meeting that the second draft, along with a tabulation of all comments on the first draft and how they were addressed in the second draft, would be circulated for a further review period of 30 days. After the review and incorporation of the comments, the regulations would go for legal drafting.

The revised drafts of the regulations as well as documentation of responses indicating how the comments were addressed in the revised drafts were also provided for circulation. These documents were submitted to NRCA early in January 1999. The revised draft regulations were circulated in February/March and comments were requested by April 30, 1999. Responses to the second set of comments were provided in June and were circulated to those that commented. Other stakeholders were advised of the availability of the responses and were invited to request copies of the comments. Stakeholders that commented were requested to meet with NRCA to discuss the responses. Other stakeholders who did not comment were notified and were also invited to attend the meeting. A meeting was held on July 13, 1999 and was attended by representatives from the bauxite and alumina industry and the Jamaica Public Service Company.

The range of issues addressed and resolved during the consultation process was extensive and are well documented. Although the Bauxite and alumina Industry commended NRCA "on the extensive review ... and the manner in which the Authority treated responses to previous comments", the industry identified three significant unresolved issues[40], namely:

- Definition of major modification;
- Improved specification for Compliance Plans; and
- Discharge fees.

NRCA agreed to review the first two issues and the bauxite industry agreed to suggest alternatives to discharge fee structure. In December 2000, the bauxite industry acknowledged[41] acceptance as reasonable the compliance plans for existing facilities. Subsequently, bauxite and alumina companies raised additional issues surrounding compliance plans that are addressed below. During the review of the regulations (for consolidating the regulations from four to one) there was no change in NEPA's definition of major modification. In subsequent discussions with stakeholders during the RIA process the issue of major modification was not raised. Additional issues were raised and these are discussed below.

8.3 ADDITIONAL COMMUNICATION

Since the July 13, 1999 meeting, discussions among the Bauxite and Alumina Industry and the Jamaica Bauxite Institute (JBI) led to further elaboration of issues surrounding the Air Quality as well as Trade Effluent and Sewage Regulations. Bauxite and alumina companies identified additional issues that should be addressed and considered in the regulations. These discussions eventually led to the current RIA process.

During the RIA process, three major concerns – the regulation development and consultation process, competitiveness and discharge fees - were expressed. Bauxite and alumina industry companies expressed concern about the potential impact the regulations could have on the industry's competitiveness and its future viability. The Jamaica Manufacturers Association indicated it was not initially consulted about the regulations and requested additional time to review the regulations. These three major concerns as well as some specific technical issues (odour regulations and targets for PM for existing sources) are summarised below and are followed by a discussion in terms of the following:

- The guiding principle(s) and/or rationale
- Comparisons with other jurisdictions
- Suggested alternatives
- Pro's and cons of suggested alternatives

Concern/Item	Category
a) The need to conduct a Regulatory Impact Analysis to include analyses of benefit cost, alternatives and industry and technology capability. Key groups (Jamaica Manufacturers' Association (JMA)) were not initially consulted.	Regulation development and consultation process
b) Short time for review of the regulations	Consultation process
c) Overall impact of the regulations on the competitiveness of Jamaica's bauxite and alumina industry. The JMA asked about air quality regulations in other CARICOM countries. Current inability of some plants to meet the emission	Competitiveness

Concern/Item	Category
target for particulate matter from alumina kilns and the high cost to comply with PM targets for alumina kilns Concerns over impact of regulations on expansion plans	
d) Bauxite and alumina companies proposed removal of discharge fees and basing regulations on prevention of significant deterioration and not cleanup of areas that meet the ambient standard. Considered level of fees burdensome. Disagreement with the application of the polluter pays principle Considered burdensome/unnecessary/unfair to meet both stack emission targets and ambient standards Bauxite and Alumina companies viewed fees as new tax Concerned that the quantum of fees could be raised arbitrarily and would be an “unknown” in the future . Posited that only fines should be applicable when standards are exceeded	Discharge fees (per tonne) Integrated Licence with a flat fee proposed by B&A companies as alternative approach
e) Different ages of plants and their associated technological capabilities to meet targets B&A companies proposed that existing plants never be required to meet emission targets (grandfathering) (which was deemed unacceptable to JBI and NEPA)	Competitiveness/Lifetime Compliance Plan (a proposal put forward in response to grandfathering and the time and costs to meet targets)
f) Bauxite and alumina companies proposed removal of the odour regulation Regulations do not include measurement of odours Potential for costly litigation	Technical
g) A utility company questioned the lack of a PM target for combustion sources Arising from this concern, it was proposed to add a particulate matter (PM) emission target for combustion sources	Technical

It should be noted that in the course of discussions during the RIA process the following issues were resolved:

- NEPA agreed to include a 30 day comment period after initial drafting by Chief Parliamentary Counsel (during which stakeholders would be invited to comment on the regulations) in the regulatory development process and this has been implemented.

- NEPA agreed to look at technology based trade effluent standards (instead of universally applicable limits)

- Other issues that were resolved relate to the sewage effluent and trade effluent regulations. It was also believed that there was clarification on the manner in which ambient water quality standards would be implemented but recent comments from industry indicate that this issue requires additional clarification. An issue concerning the monitoring method for nitrates in sewage effluent was resolved.

8.4 REGULATION DEVELOPMENT AND CONSULTATION PROCESS

The process followed for the air quality regulations included a formal consultation period of 15 months. Since January 2002 the discussions with bauxite and alumina companies and with other sectors (since June 2002) provided additional opportunity to discuss the regulations. The interactions have led to proposed changes in the process and also in the regulations.

Bauxite and alumina companies expressed concern about the regulatory development process and their ability to influence the air quality regulations during the RIA process. JMA indicated that they were not initially consulted and requested additional time to review and respond to the draft regulations as received from the Chief Parliamentary Counsel (CPC).

The current regulation development process (see Table 2-1) does include a provision for a comment period once regulations are drafted by CPC but no time period is specified. Arising from these concerns, three actions took place:

- NEPA provided all stakeholders with the most recent version of the drafting instructions for regulations that were sent to the Chief Parliamentary Counsel in January 2002. In the communication that accompanied the drafting instructions, NEPA indicated that the drafting instructions were an amalgamation of what were previously four regulations into a single regulation (other than format) and minor changes were indicated.
- NEPA agreed to include a 30 day comment period after draft regulations are received from the Chief Parliamentary Counsel. During this period comments were invited from the public.
- Based on a request from JMA, the 30 day comment period was extended to allow JMA to respond to the draft regulations. Upon request, NEPA presented stakeholders with an overview of the regulations and provided verbal answers to issues and questions raised. Such meetings took place with the bauxite and alumina companies, Private Sector Organization of Jamaica (PSOJ) Business Council for the Environment (BCE) representatives, Jamaica Private Power Company (JPPC), JMA and the Ministry of Health.

The period during which comments on various stages of the U.S. EPA rulemaking process are accepted may vary for individual actions, but it usually is 30, 60 or 90 days. The comment periods for Canadian jurisdictions typically are 30, 45 or 60 days. The Federal Government in Canada publishes in the Canada Gazette, Part I, the RIAS along with the proposed regulation and invites a 30-day comment period. When required by legislation or international trade agreements, the comment period is extended. Ontario has a minimum 30 day comment period as provided in the Ontario Environmental Bill of Rights.

The initial 30 day comment period for the air quality regulations is in line with practice elsewhere. The extension of the 30 day comment period (on request from JMA) directly responds to the request. NEPA intends to respond to comments in the same manner that it addressed comments made during the consultation process. (A written response was provided to each comment and was made available to all stakeholders).

In addition, this report includes a proposal for a “lifetime compliance plan” that includes equipment performance assessment, operational and maintenance protocols and site specific emission limits based on a number of criteria. This proposal elaborates and makes more specific provisions than were included in the compliance plan and would apply only when capital expenditures for pollution control equipment exceed US $0.5million.

NEPA indicated that in view of the significant nature of odour problems that odour would remain in the regulations but invited bauxite and alumina companies to make alternate proposals.

In response to the general concerns about the regulation process, it should be noted (as was indicated previously) that since the regulation development processes (for all three regulations) were initiated before the RIA approach was even contemplated, it is not feasible to conduct a full RIA. Consequently, NEPA did not conduct any formal analysis of alternatives to regulation.

NEPA is committed to applying the RIA concepts to the outstanding aspects of the regulation development process for the three regulations. This issue was addressed in Section 2.

8.5 OVERALL IMPACT OF THE REGULATIONS ON COMPETITIVENESS

When regulations are introduced in any jurisdiction, of particular concern are effects on firms' profitability, productivity and competitiveness and also on employment. Since bauxite and alumina companies export all of their output, they are particularly concerned about cost competitiveness only with offshore competitors who may not face the same degree of regulatory compliance costs or have other competitive advantages. In the case of electricity generating sector, the converse applies since all of the output (electricity) is sold locally and local competitiveness will be the issue. Both of these sectors rely heavily on fuel oil which is imported. For other sectors (e.g., sugar, manufacturing) the products are often sold in local as well as international markets.

In many instances local and external competitive pressures can be healthy since they force firms to develop new ways of reducing production costs or new products which can command premium prices. Comparisons of costs to determine competitiveness are often challenging especially when there are differing technologies, small markets and facilities for which cost data are not readily available.

There are two types of major expenditure for pollution control that the regulations will require:

- Capital expenditures to repair/refurbish/replace particulate emission control equipment; and
- Ongoing conduct of a boiler efficiency program for sugar factories.

Major capital expenditures are expected in the case of alumina and cement kilns that currently exceed the emission target. Although no capital expenditures for reducing PM emissions from large boilers (at electricity generating stations and alumina plants burning heavy fuel oil), small reductions in PM emissions from these boilers are expected as a result of improved maintenance. The boiler efficiency program mandated for the sugar industry will offset any perceived benefits derived from waiving discharge fees that arise from burning renewable fuels.

The discussion of competitiveness therefore will focus on the bauxite and alumina sector. A full analysis of the overall competitiveness of the industry in Jamaica is beyond the scope of this RIA A brief description of the overall investment climate and the current production costs for Jamaican alumina plants relative to other plants world wide provide an overview against which we may examine how regulations could affect production costs and hence competitiveness. Comparisons of:

- ambient air quality standards and stack emission standards;
- discharge fees; and
- regulatory approaches and the regulatory burden;

were used to infer how these factors could affect production costs and hence competitiveness.

8.5.1.1 Alumina Production Costs

Alumina capacity in Jamaica is currently 3.75 million tonnes/y and has been close to this level since 1990. Annual alumina exports since 1990 rose from 2.89 million tonnes to 3.55 million tonnes in 2001. Over the same period, bauxite exports varied between 3.55 and 4.26 million tonnes except for 1999 and 2000 when exports were curtailed because of the temporary closure of the Gramercy plant to which significant amounts of bauxite were shipped.

In the past decade, larger and more efficient alumina plants have been constructed primarily in Australia. Plant expansions in Jamaica are now being contemplated in conjunction with the removal of the bauxite levy[42] and this will place Jamaica's royalty and tax regime on similar bases as other alumina producing countries. The bauxite levy accounted for about 10% of gross earnings from bauxite and alumina between 1988 and 2001. Since production costs are calculated including the levy, its removal will effectively lower production costs.

World-wide alumina production in 2000 was 49.3 million tonnes[43] and production costs ranged from US $75 to US $240/tonne[44]. Production costs for Jamaican plants are in the second (one plant) and third quartile (three plants) of the world industry cost curve (see Figure 8-1) and are therefore very vulnerable to movements in metal prices (aluminium) and the general economic conditions which influence the demand and supply of aluminium. The component production costs for alumina are typically broken down into bauxite, caustic/lime, energy, labour and other. Environmental costs would be included in the "Other" category together with a small component of the labour costs (for environmental staff)[45]. No industry-wide information on the environmental costs for the industry was available.

Since the removal of the levy places Jamaica's tax and royalty regime on par with other bauxite and alumina countries, it is therefore vital to examine the relative environmental regimes in which bauxite and alumina countries operate. The environmental regime can be described in terms of standards (ambient and emission) and the legislative burden based on monitoring and reporting requirements.

8.5.1.2 Comparison of Ambient Air Quality Standards

Although ambient air quality standards have been promulgated in previous regulations it is useful to see how Jamaican ambient standards compare with those in other jurisdictions. Figures 8-2 to 8-4 show respectively the comparisons for SO_2, TSP and PM_{10}. The comparisons are nominal since in some cases the criteria for non-compliance with the standards (e.g., not at all, or the 98th percentile, or no more than 5 days per year etc.) are different across jurisdictions.

Jamaica's one-hour NAAQS for SO_2 is numerically more stringent than standards in the Philippines and Singapore – neither of which is a bauxite producing country. It is also numerically lower (more stringent) than Canada's maximum acceptable air quality objective but higher (less stringent) than Canada's maximum desirable air quality objective. Jamaica's NAAQS for the 1 h standard for SO_2 is numerically less stringent than those in Australia, India and Ontario.

The TSP standards are more stringent than those in India, Thailand, Colombia and Chile but less stringent than those in Canada, Ireland/EU and Venezuela.

The Jamaican 24-h average PM_{10} standard is numerically similar to those in Brazil, Singapore, Philippines and U.S. but is less stringent than those in Australia and Ireland/EU.

Figure 8-1 World Wide Alumina Costs

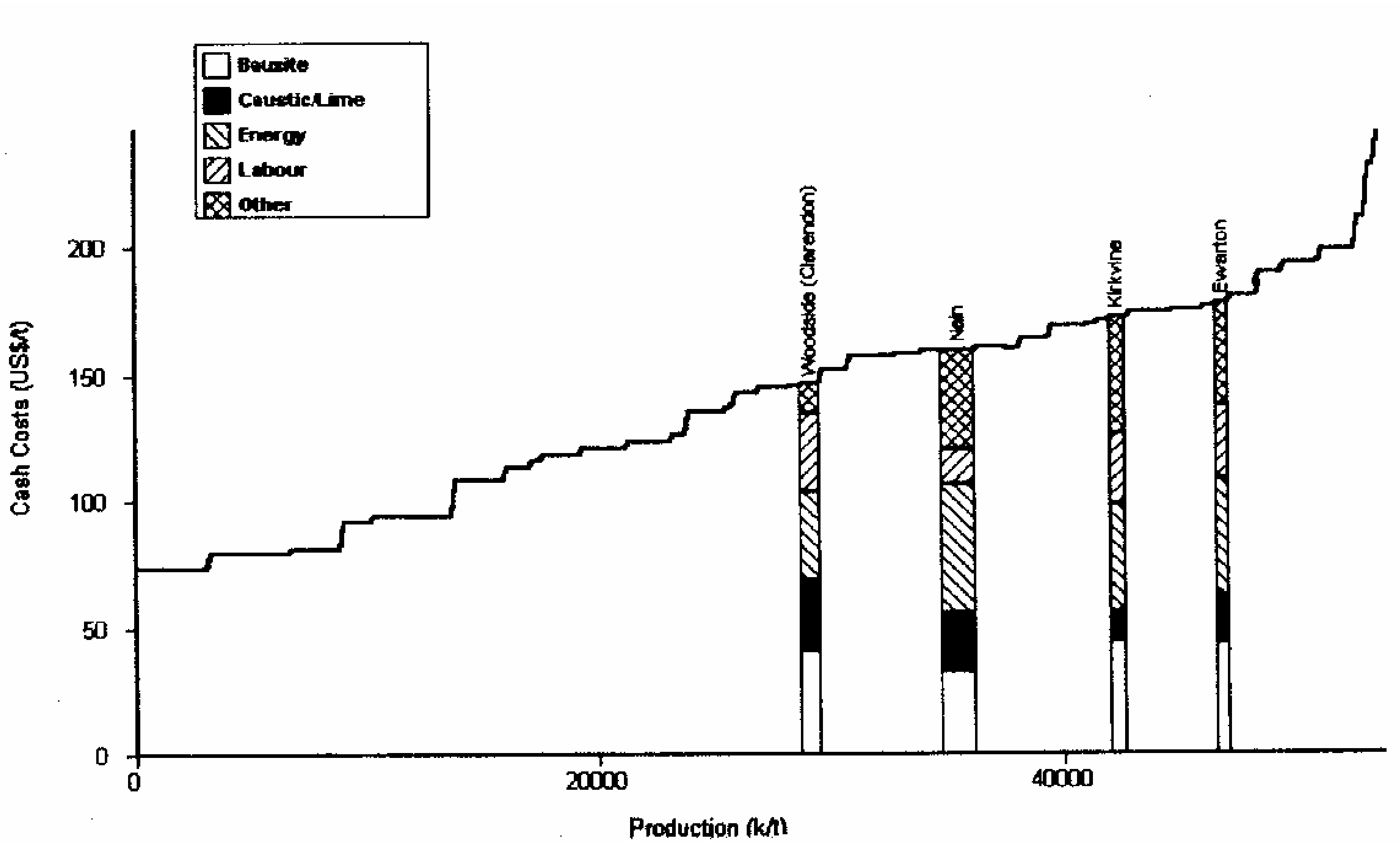


Figure 8-2 Ambient Air Quality Standards for SO_2 in Selected Jurisdictions

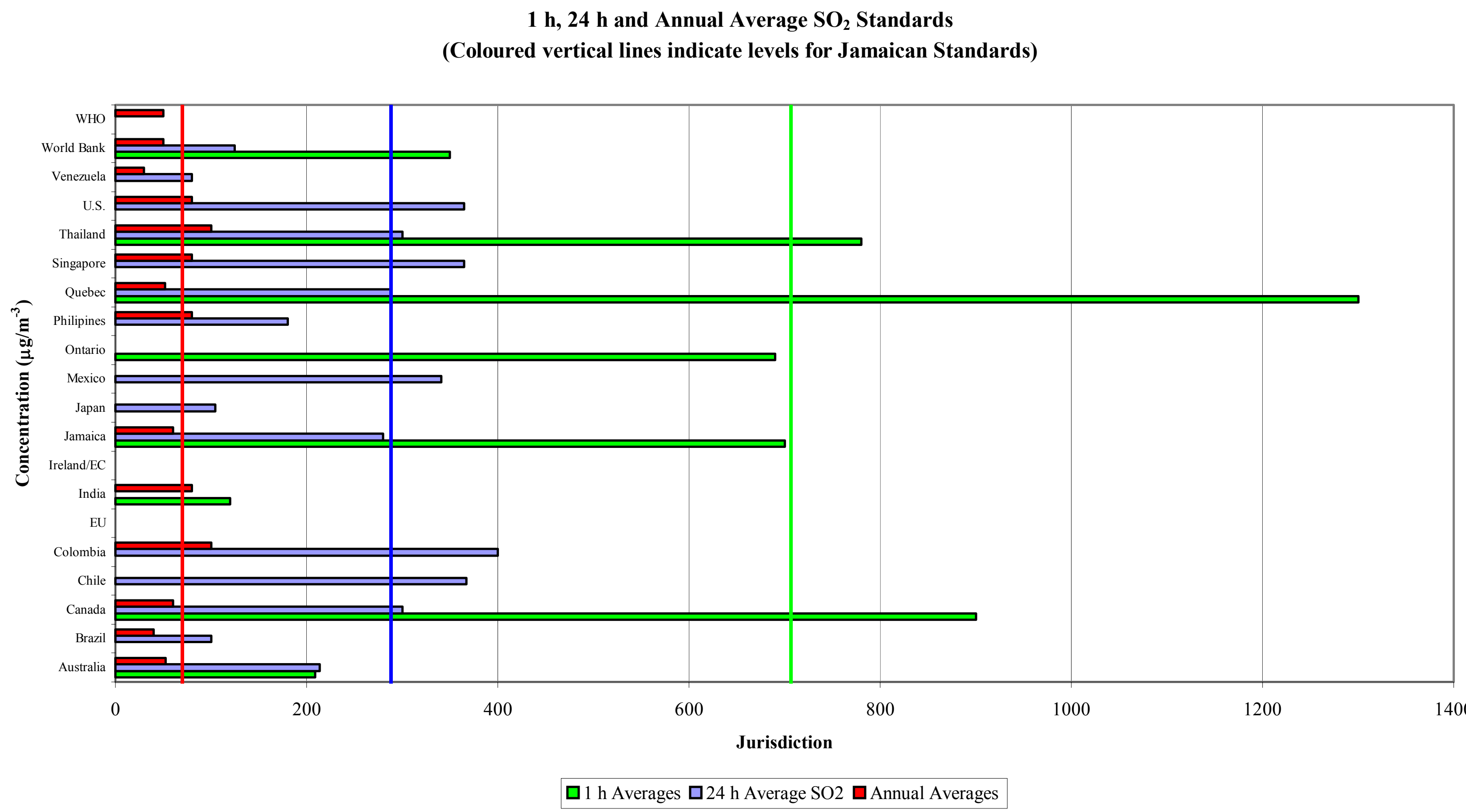


Figure 8-3 Ambient Air Quality Standards for Total Suspended Particulate Matter in Selected Jurisdictions

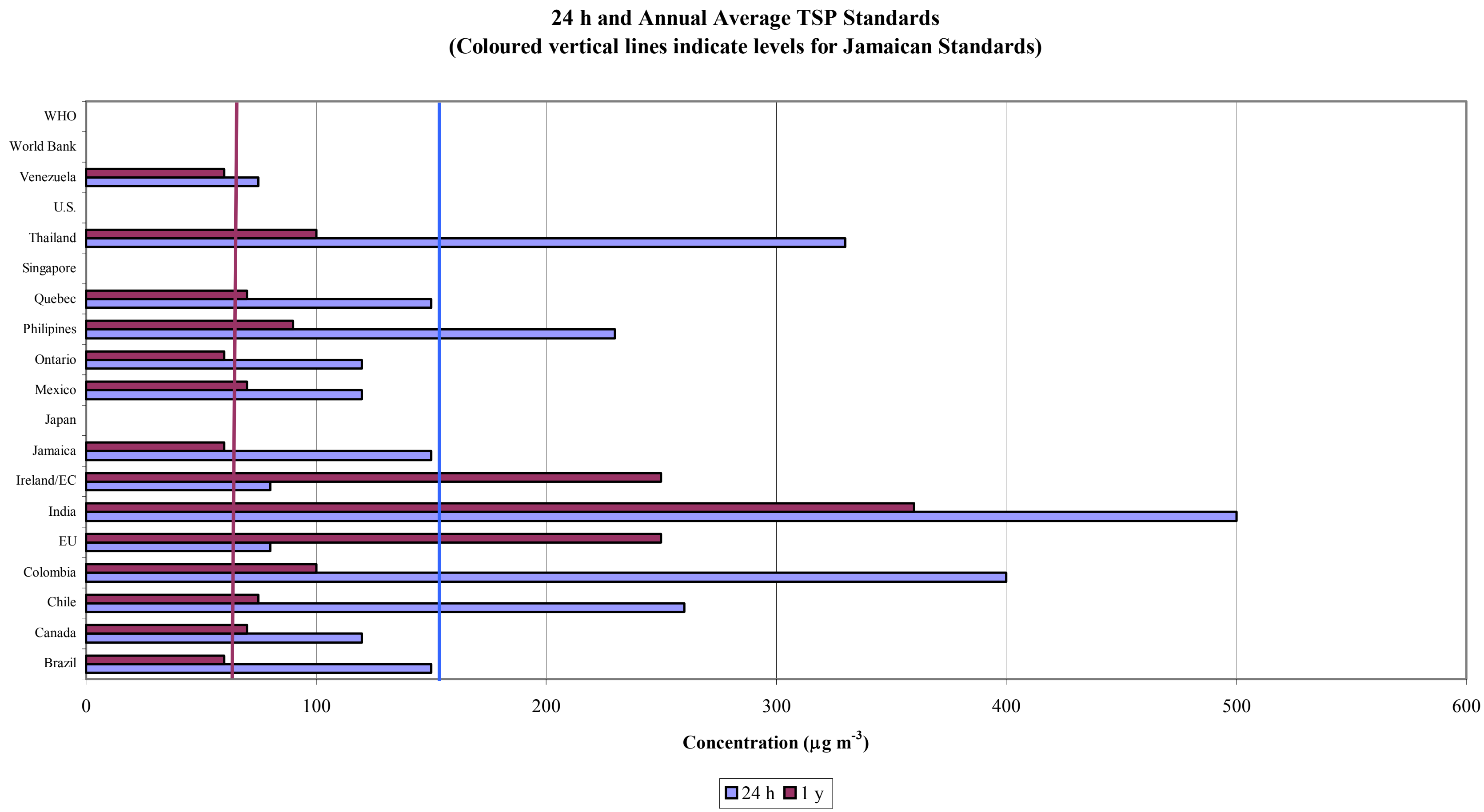
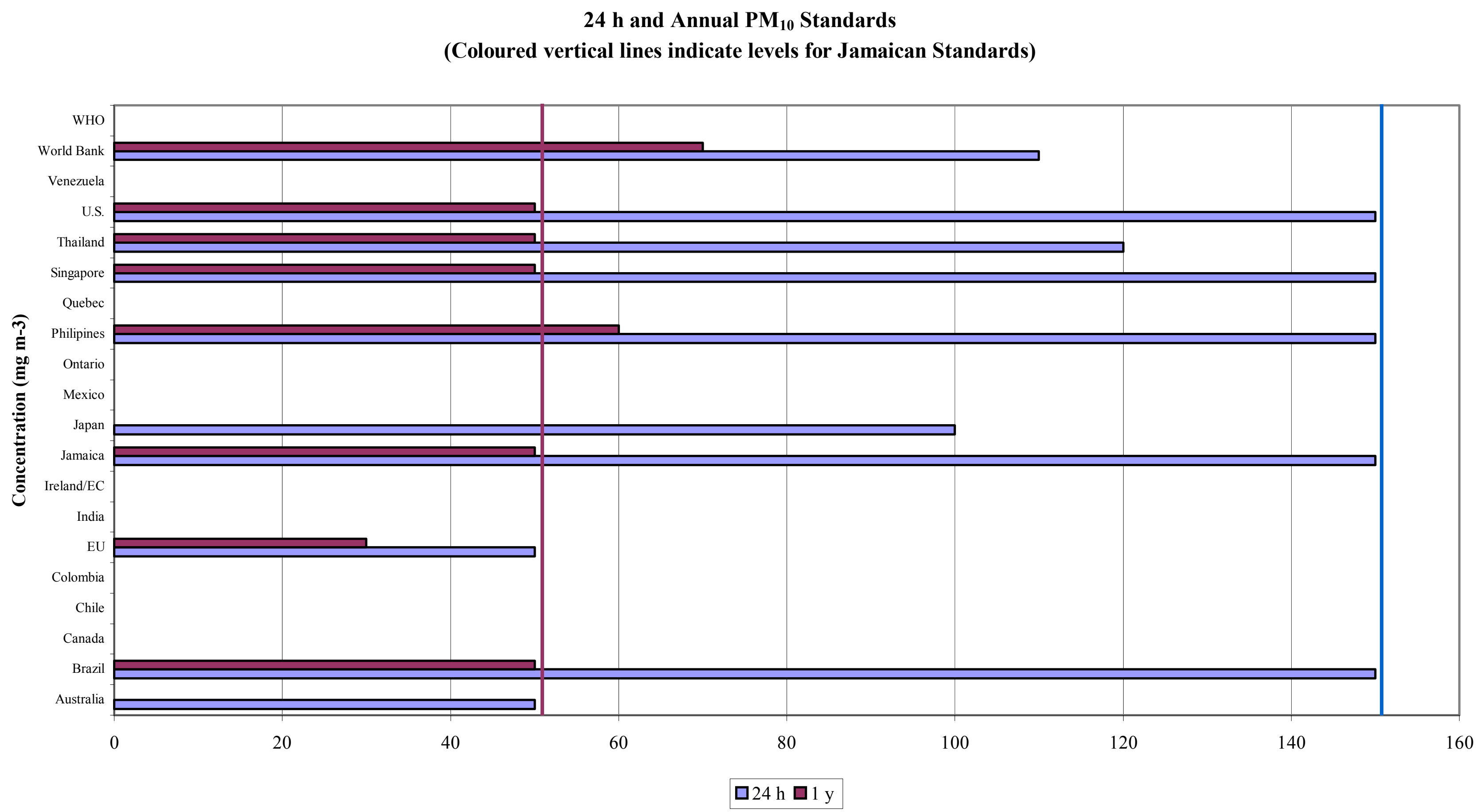


Figure 8-4 Ambient Air Quality Standards for Particulate Matter Less Than 10 μm Diameter (PM_{10}) in Selected Jurisdictions



These comparisons indicate that the NAAQS do not make the local bauxite and alumina industry uncompetitive relative to the industries in countries in which local owners operate alumina plants. The regulations will provide the means to enforce the air quality standards since the current arrangements provide no sanctions nor do they provide guidance for monitoring and reporting requirements.

In response to questions raised by the JMA about air quality standards and regulations in CARICOM countries, only in Trinidad & Tobago are there firm plans to set ambient air quality standards and associated regulations. The regulations have been drafted but details are not yet available. It is not known when the Trinidad & Tobago air quality regulations will be promulgated. There are plans for developing air quality standards in Guyana but a firm timetable has not been established. The levels of industrial activity in the remaining CARICOM countries are such that establishment of air quality regulations for industrial emissions is not a priority.

8.5.1.3 Stack Emission Standards and Targets

In developing stack emission standards and targets, standards in various jurisdictions (especially those for Canada, U.S., European Union and Japan) were reviewed and compared. The standards selected for Jamaica were generally the least stringent of those compared. No further comparison is provided here except in the case of opacity and PM emissions from kilns and fuel sulphur content levels.

Bauxite and alumina companies have argued that the opacity limits are too stringent and suggest that targets should be applicable only when NAAQS are exceeded. This issue (to require compliance with targets only when NAAQS are exceeded) is addressed below. Here we address the opacity limit.

The opacity limit of 20% is typical of the vast majority of jurisdictions and it is difficult to argue that it is too stringent. Of seven jurisdictions cited in the Stack Emissions Standards and Targets report, six had limits of 20% and one (Alberta) of 40%. The Alberta opacity limit is applicable only when the source is not covered by terms and conditions of approvals.

The approach used in developing the Stack Emission Standards and Targets for Jamaica was tailored to the Jamaican situation such that for existing sources the limits were set as targets. The regulations provide facilities with up to seven years to meet the targets and with requirements to provide a compliance plan and steps to show progress.

Related to the emission limits, the regulations also include the "bubble concept" in that facilities with multiple sources of a pollutant would be required to achieve targets only when the bubble is exceeded. Thus individual sources may be over and under the target or standard but should compensate for each other while meeting the overall facility wide limit.

In the course of this review it was evident that additional flexibility could be afforded to facilities if there were a mass based emission target for combustion sources namely boilers, as an alternative to the opacity limit of 20%. It is therefore proposed that a mass based limit for particulate matter be established for PM as an alternative to opacity. Facilities would have the option to meet either one[1]. Once such a mass based limit is in place the facilities would have the added option of including PM (and other pollutants too) emissions from boilers in the bubble.

PM emission standards for existing oil fired sources in several jurisdictions range from 14 to 42 ng/J or 50 to 150 mg m^{-3} for units >15 MW heat input. A value of 42 mg m^{-3} is considered equivalent to 20% opacity. None of the five existing oil fired steam units would meet the PM target.

[1] This provision was subsequently altered to require facilities to meet <u>both</u> the opacity and the mass based PM target.

The permit conditions at the Point Comfort (Texas) plant[46] include requirements to meet emission limits for several pollutants (e.g., CO, Hg, NaOH, NOx, PM_{10}, SO_2, TSP and VOC) at several process emission sources (e.g., conveyor transfer points, storage piles, blow off and other vents, tanks etc.). The plant is also required to meet PM emission standards for calciners, and boilers and opacity limits for several area/fugitive sources. No bubble policy is indicated. These and other conditions are suggest considerably more demanding permitting than at the Aughinish plant or those proposed in the regulations.

Jamaica's PM emission target of 100 mg m^{-3} is less stringent than the emission limit required for the calciner stacks at Aughinish alumina plant in Ireland which are required to meet 50 mg m^{-3} as of January 1, 2005 (with an interim limit of 150 mg m^{-3} until December 31, 2004) or the QAL plant (80 mg/Nm^3) in Queensland, Australia. This requirement (which is the same as the limit for new facilities) is to be met seven years after the licence was first granted (May 1998). Monitoring requirements (from the kilns) are similar (continuous monitoring).

During the latter stages of the RIA process, bauxite and alumina companies indicated that the fuel sulphur content limit (3% for existing plants and 2.2% for new facilities) precluded companies from using lower cost fuel with higher sulphur content. In view of this SO_2 emission standards in selected jurisdictions are compared in Table 8-1 where the base unit of the standards is noted and the standards is expressed in various equivalent units to allow ready comparison. It is clear that the fuel sulphur content/SO_2 limits in Jamaica are generally less stringent than in other jurisdictions. The limit in Ireland is similar to that in Jamaica. The Aughinish plant is required to use 1% S in the salt cake calciner and also to undertake studies to determine the feasibility and economic implications of using lower sulphur fuel and to use combined heat and power – to improve energy efficiency and reduce SO_2 and other emissions. For those who would argue that the Jamaican fuel sulphur content limits are too lenient, it should be noted that the regulations also provide for ambient monitoring and/or dispersion modelling to manage ambient SO_2 concentrations. The experience (noted in Section 3) is that ambient SO_2 concentrations at some Jamaican facilities are predicted (by dispersion modelling) to exceed the ambient standards and hence require ambient monitoring[47] to determine compliance. Where ambient monitoring shows exceedance of the standard NEPA would (presumably) require the facility to use lower fuel sulphur content or other means to lower SO_2 emissions.

It is clear that the emission targets for PM and SO_2 (through the fuel sulphur content limit) do not place Jamaica's industry in an uncompetitive position based on emission limits. It could be argued that since the emission limits are generally less stringent, they therefore provide a competitive advantage but other factors (unrelated to the regulations) such as use of different fuels and technologies make the comparisons difficult.

8.5.1.4 Comparisons of Discharge Fees and Application Fees

Only the relative magnitude of the fees i.e., from a competitiveness perspective, is discussed in this section. The bases for discharge fees are discussed elsewhere.

The amount of fees for licences (or permits as they are called in some jurisdictions) and the bases for determination of application fees vary widely. Since the magnitude of the application fees was not raised as an issue the discussion will be limited to the per tonne discharge fees.

Table 8-1 Comparison of SO_2 Emission Standards in Selected Jurisdictions

Authority/Jurisdiction	Base Unit of standard	Standard	%S in fuel	mg m^{-3}	ng SO_2/J	lbSO_2/10^6 Btu
Ireland		5,100	3.04	5,100	1,428	3.327
Jamaica (target – existing sources)	%S in fuel	3.0	<3.0	5,027	1,408	3.281
Jamaica (standard – new sources)	%S in fuel	2.2	2.2	3,688	1033	2.407
Germany	mg m^{-3}	400	0.24	400	112	0.261
Canada (up to 300 MW)	mg m^{-3}	1700	1.01	1,700	476	1.109
Queensland, Australia	%S in fuel	<3.0	<3	5,207	1,408	3.281
US NSPS ((29 - 73 MW)	ng SO_2/J	340	0.72	1,214	340	0.792
US NSPS ((2.9 to 29 MW)	ng SO_2/J	215	0.46	768	215	0.501
	Lb SO_2 /10^6 Btu					
World Bank (< 1000 MWe)	tonnes SO_2/day/MWe	0.20	1.23	2,066	579	1.348
World Bank (< 1000 MWth)	tonnes SO_2/day/MW (25% eff)		1.23	2,066	579	1.348
	tonnes SO_2/day/MW (30% eff)		1.48	2,479	694	1.618
	tonnes SO_2/day/MW (35% eff)		1.73	2,892	810	1.888
	tonnes SO_2/day/MW (40% eff)		1.97	3,306	926	2.157
	tonnes SO_2/day/MW (45% eff)		2.22	3,719	1042	2.427
World Bank (< 1000 MWe)	mg m^{-3}	2000	1.19	2,000	560	1.305

The discharge fee of J$100/tonne for each of SO_2, NOx and PM and J$200/tonne for priority air pollutants can be compared with similar fees charged (called permit fees, contaminant fees or annual fees) in other jurisdictions. Table 8-2 summarises fees for selected jurisdictions – noting that the list of jurisdictions is not exhaustive.

Except for SO_2 fees in New South Wales, the per tonne discharge fees for Jamaican regulations are much lower than in other jurisdictions.

Bauxite and alumina companies estimated that the discharge fees payable would be US$294,000 for an annual production of 3.5 million tonnes alumina. This would be equivalent to US$0.08/tonne of alumina. In the case of utility companies, the estimated fees are J$4.1 million which corresponds to J$0.00125/kWh (for assumed generation of 3,300 GWh in 2000). These metrics can be compared with the median worldwide cost of producing alumina (~US$145/tonne) and with the cost of electricity (J$6.31/kWh) to general service Jamaican customers (the rate category using the largest share of generation). These relative costs indicate that the discharge fee will not materially affect the production costs of alumina nor is it a significant fraction of the cost (to customers) in the case of electricity generation. The discharge fees estimate for JPSCo (J$4.1 million) is negligible compared with JPSCo revenues (J$16.5 billion in 2000). In the case of bauxite and alumina companies their estimate of the discharge fees (US$0.3 million) is small compared with the export value of bauxite and alumina (~US0.74 billion in 2000) or with the bauxite levy (US $68.7 million).

Discharge fees may also be examined by comparison with costs for pollution control equipment costs. The use of discharge fees – sometimes called pollution charges are common in OECD countries, economies in transition and are being introduced in Latin American and East Asia countries[48,49]. Ideally, pollution charges are set at a level such that it is economically advantageous to implement pollution abatement measures rather than pay pollution charges (discharge fees).

By way of example, discharges fees that are equal a US $1 million capital investment would be equivalent to about 16,000 tonnes/y over a 30 year period based on J$100/tonne or US $2.09/tonne and for undiscounted payments. If the current PM emission rates at an alumina plant are ~16,000 tonnes above the emission target then if the abatement costs are higher than US$1 million, it would be less costly (in undiscounted monetary terms) for a company to pay the discharge fees rather than install pollution control equipment. Actual abatement costs for 16,000 tonne reduction are 3 to 10 times higher based on estimates provided by companies and thus the discharge fees of J100/tonne are too low to provide a real incentive for changing behaviour.

The discharge fees provide an equitable way of allocating fees among licensees. Other means for allocating charges among licensees (equally among all licensees, or two tiered charges, based on plant capacity etc) were examined and considered less equitable. Since the reporting requirements (annual emissions for common and priority pollutants) are required for other purposes, the administration of a per tonne based system does not increase the administrative burden for the licensee or the regulator.

A key complementary aspect of the regulatory reporting requirements is the use of the annual emissions data for public reporting in a pollutant release and transfer register (PRTR). The PRTR is planned also to report compliance information as well as pollution prevention and energy efficiency measures that facilities have implemented and/or plan to undertake. The register will provide communities with information on facilities' discharges and should act as additional incentives for facilities to reduce emissions. Similar programs undertaken in Indonesia and Philippines have shown that such public disclosure programs can curb pollution at modest cost[41].

Table 8-2 Comparison of Discharge Fees for Air Pollutants (US $/tonne)

Jurisdiction	Pollutant								
	NOx	SO_2	PM	PM_{10}	$PM_{2.5}$	CO	VOC	Metals	Other contaminants not otherwise specified
Jamaica	2.09	2.09	2.09						4.18[1]
British Columbia	4.84	5.60	7.20			0.19		288.86	7.20
Louisiana	9.72	9.72	9.72				9.72		108[2], 54[3], 27[4]
Kansas	27.89	27.89	27.89						
Texas	26.00	26.00	26.00						
Ohio	32.65	32.65	32.65				32.65		
Kentucky	27.89	27.89	27.89				27.89		
Western Australia	4.44	4.44	4.44	4.44					
New South Wales	3.25	0.81	6.49		46.53				

[1] Priority Air Pollutants as defined in the regulations
[2] Known and probable human carcinogens;
[3] Suspected human carcinogens and known or suspected human reproductive toxins;
[4] Acute and chronic non-carcinogenic toxics

8.5.1.5 Other Comparisons to Determine Cost Competitiveness

Information on environmental costs at other bauxite and alumina facilities could be used as another of the bases examining cost competitiveness. In addition to the cost information, some of the contextual information that help to determine costs (e.g., demographic and receptors near facilities, background air quality and legislative arrangements) was requested so that the numeric cost information could be put in perspective. Such information was requested of companies and only limited amounts have been received. The discussion is therefore limited to cursory comparisons of the regulatory requirements.

Some of the regulatory requirements in bauxite and alumina producing countries (Australia, Canada, Ireland, U.S.) include annual reporting for pollution registers. Such requirements are planned for Jamaica and will be implemented in a manner that will not entail any additional reporting beyond that required in the air quality (and eventually trade and sewage effluent) regulations. It is not clear if the reporting requirements in the aforementioned countries have similar provisions.

Other issues relate to the amount of ambient monitoring (number of stations, parameters measured) and the type (parameters and frequency) of stack testing required. In any event, much of the required the ambient monitoring and to a lesser extent stack testing requirements are already being done by bauxite and alumina companies.

8.5.1.6 Global Competitiveness

Current attitudes and indeed requirements for some areas of trade are increasingly requiring companies to demonstrate green procedures or good environmental practices as conditions for trading or business transactions. Some companies use public reporting and their environmental management systems (e.g., ISO 14000 accreditation) and environmental performance generally to enhance their public relations and corporate image.

At the international level, there is increasing support for the notion that economic competitiveness and good environmental performance are not only compatible but mutually reinforcing. Policies and regulations that promote energy efficiency and reduce pollution will bode well for sustainable economic growth. Preliminary analysis of the ranking of environmental regulation and performance suggests that a stringent environmental regime relative to income (GDP) may enhance rather than curtail economic growth[50].

8.5.2 Integrated Licences/Regulatory Approach

Bauxite and alumina companies proposed removal of discharge fees and "basing regulations on prevention of significant deterioration and not on the cleanup of areas that meet the ambient standard". They voiced disagreement with the application of the polluter pays principle and considered fees to be burdensome, unnecessary and unfair because there is a requirement to meet both stack emission targets and ambient standards. Bauxite and Alumina companies and others view fees as new tax. There is also concern that fees could be raised arbitrarily and would be an "unknown" in the future. They proposed that only fines should be applicable when standards are exceeded.

As an alternative bauxite and alumina companies proposed an integrated licence similar to that in Ireland and in particular that at the Aughinish alumina plant. This would be an alternate strategy to three separate single-medium licences that the Jamaican regulations would require. At the same time companies urged that the conditions of the licence or permit at the QAL and Gramercy plant be reviewed with a view to using desirable features of these licences/permits.

Analysis of the "Aughinish alternative" requires information on the context of the Aughinish licence and that information is provide here.

Ireland is among the leaders in Europe in establishing an independent Environmental Protection Agency with wide executive functions. Under Ireland's EPA Act of 1992, all major industrial activities with potential to cause environmental pollution are required to hold an Integrated Pollution Control Licence (IPCL). The Environmental Protection Agency (EPA) runs the IPC licensing system in Ireland with similar legislation being introduced across the European Union. The licensing is based on BATNEEC (best available technology not entailing excessive costs). Specific guidance for the alumina industry (and also for other industries) was prepared by EPA in preparation for licensing. The technologies and emission limits specified in the guidance are intended for a new facility but existing facilities are required to move towards such limits. The policy also indicates that more stringent site specific limits may be set whenever environmental protection so requires.

After a lengthy application process including a public hearing, the EPA issued Aughinish Alumina Ltd (AAL) with an Integrated Pollution Control licence on 27 May 1998. Previously, separate licences were required for water, air and waste discharges. The main conditions of the licence are shown in Table 8-3.

The concept of an integrated licence is an excellent one. In Ireland, the air quality (as well as trade effluent) standards were in place prior to the licence. As a member of the European Union, Ireland has the benefit and the requirement to conform with EU regulations and policies. Unfortunately, Jamaica is not in a position to benefit similarly and it would be prudent to develop Jamaican solutions to such a licence.

NEPA should be encouraged to move in that direction. Some indications of such movement can be seen in the development of the three regulations. Specifically, the application and reporting forms for the Air Quality, Sewage and Trade Effluent regulations are being designed to be common. Also, in principle, the same common "front end" of the form would be used in all three regulations. Until all three regulations are developed, the integrated licence is not feasible. It is also not prudent to await their completion simply to have an integrated licence. In the interim, fees based on regulations that are in place in effect would "modularise" the fees as noted during the review of the report.

Table 8-3 Summary of the Main Features of the Aughinish Licence

	Year	Year
Boilerhouse (expressed as mg/Nm^3 @3% O2 dry basis)	2000	2005
Sulphur dioxide concentration*	5100	5100
Nitrogen oxide concentration	750	670
Particulate concentration (dust)	none	50
Opacity (Ringleman scale)	20	20
Calciner (expressed as mg/Nm^3 @11% O2 wet basis)		
Sulphur dioxide concentration	1350	1350
Particulate concentration (dust)	150	150
Licensed Bag Filters (expressed as mg m^{-3})		
Particulate concentration (dust)	50	50
Bauxite Scrubber (expressed as mg m^{-3})		
Particulate concentration (dust)	100	100

Some of the specific conditions in the Aughinish Licence (see Table 8-4) are more stringent than requirements under the air quality regulations.

The terms and conditions of the air emissions requirements for the Aughinish licence are more stringent than that proposed in the Jamaican targets – in terms of limits (licence conditions vs targets) and time to comply (2005 for Aughinish vs up to 7 years for Jamaica – or up to 10 years in the lifetime compliance plan proposal). The Lifetime Compliance Plan proposal for Jamaica also includes the provision for extending the time for compliance beyond ten years but at NEPA's sole discretion.

Bauxite and alumina plants in Queensland, Australia also have an incentive licensing scheme that rewards businesses that achieve high standards of environmental management. The licensing scheme encourages them to move towards best available environmental management practice in environmental management. Similarly, Western Australia has a category of licensing termed Best Practice Environmental Licences (BPEL). These are earned when good performance is demonstrated, best practice environmental management is utilised and there is an ongoing program for continual improvement in environmental performance. No discharge fees are charged when a facility has a BPEL. The QAL plant in Queensland and the Alcoa plant in Western Australia have been awarded such licences.

These programs clearly require a well established regulatory system and demonstrated environmental performance for their implementation. For example, the criteria for the Western Australia BPEL include features that companies in Jamaica already have (environmental policy, environmental management plan, monitoring program) but they also include:

- Environmental objectives agreed with the regulatory agency;
- An implementation program;
- Benchmarking environmental performance;
- Community involvement;
- Reporting environmental performance; and
- Acceptable audit plan to demonstrate control and verification of environmental actions.

The BPEL can be revoked if facilities are issued an abatement notice, successfully prosecuted under the Act or if there is non compliance with BPEL criteria.

It would be challenging at best for such a system to be implemented from the outset of regulations in Jamaica because of the amount of capacity building that will be necessary in both the private and public sectors. However, the regulations (air, trade effluent, sewage) will provide the framework for these issues to be addressed and NEPA is encouraged to move in this direction.

8.5.3 Discharge Fees/Polluter Pays Principle

During the consultation and since, bauxite and alumina companies and others have raised various objections about the discharge fees. Companies initially proposed that the discharge fees be reduced from J$100/tonne to J$50/tonne for SO_2, PM, NOx and CO and recommended J$200/tonne for each priority pollutant.

Table 8-4 Comparison of Selected Features of the Aughinish Licence and Provisions in Jamaican Air Quality Regulations

Item	Aughinish	Jamaica Plants
Sulphur content of heavy fuel oil to be used in Salt Cake calciner	<1%	<3% (existing) <2.2% (new)
NOx Boiler house (mg m^{-3})	750 670 in 2005	200 ng/J (713 mg m^{-3})
PM Boiler house	50 mg m^{-3} (in 2005)	
Opacity Boiler house	20%	20%
PM calciner	150	
PM Lime kiln	NA	1000 g/tonne for all plant sources

The current proposals articulated by the companies appear to be:

- Eliminate all discharge fees – but as a fallback position; and
- Introduce a flat fee to include air, liquid and solid waste (similar to what takes place in Ireland). The companies also noted that the discharge fees support the polluter pays principle and that companies in North America have encouraged US EPA to levy taxes towards the prevention of significant deterioration.

As indicated previously an integrated licence although attractive is impractical without regulations for trade effluent and thus does not warrant further consideration until such regulations are in place. A flat fee for the air quality regulations will then require some basis for allocating fees among licensees. In the absence of specific proposal several strategies can be considered based on practices in other jurisdictions. Some of the bases for assigning fees include:

- Base fees on the complexity of processing applications (e.g., number and types of processes, time to review application)
- Assign facilities to two or more categories (e.g., Significant and Major) and assign a different fee to each category. (Bases and hence assignment of fees for more than two categories could be developed.)
- Set fees based on facilities' capacity or potential to emit
- Set fees based on actual emissions

The polluter pay principle (as proposed in the regulations) is considered the most equitable basis. The polluter pays principle and user fees are the basis adopted by NEPA for charges to its customers. These bases are consistent with the National Industrial Policy[20].

Bases for Discharge fees can be summarised as follows:

- Application of the polluter pays principle.
- The fees provide an equitable means to allocate costs among licensees.
- It should be noted that the regulations also include fines to be applied when ambient and stack emission standards are exceeded. The regulations specifically exclude existing facilities from being fined when targets are exceeded for the period during which facilities file and conform to a compliance plan.
- It should also be noted that fines levied through the courts go into the Consolidated Fund and not to NEPA
- The regulations include provisions that would limit the rate at which the fees could be raised – as proposed by the bauxite and alumina companies. These provisions were excluded from the draft regulations on the grounds that such changes to fees would require a revision to the regulations. It is recommended that NEPA request CPC to include the provision of limiting fee adjustment to no more frequently than every 5 years (the duration of the licence) and the increase to no more than the change in the consumer price index. Alternately, these provisions could be stated as a formal NEPA policy.

Practices in other jurisdictions

- Discharge fees or load based fees for air and/or water pollutants are in place in jurisdictions with bauxite and alumina plants e.g., New South Wales, Western Australia, U.S. (Louisiana, Texas) and others (China, Malaysia, Philippines, Colombia, several OECD countries and U.S. states).

- It is common practice for jurisdictions to have both ambient air quality standards as well as emission limits and to require both to be met. Emission limits are established for many types of industrial sources as well as for mobile sources. It is likely that energy efficiency standards expressed as mobile source fleet mileage standards or as CO_2 emission limits could in the future be added to the mix of limits for industrial sources.

- Some jurisdictions, notably in the U.S., set permit fees that entail a charge per tonne of pollutant emitted for cost recovery by the government agency or department administering and enforcing the regulations.

- The per tonne discharge fees sometimes are weighted so that they are higher for more toxic pollutants. The complexity of such systems vary from individual weighting for each pollutant to groups of pollutants (such as is proposed in Jamaica).

- Some jurisdictions in the U.S. do not charge per ton fees above a certain level of emissions.

- Some jurisdictions adjust rates annually, or set limits on the increases (e.g., no greater than the relative changes in the consumer price index).

Pros and cons of the alternative scheme (a flat fee) proposed.

Without the benefit of any details from bauxite and alumina companies, it is necessary to develop a basis for setting fees. Such a scheme will need take into account the differences among licensees. Possible bases are as follows:

A single tier of fees – i.e., share costs equally among all licensees;

Two (or more) tiers of fees – one for major facilities and another one for significant facilities (or other multiple categories of facilities); and

Allocate fees according to the capacity or potential for facilities to emit pollutants (e.g., the maximum emissions for which a facility is licensed).

Pros

- A flat fee system is simple to administer

As the mechanism for setting the amount of the fees becomes more complex the simplicity is removed. Basing fees on the potential to emit will create problems when production levels and hence emissions are significantly different from the licensed amount.

Cons

- A flat fee system does not reward facilities that improve performance (reduce emissions) or go beyond compliance. For example, if there are two facilities that both comply with standards, the one with lower emissions is not rewarded;
- No distinction is made between large and small facilities (this can be mitigated by multiple tiers but with added complexity);
- Facilities will have no incentive to minimise their releases;
- Basing compliance on ambient standards only would place additional emphasis on ambient monitoring (number and placement of monitors). Ambient monitoring especially by smaller facilities will be very expensive; and

- Proving non-compliance with ambient standards has been traditionally difficult for jurisdictions to achieve. This is especially true in areas where multiple sources impact on an ambient monitor.

Comments on the remaining concerns are summarised as follow.

a)	Different age in plants and their associated technological capability to meet targets B&A companies proposed that existing plants never be required to meet emission targets (grandfathering) (which was unacceptable to JBI and NEPA)	Lifetime Compliance Plan (a proposal put forward in response to grandfathering and the time and costs to meet targets)
b)	Concerns over impact of regulations on expansion plans Level of PM emission standard for new alumina kiln sources	Competitiveness
c)	Bauxite and alumina companies proposed removal of the odour regulation and claimed that odour regulation increased the potential for costly litigation	Regulations do not include a requirement for measurement of odours. They do require the development of industry- and sector-specific guidelines and protocols to manage odours. Such guidelines are to be developed jointly between NEPA and the sectors/industries.
d)	A utility company questioned the lack of a PM target for combustion sources	Arising from this concern, it was proposed to add a particulate matter (PM) emission targets for combustion sources and that the PM target be in addition to the opacity target

8.5.4 Grandfathering

Alumina plants in Jamaica were established in 1952, 1959, 1969 and 1972 and thus are 50 (Kirkvine), 43 (Ewarton), 33 (Alpart) and 30 years (Jamalco) old. The most recent plant expansions and installation or upgrades of major pollution control equipment are summarised in Table 8-5.

The bauxite and alumina companies have proposed grandfathering of older plants. The bases for the companies' proposal are the age of the plants, high costs and some jurisdictions, notably states in the U.S., have allowed grandfathering. This would mean that the grandfathered plants, i.e., all plants would never be required to meet emission targets unless certain conditions - usually plant expansion – occur. Grandfathering was applied in the U.S. on the mistaken belief (as it turns out) that older plants would cease to operate soon after the Clean Air Act was introduced in 1970 and that they would be replaced by newer plants. Many of these older plants continue to operate today. For example, the Gramercy plant is grandfathered (except for a few sources) and as such is not required to meet the New Source Performance Standards.

The Jamaica air quality regulations do not include any consideration of grandfathering so it is not appropriate to indicate any guiding principles.

NEPA and JBI have indicated that grandfathering is not acceptable. It should be noted that given what is known of the effects of PM on human health, it would be responsible for companies to reduce and minimise the PM emissions and for NEPA to ensure and encourage that this is done. At the same

Table 8-5 Summary of Plant Capacity Expansions and Pre-1996 Pollution Control Changes

Plant	Year	Capacity ('000 tonne)	Comment
Alumina			
Alpart	1969 1973 1990 1992	600 1,000 1,450	ESPs & multiclones There is a need to determine if ESPs on rotary kilns were upgraded to meet increased capacity when 1973 and 1990 capacity upgrades took place ESPs & baghouses for 2 Lurgi kilns
Jamalco	1972 1990 1991/2 1998	500 750 1,000	 ESP addition/upgrade Dust control at port Was emission control equipment upgraded?
Windalco - Ewarton	1959	650	
Windalco - Kirkvine	1952	600	
Bauxite			
KJBC	1952 1988	3,800 4,500	 Was emission control equipment upgraded?

time reasonable bases and strategies for achieving timely and cost effective emissions reductions are needed.

The regulations explicitly recognise this need by a) formulating emission limits for existing sources as emission targets and b) specifying a process (compliance plans) that includes a period of up to seven years for compliance.

Bauxite and alumina companies requested a more flexible and less restrictive arrangement and in response to this request a "Lifetime Compliance Plan" scheme was proposed. The key features of the LCP process are:

- The LCP is to be applied when an existing facility is applying for a licence and when compliance with emission targets would require expenditures in excess of US $500,000. The normal compliance plan also would be required when costs are les than US $500,000.
- Implementation of the LCP would entail:
    - Problem Assessment – stack tests, verification of design features for emission control equipment and associated processes
    - Implementation of industry best practice **maintenance** and operational procedures for emission control equipment and related processes
    - Based on some history of best practice operation and knowledge identify system capabilities allowing a reasonable operating margin
    - Establish site-specific limits that would be specified in the licence. The limits would be based on matching the refurbished/repaired or new emission control equipment to current (August 2002) plant capacity and production levels.
    - Revision of regulations to preclude prosecution for violation of emission targets until after the site-specific limits are set
    - Warnings, control orders and prosecutions would be based on non-compliance with Lifetime Compliance Plans (which would include best practice maintenance and operation procedures etc.)
    - Include provision for additional time for achievement of site specific limits

8.5.5 Odour Regulation

Bauxite and alumina companies asserted that the odour regulations:

are not clear;

will be open to many interpretations;

should be based on measurements ; and

are not necessary since, as a nuisance, odour is already covered by common law.

The companies also asserted that "the regulations as printed will create more harm than good" and proposed that the odour issues be included as conditions of licences.

Basis for odour regulation

Because of frequent complaints, NEPA asserts that measures to address odours need to be included in the regulations so that facilities responsible for such odours can be forced if necessary to address the odour problem. NEPA is also of the view that management of odours will be more effectively done at this time by best management practices rather than requiring expensive and dubious monitoring and measurement of odours.

In general, odours can be measured on a compound specific basis when the agent (the specific compound) responsible for the odour is known. Another measurement technique which does not require knowledge of the responsible compound is to use an odour panel. The panel consists of a prescribed number of individuals who are asked to indicate when they do not detect an odour after a series of dilutions of a malodourous sample of air. The amount of the dilution is used as a measure of the odour.

Both measurement methods are complex, cumbersome and expensive. This is why the approach adopted in the regulations does not require measurement of odours but requires facilities responsible for odour to use best management practices in attempting to minimise or eliminate the basis for odour complaints. Common law makes no such provisions and would require proof of nuisance. The regulations will require proof of best efforts to address odour. The regulations also require NEPA to develop, in conjunction with industry, guidelines for odour management. These guidelines have not been written as yet and would be done with industry participation and consultation. As suggested by the bauxite and alumina companies, the regulations provide for odour management to be conditions of licences – but the Guideline Document would provide the basis for industry-specific odour management practices.

Without guidance on what should be done, there would be no transparency or guidance as to what NEPA would include or what can be expected on a consistent basis. Once there are protocols and guidance for odour in the Guideline Document that specifies the requirements then NEPA, licensees and the public will all know what the expectations are and both parties may act accordingly.

It is recommended that the industry specific odour guidance be developed in conjunction with industry sectors which initially should include waste management (sewage treatment), bauxite and alumina and selected agriprocessing industries.

8.5.6 Concerns Over the Impact of Regulations on Expansion Plans

The potential impact of the regulations on expansion plans was raised indirectly by bauxite and alumina companies. A practical example which was discussed during the RIA process, indicated how fuel sulphur content would be determined for a plant expansion that is considered a major modification.

The regulations stipulate new sources or existing sources undertaking a major modification will be required to use heavy fuel oil with no more than 2.2% sulphur. The regulations also indicate that a bubble can be applied to the facility. The fuel sulphur allowances for the old part of the plant (based on up to 3% sulphur) and for the new part of the plant (up to 2.2% sulphur) would be estimated. The average sulphur content will be somewhere between the two and the modified plant would then use fuel sulphur in both old and new parts with this average fuel sulphur content.

The regulations require that plants with major modifications use pollution control equipment that meet the emission standards for the new sources at the facility (while existing sources would meet emission targets). Use of the bubble policy will allow existing non-compliant existing sources to be offset by new (or existing) sources that are below the standard (or target) as the case may be.

Another issue that could arise is the switch from heavy fuel oil to liquefied natural gas (LNG). Since LNG has negligible amounts of sulphur and particulate emissions from LNG combustion are considerably lower than those from heavy fuel oil, SO_2 and particulate emissions would be reduced if the switch were made. The relative amounts of NOx emitted would depend on the type of burner technology and efficiency etc. The regulations already include provisions for emission standards for LNG combustion.

9. COMPLIANCE, ENFORCEMENT AND MEANS TO EVALUATE EFFECTIVENESS OF THE REGULATIONS

Compliance and enforcement issues together with means to evaluate the effectiveness of the regulations are described in this section.

The number of major facilities is small (<50) and most if not all of the major facilities have participated in the development of the regulations. It is anticipated that all of the major facilities will be licensed.

The number of significant facilities is less certain and for cost estimation 150 significant facilities were assumed. It is likely that the actual number will be lower than this. The phasing in of the regulations to include significant facilities one year after the major facilities are licensed will provide much needed time for NEPA and the facilities to build capacity. There is little doubt that capacity is lacking in smaller facilities but the human capital undoubtedly exists in these firms. Hence training should be effective in providing staff in these companies with the needed skills. In addition, training of local consultants and academics can supplement the in-house pool as needed.

Capacity is required within NEPA and JBI (and other government agencies that can assist) to undertake all of the tasks required for outreach to the regulated community and the public, assessment and review of licence applications and ongoing inspection and enforcement activities. Initial training for public sector staff took place in 1999 but with staff turnover and the passage of time the training needs to be repeated and reinforced. Similar or equivalent training for private sector is planned to take place as soon as the regulations are promulgated.

Methods to evaluate the long-term effectiveness of the regulations are described. The measures are expressed in terms of specific objectives and measures for managing air quality, together with indicators for measuring progress towards achievement of objectives.

The primary goal of air quality management is to ensure that air quality levels in Jamaica are protective of human health and welfare. The regulations provide some of the tools and mechanisms for air quality management. In cases where existing air quality is poor (ambient air quality standards are exceeded) because of pollutant emissions, the immediate goal is to reduce emissions to levels that will improve ambient air quality to meet ambient standards and emission targets. Where ambient air quality levels are below the standard, the goal is to avoid deterioration especially in areas such as parks and protected areas. This latter goal must take account of the fact that airsheds in Jamaica are relatively small. Furthermore, given the relatively large number and small sizes of some of the protected areas and their proximity to urban and already industrialised areas, it may not always be feasible to avoid deterioration of air quality in all protected areas. The methods to evaluate the effectiveness of the regulations are summarised in Table 9-1.

Table 9-1 Summary of Air Quality Management Goals, Objectives, Measures, Indicators and Schedule

GOALS/ OUTCOMES	OBJECTIVE	MEASURES	PERFORMANCE MEASURES	TIME PERIOD
Achieve ambient air quality standards throughout all areas of Jamaica by 2010		Implement Air Quality regulations	Trends in ambient air quality and national emissions	1999-2009
	Characterise emissions and air quality near Major and Significant Facilities	Identify air pollutant sources. Issue notices for Air Pollutant Discharge Licence Applications (Major Facilities) Major Facilities to conduct air quality assessments Licence Major Facilities	Monitor progress. Meet with Facilities Monitor progress Licences issued	1999 – 2000
		Identify Significant Facilities. Issue notices for Air Pollutant Discharge Licence Applications (Significant Facilities) Significant Facilities to conduct air quality assessments Licence Significant Facilities	Monitor progress. Meet with Facilities Monitor progress Licences issued	2001
		Compile emission inventory (criteria pollutants, GHG)	Completed inventory, annual updates	2002 -
	Establish target air emissions reductions (Major Facilities)	Compliance Plans for Major Facilities	Track emissions annually	2002 -
	Characterise ambient air quality near industrial facilities	Compliance Plans and licence conditions	Track progress through bi-annual (every 6 months) reporting or more frequently as may be required.	2000 -

Table 9-1 Summary of Air Quality Management Goals, Objectives, Measures, Indicators and Schedule (Continued)

GOALS/ OUTCOMES	OBJECTIVE	MEASURES	PERFORMANCE MEASURES	TIME PERIOD
Achieve ambient air quality standards throughout all areas of Jamaica by 2010	Characterise urban ambient air quality (criteria pollutants, (Kingston Metropolitan Region (KMR), Montego Bay Metropolitan Region (MBMR))	NRCA or other Public Sector to undertake ambient urban air quality monitoring	Review and analysis of data, comparisons with NAAQS	2003 -
	Establish emission reduction targets for industrial sources	Compliance Plans for Significant Facilities	Track emissions annually	2002 -
	Characterise urban ambient air quality (Priority air pollutants, (KMR, MBMR))	Plan and conduct ambient air quality monitoring programs		2002 -
	Address air pollution from motor vehicles	Support phase-out of leaded gasoline Support implementation of Motor vehicle emission standards and inspection and maintenance measures	Input & support. Implementation of motor vehicle emission standards	1999 -
Internal NRCA Goals				
Implement an efficient and fully cost recoverable system for the Air Pollution Regulations by 2008	Secure adequate levels of staffing to implement regulations	Identify needs, train staff	Staff secured or outsourcing	1999 – 2000

Table 9-1 Summary of Air Quality Management Goals, Objectives, Measures, Indicators and Schedule (Continued)

GOALS/ OUTCOMES	OBJECTIVE	MEASURES	PERFORMANCE MEASURES	TIME PERIOD
Implement an efficient and fully cost recoverable system for the Air Pollution Regulations by 2008	Train staff to process licence applications and review of air quality assessments	ENACT Training program – Self instruction and other courses	Courses attended	1998/1999
	Establish Public Register for Licence Applications and Complaints	Address air quality complaints in a timely manner	Register established	2000
	Timely review of Air Pollutant Discharge Licences	Set up internal policies and procedures	60 days for Administrative Review; 90 days for Technical Review	2001 – 2003
Reduce to 60 days the time needed to complete the Technical Review of new Licence applications and renewals		Ongoing staff training	Review period reduced to 60 days	2004 - 2008

10. APPENDICES

10.1 APPENDIX 1 TERMS OF REFERRENCE

ANNEX “A”

Terms of Reference and Work Plan

Regulatory Impact Assessment Statement

Note:

The Canadian Consultancy Terms of Reference and Work Plan is based on Phase 1 for the Bauxite Industry (But must be conducted in a manner that supports Phase 2 (Other industry sectors), the assumption that the Air Regulation RIAS is comprehensive model for building from, and that the Canadian Consultant role is to build the Capacity of the Jamaican Consultancy to deliver similar RIAS for future regulations.

Purpose

NEPA (with the support of ENACT) will complete a Regulatory Impact Assessment Statement (RIAS) on the Air Quality, Sewage Effluent, Trade Effluent Regulations with input to the Ambient Water Quality Standards. The RIAS is to be an objective evaluation of the selected regulations to confirm the basis for their development and to assess how well the drafted regulations balance Jamaica's societal and economic priorities. The RIAS will provide the interpretation of new environmental policies and management concepts for the application and how technical standards and guidelines are to be applied.

Scope of RIAS

The RIAS will be used to facilitate dialogue between the regulator, the regulated community and society so that the legislation is efficiently introduced and effectively applied. While a RIAS has been done for the air quality regulations, it is proposed to expand the scope of the existing RIAS for the Air Quality Regulations and to apply the process to the sewage effluent and trade effluent regulations and to address their application to the bauxite / alumina sector in particular, and all industries in general.

The RIAS will address those issues raised by the bauxite / alumina industry, by other industries (to be defined through the PSOJ / Business Council for the Environment) and by general public (NEST Focus Group) to the pending legislation by assessing:

a) The regulatory alternatives considered,

b) The cost / benefit (full cost assessment) and

c) The consultative approaches used.

The Regulatory Impact Assessment will be carried out in two phases:

- Phase one will apply the RIAS methodology to the Bauxite / Alumina industry for the four regulations. Phase two will apply the experience of the phase one activity in

  other industrial sectors and the public.

  The RIAS will use existing data where practical, use questionnaires for data input and will work with defined work groups from:

- The Bauxite / Alumina Industry Work Group
- The Business Council for the Environment, and
- A NEST Focus Group.

a) Alternatives Assessment:

1) Evaluation of the principles used in the regulations and standards to include:

Polluter Pays Principle application with respect to Discharge Fees and Administrative penalties

Precautionary Principle application with respect to setting National Targets and Standards / International Standards for National Application / environmental impact and/or technological performance.

Stewardship principles with respect to use of Environmental Management Systems including: certification, verification and flexible instruments - self-monitoring and data management / strategies for new factors such as compliance planning and demonstrated competence / linkages with other Government of Jamaica ministry priorities and directives.

2) Comparison to regulatory frameworks to include:

Other similar countries / self-regulatory tools / economic instruments / incentives for compliance and disincentives for non-compliance /

Regulatory review (sun-setting processes) for Jamaican regulations.

3) Technical interpretation to include:

Site specific vs. national standards / application of Odour & Sodium and other standards measurability (analytical capability and capacity)

Technological issues (existing, best existing economically available technology) / Specific technical issues such as sequential land use (mining areas)

b) Cost / Benefit assessment:

1) The cost / benefit assessment will be based on:

Existing cost / benefit data, with additional data when appropriate, and reach a considered consensus estimate for the regulatory impact on the industries and society costs and benefits. Existing studies will be used where practical, and the assessment will include relevant aspects of health, environment and work force adjustment / training

2) Costs to industries will be based on:

Direct (operating and maintenance), capital (giving consideration to past / present and future) and indirect (administration and training) with respect to the regulations and standards under consideration. Similarly, costs to NEPA and other Government of Jamaica Agencies will additionally include compliance and enforcement plans under indirect costs.

3) Competitiveness sensitivity of the industries (particularly Bauxite / Alumina) will be based on:

Regional competitiveness (Like with like), with global competitiveness a secondary factor. Application of Cost curves where available.

c) Consultation methodology:

1) Assessment of consultation methodology will include:

Previous consultations (what was learnt from them, how were they done, and what should be done to complete the consultation)

2) A communication and information management strategy with respect to:

The implementation of the regulations will be recommended. Data Management with respect to (electronic?) monitoring data gathering, confidential information management and public information (PRTR) will be presented. The communication strategy is to be part of bi-partisan discussions. All RIAS information is confidential.

RIAS Deliverables

This RIAS will present the first of Two phases:

Phase 1: Statement will follow the format of a briefing to the Ministers (MLE and MMEQ) describing the RIA for the Bauxite /Alumina Industry for the four elements listed above and publish the RIAS as model for regulatory development by NEPA for the other sectors. Review prior to minister briefing

Phase 2: Statement for Industrial Sectors will follow the normal format for a RIAS as the accompanying statement to new legislation (overview, Alternatives, Cost Benefit assessment, Consultations), and with appropriate Recommendations for future RIAS drafting.

Reporting Structure:

Report on-going progress through NEPA Technical Committee (Paulette Kohlbusch) with copy to JBI (Parris Lyew-Ayee) for NEPA and JBI management reviews.

Schedule completion: No later than April 30 2002. Target will be to achieve at least a draft for March 31, 2002

Resources:

ENACT will contract Jamaican consultant(s) to:

- Define resources needed to provide information and verify industry and NEPA perspectives. (Additional consultant resources could involve - Health / Water / Industry)
- Gather data, and compile RIAS as defined in TOR.
- Review Existing data from industry and government and academic sources.
- Develop and utilize a questionnaire based of data deficiencies
- Facilitate workgroup meetings.

The actions arising for the RIAS will require the mutual support of NEPA / The Bauxite-Alumina companies / JBI / and the other selected industries to participate in the questionnaire and work group meetings as well as to provide relevant information and data..

10.2 APPENDIX 2 GUIDANCE DOCUMENTS FOR REGULATORY IMPACT ANALYSIS STATEMENTS AND EQUIVALENTS

Country/Jurisdiction	**Document**	**Comment**
UK	The Better Regulation Guide, by Cabinet Office	Made public in 1998, the guide integrated compliance costs assessment and regulatory appraisal (benefit analysis). It is applied to regulations that are expected to increase costs to industries, charities and voluntary bodies, or to proposals that may reduce regulatory costs (deregulation). In the case of deregulation, simpler analysis is allowed.
US (Federal)#	Executive Order #12866 Economic Analysis of Federal Regulations Under Executive Order 12866, by OMB	The Executive Order stipulates that when the federal government introduces or changes regulations, regulatory impact analysis should be conducted, and the roles of departments and Office of Management and Budget (OMB) in proposing federal regulations.
Canada	Government of Canada, Regulatory Policy Federal Regulatory Process Management Standards Compliance Guide Assessing Regulatory Alternatives Benefit-Cost Analysis Guide for Regulatory Programs RIAS Writer's Guide , etc. by Treasury Board: RIAS is the acronym of Regulatory Impact Analysis Statement	The Regulatory Policy stipulates that the federal departments conduct regulatory impact analysis in introducing or changing regulations, and the roles of departments and the Treasury Board in proposing federal regulations. Other documents, prepared by Treasury Board, plainly explain the regulatory process, analysis of non-regulatory options, cost-benefit analysis, and the preparation steps of regulatory impact analysis.
Australia	A Guide to Regulation (second edition), by Office of Regulation Review	A manual for officials preparing the regulatory impact analysis documents within federal departments. As a minimum requirement for the impact analysis, "a qualitative assessment of all the expected effects of the proposed option is expected".

Some state governments also require RIAS

APPENDIX 2 Guidance Documents For Regulatory Impact Analysis Statements And Equivalents (Cont'd)

Country/Jurisdiction	Document	Comment
Ontario	Less Paper More Jobs Test	In 1996 the Ontario provincial government introduced the Less Paper/More Jobs Test in an effort to reduce the detrimental effect that increased government regulation on businesses and institutions. The process includes requirements to apply tests against 14 principles as may be applicable to the particular regulation. All of the Federal Government's RIA components are among those included in the Ontario process.
OECD	Regulatory impact analysis: Best Practices in OECD Countries	In this guide, OECD researched how regulatory impact analysis was actually conducted by member countries, extracted examples of best practices which were likely to contribute to the improvement of the effects of regulatory impact analysis, and gave explanations of them. This guide is not mandatory but aims at spreading best practices to member countries.

10.3 APPENDIX 3 INDUSTRIAL PROFILES

Profile Elements	Mineral Industries - Bauxite/Alumina Sector
General Description	This sector is second only to tourism in importance to the economy of Jamaica. Plants were built in the 1950's to the early 70's. Four plants refine bauxite into alumina for export to parent companies and/or third parties while one exports dried bauxite. The industry is small when considered on a world scale. A plant currently under construction in Australia is expected to exceed the combined out put of all the Jamaican plants. All the plants, except for Jamalco, are in the third quartile of the world industry cost curve and as such are high cost facilities which are very vulnerable to movements in metal prices (aluminium) and the general economic conditions which influence the demand and supply of aluminium. In recent years there has been a virtual stagnation of investment in the industry due mainly to the high cost of operating in Jamaica, the fiscal regime that governs operation (bauxite levy) and the benefits of large-scale production elsewhere. One of the major players in the industry that was a pioneer in investment in Jamaica, ALCAN, sold its holdings and left in 2001.
No. of Facilities	There are 9 facilities in the sector: 4 alumina processing pant; 1 bauxite drying plant; 4 shipping ports.
Capacity (annual production in '000 MT)	Bauxite – 4,500 Alumina – 3,750
Age profile of Plants	Kaiser Jamaica Bauxite Company (KJBC) – 50 years (established 19952) Jamaica Bauxite Mining (JBM) /Lydford Mines – 50 years (established 1952) West Indies Alumina Company (Windalco): • Kirkvine Plant – 50 years (established 1952) • Ewarton Plant – 43 years (established 1959) Jamalco: • Bauxite – 39 years (established 1963) • Alumina – 30 years (established 1972) Alumina Partners of Jamaica (Alpart) – 33 years (established 1969)
Ownership	KJBC – Kaiser Aluminium and Chemical Corporation 49%; Government of Jamaica 51% Windalco Plants – Glencore 93%; Government of Jamaica 7% Jamalco – Alcoa 50%; Government of Jamaica 50% Alpart – Kaiser Aluminium 65%; Hydro Aluminium 35%
Technology	Alumina plants utilize the Bayer process; the sole bauxite drying plant uses oil fired rotary kilns to dry bauxite. All plants use emission control technology that is on average over 30 years old.
Location of Plants	Kaiser Jamaica Bauxite Company (KJBC) – Discovery Bay, St. Ann Windalco's Ewarton Plant - St. Catherine Windalco's Kirkvine Plant - Manchester Jamalco - Halse Hall, Clarendon Alpart - Nain, St. Elizabeth
Demographics around each plant	Bauxite/alumina operations in Jamaica are concentrated in 5 parishes, Clarendon, Manchester, St. Ann, St. Catherine and St. Elizabeth. Clarendon, Manchester and St. Elizabeth are contiguous parishes and are located on the south coast. Mining and refining of bauxite date back to the 1950's. Bauxite/alumina company leaseholds constitute more than half the land area of St. Elizabeth and Clarendon and more than three-quarters of the parish of Manchester. These parishes have a combined area of 3,238.8 km^2 and a population of 924,465[1]. A JBI

Profile Elements	Mineral Industries - Bauxite/Alumina Sector
	study in October 2001[2] that used STATIN 1991 population data, estimated total population in the areas of influence of the plants located in these parishes at 247,309 persons, comprising 123,500 males and 123,809 females. The study showed that 89% of persons surveyed were within the 18-69 year age category and therefore in the age range that would participate in activities related to industrial production. The ALPART plant exerts the dominant influence of the industry in the parish of St. Elizabeth. The creation of new resettlements sites such as Montpelier in the 1990's) by ALPART, the expansion of mud ponds and the resettlement of households at Northhampton, Southhampton, Bona Vista and Ashwood (1991-2001) have had some influence on population movement within the parish. In the parish of Manchester both Alpart and Windalco have significant influence on population movements in terms of resettlement and relocation caused by mining. Manchester is the parish most impacted by the bauxite/alumina industry. Both Windalco and ALPART mine bauxite in the parish while a Windalco alumina processing plant, Kirkvine, is located in the parish. Jamalco's influence on population changes in Clarendon is similar to that of the other companies in the St. Elizabeth and Manchester, resulting mainly from the necessities of mining and resettlements. The sole bauxite exporting facility, Kaiser Jamaica Bauxite Company (KJBC), is located on the north coast of the island. It co-exists in an area with other key economic activities such as tourism, commercial/retail and agriculture. Total population in the areas of influence of this plant is 61,788 persons (STATIN 1991), 30,829 males and 30, 959 females[3]. Like on the south coast, population movements have been due mainly to the mining and resettlements needs of the company. The push-pull effects of various labour markets such as tourism, agriculture, retail and services have also been influential. St. Catherine, the location of Windalco's Ewarton plant, is the other bauxite/alumina area. This parish has the largest population outside the Kingston Metropolitan Region (KMR) and is in closest proximity to it: 369,274 persons (STATIN, 1991) of which 180,036 are males and 189, 238 females. The population in the areas of influence of the Ewarton Plant is 147,773 persons, comprising 74,083 males and 73,690 females. The explosive movement (growth) in population that has occurred in this parish cannot be attributed to bauxite and alumina influences in the main but to other factors such as the massive housing developments in the southeast. Employees in the industry are mainly skilled persons and professionals and a limited number of persons who are unskilled labourers. Indirect employment arising from the use of contractors who hire persons form local communities is quite significant. Total direct employment in the industry in 2000 was 3,882 persons, according to JBI 2000 statistics.
Value to local communities	The value to local communities of Bauxite/alumina operations are related to: - Direct employment - Indirect employment - Purchasing of supplies from local businesses such as hardware stores, supermarkets, furniture shops, gas stations, etc. - Spending by employees and the consequent multiplier effect - Community assistance programmes ranging from road repairs, small business projects in partnership with communities, school assistance programmes, scholarships, apprenticeship programmes, provision of water supplies to schools and communities, sports programmes, development of community centres, agricultural extension services, leasing of lands to small farmers prior to mining and leasing of reclaimed lands subsequent to mining, upgrading of livestock farming through the provision of imported stock and community assistance in natural disasters.

Profile Elements	Mineral Industries - Cement and Lime
General Description	The Caribbean Cement Company Limited (CCCL) plant has a wet and dry process facilities.
Capacity	
Number and location of facilities	Caribbean Cement Company Limited – cement plant at Rockfort, Kingston Rugby Lime (Jamalco plant, Clarendon); Western Cement (Maggotty, St. Elizabeth) Bauxite and alumina companies (Alpart, Windalco Ewarton and Windalco Kirkvine also operate lime kilns. Lime for the Jamaslco plant is supplied by Rugby Lime.
Age profile of plants	Caribbean Cement Company – incorporated 1947, started production in 1952. Rugby lime and Minerals Limited – Quarry commenced operation in December 1999; plant started in June 2000. Western Cement – Commenced operations in 1997.
Ownership	All cement and lime plants are privately owned. Caribbean Cement Company is a wholly owned subsidiary of Trinidad Cement Limited. Rugby Lime and Minerals Limited – Joint venture between NIBJ and Horace Clarke (39%) and Redimix Concrete (RMC) of the UK (61%)
Technology	Cement plant, wet process 6.6 tons clinker/h and 5a dry process .5 tons clinker/h. Fuel used is a mixture of coal and heavy fuel oil. Emission controls include baghouses for process vents and a baghouse for the wet process stack and a precalciner cyclone and ESP for the dry process. Rugby Lime - Two (2) kilns each 125,000 tonne/year; Western Cement (Vertical shaft kiln,
Demographics around each plant	Caribbean Cement Company - residential communities of varying living standards are to the east and west of the plant. The demographic characteristics entire Kingston metropolitan area can be said to be applicable to in the case of this facility. Nearer to the plant income levels are lower and the population mix is comprised of working class and professionals such as nurses, policemen, teachers and civil servants. Rugby Lime and Minerals Limited – similar to demographics around the Jamalco plant. Western Cement – The population is largely engaged in farming and work on the nearby Appleton Sugar Estate.
Value to local communities	Caribbean Cement Company -Employment and community services of a public relations nature are the main values. Higher order professionals are not from the plant’s immediate environment but from the wider KMTR. Rugby Lime and Minerals Limited – Employment and community services Western Cement – Employment and community services.

Profile Elements	Energy Industries – Electric Power Generation Sector
General Description	The Jamaica Public Service Company is the sole distributor of electricity in Jamaica since 1923. The company owns and operates 23 generating plants, 64 substations, 1,116 kilometres of transmission lines and 12,000 kilometres of distribution lines, and is engaged in the generation, purchase, transmission and distribution of electricity. Service is supplied to approximately 95 percent of a population of 2.6 million. A network of 21 commercial offices located island-wide provides customer service to JPSCo's approximately 500,000 customers.
Number and location of facilities	JPSCo: Old Harbour Power Station (223.5 MW from 4 steam oil fired units), Rockfort Power Station (18 MW from 2 slow speed diesel engines and generators), Bogue Power Station (108.5 MW from 6 gas turbines), Hunts Bay Power Station (144 MW from 1 steam unit and 3 gas turbines), 8 Hydro Generation units (23 MW at 7 locations [Upper White River, Lower White River, Roaring River, Maggotty, Rio Bueno A&B, Constant Spring, Rams Horn]). Jamaica Private Power Company. 57.8 MW two engines at Rockfort. Jamaica Energy Partners: 72 MW from 8 Wartsila engines (9.6 MW each) firing heavy fuel oil (up to 2.2% sulphur) located at the Dr. Bird barge Old Harbour. Jamalco 5 MW Jamaica Broilers 12.1 MW from three? Wartsila 18V26 engines (~4.65MW each) firing heavy fuel oil (up to 2.2%S) located at Spring Village St. Catherine
Age profile of plants	Steam units: 1967, 1968, 1973, 1973 (upgraded in 1996), 1976 Engines: 1985, 1996 (JPPC), 1995 (JEP), 1998 (Broilers) Gas Turbines: 1972, 1990, 1991, 2001, 1993, 1974 Hydro: 1945, 1948, 1951, 1955, 1959, 1988
Ownership	JPSCo was the largest state-owned enterprise in Jamaica until March 2001 when Mirant acquired 80 % share ownership. Jamaica Private Power Company (JPPC) and Jamaica Energy Partners are 100% privately owned.
Technology	Steam plants, slow speed diesel engines, gas turbines
Demographics around each plant	Population around plants vary, ranging from rural to urban. Plants located in Kingston are in close proximity to other heavy industrial facilities and within easy reach of major population centres. Rural plants are also fairly close to or within townships. Consequently population characteristics typify the usual mix that is found in rural/urban populations.
Value to local communities	Plants provide employment, social services of a public relations nature. The highly technical nature of work however precludes mass employment from local communities which invariably are lacking in the type and range of skills required. Consequently, the best jobs are held by persons from outside the immediate environment of the plants.

Profile Elements	Energy Industries – Petroleum Refining
General Description	Integrated hydroskimming refinery with nameplate capacity of 35,000 barrels per stream day (b/sd) of crude oil. Produces liquefied petroleum gas (LPG), regular and premium unleaded gasoline, kerosene, turbo fuel, auto diesel and heavy fuel oils and two grades of asphalt.
Capacity	
Number and location of facilities	Located at Marcus Garvey Drive in Kingston
Age profile of plants	Constructed in 1963/1963 by ESSO and was purchased by Petrojam in 1982.
Ownership	Owned by the Petroleum Corporation of Jamaica a wholly owned government company
Technology	Crude pipestill, hydrofiners, light ends fractionation equipment, catalytic powerformer and vacuum pipestill and asphalt facilities
Demographics around each plant	Located in Kingston. Immediate vicinity in an industrial area and nearby predominantly low income residential areas.
Value to local communities	The Petrojam Refinery is the only refinery in Jamaica. Under trade liberalisation other entities can import petroleum products. Petrojam employs about 136 full time staff and additional staff for maintenance duties.
General Description	Eight factories manufacture sugar from sugar cane. Sugar manufacturing
Capacity	Appleton (160 ton/day). Annual sugar production in the past 5 years ranged from 180,000 to 230,000 tonnes. The production target is 311,000 tonnes which would meet the preferential export and domestic markets.
Number and location of facilities	Frome (Westmoreland), Monymusk (Clarendon), Bernard Lodge (St. Catherine), Long Pond (Trelawny), Hampden (Trelawny), Worthy Park (St. Catherine), Appleton (St. Elizabeth), St. Thomas Sugar Estate [Tropicana] (St. Thomas)
Age profile of plants	All factories are over 40 years. Plants are generally old dating from the 18th century to the 21st century (Appleton). All have been upgraded over the years in order to maintain some level of competitiveness. Appleton Estate in St. Elizabeth boasts a modern factory on par with any in the developed world.
Ownership	Six of the eight factories are government owned under the Sugar Company of Jamaica. Worthy Park and Appleton are privately owned.
Technology	Bagasse (supplemented at some factories with heavy fuel oil) is used as fuel in boilers to produce steam that produces electricity, operate cane crushing and other factory machinery and evaporating equipment. Juice extraction via milling, clarification, evaporation, crystallization and separation of sugar from molasses.
Demographics around each plant	Generally surrounded by farming subsistence communities but some entities are located near major population centres such as Bernard Lodge in St. Catherine (Spanish Town, Portmore) and Monymusk in Clarendon (Hayes). Educational levels vary depending on location; age and gender characteristics are typical of rural population centres.
Value to local communities	The industry employs about 50,000 and is the third largest earner of foreign exchange. Employment is the main value in addition to a wide range of community services provided by the estates such as assistance with schools and community centres, scholarships, training and apprenticeship programmes.

[1] STATIN Population Census, 1991.

[2] The Economic and Social Impacts of the South Coast Bauxite/Alumina Industry on Communities in St. Elizabeth, Manchester and Clarendon, Jamaica
The Economic and Social Impacts of Kaiser Jamaica Bauxite Company on St. Ann, Jamaica

10.4 APPENDIX 4 VARIOUS DOSE RESPONSE RELATIONSHIPS

The Health Effects of Air Pollution in Delhi, India, World Bank WPS #1860

City	Percentage Change in Daily Mortality per 100 μg/m³ Increase in TSP	Particulate Measure Used in Analysis	Mean Daily TSP[1] (μg/m³)
U.S. Studies:			
Steubenville, OH (Schwartz & Dockery, 1992b)	4	TSP(-1)	111
Birmingham, AL (Schwartz, 1993)	6	PM_{10}	87
Detroit, MI (Schwartz, 1991)	6	TSP(-1)	87
Utah Valley (Pope et al., 1992)	9	PM_{10} (5-day MA)	85
Philadelphia, PA (Schwartz & Dockery, 1992a)	7	TSP (2-day mean)	77
St. Louis, MO (Dockery et al., 1992)	8	PM_{10} (-1)	50
Kingston/Harriman, TN (Dockery et al., 1992)	9	PM_{10} (-1)	55
European Studies:			
Athens, Greece (Touloumi et al., 1996)	3 (winter)	BS (-1)	153
Paris, France (Dab et al., 1996)	4 9	Ln (BS) ln(PM13)	58 93
Erfurt, Germany (Spix et al., 1993)	7	ln(BS)	106 (median)
Barcelona, Spain (Sunyer et al., 1996)	4	BS	64-91 (median)
Developing Country Studies:			
Santiago, Chile (Ostro et al., 1996)	4	ln(PM_{10})	210
Bangkok, Thailand (Chestnut et al., 1997)	6	PM_{10} (-3)	118
Beijing, China (Xu et al.,1994)	4 (summer)	TSP (-1)	375
Delhi, India	2	TSP (-2)	375

[1]PM13, PM10, PM7, and BS values were converted to TSP using the following relationship: PM13=PM10=PM7=BS= 0.55TSP.

Appendix 4 (Cont'd) Concentration-response Relationships Utilized in Air Quality Valuation Model for PM_{10}

Health Event Category	**Concentration-Response Parameter (Probability Weighting Applied))**
Annual mortality risk factors	Low 4.4 x 10^{-6} (22%) Central 12.1 x 10^{-6} (67%) High 28.2 x 10^{-6} (11%)
Sources: Schwartz et al. (1996), Pope et al. (1995)	
Chronic bronchitis (CB) annual risk factors given a For population 25 years and over: change in 1 μg/m3 annual average PM_{10} concentration	Low 3.0 x 10^{-5} (25%) Central 6.1 x 10^{-5} (50%) High 9.3 x 10^{-5} (25%)
Source: Abbey et al. (1993).	
Respiratory hospital admissions (RHAs) daily risk factors given a 1 μg/m^3 change in daily PM_{10} concentrations	Low 0.64 x 10^{-8} (33%) Central 0.78 x 10^{-8} (50%) High 3.26 x 10^{-8} (17%)
Sources: Burnett et al. (1995), Pope (1991)	
Cardiac hospital admissions (CHAs) daily risk factors given a 1 μg/m^3 change in daily PM_{10} concentration	Low 5.0 x 10^{-9} (25%) Central 6.6 x 10^{-9} (50%) High 8.2 x 10^{-9} (25%)
Source: Burnett et al. (1995)	
Net emergency room visits (ERVs) daily risk factors given a 1 μg/m^3 change in daily PM_{10} concentration	Low 2.96 x 10^{-8} (25%) Central 3.66 x 10^{-8} (50%) High 14.3 x 10^{-8} (25%)
Source: Stieb et al. (1995)	
Asthma symptom days (ASDs) daily risk factors given a 1 μg/m^3 change in daily PM_{10} concentration	For population with asthma (6% of population) Low 1.62 x 10^{-4} (33%) Central 1.72 x 10^{-4} (34%) High 1.82 x 10^{-4} (33%)
Sources: Whittemore and Korn (1980), Ostro et al. (1991)	
Restricted activity days (RADs) daily risk factors given a 1 μg/m^3 change in daily PM_{10} concentration	For nonasthmatic population (94% of population) 20 years and older: Low 0.8 x 10^{-4} (33.3%) Central 1.6 x 10^{-4} (33.4%) High 2.5 x 10^{-4} (33.3%)
Sources: Ostro (1987), Ostro and Rothschild (1989)	
Net days with acute respiratory symptoms (ARSs) daily risk factors given a 1 μg/m^3 change in daily PM_{10} concentration	For nonasthmatic population (94% of population) Low 1.62 x 10^{-4} (25%) Central 3.44 x 10^{-4} (50%) High 5.18 x 10^{-4} (25%)
Sources: Krupnick et al. (1990)	
Children with acute bronchitis (B) annual risk factors For population under age 20: given a 1 μg/m^3 change in annual average PM_{10} concentration	Low: 0.57 x 10^{-3} (25%) Central: 1.42 x 10^{-3} (50%) High 2.27 x 10^{-3} (25%)
Source: Dockery et al. (1996)	

Source: Human Health and Environmental Benefits of Achieving Alternate CWS for Inhalable Particulates ($PM_{2.5}$, PM_{10}) and Ground Level Ozone. Final Report. Prepared by Paul De Civita, Environment Canada, David Stieb, Health Canada, Lauraine Chestnut, David Mills, Robert Rowe, Stratus Consulting. July 25, 1999. In Compendium of Benefits 99-08-17.

11. GLOSSARY

A&E	Accidents and Emergencies
AAL	Aughinish Alumina Ltd
ALOS	Average Length of Stay
B&A	Bauxite and Alumina
BATNEEC	Best available technology not entailing excessive costs
Bbl	Barrel
BCE	Business Council for the Environment
BPEL	Best Practice Environmental Licences
Cardiovascular	Pertaining to the heart and blood vessels.
CARICOM	Caribbean Community
CCCL	Caribbean Cement Company Limited
CEM	Continuous emission monitoring
CO	Carbon monoxide
COPD	Chronic obstructive pulmonary disease
CPC	Chief Parliamentary Counsel
CPC	Chief Parliamentary Counsel
EMS	Environmental Management Systems
ENACT	Environmental Action Program
ESP	Electrostatic precipitator
EU	European Union
GDP	Gross domestic product
GHG	Greenhouse gas
GVRD	Greater Vancouver Regional District
GWh	Gigawatt hour (10^9 Wh)
IPCL	Integrated Pollution Control licence
JBI	Jamaica Bauxite Institute
JBM	Jamaica Bauxite Mining
JMA	Jamaica Manufacturers' Association
JPPC	Jamaica Private Power Company
JPPC	Jamaica Private Power Company
JPSCo	Jamaica Public Service Company
KJBC	Kaiser Jamaica Bauxite Company
KMR	Kingston Metropolitan Region
kWh	kilowatt-hour (10^3 Wh)
LCP	Lifetime compliance plan
Life expectancy	The number of years that an average person of a given age may be expected to live, according to mortality tables.
LPG	Liquefied petroleum gas
LRTI	Lower respiratory tract infection
MBMR	Montego Bay Metropolitan Region
MLE	Ministry of Land and Environment
Morbidity	The number of sick persons or cases of disease in relationship to a specific population.
Mortality	The death rate; the ratio of the number of deaths to a given population.
MOU	Memorandum of Understanding

MWe	Megawatts of electrical output
MWth	Megawatts of thermal energy input
NaOH	Sodium hydroxide
NAAQS	National Ambient Air Quality Standards
NEPA	National Environment and Planning Agency
Net present value	The current value of net benefits (benefits minus costs) that occur over time. A discount rate is used to reduce future benefits and costs to their present time equivalent.
NGO	Non-government organizations
NMVOC	Non-methane volatile organic compound
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
NRCA	Natural Resources Conservation Authority
NSPS	New source performance standard
OECD	Organisation for Economic Cooperation and Development
OMB	U.S. Office of Management and Budget
OPC	Office of the Parliamentary Counsel
Outpatient	One who receives treatment at a hospital, clinic, or dispensary but is not hospitalised.
Particle aerodynamic diameter	Diameter of a sphere of density 1 g/cm^3 with the same terminal velocity due to gravitational force in calm air as the particle, under the prevailing conditions of temperature, pressure and relative humidity (ISO 1995).
Pb	lead
PM	Particulate matter
PM_{10}	Particulate matter less than 10 μm diameter
PM2.5	Particulate matter less than 2.5 μm diameter
PPPGDP	Parity Purchasing Power GDP
Present value	The value today of a sum to be paid or collected in the future to buy a good or service.
PRTR	Pollutant Release and Transfer Register
PSOJ	Private Sector Organization of Jamaica
Purchasing power parity (PPP)	A method of measuring the relative purchasing power of different countries' currencies over the same types of goods and services. Because goods and services may cost more in one country than in another, PPP allows us to make more accurate comparisons of standards of living across countries. PPP estimates use price comparisons of comparable items but since not all items can be matched exactly across countries and time, the estimates are not always "robust."
Respiration	The act of breathing (i.e. inhaling and exhaling) during which the lungs are provided with air through inhaling and carbon dioxide is removed through exhaling.
Respiratory	Pertaining to respiration.
RHA	Respiratory hospital admissions
RIA	Regulatory Impact Analysis
RIAS	Regulatory Impact Analysis Statement
RTI	Respiratory tract infection
SO_2	Sulphur dioxide
TSP	Total suspended particulate
UNFCCC	United Nations Framework Convention on Climate Change

URTI	Upper respiratory tract infection
UWI	University of the West Indies
VOCs	Volatile organic compounds
VSL	Value of a statistical life
VSL	Value of a statistical life
WHO	World Health Organization
Willingness To Pay (WTP)	One form of economic value associated with a change in quality or quantity of a good or service. WTP is a theoretical measure of the value an individual places on the good or service, or in the case of health effects, reflects the value of avoiding an adverse health effect based on an individual's willingness-to-pay (WTP) for risk reduction. By summing many individuals WTP to avoid small increases in risk over a large sample, the value of a statistical premature death avoided can be inferred. This valuation is expressed as dollars per mortality avoided or value of a statistical life (VSL) even though the actual valuation represents small changes on mortality risk experience by a large number of people. The VSL method estimates the dollar value of a given reduction in risk, in reference to an individual's WTP to reduce that risk. WTP is often based on wage-risk studies, which derive WTP values from estimates of the additional compensation demanded in the labour market for riskier jobs, or from contingent valuation (CV) studies which directly solicit WTP information from personal interviews.
Windalco	West Indies Alumina Company

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