

NATURAL RESOURCES CONSERVATION AUTHORITY
AMBIENT AIR QUALITY
GUIDELINE DOCUMENT

Prepared for
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1. INTRODUCTION

The purpose of this Ambient Air Quality Guideline Document (*Guideline Document*) is to provide assistance and information for the implementation of the *Natural Resources Conservation Authority (Air Quality) Regulations (2006)* under the Natural Resources Conservation Authority (NRCA) Act. This *Guideline Document* provides owners and operators of facilities requiring air pollutant discharge licences with information that will assist them to satisfy the requirements for licence applications and to satisfy conditions of air pollution discharge licences. The *Guideline Document* is also to be used by persons conducting ambient air quality assessments (source testing, ambient monitoring, modelling, impact assessment and reporting) that are to be used for regulatory or other purposes. This *Guideline Document* also outlines the requirements for the management of ambient monitoring data which will be compiled in a national archive by the National Environment and Planning Agency (NEPA).

A separate Staff Guidance Document (*Staff Guide*) provides NEPA staff with performance based standards for processing Air Pollutant Discharge Licence applications and addressing the ongoing requirements of conditions attached to such licences. The ultimate goal of the *Guideline Document* and the *Staff Guide* is consistent and objective enforcement of the air quality standards and regulations by promoting generation of air quality data that satisfy monitoring and assessment objectives and the transparent and consistent evaluation and assessment of the information.

The *Guideline Document* does not provide standard operating procedures or step-by-step procedures, nor is it a user's guide. Instead, it should be used as one of the bases for selection of standard operating procedures (SOPs) which provide step-by-step instructions for conducting field, laboratory and office procedures required for monitoring. Similarly, the reader must refer to users' manuals for the use of dispersion models and other software programs or applications needed for data management.

The advice and interpretation in this *Guideline Document* is not legally binding since any legal interpretation of the regulations must ultimately be decided by the courts.

1.1 SCOPE - WHAT IS INCLUDED IN THIS GUIDELINE DOCUMENT

1.1.1 Requirements For Air Quality Assessments

The *Natural Resources Conservation (Air Quality) Regulations 2006* specify that some or all aspects of air quality assessments are required for the following:

Applications for an Air Pollutant Discharge Licence

Major facilities (mineral processing facilities by January 31, 2008; electric power generation and cogeneration only), on or before April 30, 2008; other fuel combustion (sugar industry, industrial boilers), on or before April 30, 2008; petroleum refining, on or before April 30, 2008; all other major facilities, on or before April 30, 2008)

Significant facilities in Phase II (by August 1, 2008 where oil fired boilers are the only source and by December 1, 2008 for all other significant facilities)

Applications for major modifications to existing sources

When specified as a requirement for an Environmental Impact Assessment

Where specified as a condition of an Air Pollutant Discharge licence

Where the Authority or agencies to whom the Authority delegates specified powers determines that such assessments are necessary

This document provides the guidance for persons conducting such assessments.

The main requirements of the air quality assessments are:

source assessment/testing;

ambient air quality monitoring;

dispersion modelling; and

impact assessment and reporting

Under the regulations, assessments of impacts for criteria pollutants will be based on ambient air quality standards and emission standards and targets. Impacts of Priority Air Pollutants emitted from new sources or major modifications to existing sources will be based on the ambient air concentration limits for these pollutants.

1.1.2 Guidelines for Risk Assessments

The sources requiring risk assessments and risk management policy and guidelines for conducting screening and refined risk assessment are presented.

1.2 WHO SHOULD DO WHAT?

All applicants for a license to discharge air pollutants must assess the air quality impact of the emissions. The type of assessment will depend on the size of the facility (significant or major) and the predicted impacts. The requirements and the location in this document are given in Table 1-1.

1.3 REPORT STRUCTURE

Summaries of the stack emission standards (SES) and targets (SET) and of the Jamaican ambient air quality standards (JAAQS) are presented in Section 2. Also included in Section 2 are the rationale for the selection of Priority Air Pollutants (PAPs) and the ambient air concentration limits for each pollutant and the bases for additional or revised stack emission standards and targets. Section 3 describes how emission rates from sources may be estimated and the requirements for source testing. Section 4 describes the requirements for ambient air quality monitoring including those for an Air Quality Monitoring Plan, the siting of ambient air quality and meteorological monitoring stations, measurement methods and data management and reporting. Protocols for dispersion modelling are presented in Section 5 and the requirements for air quality impact assessment and risk assessment are described in Section 6. A list of References, a Glossary and Appendices are provided in Sections 7, 8 and 9 respectively.

Table 1-1 Summary of Requirements for Air Quality Assessments

Activity	Requirement	Report Section
Estimate the emission rates from all point and area sources at the facility	All new and existing sources and major modifications of existing sources are required to estimate the emission rates for PM or PM ₁₀ , NO _x , SO ₂ , CO and Pb. New or proposed sources and major modifications of existing sources must also estimate emission rates for priority air pollutants. The estimates will determine if the facility is a major or a significant source	Section 3.1 Section 2.3
Compare the emissions with stack emission targets or standards	All sources are required to compare emission rate estimates with emission targets (existing sources) or standards (new sources or major modifications to existing sources)	Section 2.1
Predict ambient concentrations due to emissions (screening modelling or, if required, detailed modelling)	All significant and major facilities must predict, using a screening model, the maximum ground level concentration. Detailed model if screening model is inappropriate (multiple sources that can not be combined, complex terrain, predictions > 75% of JAAQS)	Sections 5.1 and 5.1 Section 5.3
If required, measure the emissions from point sources at the facility	Required if rate is > 75% of emission target or standard Sources whose uncontrolled emissions would not exceed emission standard or target would not be required to install CEMs. Sources whose uncontrolled emissions exceed emission targets or standards will be required to install CEM. Sources whose emission rate is >75% of target or standard may require periodic source monitoring and compliance plan as license conditions	Section 3.3
Measure ambient concentrations if required by conditions of license or conditions of permit application or Environmental Impact Assessment Terms of Reference	Measurements required if predicted concentrations + background > 75% of JAAQS. Major facilities whose uncontrolled emission could result in JAAQS being exceeded will be required to do ambient monitoring. In general, significant facilities will not be required to undertake ambient monitoring. Instead, significant facilities must prepare and implement a compliance plan based on pollution prevention or emission reduction. Very large sources may be required to undertake background ambient monitoring as a condition of EIA terms of reference	Sections 2.2, 2.3, Section 4
Report on all estimates and measurements	All sources are required to submit a written report on the applicable components of Air Quality Assessments	Section 6

2. AMBIENT AIR STANDARDS AND GUIDELINES

2.1 STACK EMISSION STANDARDS

The stack emission standards specified in the regulations are applicable to major and significant facilities in the following categories:

- Mineral Industries
- Fuel Combustion
- Petroleum Refining
- Waste Management
- Inorganic Chemicals (Sulphuric Acid Manufacture)

The emission targets and standards are summarised in Tables 2-1 and 2-2.

2.1.1 Guidance on Sulphur Dioxide Emissions

The stack emission standards do not include specification of emission limits for sulphur dioxide for fuel combustion. Instead, the regulations specify the sulphur content of fuel used in combustion since the amount of SO₂ emitted is directly related to the sulphur content of fuel. The testing of sulphur content in fuel should be less costly than periodic stack monitoring for SO₂.

It should be noted that in cases where the combustion gases come into contact with products that can absorb SO₂, it will be necessary to make stack emission measurements to determine the amount of SO₂ absorbed. In such cases (e.g., calcination of lime and alumina, cement manufacture), the regulations allow plant wide SO₂ emissions equivalent to the fuel sulphur content specified (3% for existing facilities or 2.2% for new facilities). This means that the sulphur content and thus SO₂ emissions from sources with no absorption of SO₂, for example a boiler, could be higher than the 3% provided SO₂ **emissions** (not the sulphur content) from another process at the same facility are lower by an equivalent amount. Emissions from the plant may be considered as going into a bubble in which the SO₂ emissions are equivalent to using 3% S in fuel for existing sources (or 2.2% S for new sources). This is termed the bubble concept. The bubble is applicable only on a facility basis and only for sulphur dioxide. Thus facilities in two different parishes for example each must have SO₂ emissions that are equivalent to no more than emissions from burning 3% S for existing sources (or 2.2% S for new sources). The regulations are designed to promote similar air quality around all facilities instead of potentially different air quality at different facilities.

Making use of the bubble around each facility will require source testing for SO₂ for those processes that absorb SO₂ in products or which may employ SO₂ control devices.

2.1.2 Additional Stack Emission Standards and Targets

Emission standards for other pollutants are based on mass emission rates or concentrations. These emission standards must be met on a source-by-source basis.

The Draft Stack Emission standards previously proposed (Davis et al., 1996) have been augmented to include the following:

SO₂ emission standard for new coal fired power plants (These are based on the lower of World Bank Guidelines or U.S. EPA New Source Performance Standards (NSPS) standards)

SO₂ and H₂SO₄ standards for new sulphuric acid manufacturing plants (based on standards in various jurisdictions (U.S. EPA and selected U.S. states and Canadian provinces)

Addition of targets for SO₂ and H₂SO₄ mist for existing sulphuric acid plants

Emission standards for gas fired combustion sources

Emission standards for stationary internal combustion engines for electricity generation

Revision of the PM standard for Municipal and Biomedical incinerators and addition of a standard for polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs).

Addition of emission standards for burning hazardous and non-hazardous wastes in cement kilns.

Table 2-1 Stack Emission Targets for Existing Sources

SOURCE CATEGORY	SEGMENT	TARGET FOR EXISTING SOURCES	
		Pollutant	Value
ALL SOURCES		Opacity	20% opacity and up to 40% opacity for 6 minutes in any hour or 6 hours in 10 days except during start-up, shutdown, soot blowing or malfunction for each stack
MINERAL INDUSTRIES	Portland Cement	PM	800 g/t clinker for kilns
		PM	300 g/t clinker for clinker cooler
		PM	50 g/t clinker for finish grinding
		PM	100 g/t aggregate for all other sources
		SO ₂	3.0 % sulphur in heavy (Nos. 5 or 6) fuel oils
	Lime manufacture	PM	1000 g/t for all plant sources
		SO ₂	3.0 % sulphur in heavy (Nos. 5 or 6) fuel oils
	Alumina manufacture	PM	20% opacity with 40% opacity for 6 minutes in any hour or 6 hours in 10 days except during start-up, shutdown or malfunction for each stack
		SO ₂	Up to 3.0 % sulphur in heavy fuel oil
	Glass manufacture	Opacity	20% opacity with 40% opacity for 6 minutes in any hour for each stack
FUEL COMBUSTION	Liquid fuels	SO ₂	3% sulphur in heavy fuel oils (Nos. 5 & 6) 2.0 % sulphur in Nos. 3 and 4 oils 0.5% sulphur in light fuel oils (Nos. 1 & 2) and diesel oils
	Coal Fired >70 MW	PM	60 ng/J input except during start-up, shutdown, soot blowing or malfunction for each stack
	All Other Coal Fired	PM	85 ng/J input except during start-up, shutdown, soot blowing or malfunction for each stack
		NO _x	300 ng/J input
	Oil Fired	PM	20% opacity with 40% opacity for 6 minutes in any hour for each stack except during start-up, shutdown, soot blowing or malfunction for each stack
		NO _x	200 ng/J input
	Gas Turbines > 50 MW	NO _x	140 ng/J input (water injection)
	20 - 50 MW	NO _x	300 ng/J input (water injection)

Table 2-1 Stack Emission Targets for Existing Sources (Continued)

KEY AREA	SEGMENT	TARGET FOR EXISTING SOURCES	
FUEL COMBUSTION (Contd)		Pollutant	Value
	< 20 MW	NO _x	300 ng/J input
	Gas turbines (all)	SO ₂	1.1% for medium (Nos. 1 and 2) oils
	Bagasse Boilers	PM	Develop code of practice based on combustion efficiency optimisation
PETROLEUM REFINING	Sulphur Plant	SO ₂	98% Sulphur Removal
	Steam Plant	PM	200 mg/m ³ Exhaust
		SO ₂	1650 mg/m ³ Exhaust
	All	VOC	Leak detection and repair program
WASTE TREATMENT	Municipal/Bio medical Incinerators (<1 tonne/h) (1)	PM	200 mg/m ³ (a)
		CO	150 mg/m ³ (a)
		SO ₂	300 mg/m ³ (a)
		VOC	20 mg/m ³ as C (a)
INORGANIC CHEMICALS	Sulphuric Acid	SO ₂	15 kg/tonne 100% acid produced

(a) Reference conditions: 25° C, 101.3 kPa, dry gas (This should have been included as a footnote in the Tenth Schedule in the regulations.)

Table 2-2 Emission Standards for New Sources

KEY AREA	SEGMENT	STANDARD FOR NEW SOURCES	
		Pollutant	Value
ALL SOURCES		OPACITY	20% opacity and up to 40% opacity for 6 minutes in any hour or 6 hours in 10 days except during start-up, shutdown, soot blowing or malfunction for each stack
MINERAL INDUSTRIES	Portland Cement	PM	100 mg/m ³ from clinker cooler (a)
		PM	50 mg/m ³ from kilns, finish grinders and all other sources (a)
		SO ₂	Equivalent of 2.2% sulphur in residual (Nos. 5 & 6) fuel oils based on plant wide SO ₂ emissions
	Lime	PM	100 mg/m ³ for all sources (a)
		SO ₂	Equivalent of 2.2% sulphur in residual (Nos. 5 or 6) fuel oils based on plant wide SO ₂ emissions
	Alumina	PM	0.092 g/dscm (20°C, 101.3 kPa, dry gas); 10% opacity with 40% for 6 minute/hour at start-up
		SO ₂	Equivalent of 2.2% sulphur is residual (Nos. 5 or 6) fuel oils based on plant wide SO ₂ emissions
	Glass (oil fired)	Opacity	20% opacity with 40% opacity for 6 minutes in any hour during or 6 hours in 10 days except during start-up, shutdown, soot blowing or malfunction for each stack
	Container, flat, pressed & blown soda lime; textile & wood fibreglass	PM	0.5 kg/Mg glass produced modified process
	Blown with borosilicate recipe melting furnace modified process	PM	1.0 kg/Mg glass produced
	Pressed & blown Borosilicate regular process	PM	0.65 kg/Mg glass produced
	Soda lime regular process	PM	0.13 kg/Mg glass produced
	Other, wool fibreglass regular process	PM	0.325 kg/Mg glass produced
	Flat glass regular process	PM	0.225 kg/Mg glass produced
	Oil fired, container glass, regular process	PM	0.13 kg/Mg glass produced

Table 2-2 Emission Standards for New Sources (Continued)

KEY AREA	SEGMENT	STANDARD FOR NEW SOURCES	
		Pollutant	Value
FUEL COMBUSTION	Fuel oils	SO ₂	2.2% sulphur in heavy fuel oil (Nos. 5 & 6 oils) 1.0 % sulphur in medium (Nos. 3 or 4) fuel oils 0.5% sulphur in light fuel oils (Nos. 1 & 2 oils) and diesel oils
		PM	45 ng/J input except during start-up, shutdown, soot blowing or malfunction for each stack
		SO ₂	520 ng/J input
		NO _x	260 ng/J
	Coal Fired >70 MW	PM	60 ng/J input except during start-up, shutdown, soot blowing or malfunction for each stack
		SO ₂	520 ng/J input
		NO _x	260 ng/J input
	All Other Coal Fired	PM	60 ng/J input except during start-up, shutdown, soot blowing or malfunction for each stack
		SO ₂	520 ng/J input
		NO _x	260 ng/J input
	Oil Fired	PM	43 ng/J input except during start-up, shutdown, soot blowing or malfunction for each stack
		NO _x	130 ng/J input
	Gas fired >73 MW 29 – 73 MW 2.9 to 29 MW Any size Any size	NO _x	86 ng/J
		NO _x	40 ng/J
		NO _x	26 ng/J
		CO	125 ng/J
		PM	13 ng/J
	Gas turbine >29.7 MW	NO _x	STD = 0.0075*14.4/Y + F (b)
	Gas turbine >2.9 and < 29.7 MW)	NO _x	STD = 0.0150*14.4/Y + F (b)
	Gas turbines > 20 MW non peaking	NO _x	380 ng/J output
	Gas turbines 3 - 20 MW non peaking	NO _x	460 ng/J output
	Gas turbines < 3 MW non peaking	NO _x	1250 ng/J output
	Gas turbines peaking	NO _x	530 ng/J output
	Gas turbines (all)	so ₂	1.0% sulphur content in light (Nos. 1 or 2) fuel oils
	Bagasse Boilers	PM	4,200 g/t input
PETROLEUM REFINING	Sulphur Plant	SO ₂	99 % sulphur removal
	FCCU Regenerator	PM	115 mg/m ³ exhaust (a)
		SO ₂	830 mg/m ³ exhaust (a)
		CO	2,400 mg/m ³ exhaust (a)
	Coking Calciner	PM	100 mg/m ³ exhaust (a)
	Fluid Coking	PM	0.02 kg/m ³ feed (a)
	Steam Plant	PM	150 mg/m ³ exhaust (a)
		SO ₂	830 mg/m ³ exhaust (a)
	All	VOC	Leak detection and repair program

Table 2-2 Emission Standards for New Sources (continued)

KEY AREA	SEGMENT	STANDARD FOR NEW SOURCES	
		Pollutant	Value
WASTE TREATMENT	Municipal/Bio medical Incinerators	PM	200 mg/m ³ (c)
		CO	100 mg/m ³ (c)
		SO ₂	300 mg/m ³ (c)
		VOC	20 mg/m ³ as C (c)
	Cement Kilns burning hazardous and non-hazardous wastes as supplementary fuel	PM	20 mg/Rm ³ (d) for that portion of the fuel resulting from combustion of waste fuel
		PCCD & PCDF	0.5 ng/m ³ (d)
		HCl	50 mg/Rm ³ (d)
		Sum of Sb, Cu, Pb, Mn, V, Zn	1.5 mg/Rm ³ (d)
		Sum of As, Cr, Co, Ni, Se, Te	0.15 mg/Rm ³ (d)
		Sum of Cd, Hg, Tl	0.15 mg/Rm ³ (d)
INORGANIC CHEMICALS	Sulphuric Acid by contact process	Sulphuric acid mist	0.075 kg/tonne 100% acid produced
		SO ₂	2 kg/tonne 100% acid produced

(a) 20°C, 101.3 kPa, dry gas

(b) (H) High heat release rate means a heat release rate greater than 730,000 J/sec-m³ (70,000 Btu/hour-ft³). (L) Low heat release rate means a heat release rate of 730,000 J/sec-m³ (70,000 Btu/hour-ft³) or less. Heat release rate means the steam generating unit design heat input capacity (in MW or Btu/ hour) divided by the furnace volume (in cubic metres or cubic feet); the furnace volume is that volume bounded by the front furnace wall where the burner is located, the furnace side waterwall, and extending to the level just below or in front of the first row of convection pass tubes. STD = allowable NO_x emissions (percent by volume at 15 percent oxygen and on a dry basis). Y = manufacturer's rated heat rate at manufacturer's rated load (kilojoules per watt hour) or, actual measured heat rate based on lower heating value of fuel as measured at actual peak load for the facility. The value of Y shall not exceed 14.4 kilojoules per watt-hour. F=NO_x emission allowance for fuel-bound nitrogen as defined below.

Fuel-bound nitrogen (percent by weight)	F (NO _x percent by volume)
N≤0.015	0
0.015<N≤0.1	0.04(N)
0.1<N≤0.25	0.004+0.0067(N-0.1)
N>0.25	0.005

where: N = the nitrogen content of the fuel (percent by weight). Or: Manufacturers may develop custom fuel-bound nitrogen allowances for each gas turbine model they manufacture.

(c) 273°K, 101.3 kPa, dry gas

(d) Rm³ refer to standard conditions of 25°C, 101.3 kPa corrected to 11% O₂, dry basis.

2.2 AMBIENT AIR QUALITY STANDARDS

Ambient air quality standards have been promulgated (The Jamaica Gazette, 1996) for six pollutants which are referred to as criteria pollutants. These pollutants are particulate matter (PM) expressed as total suspended particulate matter (TSP) or PM with aerodynamic diameter less than a nominal 10 µm (PM₁₀), lead, sulphur dioxide (SO₂), photochemical oxidants (ozone (O₃)), carbon monoxide (CO) and nitrogen dioxide (NO₂). Ambient Air Quality Standards (AAQS) are maximum air contaminant concentrations allowed in the atmosphere. The national Jamaican Ambient Air Quality Standards (JAAQS) for criteria pollutants are summarised in Table 2-3.

Dispersion models can be used to predict the maximum ground level concentration that could result from emissions from existing or proposed sources. Compliance with an AAQS is demonstrated through a comparison of the predicted concentration due to the source **plus** the existing background concentration. The six criteria pollutants are not the only ones emitted from point or area sources and air quality assessments must also assess impacts of other pollutants. For these reasons a list of Priority Air Pollutants (PAPs) and corresponding **maximum guideline concentrations** have been developed and are presented in this section. The guidelines will form the basis for assessing the impacts of pollutants other than the criteria pollutants.

2.3 BASIS FOR JAMAICA'S PRIORITY AIR POLLUTANT LIST

Selection of the compounds on the PAP list was based on a review of substances on the following lists:

U.S. EPA Hazardous Air Pollutants list (188 substances)

Priority Substances Lists under the Canadian Environmental Protection Act (CEPA) (69 substances)

Canadian National Pollutant Release Inventory (NPRI) list (176 substances)

Lists of substances for which there are ambient air standards or guideline concentrations in Ontario, Michigan, Texas and Vermont

Control of toxic or hazardous pollutants is generally based on reference or comparison with either a stack emission limit or an ambient concentration (due to emissions) that must not be exceeded. Selected stack emission standards for toxic substances in various jurisdictions were noted in Appendix A-5 in the Stack Emission Standards for Jamaica. Emissions standards for various subcategories of hazardous air pollutant sources as defined by U.S. EPA are undergoing development. These emission standards are based on the best available emission control technology (BACT) while taking into consideration costs, health and non-air quality health and environmental impacts and energy requirements. The development of the U.S. national emission standards for hazardous air pollutants (NESHAPs) was scheduled over a 10-year period after enactment of the 1990 Clean Air Act Amendments and will be applicable to new and existing sources and limits for each may be different.

Table 2-3 Ambient Air Quality Standards for Jamaica

Pollutant	Averaging time	Standard (Maximum concentration in $\mu\text{g}/\text{m}^3$) ¹
Total Suspended Particulate Matter (TSP)(a)	Annual	60
	24 h	150
PM ₁₀ (b)	Annual	50
	24 h	150
Lead	Calendar Quarter	2
Sulphur Dioxide	Annual	80 Primary; 60 Secondary (c)
	24 h	365 Primary; 280 Secondary
	1 h	700
Photochemical oxidants (ozone)	1 h	235
Carbon Monoxide	8 h	10,000
	1 h	40,000
Nitrogen Dioxide	Annual	100

¹ Note that the regulations should have specified that all air quality measurements expressed in mass per unit volume are to be corrected to 25 °C and 101.3 kilopascals.

TSP – all particles and aerosols with aerodynamic diameter of 100 micrometres or less and can be measured by the high volume sampling method

PM₁₀ refers to particles with an aerodynamic diameter of 10 micrometres or less as measured by the PM₁₀ sampler.

The secondary standards for sulphur dioxide are designed to protect public health and welfare. They represent the long-term goal for air quality and provide the basis for an anti-degradation policy for unpolluted areas of the country and for continuing development of pollution control technology.

Some jurisdictions have developed ambient air quality limits for selected toxic air pollutants and have termed the limits as standards, criteria or guidelines. In general, the limits are applicable to new sources or major modifications of existing sources. The ambient guideline concentrations take into account human and other environmental effects of compounds and in some cases jurisdictions specify BACT for the toxic pollutants. The approach taken in the case of PAPs for Jamaica is the adoption of the guideline concentrations based on the selection of the least stringent guideline concentrations established by selected jurisdictions. Only a few jurisdictions have rigorously assessed the toxicological and environmental effects data to establish ambient standards. The leading jurisdictions are Michigan, Ontario, Vermont. Assessments of toxic air pollutants have also been conducted by Environment Canada/Health Canada, WHO, U.S. EPA, California, Massachusetts, New York State, Netherlands and Sweden. In these cases, the assessments have not always established ambient air concentration limits for compounds.

The PAPs and the corresponding guideline concentrations are based on a review of similar limits set in Michigan, Ontario and Vermont. The approach in Texas uses Environmental Screening Levels (ESLs) which are guideline concentrations which, if exceeded based on measurements or model predictions, trigger further review. The purpose of the guidelines is to specify the toxic substances that require assessment in the case of new sources or major modifications to existing sources in Jamaica. Ambient Air Quality Guidelines for the Priority Air Pollutants (PAPAAQG) are listed in Table 2-4. The list includes the Chemical Abstract Service (CAS) number and 1-h, 24-h and annual guideline concentrations as appropriate.

Table 2-4 Ambient Air Quality Guidelines for Priority Air Pollutants

Chemical	Chemical Abstract Service No.	Concentrations in $\mu\text{g}/\text{m}^3$		
		1 h	24 h	Annual
1,1,2,2-tetrachloroethane	79-34-5	0.2		
1,1,2-trichloroethane	79-00-5	0.6		
1,2-dichloroethane	107-06-2	0.4		
1,3-butadiene	106-99-0	0.04		
1,3-dichloropropene	542-75-6	50	20	
2,3,7,8-tetrachlorodibenzo (p)dioxin	1746-01-6	2.3×10^{-7}		
2,4-dinitrotoluene	121-14-2	0.05		
2-nitropropane	79-46-9	50	20	
Acetaldehyde	75-07-0	1,250	500	
Acetonitrile	75-05-8	375	150	
Acrolein	107-02-8	58.75	23.5	
Acrylic acid	79-10-7	2.5	1	
Acrylonitrile	107-13-1	250	100	
Aldrin	309-00-2	0.002		
Ammonia	7664-41-7	9,000	3,600	
Aniline	62-53-3	2.5	1	
Antimony & compounds	7440-36-0	62.5	25	
Arsenic & compounds	7440-38-2	0.75	0.3	
Benzene	71-43-2			1
Benzo(a)pyrene	50-32-8	0.00275	0.0011	
Benzyl chloride	100-44-7			0.2
Beryllium & compounds	7440-41-7			0.0013
Cadmium & compounds	7440-43-9	5	2	
Calcium oxide	1305-78-8	25	10	
Carbon dioxide (process emissions)	124-38-9			
Carbon disulphide	75-15-0	1,750	700	
Carbon tetrachloride	56-23-5	6	2.4	
Chlordane (technical)	12789-03-6	12.5	5	
Chlorinated dibenzo-p-dioxins (cdds)	NA	12.5 TEQ/ m^3	5 pg TEQ/ m^3	
Chlorine dioxide	10049-04-4	75	30	
Chloroform	67-66-3	1,250	500	
Chromium, hexavalent compounds	18540-29-9	3.75	1.5	
Chromium, trivalent compounds	16065-83-1	3.75	1.5	
Cobalt & compounds	7440-48-4		0.12	
Copper & compounds	7440-50-8	125	50	
Cresols	1319-77-3	187.5	75	
DDT	50-29-3			0.1
Dieldrin	60-57-1			0.002
Endrin	72-20-8			
Ethylene dibromide	106-93-4	7.5	3	

Chemical	Chemical Abstract Service No.	Concentrations in $\mu\text{g}/\text{m}^3$		
		1 h	24 h	Annual
Ethylene dichloride	107-06-2	5	2	
Ethylene glycol	107-21-1	31,750	12,700	
Formaldehyde	50-00-0	162.5	65	
Heptachlor	76-44-8			0.008
Hexachlorobenzene	118-74-1			0.02
Hydrogen chloride	2099-048	100	20	
Hydrogen sulphide	7783-06-4	2.5	1	
Lead	7439-92-1			
Manganese & compounds	7439-96-5			119
Mercaptans (as methyl mercaptan)	74-93-1	50	20	
Mercury & compounds	7439-97-6	5	2	
Mercury alkyl	7439-97-6	1.25	0.5	
Methyl bromide	74-83-9	3,375	1,350	
Methylene chloride	75-09-2	550	220	
Mirex	2385-85-5			
Nickel & compounds	7440-02-0	5	2	
Nitric acid	7697-37-2	87.5	35	
Nitrogen oxides as nitrogen dioxide	10102-44-0	400		
Polycyclic Aromatic Compounds				
P-dichlorobenzene	106-46-7	237.5	95	
Pentachlorophenol	87-86-5	250	100	
Phenol	108-95-2	250	100	
Polychlorinated biphenyls	1336-36-3	0.375	0.15	
Polychlorinated dioxins and furans				0.02 pg/m^3 #
P-xylene	106-42-3	5,750	2,300	
Quinoline	91-22-5			0.003
Selenium & compounds	7782-49-2	25	10	
Sodium hydroxide	1310-73-2	25	10	
Styrene	100-42-5	2,500	1,000	
Sulphuric acid	7664-93-9	1	23.8	
Sulphuric acid	7664-93-9	87.5	35	
Tetrachloroethylene	127-18-4	900	360	
Toxaphene	8001-35-2			0.03
Trichloroethylene	79-01-6	57.5	23	
Vinyl chloride	75-01-4		1	0.2
Vinylidene chloride	75-35-4	87.5	35	
Xylenes	1330-20-7	5,750	2,300	
Zinc and compounds	7440-66-6		12	

The guidelines for the PAPs will apply specifically to new sources or major modifications of existing sources. Existing sources will not automatically be required to meet the guideline concentrations nor will they be required to develop a compliance plan if the ambient concentrations of PAPs exceed the guidelines. The guidelines are therefore distinct from the ambient air quality standards which apply to existing and new sources. Note that where emissions from existing sources result in concentrations that are higher than the AAQS, the source must develop a compliance plan to reduce the emissions.

As a counterpart to the Guideline concentrations, a list of source subcategories that should specifically assess the potential to emit PAPs is also provided in Appendix 1. The subcategories are potential sources of Priority Air Pollutants and are based on the U.S. EPA list of source categories of Hazardous Air Pollutants.

NRCA will reserve the right to add to this list as may be appropriate.

The practical use of the PAP list is to determine whether or not new sources emit any of these pollutants and to estimate their impact relative to the guideline concentrations. Compounds on the PAP list should be considered for any annual reporting on emissions to air, water and land of toxic compounds that may be required in the future. This would be the Jamaican equivalent of the U.S. Toxic Release Inventory (TRI) and similar inventories in Canada (National Pollutant Release Inventory (NPRI)) and Mexico (RTEC (Registro de Emisiones y Transferencia de Contaminantes)).

3. SOURCE ASSESSMENT

Estimating the quantity of air contaminant emissions produced by a source or facility is necessary to properly assess its impact on human health and the environment. Knowledge of emission rates from sources will also determine whether the facility is classified as major, significant or minor. The initial step in making the determination is to identify all sources at the facility and to estimate the emissions from each source. This section will outline the requirements for estimating emission rates (when estimate or measurements are required), the methods for estimating emissions and guidance for conducting stack testing.

As with all other sections, detailed step-by-step procedures or methods are not provided but rather guidance on the requirements for performing the estimates or tests as the case may be.

3.1 REQUIREMENTS FOR ESTIMATES OR MEASUREMENTS

Estimates of emission rates from sources are required for air quality assessments, reporting of annual emissions and for calculating annual air pollutant discharge fees. The latter are a requirement of all licences and estimates may be calculated or based on measurements. Measurements or estimates may be required for one or more of the following:

Initial applications for Air Pollutant Discharge Licences for all major facilities

Stack emission monitoring to satisfy monitoring and reporting requirements or conditions of Air Pollutant Discharge Licences

Assessing compliance with stack emission standards and targets,

Any other monitoring and reporting requirements as may be specified by the Authority from time to time.

3.2 ESTIMATION OF EMISSIONS

It is important that emissions estimates are representative of the normal operation of the existing facility (and for the proposed facility if applicable). Care should be taken in estimating emissions in order to avoid over predicting or under-predicting emissions rates. Over prediction may result in higher discharge fees and unnecessary restrictions or conditions of the licence while under predicting emission rates may result in compliance problems during post-construction compliance emission testing and lower discharge fees.

Emission estimates should be determined for each averaging period corresponding to the pollutants' emission standard or target and must be consistent with the methodology. Rates required for annual reporting must be based on measurements or estimates for shorter periods and should account for variations in emissions due to production/activity levels and non-operating periods. Annual estimates should include estimates during upset or malfunction conditions where such emissions are significant (e.g., greater than about 1% of the annual emissions). Some sources at a facility are insignificant and need not be reported. The list of such insignificant sources are given in Appendix 2). Estimates should be accompanied by documentation of the basis for developing the rate and an indication of the quality of the data. For example, particulate matter emission results are typically based on a one-hour emission test run and therefore are usually considered one-hour average values. The average rates

reported must reflect normal operations and when the process is in actual operation. For example emissions of 12 kg for the entire shift at a facility that operates for only 8 hour each day will result in an hourly rate of 1.5 kg/h (not 0.5 kg/h).

Emission rates can be estimated by several methods. These methods in order of preference are:

Direct measurement

Manufacturer's emission data for representative equipment

Mass balance calculations

Emission factor estimates

Engineering calculations

3.2.1 Direct Measurement

Ideally, compliance or demonstration stack testing data from the specific equipment should be used. Otherwise emission testing data performed on an identical piece of equipment at a representative source should be used. Care must be taken in selection of a representative source, since process inputs or actual site conditions may vary considerably and consequently result in different emission rates. A copy of the full test report, including the procedures used, summary of results and operational data, must be submitted in support of emission rates based on measurement data.

3.2.2 Manufacturer's Emission Data for Representative Equipment

If compliance test data are not available, use of other representative data as specified by the equipment manufacturer is suggested. The applicant should request a guaranteed maximum emission rate for the equipment from the manufacturer, if possible, in order to avoid potential compliance problems in the future. It may be in the applicant's interest to include these guaranteed emission rates and conditions for their measurement in any purchase agreement with the equipment manufacturer.

3.2.3 Mass Balance Calculations

A mass balance is an accounting of the quantity of a substance going in and out of a facility, process, or piece of equipment. Emissions can be calculated as the difference between input and output amounts. Accumulation or depletion of the substance in the equipment should be accounted for in the calculation. Only those processes in which chemicals are not altered prior to exhaust to the atmosphere may be suitable for use of the mass balance method. Some examples of where a mass balance approach may be appropriate include emissions of volatile organic compounds and hazardous air contaminants from paints, stains, lacquers, inks and cleaning solutions. It is necessary to know the quantity of the product used and the chemical composition to calculate the emissions of volatile organic compounds and hazardous air contaminants using the mass balance approach. The constituents of the product can be obtained from the product's Material Safety Data Sheet (MSDS). Generally, for these types of volatile materials, mass balance relies on a conservative assumption that 100% of the process input is lost to the atmosphere.

Mass balance should not be employed when chemical reactions, such as combustion, occur in the process stream. These reactions often form new contaminants not specifically input into the process

in the first place. A chemical mass balance would not be representative of the true emissions in these situations.

3.2.4 Emission Factor Estimates

If equipment-specific stack test data are not available or mass balance is not appropriate, emission factors such as those in the current edition of the U.S. EPA publication [AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources](http://www.epa.gov/ttn/chief/ap42/index.html), (<http://www.epa.gov/ttn/chief/ap42/index.html>) should be used. An emission factor is an average value of the quantity of a pollutant released to the atmosphere based on the activity associated with the release of that pollutant. It is usually expressed as the weight of the pollutant emitted divided by a unit weight of material input or material produced (e.g., kilograms of particulate matter emitted per tonne of wood burned or kilograms of particulate matter emitted per batch) or as the weight of pollutant emitted divided by the duration (hours) of the activity that emits the pollutant. An emission factor is based on average measured emissions from several similar processes. When emission control devices are used, atmospheric releases are estimated by multiplying the “uncontrolled” emission by the quantity $(1 - C/100)$, where C is the control device efficiency.

For Criteria and Priority Air Pollutants, emission factors for a variety of sources are available from:

- U.S. EPA (WebFIRE (Factor Information Retrieval System) (<http://cfpub.epa.gov/oarweb/index.cfm?action=fire.main>),
- the Australian National Pollutant Inventory (NPI) (http://www.npi.gov.au/handbooks/approved_handbooks/sector-manuals.html); and
- European Union EMEP/CORINAIR Emission Inventory Guidebook – 2005 (http://reports.eea.europa.eu/EMEP_CORINAIR4/en/page002.html).
- The Locating and Estimating (L&E) series documents titled (Locating and Estimating Air Toxic Emissions from Sources of (source category or substance) (<http://www.epa.gov/ttnchie1/le/>) is suitable for some of the PAPs.

Care must be taken to express the emissions in the required units by application of suitable conversion factors. The Authority will not accept estimates that are not in metric units.

3.2.5 Engineering Calculations

This method is based on fundamental scientific principles and measurements including physical/chemical properties (e.g., vapour pressure) of the substance and mathematical relationships (e.g., ideal gas law).

3.3 SOURCE TESTING

The regulations require in some circumstances that the owner or operator of a stationary source perform emission testing to determine the emission rate of pollutants and to prepare written reports of the results. The test and report should provide data adequate to determine compliance with the emission standards specified in the regulations or in the source's own licence.

These guidelines are not step by step procedures but rather are intended to provide the owners or operators of stationary sources and their testing consultants with guidance regarding site preparation,

sampling protocols to be followed during the compliance testing and reporting requirements. Compliance testing must be conducted in accordance with standard procedures specified in the regulations. In general, these methods are U.S. EPA approved test methods contained in Title 40 Code of Federal Regulations Part 60, Appendix A and Part 61, Appendix B or various Environment Canada methods.

3.3.1 General Emission Testing Requirements

3.3.1.1 Testing Consultants

Because of the complexity of stack testing procedures and report preparation the Authority recommends that a qualified and experienced stack testing consultant be retained. Although not specified in the regulations, it is recommended that the first compliance test on a given source, including visible emissions evaluations (if required), be performed by a 3rd party (consultant) unrelated to the source or equipment vendor to avoid the appearance of conflict of interest. Further testing on that source, if required, may be performed either by a consultant or by "in house" personnel at the discretion of the source operators/owners.

3.3.1.2 Site Preparation

A source owner or operator is required to provide reasonable and necessary sampling ports in any stacks, vents, or ducts of interest. For particulate matter and other isokinetic testing, ports and sampling traverse points should be located in accordance with Method 1 of 40 CFR 60, Appendix A. Stack sampling ports should be located at least eight duct diameters downstream and two diameters upstream from any flow disturbances (e.g., bend, expansion, contraction, or exit).

Safe and easy access to these ports and a suitable power source at the testing location, are also required. Scaffolding, ladders, electrical power supply components and any other site preparation equipment used to aid the performance of the testing should be constructed and assembled in conformance with any Labour and Industry standards.

The site preparation requirements apply to tests made by the owner or operator or their consultant or by the Authority. Prior to tests made by the Authority, personnel from the Authority will visit the test site to inspect the process, determine a test location, discuss sampling procedures, arrange tentative test dates and determine the necessary test facilities. If a proposed sampling location or sampling method does not conform to those recommended in the regulations, prior approval from the Authority should be obtained before proceeding with the tests.

3.3.1.3 Notification of Testing

The regulations require that the Authority be notified at least 60 days in advance of testing when the test results will be submitted to the Authority. The regulations give the Authority the option to witness such tests and also to make its own tests at the same or at different times. When the Authority wishes to conduct its own testing at a facility, the Authority must notify the owner of a facility at least 60 days before such test are conducted.

3.3.1.4 *Testing of Priority Air Pollutants*

The regulations require submission of a Pretest Plan where monitoring for Priority Air Pollutants is required. The plan should indicate the program objectives, sampling locations, sampling and analytical procedures, quality assurance and quality control activities, reporting and data reduction, site preparation including plant entry and safety, personnel responsibilities, the proposed test schedule and a list of test methods.

3.3.1.5 *Process Operating Conditions*

Process conditions during the test periods should reflect normal operations and the equipment must be operated by the normal operating personnel. Any operating condition changes made during the tests must be thoroughly documented. In order to determine the maximum expected emission rate and provide some consistency among emission tests from time to time, sources must be operated at 90% or above of manufacturer's maximum production rating while tests are being conducted. The numbers of tests and the reporting requirements have been set out in detailed the regulations and will not be repeated here.

3.3.2 *Stack Test Report Requirements*

Reporting requirements for stack tests are detailed in the Stack Emission Monitoring Regulations. The requirements are as follows.

Name and location of the facility tested, the purpose of the tests, the test participants and their titles, and the date of test

Executive Summary (emission rates for each pollutant and a comparison with applicable emission standards and targets and to any emission limitations in the licence).

A description of the facility or facilities being tested, the type of process and control equipment utilised, the source name and location, names of participating organisations

A description of the process sampled and associated emission control devices referenced to process ID, and locations at which sampling took place consistent with information provided in the associated Air Pollutant Discharge Licence application or licence.

A schematic of each location including duct diameter, direction of flow, dimensions to nearest upstream and downstream, disturbances (include number of duct diameters), location and configuration of the sampling ports, nipple length and port diameters, and number and configuration of traverse points

Confirmation that the sampling location(s) meet the U.S. EPA criteria. If not, give reasons and discuss effect on results.

Discussion of any special traversing or measurement schemes.

A process flow diagram, maximum design capacities, a fuel analysis and heat value for heat input rate determinations, process and control equipment operating conditions, a discussion of variations from normal plant operations, and stack height, exit diameter, volumetric flow rate, exit temperature, and exit velocity. All data must be reported in metric units.

Sampling and analytical methods used

A brief discussion of the analytical procedures with justifications for any variance from reference method procedures

The specification of the number of sampling points, time per point, and total sampling time per run, a cross-sectional diagram showing sampling points, a diagram showing stack dimensions, sampling location and distance from the nearest flow disturbance upstream and downstream of the sampling points, and a diagram of the sampling train.

The sampling and analytical procedures

Results and calculations in units consistent with the applicable emission limitation with one (1) complete calculation using actual data for each type of test performed

The tabulated data and results of the process weight rate or heat input rate in metric units, the referenced or derived conversion factors, the stack gas flow rate, the measured emissions given in units consistent with the applicable emission limitations, the visible emissions observations or six (6) minute average continuous opacity monitor readings, and the average value of emissions from any continuous gaseous emissions monitoring system in units consistent with the applicable emission limitations, if applicable to the pollutant being tested.

Quality Assurance procedures

Appendices with raw data and details of calculations including:

Certification of the testing methods and results

Raw production data signed by the source official

Photocopies of all actual field data

A laboratory report with the chain of custody shown

Copies of all calibration data

For particulate matter tests, copies of visible emissions evaluations or opacity monitor readings, and, for gaseous pollutant tests, copies of any continuous gaseous emissions monitoring system readings during the tests.

4. GUIDELINES FOR AMBIENT AIR QUALITY MONITORING

This section outlines the circumstances when ambient monitoring is required and provides guidelines for conducting ambient air quality monitoring. The regulations provide broad stipulations for monitoring and indicate that a Guideline Document will provide details on the monitoring requirements. This section provides guidance on the following:

General requirements for ambient monitoring

Planning for ambient monitoring programs

Siting of air quality and meteorological monitoring stations

Requirements for the frequency and averaging periods of measurements

Monitoring methods

Documentation

Data management and reporting including formats for reporting data to the Authority

4.1 WHEN IS AMBIENT MONITORING REQUIRED?

4.1.1 Source-Specific Air Quality Monitoring

The Authority may require an applicant to conduct source-specific ambient monitoring for a number of situations. The monitoring generally will be limited to the primary¹ criteria pollutants emitted from the facility. Monitoring for meteorological data will be required only when suitable meteorological data are not available. These requirements will be evaluated on a case by case basis.

Some of these situations are:

The predicted impact of emissions from an existing major source exceeds the ambient air quality standard or in some circumstances (c and d below) is greater than 75% of any Jamaican ambient air quality standard

Historical ambient air quality data are greater than 75% of any current ambient air quality standard (this applies to data collected before standards were promulgated)

Predicted concentrations due to uncontrolled emissions would exceed the standard. This applies to facilities that have emission control equipment installed. The ambient monitors would indicate air quality levels in the event of failure of equipment.

¹ Primary pollutants are those emitted directly from a process or source. Secondary pollutants are those formed through chemical or other transformations of primary pollutants e.g., ozone is a secondary pollutants formed from nitrogen oxides and volatile organic compounds (in the presence of sunlight); sulphate is another secondary pollutant is formed by chemical transformations of sulphur dioxide.

There are no existing monitoring sites in the area around the proposed source and data from other sites cannot be shown to be representative of the area.

There is sufficient public concern over pre- and/or post-construction ambient levels of criteria and non-criteria e.g. priority air pollutants in the vicinity of major proposed facilities and there is little or no existing air monitoring data available.

In some circumstances, when the primary pollutants have the potential to significantly affect secondary pollutants (ozone), monitoring for secondary pollutants, namely ozone, may be required in addition to the primary pollutants. Such circumstances may include sources with high NO_x and/or VOC emissions when the sources are located in or near to urban areas.

4.1.2 Pre- and Post-Construction Monitoring

When pre-construction monitoring is required, proponents will be required to monitor for at least one year prior to submission of the EIA. The Authority may allow the collection of data during the EIA or license review process provided one year of data is available prior to the proposed approval of the project and the issuance of a draft permit for public comment. In such a case, monitoring data from other sites can be used to represent background concentrations. Data from the site-specific monitoring program must be used to confirm the air quality impact analysis and must be used in any future regulatory requirements.

If there is any question as to whether pre-construction air quality monitoring may be required, the applicant should consult with the Authority as early as possible so that sufficient time is available to collect a representative database. Post-construction or post-operational ambient air quality monitoring is generally required for a period up to one year after the source commences operation, unless the results of the air quality monitoring and dispersion modelling demonstrate that the source does not exceed 75% of any ambient air quality standard.

4.1.3 Urban Air Quality Monitoring

Ambient air quality monitoring in urban areas provide indication of the exposure of people to air pollutants. In urban areas, most of the pollutants will be due to motor vehicle emissions and also from industrial facilities located in or upwind of urban areas. The Guideline document includes recommendations for the numbers monitoring stations needed to assess population exposure in urban areas. Such monitoring will normally be carried out by public agencies (e.g., NRCA, EHU, JBI). Where industrial plants are located in urban areas, the monitoring stations will be located to assess compliance with ambient standards and also to measure population exposure. Specific guidance on the numbers and locations of such stations is provided.

4.2 AMBIENT AIR QUALITY MONITORING PLAN

The Regulations indicate the need for an Ambient Air Quality Monitoring Plan, “Persons required to conduct ambient air quality monitoring shall submit an Air Quality Monitoring Plan and shall provide documentation and reporting of the monitoring program according to the methods given in the NRCA document Guidelines for Air Quality Assessments”. The Ambient Air Quality Monitoring Plan shall at a minimum:

Indicate the airshed to which the monitoring plan will be applicable: include a list of the major facilities in the airshed

State the monitoring objectives

Indicate the administrative arrangements for the program

Specify the types and locations of monitoring sites

Indicate the air pollutants and meteorological parameters to be monitored

List the sampling and analysis methods

Indicate the frequency of sampling

Indicate data recovery and storage methods

Include a Quality Assurance plan

4.3 SITING OF AMBIENT AIR QUALITY MONITORING STATIONS

The selection of a specific monitoring site includes four major activities:

1. Developing and understanding the monitoring objectives and appropriate data quality objectives.
2. Identifying the spatial scale most appropriate for the monitoring objective of the site.
3. Identifying the general locations where the monitoring sites should be placed.
4. Identifying specific monitoring sites.

4.3.1 Classes of Ambient Air Quality Monitoring Stations

For the purposes of air quality assessments in Jamaica, the ambient air quality monitoring stations can be classified based on the following monitoring objectives:

compliance stations

population exposure stations

background stations

special purpose monitoring stations

Compliance stations: Persons required to conduct ambient air quality monitoring as conditions of licences will generally be required to locate stations as close as practicable to the locations where the maximum ground level concentrations are expected to occur. Other compliance stations may be located in urban and other areas where assessment of compliance with ambient air quality standards is needed.

Population Exposure Stations are located where a substantial number of people may spend a significant fraction of their day such as residential or recreational areas where people live and play, or in commercial or industrial areas where a substantial number of workers are employed.

Background Stations are located in remote areas that have minimal influences from man made point or area sources or are located in areas that will provide representative measurements of air quality entering an airshed with point or area sources.

Special Purpose Stations are established to achieve specific and generally short-term objectives including episode or emergency response monitoring, or for investigative or research purposes. Where acceptable measurement methods are used, data from these stations may be used to judge compliance with ambient air quality standards.

4.3.2 Representative Scales For Ambient Air Quality Monitoring Stations

Stations must be sited appropriately to achieve the monitoring objectives. The goal in siting stations is to correctly match the spatial scale represented by the sample of monitored air with the spatial scale most appropriate for the monitoring objective.

Ambient air quality measurements will be representative of the air in the immediate vicinity of the sampler (nominal horizontal extent of 1 metre) but can be representative of a much larger area depending on local site characteristics. The concept of representative spatial scale is used to define a characteristic area in which pollutant concentrations are essentially uniform.

The spatial scales that are generally defined are:

Microscale: Areas with radii from a few metres to as much as 100 m. The microscale is the area in the immediate vicinity of the monitor. Monitors in areas with PM₁₀ or other sources may be only representative of the microscale. A site visit is recommended to assess the applicability of microscale monitors, because maps rarely indicate or show confounding influences in sufficient detail.

Middle scale: Areas larger than microscale but generally no more than 0.5 km in radius. In populated or settled areas, this may amount to several city blocks. The middle scale is essentially the lower limit of resolution for most air dispersion models.

Neighbourhood scale: Areas generally between 0.5 and 4 km in radius. It is useful in defining extended areas of homogeneous land use.

Urban scale: Areas with radii ranging from about 4 km and 50 km. This is frequently the most desirable representative spatial scale, because it captures an entire urban area. However, the diversity of sources that prevail within such areas argues against homogeneity at this scale.

Regional scale: Ambient air volumes whose horizontal extent ranges from tens of kilometres to hundreds of kilometres. Monitors that are unaffected by specific sources or by localised groups of sources can be representative at this scale.

Global scale: Seek to characterise air quality from a global perspective (tens of thousands of kilometres).

The first three of these scales are of primary interest in Jamaica. The relationship between the station classification and the spatial scales that are generally most appropriate for the monitoring objectives are given in Table 4-1.

Table 4-1 Relationships Among Station Classification Monitoring Objectives and Siting Scale of Representativeness

Station Classification/Monitoring objective	Scales of Representativeness
Highest concentration/Compliance	Micro, middle, neighbourhood (sometimes urban)
Population exposure	Neighbourhood, urban
General/background	Neighbourhood, regional
Special purpose	Micro, middle, neighbourhood

4.3.3 Siting Criteria for Ambient Air Quality Monitoring Stations

Siting of air quality monitoring stations and sampling probes shall be done in accordance with the protocols set out below. The criteria are based on Appendix E of 40CFR 58 and the National Air Pollution Surveillance (NAPS) Network Quality Assurance and Quality Control Guidelines (NAPS, 1995) which have been adapted for Jamaican conditions.

The selection of sampling sites to meet monitoring objectives requires detailed information on the location of air emissions sources, spatial variability of ambient pollutant concentrations, meteorological conditions and population density. Since the terrain, meteorological conditions, demographic features and variability of emission sources are site-specific, the stations in each network must be developed individually. The site selection process involves considerations of the following factors:

Resources and Costs

The amount of resources required for the entire data collection activity, including instrumentation, installation, maintenance, data retrieval, data analysis, quality assurance and data interpretation.

Logistics

The process of dealing with the procurement, maintenance and transportation of material and personnel for a monitoring operation requires the full knowledge of all aspects of the data collection operation including planning, staffing, reconnaissance, procurement of goods and services, training, communications, scheduling, inventory and safety.

Security

The security of monitoring stations and the equipment therein is invariably a key consideration in site selection. If security problems cannot be solved by the use of standard measures such as restricted access, lighting, fences, alarm/telemetry systems, as well as periodic patrolling by local personnel, then the site should be located as near as possible to the identified location while maintaining adequate security.

Meteorological Considerations

Buildings, terrain and heat sources or sinks can affect movement of air in their vicinities and can produce local anomalies of too high or too low pollutant concentrations. Meteorology must be considered in determining not only the geographical location of a monitoring site but also such factors as height, direction and extension of sampling probes.

Topography

The transport and diffusion of air pollutants are complicated by topographical features. Minor topographical features may exert small influences; major features, such as deep river valleys or mountain ranges, may affect large areas. Before final site selection, review the topography of the area to ensure that the purpose of monitoring at that site will not be adversely affected. Land use and topographical characterisation of specific areas can be determined from topographical or land use maps.

Pollutant Considerations

Pollutants can undergo physical and chemical changes between their emission and their detection; therefore, the impact of such changes on the measuring system should be considered. Atmospheric chemical reactions such as the production of O₃ from its precursors (NO_x and HC) in the presence of sunlight and the time delay between the precursor emission and the detection peak of O₃ values may require different monitoring sites for the precursors and O₃.

4.3.4 Instrument Enclosure Requirements

Instrument Shelters

Continuous analysers such as for measurement of sulphur dioxide (SO₂), ozone (O₃), nitrogen oxides (NO and NO₂) and CO require instrument enclosures containing electronics, gas sensors and data acquisition, data logging and telemetry systems. The instrumentation should be housed in a climate-controlled environment or shelter to ensure proper functioning of sensors and electronics. Air sampling lines connect the instrument to the sampling probes located outside of the climate controlled instrument enclosure.

The shelter for housing instruments should be capable of maintaining the temperature and relative humidity of the instrumentation according to manufacturer's specifications. These will typically be between 10 °C and 30 °C and 10% and 90% relative humidity.

Sample inlet line characteristics:

The line connecting the sampling inlet to the instrument (e.g., SO₂, O₃, CO or NO_x analysers) should be made of inert materials such as borosilicate glass, stainless steel or teflon and should be demonstrated to be inert during the residence time in the line for the specified compound.

4.3.5 Sample Probe Placement Characteristics

Horizontal and Vertical Placement

The sample inlet should be located as follows:

3 to 15 m above ground level for SO₂, O₃, NO_x and or 2 to 7 m for lead and particulate matter. Carbon monoxide monitoring is generally required to assess population exposure especially in urban areas. Ideally, probe heights should be in the breathing zone. The specified height of 3.0 ± 0.5 m is a compromise between the ideal breathing zone height and the minimum height that is considered to minimise vandalism.

The horizontal distance from the sampler inlet to any airflow obstacle must be at least twice the height of the obstruction from the obstruction. Generally, a probe or monitoring path located near or along a vertical wall is undesirable because air moving along the wall may be subject to possible removal mechanisms. A probe must have unrestricted airflow in an arc of at least 270 degrees around the inlet probe, or 180 degrees if the probe is on the side of a building. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential.

At least 1 m from the walls of a building or structure supporting the probe for gaseous pollutants and 2 m for lead and TSP or PM₁₀. If the probe or a significant portion of the monitoring path is located near the side of a building, then it should be located on the wind-ward side of the building relative to the prevailing wind direction during the season of highest concentration potential for the pollutant being measured.

More than 20 m for SO₂, O₃, NO and NO₂ monitors or more than 10 m for CO from the drip line of trees. No trees between traffic source and CO monitors.

PM monitors should not be located in unpaved areas unless there is year round vegetative cover. This will minimise the potential influence of wind blown dust.

4.3.6 Distance From Roadways

Special purpose monitoring stations for measuring the highest PM₁₀ concentration from mobile sources should be located on roadways with the highest traffic volume and at the distance most likely to produce the highest concentrations. For the microscale traffic related station, the location must be between 5 and 15 metres from the major roadway. For the microscale street site the location must be between 2 and 10 metres from the roadway. For the middle scale and neighbourhood or larger scale stations, a range of acceptable distances from the roadway is shown in Figure 4-1. Any station, 2 to 15 metres high and further back than the middle scale requirements will generally be neighbourhood, urban or regional scale.

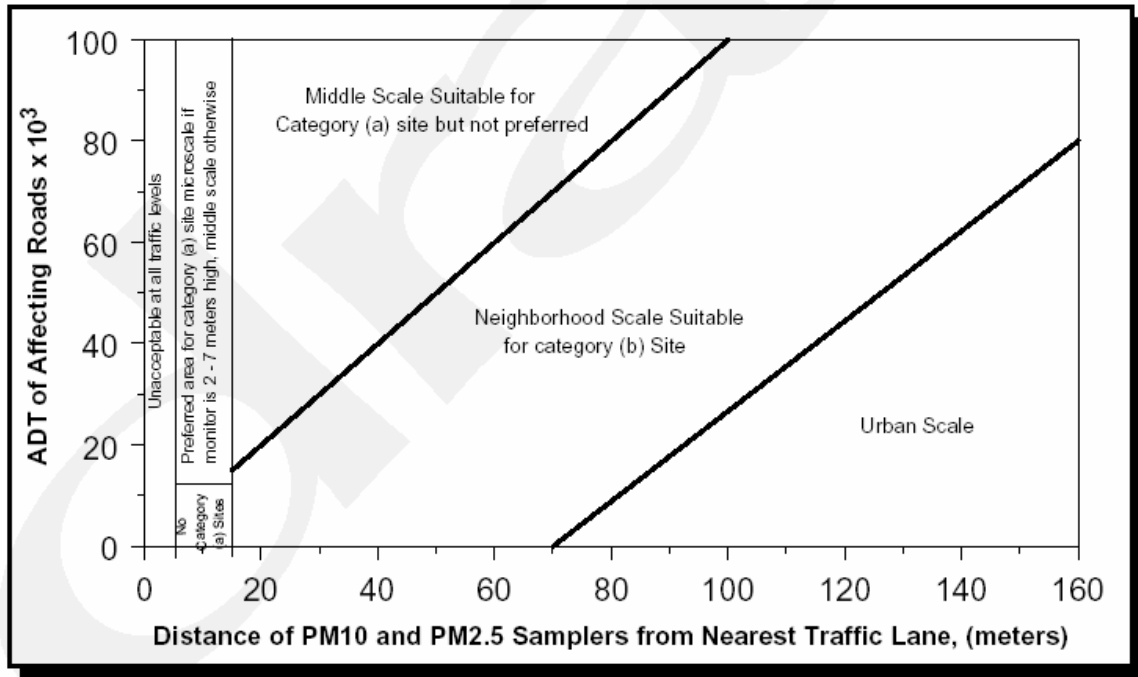
Vehicles are the major sources of CO and nitrogen oxides. Where leaded gasoline is used, these vehicles will be a source of particulate lead. Nitric oxide reacts rapidly with ozone to form nitrogen dioxide. Monitors placed close to mobile sources would read low in the case of ozone and high in the case of NO₂. Placement of ozone and nitrogen oxides monitors must therefore minimise the direct interferences from mobile sources. The separation distances between the edge of roadways and CO, NO_x, O₃ and Pb monitors are summarised in Table 4-2.

Table 4-2 Distances between the Edge of the Nearest Traffic Lane and Monitors for NO_x, O₃, CO and Pb

Roadway Traffic (vehicles/day)	Distance between edge of nearest traffic lane and monitor (metres)				
	NO _x , O ₃	CO	Pb		
Daily			Micro	Middle	Neighbourhood
<10,000	10	10	5 to 15	>15 - 50	>50
15,000	20	25			
20,000	30	45	5 to 15	>15 – 75	>75
30,000		80			
40,000	50	115	5 to 15	>15 - 100	>100
50,000		135			
<60,000		150			
70,000	100				
>110,000	250				

(1) Distances should be interpolated based on traffic flow.

Figure 4-1 Recommended Distances of PM Samplers from Roadways (from Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Part 1, Ambient Air Quality Monitoring Program Quality System Development, US EPA)



4.4 SITING FOR METEOROLOGICAL MONITORING STATIONS

Site-specific meteorological data are required for air quality assessments when more detailed dispersion modelling is required. Ideally, the meteorological station should provide data that are representative of the modelling domain (typically an area within a radius of up to about 20 km from a point source). Where data from the nearest National Meteorological Office station provides data that are representative of the site, these data may be used for dispersion modelling and other air quality assessment purposes. Currently, the numbers of National Meteorological Service stations are limited to those at the international airports. These data will be suitable for sources near to the coastal/plain areas in Kingston, St. Andrew and St. Catherine in the case of the Norman Manley International (NMIA) Airport in Kingston and the coastal/plain areas near Montego Bay Metropolitan Region for the Donald Sangster International Airport (DSIA) in Montego Bay.

Meteorological stations should be located according to the following siting guidelines:

Open ground with a primary area of interest at least 15 m by 15 m covered by short grass.

Wind speed and direction instruments at a height of 10 m above the ground

Sensors must be at a horizontal distance that is at least 10 times the height of the nearest obstruction

24 h access to the site

Adequate security for the instrumentation

4.5 NUMBERS OF MONITORING STATIONS

4.5.1 Number of stations Near Major facilities

In the vicinity of each major source, at least three monitoring stations generally will be required:

Two (2) compliance stations located near the maximum predicted concentration in each of two downwind directions. When there are major diurnal shifts in wind directions due to land/sea breeze effects and/or valleys, a monitoring station should be located in each of the two prevailing wind directions.

At least one population exposure station. The location should be selected bearing in mind the following:

Communities with the highest predicted concentration

Communities with a history of community complaints

Freedom from the presence of other confounding local or fugitive sources

One (1) background station. The background station should be upwind of major facilities and be representative of air masses entering the airshed.

The number of stations will be based on site or area specific features. Where a station may serve multiple purposes or is suitable for more than one major source, the number of stations may be

reduced. Examples are a common background or meteorological station may serve major point sources that are located close to each other.

The conditions of licences may specify the need for additional monitoring locations that may be required to assess impacts from area or fugitive sources for example, loading/unloading operations, mining activities and haulage roads.

4.5.2 Numbers of Monitoring Stations for Other Monitoring Objectives

Monitoring in urban areas or for special purposes will require selection of the number of stations based on the peculiar situation. In the case of urban areas, the monitoring objectives are for population exposure or trend monitoring based on measurements of TSP/PM₁₀/Pb, SO₂, O₃, NO_x and CO. Areas with high photochemical oxidant (ozone) concentrations may benefit from speciated volatile organic compound (VOC) and carbonyl monitoring. Most jurisdictions that conduct extensive ambient monitoring tend to have much larger urban centres than in Jamaica; these generally base the number of stations on the total population. For selected urban areas with less than 1 million population, guidelines for the numbers of monitoring stations are summarised in Table 4-3. Other jurisdictions have used population density as the basis, for example in Taiwan the basis is:

1 station /80,00 for density > 2,000/km²

1 station per 120,00 for density < 2,000/km²;

or

Number of stations = A/25 x D/1,900 for density < 1,900/km²

Number of stations = A/25 for density > 1,900/km²

where A is the habitat area in km² and D is the population density.

Table 4-3 Requirements for Monitoring Stations in Selected Networks

Jurisdiction	Population (millions)	Average number of monitoring stations					
		TSP or PM ₁₀	SO ₂	NO _x	O ₃	CO, Pb	Wind
WHO	<1	2	2	1	1	1	1
U.S. EPA NAMS	0.5 to 1	4 to 8 (H) 2 to 4 (M) 1 to 2 (L)	4 to 8 (H) 2 to 4 (M) 1 to 2 (L)	0	2	≥2	
	0.65 to 0.5	3 to 4 (H) 1 to 2 (M) 0 to 1 (L)	3 to 4 (H) 1 to 2 (M) 0 to 1 (L)	0	2	0	
	0.1 to 0.65	1 to 2 (H) 0 to 1 (M) 0 (L)	1 to 2 (H) 0 to 1 (M) 0 (L)	0	0	0	

(H) High concentration, exceeding level of the primary U.S. national ambient air quality standard (NAAQS)

(M) Medium concentration, exceeding 60 percent of the level of the primary or 100% of the secondary U.S. NAAQS

(L) Low concentration, less than 60 percent of the level of the primary or 100% of the secondary NAAQS.

The types of ambient monitoring stations and the criteria for the distribution numbers of stations in the Canadian National Air Pollutant Surveillance (NAPS) network are summarised in Table 4-4.

Table 4-4 NAPS Network Station Classification and Distribution Criteria

Type	Distribution	Separation	Location		Spatial Scale (a)
Class I	1 per 250,000 population (exceptions for some cities) Maximum of 6 sites per urban area	6 – 8 km between sites	1 st site 2 nd site 3 rd site 4 th site 5 th site 6 th site	Downtown (commercial) Residential with worst air quality Residential with poor air quality at a 90° quadrant from 1 st and 2 nd sites Secondary commercial with heavy traffic Residential in third quadrant Residential in fourth quadrant or third commercial	Middle Neighbourhood Neighbourhood Middle or Neighbourhood Neighbourhood Neighbourhood
Class II	1 per 100,000 up to 15 less the number of Class I stations. For urban areas with population of 25,000 to 100,000 one station where there is a demonstrated need	3 - 5 km		Sited to satisfy specific pollutant monitoring requirements or objectives	Neighbourhood But may be middle

Middle scale - typically 0.1 to 0.5 km radius; Neighbourhood scale - typically 0.5 to 4 km radius

The numbers of stations recommended for determination of population exposure in urban areas in Jamaica are given in Table 4-5. It should be noted that additional monitors would be required for compliance monitoring when major and other sources are located in urban areas.

Table 4-5 Guidelines for Number of Urban Population Exposure Stations in Jamaica

Pollutant	Population		
	100,000 to 250,000	250,000 to 500,000	> 500,000
PM (TSP or PM ₁₀ or PM _{2.5})	1 to 2	2 to 4	>4
Pb	0	0 to 1	1 to 2
CO	0	1 to 2	2 to 4
NO _x	0	1 to 2	2 to 4
O ₃	0	1 to 2	2 to 4
SO ₂	0	0	1
VOCs	0	0	2 to 4

4.6 SAMPLING SCHEDULE AND FREQUENCY

4.6.1 Schedule

Measurements are required primarily for comparison with National Ambient Air Quality Standards which specify concentrations for hourly, 8 hour, daily (24 hours), quarterly (3 months) or annual averaging times. Hourly samples must correspond to the 60 minutes starting on the hour. The 24-hour samples should be taken from midnight (local standard time) to midnight and thus represent calendar days to permit the direct use of sampling data in standard daily meteorological summaries. Quarterly averages must correspond to calendar quarters.

4.6.2 Sampling Frequency

The following are the minimum sampling frequencies:

Noncontinuous Hivol sampling for TSP, Pb and PM₁₀ levels:

Every 6 days preferably corresponding to the North American Schedule for Hivol sampling.

Continuous measurements for SO₂, NO, NO₂, CO, O₃, PM₁₀.

Raw measurements for example those taken every three minutes must be averaged to hourly averages.

4.7 REQUIREMENTS FOR CALCULATION OF SUMMARY STATISTICS

The minimum numbers of valid measurements required for calculation of summary statistics are as follows. At least 75% of the total possible observations must be present and valid before summary statistics are calculated. The exact requirements are as follows:

Averaging period Minimum number of valid observations/averages

8-h running average 6 hourly observations in the 8 h period

Daily 18 hourly measurements

Monthly 21 daily averages

Quarterly 3 consecutive monthly averages

Annual 9 monthly averages with at least 6 monthly averages/quarter

For intermittent sampling data, there must be at least five observations/quarter; if one month has no observations, the remaining two months must have at least two.

If validation procedures indicate that the requirements are not fulfilled (the minimum numbers must be valid observations), the sampling frequency should be increased during the period in which corrective measures are being pursued.

4.8 MEASUREMENT METHODS

The measurement methods are specified in the regulations in terms of data quality objectives (DQOs) that must be met. The regulations also refer to instrumentation that will satisfy the DQOs. The instrumentation references are the reference and equivalent methods designated by U.S. EPA. Methods and instruments used by other jurisdictions are acceptable provided they meet or exceed the DQOs. The purpose of this section of the guide is to indicate the sources of information on instrumentation and to provide a current list of methods and instruments for ambient air quality monitoring. Note that all air quality measurements expressed in mass per unit volume are to be corrected to 25 C and 101.3 kilopascals.

The DQOs specified in the regulations are reproduced in Table 4-6.

Methods for measurement of the criteria pollutants are available from the U.S. EPA AMTIC web site <http://www.epa.gov/ttn/amtic/all.html>.

4.8.1 Measurement Methods for Other Pollutants

Ozone Precursors

Measurement of speciated non-methane hydrocarbons (NMHC) should be made by U.S. EPA method TO-14 (U.S. EPA, 1991). NMHCs are non-methane hydrocarbons with 2 to 12 carbon atoms. Other species that are important for assessment of photochemical oxidants are carbonyls and alcohols. The VOC species that are recommended for ambient monitoring of ozone precursors are given in Appendix 3.

Priority Air Pollutants

Methods for measuring priority air pollutants should follow U.S. EPA methods. A list of methods can be found in the U.S. EPA Report, Ambient Measurement Methods and Properties of the 189 Clean Air Act Hazardous Air Pollutants, EPA 600/R-94/098, March 1994, US EPA, Research Triangle Park, NC.

4.9 NETWORK AND SITE DOCUMENTATION

4.9.1 Network Documentation

The documentation recommended for monitoring should include the following:

Statement of Network monitoring objectives

Reporting relationships

Name of network

Name of the organisation that owns the network

Organisation or department operating the network

Individuals with responsibility for various aspects of network operation

Monitoring Plan

The plan should include the following:

Monitoring objectives

Parameters monitored

Air pollutants

Meteorological parameters

Monitoring strategy and rationale

- Duration of program

- Number of monitoring sites

- Site selection

Monitoring and analysis methods and rationale for their selection

- Data Management

- Data Analysis and Interpretation

- Reporting

- Overall Schedule for monitoring program

Quality Assurance Plan

Standard Operating Procedures for field, laboratory and office procedures

4.9.2 Site Documentation

Site documentation should consist of the following:

Location: (Street Address, City/Town, Parish, UTM coordinates)

A topographic map at a scale of 1:12,500 to 1: 25,000 with the location of the station marked on it

A station site plan showing the location of equipment (sensors, probes etc), nearest obstructions (trees, buildings), features such as roads, landmarks for an area 100 m from the station.

Four photographs taken facing each of the cardinal compass directions

Species monitored (include air quality and meteorological parameters)

Comments describing the main features of the site (site classification, types of nearby sources, major land use pattern, general description of the terrain within 5 km of the station)

Details of instrumentation (manufacturer, model, serial number, installation date, sensor/probe location/height above ground, data storage method (chart recorder, data logger, telemetry))

Field Monitoring protocols (instrumentation/method, schedule for each parameter)

List of monitoring protocols: method, instrumentation

A site documentation form is provided in Table 4-7.

Table 4-6 Minimum Performance Specifications for Ambient Air Quality Monitoring of Criteria Pollutants

Specification	SO ₂	NO ₂	CO	O ₃	TSP	PM ₁₀	Pb
Reference Method	Pararosaniline Method	Chemiluminescence	Non-dispersive IR Gas filter correlation spectroscopy	Ultraviolet photometry	Manual High Volume sampler	Hivol sampler	
Equivalent Methods	See Appendix 4	See Appendix 4	See Appendix 4	See Appendix 4	See Appendix 4	See Appendix 4	See Appendix 4
Operating Range	0 to 0.5 ppm	0 – 0.5 ppm	0 – 50 ppm	0.01 – 0.5 ppm	2 – 750 µg/m ³		
Minimum Detection Limit	0.010 ppm	0.010 ppm	1.0 ppm	0.010 ppm	2 µg/m ³	0.07 µg/m ³	0.07 µg/m ³
Noise	0.005 ppm	0.005 ppm	0.5 ppm	0.005 ppm	NA	NA	NA
Zero drift (24 h)	±0.02	±0.02	±1.0	±0.02	NA	NA	NA
Span Drift (24 h)					NA	NA	NA
20% of upper range	±20.0%	±20%	±10%	±20%			
80% of upper range	±5.0%	±5%	±2.5%	±5.0%			
Precision					3%	□ 5 µg/m ³ for conc □ 80 µg/m ³ and 7% for conc > 80 µg/m ³	
20% of upper range limit	0.010 ppm	0.02 ppm	0.5 ppm	0.01 ppm			
80% of upper range limit	0.015 ppm	0.03 ppm	0.5 ppm	0.01 ppm			
Accuracy Annual	±15% 95% CI □ ±20%	±10%	95% CI □ ±20%	±10% 95% CI □ ±20%	±10%	PD □ 7%	
Completeness (minimum averaging period)	75% (hourly)	90% (hourly)	75% (8 h block)	90% (hourly)	90% (monthly)	75% (Quarterly)	75% (Quarterly)
Maximum cycling time		5 minutes	5 minutes	5 minutes	NA		
Averaging time	1 h	1 h	1 h	1 h	24 h	24 h	

NA Not applicable

CI Confidence interval PD Percent difference

(*) or 7% of 3 collocated samplers. Average flow rate over 24 h within ±5% of initial flow rate; all measured flow rates over 24 h within ±10% of initial flow rate.

To convert from parts per million to µg/m³ at 25°C and 760 mm Hg, multiply by M/0.02447, where M is the molecular weight of the gas.

Table 4-7 Site Documentation Form

Site Documentation Form

Station ID		Street Address					
Station name		City/Town					
Network name		Parish					
Network Manager							
UTM North		Attachments Site Plan <input type="checkbox"/> Photographs <input type="checkbox"/> Topographic map <input type="checkbox"/>					
UTM East							
Pollutant							
Manufacturer							
Model							
Serial number							
Installation date							
Sensor/probe location							
/height above ground							
Data storage method							
(chart recorder, data logger, telemetry, other)							
Field monitoring protocol available <input type="checkbox"/>							
Description of site							

4.10 DATA MANAGEMENT

4.10.1 Data Reporting Formats

All long term ambient air quality monitoring data will be compiled in a national database. It is essential that all data be reported in electronic format in a consistent format. Ambient monitoring data will consist of three types with a corresponding format for each:

hourly ambient air quality concentration measurements

daily (24-hour) average ambient air quality concentration measurements

hourly Meteorological Measurements

The electronic formats or records require assignment of codes for each pollutant or meteorological parameter. The pollutant codes for the most commonly measured pollutants are given in Table 4-8 and are assigned codes in the range 001 to 015. Additional pollutant codes for elements and other species based on analysis of Hivol (TSP), PM₁₀ or PM_{2.5} samples for example, or for volatile organic compounds are given in Appendix 5. Pollutant codes for elements are assigned as 100 + the atomic number while those for volatile organic compounds and hazardous pollutants are assigned codes identical to their Chemical Abstract Service (CAS) Number. Note that the units are implied by the code and that the same chemical species measured by different methods are assigned a different pollutant code (e.g., lead by Hivol and lead by PM₁₀ are assigned to distinct codes).

The electronic files must be submitted in ASCII format with the file structures shown in Tables 4-9 to 4-10.

Table 4-8 Pollutant Codes in the NRCA Ambient Air Quality Database

Pollutant Code	Formula	Description	Units	Record Type
COH	COH	Soiling Index	COH units/ 1000 linear ft	Hourly
TSP	TSP	Total Suspended Particulate	$\mu\text{g}/\text{m}^3$	Daily
DF	DF	Dustfall	$\text{g}/\text{m}^2/30\text{days}$	Monthly
SO2	SO ₂	Sulphur Dioxide	$\mu\text{g}/\text{m}^3$	Hourly
CO	CO	Carbon Monoxide	mg/m^3	Hourly
NO2	NO ₂	Nitrogen Dioxide	$\mu\text{g}/\text{m}^3$	Hourly
O3	O ₃	Ozone	$\mu\text{g}/\text{m}^3$	Hourly
NO	NO	Nitric Oxide	$\mu\text{g}/\text{m}^3$	Hourly
Pb	Pb	Lead	$\mu\text{g}/\text{m}^3$	Daily
SO4	SO ₄	Sulphate	$\mu\text{g}/\text{m}^3$	Daily
SO3	SO ₃	Sulphation	$\text{mg}/(100\text{cm}^2/\text{day})$	Monthly
NO3	NO ₃	Nitrate	$\mu\text{g}/\text{m}^3$	Daily
NOx	NO _x	Nitrogen Oxides	ppb	Hourly
PM10	PM ₁₀	Particulate matter less than 10 microns	$\mu\text{g}/\text{m}^3$	Daily
PM25	PM _{2.5}	Particulate matter less than 2.5 microns	$\mu\text{g}/\text{m}^3$	Daily

Table 4-9 Format for Hourly Records, NRCA Ambient Air Quality Database

Field Number	Description	Length	Start Column	End Column
1	Station identification	6	1	6
2	Year	4	7	10
3	Month	2	12	13
4	Day	2	14	15
5	Hour	2	16	17
6	Pollutant code	10	18	27
7	Hourly average in units as specified for the pollutant code with five integers and a decimal point as needed. (Table 4-15). 999999 = Missing data	6	28	33
8,9	Fields 6 and 7 are repeated for as many pollutants as needed in ascending alphanumeric order of the pollutant code.			

Table 4-10 Format for Daily Records, NRCA Ambient Air Quality Database

Field Number	Description	Length	Start Column	End Column
1	Station identification*	6	1	6
2	Year	4	7	10
3	Month	2	12	13
4	Day	2	14	15
5*	Pollutant code	10	16	25
6*	Daily average in units as specified for the pollutant code (Table 4-15). (field length including decimal point; 999999 = Missing data)	6	26	31
*	Fields 5 and 6 are repeated for as many pollutants as needed in ascending numerical order of the pollutant code.			

* A suggested (but not required) numbering system for the station ID is to use the last three or four digits of the permit or licence number followed by a dash and a sequential letter code A through Z (e.g., P121-A for the first station and P121-B for the second station etc.).

Meteorological Data

The file structure for meteorological parameters is given in Table 4-11. The file structure is similar to that used for storage of international surface weather observations data but with additional fields for ceiling height in tens of metres and also for solar radiation. The file structure has fixed positions for various parameters with a blank column between each weather element.

Wind data are often displayed as wind roses in 16 compass directions. The conversion scheme used for this conversion is given in Table 4-12.

Table 4-11 Format for Hourly Meteorological Data Records, NRCA Air Quality Database

Field	Width	Start Column	End column	Description
1	6	1	1	STATION NUMBER. A six-digit number
2	4	8	11	YEAR, in four digits.
3	2	12	13	MO (Month). January through December, 01-12.
4	2	14	15	DA (Day). Day of the month, 01-31.
5	2	16	17	HR (Hour). Local time, 00-23.
6	3	21	23	WIND DIR (Wind Direction). Given in whole degrees (001-360). 990 = Variable wind direction 000 = Calm. 999 = Missing
7	4	25	28	WIND SPEED. Stored in tenths of metres per second (e.g., 22.2 stored as 0222). 0000 = Calm. 9999 = Missing
8	3	35	37	CIG (Ceiling). The height above the earth's surface of the lowest layer that is reported as broken or overcast; or the vertical visibility into an indefinite ceiling. Height of cloud ceiling given as a distinct number (000-099) - See Table 4-11a. 999 = Missing.
9	2	44	45	Nh (Fraction in tenths of celestial dome covered by all low clouds present). If no low clouds are present, the fraction covered by all the middle clouds (CM) present. 99 = Missing.
10	6	60	65	VSBY (Visibility in Whole Metres). Values greater than 160,000 are entered as 160000. 999999 = Missing.
11	4	95	98	DRY BULB TEMP (Dry-Bulb Temperature). Stored in tenths of degrees Kelvin (e.g., 284.4 stored as 2844). 9999 = Missing.
12	4	100	103	DEW PT TEMP (Dew-Point Temperature). Stored in tenths of degrees Kelvin (e.g., 284.4 stored as 2844). 9999 = Missing.
13	5	123	127	STATION PRESSURE. Stored in tenths of millibars (1012.2 stored as 01022. 99999 = Missing
14	5	129	133	SOLAR RADIATION. Solar radiation in tenths of watts/square metre. (e.g., 750.2 w/m ² stored as 7502.
15	4	135	138	CLOUD CEILING HEIGHT in tens of metres (0000 – 2100). The height above the earth's surface of the lowest layer that is reported as broken or overcast; or the vertical visibility into an indefinite ceiling. Unlimited ceiling > 21,000 m or no clouds ----. Missing = 9999. Data from manual observations or ceilometer or ceiling light.
16	5	140	144	RAINFALL in tenths of mm (e.g., 0.2 mm stored as 20)

Table 4-11a Codes for Cloud Ceiling Heights (height of base of cloud layer)

Code Figure	Metres	Code Figure	Metres	Code Figure	Metres
0	< 30	32	960	68	5400
1	30	33	990	69	5700
2	60	34	1020	70	6000
3	90	35	1050	71	6300
4	120	36	1080	72	6600
5	150	37	1110	73	6900
6	180	38	1140	74	7200
7	210	39	1170	75	7500
8	240	40	1200	76	7800
9	270	41	1230	77	8100
10	300	42	1260	78	8400
11	330	43	1290	79	8700
12	360	44	1320	80	9000
13	390	45	1350	81	10500
14	420	46	1380	82	12000
15	450	47	1410	83	13500
16	480	48	1440	84	15000
17	510	49	1470	85	16500
18	540	50	1500	86	18000
19	570	51-55	Not Used	87	19500
20	600	56	1800	88	21000
21	630	57	2100	89	>21000
22	660	58	2400	90	less than 50 m
23	690	59	2700	91	50 to 100 m
24	720	60	3000	92	100 to 200 m
25	750	61	3300	93	200 to 300 m
26	780	62	3600	94	300 to 600 m
27	810	63	3900	95	600 to 1000 m
28	840	64	4200	96	1000 to 1500 m
29	870	65	4500	97	1500 to 2000 m
30	900	66	4800	98	2000 to 2500 m
31	930	67	5100	99	2500 m or more, or no clouds

Table 4-12 Sixteen (16) Point Wind Direction Conversion Table

Assignment	Wind Direction	Wind direction
	Degrees	10's of degrees
NNE	012 – 033	2
NE	034 – 056	5
ENE	057 – 078	7
ESE	079 – 101	9
SE	102 – 123	11
SSE	124 – 146	14
S	147 – 168	16
SSE	169 – 191	18
S	192 – 213	20
SSW	214 – 236	23
SW	237 – 258	25
WSW	259 – 281	27
WNW	282 – 303	29
NW	304 – 326	32
NNW	327 – 348	34
N	349 – 011	36
Calm	0	00

4.10.2 Data Review, Verification and Validation

Data review, verification and validation are techniques used to accept, reject or qualify data in an objective and consistent manner. Verification confirms that specified requirements have been fulfilled based upon examination and provision of objective evidence. Validation confirms that the particular requirements for a specific intended use are fulfilled by examination and provision of objective evidence.

The review, verification and validation methods must ensure:

- Consistency with sample collection, handling and analysis procedures
- Consistency with Analytical Procedures
- Proper Quality Control procedures followed (analyses of check standards, blanks and replicates), comparison with acceptance criteria
- Corrective action taken and the potential effect of the action on the validity of the data are noted and indicate which samples were affected.
- Calibration - timing and sequence relative to when measurement data were generated, number of calibration points, proper values of standards (that “bracketed” the range of reported measurement)
- Acceptable linearity checks and other checks to ensure that the measurement system was stable when the calibration was performed.

- Maintenance of data precision across reporting and calculation procedures
- Data are representative of conditions and hence data may be used as intended

Effective data validation procedures usually are handled completely independently from the procedures of initial data collection. A variety of computerised methods are available for automated data validation.

Recommended methods are as follows:

- Pattern tests for hourly data
- Compare data with the maximum values shown in Table 4-15 for:
- adjacent hourly values; and
- moving 24-h averages

Gap test by examination of the frequency distribution of the data. Large gaps in the frequency distribution (the length of the gap and the number of values above the gap) indicate potential suspect data.

Data that fail these tests would be flagged for further investigation by review of strip charts, data logs, meteorological conditions and if necessary contacting the agency that collected the data. Potential sources of error include zero or span periods reported as data, improper instrument operation, manual data reduction errors and improper scaling or conversion factor used.

Table 4-13 Data Validation Limits

Pollutant	Data Stratification	Maximum hourly	Adjacent Hour	Moving 24-h	S Max
SO ₂ (ppb)		10	100	130	200
CO (ppm)	Rush hour	20	12	12	15
	Non-rush hour	13	8	12	15
NO ₂ (ppb)		170	80	80	170
O ₃ (ppb)		90	40	60	90

For 24-h average data such as TSP, Pb and PM₁₀ measurements, the current monthly average and range of values are compared with similar data for the previous three months. Data that exceed the values are flagged for further investigation.

5. DISPERSION MODELLING

Dispersion modelling provides a basis for estimating the air quality concentrations due to proposed changes in air pollutant emissions from proposed sources or modifications to existing sources or for estimating the impacts of existing sources.

Emissions from all types of sources that may influence the total ambient concentration must be included in dispersion modelling for air quality assessments. The types of sources which can be evaluated at any one time depend on the specific dispersion models. Source types handled by models are listed in Table 5-1. This section of the Guideline Document focuses on point sources since they are the most common.

5.1 OVERVIEW OF MODELLING REQUIREMENTS

The regulations refer to two levels of dispersion modelling:

screening modelling ; and

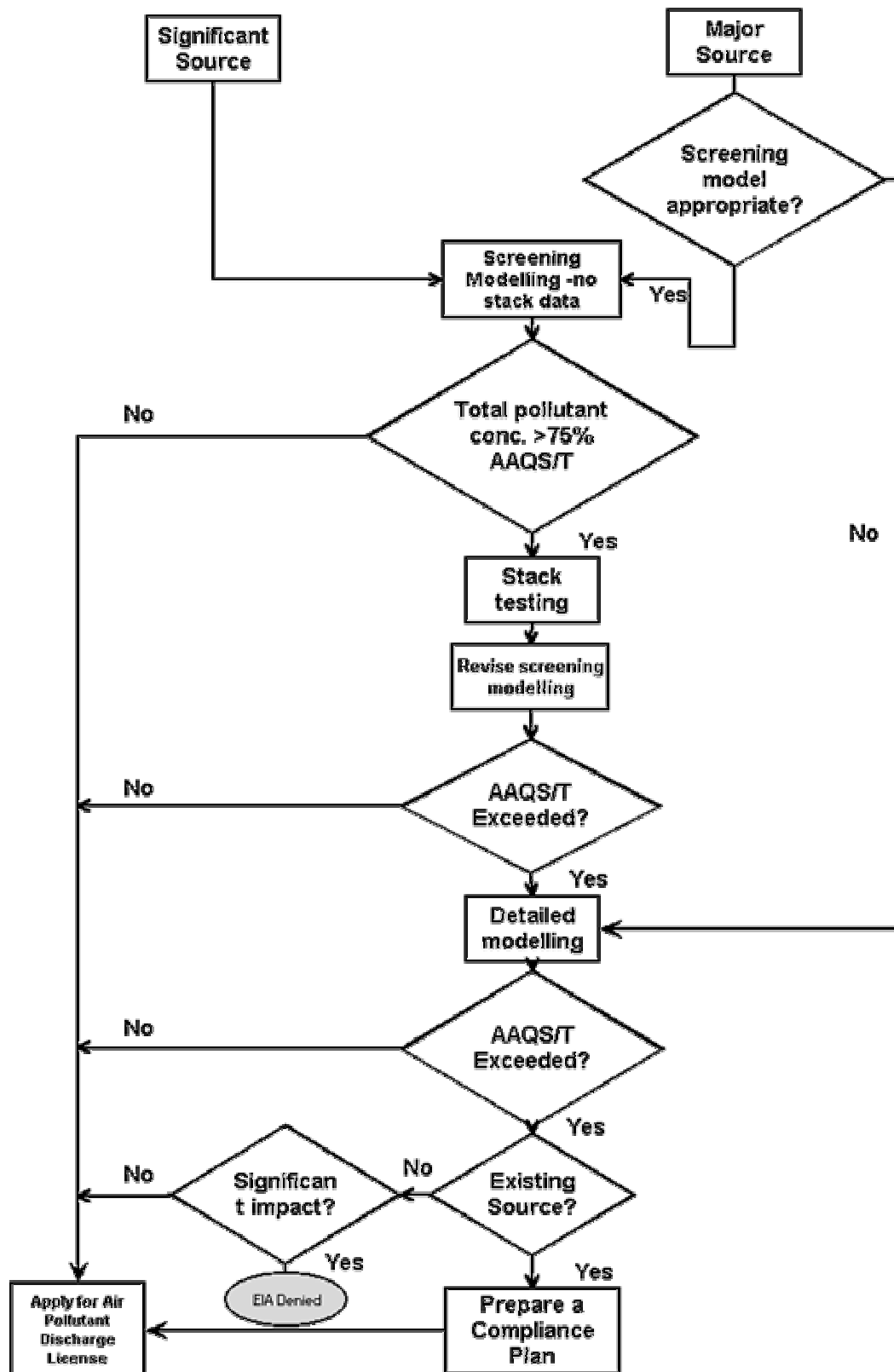
detailed modelling.

The air quality assessments entail air dispersion modelling, and in some cases ambient air quality and meteorological monitoring. One or two levels of dispersion models are required. The regulations have been designed so that generally only screening modelling is required of Significant Facilities except when:

- a) the use of a screening model is inappropriate for example when there are many different types of stack at a facility; or
- b) a screening model predicts ambient concentrations greater than the prescribed percentage of an ambient air quality standard or objective or if significant impacts are predicted.

The decision tree is shown in Figure 5-1.

Figure 5-1 Modelling Decision Tree



For Significant Facilities the regulations state that:

Owners or operators of existing or proposed significant facilities shall conduct screening modelling and:

(a) Where the maximum predicted ground level concentration of an emitted pollutant plus the background pollutant concentration is less than or equal to 75% of the applicable National Ambient Air Quality standard (for any criteria pollutant) or objective (for any Priority Air Pollutant), the owner or operator shall proceed with the application for an Air Pollutant Discharge Licence or other permit as required by the Authority.

(b) Where the maximum ground level ambient concentration plus the background concentration predicted by a screening model is greater than 75% of the applicable National Ambient Air Quality standard (for any criteria pollutant) or objective (for any Priority Air Pollutant), the owner or operator shall conduct stack tests as appropriate except as noted in section 10d) and revise the screening model estimates based on such tests before continuing with the application for an Air Pollutant Discharge Licence.

(i) Where the stack tests show that any stack emission standard is exceeded, the owner or operator shall be required to prepare a Compliance Plan as a condition of the Air Pollutant Discharge Licence.

(ii) Where the stack tests show that no stack emission standard is exceeded, the owner or operator shall proceed with the application for an Air Pollutant Discharge Licence.

(c) Where the maximum predicted ground level ambient concentration plus the background concentration is greater than the applicable National Ambient Air Quality standard (for any criteria pollutant) or objective (for any Priority Air Pollutant), the owner or operator shall conduct detailed modelling as a requirement for completing the application for an Air Pollutant Discharge Licence.

(i) Where the dispersion modelling shows that any ambient air quality standard or target is predicted to be exceeded, the owner or operator shall be required to prepare a Compliance Plan as a condition of the Air Pollutant Discharge Licence.

d) Stack tests are not required for estimating emissions of sulphur dioxide from any fuel combustion process where the exhaust gases are emitted directly into the atmosphere and do not come in contact with any process stream, such as in cement kilns, alumina kilns and lime kilns, that may remove sulphur dioxide.

For Major Facilities, the regulations state that:

Owners and operators of existing, new or proposed major sources or proposed major modifications to existing sources shall, except as specified in (a), conduct the screening modelling.

(a) Owners or operators of existing, new or proposed sources for which screening modelling is not appropriate as specified in the NRCA Guideline Document shall conduct detailed dispersion modelling.

(b) Where the maximum predicted ground level concentration plus the background pollutant concentration is less than or equal to 75% of the applicable National Ambient Air Quality standard (for any criteria pollutant) or objective (for any Priority Air Pollutant), the owner or operator shall proceed with the application for an Air Pollutant Discharge Licence.

(c) Where the maximum ground level ambient concentration plus the background concentration predicted by a screening model is greater than 75% of the applicable National Ambient Air Quality standard (for any criteria pollutant) or objective (for any Priority Air Pollutant), the owner or operator shall conduct stack tests as appropriate except as specified in 11 d), and conduct detailed modelling before continuing with the application for an Air Pollutant Discharge Licence or any other permit required by the Authority in the case of a proposed construction of a new facility or major modification to an existing facility.

d) Stack tests are not required for estimating emissions of sulphur dioxide from any fuel combustion process where the exhaust gases are emitted directly into the atmosphere and do not come in contact with any process stream, such as in cement kilns, alumina kilns and lime kilns, that may remove sulphur dioxide.

(d) Any application for permission to construct a new sources or for proposed major modifications to existing sources shall not be approved when the impact predicted is significant.

(e) For existing or new sources, where the maximum ground level ambient concentration is predicted by the detailed model to have significant impact, the source will be required to prepare a Compliance Plan as a requirement for the application for an Air Pollutant Discharge Licence. Conditions of the licence shall include ambient and stack emission monitoring and reporting.

(f) Where, the stack test results show a pollutant is above the applicable emission standard or target, the source will be required to prepare a Compliance Plan as a requirement for the application for an Air Pollutant Discharge Licence.

5.1.1 Requirements for Screening Modelling

All major and significant facilities must undertake at least screening modelling. If sources are suitable for application of screening models, the modelling results are used to determine the need for more detailed modelling.

Screening models are usually designed to evaluate a single source or sources that can be collocated. Multiple sources can be modelled individually and then the maximum concentration from each source summed for an overall estimate of maximum concentration from the facility. This technique for multiple sources is conservative (higher than may actually apply) as the concentrations from each source are added without regard to location.

The two key inputs into the screening models are the stack parameters and meteorological data. The screening model itself generates a range of meteorological conditions which are examined in the model to determine the worst case or highest concentration. The user provides estimates of emission rates and other stack parameters.

Table 5-1 Types of Sources Simulated by Atmospheric Dispersion Models

Type	Characteristics
Point sources	Stacks, chimneys, exhaust fans and isolated vents. These are the most common types of sources encountered and can be modelled with most dispersion models including SCREEN3, AERMOD, COMPLEX I, CTSCREEN and CTDMPLUS.
Line sources	Roads, runways, conveyor belts or long rows of process vents. Roadway modelling typically uses the CAL3QHC model. Line sources can also be modelled with ISC3 or SCREEN3 by representing the line source as a series of volume sources.
Area sources	Ponds, storage piles, residential subdivisions, gasoline storage tank farms and quarry operations on level ground. Area source algorithms are used to model low level or ground level releases with no plume rise. These types of sources can be modelled with most dispersion models.
Volume sources	Used to model releases from a variety of industrial sources such as, building roof monitors, multiple vents, fugitive VOC sources and conveyor belts. Volume sources have initial dispersion prior to discharge into the ambient air. Volume sources can be modelled by SCREEN3 and ISC3.
Open flares	Such as those found at refineries and some landfill off gas facilities can be modelled as a separate source type with SCREEN3.
Open pits	Source type used to model particulate emissions from open quarrying or mining operations. The open pit algorithm found in the ISC3 model uses an effective area for modelling pit emissions based on meteorological conditions. The ISC3 model will accept rectangular pits with an optional rotational angle specified relative to a north-south orientation.

Assessment of the air quality impact of a facility must take into account the existing background concentration of the pollutant modelled. The background concentration includes the resulting concentration due to all sources except the one being modelled. This is done by adding the background concentration to that predicted.

Screening modelling is sufficient for licence application when the maximum predicted ground level concentration of an emitted pollutant plus the background pollutant concentration is less than or equal to 75% of the applicable National Ambient Air Quality standard (for any criteria pollutant) or objective (for any Priority Air Pollutant).

5.1.2 Dispersion Models

The models recommended for use in screening and detailed modelling are the U.S. EPA models listed in Appendix W² and summarised Table 5-2. Models other than those listed in Table 5-2 may be used upon prior approval on a case-by-case basis where it can be demonstrated that the proposed model is superior or more appropriate. **Note that ISCST3 is no longer acceptable for use unless its use can be justified. The alternate models include ADAM, ADMS-3, AFTOX, ASPEN, DEGADIS, HGSYSTEM, HOTMAC/RAPTAD, HYROAD, ISC3, ISC-PRIME, OBODM, OZIPR, Panache, PLUVUEII, SCIPUFF, SDM, and SLAB.**

5.2 GUIDELINES FOR THE USE OF SCREENING MODELS

The SCREEN3 model is relatively simple to use. The minimum computer requirements are an IBM-PC compatible computer with 256k RAM and a floppy disk (5 1/4 or 3 1/2 inch low or high-density drives). A math coprocessor is not necessary but the program will run up to 5 times faster when a coprocessor is present.

The SCREEN3 model can be used for point, area, flare and volume sources. The model has been designed for modelling single sources. It was developed to perform the single source, short-term calculations found in EPA's Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised, EPA-450/R-92-019. The SCREEN3 runs interactively - by asking the user a series of questions to obtain the necessary input data and to determine which options to exercise. For simple point sources the model will calculate:

the maximum ground-level concentrations and the distance to the maximum

concentrations that incorporate the effects of building downwash on the maximum concentrations for both the near wake and far wake regions

concentrations in the cavity recirculation zone

concentrations due to inversion break-up and shoreline fumigation

plume rise for flare releases

² Federal Register: US EPA CFR 40 CFR Part 51, November 5, 2005: Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule)

Table 5-2 Summary of Recommended Models

Category	Screening Analysis	Detailed Analysis	
		Short Term	Long Term
Cavity Analysis	SCREEN3	None	None
Flat Terrain	SCREEN3	AERMOD, CALPUFF	ISCLT3
Rolling Terrain Below Stack top	SCREEN3	AERMOD	ISCLT3
Complex Terrain Above Stack top	SCREEN3 or AERMOD	AERMOD or CTDMPUS	3/CTSCREEN or CTDMPUS
Highway - uncomplicated terrain		CALINE3, ,	
Highway - delays and queues at intersections		CAL3QHC/CAL3 QHCR	
Industrial sources where plume rise and downwash effects from stationary line sources are important		BLP	
Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations	CTSCREEN	CTDMPLUS	
Offshore point, area or line sources – to determine their air quality on coastal regions		OCD.	

The model can also:

- incorporate the effects of simple elevated terrain on maximum concentrations
- estimate 24-hour average concentrations due to plume impaction in complex terrain
- model simple area sources using a numerical integration approach
- model simple volume sources using a virtual point source procedure
- calculate the maximum concentration at any number of user-specified distances in flat or elevated simple terrain.

Details of the procedures are found in the "SCREEN3 Model User's Guide", EPA-454/B-95-004. Additional guidance is provided below.

5.2.1.1 *Meteorological Option*

The model has a range of built-in meteorological conditions (combinations of wind speeds and stability classes) and the full meteorology option is recommended in most cases. Exceptions are for those significant facilities that are restricted to operate only during daytime hours.

5.2.1.2 *Complex Terrain*

Point sources located in complex terrain (terrain above release height) should use the terrain options in SCREEN3 unless the source is subject to building downwash. Terrain elevations near the source may be obtained from Survey Department 1:25,000 or 1:12,500 topographic maps. Note that the complex terrain algorithms in SCREEN3 are for point sources, not area sources and are for elevated plumes. It should also be emphasised that SCREEN3 "will not consider building downwash effects in either the VALLEY or the simple terrain component of the complex terrain screening procedure, even if the building downwash option is selected."

5.2.1.3 *Conversion to NO₂ When Modelling NO_x Sources*

When modelling NO_x sources, assume that 75% of the NO_x is present as NO₂.

5.2.1.4 *Adjustment Factors For Averaging Times Other than 1 hour*

Except for the 24-hour estimate for complex terrain impacts, SCREEN estimates maximum 1-hour concentrations. Adjustment factors (see Table 5-3) are provided to estimate longer period averages from the maximum 1-hour value. These adjustment factors are not to be applied with area source modelling for averaging periods of 24-hours or less. For seasonal or annual averages long-term model (e.g., ISCLT) is recommended. For area sources modelled with the "area" source algorithm in SCREEN3, EPA guidance recommends that the maximum 1-hour concentration be assumed to apply to averaging periods up to 24-hours; this is generally conservative (results in a high value).

5.2.1.5 Multiple Sources and Merged Parameters For Multiple Stacks

In certain circumstances (see below), the model can be used for multiple sources by merging nearby stacks into a single representative stack and also by adding the maximum impacts for multiple model runs. However, this method is very conservative and the user is encouraged to use AERMOD for facilities with many emission points. The reader is referred to the SCREEN3 Model User's Guide, EPA-454/B-95-004 for further information on the SCREEN3 model.

Stacks that are located within 100 metres of each other and which emit the same pollutant and have similar stack parameters may be combined into a single representative stack. If the stacks have stack heights or volumetric flow rates that differ by more than 20%, then they should be merged with caution. This technique can only be used when demonstrated to provide the most conservative results.

Table 5-3 Conversion Factors to Convert Short-term to Long-term^a

Averaging Period	Simple Terrain ^c & Cavity	Complex Terrain	
		Simple ^d	Complex
1 hour	^b	2.5	4
3 hour	0.9	2.5	4
8 hour	0.7	1.75	2.8
24 hour	0.4	^b	^b
Annual	0.1	0.2	0.2

a - Factors may not be used to convert long term impacts to short term

b - The model calculates the concentrations for these averaging periods

c - These factors also be used with the AERMOD model and cavity results

d - The simple terrain referred to is the simple terrain impact estimated by the complex terrain portion of SCREEN3.

5.3 DETAILED MODELS

Detailed modelling is required when there are complex sources with many emission points in which screening techniques are not practical and when sources do not pass the screening procedures.

The detailed modelling must consider the following:

All point and area sources within the boundary of the facility

Reliable data for source locations, emission rates, source type, source release parameters (point, volume, or area source model input parameters) and operating schedules for the new or modified source(s) and for existing sources.

Reliable data for location, emission rates, source type and source release parameters for all surrounding sources that would have an additive impact with the subject source.

The surrounding terrain and the effects it will have on pollutant dispersion.

Technical options to be used with the model(s).

Use of meteorological data that are representative of the model domain.

Receptor grid(s) type and spacing to be used in the analysis.

Background concentrations and monitoring data that may be used for comparative analysis.

Air quality standards and priority air pollutant guideline concentrations to be addressed in the analysis.

Specific guidelines are offered for the source data, building effects, meteorological data, background concentrations, terrain considerations and receptor requirements.

5.3.1 Source Data

5.3.1.1 Emission Scenarios

Use of the proper emission rates is essential in the air dispersion modelling. The emission rate for each modelled source must reflect the maximum allowable emissions for each applicable AAQS averaging period (e.g., annual, 3-month, 24-hour, 8-hour, 1-hour), as expressed by license condition, emission standard, regulation, or other enforceable condition.

Where multiple sources operate under well-defined scenarios, it will be appropriate to model each of these operating scenarios. The operating scenario that causes the maximum ground level concentrations must be determined for the "primary" source. The highest load may not always correlate to the greatest impacts. Applicants should include in the reporting of modelling results the justification of the scenarios and their representativeness.

For new sources, the emission rate should be derived from published emission factors (AP-42), actual or representative stack test data, manufacturer's test data, material balance, or other engineering methods approved on a case-by-case basis. For emission rates other than those permitted, all calculations and assumptions should be provided. For sources using backup fuels, the fuel that produces the highest emission rate for each pollutant should be used when determining emission rates for modelling.

5.3.1.2 Emission Rates for Surrounding Source Contributions

Surrounding sources that will 'significantly' contribute to the impact of the source or sources under consideration (termed the subject source) must be included in the modelling analysis. All major point

and area³ sources located within 10 km and all significant point sources within 5 km of the subject source should be included in the analysis.

All major point sources between 10 km and 40 km from the subject source should be examined (using a simple screening model) to determine if there is significant impact. These sources may be excluded from the modelling analysis if the user can demonstrate that the source does not significantly contribute to the area in which the subject source has a significant impact. This can sometimes be addressed using a simple screening model. The significant impact levels are listed in Table 5-4. Alternately, if the background concentrations can be considered to include the impact of the point sources between 10 and 40 km from the subject source they may be excluded from the modelling.

The emission rates for the nearby sources used in the model must be the maximum permitted rates - not actual historical rates.

³ Exclude mobile sources and sugar cane burning. This is intended to apply to fugitive dust sources.

Table 5-4 Significant Air Quality Impact for Determining Impact Area ($\mu\text{g}/\text{m}^3$)

Pollutant	Annual	24-Hour
SO ₂	20	80
PM ₁₀	20	80
NO ₂	20	80

5.3.1.3 *Modelling Major and Significant Facilities Within or Near to Urban Areas*

In the case of modelling particulate emissions for major or significant facilities located in or close to an urban area, the mobile area sources may be excluded from the analysis provided a suitable background is used.

5.3.2 Building Effects

Buildings located close to stacks may significantly affect the dispersion of the pollutants from the stack. If the stack is low, the air pollutants that are released may be trapped in the wake zone of nearby obstructions (structures or terrain features) and may be brought down to ground level in the immediate vicinity of the release point (down-wash). It is therefore necessary to determine if such effects are present for each stack.

The "Good Engineering Practice" (GEP) stack height is defined as the height necessary to ensure that stack emissions do not result in excessive pollutant concentrations in the immediate vicinity of the source. These excessive concentrations may be as a result of atmospheric downwash, eddies or wakes which may be created by the source itself, nearby structures or nearby terrain obstacles. If a stack is below the GEP height, then the plume entrainment must be taken into account by modifying certain dispersion parameters used in the dispersion models. However, if the stack height meets GEP, then entrainment within the wake of nearby obstructions is unlikely and need not be considered in the modelling.

The GEP stack height formula is: $H_g = H + 1.5 \cdot L$ where H_g is the GEP height measured from ground level elevation at the base of the stack, H is the height of nearby structure(s) measured from the ground level elevation at the base of the stack and L is the lesser dimension, height or projected width, of nearby structure(s).

A building or structure is considered sufficiently close to a stack to cause wake effects when the minimum distance between the stack and the building is less than or equal to five times the lesser of the height or projected width of the building (5L). This distance is commonly referred to as the building's "region of influence." If the source is located near more than one building, each building and stack configuration should be assessed separately. (Terrain features located within 5 L of a stack (L is the terrain feature height) can cause wake effects and should be considered on a case-by case basis.)

If a building's projected width is used to determine 5L, the apparent width of the building must be determined. The apparent width is the width as seen from the source looking towards either the wind direction or the direction of interest. For example, for short-term modelling, the AERMOD model requires the apparent building widths (and also heights) for every 10 degrees of azimuth around each source.

To account for downwash, the SCREEN model requires the entry of a building (or structure) height and the respective maximum and minimum horizontal dimensions. Generally, to evaluate the greatest downwash effects for each source, the building with dimensions that result in the highest GEP stack height for that source should be modelled.

The ISC models also contain algorithms for determining the impact of downwash on ambient concentration and should be used for determining estimates from detailed modelling. Methods and procedures for determining the appropriate entries to account for downwash are discussed in the EPA's GEP guidance document (EPA, 1985). The modeller should document procedures used for downwash. As an alternative to the GEP equation, a source can use a fluid modelling study to determine GEP stack height. Guidance regarding the application of fluid models or field studies in determining GEP may be obtained from the literature (U.S. EPA, 1981; Snyder and Lawson, 1985).

5.3.3 Meteorological Data

Screening models generally employ a limited set of meteorological parameters representing worst case conditions and therefore provide a conservative prediction of air quality impacts. Detailed models rely on historical meteorological data to provide a more realistic prediction of air quality impacts. Depending on the circumstances, applicants may be required to perform site-specific meteorological data collection. In such cases, a minimum period of one year would be required.

For refined models, ideally five consecutive years of the most recent representative meteorological data from the nearest National Meteorological Service station (Norman Manley or Donald Sangster International Airports) or a minimum of one year of on-site data are required. Currently, five years of data from the National Meteorological Service are not readily available so that maximum data available should be used. Data from these stations may be obtained from the National Meteorological Service or from the U.S. National Climatic Data Centre (NCDC). NCDC compiles and has for sale surface and upper air data from stations worldwide.

The only upper air measurements at a Jamaican station are made at the Norman Manley International Airport (NMIA) but the most recent data are derived from twice daily soundings during the hurricane season and once daily otherwise. Upper air measurements suitable for modelling traditionally required twice daily upper air measurements (in addition to hourly surface measurements) every day of the year but the most recent versions of AERMOD allow the use of one sounding per day and hence data from NMIA should be used (along with procedures for substituting any missing data). The closest upper air station to NMIA is the Owen Roberts Airport station in the Cayman Islands and these soundings are also made twice daily soundings during the hurricane season and once daily otherwise. Complete upper air data from San Juan in Puerto Rico are available but since that station is so far away (~1,100 km) they are likely to be unsuitable for use in Jamaica. Use of data from Puerto Rico should be used only if they can be clearly demonstrated to be representative of NMIA (e.g., by statistical comparison for previous years).

Surface data from NMIA may be used to estimate the mixing height data from the surface observations using the RAMMET program. Use of these procedures should include demonstration

that the RAMMET estimates are representative (e.g., by statistical comparisons with previous year's data when twice daily soundings were available)

Additional guidance on meteorological data collection may be obtained from the following documents:

On-Site Meteorological Program Guidance for Regulatory Modelling Applications U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711. (EPA-450/4-87-013) (This document and the update for Chapters 8 and 9 are available from the U.S. EPA SCRAM web site <http://www.epa.gov/scram001/t26.htm>)

U.S. Environmental Protection Agency. Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD). Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA Publication No. EPA-450/4-87-007. May 1987. (Available from the U.S. EPA AMTIC web site (<http://www.epa.gov/ttn/amtic/cpreldoc.html>) and the NTIS as #PB90-168030).

5.3.3.1 Replacement of Missing Meteorological Data

Missing meteorological data must be replaced before these data can be processed for dispersion modelling. Modellers should follow the guidance in Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models (Atkinson, 1992) to replace missing values.

5.3.3.2 Background Concentration Data

Both the screening and detailed modelling require addition of the background concentration to the maximum predicted concentration in order to determine compliance with National Ambient Air Quality Standards. Background air quality includes pollutant concentrations due to natural sources, nearby sources other than the one(s) currently under consideration and unidentified sources. Background concentrations should be determined for each critical (concentration) averaging time. Air monitoring data used in the background determination should be representative of the area of interest i.e., it should be typical of the existing concentrations expected at locations of predicted maximum impacts.

Since relatively few ambient measurements are currently available in Jamaica, the following guidance (interim background concentrations) should be followed in selecting background concentrations. As more data become available, these guidelines should be replaced by use of site-specific background data or by using measurements from similar representative sites in Jamaica.

The interim background concentrations are pollutant-specific and also apply to urban and other areas of the country. The same background concentrations should be used when modelling major and significant facilities in the same area.

Major facilities that have been making ambient measurements as part of the air quality assessment should analyse their data to select a suitable background for each averaging time of concern. Data from sources must be shown to meet the Authority's air monitoring quality assurance and quality control requirements. These requirements have been established in order to ensure representative, complete, precise and accurate data collection. Such determinations will be made on a case-by-case basis by the Authority.

The analysis will entail determining the mean background concentration at each monitor by excluding values when the source in question is impacting the monitor. The mean annual background is the average of the annual concentrations so determined at each monitor. In the absence of data that would indicate whether or not the measurements were affected by the source(s), the minimum values at stations will be used.

For shorter averaging periods, meteorological data (especially wind direction) should be used to isolate periods when background conditions apply at each monitor and the accompanying concentrations of concern should be identified. The concentrations at monitors not impacted by the source in question should be averaged for each separate averaging time for which there is an ambient air quality standard to determine the corresponding background values.

For sources located in areas that do not have ambient air quality measurements, the recommended interim background concentrations are listed in Table 5-5. These were based on the analyses of data between 200 and 2005 and selecting the minimum values after excluding (low) outliers. These values will be updated as more reliable data become available.

Table 5-5 Interim Background Concentrations ($\mu\text{g}/\text{m}^3$) for Use in Air Quality Assessments

Area	Pollutant				
	TSP	PM ₁₀	Pb	SO ₂	NO ₂
Urban (a)					
1 h				0	0
24 h	14	9	0.8	0	0
Annual	45	25	0.2	0	0
Rural (b)					
1 h				0	0
24 h	14	9	0.5	0	0
Annual	20	20	0.13	0	0

a) Urban (Kingston Metropolitan Region, Montego Bay Metropolitan Region)

b) All areas other than in a)

5.3.4 Terrain Considerations

5.3.4.1 *Rural/Urban*

The classification of the land use in the vicinity of sources of air pollution is needed because dispersion rates differ between urban and rural areas. In general, urban areas cause greater rates of dispersion because of increased turbulent and buoyancy-induced mixing. This is due to the combination of greater surface roughness caused by more buildings and structures and greater amounts of heat released from concrete and similar surfaces.

EPA guidance provides two procedures to determine whether the character of an area is predominantly urban or rural. One procedure is based on land-use typing and the other is based on population density. Both procedures require an evaluation of characteristics within a 3-kilometre radius from a source. The land-use typing method is based on the work of August Auer (Auer, 1978) and is preferred because it is more directly related to the surface characteristics of the evaluated area that affect dispersion rates.

5.3.4.2 *Simple, Complex and Intermediate Terrain*

The topography in the region of a source is defined as either simple terrain, terrain lying below the stack top elevation, or complex terrain, for terrain above the top of the stack. Simple or flat terrain is defined as terrain equal to the elevation of the stack base. The type of terrain is important for selecting the appropriate model or model option. A modeller should evaluate the topography near each facility to determine how terrain elevations should be addressed. Measurements of the terrain in the area surrounding the facility should be made using topographic (1:25,000 or 1:12,500) maps. Models which include complex terrain algorithms should be used if any terrain within the source's area of impact is at an elevation above the source's stack top elevation.

Terrain is generally not a consideration for releases from ground-level fugitive sources which are typically neutrally buoyant, with no plume rise to consider. Maximum concentrations from fugitive releases are thus expected to occur at the nearest downwind receptor location. Modellers should consider terrain near a property or fence line for elevated fugitive releases.

When the terrain lies above the height of the stack top, but below the predicted elevation of the plume's centreline, both simple and complex algorithms should be run. The more conservative (higher) concentration should be used to assess the impact.

5.3.5 Receptor Requirements

The selection and location of receptors are important in determining the maximum impact from a source and the area where there is significant air quality impact (see Table 5-4). In general, impacts should be assessed at locations beyond the fence line but areas within the fence line should be included if there is public access. Public access includes roadways or walkways, paths, areas used for purposes such as for recreation, agriculture or farming (crops used for human consumption or grazing of animals that ultimately may be consumed by humans). Areas within plant boundaries that are not in enclosed buildings and that are considered as having occupational exposure are excluded from meeting ambient air quality standards.

It should be noted that some jurisdictions categorically state that air over any of the source's property is not ambient and as such would be excluded from meeting the jurisdiction's ambient air quality

standards. Some of these (state) jurisdictions however require conformance with prevention of significant deterioration (PSD) increments within the property if there is public access. Other jurisdictions require that ambient air quality standards are met outside the property line unless there is public access.

The NRCA policy is to define ambient air as "that portion of the atmosphere, external to the source, to which the general public has access". Thus, receptors may be omitted from the property of the facility under review, provided it is inaccessible to the general public. This usually means that receptors are placed at the fence line and beyond. It may be necessary to place receptors on the source's property if there is not a physical barrier preventing public access. See above for elaboration of public access.

Receptors should consist of a regular grid and specific locations (special receptors) that address potential exposure of sensitive receptors. If other than flat terrain is modelled, the modeller should use appropriate receptor elevations.

The receptor grid should take into consideration factors such as the results of screening analyses; a source's release height; the proximity of emission points, fugitive areas and other sources to the property line; the location of nearest residents and other sensitive receptors and monitors; and, topography, climatology, etc. Generally, the spacing of receptors increases with distance from the sources being evaluated. A rectangular receptor grid is recommended.

The grid should be placed so that the location of the maximum concentration for which the general public has access to can be determined. Therefore, receptors may be required within the source's fence line to evaluate cavity and wake regions if the general public is not restricted from gaining access.

When multiple sources are modelled, the grid spacing used should allow determination of representative concentrations from each source type. For example, in order to determine the overall maximum predicted concentration and the location for a mix of tall and short sources, it may be necessary to extend the grid several kilometres away from the property line to identify concentrations related to tall stacks. It is appropriate to use a smaller receptor spacing located close to the property line to identify concentrations caused by short stacks or fugitive sources.

For significant facilities, it is recommended that discrete receptors be placed along the property line at 25 to 50-metre maximum increment spacing. From there, the receptor grid should extend outward for a minimum distance of 1000 m from the centre of the grid or further if the source has a tall stack and the maximum impacts are occurring beyond 1000 m. Receptor grid spacing should not exceed 100 m. Depending on the circumstances, such as an impact evaluation for a priority air pollutant source, it may be necessary to reduce receptor spacing to 25 m near points of maximum impact.

Major facilities should first establish the impacts along the fence line. It is recommended that discrete receptors be placed along the fence line at 50 to 100-metre maximum increments. Receptors should then be placed out far enough to determine maximum ambient concentrations, as well as the extent of the significant air quality impact area. However, coarser grid spacing can be used to locate the general areas of maximum ambient impact and the extent of the significant air quality impact area.

For both major and significant facilities, special receptors should be located at sensitive receptor locations such as:

schools

hospitals

churches

recreational areas

residences/residential areas

high (people) density commercial and industrial areas

national parks, protected areas and national monuments

the closest terrain point at an elevation equivalent to stack top.

5.4 DISPERSION MODELLING REPORT REQUIREMENTS

The results of the dispersion modelling should be presented in a report that includes the following items. The items marked with an asterisk are required only for detailed modelling.

Executive Summary

A brief description of the plant and the processes that lead to emissions that are being modelled, pollutants modelled, reference to license application

A diagram of the site including existing and/or proposed exhaust stacks, area sources, building locations, property boundaries, distances to adjacent property and description of adjacent property use. Include a scale and true north arrow.

Maps showing location of source(s) with overlays describing significant impact areas, if any, receptor grid overlays, special receptors, north arrow, scale and appropriate UTM coordinates.

The location of the site and other sources included in the analysis on a topographic map (may be the same as 3 above).

A list of on-site point and area sources and their UTM coordinates, building dimensions (heights, widths and lengths).

* A list of off-site point and area sources included in the analysis and their UTM coordinates, emission rates (request data from Authority).

* Discussion of nearby (off-site) sources included and background pollutant concentrations used in the modelling analysis.

A description of the modelling methodology used (inputs, model selection, options, terrain, building effects, receptor grid, etc.). Clear presentation of all assumptions made in the evaluation.

Discussion of techniques for calculating GEP stack height for each stack. Sample calculations for merging stacks, etc.

Discussion of techniques for evaluating cavity effects, impacts on rolling and complex terrain, building wake effects, urban/rural considerations, etc.

* If alternate proprietary model was used, present a discussion of reasons for model selection and a clear presentation of all assumptions made in the evaluation

* Discussion of meteorological data used.

Discussion of background ambient air quality data used

Stack parameters and emission rates for each source.

* Discussion of receptor locations.

Modelling results (raw input/output attached as appendix). Concentration output should include at least the top 10 concentrations and their locations and the highest concentration at each receptor.

Modelling results in tabular summary relative to ambient air quality standards or guidelines for each averaging time. For new sources or major modifications to existing sources, include also comparisons of modelling results to acceptable increments.

Air quality impact analysis - human health, vegetation, soils, water, visibility, other receptors (national parks, protected areas and monuments).

References

* CD ROM containing model input and output data and also the meteorological data used in the modelling (zipped or compressed files) along with instructions on unzipping, etc.

All of the above should be in sufficient detail to enable the Authority to determine the validity of the results and the compliance of the proposed project with all air quality standards.

6. AIR QUALITY ASSESSMENT REPORT REQUIREMENTS

This section presents guidelines for reporting on air quality assessments and for risk assessments.

6.1 AIR QUALITY ASSESSMENTS

The air quality assessment may have entailed source testing and dispersion modelling which may have been presented in separate reports (see Sections 3.4 and 5.4). The overall assessment report should be based on information from any such reports as well as data from any site-specific or other ambient air quality and meteorological monitoring. Include sufficient information from the supporting reports so that a complete evaluation can be made using only the assessment report. The assessment report should include the following:

Executive Summary

Introduction

Outline why the assessment was undertaken and the objectives of the assessment

Study Scope and Methodology

Indicate the range of activities (source characterisation (estimate or measurement), dispersion modelling (screening and/or detailed), ambient monitoring data (site-specific or other data) and the methodology for each. Where separate reports (e.g., source testing or modelling are available, a brief summary of the methods should be presented and the supporting reports must be provided. The formats for the supporting reports were presented in Sections 3 (source characterisation), 4 (ambient monitoring) and 5 (dispersion modelling).

Presentation of results

Data for each relevant type of activity should be presented. Measurements or estimates must be compared with relevant standards, targets or guidelines as the case may be.

Discussion of results

Implications of the comparisons with the standards, targets or guideline concentration could indicate a requirement for the preparation of a compliance plan or could suggest continuation or revisions conditions of licenses. Arguments for the particular implication should be presented.

Summary and Conclusions

6.2 RISK ASSESSMENTS

6.2.1 What is risk assessment?

Risk assessment is a process for organizing and analyzing information to determine if an environmental chemical or other agent might cause harm to exposed persons and ecosystems. The risk assessment process consists of four primary steps: hazard assessment, dose-response assessment, exposure assessment, and risk characterization. The Priority Air Pollutant (PAP) list defines the

hazardous substances that potentially could require risk assessments. Additional toxic and/or hazardous substances may be defined as NEPA sees fit.

Risk assessment will estimate the probability of adverse health effects resulting from human exposure to hazardous substances. Risk assessment will be one component of the environmental impact assessment or licensing process for proposed sources that qualify for risk assessment. Risk assessments will be used to:

evaluate potential risks remaining after the application of pollution controls (residual risk);

make policy decisions regarding licensing and/or regulation of PAPs; and

assist individuals and communities in understanding risk, the risk assessment process, and the risk management decisions.

The following are guidelines for defining sources that require risk assessments and the protocols for conducting risk assessments. These guidelines are limited to air pollution sources although the risk assessment will require multimedia approaches.

6.2.2 Sources Requiring Risk Assessments

The following sources will be considered by NRCA as requiring risk assessment

All proposed facilities that are defined as Major Facilities with respect to 1 or more PAP (emitting 10 tonnes/y of any one PAP or more than 25 tonnes/year of any number of PAPs).

All incineration facilities that burn hazardous or non-hazardous wastes

6.2.3 Risk Management Policy

The Risk Management policy for carcinogenic and non-carcinogenic PAPs is as follows:

Carcinogens

If the incremental cancer risk from any contaminant evaluated is less than or equal to one in one million (1×10^{-6}), the risk is considered negligible.

If the incremental cancer risk is greater than or equal to one in ten thousand (1×10^{-4}), the risk is considered unacceptable.

If the incremental cancer risk is between one in one million and one in ten thousand, the risk is evaluated on a case-by-case basis.

Non-carcinogens

Hazard quotients are calculated and summed separately for inhalation and oral exposures, and for different averaging times, to give hazard indexes.

The Risk Management policy (see text box) will be based on the following:

If the hazard index for any contaminant evaluated is less than or equal to one, the risk is considered negligible.

Key Terms in Risk Assessment

Public health risk estimates for **inhalation of carcinogens** are based on the following calculation:

$$\text{Incremental risk} = C \times \text{URF}$$

where:

C = maximum annual average ambient air concentration of a pollutant, $\mu\text{g}/\text{m}^3$

URF = pollutant-specific inhalation unit risk factor, $(\mu\text{g}/\text{m}^3)^{-1}$

For routes of exposure other than inhalation, risk is calculated by multiplying the chemical dose (in $\text{mg}/\text{kg}/\text{day}$) by the chemical-specific oral slope factor (in $(\text{mg}/\text{kg}/\text{day})^{-1}$).

Public health risk estimates for **inhalation of non-carcinogens** are based on the following calculation:

$$\text{Hazard Quotient} = C/\text{RfC}$$

where:

C = maximum ambient air concentration, $\mu\text{g}/\text{m}^3$

RfC = pollutant-specific reference concentration, $\mu\text{g}/\text{m}^3$

The averaging time for non-carcinogen concentrations can be either annual, 24 hours, or 1 hour, depending on the basis of the reference dose.

For routes of exposure other than inhalation, the hazard quotient is calculated by dividing the chemical dose (in $\text{mg}/\text{kg}/\text{day}$) by the pollutant-specific reference dose (in $\text{mg}/\text{kg}/\text{day}$).

If the hazard index is greater than one, the risk is evaluated on a case-by-case basis.

6.2.4 Risk Assessment Protocols

Two levels of risk assessment are proposed, namely, a screening level and a detailed level. The screening process is designed to minimise the likelihood of incorrectly approving sources that pose a significant health risk. It is designed to overestimate the risk for most sources. This ensures that any source which needs closer scrutiny will be identified.

Sources which are either unacceptable or fail the first-level screening go on to a second-level or detailed risk screening. The **detailed risk screening** uses additional source-specific parameters along with a detailed dispersion model to predict concentrations and deposition for risk estimates more accurately. Sources which have negligible risk as defined in the risk management policy will not be

required to do any further risk assessment. Those sources that have non-negligible risks will be required to conduct a detailed risk assessment.

6.2.5 Screening Risk Assessments

All proponents of new air pollution sources or major modifications of existing sources are required to identify and estimate emissions of PAPs. A screening risk assessment will be required if the source would be classified as a major PAP source or if the facility burns hazardous or non-hazardous waste regardless of whether or not it is a major source.

All air pollutant discharge licence applications are required to conduct at least screening dispersion modelling for each PAP.

The risk screening procedure considers only inhalation exposure and assumes the receptor is exposed to this maximum ambient concentration all the time. For carcinogens, the averaging time is annual. For non-carcinogens, the averaging time for a contaminant (annual, 24 hours, or 1 hour) is based on the health endpoint and averaging time used in developing its reference concentration.

6.2.5.1 Risk Characterisation

Carcinogens

Multiply the maximum annual average ambient concentration by the unit risk factor to get the incremental risk from each chemical. Add the risks for all pollutants.

Non-carcinogens

Divide the appropriate ambient concentration by the reference concentration to get the hazard quotient for each chemical. Add those with the same averaging time to get the hazard index.

If a source fails the risk assessment screening by exceeding the risk management guidelines that categorises them as not negligible, the Authority may re-examine the licence application to see if the risks have been overestimated (e.g., if emission rates or operating hours are overestimated). This re-examination may involve a discussion with the applicant and may result in a modification of the licence application.

If conditions on the licence application are not changed as a result of this review, then the proponent will be required to carry out a more refined risk analysis to more accurately estimate ambient air concentrations, deposition, to assess the effect of aerodynamic downwash on plume dispersion and considers exposure pathways other than inhalation (dermal, ingestion).

6.2.6 Refined Risk Assessment Guidelines

Detailed risk assessments are required when the screening level indicates unacceptable risks (cancer risks $> 10^{-6}$ or for non-cancer risks when the hazard index > 1 [the hazard index is the exposure level divided by the reference level such as the RfC]).

The refined or more detailed risk assessments should be geared to human health or ecological risk assessments.

Human health risk assessment should follow EPA's Risk Assessment Guidelines for assessing risks to human health from chemicals or other agents in the environment. The current US EPA Risk Assessment Guidelines for human health are as follows:

Guidelines for Carcinogen Risk Assessment (Federal Register 70 (66) 17765-17817, 7 April 2005) [(EPA/630/P-03/001f) (http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=439797)

Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens] (http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=439798)

Guidelines for Chemical Mixtures Risk Assessment (Federal Register 51 (185) 34014-34025, 24 September 1986)

Guidelines for Developmental Toxicity Risk Assessment (Federal Register 56 (234) 63798-63826, 5 December 1991)

Guidelines for Exposure Assessment (Federal Register 57 (104) 22888-22938, 29 May 1992)

Guidelines for Mutagenicity Risk Assessment (Federal Register 51 (185) 34006-34012, 24 September 1986)

Guidelines for Neurotoxicity Risk Assessment (Federal Register 63 (93) 26926-26954, 14 May 1998)

Guidelines for Reproductive Toxicity Risk Assessment (Federal Register 61 (212) 56274-26322, 31 October 1996)

Other useful documents are:

- Environmental Health Risk Assessment Guidelines for assessing human health risks from environmental hazards (Australia) (<http://www.health.gov.au/internet/wcms/publishing.nsf/Content/ohp-ehra-2004.htm>)
- Health Impact Assessment Guidelines (Australia) ([http://www.health.gov.au/internet/wcms/Publishing.nsf/Content/health-pubhlth-publicat-document-metadata-env_impact.htm/\\$FILE/env_impact.pdf](http://www.health.gov.au/internet/wcms/Publishing.nsf/Content/health-pubhlth-publicat-document-metadata-env_impact.htm/$FILE/env_impact.pdf))
- Health Risk Assessment in Western Australia (http://www.health.wa.gov.au/envirohealth/planning/docs/Health_Risk_Assessment.pdf)

Other protocols that may be appropriate for ecological risk assessment are:

US EPA Guidelines (Guidelines for Ecological Risk Assessment, U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC, EPA/630/R095/002F, 1998.)

Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Peer Review Draft, November, 1999 (<http://www.epa.gov/epaoswer/hazwaste/combust/ecorisk.htm>)

Ecological risk assessment “evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors” and includes three primary phases:

problem formulation;

analysis; and

risk characterization.

In problem formulation, risk assessors evaluate goals and select assessment endpoints, prepare the conceptual model, and develop an analysis plan. During the analysis phase, assessors evaluate exposure to stressors and the relationship between stressor levels and ecological effects. In the third phase, risk characterization, assessors estimate risk through integration of exposure and stressor-response profiles, describe risk by discussing lines of evidence and determining ecological adversity, and prepare a report.

After completion of the risk assessment, risk managers may consider whether follow-up activities are required. They may decide on risk mitigation measures, then develop a monitoring plan to determine whether the procedures reduced risk or whether ecological recovery is occurring. Managers may also elect to conduct another planned tier or iteration of the risk assessment if necessary to support a management decision.

When preparing a refined risk assessment, the following minimum guidelines should be observed.

6.2.6.1 Hazard Identification

List all **potential PAPs** which may reasonably be expected to be emitted from the facility into the ambient air.

Proponents should propose to the Authority a subset of PAPs that will be evaluated in the risk assessment, based on this "potential PAP" list and the overall risk assessment protocol. The protocol should include the items discussed below.

The rationale used in omitting items on the "potential contaminants" list from the risk assessment must be discussed and a summary of the health effects of each contaminant must be included in an appendix to the risk assessment document, titled "Toxicity Profiles." All references must be listed.

If the following contaminants are emitted, they must be included in the risk assessment:

all known human carcinogens (U.S. Environmental Protection Agency Group A)

arsenic

mercury

cadmium

nickel

lead

polycyclic aromatic hydrocarbons

For incinerators, the risk assessment should also include:

Hexavalent chromium

Hydrogen chloride

2,3,7,8-Tetrachloro-dibenzo-*p*-dioxin

total dioxins and furans (PCDDs and PCDFs)

6.2.6.2 *Dose-Response Assessment*

The dose-response assessment must include calculation of inhalation, ingestion and dermal exposure routes according to the following guidelines which are similar to the New Jersey Guidelines for detailed risk assessment (NJDEP, 1994).

For inhalation of carcinogens, unit risk factors (URFs) (not potency slope factors (SFx)) must be used to calculate the risk.

For ingestion of and dermal exposure to carcinogens, use the most recent slope factors from U.S. EPA's Integrated Risk Information System (IRIS) (U.S. EPA, 1994a) and U.S. EPA's Health Effects Assessment Summary Tables (HEAST) where available (U.S. EPA, 1994b).

For dioxins and furans, use U.S. EPA's latest toxic equivalency factors (TEQs), which are equivalent to the "International TEFs/89." For information, refer to Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of CDDs and CDFs 1989 Update (U.S. EPA 1989a).

For noncarcinogenic effects for inhalation, use inhalation reference concentrations such as the New Jersey Bureau of Air Quality Evaluation's list which is updated annually.

If inhalation RfCs for specific chemicals cannot be found, they may be derived from the literature if adequate toxicity data exist. A recommended methodology can be found in Interim Methods for Development of Inhalation Reference Concentrations (U.S. EPA 1990a). RfCs and reference doses (RfDs) developed by the applicant should be carefully documented.

For noncarcinogenic effects from ingestion and dermal exposures, the most recent verified U.S. EPA RfDs from IRIS or HEAST should be used where available.

References for all URFs, SFs, RfCs, and RfDs must be given.

Present URFs, SFs, RfCs, RfDs, and their references in table form.

6.2.6.3 *Exposure Assessment*

For most cases, especially incinerators and waste combustion facilities, assume that the facility will be operating 24 hours a day, 365 days a year, for seventy years.

If ingestion or dermal exposure pathways must be analyzed, deposition must be modelled. For municipal solid waste and commercial hazardous waste incinerators, the soil ingestion exposure route must always be analyzed. In areas with backyard gardens and in rural areas, ingestion of contaminated vegetables should be calculated. Other exposure routes may include drinking water, cow's milk, locally grown meat, and mother's milk. Refer to the *Exposure Factors Handbook* (U.S. EPA 1989b), and *Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions* (U.S. EPA 1990b). Give references for all exposure assumptions.

In most refined risk assessments, when evaluating carcinogens it should be assumed that the most exposed individual remains at the point with the maximum annual average concentration for an entire 70-year lifetime.

For exposure routes other than inhalation, calculate the dose to the maximum exposed individual in mg/kg/day. Present doses in table form.

For ingestion routes, childhood exposures should be considered, particularly for soil ingestion.

Note that some RfCs are based on short-term effects, such as fetal development, and therefore must be compared with maximum 24-hour average ambient concentrations. RfCs for a few other pollutants (such as ethylene oxide and hydrogen chloride) are based on acute exposures and must be compared with maximum 1-hour average ambient concentrations. All others must be compared with maximum annual average ambient concentrations.

It is assumed that the average body weight for adults is 70 kg and 25 kg for children.

The inhalation rate for an adult is 20 m³/day.

6.2.6.4 Risk Characterization

Present results of risk calculations and hazard indices in table form.

If a person may be exposed to the same contaminant from more than one ingestion pathway, the calculated dose from each pathway may be summed to yield the total dose.

Discuss the level of uncertainty in the overall assessment. This should include the uncertainty involved in the estimation of individual parameters such as emission rates, levels of exposure, and health effects, as well as the implications of complex uncertainties.

For carcinogens, express risk in terms of incremental individual risk. Do not calculate total population risk. It is not necessary to add the risks from the different contaminants which are being considered.

For non-carcinogens, calculate a hazard index for each contaminant and each pathway.

The hazard index table must include all of the information used in the calculation (ambient concentration and RfC; or daily dose and RfD). A brief discussion of the relationship between the two sets of numbers should be included in the text.

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8. APPENDICES

8.1 APPENDIX 1 CATEGORIES FOR PRIORITY AIR POLLUTANTS

This is a list of 15 categories of industrial sources of hazardous air pollutants that are relevant to Jamaica. The categories are similar to those identified by EPA under the air toxics provisions of the Clean Air Act Amendments of 1990.

1. FUEL COMBUSTION
2. NON-FERROUS METALS PROCESSING
3. FERROUS METALS PROCESSING
4. MINERAL PRODUCTS PROCESSING
5. PETROLEUM AND NATURAL GAS PRODUCTION AND REFINING
6. LIQUIDS DISTRIBUTION
7. SURFACE COATING PROCESSES
8. WASTE TREATMENT AND DISPOSAL
9. AGRICULTURAL CHEMICALS PRODUCTION
10. FIBRES PRODUCTION PROCESSES
11. POLYMERS AND RESINS PRODUCTION
12. PRODUCTION OF INORGANIC CHEMICALS
13. MISCELLANEOUS PROCESSES
14. FOOD AND AGRICULTURAL PROCESSES
15. PHARMACEUTICAL PRODUCTION PROCESSES

8.2 APPENDIX 2 LIST OF INSIGNIFICANT SOURCES

The following emission units, operations, or activities need not be included in a licence application or reports of emissions:

Air compressors and pneumatically operated equipment, including hand tools.

Air conditioning, ventilating and heating units used for comfort that do not exhaust air pollutants into the ambient air from any manufacturing/industrial or commercial process.

Barbecue equipment or outdoor fireplaces used in connection with any residence or recreation.

Bathroom/toilet emissions.

Batteries and battery charging stations, except at battery manufacturing plants.

Bench-scale laboratory equipment used for physical or chemical analysis not including lab fume hoods or vents.

Boiler water treatment operations, not including cooling towers.

Brazing or soldering equipment related to manufacturing activities that do not result in emission of PAPs.

Consumer use of office equipment and products, not including commercial printers or business primarily involved in photographic reproduction.

Consumer use of paper trimmers/binders.

Demineralized water tanks and demineralizer vents.

Drop hammers or presses for forging or metalworking.

Electric or steam-heated drying ovens and autoclaves, but not the emissions from the articles or substances being processed in the ovens or autoclaves or the boilers delivering the steam.

Emergency (backup) electrical generators at residential locations.

Emergency road flares.

Emissions from combustion controllers or combustion shutoff devices but not combustion units itself.

Emissions from engine crankcase vents.

Emissions from equipment lubricating systems (i.e., oil mist), not including storage tanks, unless otherwise exempt.

Emissions from storage or use of water treatment chemicals, except for hazardous air pollutants or priority air pollutants (PAPs) listed under these regulations for use in cooling towers, drinking water systems, and boiler water/feed systems.

Environmental chambers not using hazardous air pollutant gases.

Equipment used exclusively to mill or grind coatings in roll grinding rebuilding, and molding compounds where all materials charged are in paste form.

Equipment used exclusively to slaughter animals, but not including other equipment at slaughterhouses, such as rendering cookers, boilers, heating plants, incinerators, and electrical power generating equipment.

Equipment used for quality control/assurance or inspection purposes, including sampling equipment used to withdraw materials for analysis.

Equipment used to mix and package soaps, vegetable oil, grease, animal fat, and non-volatile aqueous salt solutions, provided appropriate lids and covers are used and appropriate odour control is achieved.

Fire suppression systems.

Fugitive emissions related to movement of passenger vehicles except where they are involved in a Compliance Plan or for the control of fugitive dust.

Hand-held applicator equipment for hot melt adhesives with no VOCs in the adhesive.

Hand-held equipment for buffing, polishing, cutting, drilling, sawing, grinding, turning, or machining wood, metal, or plastic.

Hydraulic and hydrostatic testing equipment.

Janitorial services and consumer use of janitorial products.

Laser trimmers using dust collection to prevent fugitive emissions.

Lasers used only on metals and other materials which do not emit HAPs in the process.

Laundry activities, except for dry-cleaning and steam boilers.

Maintenance of grounds or buildings, including: lawn care, internal combustion engines used for landscaping purposes, weed control, pest control, and water washing activities.

Miscellaneous additions or upgrades of instrumentation.

Mixers, blenders, roll mills, or calendars for rubber or plastic for which no materials in powder form are added and in which no organic solvents, diluents, or thinners are used.

Natural gas pressure regulator vents, excluding venting at oil and gas production facilities.

Non-commercial food preparation or food preparation at restaurants, cafeterias, or caterers, etc.

Oxygen scavenging (de-aeration) of water.

Ozone generators.

Periodic use of pressurized air for cleanup.

Portable electrical generators that can be "moved by hand" from one location to another.

Process water filtration systems and demineralizers.

Repair, up-keep, maintenance, or construction activities not related to the facility's primary business activity, and not otherwise triggering a licence modification

Residential wood heaters, cook stoves, or fireplaces.

Routine calibration and maintenance of laboratory equipment or other analytical instruments.

Salt baths using non-volatile salts that do not result in emissions of any air pollutant covered by this regulation.

Shock chambers, humidity chambers, and solar simulators.

Site assessment work to characterize waste disposal or remediation sites.

Solid waste dumpsters.

Stacks or vents to prevent escape of sanitary sewer gases through the plumbing traps.

Steam vents and safety relief valves, steam leaks, steam cleaning operations, steam and microwave sterilizers.

Storage tanks used for the temporary containment of materials resulting from an emergency reporting to an unanticipated release.

Storage tanks, reservoirs, and pumping and handling equipment of any size containing soaps, vegetable oil, grease, animal fat, and no volatile aqueous salt solutions, provided appropriate lids and covers are used and appropriate odour control is achieved.

Storage tanks, vessels, and containers holding or storing liquid substances that do not contain any VOCs or PAPs.

Surface-coating equipment during miscellaneous maintenance and construction activities (does not include any facility whose primary business activity is surface-coating or includes surface-coating or products).

Tall oil soap storage, skimming, and loading.

The following natural gas and oil exploration production site equipment: separators, dehydration units, natural gas fired compressors, and pumping units. This does not include compressors located on natural gas transmission pipelines.

The storage, handling, and handling equipment for bark and wood residues not subject to fugitive dispersion offsite (this applies to the equipment only).

Tobacco smoking rooms and areas.

Use of products for the purpose of maintaining motor vehicles operated by the facility, not including air cleaning units of or such vehicles (i.e., antifreeze, fuel additives).

Vents from continuous emissions monitors and other analyzers.

8.3 APPENDIX 3 RECOMMENDED VOLATILE ORGANIC COMPOUNDS (VOCS) FOR AMBIENT MONITORING FOR ASSESSMENT OF PHOTOCHEMICAL OXIDANTS

C ₂ to C ₁₂ Hydrocarbons	Biogenic compounds	Carbonyls and alcohols
Ethane	Isoprene	Formaldehyde
Ethylene	α-Pinene	Acetaldehyde
Propylene	β-Pinene	Acetone
Propane		Propionaldehyde
Isobutane		Methanol
1-Butene/Isobutene		Ethanol
Butane		
Isopentane		
Pentane		
2-Methylpentane		
3-Methylpentane		
Toluene		
Ethylbenzene		
m-Xylene		
p-Xylene		
o-Xylene		
3-Ethyltoluene		
1,3,5-Trimethylbenzene		
1,2,4-Trimethylbenzene		
2-methyl-2-butene		
Trans-2-pentene		

8.4 APPENDIX 4 LIST OF REFERENCE AND EQUIVALENT METHODS FOR THE MEASUREMENT OF CRITERIA POLLUTANTS IN AMBIENT AIR, JULY 26, 2006

SO₂ Manual Methods		
Method	Designation Number	Method Code
Reference method (pararosaniline)	--	097
Technicon I (pararosaniline)	EQS-0775-001	097
Technicon II (pararosaniline)	EQS-0775-002	097

SO₂ Analyzers		
Method	Designation Number	Method Code
Advanced Pollution Instr. 100	EQSA-0990-077	077
Advanced Pollution Instr. 100A/100AS	EQSA-0495-100	100
Asarco 500	EQSA-0877-024	024
Beckman 953	EQSA-0678-029	029
Bendix 8303	EQSA-1078-030	030
Casella ML9850, ML9850B	EQSA-0193-092	092
Columbia Scientific Industries 5700	EQSA-0494-095	095
Dasibi 4108	EQSA-1086-061	061
DKK-TOA Corp. GFS-32	EQSA-0701-115	115
DKK-TOA Corp. GFS-112E, G FS-112E-1	EQSA-0100-133	133
Ecotech ML9850/EC9850, ML9850B/EC9850B	EQSA-0193-092	092
Ecotech EC9850T	EQSA-0193-092	092
Environnement S.A AF21M	EQSA-0292-084	084
Environnement S.A AF22M	EQSA-0802-149	149
Environnement S.A. SANOA	EQSA-0400-138	138
Horiba Model APSA-360/APSA-360ACE	EQSA-0197-114	114
Horiba Model APSA-370	EQSA-0506-159	159
Lear Siegler AM2020	EQSA-1280-049	049
Lear Siegler SM1000	EQSA-1275-005	005
Meloy SA185-2A	EQSA-1275-006	006
Meloy SA285E	EQSA-1078-032	032
Meloy SA700	EQSA-0580-046	046
Monitor Labs 8450	EQSA-0876-013	513
Monitor Labs or Lear Siegler 8850	EQSA-0779-039	039
Monitor Labs or Lear Siegler 8850S	EQSA-0390-075	075
Opsis AR 500, System 300 (open path)	EQSA-0495-101	101
Philips PW9700	EQSA-0876-011	511
Philips PW9755	EQSA-0676-010	010
Teledyne-Advanced Pollution Inst. 100E	EQSA-0495-100	100
Teledyne Analytical Instruments 6400A	EQSA-0495-100	100
Teledyne Monitor Labs ML9850, ML9850B	EQSA-0193-092	092
Teledyne Monitor Labs TML-50	EQSA-0495-100	100

APPENDIX 4 List of Reference and Equivalent Methods for the Measurement of Criteria Pollutants
in Ambient Air, October 1, 1996 (Continued)

Method	Designation Number	Method Code
Thermo Electron 43	EQSA-0276-009	009
Thermo Electron 43A, 43C-TLE, 43i	EQSA-0486-060	060
Thermo Environmental Instruments 43B, 43C	EQSA-0486-060	060
Wedding 1040	EQSA-0193-092	092

O₃ Analyzers		
Method	Designation Number	Method Code
Advanced Pollution Instr. 400/400A/400E	EQOA-0992-087	087
Beckman 950A	RFOA-0577-020	020
Bendix 8002	RFOA-0176-007	007
Casella ML9810, ML9810B, ML9811, ML9812	EQOA-0193-091	091
Columbia Scientific Industries 2000	RFOA-0279-036	036
Dasibi 1003-AH, -PC, -RS	EQOA-0577-019	019
Dasibi 1008-AH, -PC, -RS	EQOA-0383-056	056
DKK-TOA Corp. GUX-113E, GUX-113E-1	EQOA-0200-134	134
Ecotech ML9810/EC9810, -9810B, -9811, -9812	EQOA-0193-091	091
Enviro-nics 300	EQOA-0990-078	078
Environnement S.A O341M	EQOA-0895-105	105
Environnement S.A O342M	EQOA-0206-148	148
Environnement S.A SANO A	EQOA-0400-137	137
Horiba APOA-360	EQOA-0196-112	112
Horiba APOA-370	EQOA-0506-160	160
McMillan 1100-1	RFOA-1076-014	514
McMillan 1100-2	RFOA-1076-015	515
McMillan 1100-3	RFOA-1076-016	016
Meloy OA325-2R	RFOA-1075-003	003
Meloy OA350-2R	RFOA-1075-004	004
Monitor Labs 8410E	RFOA-1176-017	017
Monitor Labs or Lear Siegler 8810	EQOA-0881-053	053
Opsis AR 500, System 300 (open path)	EQOA-0495-103	103
PCI Ozone Corp. LC-12	EQOA-0382-055	055
Philips PW9771	EQOA-0777-023	023
Seres Model OZ 2000 G	EQOA-0506-161	161
Teledyne - Advanced Pollution Instr. 400E	EQOA-0992-087	087
Teledyne Monitor Labs ML9810/9810B, ML9811, ML9812	EQOA-0193-091	091
Teledyne Monitor Labs TML-10	EQOA-0992-087	087
Thermo Electron or Thermo Environmental Instruments 49, 49C, 49i	EQOA-0880-047	047
Wedding 1010	EQOA-0193-091	091

APPENDIX 4 List of Reference and Equivalent Methods for the Measurement of Criteria Pollutants
in Ambient Air, October 1, 1996 (Continued)

CO Analyzers		
Method	Designation Number	Method Code
Beckman 866	RFCA-0876-012	12
Bendix 8501-5CA	RFCA-0276-008	8
Casella ML9830, ML9830B	RFCA-0992-088	88
Dasibi 3003	RFCA-0381-051	51
Dasibi 3008	RFCA-0488-067	67
Ecotech ML9830/EC9830, ML9830B/EC9830B	RFCA-0992-088	88
Ecotech EC9830T	RFCA-0992-088	88
Environnement S.A CO11M	RFCA-0995-108	108
Environnement S.A CO12M	RFCA-0206-147	147
Horiba AQM-10, -11, -12	RFCA-1278-033	33
Horiba 300E/300SE	RFCA-1180-048	48
Horiba APMA-360	RFCA-0895-106	106
Horiba APMA-370	RFCA-0506-158	158
MASS - CO 1 (Massachusetts)	RFCA-1280-050	50
Monitor Labs 8310	RFCA-0979-041	41
Monitor Labs or Lear Siegler 8830	RFCA-0388-066	66
MSA 202S	RFCA-0177-018	18
Teledyne Advanced Pollution Instr. 300 or 300E	RFCA-1093-093	93
Teledyne Monitor Labs ML9830/9830B,	RFCA-0992-088	88
Teledyne Monitor Labs TML-30	RFCA-1093-093	93
Thermo Electron or Thermo Environmental Instruments 48, 48C, 48i	RFCA-0981-054	54
Wedding 1020	RFCA-0992-088	88

NO₂ Manual Methods		
Method	Designation Number	Method Code
Sodium arsenite (orifice)	EQN-1277-026	84
Sodium arsenite/Technicon II	EQN-1277-027	84
TGS-ANSA (orifice)	EQN-1277-028	98

APPENDIX 4 List of Reference and Equivalent Methods for the Measurement of Criteria Pollutants
in Ambient Air, October 1, 1996 (Continued)

NO₂ Analyzers		
Method	Designation Number	Method Code
Advanced Pollution Instr. 200	RFNA-0691-082	82
Advanced Pollution Instr. 200A/200AU	RFNA-1194-099	99
Beckman 952A	RFNA-0179-034	34
Bendix 8101-B	RFNA-0479-038	38
Bendix 8101-C	RFNA-0777-022	22
Casella ML9841, ML9841A, ML9841B	RFNA-1292-090	90
Columbia Scientific Indust.1600, 5600	RFNA-0977-025	25
Dasibi 2108	RFNA-1192-089	89
DKK-TOA Corp GLN-114E, GLN-114E-1	RFNA-0798-121	121
Ecotech ML9841A/EC9841A,ML9841B/EC9841B	RFNA-1292-090	90
Ecotech EC9841T	RFNA-1292-090	90
Environnement S.A. AC31M	RFNA-0795-104	104
Environnement S.A. AC32M	RFNA-0202-146	146
Environnement S.A. SANO A	EQNA-0400-139	139
Horiba APNA-360	RFNA-0196-111	111
Horiba APNA-370	RFNA-0506-157	157
Meloy NA530R	RFNA-1078-031	31
Monitor Labs 8440E	RFNA-0677-021	21
Monitor Labs or Lear Siegler 8840	RFNA-0280-042	42
Monitor Labs or Lear Siegler 8841	RFNA-0991-083	83
Monitor Labs ML9841	RFNA-1292-090	90
Opsis AR 500, System 300 (open path)	EQNA-0495-102	102
Philips PW9762/02	RFNA-0879-040	40
Seres Model NOx 2000 G	RFNA-0706-163	163
SIR S-5012	RFNA-0804-152	152
Teledyne-Advanced Pollution Inst. 200E	RFNA-1194-099	99
Teledyne Analytical Instruments 9110A	RFNA-1194-099	99
Teledyne Monitor Labs ML9841, ML9841A, ML9841B	RFNA-1292-090	90
Teledyne Monitor Labs TML-41	RFNA-1194-099	99
Thermo Electron or Thermo Environmental Instruments 14B/E	RFNA-0179-035	35
Thermo Electron or Thermo Environmental Instruments 14D/E	RFNA-0279-037	37
Thermo Environmental Instr. 42, 42C, 42i	RFNA-1289-074	74
Wedding 1030	RFNA-1292-090	90

APPENDIX 4 List of Reference and Equivalent Methods for the Measurement of Criteria Pollutants
in Ambient Air, October 1, 1996 (Continued)

Method	Designation Number	Method Code
Pb Manual Methods Reference method (hi-vol/AA spect.)	--	803
Hi-vol/AA spect. (alt. extr.)	EQL-0380-043	43
Hi-vol/Energy-disp XRF (TX ACB)	EQL-0783-058	58
Hi-vol/Energy-disp XRF (NEA)	EQL-0589-072	72
Hi-vol/Flameless AA (EMSL/EPA)	EQL-0380-044	44
Hi-vol/Flameless AA (Houston)	EQL-0895-107	107
Hi-vol/Flameless AA (Omaha)	EQL-0785-059	59
Hi-vol/ICAP spect. (Doe Run Co.)	EQL-0196-113	113
Hi-vol/ICAP spect. (EMSL/EPA)	EQL-0380-045	045
Hi-vol/ICAP spect. (Illinois)	EQL-1193-094	094
Hi-vol/ICAP spect. (Kansas)	EQL-0592-085	085
Hi-vol/ICAP spect. (Montana)	EQL-0483-057	057
Hi-vol/ICAP spect. (NE&T)	EQL-1188-069	069
Hi-vol/ICAP spect. (New Hampshire)	EQL-1290-080	080
Hi-vol/ICAP spect. (Pennsylvania)	EQL-0592-086	086
Hi-vol/ICAP-OE spect. (Pima Co.,AZ)	EQL-0995-109	109
Hi-vol/ICAP-MS spect. (Pima Co.,AZ)	EQL-0995-110	110
Hi-vol/ICAP spect. (Rhode Island)	EQL-0888-068	068
Hi-vol/ICAP spect. (Silver Val. Labs)	EQL-1288-070	070
Hi-vol/ICAP spect. (TNRCC)	EQL-0400-140	140
Hi-vol/ICAP spect. (West Virginia)	EQL-0694-096	096
Hi-vol/WL-disp. XRF (CA A&IHL)	EQL-0581-052	052

PM₁₀ Samplers		
Method	Designation Number	Method Code
Andersen Instruments RAAS10-100	RFPS-0699-130	130
Andersen Instruments RAAS10-200	RFPS-0699-131	131
Andersen Instruments RAAS10-300	RFPS-0699-132	132
BGI Model PQ100	RFPS-1298-124	124
BGI Model PQ200	RFPS-1298-125	125
Ecotech Model 3000 PM ₁₀ High Volume Sampler	RFPS-0706-162	162
New Star Environmental Model NS-6070	RFPS-0202-141	141
Oregon DEQ Medium volume sampler	RFPS-0389-071	071
Rupprecht & Patashnick Partisol 2000	RFPS-0694-098	098
R & P Partisol-FRM Model 2000	RFPS-1298-126	126
R & P Partisol-Plus Model 2025 Seq.	RFPS-1298-127	127
Sierra-Andersen/GMW 1200	RFPS-1287-063	063

APPENDIX 4 List of Reference and Equivalent Methods for the Measurement of Criteria Pollutants
in Ambient Air, October 1, 1996 (Continued)

Method	Designation Number	Method Code
Sierra-Andersen/GMW 321-B	RFPS-1287-064	064
Sierra-Andersen/GMW 321-C	RFPS-1287-065	065
Sierra-Andersen/GMW 241 Dichot.	RFPS-0789-073	073
Tisch Environmental Model TE-6070	RFPS-0202-141	141
W&A/Thermo Electron Mod 600 HVL	RFPS-1087-062	062
PM 10 Analyzers		
Andersen Instruments FH62I-N Beta	EQPM -0990-076	076
DKK-TOA FPM-222/222C/223/223C	EQPM -0905-156	156
DKK-TOA DUB-222(S)/223(S)	EQPM -0905-156	156
Environnement S.A. M P101M Beta	EQPM -0404-151	151
Met One BAM 1020, GBAM1020, BAM1020-1, GBAM1020-1 Beta	EQPM -0798-122	122
R & P TEOM 1400, 1400a	EQPM -1090-079	079
Thermo Andersen Series FH 62 C14 Beta Monitor	EQPM -1102-150	150
W&A/Thermo Electron 650 Beta Gauge	EQPM -0391-081	081
PM 2.5 Samplers		
Andersen Model RAAS2.5-200 Audit	RFPS-0299-128	128
BGI PQ200/200A	RFPS-0498-116	116
BGI PQ200-VSCC or PQ200A-VSCC	EQPM -0202-142	142
Graseby Andersen RAAS2.5-100	RFPS-0598-119	119
Graseby Andersen RAAS2.5-300	RFPS-0598-120	120
R & P Partisol-FRM 2000 PM -2.5	RFPS-0498-117	117
R & P Partisol-FRM 2000 PM-2.5 FEM	EQPM -0202-143	143
R & P Partisol 2000 PM-2.5 Audit	RFPS-0499-129	129
R & P Partisol 2000 PM-2.5 FEM Audit	EQPM -0202-144	144
R & P Partisol-Plus 2025 PM-2.5 Seq.	RFPS-0498-118	118
R & P Partisol-Plus 2025 PM-2.5 FEM Seq.	EQPM -0202-145	145
Thermo Electron RAAS2.5-100 FEM	EQPM -0804-153	153
Thermo Electron RAAS2.5-200 FEM	EQPM -0804-154	154
Thermo Electron RAAS2.5-300 FEM	EQPM -0804-155	155
Thermo Environmental Model 605 CAPS	RFPS-1098-123	123
URG-MASS100	RFPS-0400-135	135
URG-MASS300	RFPS-0400-136	136
TSP Manual Method		
Reference method (high-volume)	--	802

8.5 APPENDIX 5 POLLUTANT CODES FOR GASES, ELEMENTS AND OTHER SPECIES IN SUSPENDED PARTICULATE MATTER AND FOR SELECTED VOLATILE ORGANIC COMPOUNDS

Pollutant Code*	Formula or CAS Number	Description	Units	Measurement Period
COH	Coh	Soiling Index	Coh	Hourly
TSP	TSP	Total Suspended Particulate (Hi-Vol)	$\mu\text{g}/\text{m}^3$	Daily
TSPSO2		Combination TSP * SO2	$1000 * (\mu\text{g}/\text{m}^3)^2$	Daily
DUST	DF	Dustfall	$\text{g}/\text{m}^2/30 \text{ days}$	Monthly
SO2	SO2	Sulphur Dioxide	ppb	Hourly
CO	CO	Carbon Monoxide	ppm	Hourly
NO2	NO2	Nitrogen Dioxide	ppb	Hourly
NOX	NOx	Nitrogen Oxides	ppb	Hourly
O3	O3	Ozone	ppb	Hourly
NO	NO	Nitric Oxide	ppb	Hourly
Pb-X	PB	Lead (Hi-Vol)	$\mu\text{g}/\text{m}^3$	Daily
HCOO-X	HCOO	Formate	$\mu\text{g}/\text{m}^3$	Daily
C2O4-X	$\text{C}_2\text{O}_4^{2-}$	Oxalate	$\mu\text{g}/\text{m}^3$	Daily
PO4-X	PO_4^{---}	Phosphate	$\mu\text{g}/\text{m}^3$	Daily
	NO_2^-	Nitrite	$\mu\text{g}/\text{m}^3$	Daily
F-X	F^-	Fluoride	$\mu\text{g}/\text{m}^3$	Daily
NH4-X	NH_4^+	Ammonium	$\mu\text{g}/\text{m}^3$	Daily
BR-X	Br^-	Bromide	$\mu\text{g}/\text{m}^3$	Daily
SO4-X	SO4	Sulphate (Hi-Vol)	$\mu\text{g}/\text{m}^3$	Daily
SULPH	SO3	Sulphation	$\text{mg}/100\text{cm}^2/\text{day}$	Monthly
NO3-X	NO3	Nitrate (Hi-Vol)	$\mu\text{g}/\text{m}^3$	Daily
SP-X		Suspended Particulate (TEOM)	$\mu\text{g}/\text{m}^3$	Hourly
PM10	PM_{10}	PM < 10 μm aerodynamic diameter	$\mu\text{g}/\text{m}^3$	Daily
PM25	$\text{PM}_{2.5}$	PM < 2.5 μm aerodynamic diameter	$\mu\text{g}/\text{m}^3$	Daily
NA-X	Na	Sodium	$\mu\text{g}/\text{m}^3$	Daily
MG-X	Mg	Magnesium	$\mu\text{g}/\text{m}^3$	Daily
AL-X	Al	Aluminium	$\mu\text{g}/\text{m}^3$	Daily

Pollutant Code*	Formula or CAS Number	Description	Units	Measurement Period
SI-X	Si	Silicon	µg/m ³	Daily
P-X	P	Phosphorus	µg/m ³	Daily
S-X	S	Sulphur	µg/m ³	Daily
CL-X	Cl	Chlorine	µg/m ³	Daily
K-X	K	Potassium	µg/m ³	Daily
CA-X	Ca	Calcium	µg/m ³	Daily
SC-X	Sc	Scandium	µg/m ³	Daily
TI-X	Ti	Titanium	µg/m ³	Daily
V-X	V	Vanadium	µg/m ³	Daily
Cr-X	Cr	Chromium	µg/m ³	Daily
MN-X	Mn	Manganese	µg/m ³	Daily
FE-X	Fe	Iron	µg/m ³	Daily
CO-X	Co	Cobalt	µg/m ³	Daily
NI-X	Ni	Nickel	µg/m ³	Daily
CU-X	Cu	Copper	µg/m ³	Daily
ZN-X	Zn	Zinc	µg/m ³	Daily
GA-X	Ga	Gallium	µg/m ³	Daily
GE-X	Ge	Germanium	µg/m ³	Daily
AS-X	As	Arsenic	µg/m ³	Daily
SE-X	Se	Selenium	µg/m ³	Daily
BR-X	Br	Bromine	µg/m ³	Daily
RB-X	Rb	Rubidium	µg/m ³	Daily
SR-X	Sr	Strontium	µg/m ³	Daily
Y-X	y	Yttrium	µg/m ³	Daily
ZR-X	Zr	Zirconium	µg/m ³	Daily
NB-X	Nb	Niobium	µg/m ³	Daily
MO-X	Mo	Molybdenum	µg/m ³	Daily
PD-X	Pd	Palladium	µg/m ³	Daily
AG-X	Ag	Silver	µg/m ³	Daily
CD-X	Cd	Cadmium	µg/m ³	Daily

Pollutant Code*	Formula or CAS Number	Description	Units	Measurement Period
In-X	In	Indium	µg/m ³	Daily
SN-X	Sn	Tin	µg/m ³	Daily
SB-X	Sb	Antimony	µg/m ³	Daily
TE-X	Te	Tellurium	µg/m ³	Daily
I-X	I	Iodine	µg/m ³	Daily
CS-X	Cs	Cesium	µg/m ³	Daily
106989	106-98-9	1-butene	µg/m ³	Daily
106990	106-99-0	1 3-butadiene	µg/m ³	Daily
107006	107-00-6	1-butyne	µg/m ³	Daily
109671	109-67-1	1-penthne	µg/m ³	Daily
115071	115-07-1	propylene	µg/m ³	Daily
115117	115-11-7	2-methylpropene	µg/m ³	Daily
14686136	14686-13-6	trans-2-heptene	µg/m ³	Daily
513359	513-35-9	2-methyl-2-butene	µg/m ³	Daily
563462	56346-2	2-methyl-1-butene	µg/m ³	Daily
590181	590-18-1	cis-2-butene	µg/m ³	Daily
592416	59241-6	1-rexene	µg/m ³	Daily
616126	616-12-6	trans-3-methyl-2-pentene	µg/m ³	Daily
624646	624-64-6	trans-2-butene	µg/m ³	Daily
625274	625-274	2-methyl-2-pentene	µg/m ³	Daily
627203	627-20-3	cis-2-pentene	µg/m ³	Daily
6443921	6443-92-1	cis-2-heptene	µg/m ³	Daily
646048	646-04-8	trans-2-pentene	µg/m ³	Daily
74997	74-99-7	1-propyne	µg/m ³	Daily
763291	763-29-1	2-methyl-1-pentene	µg/m ³	Daily
7688213	7688-21-3	cis-2-rexene	µg/m ³	Daily
78795	78-79-5	isoprene	µg/m ³	Daily
922612	922-61-2	cis-3-methyl-2-pentene	µg/m ³	Daily
106978	106-97-8	butane	µg/m ³	Daily
107835	107-83-5	2-methylpentane	µg/m ³	Daily

Pollutant Code*	Formula or CAS Number	Description	Units	Measurement Period
108087	108-08-7	2,4-dimethylpentane	µg/m ³	Daily
108872	108-87-2	methylcyclohexane	µg/m ³	Daily
109660	109-66-0	pentane	µg/m ³	Daily
110543	110-54-3	hexane	µg/m ³	Daily
110827	110-82-7	cyclohexane	µg/m ³	Daily
111659	111-65-9	octane	µg/m ³	Daily
111842	111-84-2	nonane	µg/m ³	Daily
112403	112-40-3	dodecane	µg/m ³	Daily
1120214	1120-214	undecane	µg/m ³	Daily
124185	124-18-5	decane	µg/m ³	Daily
142825	142-82-5	heptane	µg/m ³	Daily
3/6/2207	3/6/2207	trans-1,3-dimethylcyclohexane	µg/m ³	Daily
2216300	2216-30-0	2,5-dimethylheptane	µg/m ³	Daily
2216333	2216-33-3	3-methyloctane	µg/m ³	Daily
2216344	2216-344	4-methyloctane	µg/m ³	Daily
589435	589-43-5	2,4-dimethylhexane	µg/m ³	Daily
589537	589-53-7	4-methylheptane	µg/m ³	Daily
589811	589-81-1	3-methylheptane	µg/m ³	Daily
591764	591-764	2-methylhexane	µg/m ³	Daily
592132	592-13-2	2,5-dimethylhexane	µg/m ³	Daily
592278	592-27-8	2-methylheptane	µg/m ³	Daily
638040	638-04-0	cis-1,3-dimethylcyclohexane	µg/m ³	Daily
75285	75-28-5	isobutane	µg/m ³	Daily
75832	75-83-2	2,2-dimethylbutane	µg/m ³	Daily
78784	78-784	isopentane	µg/m ³	Daily
79298	79-29-8	2,3-dimethylbutane	µg/m ³	Daily
96140	96-14-0	3-methylpentane	µg/m ³	Daily
96377	96-37-7	methylcyclopentane	µg/m ³	Daily
75070	75-07-0	acetaldehyde	µg/m ³	Daily
71432	71-43-2	benzene	µg/m ³	Daily

Pollutant Code*	Formula or CAS Number	Description	Units	Measurement Period
74986	74-98-6	propane	µg/m ³	Daily
10061015	10061-01-5	*cis-1,3-dichloropropene	µg/m ³	Daily
10061026	10061-02-6	*trans-1,3-dichloropropene	µg/m ³	Daily
106467	106-46-7	1,4-dichlorobenzene	µg/m ³	Daily
106934	106-934	1,2 dibromoethane	µg/m ³	Daily
107062	107-06-2	1,2-dichloroethane	µg/m ³	Daily
108907	108-90-7	chlorobenzene	µg/m ³	Daily
120821	120-82-1	1,2,4-trichlorobenzene	µg/m ³	Daily
124481	124-48-1	dibromochloromethane	µg/m ³	Daily
127184	127-18-4	tetrachloroethylene	µg/m ³	Daily
156605	156-60-5	trans-1,2-dichloroethylene	µg/m ³	Daily
541731	541-73-1	1,3-dichlorobenzene	µg/m ³	Daily
56235	56-23-5	carbon tetrachloride	µg/m ³	Daily
67663	67-66-3	chloroform	µg/m ³	Daily
71556	71-55-6	1,1,1-trichloroethane	µg/m ³	Daily
74953	74-95-3	dibromomethane	µg/m ³	Daily
74975	74-97-5	bromochloromethane	µg/m ³	Daily
75014	75-014	vinylchloride	µg/m ³	Daily
75092	75-09-2	dichloromethane	µg/m ³	Daily
75252	75-25-2	bromoform	µg/m ³	Daily
75274	75-27-4	bromodichloromethane	µg/m ³	Daily
75343	75-34-3	*1,1-dichloroethane	µg/m ³	Daily
75354	75-354	1,1-dichloroethylene	µg/m ³	Daily
75456	75-45-6	freon22	µg/m ³	Daily
75694	75-694	freon 11	µg/m ³	Daily
75718	75-71-8	freon12	µg/m ³	Daily
76142	76-14-2	freon114	µg/m ³	Daily
78875	78-87-5	1,2-dichloropropane	pg/m ³	Daily
79005	79-00-5	1,1,2-trichloroethane	µg/m ³	Daily
79016	79-01-6	trichloroethylene	µg/m ³	Daily

Pollutant Code*	Formula or CAS Number	Description	Units	Measurement Period
79345	79-34-5	1,1,2,2-tetrachloroethane	µg/m ³	Daily
87683	87-68-3	hexachlorobutane	µg/m ³	Daily
95501	95-50-1	1,2-dichlorobenzene	µg/m ³	Daily
104518	104-51-8	n-butylbenzene	µg/m ³	Daily
105055	105-05-5	1,4-diethylbenzene	µg/m ³	Daily
108383	108-38-3	m and p-xylene	µg/m ³	Daily
108678	108-67-8	1,3,5-trimethylbenzene	µg/m ³	Daily
135013	135-01-3	1,2-diethylbenzene	µg/m ³	Daily
141935	141-93-5	1,3-diethylbenzene	µg/m ³	Daily
526738	526-73-8	1,2,3-trimethylbenzene	µg/m ³	Daily
611143	611-14-3	2-ethyltoluene	µg/m ³	Daily
50000	50-00-0	formaldehyde	µg/m ³	Daily
110623	110-62-3	2-pentanal	µg/m ³	Daily
565617	565-61-7	methyl iso-butyl ketone	µg/m ³	Daily
66251	66-25-1	hexanal	µg/m ³	Daily
67641	67-64-1	acetone	µg/m ³	Daily
78933	78-93-3	methyl ethyl ketone	µg/m ³	Daily
100414	100-41-4	ethylbenzene	µg/m ³	Daily
100425	100-42-5	styrene	µg/m ³	Daily
10365I	103-65-I	n-propylbenzene	µg/m ³	Daily
108883	108-88-3	toluene	µg/m ³	Daily
135988	135-98-8	sec-butylbenzene	µg/m ³	Daily
496117	496-11-7	indane	µg/m ³	Daily
538932	538-93-2	iso-butylbenzene	µg/m ³	Daily
98828	98-82-8	iso-propylbenzene	µg/m ³	Daily
74840	74-84-0	ethane	µg/m ³	Daily
74862	74-86-2	acetylene	µg/m ³	Daily
100527	100-52-7	benzaldehyde	µg/m ³	Daily
107028	107-02-8	acrolein	µg/m ³	Daily
123386	123-38-6	propionaldehyde	µg/m ³	Daily

Pollutant Code*	Formula or CAS Number	Description	Units	Measurement Period
4170303	4170-30-3	Crotonaldehyde	$\mu\text{g}/\text{m}^3$	Daily

* For speciation of particulate matter, “-X” is added to the pollutant code where X represents the size fraction (X=10, 25 or T for PM₁₀, PM_{2.5} and TSP respectively).

9. GLOSSARY OF TERMS

AAQS Ambient Air Quality Standards

Audit A systematic check to determine the quality of operation of some function or activity. Audits may be of two basic types: (1) performance audits in which quantitative data are independently obtained for comparison with routinely obtained data in a measurement system, or (2) system audits of a qualitative nature that consist of an on-site review of a laboratory's quality assurance system and physical facilities for sampling, calibration and measurement.

Background Ambient pollutant concentrations due to natural sources, nearby sources other than the one(s) currently under consideration and unidentified sources.

Calibrate An objective adjustment using measured air quality data (e.g., an adjustment based on least-squares linear regression).

Calm For purposes of air quality modelling, calm is used to define the situation when the wind is indeterminate with regard to speed or direction.

CEPA Canadian Environmental Protection Act

CI Confidence interval

Combustion turbine An engine that operates according to the Brayton thermodynamic cycle in which fuel is burned and the products of combustion at a high temperature are allowed to expand through a rotating power turbine thus producing a net amount of motive power.

Complex terrain Terrain exceeding the height of the stack being modelled.

Cyclic engine An engine that under normal operating conditions varies in shaft load by 40 percent or more of rated brake horsepower during recurrent periods of 30 seconds or less, or is used to power an oil well reciprocating pumping unit.

Data Quality The totality of features and characteristics of data that bears on their ability to satisfy a given purpose. The characteristics of major importance are accuracy, precision, completeness, representativeness and comparability. These five characteristics are defined as follows:

Accuracy - the degree of agreement of a measurement X with an accepted reference or true value, T , usually expressed as the difference between the two values, $X-T$, or the difference as a percentage of the reference or true value, $100 (X-T)/T$, and sometimes expressed as a ratio, X/T .

Precision - a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is best expressed in terms of the standard deviation. Various measures of precision exist depending upon the prescribed similar conditions."

Completeness - a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under correct normal conditions.

Representativeness - expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

Comparability - expresses the confidence with which one data set can be compared to another.

Data Validation A systematic process for reviewing a body of data against a set of criteria to provide assurance that the data are adequate for their intended use. Data validation consists of data editing, screening, checking, auditing, verification, certification and review.

Detailed model An analytical technique that provides a detailed treatment of physical and chemical atmospheric processes and requires detailed and precise input data. Specialised estimates are calculated that are useful for evaluating source impact relative to air quality standards and for allowable increments. The estimates are more accurate than those obtained from conservative screening techniques.

DQO Data quality objectives

Environmentally Related Measurements - A term used to describe essentially all field and laboratory investigations that generate data involving (1) the measurement of chemical, physical, or biological parameters in the environment, (2) the determination of the presence or absence of criteria or priority pollutants in waste streams, (3) assessment of health and ecological effect studies, (4) conduct of clinical and epidemiological investigations, (5) performance of engineering and process evaluations, (6) study of laboratory simulation of environmental events and (7) study or measurement on pollutant transport and fate, including diffusion models.

Evaluate To appraise the performance and accuracy of a model based on a comparison of concentration estimates with observed ambient air quality data.

Fluid modelling Modelling conducted in a wind tunnel or water channel to quantitatively evaluate the influence of buildings and/or terrain on pollutant concentrations.

Fugitive dust Dust discharged to the atmosphere in an unconfined flow stream such as that from unpaved roads, storage piles and heavy construction operations.

Fugitive emissions Emissions from an industrial source complex such as those resulting from the industrial process that are not captured and vented through a stack but may be released from various locations within the complex. Where such fugitive emissions can be properly specified, the ISC model, with consideration of gravitational settling and dry deposition, is the recommended model. In some unique cases a model developed specifically for the situation may be needed.

HEAST U.S. EPA's Health Effects Assessment Summary Tables

ICCR Industrial Combustion Coordinated Rulemaking

IRIS U.S. EPA's Integrated Risk Information System

MACT Maximum achievable control technology

Model A quantitative or mathematical representation or simulation that attempts to describe the characteristics or relationships of physical events.

MSDS Material Safety Data Sheet

NAAQS National ambient air quality standard

NESHAPs National emission standards for hazardous air pollutants

NMHCs Non-methane hydrocarbons

NPRI (Canadian) National Pollutant Release Inventory

NSPS New Source Performance Standards

Noncyclic engine Any engine which is not a cyclic engine.

NRC National Research Council

PCDDs Polychlorinated dibenzo-p-dioxins

PCDFs Polychlorinated dibenzofurans

Performance Audits Procedures used to determine quantitatively the accuracy of the total measurement system or component parts thereof.

Preferred model A detailed model that is recommended for a specific type of regulatory application.

Quality Assurance The total integrated program for assuring the reliability of monitoring and measurement data. A system for integrating the quality planning, quality assessment and quality improvement efforts to meet user requirements.

Quality Assurance Program Plan - An orderly assemblage of management policies, objectives, principles and general procedures by which an agency or laboratory outlines how it intends to produce data of known and accepted quality.

Quality Assurance Project Plan An orderly assembly of detailed and specific procedures which delineates how data of known and accepted quality are produced for a specific project. (A given agency or laboratory would have only one quality assurance program plan, but would have a quality assurance project plan for each of its projects.)

Quality Control The routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process.

Receptor models Statistical procedures that examine historical ambient concentration data and specific or generic source profiles to infer the relative contributions of the sources to measured concentrations in each sample.

RTEC Registro de Emisiones y Transferencia de Contaminantes (the Pollutant Release and Transfer Register (PRTR) for Mexico.

Receptor A location at which ambient air quality is measured or estimated.

RfC Reference concentration

RfD Reference dose

Rollback A simple model that assumes that if emissions from each source affecting a given receptor are decreased by the same percentage, ambient air quality concentrations decrease proportionately.

Screening technique A relatively simple analysis technique to determine if a given source is likely to pose a threat to air quality. Concentration estimates from screening techniques are conservative.

SF Slope factor

Significant impact The impacts of sources on ambient air quality are deemed significant when the increment in the predicted average concentration of SO₂, TSP, PM₁₀ or NO₂ is greater than an annual average of 20 µg/m³ or a 24-hour average of 80 µg/m³ and when such predictions are made using an approved air dispersion model.

Simple terrain An area where terrain features are all lower in elevation than the top of the stack of the source.

Standard Operating A written document which details an operation, analysis or action whose

Procedure (SOP) mechanisms are thoroughly prescribed and which is commonly accepted as the method for performing certain routine or repetitive tasks.

TRI (U.S.) Toxic Release Inventory

URF Unit risk factor

UTM The Universal Transverse Mercator (UTM) system is a widely used plane coordinate system for the earth. The grid has been designed to cover the area between 84 degrees north (84° N) and 80 degrees south (80° S). In the UTM system, the earth between 84° N and 80° S is divided into 60 north-south zones, each 6 degrees wide. UTM zone characters designate 8° zones extending north and south from the equator. There are special UTM zones between 0° and 36° longitude above 72° latitude and a special zone 32 between 56° and 64° north latitude. Each zone is numbered consecutively beginning with zone 1, near the International Date Line between 180° and 174° west longitude, and progressing eastward to zone 60, between 174° and 180° east longitude. In each zone, coordinates are measured north and east in metres. The northing values are measured continuously from zero at the equator, in a northerly direction. Southerly values are similarly measured from the equator, south. A central meridian through the middle of each 6 degrees; zone is assigned an easting value of 500,000 metres. Grid values to the west of this central meridian are less than 500,000; to the east, more than 500,000. Jamaica is located between longitudes 76.2° W and 78.4° W. hence most of Jamaica is located in zone 18 except for the portion west of 78° W which is in zone 17.

Available Maps and Coordinate Systems

The Survey Department of Jamaica publishes two sets of maps:

A series in imperial units (feet) e.g., 1:12,500, 1:2,500 series referenced as the Jamaica Imperial Grid (JIG) based on the following:

Unit of measure: feet

Origin 77° West of Greenwich, 18° North

False coordinates of origin 550,000feet Easting, 400,000 feet Northing

Projection Lambert Conical Orthomorphic with one standard parallel

Spheroid Clark, 1980

The full six digits are generally displayed at the four corners of each sheet with the most significant and the three least significant digits in a smaller font.

A metric edition, referenced as the Jamaica Metric Grid (JMG) e.g., 1:50,000, based on the following:

Unit of measure: metres

Scale factor at origin 1,000

Origin 77° West of Greenwich, 18° North

False coordinates of origin 250,000 m Easting, 150,000 m Northing

Projection Lambert Conical Orthomorphic with one standard parallel

Spheroid Clark, 1868

The 1:50,000 series consists of 20 maps (sheets) that cover the island. A 5 km radius around a plant site will fit on an 8½" by 11" sheet. This will be suitable for defining the area around a site.

Coordinates (in six digits for each of the easting and northing) must be recorded in one of the following coordinate systems Jamaica metric grid (JMG) based on the 1:50,000 scale series of maps, the Jamaica imperial grid (JIG) based on the 1:12,500, 1:2,500 or other series of maps or UTM based on any in-house maps various organisations may have. In the latter case, details on the source of the maps must be provided.

Care should be taken in recording the coordinates which should all have 6 digits. The grid on the map is in km and the scale is marked in two digits with indication of the three digits every ten km but the most significant digit is smaller than the remaining digits (e.g. 175 m N for 175,000 m N or 270 for 270,000 m E). The full six digits are generally displayed at the bottom right and left corners of each sheet with the most significant and the three least significant digits in a smaller font size. Distances accurate to the nearest 50 m (nearest mm) must be interpolated from the map.