AN ASSESSMENT OF LOCAL GOVERNMENT CAPACITY IN KWAZULU-NATAL TO IMPLEMENT THE NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY ACT

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ABSTRACT

The radical shift in approach to the Air Quality Management (AQM) strategy that has been introduced recently, through the promulgation of the National Environmental Management: Air Quality Act (AQA), makes provision for a number of innovative measures in the control of air pollution in South Africa. These include the appointment of Air Quality Officers, the development of Air Quality Management Plans, the designation of priority areas, the provision for stricter enforcement conditions, and the broad implementation of monitoring. A significant change is in the form of delegating the greatest responsibility for implementation of measures to the local government tier, comprised of metropolitan areas, district and local municipalities. Local authorities are recognised as a sphere of government, however, they are impeded, *inter alia*, by matters of limited financial resources, lack of skills capacity, and the slow transformation of organisational culture and structure (Cloete, 2002).

The implementation of the AQA by local government is framed by an understanding of the responsibilities of local government, as well as the principal components of AQM and their implementation. The selected areas for study are Uthungulu, Uthukela, and Ugu district municipalities in KwaZulu-Natal, representing administrative and geographical variation. Existing and potential air quality issues, and their plans to address these issues, were identified and assessed in the municipalities using the Integrated Development Plans. The capacity of municipalities to implement the AQA was assessed using interviews, focusing on the interpretation of the AQA, technical capabilities, and implementation of AQM. Awareness of municipal responsibilities under the AQA was limited, although advances in AQM implementation had been made by municipalities. Responsibilities reflecting technical measures or activities that were currently undertaken by the municipality, such as monitoring and enforcement, were well recognised. However, the related policy and management tools, of Air Quality Officer (AQO) appointment and Air Quality Management Plan (AQMP) development, were less emphasised by municipal respondents. Limited progress in implementation of the AQA was observed, with only AQO appointment and ambient monitoring being significantly applied.

The greatest challenge facing municipalities is the securing of financial resources for personnel and equipment. Progress in technical fundamentals is noted, most notably in emission inventories and monitoring capabilities, although communication on air quality issues remains poor, with limited mechanisms in place for inter-governmental or public communication. There is a prevalence of the use of AQMPs as planning tools, as well as general concepts of town planning and zoning. However, in general, planning departments are not involved. A significant proportion of municipalities have a means of assessing progress, whether explicitly or not. A framework for implementing the AQA is produced to guide local government efforts, and provides a summation of the outcomes of the research.

PREFACE

The work described in this dissertation was carried out in the School of Environmental Sciences, University of KwaZulu-Natal, between February 2005 and January 2007, under the supervision of Professor R.D. Diab, in fulfilment of the academic requirements for the degree of Master of Science.

This study represents the original work undertaken by the author and has not been submitted in any other form to another university. Where use has been made of the work of others, it has been duly acknowledged in the text.

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TABLE OF CONTENTS

CHAPTER FOUR: DATA AND METHODOLOGY

CHAPTER FIVE: AQA IMPLEMENTATION: LOCAL GOVERNMENT PERSPECTIVES

List of Figures

List of Tables

List of Acronyms

AEL	Atmospheric Emission License
AIR	Atmospheric Impact Report
APCO	Air Pollution Control Officer
APPA	Atmospheric Pollution Prevention Act
AQA	Air Quality Act
AQAP	Air Quality Action Plan
AQCR's	Air Quality Control Regions
AQM	Air Quality Management
AQMA	Air Quality Management Area
AQMP	Air Quality Management Plan
AQMS	Air Quality Management System
AQO	Air Quality Officer
BACT	Best Available Control Technology
BATNEEC	Best Available Technology Not Entailing Excessive Cost
CAPCO	Chief Air Pollution Control Officer
CBA	Cost-Benefit Analysis
CCE	Centre for Co-ordination of Effects
CFC's	Chlorofluorocarbons
CLRTAP	Convention on Long Range Transboundary Air Pollution
CO	Carbon monoxide
CSIR	Council for Scientific and Industrial Research
DAEA	Department of Agricultural and Environmental Affairs
Danida	Danish International Development Assistance
DEAT	Department of Environmental Affairs and Tourism
DEFRA	Department for Environment, Food and Rural Affairs
EEA	European Environment Agency
EC	European Commission
ECE	Economic Commission for Europe
EHP	Environmental Health Practitioner
EIA	Environmental Impact Assessment
EMCA	Environmental Management Co-operation Agreement
EMP	Environmental Management Plan
EMS	Environmental Management System
ERC	Emission Reduction Credit

EU	European Union
GEMS	Global Environmental Monitoring System
HMIP	Her Majesty's Inspectorate for Pollution
IDP	Integrated Development Plan
IDZ	Industrial Development Zone
IPWM	Integrated Pollution and Waste Management
IUCN	International Conservation Union
KZN	KwaZulu-Natal
LPG	Liquid Petroleum Gas
LUMS	Land Use Management System
MARC	Monitoring and Assessment Research Centre
NAAQS	National Ambient Air Quality Standards
NACA	National Association for Clean Air
NAQAC	National Air Quality Advisory Committee
NAQMP	National Air Quality Management Programme
NAQS	National Air Quality Strategy
NEAF	National Environmental Advisory Forum
NECD	National Emission Ceiling Directive
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NEMA	National Environmental Management Act
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
O_3	Ozone
OMEGA-2	Optimisation Model for Environmental Integrated Assessment
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PM_{10}	Particulate matter with aerodynamic diameter less than 10 micron
$PM_{2.5}$	Particulate matter with aerodynamic diameter less than 2.5 micron
PSD	Prevention of Significant Deterioration
QA/QC	Quality Assurance and Quality Control
RBCAA	Richards Bay Clean Air Association
ROG's	Reactive Organic Gases
SAAQIS	South African Air Quality Information System
SANAS	South African National Accreditation System
SDI	Spatial Development Initiative

SEA	Strategic Environmental Assessment
SIP	State Implementation Plan
SMME	Small, Medium and Micro Enterprises
SO_2	Sulphur dioxide
TSP	Total Suspended Particulates
UCT	University of Cape Town
UK	United Kingdom
UN	United Nations
UN ECE	United Nations Economic Commission for Europe
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNITAR	United Nations Institute for Training and Research
US	United States
US EPA	United States Environmental Protection Agency
USA	United States of America
VOC's	Volatile Organic Compounds
WITS	University of the Witwatersrand
WTA	Willingness to Accept
WTP	Willingness to Pay
WHO	World Health Organisation
WWF	Worldwide Fund for Nature
ZEAL	Zululand Environmental Alliance

CHAPTER ONE
INTRODUCTION

1.1 Background

The pollution of the atmosphere has existed since the discovery of fire, smoke being the associated by-product of combustion; however, prior to this, natural sources of atmospheric pollutants such as volcanoes and sea spray introduced substances into the atmosphere. For the purposes of control, the broader perspective of air pollution and pollutants is narrowed down into a definition that addresses the assimilative capacity of atmosphere and employs an effects-based approach to control. Pollution, according to the context of South African legislation, deals specifically with the introduction of substances, or other foreign elements, into the environment that inhibit human health and well-being, ecosystem functioning and materials utility, both currently and in the future (Republic of South Africa, 1998). Air pollution then refers to elements and substances that alter the natural composition of the atmosphere, causing negative impacts (Elsom, 1992; Republic of South Africa, 2005).

Anthropogenic contributions to pollution exceed natural emissions greatly, with the exceptions being infrequent events of large pollutant loading generally of the natural disaster scale such as large-scale forest fires and volcanic eruptions. Since the Industrial Revolution, with the advent of motorised production on a factory-scale, anthropogenic emissions to the atmosphere have increased dramatically, presenting increasingly complex pollution scenarios (Jacobson, 2002). Temporal and spatial scales affect air pollution, with industrial stack emissions presenting localised pollution problems, motor vehicles representing urban-scale pollution, acidification and eutrophication as regional pollution, and global warming and associated climate change being a global and centuries-long pollution problem (Boubel *et al.*, 1994; Fenger, 2002).

The recognition of air pollution as an unwanted occurrence, coupled with the negative impacts, provides an impetus for control of pollutant sources that has a long historical record. Countries such as the United Kingdom (UK) and the United States of America (USA) offer early examples of control in their industrialised cities; as early as 1306, the introduction of control measures aimed at reducing air pollution can be seen, although these were poorly enforced (Jacobson, 2002). Modern legislation experiences greater support from authorities and emitters alike, with increased awareness of the need to conserve natural resources and the greater environment and reduce impacts on health and property.

In South Africa, our status as a developing country sees us grapple with pollution problems caused by industrialisation, as well as typical Third World issues created by uneven development and access to resources. Industrial emissions and excessive private vehicle use are juxtaposed against domestic fuel burning and polluting agricultural practices. The Atmospheric Pollution Prevention Act (APPA, Act

45 of 1965), until recently, has been the legislation responsible for pollution control. APPA employed the 'best practicable means' approach, designating no desired level of ambient air quality, and has led to the development of pollution 'hotspots' around South Africa (Barnard, 1999; UNEP/WHO, 1996).

The Constitutional imperative in Section 24, which purports environmental management based on the reduction of harmful health effects and pollution prevention, created a vacuum in environmental legislation that necessitated a law reform process. APPA, being over 30 years old and not providing any mechanism that allowed for the pro-active management of air quality, was repealed in part through the promulgation of the National Environmental Management: Air Quality Act (AQA, Act 39 of 2004) in September 2005. Currently, some degree of APPA regulation remains in place under a transitional arrangement, until the full measure of AQA controls can be introduced by authorities.

The AQA brings the air quality management (AQM) approach into the realm of pollution control in South Africa, utilising health-based standards and the AQM tools to achieve them as the critical elements of the strategy (Scott *et al.*, 2005). All tiers of government are empowered through the AQA, though significant responsibility for the implementation of air pollution control is devolved to local government. While the organisational term 'sphere' is used in describing the different levels of government in South African policy, the observed relationship is, in fact, more hierarchal, and the study employs the term 'tier'. The AQA also considerably modernises legislation to bring South African legislation in line with internationally accepted practices. Concerns have been raised previously over the capacity of local government, and the burden of responsibility placed on local government for implementing the AQA currently, in terms of human and financial resources (Cloete, 2002; Scott *et al.*, 2005). It is therefore pertinent, at this juncture, to undertake an assessment of the capacity of local government to implement the AQA.

1.1.1 Area of Interest

The study is located within KwaZulu-Natal (KZN) and selects three district municipalities: Uthungulu, Uthukela and Ugu district municipalities, to investigate the capacity to implement the AQA. The district municipalities that form the basis of the study are illustrated in Figure 1.1. Uthungulu is situated on the north coast of KZN with Richards Bay as a major service node in the district, together with the smaller towns of Empangeni and Eshowe. Uthukela is positioned inland, with Ladysmith and Estcourt being centres of note. Ugu is located on the south coast of KZN and Port Shepstone and Margate are major towns.

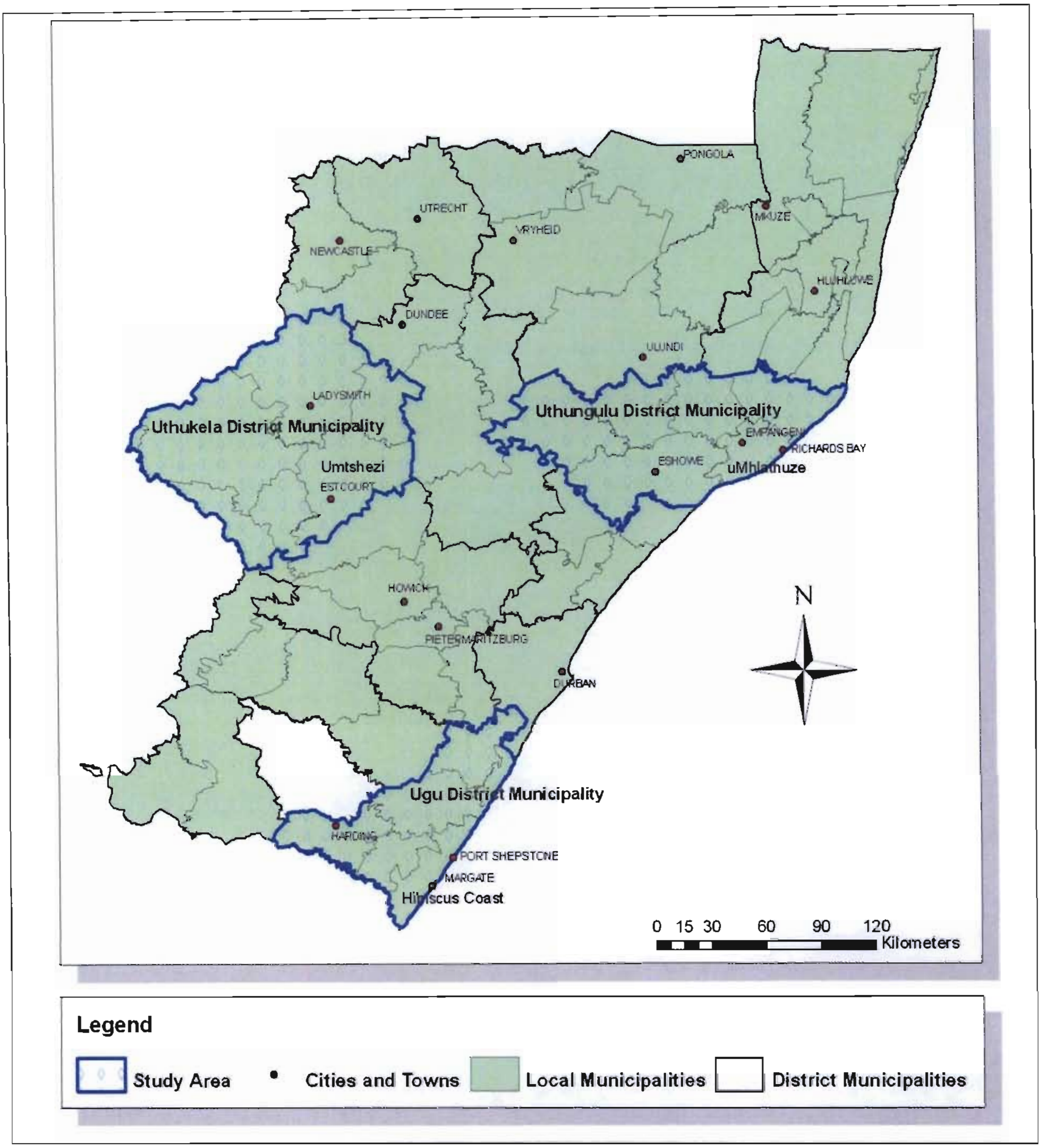

Figure 1.1. Map of KwaZulu-Natal indicating the district municipalities selected for the study

Within the districts, local municipalities displaying a degree of air pollution control capability were also incorporated into the sample. Umhlatuze local municipality in Uthungulu, Umtshezi municipality in Uthukela and Hibiscus Coast municipality in Ugu were the local municipalities, which indicated during preliminary contact that some degree of functioning in air pollution control was present. Umhlatuze is highly industrialised with a large number of heavy industries in the municipality and includes Richards Bay and Empangeni. Umtshezi is largely the towns of Estcourt and Weenen and surrounds, with Estcourt hosting some significant industry. Hibiscus Coast comprises a number of coastal towns including Port Shepstone and Margate, with Port Shepstone forming the industrial hub in the municipality, with light to medium industries.

The selection was based on a number of factors including a preliminary review of air pollution issues contained in the Integrated Development Plans, and a desire to include geographical variability and rural and urban contrast. On the last point, as a result of the industrialised nature of Umhlatuze, Uthungulu experiences a high level of development in the surrounding areas although a number of rural areas exist outside this periphery. Ugu and Uthukela have a similar experience, with rural areas outside of urban cores. Uthukela can be regarded as largely rural, with limited urbanisation in the major towns. The selected districts face differing pollution scenarios, and development priorities, such that each case study provides a contrasting insight into the challenges facing local government.

Ethekwini municipality was not included in the study as this metropolitan area, in line with most other large metropolitan areas in South Africa, is well-equipped to implement the AQA. The municipality is significant in the national context, having implemented control measures and utilised AQM tools in the management of air quality issues in the South Durban Basin for a considerably longer period than a number of other municipalities. The South Durban Basin Multi-Point Plan, instituted through the intervention of national government, has achieved major reductions in emissions in the Basin (Groenewald, 2005). The major components include an Air Quality Management Plan, Health Risk Assessment and epidemiological studies, chemical and fugitive emissions control, phasing out of dirty fuels, air quality standards-setting, and incorporation of the national vehicle emissions strategy (Chetty, 2005). On the other hand, with the smaller district municipalities, the challenges with respect to implementation of the AQA are enormous. It is on these challenges that the study is focused.

1.2 Aim and Objectives

The aim of the research is described as determining the capacity of selected district municipalities in KwaZulu-Natal to implement the National Environmental Management: Air Quality Act and making recommendations to facilitate the implementation of the Act. Four objectives have been derived from the prior statement to fulfil the aim. These are, in the order in which they have been carried out:

- To determine the responsibilities of local government in terms of the AQA and AQM theory;
- To identify existing and potential air quality issues within selected municipalities and assess their plans to address these issues in terms of the AQA;
- To determine the current and planned capacity of local authorities to fulfil the requirements of the AQA; and
- To develop a systematic framework for the implementation of the AQA by local authorities.

1.3 Structure of Thesis

Following the introduction of the subject matter and a rationale for conducting the study in Chapter 1, Chapter 2 presents the theoretical underpinnings of air pollution control, including significant strategies, of which AQM is discussed in detail as the basis for many recognised international control programmes and the AQA. Chapter 3 examines air pollution control as it is applied in South Africa, from legislative and governance perspectives, and other noteworthy regulatory approaches including the United Nations, the USA and the European Union (EU). Chapter 4 details the methodology used in the study and Chapter 5 presents the results of the study, outlining the capacity of local government. Chapter 6 discusses the significant outcomes of the research, analysing responses to determine the themes contained therein, and producing a systematic framework to guide AQA implementation by local government. Chapter 7 concludes the study by succinctly presenting the major outcomes. References and an appendix are compiled at the end of the dissertation.

CHAPTER TWO
AIR POLLUTION CONTROL STRATEGIES

2.1 Introduction

The destructive impact of air pollution on people and the environment compels the introduction of air pollution control. Accordingly, the primary motivation for control is protection of human health and this objective frames programmes and actions (Scheuneman, 1977). However, other considerations include protection of plant and animal life, buildings and materials, visibility and aesthetics, as well as limiting impacts on economic growth and development (Scheuneman, 1977). These aspects of protection are subsidiary to human health concerns and are therefore, less emphasised in initial control conditions.

Early air pollution problems were the result of combustion of various bio-fuels, such as wood and vegetation, and typical fossil fuel sources, such as coal (Jacobson, 2002). Manufacturing industries and domestic usage both contributed to pollution and centred on urban conurbations. Sulphur dioxide (SO_2) and particulate matter, in the form of soot and smoke, are pollutants commonly associated with industrial air pollution and as the health and environmental costs became evident, regulations and controls on production were introduced (Elsom, 1992). Controls included the appointment of an inspector to examine smoke-related issues, smoke-control laws in many cities, and various regulatory limits introduced on emissions (Jacobson, 2002). The rationale and objectives of control dictated the strategy needed, accompanied by a suite of tools to enable agencies to achieve these targets.

However, in modern times, the rapid increase in the number of motor vehicles resulted in pollutants such as nitrogen dioxide (NO_2), benzene and carbon monoxide (CO) reaching harmful levels (Elsom, 1992). Modern air pollution problems, such as photochemical smog and accelerated climate change, necessitated controls that are multi-pronged in their approach and able to address and harmonise goals for air quality. In addition, pollution controls have now evolved to view the environment holistically and integrate pollutant releases across media; environmental performance standards are an expansion of the approach. The 'best practicable environmental option' is an example of performance standards, and advocates source prevention as a means of addressing impacts that may simply be transferred cross-media. Impacts such as solid waste disposal and the pollution of water used for scrubbing pollutants represent significant cross-media impacts, and pollution control has an expanded focus to curtail transferral through pollution prevention and minimisation approaches and techniques.

2.1.1 Sustainability and Air Pollution Control

The motivation for environmental management and recognising and halting environmental degradation has stemmed from realising the finite nature of environmental systems and the planet as a whole (Hajer, 1995). The typical policy response to an environmental management issue is illustrated in Figure 2.1, where the cycle of problem identification, policy response, followed by a scenario where the problem is controlled, highlights how control measures are influenced by the broader policy background (UNEP/WHO, 1996). In addition, the iterative nature of environmental policy is highlighted, where continual incremental improvements are desirable as the standard of environmental quality increases. While the figure represents a general cycle applicable to an environmental management issue, it remains relevant to policy formulation within air pollution control, and more specifically air quality management. However, excluded from this cycle are the political and societal influences on control, which exert considerable bias in real-world situations. With reference to pollution control, factors such as political bargaining based on traditional support-base, emotive responses of affected communities, and the non-co-operation of environmental action groups invalidating processes, affect and alter the course of policy and control objectives (Weale, 1992).

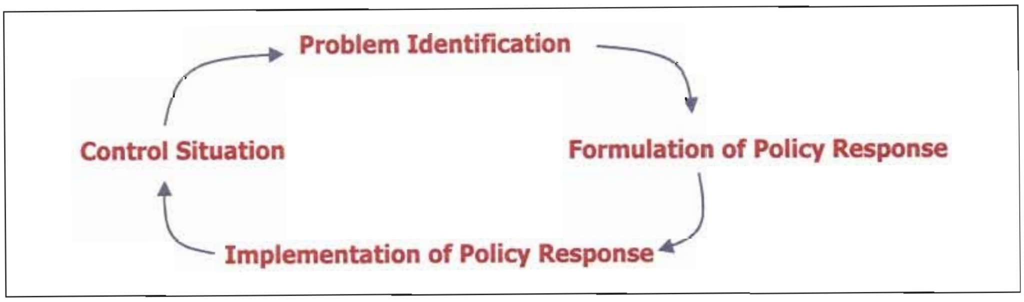

Figure 2.1. The Environmental Management Cycle, illustrating the methodology of problem identification and policy response to the issue (Source: UNEP/WHO, 1996)

Sustainable development represents a paradigm shift in the approach to managing the environment; and has been popularly defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Atkinson *et al.*, 1997; Kidd and Shaw, 2000). It seats development within a framework of ecological and social sustainability, ensuring that impacts arising from pursuing improvements do not greatly inhibit the integrity of the environment or humankind beyond the benefits gained. Sustainability can be viewed as a function of 'sustain' which is defined 'enduring' or 'lasting', and the quality of persistence (Pearce *et al.*, 1993).

In practice, weak and strong sustainability are differentiated, and this is dependant on the balance of objectives promoted in the approach. They are commonly differentiated based on the approach to preserving capital stock for future use, with weak sustainability advocating any mix of natural and man-made stock and strong sustainability asserting that a critical natural capital must be maintained

(Pearce *et al.*, 1993). Weak sustainability is characterised by a formal policy integration with deliverable targets, the substantial restructuring of microeconomic incentives, and wider public education for future visions; whereas strong sustainability constitutes binding policy integration and strong international agreements, a full economic valuation with green accounts and taxes, and curriculum integration and local initiatives as part of community growth (Pearce *et al.*, 1993).

Ecological modernisation is touted as a mechanism for weak sustainability, describing the current wave of environmental policies, including waste minimisation and pollution prevention, integration of pollution control, and using the existing investment patterns of industry to promote cleaner production and technology (Christoff, 1996). Variations on the interpretation of ecological modernisation are presented, with it being regarded as a technological adjustment promoting a technical cost-minimisation strategy for industry, a policy discourse defining changes in environmental policy-making and other related realms, and a new belief system with the understanding that environmental protection is a pre-condition of long-term economic development (Christoff, 1996; Hajer, 1995; Weale, 1992). It is evident that South African environmental policy follows these trends as well and observations made regarding the suitability of ecological modernisation as a theory for pollution control, and the shortcomings, can be extended to improve the performance of policies.

The development of ecological modernisation theory is subject to clarity on issues such as the focus of the interpretation being economic or ecological, where the environment is reduced in meaning to the exclusion of cultural and non-anthropocentric value, and economic efficiency incorporating environmental externalities is promoted (Christoff, 1996). Addressing ecological modernisation outside of the changes initiated within the nation state in light of a globalised economy, and presenting industrial transformation using a hegemony of Western culture, expressed in science, technology and consumer culture, as the idealised path to sustainability exposes weak interpretation of the theory. Evident in the approach to ecological modernisation are inconsistencies in terms of encouraging democratic, participatory decision-making in contrast to technocratic legitimisation with limited environmental improvement (Christoff, 1996).

Assessment of sustainability, and progress towards sustainable development, can be guided by the use of principles, and the Bellagio principles of assessment provide 10 such principles that are used to frame the process. A guiding vision and goals are needed for decision-making, providing direction and a measure of comparison (Hardi and Zdan, 1997). Integrating the overall system with practical objectives can be achieved by employing a holistic perspective, considering the essential elements of the system and making provision for an adequate scope and practical focus (Hardi and Zdan, 1997). Key issues in the assessment are openness, effective communication and broad participation, while on-going assessment and institutional capacity are necessary for continued assessment (Hardi and Zdan, 1997). The principles can influence the choice of indicators and assessment of the system as a whole, and can serve as a guideline for moving toward stronger sustainability.

The management of air quality issues falls within the broader framework of environmental management, which supports the philosophical foundations of AQM (UNEP/WHO, 1996). The principles of environmental management, such as sustainability, equity and public participation, shape the application of AQM. Ecological modernisation is the theory that frames action, and as such, can be used to understand the underlying social mechanisms influencing environmental degradation, including air quality, and identify solutions that address these pitfalls.

2.2 Control Strategies

An air pollution control strategy is a master plan that addresses air pollution problems at a regional or national level and focuses on attaining acceptable levels of pollutant concentrations through minimising or maintaining emissions (Elsom, 1992). A strategy presents a broad outline of objectives, which are complemented by specific actions taken to control air pollution (de Nevers *et al.,* 1977). A country may define a strategy that is dependant on the controls needed, or subscribe to regional leadership such as the EU, which provides a framework for pollution control and enforceable limits on pollutant concentrations. Acceptable levels are determined in a manner dependant on the strategy, with human health impacts playing a pivotal role. There are four distinct strategies that can be identified, *viz*. air quality management, emission standards, emission taxes, and cost-benefit strategies (de Nevers *et al.,* 1977).

While each strategy is distinct in its approach, there are general qualities that are desirable in a control strategy and accompanying management tools. Cost-effectiveness and fairness are important attributes, where the benefits received from pollution control are balanced, in an equitable manner, against the costs (de Nevers *et al.,* 1977). In addition, a portion of the population should not carry a greater burden of costs, expressed as excessive pollutant levels. Resource allocation for control, both financial and social, should attain maximum benefit. Simplicity and ease of understanding are qualities that enable a strategy to engage society as a whole (de Nevers *et al.,* 1977). It should guide the setting of objectives, as well as the implementation of actions. Although management tools are, for the large part, complex and scientific in nature, the acceptance and co-operation of stakeholders could be facilitated through simplifying their application.

An easily enforceable strategy is a positive quality, as resources for control can be most effectively utilised (de Nevers *et al.,* 1977). Consequently, ensuring compliance with conditions stipulated within the strategy is improved. Flexibility within a strategy is an important quality as the control and management of air pollution presents diverse circumstances (de Nevers *et al.,* 1977). The strategy should include elements that are capable of addressing special circumstances and hardship cases with minimal legal effort. An ideal strategy has the ability to evolve to address changes in the field of air pollution control swiftly (de Nevers *et al.*, 1977). An evolutionary strategy can process the introduction of new information regarding pollution effects and advances in control technology to amend and improve control.

The qualities discussed represent the ideal with regard to strategy development for air pollution control. A single strategy does not possess all attributes and each is advantageous in a specific context. Therefore, countries developing a control strategy may employ a combination of strategies to effectively deal with their unique air pollution scenario (Elsom, 1992). Balancing the costs and gains of pollution control are a point of contention in developing strategies, with costs ranging from environmental damage and degradation, human illness and premature death and global climate alteration. The cost of control measures is weighed against improving polluted conditions, although fluctuations in temporal, technological, resource, and social and political value scales must also be considered (Elsom, 1992). Therefore, the degree of pollution cost, and control, incurred is strongly motivated though social and political judgements. There are limits to control strategies as an ideal, or non-polluting, state cannot naturally be attained; as such, the ultimate goal of a strategy is a reduction or reapportionment of pollutant emissions (de Nevers *et al.*, 1977). Following is a discussion of the salient points of different control strategies; AQM is dealt with in detail in Section 2.3, as the AQA is based on this approach, and hence given greater attention.

2.2.1 Emission Standards

Initial air pollution control was based on the emission standards strategy, involving the control of visible emissions from the inefficient combustion of coal (de Nevers *et al.*, 1977). The strategy has evolved into the "best practicable means" or "good practice" approach, where a class of emitters is subject to use, what is regarded as, the best practicable means of control or attain a level of control corresponding to good practice (de Nevers *et al.*, 1977; Elsom, 1992). The approach therefore predicates the use of the best available and economically feasible technology; facilitating the greatest reduction of air pollution using optimal practical methods while considering reasonable costs. The philosophy underpinning an emission standards strategy is that of keeping atmospheric emissions at the absolute, practical minimum and employing emission controls that are demonstrated to be appropriate for an emitter type and can be applied uniformly to all such emitter types (de Nevers *et al.*, 1977).

An emission standard can be prescribed in a variety of ways. Commonly used categories are numerical rate, fuel specification, equipment, and prohibitive (de Nevers *et al.*, 1977). Numerical rate standards specify measurable concentrations of emissions and are not process regulations but exhaust limits.

Fuel standards are frequently used to limit use of "dirty fuels", and are conditions placed on types of fuel that can be employed. Examples are the use of low-sulphur coal in industrial and domestic settings and the specification of lead content in petrol. Equipment and design standards can be stated for a number of different settings and apply to the apparatus or machinery involved directly in a process or in storage, transportation and other areas representing fugitive emissions. Standards are set for industrial machinery, such as boilers, storage tanks, and domestic stoves to limit emissions directly. Prohibitive standards are legal instruments to ban or disallow activities that result in a negative impact on air quality. Smoke-free zones are an illustration of prohibitive standards use, where any activity that produces smoke, generally particulate emissions, is not permitted, and can include recreational activities as well, such as barbeque fires. The removal of lead from petrol and preventing vehicular access to pollution foci, such as city centres, are also examples of prohibitive standards.

Technological advances present improvements in emission control, resulting in stricter controls, and a lower standard, for new plants. Additionally, retro-fitting, the act of updating pollution control technology at existing installations, is inhibited by excessive cost. Setting different standards for new and existing plants is the preferred practice to balance economic and environmental pressures (Elsom, 1992). The simplicity of applying emission standards favours its use, especially with regard to large single-emission sources (Elsom, 1992). Many countries initiate air pollution control using emission standards motivated by simplicity in application.

Proponents of the emission standards strategy argue that it is superior to AQM, as their outcomes are essentially the same (Elsom, 1992). Where AQM develops ambient standards, the process of attaining these limits involves approaching emitters and requesting compliance with a measure influenced by good practice. Therefore, an emission standards strategy is able to circumvent the process and achieve improvements in air quality. However, uncertainty over the meaning of "good practice", as well as, critically, its absence of any judgement of acceptable air quality hinders its use without combination of an AQM or alternative strategy (de Nevers *et al.,* 1977; Elsom, 1992). The subjectivity of defining "good practice" for application opens the strategy to abuse by emitters, as well as making air quality a function of the commitment of authorities. The strategy does not require explicit air quality objectives or goals to be developed for application, and as a result, there are no weighted improvements or desired endpoints.

A noteworthy example of the 'best practicable means' approach is the UK. It favoured the approach of discussions with industry to determine the most feasible control measures by taking into account costs of control, viability of the industry within the sector and to a lesser degree, public perception (Colls, 1997; Elsom, 1992). Selected UK authorities employed non-mandatory guidelines or reference levels, a form of air quality standards; and these options were preferred over coercive penalties and regulation. Obstacles to the UK's use of the 'best practicable means' strategy were issues of public perception. The encouragement of partnerships between authorities and industry presented difficulties where public confidence in the subjectivity of British authorities was undermined and accountability to the public, over industry, questioned (Elsom, 1992). In addition, membership of the European Community (now the EU), and the subsequent adoption of an air quality management strategy for its members, implied a radical shift in air pollution control in the UK (Elsom, 1992).

2.2.2 Emission Taxes/Economic Incentives

Increasingly, economic incentives, of which emission taxes are an example, have been utilised as a component of national control strategies (Tietenberg, 2004). A strong motivation for the popularity of the strategy is the economic concept of efficiency, where resources are allocated to all users in a manner that produces the greatest gain for the least cost (Elsom, 1992). Differences in the marginal costs of controlling emissions across users imply that it is cheaper for some users to implement control measures than others and the markets, and society, exploit the opportunity (Elsom, 1992). Numerous economic incentives can be employed for pollution control and are further detailed in Table 2.1. Emission taxes and emission permits are two dominant forms of economic incentives used, however, other elements such as fines, fees and subsidies are evident in control measures for pollution. The choice of incentive is strongly motivated by intended outcome as redistribution of investment into abatement technology or reduction of pollutant concentrations, as examples, can be achieved (Elsom, 1992).

Table 2.1. List of economic incentives available to decision-makers to implement pollution control (Source: Boubel *et al.*, 1994)

Financial Incentives to Supplement or Replace Regulation & Examples of Use	
Taxes	
Sales taxes	On fuel, fuel additives, ingredients in fuel, pollution-producing equipment
Ultimate disposal taxes	On automobiles or other objects requiring ultimate disposal
Land use taxes	For pollution-producing activities
Tax Remission	
Corporate income tax	For investment in or operation of pollution control equipment; accelerated write-off of pollution control equipment
Property taxes	For pollution control equipment
Fines, effluent charges, and fees	
Fines	For violation of regulations
Effluent charges	For permission to emit excessive quantities of pollution; paid *after* emission
Fees	For permission to emit excessive quantities of pollution; paid *before* emission
Subsidies	
Direct	Governmental production (e.g. nuclear fuel)
Grants-in-aid	For pollution control installations
Indirect (low-interest bonds and loans)	For pollution control process or equipment development
Import restraints	
Duties and quotas	On materials, fuels, and pollution control-producing apparatus
Domestic production restraints	
Quotas, land and offshore use restraints	On materials and fuels

Economic incentives as a pure strategy have not been applied extensively, with the most notable proponent being the Czech Republic. The Czech experience involved taxing large emitters based on emissions, however, fee levels did not correspond to abatement costs resulting in polluters electing to pay taxes with no requisite improvement in air quality (Jurek, 2004). Upon accession to the EU, the Czech Republic has since passed legislation bringing it in line with the AQM approach of the organisation (Fiala *et al*, 2002; Jurek, 2004). By combining an economic incentive with a desired level of air quality, which is effectively an air quality management strategy, the required improvements can be attained in a cost-efficient manner (Elsom, 1992; Tietenberg, 2004).

The most commonly used version of the emission tax strategy is a flat tax rate on pollutants emitted, such as Rand amount per tonne of SO_2 emitted, charged on emitters in a designated area (de Nevers *et al.,* 1977). Emission taxes lead to cost-efficient control, as emitters blend expenditures on control measures and taxes to minimise costs (Elsom, 1992). Implementing emission taxes across different sources allows each emitter to determine their feasible level of control, which can be higher for some than others, with the overall effect that emission reductions are achieved at the least possible cost to society. The level of air quality attained is strongly dependant on the emission charges; therefore, continuous adjustments are needed to ensure progress towards desired pollution levels. Financial proceeds from control can be used to compensate victims or offset damage caused by pollution (Elsom, 1992).

"Pollution permits" or "pollution rights" are another form of economic incentive, where the authority determines the maximum allowable emissions in an area and issues permits or rights in accordance with these values, which are allocated or traded using market instruments (Elsom, 1992). The US (United States) emissions trading policy has several introduced innovative concepts such as "emission reduction credits" (ERC) and the "bubble" (Elsom, 1992; Tietenberg, 2004). Several conditions define an ERC, however, it is the difference (reduction) between actual emissions and legislative requirements that can be set aside by an emitter and used within the plant. The "bubble" policy allows an emitter to manage combined emissions across sources, by setting an aggregate emissions limit and placing an imaginary bubble over the plant, further illustrated in Figure 2.2. "Netting" allows new sources to be built by the emitter outside of regulations governing new sources, which are more stringent, providing there is no overall increase; and "banking" of ERC can be done to buffer the plant against future air quality requirements.

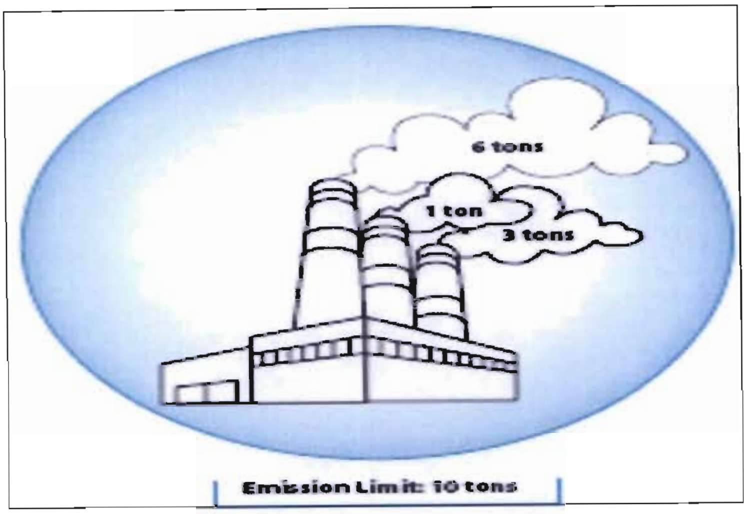

Figure 2.2. An illustrated application of the "Bubble" Policy (Source: US EPA Office of Air and Radiation, 2003)

Conflicting development and environmental priorities are addressed by "off-sets" where ERC from an existing emitter can be traded to allow new emitters to enter the market. The introduction of a tradable emission permit scheme by the USA in 1990 is the foremost example of large-scale implementation of a "cap and trade" system (Ellerman *et al*, 2000). Under the Clean Air Act Amendments of 1990, the US Acid Program introduced "allowances" for SO_2 allocated to electricity generating power plants. Allowances were determined by a desired air quality goal and the individual plant's historical emissions; and annually, companies were required to present allowances to cover their total emissions. Control measures could be used to reduce current emissions or allowances from plants with excesses, resulting from lower abatement costs, able to be purchased (Ellerman *et al*, 2000; Strevett *et al.*, 2002). The flexibility of the approach, as well as the substantial savings incurred by the economic, rather than command-and-control, regulation of emissions endorses the permit scheme (Ellerman *et al*, 2000; Lee, 1999).

The strengths and weaknesses of an economic incentive control strategy have been extensively discussed in the literature. Economic efficiency coupled with efficient resource allocation and market allocation for the dispersive capacity of the atmosphere favours this approach (de Nevers *et al.*, 1977; Lee, 1999). The responsibility for control falls mostly onto the polluter as it not regarded as command-and-control, therefore requiring less input from authorities and greater reliance on the competency of the emitter. This approach motivates the development of new technology as emitters are financially rewarded for innovations and the technology for achieving reductions is not dictated by legislation (Strevett *et* al., 2002; Tietenberg, 2004).

Criticisms of an economic incentive approach include the difficulty in setting the optimal level for charges, where the polluter is motivated to adopt abatement measures, and balancing economic, societal and political pressures on the charge rate (Elsom, 1992). Charges require contemporary adjustments to place the economic burden on the polluter, and not society. In addition, in a purely economic or market-based strategy, cost-effectiveness is prioritised over health and safety concerns (Wilson, 1980). Accurate monitoring coupled with capable supervision and enforcement is needed for successful implementation, necessitating significant resource outlays (Elsom, 1992; McCormick, 1997). The complexity of continuous monitoring of source emissions of the large number of smaller sources, such as vehicles and domestic emitters, limit the strategy's application to larger industrial emitters (Elsom, 1992). The strong economic focus of the strategy opens up possibilities of abuse and market failure, including companies with large market share passing on environmental charges to consumers or monopolising the permit system (Elsom, 1992). Expert interventions by authorities, as well as guidance of the market, are necessary to safeguard the 'public good' nature of the resource.

2.2.3 Cost-Benefit Analysis.

Within the cost-benefit analysis (CBA) approach, a benefit is a gain in human well-being and a cost is a loss. They are measured using concepts of willingness-to-pay (WTP) to experience the benefit and willingness-to-accept (WTA) in compensation to forego the benefit (Pearce, 1998). CBA is primarily employed to determine the social worth of investment projects, programmes and policies and WTP/WTA are corresponding measures of human welfare. Scenario's where benefits are greater than costs warrant a worthwhile project or policy, however, the decision to proceed is based on budgetary, political and other constraints, remaining, essentially the decision-maker's choice (Pearce, 1998). Discounting, a controversial aspect of CBA, is an adjustment to values to account for human preference for present benefits as opposed to those experienced in the future (Pearce, 1998). A net present value is derived following the application of a selected discount rate.

A cost-benefit strategy attempts to quantify the damages incurred and the costs of control for pollutants and present the combination of damages and control that is optimum for society (de Nevers *et al.*, 1977; Elsom, 1992). As illustrated in Figure 2.3, curves plotted with costs of pollution control and costs of pollution damage, determined incrementally, identify the optimal combination of control and damage and the prevailing ambient pollutant concentration. Economic efficiency is achieved at the point where costs can be minimised, represented as the optimum level and, notably, this includes a degree of pollutant concentration, not a pristine state.

In application, the complexity of employing a CBA strategy is revealed through the assignment of values to all types of pollution damage and all options for pollution control (Elsom, 1992). The large-scale quantification results in CBA being viewed as an expensive strategy to implement. Benefits transfer, where similar studies are cross-referenced for pre-calculated benefit estimates, can be used to improve the cost-effectiveness of CBA, however, this approach requires more research and expertise to facilitate better decisions (Pearce, 1998). The implicit uncertainty and theoretical foundation of

CBA renders it unsuitable for policy decisions based solely on the estimates and outcomes of analysis (Pearce, 1998). The influence of CBA in decision-making is also limited by the inability to be multi-goal oriented and incorporate other objectives of policy makers. In addition, the nature of CBA outcomes reduces flexibility in policy as defined and uncompromising judgements are produced (Pearce, 1998). CBA has also been criticised for the lack of transparency in determining estimates, as well as in identifying the stakeholders affected, either positively or negatively. There are various ethical objections to the use of CBA in policy, including the monetisation of the environment (Pearce, 1998).

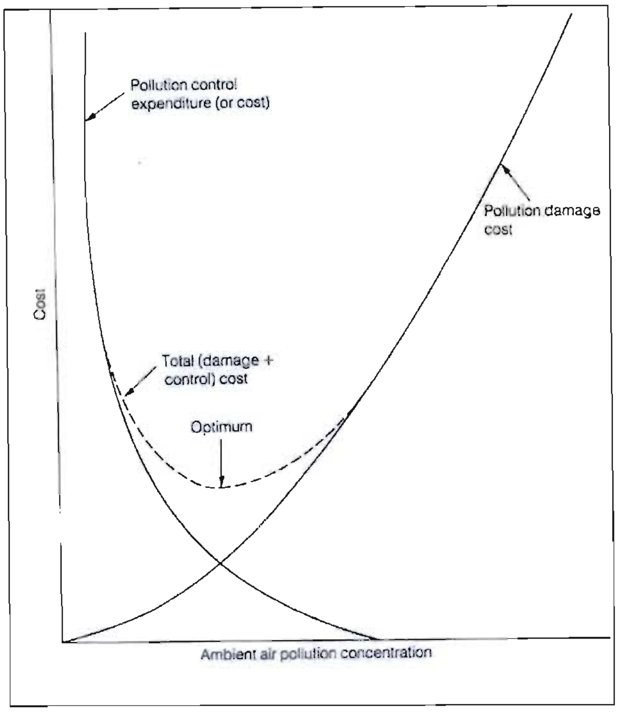

Figure 2.3. Graphic representation of control and damage costs, which are plotted against ambient pollution concentration (Source: Elsom, 1992)

CBA has entrenched its use within the environmental ministries of the USA and UK, nevertheless, a gap between CBA outcomes and political decision-making still exists (Pearce, 1998). CBA fulfils an advisory role as factors outside the scope of the analysis, such as political and societal interests, also exert an influence on decision-making. The criticisms of CBA as a decision-making tool for pollution control can be compared favourably with other strategies, although the consideration of economic efficiency, especially within the policy framework, favours the approach.

2.2.4 Non-degradation

The philosophical basis of the non-degradation strategy is a finite world with a limit for pollutant dispersion and cleansing, therefore clean air in remote areas is valuable and must be preserved (de Nevers *et al.*, 1977). Until the mid-1960's, the prevailing mindset in pollution control was that the atmosphere's cleansing ability was a resource of which maximum use should be made, with industries located in remote areas to affect the lowest population. Non-degradation emphasises control at source rather than relying on the absorptive capacity of the atmosphere for maintaining air quality. The USA has enacted the Prevention of Significant Deterioration policy to protect the air quality in pristine areas by categorising areas according to existing air quality and designating suitable levels of development (Jacobson, 2002). Uniform conditions of industrial control measures have been created for new sources to prevent inadequate control at rural locations, thus ensuring that air pollution is minimised, independent of location (de Nevers *et al.,* 1977; Jacobson, 2002). These elements of control policy moderate debate that the non-degradation rationale inhibits development, as areas for controlled growth are represented, albeit utilising permits and the best available control technology (Jacobson, 2002). Non-degradation is not considered a strategy to be applied in isolation but rather as a principle within an alternative strategy.

2.2.5 Emission Density

The premise of the strategy is controlling air pollution by implicitly understanding the density of emissions in an area (de Nevers *et al.*, 1977). It is used within urban and transportation planning, and generally requires pollution-emitting industries to be located away from residential and commercial centres. Emission density strategy has developed from the need to make explicit the assumptions regarding pollutant density, urban planning and human exposure. By incorporating legislative controls, consistent decision-making, as well as established acceptable levels of exposure, are fostered. The lack of further refinement in strategic approach renders the emission density strategy only useful for guidance within the context of an established strategy.

2.2.6 Critical Loads and Levels

The critical loads and levels, or collectively termed critical thresholds, approach to pollution control is a relatively recent addition, having its origins in negotiations between the USA and Canada regarding lake acidification and transboundary pollution in the late 1980's (Hornung *et al.*, 1997). The approach is effects-based, as opposed to source-based strategies, focusing on determining the effects of pollutants on receptors and regulating control accordingly (McCormick, 1997).

The general definition of a critical load is:

> "a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge" (Hornung *et al.*, 1997:120; McCormick, 1997: 53).

Critical levels are defined as:

"the concentrations of pollutants in the atmosphere above which direct adverse effects on receptors such as plants, ecosystems and materials may occur, according to present knowledge" (McCormick, 1997: 54).

Essentially, critical loads and levels are the values for which sensitivity to exposure is experienced, and correspond to the levels of wet/dry deposition of compounds or concentration of gaseous pollutants (Colls, 1997; McCormick, 1997). Fundamentally, these vary according to the environments studied. The definitions are based on a dose-response relationship between pollutant and receptor or indicator organism. Evidence of the link between deposition of atmospheric pollutants, mainly sulphur and nitrogen compounds, and acidification of soils and freshwaters and of forest damage has fuelled the development of this approach into a workable strategy for pollution control (Hornung *et al.*, 1997).

The critical thresholds approach is able to incorporate variations in spatial patterns of emissions and impacts, and allows targeting of emission reductions and protection. This flexibility has favoured the use of the strategy. Although the strategy was first applied at a transboundary scale, developments in the methodology have enabled the calculation of critical loads and levels for individual sources at a specific site (Hornung *et al.*, 1997). The approach is most widely applied to ecological receptors such as forests, soils, surface waters and natural vegetation communities (Hornung *et al.*, 1997).

The methodology for measuring critical loads and levels involves calculating and mapping the values. Critical loads can be measured using three different groupings of techniques; these are level 0 or empirical, level 1 or mass balance based and level 2 or dynamic modelling approaches (Hornung *et al.*, 1997). The choice of approach is dependent upon the availability of input data and the needs of the application. Calculating critical levels, which are gaseous interactions, is significantly empirical involving experimentation to derive receptor responses (Colls, 1997). Crops and trees are the focus of data collection, with natural vegetation having limited study. Exceedances of critical thresholds are commonly determined by overlaying a deposition map onto a map of calculated critical loads or levels and the examination at grid square resolution of areas where exceedances are recorded (Colls, 1997; Hornung *et al.*, 1997).

Methodologies are being continually refined, making use of research and trial applications, particularly with regard to the underlying assumptions and principles (Hornung *et al.*, 1997). Uncertainties exist in the approach, such as the relationship between emissions and thresholds, as some areas experience emission decreases with subsequent lags in predicted air quality improvements, and the ability of ecosystems to recover, which remains poorly documented (Weatherley and Timmis, 2001). Further uncertainty prohibiting greater regulatory use are data on the extent of damage to inform credible ecological standards for air quality and deposition (Weatherley and Timmis, 2001).

The critical thresholds approach has been refined and popularised by the United Nations Economic Commission for Europe (UN ECE) and is currently used to provide measurable targets within the framework of the Convention on Long Range Transboundary Air Pollution (CLRTAP) (Hornung *et al.*, 1997). The CLRTAP is seen as a landmark international agreement, and is responsible for co-ordinating research, monitoring, and the development of emission reduction strategies for air pollution and effects at the regional scale (ECE, 2004). The 1994 Protocol on Further Reduction of Sulphur Emissions, or the Second Sulphur Protocol, established critical thresholds as the main approach for controlling acidification (Hornung *et al.*, 1997; ECE, 2004). Currently, the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone comprehensively addresses all three inter-related effects on European ecosystems (ECE, 2004). Sulphur, oxides of nitrogen, Volatile Organic Compounds (VOCs) and ammonia are targeted using the innovative multi-pollutant multi-effect approach of the protocol (ECE, 2004).

The critical thresholds strategy has shaped policy development and setting of emissions targets, allowing tailoring of requirements to individual states' environmental status (Hornung *et al.*, 1997; McCormick, 1997). The methodology employed by the Protocols relies on data furnished by countries to inform critical threshold maps developed for the European continent (Hettelingh *et al.*, 1997a; Hettelingh *et al.*, 2005). The Centre for Co-ordination of Effects produces maps depicting areas of exceedances, critical thresholds at various significant levels for pollutant species and receptors of interest, acidification and eutrophication damage, and predicted recovery (Hettelingh *et al.*, 2005).

The critical thresholds strategy has been effective in initiating regulatory action, promoted by the innovative effects-based approach and tailoring of emissions reductions it facilitates. Increasing use of critical thresholds for pollution control is inferred; further indicated by the adoption of this approach by the World Health Organisation (WHO) and EU for updates to air quality and pollution control guidelines (Hettelingh *et al.*, 1997b). The definitions of critical loads and levels emphasise currently held scientific understanding, and coupled with a relatively recent introduction to pollution control, bodes well for the growth of the approach.

2.3 Air Quality Management

In the following sections, the philosophy of AQM and conditions entailing the implementation will be discussed, a major portion of which relates to the tools that are necessary for implementation. In conclusion, a summary of the strengths and shortcomings of the AQM strategy relative to the other control strategies is presented.

2.3.1 Philosophy and Approach

The philosophical basis of the AQM approach is determining acceptable levels of air quality and designating ambient air quality standards from these, following which pollutant emissions are controlled to comply with the standards (Elsom, 1992). AQM is defined as:

> "the regulation of the amount, location, and time of pollutant emissions to achieve some clearly defined set of ambient air quality standards or goals" (de Nevers *et al.,* 1977: 10).

The management of air quality involves, firstly, determining the most feasible scenario by examining all stationary and mobile sources under different conditions and, following that, developing control regulations to attain the desired state (de Nevers *et al.,* 1977). Control regulations are determined through a process of evaluating emission control schedules and the related air quality impacts, and are subject to outside constraints such as technological and financial limitations. The strategy is widely used, with the USA popularising, as well as revising and updating the approach (Elsom, 1992). AQM is referred to as air resource management in some literature, and authors agree that the strategies are aligned (de Nevers *et al.,* 1977; Elsom, 1992).

Following the interpretation of AQM, air quality management capability can be defined as:

> "the capacity to generate and utilize appropriate air quality information within a coherent administrative and legislative framework to enable the rational management of air quality" (UNEP/WHO, 1996).

The information needed refers particularly to data on pollutant types and concentrations, sources, effects and details of the exposed population; to enable decision-making, assessment of control measures, their effectiveness and costs are also needed. The definition emphasises the importance of obtaining relevant information, however, the presence of a framework of laws and administration within which to construct decision-making remains a necessary component of implementing AQM successfully. AQM capability raises the question of capacity of implementing agencies, as they bear the responsibility for the production and use of air quality information. Capacity has been identified as a critical factor, voiced in various texts, and possibly representing a stumbling block for effective implementation of an AQM strategy (Burger and Scorgie, 2005; Weale, 1992). Implementing an AQM strategy follows a general structure, where air quality data are collected to inform a situation analysis and measures for improvements are identified. At this point, cost-effectiveness can be included as a factor or a guide for the choice of measures, and mechanisms for integration and co-ordination of the strategy constructed (Kojima and Lovei, 2001).

The USA is taken as a primary example of implementation of the AQM strategy, introducing the approach nationally through legislation in 1970 (Committee on Air Quality Management in the United States, 2004). Air quality standards, termed National Ambient Air Quality Standards, are in place for criteria pollutants, and are supplemented by National Emission Standards for Hazardous Air Pollutants (Jacobson, 2002). At a federal level, the United States Environmental Protection Agency co-ordinates action at state and local level through the State Implementation Plan (SIP) process, which identifies activities leading to the attainment, maintenance and enforcement of air quality standards. Among other requirements, an attainment-demonstration SIP includes an emissions inventory, an analysis of implementation of various measures though air quality modelling and observations, and the emission control and enforcement measures needed to achieve the reductions (Committee on Air Quality Management in the United States, 2004). In addition, under the US AQM system, new sources are subject to strict emissions regulation, vehicle emission limits are enforced, and citizen action is encouraged to lobby for improved environmental quality (Elsom, 1992).

2.3.2 Management Tools

An AQM strategy combines tools with the policy to drive it and harmonises the objectives to achieve a shared vision of air quality improvements. Implementing AQM is complex, however, there are a number of tools available to air quality managers to achieve air quality goals. Five significant tools are necessary to carry out the strategy; these are ambient air quality standards, an inventory of source emissions, monitoring of air pollution concentrations, a predictive methodology such as a mathematical dispersion model, and emission control measures (de Nevers *et al.*, 1977; Elsom, 1992). They are commonly integrated into an AQM system (AQMS), as represented graphically in Figure 2.4.

Current needs require an AQMS to incorporate scientific analysis tools with policy-relevant components, as well as accommodating stakeholder information and public participation (Fedra, 2002). Therefore, air quality simulations through modelling are complemented by ambient monitoring, air quality standards and emission control measures, which are essential for environmental decision-making in management and policy spheres. In addition, an AQMS may employ a cost-benefit, or cost-effectiveness, analysis and an impact assessment for human health and the environment to determine the feasibility of control measures, according to economic and acceptable risk perspectives, and as guides for decision-making (Shah *et al.*, 1997). These analyses may be stated as an explicit requirement within the AQMS, accompanied by research, or included as value judgements by decision-makers. It is further advised that control measures be incorporated into an action plan, which represents the optimum control strategy prioritising necessary measures (Shah *et al.*, 1997). Implementation of measures is a significant element of an AQMS, with institutional, educational and investment conditions that also require action for attaining acceptable air quality. A component of an AQMS, that may be institutionalised or intuitive, is surveillance or monitoring of air quality, whereby a mechanism for feedback is included to allow controls to be influenced and adjusted by the air quality produced (Shah *et al.*, 1997).

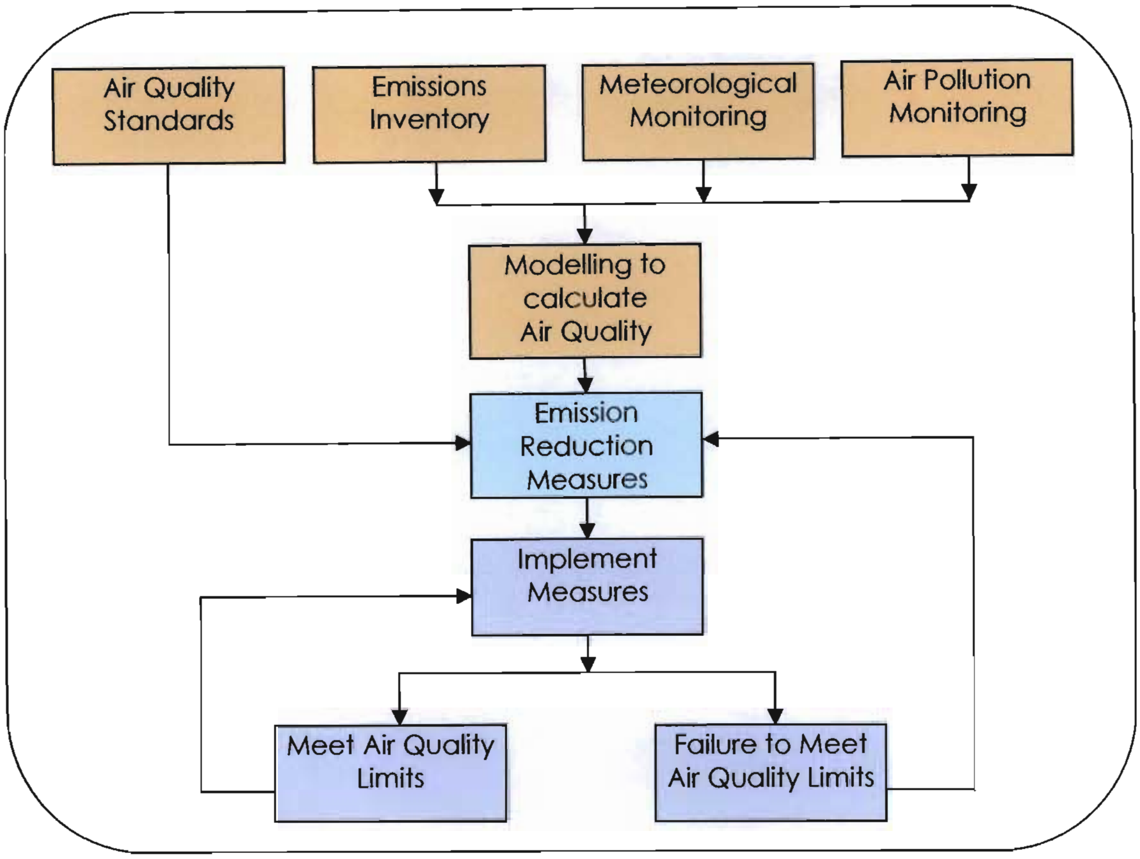

Figure 2.4. An Air Quality Management System, depicting assessment (orange), analysis (blue) and implementation (violet), or action, activities (after Scorgie, 2005)

A successful AQMS is based on sound science, as well as the correct use and interpretation of results and recommendations, with the most effective systems harmonising the different aspects of model capabilities, monitoring tools, and data handling and communication systems (Burger and Scorgie, 2005). There are numerous obstacles to successfully implementing an AQMS, including the scientific challenges and social setting of air quality problems. Aggregation is a necessary action within an AQMS as simplification of parameters allows the analysis of complex and inter-related real-world conditions. However, the loss of resolution by aggregating within and between the components limits the certainty and utility of the output data (Karatzas, 2002). Therefore, careful consideration of shortcomings and the quantification of inherent uncertainties are needed, especially for planning with longer timeframes. An AQMS is also required to make concession for the institutional and political climate of the selected area, aiding decision-making and empowering stakeholders, as well as incorporating all the elements of the system coherently and fairly (Fedra, 2002).

2.3.1.1 Ambient Air Quality Standards

Ambient air quality standards are prescribed pollutant levels, which are legally enforceable and cannot be exceeded within specified temporal and spatial boundaries (Stern *et al.*, 1973). Standards are developed from air quality criteria, which are scientifically sound statements regarding observed or inferred effects produced by degrees of exposure to specific, or a combination of, pollutants (Elsom, 1992; Stern *et al.*, 1973). Air quality criteria are determined by analysis and critical review of available information and are descriptive in nature. When determining criteria, caution must be taken to attribute effects accurately, implying apportioning only the effects that are the result of air pollution exposure and isolating these from other sources of effects (Stern *et al.*, 1973). Criteria help to inform the threshold values of safety that result in legislated standards. Air quality criteria determine, scientifically, the impacts of exposure, and standards form the regulatory outcomes that lead to control.

Air quality goals can be used in conjunction with standards to manage air quality and are set at lower pollutant concentrations than standards (Stern *et al.*, 1973). Air quality goals are levels of air quality or ambient pollutant concentrations that are aspired to in the future control scenario, and represent an overall optimum for the environment and humans. Some authorities use air quality guidelines as a non-legislative means to reach desired air quality. However, in the absence of the legal element of standards, there is little incentive on the part of emitters, in view of lower cost of production, or civil society, due to lack of redress for their concerns, to take up air quality issues. Implementing air quality guidelines are a step forward, for example, in countries in transition with strategies or enforcement approaches, but reap few tangible benefits for air quality.

A necessary feature of standards is that they are directly measurable, however, they are flexible with respect to level of application, being commonly set nationally but regional and local standards may be observed (de Nevers *et al.,* 1977; Elsom, 1992). The US state of California has set local standards, appointed at levels more stringent that federal standards. The flexibility is especially relevant to address localised conditions that may require greater or specialised intervention. Targeting problem areas or issues of air quality using standards allows resources to be maximised to achieve the greatest gain. To this end, an effects-based approach is becoming popular, where control action at the source is defined by the impacts experienced by human and environmental receptors (UNEP/WHO, 1996). This approach encourages innovation in control and the quantification of gains and benefits. Exceedances of standards can be used as indicative of the effectiveness of current approaches to AQM and changing air quality in an area (UNEP/WHO, 1996).

There are technical components of standards that are necessary to make meaningful outputs, such as averaging times and the equipment responsible for measurement. Averaging times are used to extract significant relationships from measured data for air pollution control; instantaneous measurements are not useful because they communicate the behaviour of the atmosphere and are not revealing regarding receptor impacts (Boubel *et al.*, 1994). Averaging times overcome the variability in concentrations experienced at the receptor that are the result of variations in transport and diffusion, source strength fluctuations, and scavenging and conversion mechanisms in the atmosphere (Boubel *et al.*, 1994). A range of averaging times is applied and is tailored to address the properties of each pollutant; means, maximums, and statistical indicators such as percentiles and trends are employed to derive the most significant results. However, it should be borne in mind that certain pollutants bear acute, toxic effects, and as such, instantaneous data is useful to derive meaningful exposure data in that regard. Alert thresholds can be accommodated within standards, representing ambient concentrations that necessitate warning the public in order for precautionary measures to be taken (UNEP/WHO, 1996).

Different types of pollutants are regulated by variations in standards to attenuate the risk they present. Carcinogens, like benzene, are tolerated in very low levels, along with the heavy metals, such as mercury and lead, which accumulate in soft tissue and concentrate up the food chain (Jacobson, 2002; Petrucci and Harwood, 1997). Carcinogenic compounds have no safe level and are assessed in terms of the lifetime risk of cancer they present (Colls, 1997). The commonly controlled pollutants, for example CO and SO_2, are not subject to particularly stringent norms for standards, however, secondary pollutants such as ozone (O_3), which are formed in the atmosphere, require additional constraints. The WHO have developed air quality guidelines for use in Europe that have been adopted as health-based reference points by numerous countries globally, and are given in Table 2.2. The guidelines are strongly focused on health effects of pollutants, and make use of epidemiological research and risk factors to determine safe levels for populations (Shah *et al.*, 1997).

The standard level is influenced by considerations of economic, social, technical and political principles, making standard-setting a political, as well as technical, process (Elsom, 1992). Variation of standards amongst countries is the result of these considerations, however, internationally recognised acceptable limits guidelines are in place, such as those set by WHO. Competing considerations and the availability of new research also lead to the amendment of standards by regulatory authorities. The conversion of air quality criteria to standards raises the questions of acceptability and perceptions of costs and adverse effects (Stern *et al.*, 1973). When determining standards, uniformity across a jurisdiction, and even at national level, affects the quality of air provided, particularly to discourage 'dirty industries' from re-locating to areas with weaker standards.

Other factors for consideration include the enforcement of the standard, technical specifications for measurement, and the quality of air across the area of authority, including pristine areas (Campbell and Heath, 1977). Standard levels are influenced by the presence of vulnerable groups in the population, health impact data on nature, severity and frequency, the characteristics of the population at large, and the status of air quality together with background pollutant concentrations (UNEP/WHO, 1996). Additional environmental concerns are raised by the persistence of the pollutant, the hazards posed by its degradation in the environment, and the effects of environmental conditions such as temperature and altitude (UNEP/WHO, 1996). Evidently, the significant discussion regarding ambient air quality standards centres on their development and application.

Table 2.2. Air Quality Guidelines for Europe developed by the WHO (Source: Shah *et al.*, 1997)

Substance	Air Quality Guideline	Averaging Time	Components
Organic			
Acrylonitrile	-		Carcinogen (1 μg/m^3 presents a 2x10^{-5} lifetime risk)
Benzene	-		Carcinogen (1 μg/m^3 presents a 4x10^{-6} lifetime risk)
Carbon Disulfide	100 μg/m^3	24 hours	
1,2-dichloroethane	0.7 mg/m^3	24 hours	
Dichloromethane	3 ng/m^3	24 hours	
Formaldehyde	100 μg/m^3	30 minutes	
PAH	-		Carcinogen (1 μg/m^3 presents a 1x10^{-6} lifetime risk)
Inorganic			
Arsenic	-		Carcinogen (1 μg/m^3 presents a 3x10^{-3} lifetime risk)
Asbestos	-		Carcinogen (1 fiber/m^3 presents a 10^{-6}-10^{-5} lifetime risk of developing lung cancer, and a 10^{-5}-10^{-4} lifetime risk of developing mesothelioma)
Cadmium	1 – 5 ng/m^3 10 – 20 ng/m^3	1 year (rural) 1 year (urban)	
Carbon Monoxide	100 mg/m^3 60 mg/m^3 30 mg/m^3 10 mg/m^3	15 minutes 30 minutes 1 hour 8 hours	
Chromium	-		Carcinogen (1 μg/m^3 presents a 4x10^{-2} lifetime risk)
Hydrogen Sulfide	150 μg/m^3	24 hours	
Lead	0.5 μg/m^3	1 year	
Manganese	1 μg/m^3	1 year	
Mercury	1 μg/m^3	1 year	
Nickel	-		Carcinogen (1 μg/m^3 presents a 4x10^{-4} lifetime risk)
Nitrogen Dioxide	400 μg/m^3 150 μg/m^3	1 hour 24 hours	
Ozone and other Photochemical Oxidants	150 – 200 μg/m^3 100 – 120 μg/m^3	1 hour 8 hours	
Radon	- [≥100 Bq/m^3]	 [1 year]	Carcinogen (1 Bq/m^3 presents a 0.7-2.1x10^{-4} lifetime risk) [recommended level for remedial action in buildings]
Sulfur Dioxide	500 μg/m^3 350 μg/m^3 125 μg/m^3 50 μg/m^3	10 minutes 1 hour 24 hours 1 year	
Particulate Matter	150 – 230 μg/m^3 60 – 90 μg/m^3	24 hours 1 year	NB. No safe level established; an effect-response guideline is advised
Vanadium	1 μg/m^3	24 hours	
Risk level for carcinogenic compounds calculated using a linear one-hit extrapolation model			

An additional concern that straddles standard-setting and implementation processes is the progressive realisation of air quality improvements, which is strongly related to the questions of institutional context raised. The approach is illustratively explained in Figure 2.5. The margin of tolerance refers to the level of impacts beyond which unacceptable costs are borne by receptors, in addition to other factors such as economic and political data. The margin frames the actualisation of the standard, termed 'limit value', as progressively stricter measures are taken to reduce ambient concentrations (red arrows). This can be achieved through numerous mechanisms, such as reducing the permitted number of exceedances and staggering compliance dates, and importantly, allows for desired air quality to be legislated without expecting immediate attainment, as well as the future improvement of air quality to levels that are ideal or comparative with stated air quality goals, termed 'target values' (Scorgie, 2005). Cognisance is also taken of the status quo in the regulatory regime by accommodating the current level of air pollution in predicting the attainment schedule, and preventing the deterioration of air quality beyond current limits (Scorgie, 2005). Alert thresholds are included for public safety and to allay fears that air quality that may be harmful will be experienced in the interim. By using the progressive attainment approach, where continual improvements are desirable, the principle of sustainable development and forming a pathway to the coveted environmental end-state are supported (Scorgie, 2005).

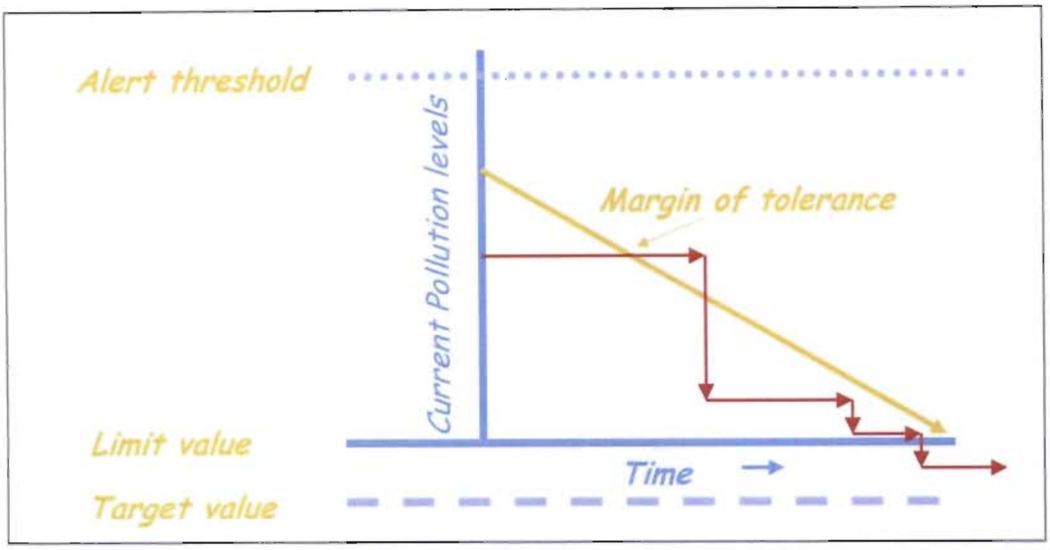

Figure 2.5. An illustrative example of desired air quality levels that are reached progressively (Source: Scorgie, 2005)

Implementing air quality standards requires consideration of the factors that have shaped their development, and additional understanding of the real-world context in which they will be placed. Whilst other management tools, such as monitoring ambient air and emissions compliance, begin to play a larger role in the application of standards there are elements that fall within the realm of standards, such as revision of acceptable limits and technical details of averaging times and equipment specifications. Enforcement, skills capacity, and the resources to acquire these attributes are concerns, as well as the relevance of specified concentration limits to the varied, and often problematic, practical situations. The greatest debate surrounds the legislated limits, where motivations from areas outside the safe levels advocated by science may draw away from primary goals of protecting human health and environmental quality. Economic and political agendas influence the process, however, there are internationally recognised standards that provide guidance and research has developed numerous ways to design strategies to overcome practical constraints. As a final assertion, standards must be accompanied by action to limit emissions where needed, as part of a strategic programme, or lose their effectiveness.

2.3.2.2 Emissions Inventory

An emissions inventory can be described as a listing or register of the amount of pollution entering the atmosphere from all sources within given time and geographical boundaries (Boubel *et al.*, 1994; Hutchinson, 1997). The inventory includes both natural and anthropogenic sources; and provides the basic information on emission quantities and contributing sources, along with details on activity and emission estimates (de Nevers *et al.*, 1977; UNEP/WHO, 1996). It is used within an AQM strategy to develop controls that are equitable, across emitters and exposed groups, and cost-effective, with regard to control technology cost and expected air quality gains (UNEP/WHO, 1996). In addition to informing the choice of control measures, an inventory can assist in the design of monitoring networks, by identifying the significant emitters and pollutants in the area and leading to appropriate location choices (Hutchinson, 1997). Inventories can lead to the production of emission maps, with geographically referenced concentrations, which can inform land-use planning by identifying possible areas of high exposure and source locations relative to sensitive areas.

Used in conjunction with an atmospheric dispersion model, an inventory may be able to predict short-term ground-level pollutant concentrations, especially during periods of forecast poor weather (Hutchinson, 1997). The predicted levels can be used to alert authorities of air pollution episodes and aid in strategy development to minimise impacts. The system of the inventory together with the dispersion model can also assess air quality trends by altering input figures to reflect expected future changes in conditions, as well as highlighting and quantifying the effect of past controls (Hutchinson, 1997; UNEP/WHO, 1996). Emission inventories also help to identify large sources, where targeted control action can lead to significant percentage reductions in emissions; and can be used for publicity and political purposes, by stressing areas of concern and presenting future scenarios (Stern *et al.*, 1973). Inventories play an important role in assessing compliance of, especially, large emitters, where quantities of pollutant submitted for compilation must coincide with permitted emissions (UNEP/WHO, 1996).

Compiling an inventory requires data on source types, nature of pollutant emitted, emission factors and activity statistics (Boubel *et al.*, 1994; UNEP/WHO, 1996). The nature of the source must be identified, such as the industrial process or fuel used, as well as its classification as a mobile or stationary and point, line or area source. Point sources refer to large, stationary sources, such as a power plant, line sources are linear in nature and commonly relate to high-traffic roads such as highways and arterial roads, and area sources are, generally, sources that are insignificant individually but relevant grouped or require large resources to address individually (Hutchinson, 1997). Volume sources, which have large vertical and horizontal dimensions, such as mine dumps, and fugitive sources, which are difficult to identify and quantify, such as leaking valves, should also be taken into consideration in compiling the inventory (Zunckel *et al.*, 2006). Outside of large industrial plants that have emissions monitoring equipment installed, accurate emissions data are generally not available and other means of eliciting emissions data are needed. Emission factors provide an observed value for emissions and relate the source type and pollutant to an actual emission estimate. A number of literature sources can provide these factors, including government publications, research papers, and handbooks; however, care must be exercised to obtain relevant and accurate data that correlate well with the conditions being studied (Boubel *et al.*, 1994; Shah *et al.*, 1997). Verification of the source, plausibility of the emission factor, and a critical analysis of research conditions that led to emission factor development are necessary to attain a reasonable degree of accuracy ($\pm$10%) (Boubel *et al.*, 1994; Stern *et al.*, 1973).

Source activity statistics are data on the activity producing the emission, and relate to details such as quantities of fuel used and period of use (UNEP/WHO, 1996). The emission factor and activity statistics allow the estimate of emission to be formed by relating the observed, literature-based emission relationship (emission factor) to quantities provided by the source being studied (activity statistic). Where abatement technology is used, emission estimates can be calculated by including an abatement factor to account for reductions in expected emission factors (UNEP/WHO, 1996).

Validity of an emissions inventory is the most important characteristic, and challenge, in its development. To this end, techniques to lessen the degree of inaccuracy, or assumptions, are available. Monitoring is well established as verifying measurements of ambient concentrations, as well as being complemented by a well-constructed inventory that aids in the interpretation of air quality measurements (Hutchinson, 1997). Consideration of uncertainties is needed, especially with respect to emission factors, due to the limited applicability and availability of suitable factors, and activity statistics, where discrepancies between consumption and delivery of fuel stocks can introduce significant inaccuracy (Hutchinson, 1997). Completeness and consistency of data is an important verification, and checks on the definitions applied to sources and pollutants, data completeness within sectors and activities, correlation of emission factors with those applied in other countries, especially at similar levels of development, and transparency relating inputs to their references are necessary (UNEP/WHO, 1996). Consistency of the inventory at differing levels of spatial disaggregation is needed, and, if limited, the most relevant and accurate, scales of the inventory should be clearly stated.

Although data may present the greatest inaccuracies, there are many sources from which to procure the necessary information, and as such, a strong correlation between values can be obtained to ensure robustness of the inventory. Governmental planning and development agencies, chambers of commerce, census bureaus, national and local associations, individual fuel dealers and distributors, utility companies, local fire and building departments, air pollution data collected by local departments, traffic surveys and models, and insurance information are examples of data that can be consulted when developing the inventory (Boubel *et al.*, 1994). Confidentiality may be cited as an issue, most notably with emissions data from large strategic or globally competitive industries, and the use of confidential information should be minimised. Advanced countries or agencies may make use of dispersion modelling as a means of verifying the inventory, provided that the model used is, itself, validated and established (UNEP/WHO, 1996). International agreements are a factor in the development of inventories, with requirements for reporting on specific pollutants included as obligations, and as such, guideline documents are prepared to assist signatories and ensure a designated level of accuracy and consistency (Hutchinson, 1997).

A current inventory is equally important as a valid inventory and updating is needed, generally from year to year, to maintain the effectiveness of control measures (Stern *et al.*, 1973). Revision of figures can also be achieved by conducting a major inventory update at specified intervals and applying a scientifically factored increase, or decrease, for intermediate years. This approach enables better resource distribution, however, major changes, such as a major electrification drive in fuelwood-consuming areas or the construction of several large industries, may necessitate a complete revision. In addition, areas where control measures are being introduced on an on-going basis, driven by shifts in strategy or vigorous attainment of standards, may not benefit from infrequent revisions due to the dynamic nature of air quality. An inventory should be flexible to allow for quick updates upon the introduction of a new source, or modifications as the result of an introduced control measure (UNEP/WHO, 1996).

Skilful presentation of the inventory facilitates understanding of the data collected and subsequent analysis, as well as the implications of the emissions data. A useful technique may be to present the inventory in a series of small, related tables representing individual pollutants in sufficient detail (Stern *et al.*, 1973). Changes in the emissions profile, the impact of controls, and agency-relevant information can be easily abstracted and public information enhanced. Presentation further highlights the issue of transparency, and the implications for confidentiality, however, the communication of emissions data to the public and other interested parties is needed to ensure that air quality is able to capture public interest.

Emission inventories enable policy development by informing baseline conditions, implementation through compliance verification and emissions data, and adaptation by developing scenario's of future conditions. Despite an emissions inventory's critical function, it is the management tool with the most limited capability on a world-scale (UNEP/WHO, 1996). Data represents a significant constraint, however, knowledgeable compilers can overcome limitations through consistent verification and validation techniques. The resolution and accuracy of the inventory is dependant upon policy objectives, which influence the level of available resources and information. While monitoring aids in identifying the extent of pollution, an inventory identifies sources and helps to develop abatement strategies. Understanding the emissions profile of an area helps in turn to inform standards as major emission source types can be correlated to pollutant levels; for example, the relationship between zinc processing and cadmium emissions, SO_2 emissions and industrial combustion and energy production, and nitrogen dioxide emissions from road traffic. The profile, together with an understanding of local conditions, can ensure the targeting of relevant pollutant species by standards and develop the most appropriate controls for the area. An emissions inventory is an element of AQM that cannot be omitted and requires effort directed at obtaining the most reliable and accurate data within resource and information constraints.

2.3.2.3 Monitoring

Monitoring provides measurements of the concentration of pollutants in the surrounding air. It is an essential tool for identifying and addressing air quality problems within an integrated AQM framework, and is used in combination with an emissions inventory and predictive modelling (Bower, 1997). As such, the primary purpose is information provision to ensure decision-makers, scientists and planners can make effective choices on environmental protection and management. Monitoring objectives are responsible for shaping a programme of response, and the resultant monitoring network. Key monitoring objectives include identifying threats to ecosystem or human health, determining compliance with standards, and providing inputs to AQM and traffic and land-use planning (Bower, 1997). Further monitoring objectives include assessing the impacts of point and area sources, qualification of trends, both future and historical, policy development and management prioritisation, validation and development of management tools, and public information and awareness (Bower, 1997). Monitoring pollutant concentrations can provide information on background levels, highest concentration levels, representative levels in high-density areas, and the impact of urban, rural, natural and anthropogenic sources (Boubel *et al.*, 1994).

The operational components of the network, such as the siting criteria and equipment choice, are based upon the identified monitoring objectives (UNEP/WHO, 1996). Assessing resource availability is a necessary step before proceeding to identify network design, and determines the sustainability of the activity (Bower, 1997). Financial resources are critical, however, factors such as personnel, skills training, and time also influence the success of implemented monitoring. Following the assessment, consideration of costs, number of sites and site location, and several micro-scale factors is needed. The initial set-up costs for a network involve purchasing equipment and infrastructure and employing or training personnel, and the continuous costs of quality assurance and control, equipment maintenance, and running costs (Bower, 1997). Siting criteria include objectives related to data use and the spatial distribution of pollutants in the area. For example, determining source impacts focuses on proximity to significant sources, whereas background concentrations will be measured in areas of near-pristine air quality. Determining representative concentrations also requires an understanding of meteorological and topographical influences, target receptors, and various population-focused data (Bower, 1997).

With regard to micro-scale factors, an assessment of the level of security, such as a minimal threat of vandalism or theft, and access to infrastructure to operate and facilitate maintenance, such as access roads and electricity supply, must be accounted for (Bower, 1997). Other concerns include the effects of localised pollution sources and aerodynamic clearance or sheltering on measured concentrations, as well as planning permission, if necessary, and measures to ensure public safety in the operation of the station. In addition, the concept of sustainable development can be incorporated into the planning of a monitoring network by balancing environmental, social and economic objectives (Chen *et al.*, 2006). While economic, environmental and social pressures often conflict, authorities that aim to address these competing objectives will derive outcomes that provide the greatest utility.

A sampling strategy, with elements such as frequency of sampling, ensures that data addresses temporal resolution, coverage and representativeness requirements (Bower, 1997). A management and training system is also needed to incorporate inputs from various stations across the network and develop an organisational structure that aids the production of quality information. Equipment choice can have a significant effect on the outcomes of monitoring, and as such, the decision should be motivated not only by financial resources, but make provision for achieving monitoring objectives and valuable data production. Four types of monitoring methodologies are available, and widely accepted; these are passive and active sampling, automatic analysers, and remote sensors (Bower, 1997; UNEP/WHO, 1996). Each method has advantages and disadvantages, with associated cost and maintenance implications, as well as data quality and complexity issues.

Quality assurance and quality control (QA/QC) procedures are needed to produce data that are sound for decision-makers and other users. Poor quality data constitutes a waste of resources, therefore QA/QC activities aim to identify constraints and derive a level of confidence in the data produced. Pre-measurement related activities, such as determining objectives, system design, site selection, equipment evaluation and operator training, are regarded as quality assurance (Bower, 1997). System operation, calibration and maintenance, field audits and training and other measurement-related activities are addressed as quality control (Bower, 1997). A QA/QC programme will address all aspects of measurement quality, including accuracy and precision, reproducibility, consistency over time, and a high level of data capture (Bower, 1997; UNEP/WHO, 1996). System review and management allows changes that occur in the emissions or management conditions to be reflected in the network set-up and QA/QC procedures, and is necessary periodically.

Data analysis and interpretation processes raw data from a monitoring network into a format that is readily understandable and relevant to the decision-making objectives. Data sets can be analysed for compliance with regulation. Monitoring datasets can be incorporated into modelling as meteorological inputs and for comparison against model outputs (Fedra, 2002). They can be assimilated across a network to allow for real-time forecasting. Methods of analysis include determining statistics of arithmetic mean and peak values, percentiles and frequency distribution plots, graphical representations, indicators and indices (UNEP/WHO, 1996). These can be communicated using paper, computer or electronic media, of which the latter is increasing in use as up-to-the-minute information can be provided (Bower, 1997).

Monitoring, as a component of an AQMS, is seen as an invaluable tool for information provision. It provides data on baseline scenarios, compliance assessment, as well as a scientific basis on which to develop policies and strategies to improve air quality. QA/QC procedures are the most important factor for monitoring success, and must be well-addressed to ensure decision-making that is relevant and able to ameliorate effectively practical experiences of air quality. Failure to implement adequate QA/QC will effectively nullify the main thrust of monitoring, i.e. to provide air quality data. This is due to the lack of explicit measures for addressing monitoring objectives and stating the limitations of data. The definition of monitoring can be expanded to include modelling and emissions inventories as 'indirect monitoring' tools, where cost-effectiveness and suitability criteria can be broadened (Burger, 2005). Monitoring and modelling are viewed as complementary activities, where monitoring provides real-world validations for modelled concentrations and modelling allows monitored data to be expanded beyond spatial and temporal constraints (Bower, 1997).

2.3.2.4 Modelling

The use of models in AQM allows the calculation and prediction of air quality levels to be carried out and effectively links monitoring data with the inventories of emissions in an area (Elsom, 1992; Middleton, 1997). Modelling techniques can be used to evaluate the suitability of emission reduction measures prior to implementation, using criteria such as reductions in ambient concentrations and deposition level and cost-effectiveness, and to demonstrate compliance with ambient air quality standards, where dispersion modelling augments the single-point concentrations of monitored data (Fedra, 2002; Scorgie and Malan, 2002). Modelling establishes individual source contributions to ambient pollutant levels at specified receptor points, which facilitates the ranking of sources and identification of reduction opportunities, and aids the investigation of complaints by determining the responsible source or identifying the non-liability of a particular source for the impact (Scorgie and Malan, 2002).

Three significant model classes are distinguishable: empirical or statistical based models, deterministic models using mathematical equations, and a hybrid of the two approaches (Committee on Air Quality Management in the United States, 2004). Empirical or statistical based models use observable relationships between pollutant concentrations and emission rates and do not account for physical and chemical transformations in the atmosphere. Deterministic models describe the physics and chemistry of atmospheric processes influencing pollutant emissions, formation, transport and removal. Hybrid models, therefore, use empirical or statistical relationships as a foundation combined with physically and chemically based algorithms (Committee on Air Quality Management in the United States, 2004).

Some commonly used models include the empirical rollback model, receptor-based model, and emissions-based model (Committee on Air Quality Management in the United States, 2004). The empirical rollback model is the simplest AQM model, allowing pollutant concentration and emission rates to be linearly related. The proportional relationship implies that emission controls that decrease emissions by a given percentage will see a requisite, and proportional, reduction in concentrations. Limitations include applicability to primary pollutants or secondary pollutants with simple transformation mechanisms, and pollutants that mix uniformly in an airshed as spatial and temporal variations are not accounted for (Committee on Air Quality Management in the United States, 2004). Receptor models use more sophisticated statistical techniques, exclude chemical and physical processes, and are seen as providing a more accurate representation of pollutant concentrations than rollback models. They are commonly used to estimate the relative contributions of various emission sources to measured ambient concentrations of particulate matter composition at monitoring sites (Committee on Air Quality Management in the United States, 2004). Successful use is noted for primary particulate matter, with a combination of receptor models providing effective strategies, but limited in application to secondary particulate matter.

Emissions-based models solve equations related to a mathematical representation of relevant physical and chemical processes, in time and space to determine the relationship between pollutant emissions and concentrations (Committee on Air Quality Management in the United States, 2004). Emissions-based models vary in complexity, from simple box models, simulating the evolution of concentrations in an idealised air parcel that is well mixed, to dispersion models, where each individual plume parcel of air is simulated as it advects and mixes with ambient air. Examples of the latter are the United States Environmental Protection Agency's Industrial Source Complex 3 and CalPUFF. State-of-the-science three-dimensional chemical transport models, recreate distributions of gases and particles, winds and turbulence, and chemical reactions, with exhaustive requirements in terms of inputs, requiring additional programs to collect and resolve data, time and resources (Committee on Air Quality Management in the United States, 2004). The predictive ability of emissions-based models is a strong advantage as various changes in emissions can be used to examine the air quality responses in pollutant concentrations.

Each model that is available has inherent strengths and weaknesses, and varies in complexity and applicability; therefore, for valuable inputs for AQM, they should be understood and quantified. Technical, as well as interpretative, experience is necessary to acknowledge the outcomes of the modelling exercise and the extent of its utility (Burger and Scorgie, 2005). Figure 2.6 further illustrates that while technical experience increases linearly for the use of increasingly complex models, even simple models require a high level of interpretation to understand the limitations of estimates provided.

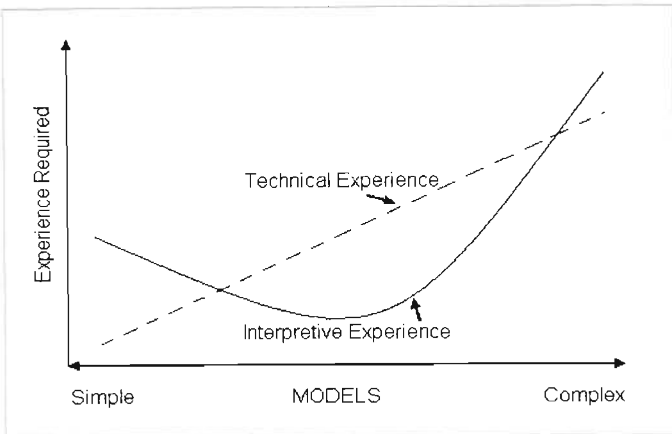

Figure 2.6. The relationship of modelling experience against modelling complexity (Source: Burger and Scorgie, 2005)

This concept can be extended to address all AQMS tools, as the fundamentals of technical, or scientific, expertise address the selection of appropriate tools, the skills to utilise tools represented as specialised training, and the cross application of results across tools (Burger and Scorgie, 2005). Interpretative, or management, experience requires an understanding of the reasons and significance of parameters and information needed for various tools, comprehension of produced results, ratings of significance, and the clear communication of information (Burger and Scorgie, 2005). The selection of an appropriate model is dependent on the characteristics of the terrain and the pollutants to be modelled, the availability of human resources and meteorological data, as well as the objectives of the exercise (Scorgie and Malan, 2002).

Modelling as an analysis tool, must be included in an operational framework and cannot be used in isolation of the regulatory and management setting, as model choice and use is influenced by these factors (Fedra, 2002). Examples include the regulatory standards that determine the level of compliance used, and the use of air quality forecasts to support public information. The prohibitive cost of initiating modelling can be offset by the subsidisation by national and provincial government for training, as well as the provision of nationally relevant models. Screening models can also be useful in mediating the costs of embarking on expensive, complex monitoring and modelling, in the event of low-level pollution (Burger and Scorgie, 2005). Additionally, models provide estimates of concentrations and include a degree of uncertainty and inaccuracy, which must be acknowledged, and are liable to over- or under-predict by a value of two (Elsom, 1992). Modelling estimates that will be incorporated into policy require careful consideration of outputs to mitigate against model limitations being carried over into legislation (Cocks *et al.*, 1998). Uncertainty analysis and peer review are mechanisms by which to quantify and reduce error, as well as the use of more than one model and inter-comparison of results to ensure optimum policy outputs.

Simulation modelling is seen as key to future AQM as a result of the tool's prediction and forecasting capabilities (Longhurst *et al.*, 1996). Use of modelling is increasing, as models are developed to be more user-friendly and accessible to a variety of stakeholders, in addition to the benefits of employing simulation modelling becoming evident. Multi-pollutant AQM, where strategies have evolved to be able to mitigate pollutants in combination, is now a possibility as models that are able to process multiple pollutants have been developed, such as the OMEGA-2 (Optimisation Model for Environmental Integrated Assessment) model (Committee on Air Quality Management in the United States, 2004; Reis *et al.*, 2005).

2.3.2.5 Emission Control Measures

The emission control measures discussed are an example of employing the emissions standards strategy as a component of a significant strategy; this section focuses on the actual control measures implemented rather than the strategic components. The AQM management tools discussed previously represent the situational assessment of air quality, evaluation and goals to work toward; emission control measures allow for changes to the emissions profile of an area to be made. The control measures can be directed at stationary or mobile sources, old or new installations, and can be technological changes or social and behavioural changes (Committee on Air Quality Management in the United States, 2004; Schueneman, 1977; Shah *et al.*, 1997). The pollutant to be controlled, the costs and benefits arising from the control action, and the effectiveness and viability of the measure also influence the choice of measure (Shah *et al.*, 1997). The choice of control measures is strongly motivated by the local conditions experienced, such that areas with extremely poor air quality and large exceedances of standards should be more willing and enjoy more public and political support for the implementation of control measures than areas where air quality is not highly valued and relatively moderate air pollution experienced.

Consideration should be taken of the enforcement of the control measures selected, specifically the availability of the skills and financial resources within the enforcement agency to ensure compliance. Technical knowledge is necessary to implement and enforce a large percentage of control measures, and as such, regulation can make use of general policy statements indicating desired emissions without explicitly stating technologies to be used for their achievement (Schueneman, 1977). This condition places the onus on the emitter, rather than the regulator, and can be further emphasised by requesting emitters to conduct compliance monitoring with independent verification, or carried out by independent bodies. A mechanism for the evaluation of a control measure is needed to ascertain progress and attribute changes in air quality to actions taken, and this is especially relevant for communities affected by emissions, and should influence the selection of measures (Schueneman, 1977). Controls to be prescribed include limitations on the amount or nature of stack emissions, equipment specifications or requirements, prohibitions on equipment use or practices, limitations on fuel or raw material composition, location restrictions for certain sources, and the requirement for adoption of additional controls during poor dispersion episodes (Schueneman, 1977).

Emission standards are a popular and well-documented form of control measure in AQM, with the earliest forms of air pollution control making use of visible emission standards. The latter example refers to a subjective standard, where visual appearance or odour is used, and a common form is the regulation of the opacity of a stack plume using a Ringelmann chart for comparison (Boubel *et al.*, 1994). Objective standards use physical or chemical measurement, and are further divided to apply to a pollutant uniformly over conditions or to apply to pollutant emissions from specific equipment or processes. The 'best practicable means' are often used as the emission standard based on demonstrated performance for emitter categories; the 'best available control technology' (BACT) is a variant excluding the consideration of economic constraints on control technology. 'Lowest achievable emission rate' is more stringent than BACT and states that the lowest emission rate demonstrated in any circumstance must be implemented, and is individually applied to emitters, generally in areas exceeding the ambient standards (Boubel *et al.*, 1994). Implementing the 'best available technology not entailing excessive cost' (BATNEEC), takes into consideration economic constraints facing emitters.

Fugitive and secondary sources may present difficulties in attaining emission standards and are challenging to regulate effectively; fugitive emissions are non-point sources such as dust from outdoor storage piles and unpaved roads, and secondary sources are different in character from major sources and necessary for the operation of the activity (Boubel *et al.*, 1994). Indirect sources require consideration as well, for determining emission standards and planning compliance, and are represented by areas such as parking lots at shopping centres and sport stadia, and the intersection of major highways and interchanges. Emissions trading and applying the principle of rollback, using linear relationships between emissions and ambient concentrations, are means of achieving standards.

New source controls are a distinct category of control measures, as they are specifically developed for sources of which the design and construction, and operation, can be influenced (Boubel *et al.*, 1994; Schueneman, 1977). In addition, new sources enter a setting where regulations are in place and a number of emitters are functioning. Demonstration of compliance with standards, without prior datasets, presents a challenge, as well as, effectively, having to attain stricter degrees of control to 'compensate' for older sources. The principle underlying implementing stricter new source controls is that older, 'dirtier' sources will leave the market as they deteriorate, leaving cleaner, efficient industries and improved air quality. Two methods can be used, firstly to develop prototypes of desired source design and operation and legislate these as required, or to allow operators to develop a unique programme of control and assume responsibility for alterations or re-design if compliance is not achieved. The latter means encourages innovation and introduces new technology into the market; an example is promulgation of stringent standards for transport-related pollutants by the USA in 1970 resulting in the development of the catalytic converter and three-way catalyst (Gerard and Lave, 2005).

2.3.2.6 Air Quality Management Plan

An air quality management plan (AQMP) is a means by which to co-ordinate all activities for AQM and develop a coherent program for the achievement of standards. An AQMP provides a basis for liaison between different actors and agencies influencing air quality, and needs to incorporate flexibility to include advances in knowledge (Longhurst *et al.*, 1996). The AQMP should facilitate the inclusion of different tiers of government, and decision-making that addresses local circumstances in control measures. Ideally, an AQMP should be located within the framework of a national implementation plan, and complement national actions and initiatives, while remaining relevant to the local context of AQM (Beattie *et al.*, 2002; Longhurst *et al.*, 1996). AQM is viewed as inter-disciplinary and as such, the AQMP should reflect these qualities through broad consultation amongst stakeholders and collaborative working with departments that impact on AQM processes. A number of professions, agencies and organisations will influence the range of measures to be included in the AQMP, as well as the input of the larger public (Beattie *et al.*, 2002). The general elements comprising an AQMP are monitoring, modelling and emission estimates, air pollution reduction strategy, public information and education, policy integration mechanisms, episode control, opportunities for local air quality standards, capacity building, and research initiatives (Longhurst *et al.*, 1996; Scorgie *et al.*, 2003). Mutually agreed upon goals and a shared vision are important aspects of a successful AQMP.

The development of an AQMP can be divided into a series of logical steps; however, feedback is an important component to attain continual improvements in air quality and revisiting assessments and strategies create a robust and relevant plan. Clear policy goals and objectives with consensus from role-players are needed before embarking on plan development (Longhurst *et al.*, 1996). These are influenced largely by the national strategy for AQM, and through consultation, conflicts in policy are avoided. A baseline assessment, or understanding of the impact scenario, is needed to create a platform of currently experienced air quality (Shah *et al.*, 1997).

An inventory of sources and emissions is the foremost requirement and should review current and future data, including sources entering a sector. Pollutants of significance may include SO_2, NO_2, suspended particulate matter, VOC's and heavy metals. Mobile sources such as vehicles, stationary combustion sources, including domestic activities, and stationary process sources should be taken into consideration as possible significant sources (Shah *et al.*, 1997). Emission estimates may also be required, if measured data are unavailable, and activity statistics and emission factors can provide relevant surrogate data. An assessment of data on ambient concentrations and meteorological conditions for the identified pollutants and sources is undertaken (Shah *et al.*, 1997). The assessment informs the characteristics of the management area's pollution problem including trends, and the location of serious pollution incidences within the area. The data aids verification of inventory data and dispersion modelling outputs, and modelling can be used for spatial interpolation producing pollution isopleth maps. Monitoring data are also a valuable tool for assessing the impacts of policy implementation and checking compliance, and the AQMP objectives should include technical specifications for carrying out monitoring (Longhurst *et al.*, 1996).

A review of applicable national standards, and international values if desired, is carried out and comparisons against emissions and ambient data done to determine areas with exceedances and the extent of population exposure in the areas (Shah *et al.*, 1997). Given the timescales for AQMP development and implementation, local standards should reflect local circumstances and the leading edge of policy recommendations, and the AQMP should take account of a mechanism for standard revision (Longhurst *et al.*, 1996). Modelling provides an important means to present future scenarios, and assess the likely impacts of prescribed conditions. However, cognisance must be taken that modelling outcomes are based on the subjective estimates inputted and as such, their validity extends as far as the robustness of inputs (Committee on Air Quality Management in the United States, 2004). Data that are representative and unbiased, with quantified errors and uncertainties will enable greater confidence in modelled outputs. An assessment of health, physical, and economic damage can be conducted to supplement issues arising out of the data on exceedances and exposure. Priorities are ascertained based on the scenarios characterised, identifying damage categories, pollutants and sources where AQM efforts should be focused.

Following the characterisation of air quality, technical measures can be identified to mitigate emissions and ameliorate the effects. Each source emitting priority pollutants should have a description of concomitant technical measures, with data on costs and the emission reduction potential (Shah *et al.*, 1997). The measures should be ranked based on cost-effectiveness for each priority pollutant (DEFRA, 2003; Shah *et al.*, 1997). However, the indirect effects of measures should be taken into account as well, such as increasing traffic on adjacent routes due to road pricing on major routes, and imposing unrealistic controls on small industrial emitters. A combination of regulatory, such as traditional command-and-control measures of enforcement, and non-regulatory measures, such as 'car-free day' and public information campaigns, achieve optimal outcomes; and an appraisal of the broader social, economic, and environmental consequences of emission reduction measures should be done (DEFRA, 2003).

While local authorities may not be able to undertake complex calculations of benefits and costs associated with implementing measures, cost-effectiveness is a necessary criterion. Guidance can be gained from examining expected improvements in air quality, the expected costs of implementing a measure or policy, both direct and indirect, and individuals or sectors bearing the cost, other options with similar results and reasons for discounting their cost-effectiveness, the indirect costs of not taking action, and obtaining surrogate cost data from alternative sources (DEFRA, 2003). Emission reduction scenarios are developed around packages of measures, beginning with the most cost-effective, and calculating total costs and emission reduction effects (Shah *et al.*, 1997).

Authorities must identify policy instruments to implement the selected technical measures, and an inventory of environmental policy instruments, together with the legislative and administrative framework assists in the identification (Shah *et al.*, 1997). Policy instruments that are effective, efficient, feasible, and that co-ordinate and complement well, are needed to implement the emission reduction measures. Command-and-control instruments are commonly used, including licensing and process changes; however, market-based instruments such as incentives, emission taxes and emission trading schemes can be also used. An understanding of the legislative, institutional and financial actions that are required for the implementation of policy is necessary. Assessments of policy instruments and technical measures are collated to determine abatement scenarios that can be implemented, and estimates of the damage reduction achieved by implementation are derived (Shah *et al.*, 1997).

Damage assessments for the scenarios can be determined using the process followed to calculate emissions estimates, and expressing the benefits in terms of population exposed, physical dose-response relationships, or monetary savings (Shah *et al.*, 1997). The costs associated with the abatement scenarios are compared with the benefits, and an incremental cost of abatement curve can be developed to consolidate the findings of the cost-effectiveness, or cost-benefit, analysis. The curve, as illustrated in Figure 2.7, is a direct outcome of the process of determining scenarios and a simple analysis tool that represents figuratively the costing of each scenario, and is effective in communicating the outcomes to policy-makers and the public (Shah *et al.*, 1997). The curve plots the cost per ton of emission reduction on the vertical axis against emission reductions on the horizontal. Retrofitting is the most financially rewarding control, indicating benefits gained through negative costs incurred, followed by inspections and emissions standards. Travel reduction methods, such as a gasoline tax, improve the cost-effectiveness of purely technical controls.

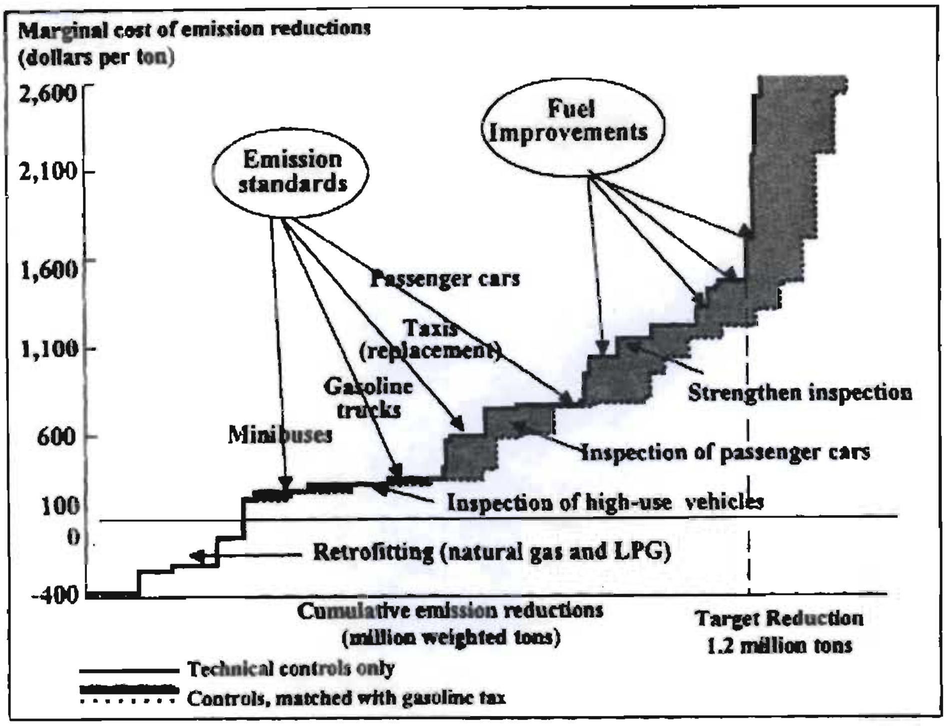

Figure 2.7. An incremental cost of abatement curve, developed specifically for Mexico City (Source: Shah *et al.*, 1997)

Following the compilation of the various components of the AQMP, a decision-making process is initiated, where goals and objectives are synchronised with the abatement scenarios presented and parties responsible for implementation consulted. The policy instruments are applied, and to improve the process, additional research can be conducted to fill gaps in data, secondary economic effects calculated, and research and implementation institutions strengthened (Shah *et al.*, 1997). Research serves to support the planning process by clarifying issues emerging from the development and implementation of the AQMP, and aiding the revision of the plan at future dates.

Consultation with stakeholders, including government agencies and departments and the public, is a necessary step throughout the development of an AQMP (Longhurst *et al.*, 1996). At the local level, the long period of applicability of the AQMP necessitates the involvement of town planning, transport and economic development departments. Land use, transport and economic development plans can be integrated within an AQMP and serve as a means for testing strategies, and a number of related policies, such as highway, public transport, cycling and industrial development policies, can be reconciled across the departments (Beattie *et al.*, 2001; Longhurst *et al.*, 1996). Groups, comprising individuals from these departments, are an effective mechanism for management of the inter-related activities of AQM (Beattie *et al.*, 2001). The groups, within local authorities or regionally, are used to address air pollution issues and share experiences, and possibly workload and resources. Consultation with tiers of government is generally ordered through regulation; however, requests for assistance require greater collaboration.

Public consultation can be formalised at specific developmental or decision stages, while information should be made available at all possible points during the preparation of an AQMP (Longhurst *et al.*, 1996). Facilitation of the participation of the public encourages buy-in for AQM programmes and support for measures that may otherwise prove unpopular, such as traffic restrictions. Public attitude surveys, progress reports on successes, clear communication on complaints, and routine information dissemination exercises in public areas actively involve the public (Longhurst *et al.*, 1996). The efficient handling of electronic and hard copy information on air quality alert situations, and a management system for organising data from the monitoring and forecasting systems are actions that authorities can implement further. Stakeholder forums are a means for continuing to ensure public access to decision-makers (Scorgie and Malan, 2002).

A procedure to initiate an air quality alert or for broader episode control should be included in the AQMP and requires a defined plan of action, a means for co-ordinating with other departments with responsibilities such as disaster management, and for ensuring swift communication with the public (Longhurst *et al.*, 1996). The response should be proportionate to the risk forecasted, and health warnings and emission controls are commensurate actions.

Capacity building can be included as a component of an AQMP to realise efficient and cost-effective service delivery, and may include human resources, equipment and facilities (Scorgie *et al.*, 2003). Capacity-building initiatives are influenced by national regulation, international best practice and the availability of local resources and capacity. Specific training programmes can be organised to develop the capacity of staff to give effect to the AQMP.

Review is an essential consideration in an AQMP as it ensures that the plan is current and achieving milestones towards air quality goals and objectives. The functional and operational framework of the AQMP is assessed with regard to continuing suitability, adequacy and effectiveness. A review identifies changes that may be necessary to the functional and operational structures, AQM systems, management and other objectives if poor performances are recorded or changes in circumstances occur, and underlines the need to work towards continual improvement in air quality (Scorgie *et al.*, 2003). Timeframes are an operational requirement for the AQMP, stating the expected dates for completion of tasks and achievement of objectives. These timelines are subject to delays caused by stakeholder and public consultation periods, and serve as a guideline.

2.3.2.7 Transportation Controls

Air quality issues caused by traffic-related pollution are occurring with greater frequency with concentrations of oxides of nitrogen (NO_x), tropospheric ozone and certain carbon compounds increasing, as well as episodes of photochemical smog (UNEP, 2002). NO_x refers specifically to nitrogen oxide (NO) and NO_2, which are strongly correlated to vehicle emissions. Emissions of VOC's, particulate matter, lead and SO_2 are also associated with traffic sources (Shah *et al.*, 1997). Transportation-related pollution is primarily attributed to road transport, including business, public and private sectors, with the latter featuring strongly, and airports and shipping contributing significantly less (Colvile *et al.*, 2001; Rayfield *et al.*, 1998).

Controls on transportation are significantly divided into technological controls and social or behavioural changes. Departments charged with controlling road transport are able to utilise a number of technological controls, such as the mandatory requirement of catalytic converters in new vehicles and lean burn engines, which have a higher fuel to air ratio (Rayfield *et al.*, 1998). Catalytic converters with three-way catalysts remove CO, hydrocarbons and NO_x from exhaust gases through catalysed chemical reactions and require the use of unleaded fuel to maintain the catalyst. Engine design and management systems are being introduced to improve fuel economy and performance of vehicles and reduce emissions (Rayfield *et al.*, 1998). The systems include the placing of sensors in the exhaust pipe and engine to optimise the functioning of the catalyst. Lean burn engines are useful in lowering NO and CO concentrations but increase hydrocarbons, and improve fuel efficiency of vehicles. Exhaust gas recirculation returns the inlet exhaust air to the air inlet reducing peak engine temperatures and NO_x levels (Rayfield *et al.*, 1998). In diesel engines, increases in hydrocarbons and particulate matter are observed, while in all engines, hot air in the exhaust system lowers hydrocarbon and CO concentrations. Turbo charging is another technological alternative having mixed results on emissions, increasing some pollutant concentrations under less than ideal conditions, reducing particulates and increasing NO_x (Rayfield *et al.*, 1998). The carbon canister, or carbon filter, reduces VOC emissions through the evaporation of fuel from the tank and fuel system (Shah *et al.*, 1997).

Alternative fuels provide a means for securing effective emission reductions, if conditions in the region are conducive to their introduction, including ease of availability and affordability. Compressed natural gas, liquid petroleum gas and alcohols are preferred alternatives over developmental fuels such as hydrogen, biomass, and electricity. Viable proposals related to fuel conditions to be considered by authorities include the reduction of sulphur content in diesel fuel, banning of lead in petrol, improving the quality of diesel fuel, introducing buses running on compressed natural gas, and introducing liquid petroleum gas as a fuel alternative (Shah *et al.*, 1997). For two- and three-wheel vehicles, by regulating lubricating oil and stipulating the use of low-smoke or smokeless oils, improvements in air quality can be obtained in areas where they represent significant sources. The majority of controls discussed are most effective at national level and require extensive consultation with manufacturers prior to introduction to ensure that pre-requisite conditions are addressed and a phased programme of technological improvement is followed to facilitate the switch in technology.

Additional controls that authorities may implement are regulatory tools such as labelling fuel economy of new vehicles with class comparisons to encourage consumer awareness and fuel economy feebates or rebates, with feebates being fees or taxes on vehicles with poor fuel economy and rebates, reductions in the purchase price of vehicles with high fuel efficiency (Black, 1996). Speed limits are also viewed as a tool in reducing energy consumption and emissions of vehicles, and changes, whether increases or decreases, are weighed against these criteria as well as increased journey times that may offset gains (Black, 1996; DEFRA, 2003). Inspection and maintenance programmes are an important component of control, encouraging tuning and motor adjustments for optimum performance, of especially older vehicles that contribute disproportionately to the pollutant load (Kojima and Lovei, 2001; Shah *et al.*, 1997). Vehicle retirement and scrappage schemes may be options for authorities, focusing on gross emitters with high vehicle kilometres travelled. However, pricing incentives require economic analysis to promote the correct response, i.e. polluting vehicles are removed from circulation for reasonable benefit (Kojima and Lovei, 2001).

Societal responses are less technical in approach, in that they look to alter behaviour that contributes to or causes pollution rather than addressing the sources. The shift in lifestyle that is necessary to implement these measures has proved challenging but presents the most sustainable outlook to controlling traffic-related pollution (Committee on Air Quality Management in the United States, 2004). Traffic management techniques require care in application and the consideration of knock-on impacts in the area, such as the displacement of traffic to other areas. Improvements and changes to the public transport sector are popularly used, including increased investment in reliability, emission control, punctuality, safety and routing of transport. Bus priority measures such as lane preferences and traffic light prioritisation, together with good interchange facilities, for switching transport modes, and waiting facilities can be implemented (DEFRA, 2003; Rayfield *et al.*, 1998). Providing information on services and introducing park-and-ride systems will also achieve increased use of public transport. Introducing new means of transportation, such as underground and light rail (streetcars) transport systems and electric buses (trolley buses) improve urban efficiency and access to urban centres with pollution reduction benefits.

Area licensing and road fees, accessibility taxes, parking restrictions, vehicle restricted areas, and high occupancy vehicle lanes can induce changes in private car use (Black, 1996; DEFRA, 2003). The pedestrianisation of streets and introduction of cycle lanes encourages non-polluting forms of transport and may act as an incentive to motorists (Crabbe and Elsom, 1998; Rayfield *et al.*, 1998). Employee travel schemes or travel plans involve co-ordinating journeys among colleagues, scholars, or any group of individuals for reduced car trips and higher occupancy rates for journeys taken, as well as choosing more sustainable forms of transport (Black, 1996; DEFRA, 2003). Traffic control systems improve traffic flow in congested areas and co-ordinate across networks for automatic response to conditions, and newer systems can queue vehicles outside congested areas and facilitate through-passage, detect and prioritise buses, and operate under isolated control for improved response in quiet periods (DEFRA, 2003).

2.3.2.8 Land Use Planning

Physical planning shapes the structure and form of areas, influencing the activities that occur there and the pollution that is intrinsically linked with human settlement. As such, land use and associated transportation planning can ameliorate the growth of, particularly urban, settlements, or contribute to increases in environmental degradation and pollution. Controls related to planning generally involve mitigating population growth and increases in movement that will occur, although authorities can introduce localised measures aimed at reducing pollutant loads in areas currently experiencing elevated concentrations. Hence, the significance of physical planning in relation to air quality is the increase in energy efficiency, minimisation of emissions, and reduction of exposure (Weatherley and Timmis, 2001).

The strategic and developmental controls of planning are emphasised in measures such as considering the air quality impacts of new developments, and reducing the need for transport and promoting public transport in developments (DEFRA, 2003). Planning is influential in determining the location of development that may give rise to pollution, and in ensuring that other developments are not affected by existing or potential sources (DEFRA, 2003). Facilitating the interaction of developers with planning and pollution control authorities prior to designing developments allows flexibility in this regard. Criteria for potentially polluting developments should be detailed, the availability of alternative sites for developments of this nature determined, and possible conflicts in land use, such as heavily polluting industries adjacent to residential development, identified and minimised (DEFRA, 2003).

Authorities, in planning the greater urban landscape, can use urban design models, subscribing to overall designs of compact, disperse or corridor cities as examples and dictating factors such as population density and land use mix (Borrego *et al.*, 2006). Compact cities, with high population density, mixed land use and ease of accessibility, are favoured with regard to air quality, over corridor cities, which develop along corridors originating in the city with high quality transport infrastructure, and disperse cities, which have low-density zones separating residential and commercial or industrial areas. Compact cities have a lower reliance on urban transportation, reducing overall transport, as compared to restricting city traffic, which may shift demand to areas outside the city, maintaining overall traffic levels (Borrego *et al.*, 2006; Fenger, 2002). While it may not be feasible to re-design major cities, concepts of integrated urban planning, building design, and supply of renewable energy can be applied (Fenger, 2002). Improvements in urban environmental quality can be secured by using open spaces and parks, especially in residential areas. The provision of housing can be influenced by increasing use of previously developed land, i.e. less greenfields development thereby discouraging urban sprawl, and improving accessibility to services and facilities (DEFRA, 2003).

Transport planning is closely linked to physical planning as consideration is taken of the means of movement for individuals with the planned area. Sustainable choices for transport should be encouraged by planning within existing transport infrastructure, both for individuals and freight. Promoting the accessibility of workplaces, shopping and leisure facilities and services through public transport, walking and cycling can be achieved through planning, as well as reducing the need for travel, especially by car (DEFRA, 2003). Locating services such as shopping centres, higher education, and large offices in town centres, which act as nodes for public transport networks and are more accessible overall reduces reliance on private transport (Rayfield *et al.*, 1998). The construction of ring-roads, which circumvent the city centre, is a planning measure for actively reducing pollutant emissions in congested areas with poor dispersion (Fenger, 2002).

Transport proposals can influence land use patterns, such as improving transport infrastructure outside urban centres leading to increased greenfields development, longer journeys and increased emissions (Rayfield *et al.*, 1998). The declaration of areas with exceedances of air quality standards and the development of air quality strategies or AQMP's to address these issues influence planning, and a degree of consultation is necessary to facilitate both planning and AQM actions (DEFRA, 2003; Longhurst *et al.*, 1996). Integration of air quality concerns and control measures with physical and transport planning is a necessary activity to ensure holistic and sustainable development (Beattie and Longhurst, 2000).

2.3.2.9 Additional Control Measures

In addition to the significant measures discussed, numerous other tools for implementing AQM objectives are documented through literature and practice. These include the declaration of areas where specialised management objectives and measures are in place, the development of a legal and administrative framework for implementing AQM, measures for addressing public information and participation, episode control procedures, and voluntary compliance and partnerships.

Areas of poor air quality with exceedances of prescribed standards require focused intervention and additional controls to reduce emissions and ambient standard exceedances. These are referred to as priority, non-attainment, or air quality management areas in the literature. Based on measured data and modelled projections, as well as an understanding of the functioning and air quality characteristics of an area, the nature of exceedances and conditions that lead to exceedances are determined, and the subsequent declaration of a priority area made (Crabbe *et al.*, 1999). Guidance in the requisite procedure for declaration can be obtained from legislation, and generally, a detailed plan for the attainment, or expected improvement toward attainment, is expected to be produced. The boundaries of priority areas are determined by a simulation technique or monitoring, or a combination of methods, however, the effect of model uncertainty, political decision-making and exposure risks impacts considerably on the outcome (Woodfield *et al.*, 2002).

The legal framework for AQM extends beyond the policy and air quality regulations to enforcement, hearings and appeals, and citizen suits (Schueneman, 1977). The responsibility for enforcement is that of the authorities, using a number of means including education programmes, following through of complaints, finding illegal conditions, achieving abatement through negotiation with and persuasion of emitters, and prosecution of non-co-operative offenders (Schueneman, 1977). Identifying violators through field inspection patrols, area surveys, and complaint investigation, conducted at various times including outside of office hours is an initial action, following which a decision on corrective or punitive action is taken. Negligence or repeat violators usually predicate punitive actions, and court appearances or penalties are prescribed (Schueneman, 1977). Corrective actions are accompanied by an agreement on violations committed, specific actions to be taken by the violator for correction and a deadline for compliance.

Meticulous record keeping and objective procedures are needed for court action and agencies must institute procedures to maintain data integrity. The hearings and appeals function provides for settling grievous issues outside of a formal court action, saving time and expense, and requires the selection of a board to preside over the activities (Schueneman, 1977). The process addresses issues related to the enforcement of pollution control regulations and laws, and allows for procedures similar to court cases with evidence and witnesses presented, cross-examination and corrective actions, and penalties or dismissal of cases. Following non-compliance, formal legal proceedings are initiated.

Citizen legal action may be in response to personal injury or material damage suffered as a result of emissions and brought against an emitter (Schueneman, 1977). Legal action can also be used to incite action on the part of regulators, if diligence in carrying out pollution control is not perceived. Organisations and citizens may act to request relief or compensation, and regulations can be instituted to address the concerns of citizens not directly impacted on by emitters. Citizens pursuing court action experience difficulties in collection of technical evidence and excessive costs of legal action. The administrative framework required for AQM implementation is elaborated on in Section 3.2.2, however, elements such as pre-determined formats for documentation such as reports and licensing applications are needed, a defined review process preferably with time-scales, and a system for setting fees and securing payment together with other financial concerns such as acquiring funding for programmes.

Public communication is a significant aspect of implementing a control programme, as public support is an essential component of successful implementation. Methods of including public opinion and aiding their awareness include establishing a complaints line, air quality alerts or an air pollution index, public education campaigns, facilitating access to information, stakeholder workshops for development of strategies, and participation in Environmental Impact Assessments (EIA's). Public complaints can be a useful tool in pollution control, guiding action by identifying problematic sources and assisting in defining air quality goals (Schueneman, 1977). However, complaints that are poorly attended to, can create dissatisfaction with the agency. Therefore, prompt action and reporting of measures taken or lack of grounds for action to the complainant encourages public participation. Air quality alerts represent a response to acute pollution episode conditions with health warnings, and air pollution indices present general forecasts to inform individuals of the expected state of the air according to forecasts, and possibly taking action to avoid these localities. Indices are directly correlated to monitored data, and alerts are an independent banding or class representation relating conditions to actions (Longhurst, 2005). Creating alerts and indices are contentious and the subjective divisions and representations are subject to abuse by interest groups, and therefore their development should be approached with caution and regulated to prevent confusion.

Public education campaigns and programmes involve providing routine information to the public on pollution issues and related health impacts, serving an advisory and educational role (Longhurst *et al.*, 1996). Various forms of media that are accessible to individuals in the area, such as newsletters, newspaper articles, local fora, displays in public libraries, radio and television broadcasts, and internet websites, can be used. Presenting air quality information in a format that is understandable to non-technical individuals is as critical a factor as overall information provision; raw data are invaluable for developing control strategies, however, decision-makers and the public may be unable to comprehend the relationships represented. Illustrations, non-technical language and relative comparisons are important tools for communication. Graphs, pie diagrams, maps, and presenting before, after and ideal scenarios can be used to effectively communicate air quality information, and undertaking surveys to determine public responses to the information aids the improvement of communication techniques (McDonald *et al.*, 2002).

Stakeholder workshops held during the conceptualisation and decision-making stages of policy development, such as the development of the AQMP, serve to both inform and involve the public, garnering their views of pollution issues, and strategies to mitigate these. The Second World Conservation Strategy purports the view that government structures should be facilitating community action to care for the environment, using policy and strategy to empower local communities to use resources sustainably and guide local environmental decision-making (IUCN, UNEP and WWF, 1992). Participation during the consultation stages of the EIA process presents an opportunity for the public to present their views and concerns, especially on air quality impacts of proposed developments. Public relationships can be enhanced through informing the public of the nature of air pollution and associated impacts experienced in the area, describing necessary control actions with an explanation of costs, and creating the perception that clean air is an attainable goal. Further, communicating results of other programmes, raising awareness of pollution-causing activities of private individuals, and describing the functions and responsibilities of control agencies and compliance of major sources contribute to improved interactions between regulators and the public (Schueneman, 1977). An educated and informed public furthers the goals of sustainable development by addressing social sustainability, enabling stakeholder interactions that are valuable and valid.

Episode control addresses the continuing, persistent build-up of pollutants through stagnant meteorological conditions; and accidental emissions from industrial plants, storage plants and other significant sources can be addressed through similar disaster control procedures (Boubel *et al.*, 1994; Fedra, 2002). Monitoring data indicating concentrations experienced, supplemented by modelled outcomes of expected emissions density and affected areas, allow information on the development of the scenario to be provided to relevant decision-makers and those responsible for AQM. Preferably, predictions on plume movement should be prepared in advance for large sources to allow for safety analysis, as well as procedures on levels of risk and corresponding responses. This is necessary to ensure prompt actions aimed directly at relieving pressures on the exposed population. Control measures can include required pollution-aversion mechanisms or shutdown at large sources, reduction or severe restriction on vehicle movement, and the cessation of domestic emissions, and action should be proportionate to the level of expected risk (Boubel *et al.*, 1994; Longhurst, 1996). Co-ordination with authorities that may have an interest or are required for intervention is necessary, as well as disseminating episode control procedures and actions to all affected parties, including the public, prior to the need arising (Schueneman, 1977). The air quality impacts of other incidents such as fires and industrial spills must be considered in planning for control (Schueneman, 1977).

Securing the participation of industry in introducing control measures without extensive litigation or managerial discussion significantly reduces the administrative and enforcement on control agencies. Factors such as rising consumer awareness, negative publicity and the action of pressure groups, and increased regulatory demands have raised the profile of environmental management issues in the corporate sector (Fryxell and Vryza, 1999). The compatibility of improved environmental performance with profitability has promoted the action toward voluntary compliance. The ISO 14001 environmental standard and environmental management systems (EMS) are concepts that have gained widespread use, espousing the ideal of continual improvement over compliance. The advantages of voluntary compliance communicated to industry should include the increased visibility of corporate proactive environmental management, consumer awareness and preference for environmentally-conscious products and firms, and the market edge offered by development of in-house control technology and expertise (Fryxell and Vryza, 1999).

Self-reporting of incidents with regular audits of emissions control conducted by authorities are means of introducing voluntary compliance measures (Burger and Scorgie, 2005). Cleaner production methods, innovative product design, raw material substitution, efficient use of natural resources, and the use, re-use and recycling of by-products for the minimisation of emissions are pro-active means of achieving compliance by emitters (Scorgie and Malan, 2002). The limitations of smaller enterprises may make voluntary compliance less attractive than to larger, more established industries. Demonstration projects employing new techniques and technologies can make headway in promoting voluntary introduction of pollution control, as well as the improvement of management capacity to recognise environmental opportunities and integrate these with the production and functioning of companies (The World Bank Group, UNEP and UN Industrial Development Organisation, 1999).

Control measures are characterised by the use of technological changes or social and behavioural changes to induce emission reductions. In addition, control measures are continuously being adapted or innovative measures are developed to obtain further reductions in emissions. While clean air and absence of health impacts remain the goal of any AQM strategy, practically these are resolved into attainment of ambient standards and control measures are the drivers of air quality improvements. However, AQM implementation has not been able to successfully campaign for lifestyle changes in the wider population, and further, has influenced policy to that effect. A shift in the mindset of individuals, as well as broadening the ambit of control, is necessary to achieve significant gains.

2.3.3 Strengths and Shortcomings of the Air Quality Management Approach

AQM is regarded as a comprehensive strategy for addressing air quality issues from a wide range of sources and adaptable to individual circumstances experienced in national, regional or local contexts. Control measures can be selectively employed at different levels of government, such as national fuel regulations or localised traffic control, and individual sectors can be targeted for defined control measures to be implemented. Elements of other pollution control strategies can be incorporated into AQM, such as the use of emission standards to address source emissions for large pollutant sources and market-based instruments such as emission trading schemes to allow emission caps and the introduction of new industries into managed areas. Implementing an AQM strategy facilitates the integration of numerous subjects, both directly and indirectly relevant to pollution control, as technical and institutional components combine with data and uncertainties, including facts, perceptions and beliefs (Fedra, 2002). The contrary view is also held, that the comprehensiveness makes it complex, difficult to implement and resource-intensive; however, the nature of the air pollution problem dictates the level of action needed.

The cost-effectiveness of an AQM strategy is good as it allows more investment in control in areas with poor air quality, while areas that are not experiencing degradation of air quality can implement measures to maintain the level of air quality (de Nevers *et al.*, 1977). In this respect, the levels at which the ambient limits are set influence the cost-effectiveness of the strategy as a balance is necessary between desired air quality for limiting impacts and the associated costs of attaining the levels. With requisite training and assistance, an agency can be capacitated to implement AQM effectively, and in accordance with the level of action needed.

Developments in AQM tools have enabled multi-pollutant multi-effect strategies to be devised that address an air quality issue, rather than attempting to integrate the controls for individual pollutants. Integration and co-ordination are essential components needed for successful implementation of AQM, addressing the multiple control measures that are necessary as well as communicating between departments and tiers of government, and other stakeholders (Beattie and Longhurst, 2000; Cannibal and Lemon, 2000). The emphasis of individual functions in developing strategies for control, such as planning or environmental health, and contradictory guidance from upper tiers of government to subsidiary authorities inhibit effective AQM. The enforcement of AQM requires the investment of resources for functions such as inspections and auditing and is not excessive. AQM has a fair degree of adaptability, as tools can be altered and improved over time; however, there may be extensive work needed to change these, such as the legislative process that is necessary to change ambient standards (de Nevers *et al.*, 1977).

Further evidence regarding the suitability of an AQM approach is provided through comparison of other significant strategies discussed, and compiled in Table 2.3. AQM is viewed as being cost-effective to a degree, although a CBA strategy has a superlative level of cost-effectiveness by using economic efficiency as the defining criterion. AQM is more cost-effective to use than emission standards or taxes, as costs and benefits do shape decision-making on implementation. However, emission standards and taxes are preferred for their simplicity, with AQM and CBA rated as complex strategies to implement (de Nevers *et al.*, 1977). Standards and taxes are easy to enforce as well, placing significantly lower resource demands on control agencies, and are frequently cited as an initial example of control. The enforceability of AQM is fair, incorporating an element of subjectivity. The enforceability and flexibility of a strategy purely based on CBA is unknown. AQM has the greatest degree of flexibility compared to emission standards, which are largely inflexible, and taxes, which do not require flexibility to be included. Additionally, the evolutionary abilities of AQM and emission standards are comparable, whereas emission taxes and CBA have greater ability to adapt and include new knowledge (de Nevers *et al.*, 1977).

Table 2.3. Comparison of control strategies using desirable qualities (Source: de Nevers *et al.*, 1977)

Strategy	Cost-effectiveness	Simplicity	Enforceability	Flexibility	Evolutionary ability
AQM	Good	Poor	Fair	Fair	Fair
Emission standards	Poor	Excellent	Excellent	Poor	Fair
Emission taxes	Fair	Excellent	Excellent	Unnecessary	Good
CBA	Excellent	Terrible	Unknown	Unknown	Good

2.4 Summary

The proliferation of environmental problems in modern times has predicated the development of environmental management, with sustainable development defining the interventions and controls to address these issues. With specific reference to pollution control, a number of control strategies have been identified to deal to differing extents with curbing or remediating pollution and incorporating economic efficiency as a criterion. Four significant strategies are AQM, emission standards, emission taxes and cost-benefit analysis, of which AQM has emerged in the global context as the favoured approach. The tenet of AQM is defining desired air quality using goals and standards, and following, managing activities that impact on air quality with a view to achieving the goal or standards set. Management tools aid the implementation of AQM, with an emissions inventory, monitoring, modelling, and a set of control measures being the most critical components of a successful strategy (de Nevers *et al.*, 1977; Elsom, 1992). In addition, an AQMP is emerging as a fundamental tool for co-ordinating the approach to AQM, defining future practices and determining the attainment of air quality standards.

CHAPTER THREE
AIR POLLUTION CONTROL:
SOUTH AFRICA AND INTERNATIONALLY

3.1 Introduction

The chapter deals with the pollution control scenario in South Africa, as well as presenting international examples from well-recognised programmes of the United Nations, the WHO, the USA and the EU. The South African approach to air pollution control is examined from a legislative perspective, tracing the evolution of regulations and policy, and a governance perspective, determining the organisational framework needed to implement the AQA effectively. International examples draw out the most relevant pollution control developments, identifying the most effective and innovative measures from AQM implementation and policy.

3.2 Air Pollution Control in South Africa

Air pollution control in South Africa is in the midst of major changes, due in part to the necessary updating of laws and the international shift in the structure and function of government. There are far-reaching implications as a result of these changes. Air pollution control is dictated, largely, by the regulatory setting, and the replacement of the 'best practicable means' approach in favour of an AQM strategy is a product of changes in current accepted thinking. Numerous principles have been introduced to air pollution control, such as sustainable development, a focus on receiving environment impacts and integrated pollution control, which have influenced strategy development, and the subsequent regulation. From the perspective of implementing authorities, the notion of 'government' has been replaced with that of 'governance', where increased participation and deliberative policy, together with networks and institutional capacity, define processes (Hajer and Wagenaar, 2003). Concomitant with the change to governing air pollution control is the organisational structure that is needed to facilitate it. An elaboration on the shifts in the thinking and implementation of air pollution control specifically related to the South African experience is proffered in the following sections.

3.2.1 Legislative Perspective

A number of relatively new legislations have been promulgated in South Africa, influenced partly by the ushering in of a democratic regime and the need to bring South African environmental law and principles in line with international best practice. The Constitution of the Republic of South Africa (Act 108 of 1996) can be viewed as the catalyst, as the enshrining of environmental rights in the document obligated regulators to prepare legislation that would make the right enforceable. The Constitution, in Section 24 (a), makes provision for the entitlement to an environment that is not harmful to health or well-being, and in Section (b) details the measures that will secure them, considering sustainability, conservation and the prevention of degradation (Republic of South Africa, 1996). The powers and responsibilities of local government are detailed in the Constitution, with Section 151 pertaining to the autonomy of local authorities and Section 156 (1) stating air pollution, among other services, as an executive responsibility of local government (Chipkin, 2002). Civil society is granted more recourse for action, including on issues of environmental decision-making, by clauses such as those relating to administrative justice, access to information, and the *locus standi* rule (Sowman, 2002).

Following this, the National Environmental Management Act (Act 107 of 1998), or NEMA, was passed that laid the principles for environmental management in South Africa and provided the framework and mechanisms that would implement the approach. NEMA supports sustainable development through principles such as waste avoidance and minimisation, pollution prevention, integration including implementation of the 'best practicable environmental option', and environmental justice (Republic of South Africa, 1998). It makes use of a risk-averse approach, promoting equity, participation and transparency, evaluation of benefits and costs, and the protection of workers. The polluter pays principle is advocated, consideration of vulnerable ecosystems, as well as societal groups, empowerment of communities, the inclusion of views of all interested and affected parties, and concern for impacts throughout an activity's life-cycle. Policy harmonisation, conflict resolution, co-operative governance and state responsibility are addressed (Republic of South Africa, 1998).

The principles of NEMA place the interests of people foremost in environmental matters, and support the notion of the environment being held in trust for people with the state serving as an agent. In addition, the AQA is recognised as an implementation of the approach proposed in NEMA now applied to air pollution control. However, a brief chronology of legislation that directly influences the AQA, notwithstanding the impact of those already discussed, is needed to provide background and frame the approach of the AQA.

3.2.1.1 Atmospheric Pollution Prevention Act

APPA provided the legal basis for air pollution control in South Africa. It was regarded as a command and control approach, implementing the 'best practicable means' as a strategy, where regulated industries were subject to utilise emission control measures as indicated by the Chief Air Pollution Control Officer (CAPCO) (Barnard, 1999; Scott *et al.*, 2005). The Act is divided into sections pertaining to noxious or offensive gases, generally termed 'Scheduled Processes' and industrial in nature, as well as the control of dust, smoke, and vehicles. The establishment of an Air Pollution Advisory Committee is also a condition in APPA, which allows for a ministerial advisory capacity and the appointment of the CAPCO (UNEP/WHO, 1996). Scheduled Processes are the most stringently regulated, where registration certificates are required by emitters dictating the conditions of operation, and fall under the regulation of central government. Smoke control is particularly applied to fuel-burning appliances, dust related to mining and industrial activities, and vehicle control targets malfunctioning engines (Barnard, 1999). APPA has strongly source-based controls, and air quality guidelines are in place for stack emissions of certain common pollutants (UNEP/WHO, 1996). APPA uses a system of notices and fines as penalties, communicating the need for greater control and emission reductions; in extreme cases of Scheduled Processes violations, the operation may be requested to cease.

APPA has received significant criticism regarding several aspects of the approach and control measures. Most notably, it is regarded as out-dated, as it was promulgated in 1965, and does not reflect current practices or innovation in air pollution control (Barnard, 1999). The 'best practicable means' approach is widely believed to be insufficient to obtain the necessary, and safe, levels of air quality as the co-operation of industry is not guaranteed and the system does not consider ambient experiences of air quality (Scott *et al.*, 2005). The lack of legally enforceable air quality standards that indicate ambient concentrations of pollutants is perceived as a shortcoming, as well as the absence of mechanisms for communities and lay-people to express concerns regarding their experiences of air quality. The latter conflicts directly with the principles laid down in NEMA, and the conflict in conditions, as well as the overall approach of APPA, is the greatest motivation for the updating of air pollution control legislation. Additionally, APPA makes no provision for setting or realising air quality goals, as needed by the constitutional mandate to provide an environment that is not harmful to health and well-being; or for the implementation of control across different tiers of government (Scott *et al.*, 2005).

The industrial focus of the legislation, evident in the emphasis on Scheduled Processes regulation, makes APPA inadequate to deal with air quality issues without industrial sources, such as motor vehicles and indoor air pollution. Market-based instruments, economic incentives and other management tools are not considered as options for control in the legislation. Poor enforcement was a major drawback in APPA, as lenient permit conditions, low fines and the rare prosecution of offenders did not provide sufficient incentive for polluters to control emissions (Scott *et al.*, 2005). Authorities, including those at local level, were not empowered by APPA regulations to act on air quality issues as and when they arose. Air pollution control, and pollution control in general, required an updated and new approach that addressed the shortcomings of previous regulatory instruments.

3.2.1.2 Integrated Pollution and Waste Management Policy

The White Paper on Integrated Pollution and Waste Management for South Africa – A Policy on Pollution Prevention, Waste Minimisation, Impact Management and Remediation (IPWM) provides the means by which to update pollution control legislation, and includes the principles that define action in environmental management. The IPWM policy is influenced by principles set out in the White Paper on Environmental Management Policy for South Africa, and subsequently NEMA, which gives effect to the environmental rights advocated in the Constitution and accepts sustainable development as the principle to guide policy and practice (Republic of South Africa, 2000). Integrated Environmental Management was necessitated by these developments and air pollution had to be considered synergistically with discharges to water and land. The IPWM policy overhauled pollution governance and altered the approach to pollution control by emphasising strategies to reduce the total pollution and waste burden (Republic of South Africa, 2000).

The international policy thrust towards integrated pollution prevention and control has influenced the development of the IPWM policy to introduce a mechanism by which South Africa's extensive environmental legislation could be co-ordinated (Kotze, 2006). The most significant goal of the IPWM policy relates to the fragmentation of policy and responsibility in dealing with the control of pollution and waste (Kotze, 2006). The policy aims to incorporate integration into all aspects of management, including the departments responsible for implementation and the multiple authorisation procedures. Co-operative governance is used as a guiding principle, with a view to reaching a holistic approach to management, to improve effectiveness and sustainability. Other strategic goals of the policy include pollution prevention, waste minimisation, impact management and remediation to deal specifically with issues arising from pollution and waste management, holistic and integrated planning to support the policy going forward, and participation and partnerships in integrated pollution and waste management governance to promote stakeholder buy-in (Republic of South Africa, 2000). Further goals address empowerment and education in integrated pollution and waste management, information management, and international co-operation.

Issues of governance are specifically addressed, with some clarification of the roles and responsibilities of different departments and their associated line functionaries, including provincial and municipal departments, as well as the enforcement system. Issues raised with exclusive reference to air pollution in the IPWM policy examine the integration of regulation by national, provincial and local authorities, and cross-media impacts such as polluted water produced by scrubbing pollutants from atmospheric emissions and gaseous emissions produced by solid waste disposal (Kotze, 2006).

While a number of issues have been raised regarding the IPWM policy, the application of the mechanisms and principles have not been forthcoming. Issues of integration have not been adequately addressed by legislation following the IPWM policy, including the AQA, as responsibilities remain distributed across a wide network of regulators, although co-ordination mechanisms are in place intermittently (Kotze, 2006). Further criticisms of the policy include the absence of the designation of a uniform pollution standard to apply technological norms across media; and the inadequate nature of timeframes set out in the policy. Deadlines for progress towards achieving goals have been exceeded and updates, which reflect realistic periods to reach desired states, are necessary (Kotze, 2006). In summary, greater efforts to utilise mechanisms for integration across media are needed and the principles of pollution prevention and minimisation require promotion to meet adequately the goals set out in the IPWM policy.

3.2.1.3 National Air Quality Management Programme

The National Air Quality Management Programme (NAQMP) has been developed upon the framework of the IPWM policy, directed by the approach, guiding principles and strategic goals. While these are distinctly mirrored in the NAQMP, the strategy applied therein refers specifically to air quality, addressing initial difficulties in implementing air quality management and working towards the goal of competent control of air quality in South Africa. The NAQMP gives effect to principles such as pollution prevention and minimisation, integration and sustainable development, and is considerate of South Africa's context by making provision for economic growth, improved equity and our unique urban and rural circumstances (DEAT, 2002). The key AQM issues facing South Africa, as identified by the NAQMP, are industrial and domestic fuel consumption, dust, vehicular emissions, noise pollution and the deficiencies of the current AQM regime (DEAT, 2002). Pollution prevention is the cornerstone of the approach of the NAQMP, encompassing all other philosophies in its achievement, and focuses on conservation and wise use of resources by industry and the people of South Africa. Techniques to aid in implementing this approach include, *inter alia,* policy and regulation, process changes and product design, raising awareness and building capacity, and developing strategies and tools to allow people to live sustainable lifestyles (DEAT, 2002).

The NAQMP has been visualised as a 10-year strategy, from 2000 extending to 2010, and is a complete framework for beginning implementation of AQM in South Africa. There are number of significant components that drive the strategy, notably the passing of the AQA, a standard-setting initiative, the APPA review project and a vehicle emission strategy (Furter, 2005). The NAQMP comprises four phases, initiated by the translation of the IPWM policy into an AQM strategy and implementation action plan, followed by a transitional period where a number of projects aimed at facilitating the implementation of the AQA will be carried out (Furter, 2005). Phase three is directed towards capacity building, and phase four focuses on maintenance and review of the governance and policy structure.

The goals contained in the IPWM policy are expanded for the context of AQM. To illustrate further, the goal of an effective institutional framework and legislation is concerned with legal documents that impact on the delivery of designated air quality and the administration, authorisation, and establishment of mechanisms to effect institutional arrangements and regulations within the realm of AQM (DEAT, 2002). In addition, integration of these processes with other media, and the overarching structure of integrated pollution and waste management are needed.

With regard to the roles and powers of the tiers of government, the NAQMP designates the Department of Environmental Affairs and Tourism (DEAT) as the lead agent to co-ordinate AQM activities, a number of provincial departments that are responsible for air quality related activities, and municipalities. The motivation is one of designating functions where they are most effective, therefore, DEAT as the national ministry is given co-ordination and legislative powers, provincial government acts largely in an advisory and over-seer capacity, with local government responsible for formulating and implementing an AQM strategy (DEAT, 2002).

Within the NAQMP, provisions are made for an integrated approach using source-based controls, methods to limit impacts to the receiving environment, including the setting of ambient air quality standards, and remediation efforts to counter and rehabilitate damaged environments. As indicated, a proposed component of the NAQMP is ambient standards. These will be prepared in accordance with the tolerance of the environment, and with adequate stakeholder consultation (DEAT, 2002). Monitoring, to establish both ambient air quality and compliance of permit-holders, is planned; capacity building will be implemented for government departments and civil society regarding technical and scientific concepts, as well as communication and educational aspects. The role of civil society is emphasised in the NAQMP, with a focus on mechanisms to increase their awareness and participation; information systems will be improved, including the creation of a monitoring network, pollutant register and other methods of guaranteeing the constitutional right to information and enhancing accessibility (DEAT, 2002). Market-based instruments, such as charges and incentives, are considered in the NAQMP, as well as voluntary agreements.

The NAQMP presents a number of opportunities with respect to AQM, such as international co-operation and introduction of innovative measures and programmes. Weaknesses of the strategy are identified as limited participation, lack of integration and co-ordination across programme elements, and a limited resource base to draw on (Furter, 2005). The NAQMP is based on legislation guiding environmental management and integrated pollution and waste management. In turn, this forms the framework on which the AQA, as a component, is developed.

3.2.1.4 National Environmental Management: Air Quality Act

The AQA has been developed on a strong framework of legislation, and successive components of environmental management policy and legislation have informed the structure of the Act, of which the significant influences have been discussed. As such, the AQA represents the culmination of a legislative process to address the shortcomings of previous approaches and incorporates principles and objectives that herald a new era of air pollution control. The AQA endorses the approach of ambient air quality management and addressing impacts on receiving environments, over those of source-based controls. It purports holistic and integrated management, promoting the prevention and minimisation of emissions, and further, the management and reduction of impacts from emissions that are produced (Scorgie and Malan, 2002).

The AQA can be distinguished into the four main activities of the setting of standards and objectives, defining the status of air quality and delineating priority areas, preparing and implementing control strategies, and measuring progress (Burger and Scorgie, 2005). Responsibility for the functions related to these activities are delegated to national, provincial or local government, with industry also given a degree of responsibility. Significant functions detailed in the AQA are identified, firstly, as the establishment of a National Framework to serve as a blueprint for AQM and achieve the objectives of the AQA as stated in the preamble, in which ambient air quality standards, emissions standards and information management standards will be set (Republic of South Africa, 2005; Scott, 2005). Priority pollutants will be subject to ambient limits, and in the interim Schedule Two of the AQA, containing APPA guidelines are being used as applicable standards. However, South African National Standards 1929 and 69, the ambient limits and framework respectively, are being developed to reflect good practice (Mañez, 2005; Scorgie, 2005).

The South African Air Quality Information System (SAAQIS) is being constructed to improve public access to air quality information, such as monitoring data, scientific reports and legislative documents (DEAT, 2006). The information system will give effect to the constitutional right to information, increase awareness and the participation of civil society, and serve as a co-ordinating mechanism for authorities. The appointment of Air Quality Officers (AQO's) and preparation of AQMPs are requirements of the AQA and provide further capacity for co-ordination of air quality activities (Republic of South Africa, 2005). Assigning the position of AQO to an individual allocates responsibility for related duties and, to a degree, ensures that air quality is addressed, and AQMPs allow for consideration of future needs and a multi-tiered approach to control and improvements.

Provision is made for the declaration of priority areas, where needed, and these areas will receive greater focus to reduce emissions and meet ambient limits (Republic of South Africa, 2005). They are commonly regarded as 'hotspots', of which the Vaal Triangle is an example, and require detailed management plans and special consideration. The listing of activities that impact air quality is required under the AQA, and the operator will be subject to emission standards and may not operate without an atmospheric emission licence. A detailed licensing process is proposed by the AQA, assessing the activity with respect to standards, effects of pollution and the best practicable environmental option, among other considerations; with registration certificates issued under APPA reviewed during a transitional period.

Monitoring of air quality is necessitated by the AQA, for ambient air and sources; and enforcement measures are enhanced, implementing compliance audits, source monitoring and a stricter penalty system. An advisory committee, the National Air Quality Advisory Committee (NAQAC) is introduced, and integrated into the National Environmental Advisory Forum, which will serve to advise the Minister on implementation of the AQA (Republic of South Africa, 2005). Controlled emitters and fuels are included in the AQA and regulate activities and appliances, in the former case, and so-called 'dirty fuels', that contribute greatly to the pollution burden, in the latter (Republic of South Africa, 2005; Scott, 2005).

Other functions in the AQA address the development of by-laws to enforce and implement more stringent standards, and the management of dust, noise and odour. International agreements to which South Africa is signatory and the related implications for air quality, the need for regulations to further enforce AQM practices, and the delegation of duties between tiers of government are also addressed (Scott, 2005). Responsibilities of industry are listed as the preparation of atmospheric impact reports and pollution prevention plans, the introduction of cleaner technology and practices, the designation of an emission control officer and the application for emission licences, of which licensing is mandatory and the remaining activities are carried out at the request of authorities (Scott, 2005). Industry is expected to comply with the stipulated licence conditions and report non-compliance where observed.

The AQA encompasses various aspects of AQM, providing a framework for implementing the new AQM approach, and is line with good practice (Scorgie, 2005). General concerns in the implementation of policy and legislation relate to the concepts of viability, capability, accountability and being purpose-driven (Pieterse, 2002). Addressing financial sustainability of the policy, ensuring skills and resources are present or will be developed, using instruments and partnerships to make the process and authorities accountable, and adopting a strategic outlook are necessary for successful implementation. However, aside from the challenges of implementing legislation, practical constraints to the implementation of the AQA include the attainment of new standards, the displacement of pollutant effects on the poor, the poor performance of older plants, and improving the understanding and protection of ecosystems (Burger and Scorgie, 2005). The health risks associated with air toxics, determining a response to pollutants with no safe threshold, and addressing transboundary pollution across provinces and borders are further challenges to the application of the AQA. In addition to these considerations, the way forward for the AQA will need the long-term allocation of resources, greater co-operation between the tiers and ministries of government, and the support of business and civil society (Scorgie, 2005).

3.2.1.5 National Health Act

The National Health Act (Act 61 of 2003) bears relevance to issues of AQM, as specific reference is made in the Act to the performing of environmental pollution control by municipalities (Republic of South Africa, 2004). In the schedule of definitions, municipal health services are defined as including the responsibility for environmental pollution control. The National Health Act also places the responsibility for municipal health services with metropolitan and district municipalities, requiring that local municipalities rescind their services to district level. A service level agreement presents a means for negotiating the provision in the act, ensuring resources and capability are available and detailing the level of performance to be expected (Republic of South Africa, 2004). Transitional arrangements are included to allow for resources and capacity to be transferred until the agreement can be finalised. The National Health Act forms part of the law reform process to harmonise legislation in South Africa, and provide uniform, structured health services.

3.2.2 Governance Perspective

The shift to 'governance' from 'government' in policy-making and analysis characterises the broader movement of society from top-down authoritarian rule to flexible, deliberative practices, which can occur outside of formal arrangements (Hajer and Wagenaar, 2003). Governance is viewed as the exercising of a country's power for the management of economic and social resources for development, and can be expanded to include the patterns emerging from the governing activities of the various social, political and administrative actors (Cloete, 2002). Partnerships are emphasised in the new governance approach, whether between the private sector or civil society, and government, and are managed using principles of good governance. Initially, the principles were politically focused, including elements of open, transparent policy-making processes, a professional bureaucracy, an accountable executive, a strong, participative civil society, and a culture of acceptance of the rule of law (Cloete, 2002). These have been expanded to recognise the need for the building of capacity of the various sectors that influence governance, as their input into partnerships for the improvement of service delivery is pivotal. Good governance can be conceptualised as the achievement of the most appropriate policy objective, by government, for the development of society, which is achieved by mobilising, applying and co-ordinating all available resources in the various sectors and considering effectiveness, efficiency and democratic criteria (Cloete, 2002).

Sustainability is a criterion in governance as well, with durability of implemented programmes examined to ensure that services are provided at a required quantity and quality over time. The availability of resources over the period of implementation is complemented by the capacity of the organisation for delivery, adaptation and improvement of the service, as a complete assessment of sustainable governance (Cloete, 2002). Thus, the obvious elements of environmental and social sustainability are incorporated with political, institutional and managerial sustainability, addressing concepts such as political will and commitment, institutional durability and learning, and clear strategic objectives, strong leadership and co-ordination and review processes (Cloete, 2002). Capacity emerges as an issue of concern in governance, most specifically in local government, and especially in the South African context. Capacity is defined as:

> "the ability to perform appropriate tasks effectively, efficiently and sustainably" (Cloete, 2002: 279).

Resources that are both tangible and intangible are needed. Examples of tangible resources are human and financial, and intangible resources include leadership, motivation, and commitment. Capacity building takes on a greater significance, amounting to a transformation of structural, functional and cultural aspects of government, and enabling outside service providers, as well as government, to achieve policy objectives. While successful implementation hinges on the capacity of those providing services, capacity building provides enabling tools for improving provision and enhancing future conditions. A number of prerequisites have been highlighted as necessary for developing the capacity for sustainable governance, however, these were developed based on the successes of the South East Asian 'tiger cub' economies, i.e. Malaysia, Thailand, the Philippines, and Indonesia, and as such may be limited in scope for the global context. These include political and administrative leadership that is committed, strong, competent and honest, as well as the direction of leadership; and the existence of, and consensus on, a national vision and action plans in strategic policy sectors (Cloete, 2002). Further requirements are the availability and utilisation of resources that are optimal, creative, pragmatic and co-ordinated in all societal sectors; and effective strategic and operational management encompassing design, implementation, monitoring, evaluation and policy review. A developmental social and organisational culture, with a strong work ethic, and amenable democratic and economic environments are seen as essential elements for success (Cloete, 2002).

Governance in South Africa is influenced by the legacy of apartheid, the democratic regime that we now experience, and international developments. The general elections held in 1994 endorsed the accession of power and authority to a democratically elected government, and the enacting of a plan of service delivery and policy objectives to facilitate this. Policy and legislation to correct the injustices of the past, which were experienced most acutely at the local level, were developed at an accelerated pace. Local government was seen as vital to the successful implementation of delivery and given responsibilities and duties delegated by national government and tasked with the economic and social development of communities, termed developmental local government (Lemon, 2002).

The promotion of local government as an autonomous tier of government is strongly influenced by the view of decentralising governance structures to address the needs of the population more effectively (Pieterse, 2002). This is achieved by situating authority at the level where it can respond to these needs, and corresponds to the principle of subsidiarity, where functions that can be effectively performed at local level are designated primary powers to local government and not impinged upon by central government (Barnard, 1999). Local government is charged with revenue generation and budgetary allocation for spending and decision-making, involving co-operation with stakeholders for empowering local communities (Parnell and Poyser, 2002).

Principles of development, participation and sustainability were introduced to local government and it was established as an autonomous tier of government. Specific powers and functions were allocated to authorities, and implementation was focused at 'grassroots' level to improve responsiveness and efficiency. Financial management, organisational uniformity, and principles such as accountability and equity were imbued into local structures as a means of empowering their delivery (Pieterse, 2002).

Integrated Development Plans (IDP's) are the chief means for structuring and organising local government and are regarded as the drivers of action in local government, forming the basis for the application of policy, budgetary allocations and future development in municipalities. In addition, it is the primary tool for communication and co-ordination of local government with tiers of government, serving to match priorities and obligations (Parnell and Pieterse, 2002). IDP's effectively map the development of a municipality or metropolitan area, over significant temporal scales, by providing a situation assessment, prioritising needs accordingly, and developing and implementing frameworks, strategies, projects, and programmes (Parnell and Pieterse, 2002). The establishment of targets and monitoring tools, effective budgets, and regular monitoring and adaptation are also incorporated into the IDP. The structure of local government is largely dictated by the functions to be performed, legislative elements such as the Municipal Structures Act (Act 117 of 1998), and to a lesser extent by the outcomes of electoral democracy, i.e. local government elections.

The shift in approach to local government has placed significant additional responsibility for service delivery, social and economic development, and local health provision on local authorities (Chipkin, 2002). This is accompanied by enhanced powers and financial autonomy to facilitate these actions, which remains an implementation challenge to local governments. The proximity of local government to communities, making them 'democracy in action', is an additional parameter, making authorities directly responsible to those they serve (Cloete, 2002).

Implementation problems are observable across local government, including structures and processes that inhibit progress towards the ideals of developmental local government, and a lack of funding, from both local sources and other tiers of government. Constraining the growth of local budgets is the transformation of attitudes in the post-apartheid state, where boycotts, protests and a culture of non-payment for services requires addressing (Parnell and Pieterse, 2002; Pieterse, 2002). Ideologies and organisational culture also require changing within government structures to halt the protection of influential vested interests, preventing staff from blocking organisational, management and policy changes, and stopping corruption and nepotism (Cloete, 2002). Political office-bearers and administrative officials lacking in experience or commitment need to be addressed as a constraint on the effectiveness of local government.

Conditions outside the control of authorities, such as regulatory practices, centralised systems that result in conflicts amongst governance levels, and political imperatives set by national government, influence their performance (Cloete, 2002). The urbanisation characteristics of specific local governments influence efficiency of service delivery, as less-urbanised municipalities experience greater difficulty in obtaining adequate funding for projects, and are lacking in human resource capacity, whereas urban municipalities have a greater tax and skilled resource base on which to draw (Pycroft, 2002). While the challenges may appear daunting, internationally, local government is seen as the most effective means to effect local change, and as such remains the vehicle of choice in South Africa to promote the aims of democratic governance.

3.2.2.1 Organisational Structure for Air Pollution Control

Using the principle of subsidiarity, a number of functions were designated with primary authority to local government, including the expansion of its mandate to eradicating poverty, local economic development and sustainable management of the environment (Parnell and Pieterse, 2002). Internationally, motivation for locating environmental management and control functions at local level can be found, locating their actions within a framework of national legislation and guidance (Beattie *et al.*, 2001; de Nevers *et al.*, 1977). In addition, the impacts of environmental degradation are experienced most acutely by local populations, and as such, local authorities are most appropriate to address the issues promptly and efficiently (Barnard, 1999). Local action empowers communities to address negative environmental impacts, and aids participation in decision-making. This is also true of air pollution control, as the most pressing pollution problems arise from locally experienced conditions, such as the localised sources and impacts of industrial, traffic and domestic emissions, as opposed to regional phenomena.

Control of air pollution falls under the ambit of local health departments, largely, as a result of the interest in the adverse health effects caused by air pollution, and the legislated imperative in the

National Health Act in South Africa. Technical and field services form the bulk of support needed, although management and administrative assistance is necessary. Technical advisory committees, to inform standards, control regulations and other complex subjects, as well as a hearing and appeals board, to ensure fair redress and swift resolutions of infringements for violators, may be needed on an intermittent basis as well (Scheuneman, 1977). A generalised organisational structure is presented in Figure 3.1, representing an ideal scenario for pollution control; however, the constraints on local government inhibit the creation of a complex agency if not warranted by sufficient concern for pollution impacts. Additionally, agencies may choose to out-source certain functions to reduce the resources burden.

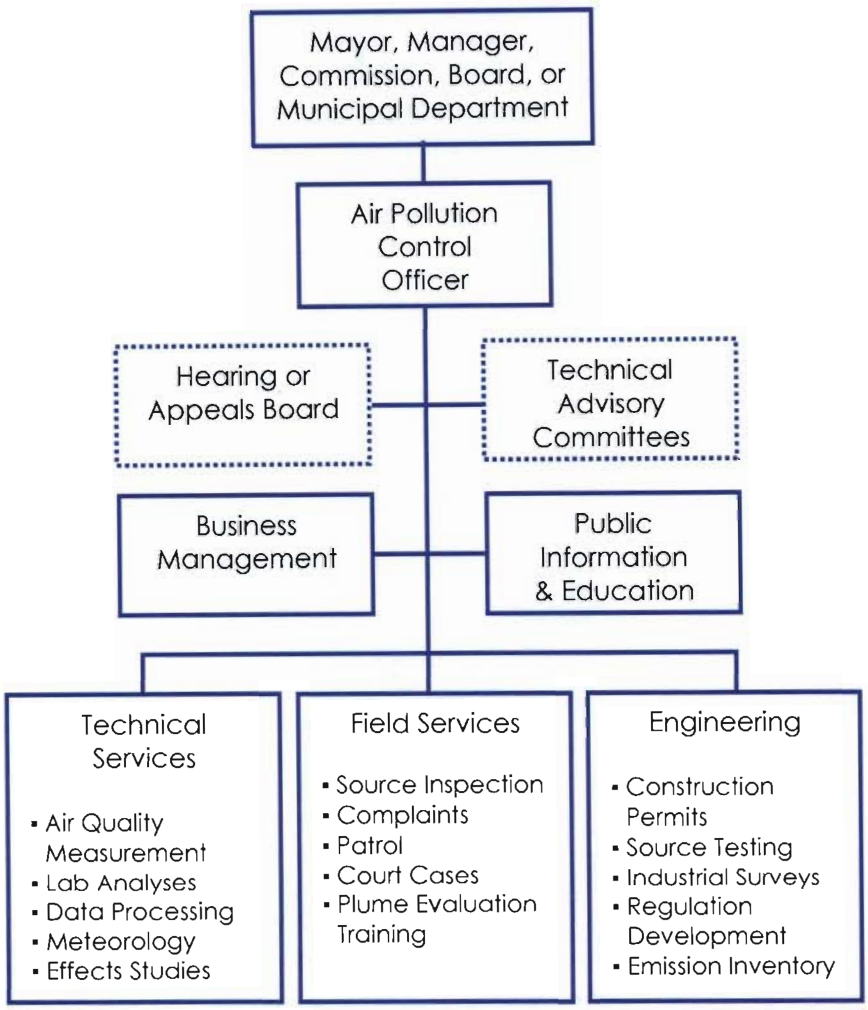

Figure 3.1. An organisational chart depicting the idealised structure for an air pollution control agency of local government. Functions with dashed outlines indicate intermittently required activities (Source: Scheuneman, 1977)

Pollution control functions may be separated into the enforcement of existing regulations and legislation and the evaluation of regulatory practice effectiveness and development of improvements (Boubel *et al.*, 1994). Enforcement focuses on the registration of sources and associated administration, following up on the stipulated conditions through inspections and testing, complaint investigation and prosecution of violations. Evaluation activities include air quality monitoring, emission inventories, statistical analysis of data, trend prediction, modelling, analytical evaluation and recommendations for regulations (Boubel *et al.*, 1994).

Technical assistance relates largely to information services, training, laboratory analysis; and administrative support is needed in terms of personnel and procurement, financial and accounting services, and generalised services such as clerical and secretarial duties and maintenance. Communication has drawn increasing attention as essential for good governance, and functions of public relations and communication, public education, inter-agency liaison, and publications distribution must be undertaken (Boubel *et al.*, 1994). Provision for legal services and a research and development function can be made within the agency, however, given the expertise required, these can be provided by governance structures as a whole.

The structure and functions of pollution control agencies can vary, influenced by the nature and extent of pollution problems and the size of the population under the agency's jurisdiction, as well as inherent factors of available financial and human resources (Scheuneman, 1977). To illustrate further, a small programme of pollution control may only be able to respond to nuisance complaints by the community, operate limited sampling stations and detail source construction to provincial authorities. Consequently, a moderately sized agency can address more complex problems, cite violations through self-initiated observations, issue permits to larger emitters, operate a large monitoring programme, enforce broader emission regulations, maintain an episode plan, conduct prosecutions and public information activities, host a modest laboratory and have more involved relationships with other government agencies (Scheuneman, 1977). Independent of the size of agency, an amenable relationship with other agencies of government is needed, for co-ordination purposes and the possible provision of assistance and resources in complex cases.

Local government is assisted in pollution control by policy and strategies developed at higher tiers of government, as well as the provision of capacity for authorities that are lacking resources to implement adequately the conditions of legislation. The general responsibilities of provincial authorities are outlined as roles of leadership, co-ordination, evaluation, service and operations (Scheuneman, 1977). Leadership through the development of an implementation plan for the entire jurisdiction is advised, considering the involvement of all concerned agencies, their roles, and a temporal schedule. A mechanism for liaison is necessary, ensuring that conflicting policies and procedures are minimised by effective communication, as well as the uniformity of technical processes. Regular meetings with other agencies, and the possible development of an agreement, are tools for improving communication. The inclusion of agencies that impact on air quality, such as those concerned with industrial development, agriculture, town and transportation planning, housing and education, aids effective communication (Scheuneman, 1977).

Evaluation includes the periodic publication of an appraisal of the air quality and related programmes, with identified trends, emission sources and controls, pollution impacts, and budgets of programmes. Consideration should be given to recommendations for improvements and future concerns, as well as the integrity of field and laboratory measurements, in evaluations. Particular services may be aptly performed at provincial level due to constraints on resources, wider access, or the concentration of expertise; these include specialised training, establishing design criteria, technical assistance, and library and data storage functions (Scheuneman, 1977). With regard to the operations role, legislated responsibilities provide the basis for their assignment, but provincial authorities can undertake those activities that cannot be performed by local authorities and those that require greater resources or expertise. Examples of activities include vehicle emission inspections and control, monitoring networks, industry-related taxation, consolidation of data and reporting, inter-provincial control programmes, and control of government-owned facilities including those operated by local government, such as waste disposal sites (Scheuneman, 1977). These roles are guidelines to general responsibilities that provincial authorities, or agencies that straddle central and local government, may undertake for air pollution control. It should be noted that defined responsibilities for provincial authorities, as well as the other tiers of government, in South Africa are given in the AQA.

These responsibilities may be extended to include national government, as well as expanded to incorporate elements of strategic control that are most effectively conducted by a centralised authority, such as framework and policy development, and the implementation of nationally relevant initiatives such as control of large, complex sources. Aspects of technical guidance and training are simple to co-ordinate at national level, as well as the ability to access broader funding resources.

3.2.2.2 Air Quality Functions of Tiers of Government

The AQA details functions relating to AQM, and specifies the tier of government at which the responsibility lies. As such, clear responsibilities can be identified for local, provincial and national departments where air pollution control is a function. National government is responsible through the Department of Environmental Affairs and Tourism (DEAT) for the establishment and review of a national framework for AQM, which details the approach to be taken in the implementation of the AQA (Republic of South Africa, 2005; Scorgie, 2005). The framework specifies norms and standards for various functions at different tiers of government and mechanisms to facilitate these, including the establishment of standards for ambient and source monitoring by municipalities and provinces, as well as for data collection and management. National government is charged with identifying priority pollutants, which are emissions posing a health risk, and determining the acceptable levels detailed in ambient air quality standards, and the possible inclusion of source emission standards. In addition, national government determines the specific monitoring protocol, prescribing the format and technical requirements for monitoring (Republic of South Africa, 2005; Scott, 2005). A National Air Quality

Advisory Committee can be established by the ministry under the National Environmental Advisory Forum (NEAF) to provide guidance on the implementation of the AQA.

Significant legislated responsibilities of national government include the appointment of a national AQO, with primary responsibilities of co-ordination and effecting the AQA and the national framework, and the development of an AQMP, detailing measures for improving air quality and their implementation to be included in the Environmental Management Plan (EMP) (Republic of South Africa, 2005; Scorgie, 2005). In terms of AQM measures, the responsibilities of national authorities are outlined as the declaration, management and withdrawal of priority areas, the approval, publication and drafting of regulations for priority area air quality management plans, identification and drafting of emission standards for listed activities and controlled emitters, and identification of controlled fuels (Republic of South Africa, 2005; Scott, 2005).

The ministry may choose to request pollution prevention plans from categories of emitters corresponding to a priority air pollutant, and prescribe dust control measures, national noise standards or odour control measures at their discretion. The investigation and regulation of transboundary air pollution is a responsibility of national government, as is the investigation of potential international agreement contraventions (Republic of South Africa, 2005; Scorgie, 2005). The ministry is responsible for drafting national regulations for various aspects of AQM including labelling, incentives for pollution reduction, and emissions trading schemes. Processes for consultation, public participation, delegations and exemptions are outlined as responsibilities for national authorities.

Provincial responsibilities follow on from national level, relating specifically to assistance and oversight functions of local authorities within the jurisdiction. Air quality monitoring, as well as monitoring of the administrative performance of municipalities, is a responsibility of provincial authorities. Identification of priority air pollutants and the drafting of ambient and emission standards within the province can be pursued (Scorgie, 2005). An AQO must be appointed within the provincial structure and an AQMP drafted to be included in the provincial EMP. The declaration of priority areas and the preparation of priority area AQMP's can be undertaken under provincial authority (Scorgie, 2005). Provincial government may choose to list activities with atmospheric impacts and declare controlled emitters. In addition, provincial government may be designated as the licensing authority if the function is delegated from local government.

The major responsibilities of local government are listed as the designation of a municipal AQO, the drafting of an AQMP, and the implementation of an Atmospheric Emission Licence (AEL) system (Scott, 2005). An AQO is responsible for co-ordinating AQM functions at municipal level and effecting the requirements of the AQA within the jurisdiction, to the extent that these are applicable to municipalities and metropolitan areas. The national framework serves as the guidance for necessary measures to be implemented by the AQO, and the AQO is given powers of delegation to enable a support team responsible for air pollution control and AQM to be administered (Republic of South Africa, 2005).

The IDP prepared by local government must include an AQMP, as legislated by the AQA. As the IDP serves as the primary guidance and budgetary tool for local authorities, AQM is accordingly prioritised in their implementation. Additionally, the AQMP must detail the implementation of the plan, and the measures for improvement of air quality, reduction of negative impacts, and effecting of various principles and control measures (Republic of South Africa, 2005). An annual report on the implementation of the AQMP is to be produced by authorities informing their AQM initiatives, various aspects of compliance and measures towards securing compliance, and monitoring activities. Metropolitan and district municipalities are charged with the responsibility of licensing authority in a section that has not been effected yet and does not require immediate action. The AEL is required for listed activities, includes processes for public participation, makes provision for the setting of operation and management conditions on the licence, is linked to the EIA procedure, and as mentioned can be delegated to provincial government (Republic of South Africa, 2005).

Local authorities are also given the responsibility to conduct monitoring of ambient air quality and emissions monitoring of point, non-point and mobile sources of air pollution (Republic of South Africa, 2005). Local government may choose to identify pollutants that present a risk to local populations or environments, *viz.* priority pollutants, and further to establish air quality standards for their control. The by-law process, which involves a process of consultation that must be adhered to, is used to establish stricter local standards. Additionally, for nationally declared priority pollutants, local authorities may establish locally applicable standards provided these are more stringent than national standards. Local government, while not empowered to declare priority areas, is required to collaborate with provincial and national government for the management of priority areas.

The AQO, at any level of government, is empowered to request an Atmospheric Impact Report (AIR) from any person that has, or is suspected of, not complying with the conditions of the AQA, allowing for greater control and transparency between emitters and authorities. Under the licensing imperative, the AQO may request the assignment of an Emission Control Officer to facilitate AQM and the compliance of the emitter. Other administrative conditions are that exemptions may be delegated as a responsibility of national government to local authorities, municipal legislation remains in place until repealed by the municipality in question thereby respecting the autonomy of local government, and transitional licence applications are lodged with local government if designated as the licensing authority (Republic of South Africa, 2005). Therefore, it is evident there are a number of functions that represent the responsibility of local government to give effect to the AQA, and the challenges facing local government are contrasted against these.

3.3 Overview of International Regulatory Approaches to Air Pollution Control

A number of noteworthy legislative and policy agreements influence air pollution control globally; these include the approaches of international bodies such as the WHO, pollution control by regional authorities such as the EU, and national approaches to control such as that of the United States and the UK. A brief understanding of the setting and regulatory outcomes of the aforementioned cases is necessary to place AQM in a context of international best practice that is largely directed by these bodies and states.

3.3.1 United Nations and World Health Organisation

The United Nations (UN) exercises international influence in many areas, and the United Nations Environmental Programme (UNEP) and UN ECE are two significant organisations that address air quality. The UN has acted as a catalyst for global and regional change, effectively mediating environmental conflict and presenting solutions that address the demands of growth of developed and developing countries. The 1992 United Nations Conference on Environment and Development, or UNCED, highlighted environmental degradation and led to the drafting of the action plan for sustainable development, Agenda 21, which was subsequently incorporated into countries' environmental policy. Issues identified include capabilities for AQM, especially for monitoring the health status of exposed populations, accessibility to abatement technologies, and developing and facilitating the use of Earthwatch, which is a monitoring and assessment programme extending to all UN member states (UNEP/WHO, 1996). The Global Environmental Monitoring System (GEMS) operates a co-operative programme in UN countries, together with the WHO, and collates information on environmental quality, including air quality, identifying trends and levels of urban air quality. UNEP conducts research and produces reports on current AQM issues and practice, including the results of the GEMS programme regularly.

The UN ECE has a membership including the EU, non-EU countries in Europe, and North America, and identifies environmental issues and defines measures to control these through Protocols and Conventions (Colls, 1997; ECE, 2004). The CLRTAP is an example of a UN ECE effort, and is recognised as a landmark agreement in addressing the long-range transport and deposition of sulphur and nitrogen in Europe, effectively promoting the adoption of the BATNEEC approach by signatories to curb emissions. Other pollutants addressed by the UN ECE include ozone-depleting substances, through the Montreal Protocol, NO_x, VOC's, heavy metals, Persistent Organic Pollutants, and ground-level O_3 (ECE, 2004). While the agreements do not represent legally binding targets, countries are under strict moral obligation to abide by the conditions upon ratification (Colls, 1997). The favourable political climate at the inception of the CLRTAP, similarities of European states, and open membership of the UN ECE have contributed to the laudable success of the CLRTAP (McCormick, 1997). Concepts within the Convention are also being continually updated and improved, enhancing its relevance and functionality. The WHO has informed international understanding of the health impacts associated with air pollution levels, and the ambient air quality guidelines developed are accepted as the maximum thresholds beyond which significant harmful health effects are experienced (Colls, 1997). A summary table of WHO guideline values was presented in Section 2.3.2.1.

3.3.2 European Union

The EU comprises 15 member states including the UK, Germany, Denmark, Finland, the Netherlands and Sweden, and while the major objectives of the organisation are economic and political regional co-operation, environmental action has been motivated to come under this overall theme (EEA, 2004; Elsom, 1992; Jacobson, 2002). Using directives, regulations and decisions, the EU promotes environmental concern among member states; directives are binding though include consideration for conditions in individual states, regulations apply uniformly across nations, and decisions are directed at specific members or are modifications of a regulation. Limit values are concentrations that may not be exceeded for specified periods and are aimed at the protection of human health, whereas guide values are long-term values for protecting health and the environment (Colls, 1997).

The first significant legislative document on air quality by the EU was drafted in 1980, and prescribed limit and guide values for SO_2 and TSP aimed at addressing urban smog. Technical constraints hampered the effectiveness of the directive and a further directive dictating the methodology for TSP was passed in 1989. A directive addressing NO_2, with limit and guide values, was drafted in 1985 and specified measurement points at locations where public exposure was expected to be the greatest (Colls, 1997). In 1988, the Large Combustion Plant directive was passed, employing BATNEEC to control SO_2 and NO_x emissions from industrial plants using a permitting system. Other directives addressed vehicle emissions, fuel content restrictions and other pollutants (McCormick, 1997).

A watershed in regulation of air quality was the establishment of the framework directive, the Ambient Air Quality Assessment and Management directive, in 1996, which provided the basic structure for AQM, and subsequent daughter directives, which elaborated with detailed requirements, such as ambient standards, technical specifications, and compliance dates (Fenger, 2002; Larssen *et al.*, 2004). Currently, ambient air quality standards, using limit values, are set for SO_2, NO_2, PM_{10}, lead, CO and benzene, with target levels for O_3 also in place, which are detailed in Tables 3.1 and 3.2 (Larssen *et al.*, 2004).

Integrated pollution prevention and control was purported to avoid inter-media transfer of pollution and address environmental pollution holistically (Fenger, 2002). The Auto-Oil I and II Programme aims at regulating vehicle emissions by setting targets for traffic-related pollutants and assessing technologies and fuel standards (Fenger, 2002). Member states are expected to give effect to the directives through national legislation, monitor air quality in accordance with requirements, and develop abatement programmes to eliminate exceedances with reports on implementation. The UN ECE influences EU actions as well, and the EU has implemented provisions for the requirements of the CLRTAP. The CLRTAP requirements together with the national emission ceiling directive (NECD) are expected to drive the next wave of emission reduction measures, and are aimed at simultaneously addressing pollutant-specific ambient air quality issues around human health, ground-level O_3, and acidification and eutrophication affecting ecosystems (Larssen *et al.*, 2004). Sector-based approaches are included to supplement the initiatives.

Table 3.1. EU limit and target values for protection of human health (Source: Larssen *et al.*, 2004)

Health-protection limit and target values				
EU directives: (European Commission, 2003)				
Compound	**Limit/target value**			**Target year**
PM_{10} Stage 1	Annual average:	40 µg/m³		2005
	Daily average:	50 µg/m³	May be exceeded up to 35 days a year	2005
PM_{10} Stage 2	Annual average:	20 µg/m³	Indicative	2010
	Daily average:	50 µg/m³	Indicative; may be exceeded up to seven days a year	2010
NO_2	Annual average	40 µg/m³		2010
	Hourly average:	200 µg/m³	May be exceeded up to 18 hours per year	2010
Ozone	Eight-hour average:	120 µg/m³ (target value)	May be exceeded up to 25 days per year (¹)	2010
SO_2	Daily average:	125 µg/m³	May be exceeded up to three days per year	2005
	Hourly average:	350 µg/m³	May be exceeded up to 24 hours per year	2005
CO	Eight-hour average:	10 mg/m³		2005
Pb	Annual average:	0.5 µg/m³		2005 (²)
Benzene	Annual average:	5 µg/m³		2010

(¹) As an average over the three preceding years.
(²) 2010 in the immediate vicinity of specific industrial sources, notified to EC before 19 July 2001.

Table 3.2. EU limit and target values for the protection of vegetation (Source: Larssen *et al.*, 2004)

Limit values and targets for protection of vegetation			
EU directives/CLRTAP			
Compound	**Limit/target value**		**Target year**
SO_2	Annual/winter average:	20 µg/m³	2001
NO_x (as NO_2)	Annual average:	30 µg/m³	2001
Ozone	Accumulated exposure over a threshold of 40 ppb (¹) (AOT 40):		
	EU directive (target)	18 000 µg/m³ · h	2010
	EU directive	6 000 µg/m³ · h	Long-term objective
	CLRTAP	6 000 µg/m³ · h	Long-term critical level
Acidifying and eutrophying components	Area exceeding critical loads: EU NECD	Reduced by 50 % within each grid. Long-term objective: no exceedance of critical loads	1990–2010

Note. (¹) Accumulated exposure in the growing season (May-July)

3.3.3 United Kingdom

The UK can be studied as a representative member state of the EU, and as the pollution control history of the UK offers particular insight to South Africa's situation because of the similarities in their history. Modern air pollution control began with the passing of the Alkali Work Act in 1863, which controlled emissions from the worst industrial polluters and drastically reduced acid emissions using standards (Beattie *et al.*, 2001; Elsom, 1992). The UK was a strong proponent of the 'best practicable means' approach, using emission standards determined on the merits of individual industries. The national Alkali Inspectorate was created to administer the nearly 3000 scheduled processes associated with the emission of 'noxious and offensive gases', with other processes controlled by local authorities (Elsom, 1992).

In December 1952, London experienced a deadly smog episode with SO_2 and particulate matter daily concentrations as high as 4000 $\mu g/m^3$ and 6000 $\mu g/m^3$ respectively, causing 4700 excess deaths (Elsom, 1992). Media attention forced the government to initiate a commission of enquiry, and following this, the Clean Air Act of 1956 was promulgated, allowing domestic emissions to be regulated for the first time. Local authorities were given powers to designate 'smoke control areas', within which fuels and heating appliances were stringently controlled. The Clean Air Act of 1968 allowed central government to compel local authorities to act on smoke control, as well as instructing industries to construct tall stacks to aid the dispersion of pollutants (Elsom, 1992; Jacobson, 2002).

The UK's entry into the EU in 1973 saw the adoption of EU policy using national legislation, and a shift in strategy to AQM. Acid rain began to emerge as an issue of concern in Europe, particularly the Scandinavian countries, and the CLRTAP, of which the EU is a signatory, was drafted to address SO_2. An EU directive in 1980 introduced ambient standards for SO_2 and smoke, which were in contrast to the UK approach of negotiating with industries to determine emissions that correlated to best practice rather than coercive penalties and as such, much opposition was presented. Compliance with the standards in urban areas was expected to be challenging, and the initial date of 1983 was extended to 1993. The 1990 Environmental Protection Act established an integrated approach to pollution control, and required authorisations for major processes which are distinguished into Part A, which are major industries falling under the authority of Her Majesty's Inspectorate of Pollution (HMIP) and Part B, which are smaller operations regulated by local authorities (Beattie *et al.*, 2001; Colls, 1997). BATNEEC was implemented as the technology standard for industrial plant, and, as a condition of authorisation, applications and emissions data were available to the public in Public Registers (Longhurst *et al.*, 1996). HMIP is the former Alkali Inspectorate, expanded to address cross-media pollution, and now the Environment Agency.

Vehicle emissions were beginning to draw attention, and in 1992, vehicle emission standards were strengthened and the following year, catalytic converters became compulsory on all new gasoline-powered vehicles, both actions being in-line with EU directives (Jacobson, 2002). The 1990 Government White Paper 'This Common Inheritance' announced a change in air pollution control, introducing effects-based controls in the form of air quality standards and establishing a new framework termed Local Air Quality Management (Beattie *et al.*, 2001; Williams, 2004). These changes were legislated in the Environment Act 1995, and this legislative document necessitated the development of policies relating to air quality assessment and management, subsequently published as the National Air Quality Strategy (NAQS), and followed by the Air Quality Regulations in 1997. These documents shape current AQM practice in the UK, of which the NAQS underwent review in 2000 and is undergoing a second review in 2006. A number of principles underpin the NAQS, with the focus being the establishment of health-based standards, now incorporating nine pollutants listed in Tables 3.3 and 3.4.

The emphasis of the NAQS was action at the local level, and using a process of review and assessment the quality of air in authorities has been characterised. The three-stage process involves compiling emissions data from sources and background concentrations, and using modelling and monitoring data to determine the likelihood of the objectives being exceeded by target dates (Beattie *et al.*, 2001). Progress to higher stages indicates a greater likelihood of exceeding objectives and necessitates the use of more sophisticated tools. When determining the risk of exceedances, consideration must be given to areas of public exposure, as these are the primary concern of the regulation. Specific areas that are predicted to exceed objectives by target dates are declared Air Quality Management Areas (AQMA's) and authorities must prepare Air Quality Action Plans (AQAP's) stating actions to be taken to bring the area in line with the objectives (Beattie *et al.*, 2001).

Table 3.3. UK air quality objectives for the protection of vegetation and ecosystems (Source: DEFRA, 2006)

Pollutant	Applies	Objective	Concentration measured as	Date to be achieved by and maintained thereafter
Nitrogen oxides	UK	30µg.m⁻³	annual mean	31 December 2000
Sulphur dioxide	UK	20µg.m⁻³	annual mean	31 December 2000
	UK	20µg.m⁻³	winter average	31 December 2000

Table 3.4. Current UK air quality objectives for the protection of human health, differentiated into standards applicable in the authority areas of England, Scotland, Wales and Northern Ireland (Source: DEFRA, 2006)

Pollutant	Applies	Objective	Concentration measured as	Date to be achieved by and maintained thereafter
Benzene	UK	$16.25 \mu g.m^{-3}$	running annual mean	31 December 2003
	England and Wales	$5 \mu g.m^{-3}$	annual average	31 December 2010
	Scotland, Northern Ireland	$3.25 \mu g.m^{-3}$	running annual mean	31 December 2010
1,3-butadiene	UK	$2.25 \mu g.m^{-3}$	running annual mean	31 December 2003
Carbon monoxide	UK	$10 mg.m^{-3}$	maximum daily running 8 hour mean/ in Scotland as running 8 hour mean	31 December 2003
Lead	UK	$0.5 \mu g.m^{-3}$	annual mean	31 December 2004
	UK	$0.25 \mu g.m^{-3}$	annual mean	31 December 2008
Nitrogen dioxide	UK	$200 \mu g.m^{-3}$ not to be exceeded more than 18 times a year	1 hour mean	31 December 2005
	UK	$40 \mu g.m^{-3}$	annual mean	31 December 2005
Ozone	UK	$100 \mu g.m^{-3}$ not to be exceeded more than 10 times a year	8 hour mean	31 December 2005
Particles (PM_{10})	UK	$50 \mu g.m^{-3}$ not to be exceeded more than 35 times a year	24 hour mean	31 December 2004
	UK	$40 \mu g.m^{-3}$	annual mean	31 December 2004
	UK (apart from London)	$50 \mu g.m^{-3}$ not to be exceeded more than 7 times a year	24 hour mean	31 December 2010
	UK (apart from Scotland & & London) also equivalent to EU indicative (stage 2) limit value	$20 \mu g.m^{-3}$	annual mean	31 December 2010
	London	$50 \mu g.m^{-3}$ not to be exceeded more than 10 times a year	24 hour mean	31 December 2010
	London	$23 \mu g.m^{-3}$	annual mean	31 December 2010
	Scotland	$18 \mu g.m^{-3}$	annual mean	31 December 2010
Polycyclic aromatic hydrocarbons	UK	$0.25 ng.m^{-3}$ B[a]P	as annual average	31 December 2010
Sulphur dioxide	UK	$266 \mu g.m^{-3}$ not to be exceeded more than 35 times a year	15 minute mean	31 December 2005
	UK	$350 \mu g.m^{-3}$ not to be exceeded more than 24 times a year	1 hour mean	31 December 2004
	UK	$125 \mu g.m^{-3}$ not to be exceeded more than 3 times a year	24 hour mean	31 December 2004

3.3.4 United States of America

The USA had enacted some legislation at federal or municipal level to address deteriorating air quality prior to 1970, including the initial Clean Air Act of 1963; however, these documents did not grant sufficient powers or resources to authorities to effect changes in air quality. The Air Quality Act of 1967 put in place requirements for Air Quality Criteria reports, for states to determine standards based on these reports, and the submission of State Implementation Plans (SIP's) detailing the measures to achieve the standards (Jacobson, 2002). The act divided the USA into Air Quality Control Regions (AQCR's), within which officials were charged with these duties, and upon approval of a SIP, federal authority for implementation was delegated to the state.

The Clean Air Act Amendments of 1970, generally referred to as the Clean Air Act, are recognised as a milestone in air pollution control in the USA, firstly, for the creation of the United States Environmental Protection Agency (US EPA), and additionally, the specification of National Ambient Air Quality Standards (NAAQS) and National Emission Standards for Hazardous Air Pollutants (NESHAPS). The US EPA, which drafted and enforced federal regulations, was tasked with the development of standards, specifying six criteria pollutants as CO, NO_2, SO_2, total suspended particulates (TSP), hydrocarbons, and photochemical oxidants (Jacobson, 2002). Criteria pollutants are divided into primary, for the protection of human health, and secondary, for the protection of human welfare including vegetation, buildings and visibility, standards. Further, regions were separated into areas that were in compliance with the standard and those in non-compliance, the former termed attainment areas and the latter, non-attainment areas. Hazardous air pollutants, or air toxics, specified included asbestos, beryllium and mercury and were expanded as knowledge on toxicity and health effects developed (Jacobson, 2002).

New Source Performance Standards were also required to regulate the emissions of new stationary sources. The SIP process was strengthened for states to address primary and secondary standard attainment through setting ambient standards at least as stringent as federal standards, to evaluate air quality in the AQCR's and determine methods and timeframes for achievement of standard levels (Jacobson, 2002). The Act addressed motor vehicles as a source of pollution, requiring significant reductions in the hydrocarbons, CO and NO_x emissions of new vehicles. The development of catalytic converter technology is seen as a response to the stringent limits and timeframes placed on manufacturers in the Act. In addition, particulate lead was added, O_3 replaced photochemical oxidants, hydrocarbons removed, and TSP redefined to PM_{10} and $PM_{2.5}$, i.e. particulate matter of aerodynamic diameter less than 10 microns or 2.5 microns respectively, for the NAAQS as understanding of complex pollution problems improved (Jacobson, 2002).

The Clean Air Act Amendments of 1977 extended the dates for reduction in motor vehicle emissions, and non-attainment areas were presented with the requirements for SIP revision to achieve standards by the end of 1982. The Prevention of Significant Deterioration (PSD) policy was legislated, to maintain the quality of air in attainment areas and ensure the protection of areas, such as wilderness areas and national parks, where pollutant effects marred the value (Jacobson, 2002). Three classes were defined, based on current air quality and value, and conditions for source development stated. The 1977 Amendments also mandated the use of computer modelling to determine the impacts on air quality of new sources, and attempted the control of chlorofluorocarbons (CFC's).

The Clean Air Act Amendments of 1990 were passed in response to the continued non-attainment of standards in urban areas throughout the USA, and attempted to ameliorate problems related to urban air pollution, air toxics, acid deposition and stratospheric ozone depletion (Jacobson, 2002). Non-attainment areas for O_3, CO and PM_{10} were classified into six categories based on severity and given strict deadlines for attainment. The 'lowest achievable emission rate' was required for new sources and 'reasonably achievable control technologies' for existing sources to reach attainment (Jacobson, 2002). Emission inventories, conducted by state authorities, had to be developed for reactive organic gases (ROG's), NO_x and CO, including mobile, stationary point, area and biogenic sources. The list of hazardous air pollutants was expanded to 189, and the US EPA was required to develop emission standards for each source category, and depending on emissions, 'maximum achievable control technology' was necessary for sources (Jacobson, 2002). The Amendments tightened emission standards for vehicles, relinquished state control of permitting for point sources to a federal programme, required additional reductions in acidification precursors, and mandated reductions in CFC's. Additional amendments were made in 1997, most notably to the particulate matter and O_3 standards as discussed. A complete list of the NAAQS is presented in Table 3.5.

The drafting of pollutant standards for ambient air and entrenching of these in legislation indicated that the USA had firmly adopted the AQM approach to air pollution control. In addition to the command-and-control regulations used, the USA made use of market-based instruments and emission standards to achieve air quality goals (Elsom, 1992). Responsibility for AQM is divided between state and federal levels of government, with the federal authority being the US EPA. The state of California is frequently cited as exceptional, as the degree of pollution and related non-attainment experienced in the state, most notably in Los Angeles and surrounds, allows more stringent measures than elsewhere to be adopted. Ambient standards and technological measures employed in the state exceed federal requirements; however, the Clean Air Act does include a mandate for states to employ such controls with adequate consultation. The SIP is an important tool in achieving standards and has been duplicated in other national strategies, although, the focus on attainment is construed as a drawback, limiting innovation in control and strongly focused on modelling (Committee on Air Quality Management in the United States, 2004).

Table 3.5. Summary of the NAAQS, with the updated standards for all pollutants (Source: Jacobson, 2002)

Pollutant	Federal Primary Standard	Federal Secondary Standard
Ozone 8-hour average 1-hour average	 0.08 ppmv [b] 0.12 ppmv [c]	 Same as primary Same as primary
Carbon monoxide 8-hour average 1-hour average	 9.5 ppmv 35 ppmv	
Nitrogen dioxide Annual average	 0.053 ppmv	 Same as primary
Sulphur dioxide Annual average 24 hours 3 hours	 0.03 ppmv 0.14 ppmv 	 0.5 ppmv
Particulate matter ≤10μm 24-hour average Annual arithmetic mean	 150 $\mu g.m^{-3}$ [d] 50 $\mu g.m^{-3}$ [e]	 Same as primary Same as primary
Particulate matter ≤2.5μm 24-hour average Annual arithmetic mean	 65 $\mu g.m^{-3}$ [f] 15 $\mu g.m^{-3}$ [g]	 Same as primary Same as primary
Lead Calendar quarter	 1.5 $\mu g.m^{-3}$	 Same as primary

[b] Standard exceeded if 3-year average of fourth-highest daily maximum 8-hour average ozone mixing ratio exceeds 0.08 ppmv
[c] Standard exceeded if value is exceeded more than once per year, averaged over 3 consecutive years (applies only to nonattainment areas designated prior to 1997 revision)
[d] Standard exceeded if 99th percentile of distribution of concentrations over 1 year, averaged over 3 years, exceeds value at each monitor in area
[e] Standard exceeded if concentrations, arithmetically averaged over 1 year, exceeds value on average for 3 consecutive years
[f] Standard exceeded if 98th percentile of distribution of concentrations over 1 year, averaged over 3 years, exceeds value at each monitor in area
[g] Standard exceeded if 3-year average of concentrations exceeds value

3.4 Summary

Air pollution control is defined by a number of legislative documents as well as the shift in the approach to governance as a whole. The Constitution remains the primary guidance document for the development of policy and legislation in South Africa, and the securing of the environmental right in Section 24, set in motion a process of law reform, which redefined environmental management through NEMA, the IPWM policy, the NAQMP, the AQA, and at a municipal level, the National Health Act. Government has shifted in meaning to governance, the result of both international trends and national democracy. Local government has undergone a major transformation and is regarded as an autonomous tier of government, capable of self-regulation and given powers to facilitate this; however, capacity and resources remain issues of concern. In terms of the AQA, local government is given significant responsibility for implementation, including appointing AQO's, monitoring air quality and emissions, and drafting an AQMP for inclusion in their IDP's, which is the primary planning tool for local governments. Guidance for AQM can be offered from the experiences of other countries and institutions, such as the USA, EU, UN, and the WHO, each of which has made internationally recognised contributions to the field.

CHAPTER FOUR
DATA AND METHODOLOGY

4.1 Introduction

The study focused on the three district municipalities of Ugu, Uthukela and Uthungulu, which were outlined in Figure 1.1. The assessment of the capacity of municipalities was based on qualitative data, comprising a review of literature and interviews with key personnel involved in pollution control functions in the municipalities sampled. Various literature sources informed an understanding of AQM, and the implementation of this approach according to the AQA. A review of the IDP's of municipalities aided the identification of relevant pollution issues in the municipality. The analysis of interviews facilitated capacity assessments and thereafter, the development of a framework to guide the implementation of the AQA by municipalities.

4.2 Integrated Development Plan Analysis

A preliminary review of municipal IDP's in the province of KwaZulu-Natal was conducted to determine municipalities to include in the sample. Following the selection of three district municipalities, an in-depth desktop study was undertaken to identify pollution control issues, including those identified by the municipality and gaps identified by the researcher. Air pollution sources and related air quality issues, as raised in the IDP's were noted, together with related environmental management principles and policy. A large number of additional air pollution issues, which municipalities had not considered as influential on their pollution burden, were identified through analysis of the IDP's. These included issues that had not yet developed into pollution problems and were not addressed by municipal controls, those that were not recognised as causing pollution, and elaborations on issues identified by municipalities. These issues were organised into categories.

Similarly, developments that have the potential to impact on air quality in the future were also identified and categorised according to common themes. These issues were, largely, the associated impacts of development that the IDP's focused on, where little consideration was given for the environmental costs of service delivery and economic development. Additional issues of relevance to the study in that they offered insight into areas, such as governance and environmental management that influence AQM in municipalities, were also identified.

The IDP analysis provided a baseline assessment and indication of air quality in the sample municipalities, and determined the nature of municipal actions that address the unique air quality scenario. The analysis also allowed interviews to remain relevant to individual municipalities. The

IDP's prepared by district municipalities in 2002 formed the major part of the analysis, with the 2005/6 review and the IDP's prepared by the constituent local municipalities also consulted.

4.3 Interview Methodology

Interviews with key personnel formed the fundamental basis of the capacity assessment, with municipalities indicating their state of preparedness for implementing the AQA. Purposive sampling was used to identify individuals with air pollution control involvement and responsibilities. An initial reluctance to participate was observed. Reasons cited included the lack of pollution issues, lack of municipal resources or little progress with the AQA; however, the researcher was able to motivate them and secure greater co-operation through informing them of the purpose of the study. The majority of municipalities identified the Environmental Health Department as the seat of implementation of pollution control. Environmental Health Practitioners (EHP's) and the associated management tier formed the bulk of the interview sample. Related departments with influence on air quality were also sampled; however, minimal co-operation with Environmental Health Departments was noted, limiting the number of individuals able to provide constructive responses.

Only a limited number of local municipalities within the district municipality indicated the presence of pollution issues to any degree and the availability of personnel to address pollution control. Frequently, the municipalities referred to other local municipalities or the district municipality as the location of pollution control functions; municipalities that were rural or with a small urban core had limited available resources to address pollution control and received assistance from other authorities. Rural and peri-urban municipalities in the sample also indicated that few pollution issues were raised in the municipality and large resources for control were unnecessary. Industrial activities were observed as the core motivation for control and municipalities where industrialisation was limited or the economy was structured around other activities placed little emphasis on pollution control. The limited human resources of municipalities to address pollution control restricted the sample size.

The sample comprised eighteen respondents who answered open-ended interview questions either in-person, or where time constraints applied, over the telephone (Table 4.1). Open-ended questions were used to provide information-rich responses to develop a comprehensive understanding of the pollution control functions of the municipality and inform the development of the implementation framework. Questions were presented iteratively to facilitate information provision, with minimal suggestion by the interviewer to reduce bias in responses. The interview questions addressed human resources, familiarity with AQA and implementation activities, and AQM technical and management capabilities. A copy of the interview questionnaire is provided in Appendix 1. A pilot study of two interviews with respondents from the Council for Scientific and Industrial Research (CSIR) and Ethekwini Municipality involved in AQM was used to refine the interview questions.

Table 4.1. List of respondents participating in the study

No.	Department	Municipality	Date
Respondent 1	Environmental Health	Umtshezi/Provincial	25-07-2006
Respondent 2	Social and Community Services	Umtshezi	28-06-2006
Respondent 3	Municipal Health Services	Uthukela	23-11-2005
Respondent 4	Environmental Health	Uthukela	23-11-2005
Respondent 5	Environmental Health	Uthukela	28-06-2006
Respondent 6	Environmental Health	Uthukela	28-06-2006
Respondent 7	Environmental Health	Uthukela	28-06-2006
Respondent 8	Environmental Health	Uthukela	11-07-2006
Respondent 9	Environmental Health	Hibiscus Coast	30-11-2005
Respondent 10	Health Services	Hibiscus Coast	30-11-2005
Respondent 11	Environmental Health	Ugu	28-09-2006
Respondent 12	Community Services	Uthungulu	18-11-2005
Respondent 13	Environmental Health	Uthungulu	07-11-2005
Respondent 14	Community Services	Umhlatuze	07-11-2005
Respondent 15	Public Health	Umhlatuze	13-07-2006
Respondent 16	Environmental Health	Umhlatuze	02-11-2005
Respondent 17	Environmental Health	Umhlatuze	07-11-2005
Respondent 18	Environmental Planning	Umhlatuze	07-11-2005

Additional perspectives were also derived from relevant stakeholders who were not employed by municipalities, as well as individuals from municipalities whose functions were not directly related to pollution control and hence were unable to provide meaningful responses to the interview questions. The latter refers particularly to personnel from the Planning Departments of municipalities, as corroboration from planners regarding AQM activities was necessary. These perspectives are external to the main set of results and are used for guidance and comment on the AQM process in municipalities. The respondents who provided additional perspectives are listed in Table 4.2.

Some shortcomings were evident in the interview methodology; however, they were not viewed as compromising to the overall results. Regarding the sample of interviewees, local municipalities with identified consideration of air pollution control, as a result of air pollution issues in the municipality, were sampled. Local municipalities in the district that indicated that they had no personnel or resources dedicated to air pollution control during preliminary consultation were not sampled. The initial focus of the study was on district municipalities but was extended to include local municipalities displaying resources following communication with district officials. The lack of personnel for interviews and the non-urban nature of excluded local municipalities suggested a limited impact on the outcomes of the study.

Table 4.2. Additional perspectives from respondents outside the main sample

No.	Department	Organisation	Date
Respondent 19	AQM & Climate Change	DAEA	24-01-2006
Respondent 20	Air Quality Unit	CSIR	29-06-2006
Respondent 21	Public Relations	RBCAA	23-01-2006
Respondent 22	-	Ecoserv	26-07-2006
Respondent 23	Planning	Uthukela District Municipality	23-11-2005
Respondent 24	Planning & Development	Uthungulu District Municipality	29-11-2005
Respondent 25	Environmental Health & Disaster Management	Ugu District Municipality	28-11-2005

An additional shortcoming was evident in the interview methodology, where AQA responsibilities and implementation were not clearly interpreted by interviewees resulting in some contradiction in the results for these questions; however, the conflict did not hinder the analysis. An aspect of the interviews, which limited the study, were the incomplete responses given by two respondents due to time constraints. Attempts were made by the researcher to contact the individuals, however these were unsuccessful and the incomplete responses were incorporated into the study. This resulted in the total number of responses being reduced from 18 to 16 for some of the questions.

4.4 Interview Analysis

Interviews were transcribed into analysis tables for each district, which allowed for the easy interpretation of results. Significant responses to questions were identified and noted, and thereafter, summary tables were organised, with percentage statistics to highlight key responses. Entries in the tables were elaborated upon based on the responses and a complete representation given of the implementation, current and planned, by the municipality of the various areas of AQM and the AQA. Distinct categories of questions were identified and the presentation of results arranged accordingly. Capacity assessments for each municipality were informed by the summary of implementation results and judgements on capacity based on the expected capacity needed for AQM implementation, as guided by theory, using the all-encompassing definition of capacity as a guide for assessment. Some intuitive guidance in this regard was provided by the '6 S model', or 'rapid capacity assessment model', used by Danish authorities and promoted by DEAT as a means to approach capacity-building holistically (Lukey, 2006; T&B Consult, 2002). The model makes use of six criteria to determine the capacity of an organisation; these are Structure, Systems, Skills, Incentives, Strategy, and Inter-relationships. They relate to various operational and strategic components, such as division of labour, organisational tools, skills of staff, strategic alignment of resources, and relationships with other organisations.

Following the investigation and assessment of capacity in municipalities, response themes were identified and analysed based on inputs from literature and legislation. The comparison of analysed responses to theoretical references identified the strengths and weaknesses of municipalities' approaches to AQM and the implementation of the AQA. The themes provide an essential reference to the major issues arising from the capacity assessment. These are elaborated upon to highlight areas of concern where further input is needed and areas that are functional and can be capitalised on in implementation.

4.5 Development of Framework for Implementation of AQA

The framework considered a number of areas that have input into the implementation. The conditions and stipulations of the AQA were the fundamental influence on the development of the framework, as it is necessary to comply with the legislation. The terminology used in the framework is a reflection of the terms used in the AQA and developed consistency and a common understanding of the inferences in the framework. The relevant theoretical concepts, together with examples, identified earlier in the text provided definition and guidance to the framework. The central constructs of AQM grounded the framework in a theoretical understanding, shaped by accepted practices. The examination of the literature allowed the development of outcomes that are relevant, accepted and workable.

Themes identified from practical exercises were inputted into the framework as well, informing the practical context into which the framework is expected to fit. The constraints and opportunities identified from the capacity assessments influenced the development of the framework by producing recommendations and processes that directly addressed the application of municipalities. Municipal IDP's informed the development through the context of planning and municipal situation assessment. IDP's outline the nature of future development in the municipalities and available budgetary resources, as well as the current pollutant load and air pollution issues in the municipality.

The framework was divided into three steps, with progress to higher steps indicating the presence of greater pollution issues. Steps one and two were designated as mandatory, fulfilling the requirements of the AQA for municipalities. Step one was intended to develop basic policy and management capabilities. Step two dealt with implementing AQM in municipalities. Step three was congruous to priority area management; however, was not specifically designed to address this issue, as guidance from DEAT is still forthcoming in this regard. Additionally, participation and consultation were advocated throughout the steps in the framework as a means of improving the sustainability of introduced measures, and AQM as a whole, in municipalities.

CHAPTER FIVE

AQA IMPLEMENTATION: LOCAL GOVERNMENT PERSPECTIVES

5.1 Introduction

The AQA represents a radical shift in the approach to air pollution control in South Africa, and as such, the implementation of the Act is a challenge as well as an opportunity for innovation. Critically, it places emphasis on the local government tier as the area of greatest action. Responsibilities are delegated to the level of government that has the most significant interactions with communities and commercial enterprises. While the legislative drive remains vested at the national tier, action commitments rest with local authorities. Monitoring of air quality, licensing of emitters, and the development of a comprehensive AQMP are among the requirements for local government structures. Although guidance is provided by national and provincial agencies, as well as assistance where needed, the AQA raises numerous questions regarding the implementation at local government level. Inconsistencies and the inability to deliver by local authorities will seriously compromise the overall effectiveness of the legislation. As such, the research has focused on local government and the ability to fulfil the responsibilities with respect to the AQA.

5.2 Air Quality Issues

The identification of air quality issues in the municipalities, both existing and potential, and the municipalities' plans to address these is indicative of the capability present in the municipality to deal with air pollution, as well as the emphasis placed on air quality as an aspect of improved quality of life. IDP's are the foremost planning tool for local government, detailing the budgetary and personnel commitments of the municipality over the medium- to long-term, and provide the means for municipalities to access financial resources outside of the limited taxation inflows available to them, extending to provincial and national ministries, grants and aid. Therefore, plans for AQM in the municipality, or any form of pollution control, would have to be included in the IDP to ensure the resource allocation for implementation.

5.2.1 Air Quality Issues identified by Municipalities

Air pollution sources and issues identified by the municipality in the IDP's are an initial step to determine recognised issues experienced in the municipality and plans to address these. A comprehensive analysis of identified issues in the IDP's is presented in Table 5.1. Air quality issues were generally incorporated into the environmental analysis section of IDP's, with Umhlatuze emphasising air pollution issues, and Uthukela also providing some emphasis on air pollution in the district.

Table 5.1: Air pollution sources and issues identified by the municipality in IDP's (Sources: Emnambithi/Ladysmith Municipality, 2002; Emnambithi/Ladysmith Municipality, 2005; Hibiscus Coast Municipality, 2002; Hibiscus Coast Municipality, 2005; Ugu District Municipality, 2002; Ugu District Municipality, 2005; Umhlatuze Municipality, 2002; Umhlatuze Municipality, 2005; Umtshezi Municipality, 2002; Umtshezi Municipality, 2005; Uthukela District Municipality, 2002; Uthukela District Municipality, 2005; uThungulu District Municipality, 2002; and uThungulu District Municipality, 2004)

District	Air pollution sources & issues
Ugu	None identified by Ugu.
Hibiscus Coast	◦ Need for clean air in Margate ◦ EMP & Strategic Environmental Assessment (SEA) needed ◦ Plans for Open Space System
Uthukela	◦ Air pollution from urban and smaller settlements a major issue ◦ Haze from industry evident in towns, especially Ladysmith and Estcourt ◦ Ladysmith has restricted air pollution dispersion due to meteorology ◦ Domestic burning, biofuel use from informal settlements ◦ Air quality is deteriorating, industrial emissions lowering air quality in Ladysmith and Estcourt ◦ Veld fires ◦ Acknowledge NEMA and IPWM policy
Umtshezi	◦ Vehicle exhaust, noise pollution ◦ Air pollution related to respiratory illness and infant mortality ◦ In implementing the Land Use Management System (LUMS), identify areas of environmental significance
Ladysmith/ Emnambithi	◦ 1997 CSIR report– air pollution standards close to exceedance ◦ Pollution management – key environmental issue – in Environmental Management policy
Uthungulu	◦ Air pollution recognised as a general issue requiring attention ◦ Industrial air pollution in Richards Bay and Empangeni ◦ Mining, cane burning ◦ Built up areas and dense settlements lead to air pollution ◦ Umhlatuze local municipality most affected – high levels of industry and pollution ◦ EMS needed – manage activities with holism and integration, form guidelines for projects ◦ Develop strategies and projects for solutions to environmental problems ◦ Integrated environmental programme for sustainable development – waste and pollution generation examined
Umhlatuze	◦ Buffers identified – no-go areas in air pollution hotspots ◦ Air quality investigations done and emphasised ◦ Focus on monitoring air pollution – done by Environmental Health

Ugu district municipality did not identify any air pollution issues, or related environmental management issues, with regard to the development plans for the district. Hibiscus Coast local municipality identified the need to maintain the air quality in Margate, a prime tourist destination in the municipality and the need for broader environmental management tools to be developed.

Uthukela district municipality identified noteworthy pollution issues in the district, with industries identified as a significant source. The poor dispersion characteristics of Ladysmith have reference for policy and actions. Acknowledgements of environmental management policy were made, suggesting awareness and possible progress towards implementation. In Umtshezi local municipality, an additional issue of pollution from motor vehicles was raised, which may have implications for the municipality regarding AQM later. The inclusion of environmental issues in land use planning suggests environmental concerns are taken note of in the municipality, influencing future developments. Ladysmith/Emnambithi local municipality, where the Environmental Health department has been incorporated into the district municipality since the publication of the IDP, was identified to be near exceedance of ambient standards, implying the existence of serious pollution issues. Accordingly, pollution management is a key issue in the municipality.

Air pollution is raised as a general issue of concern in Uthungulu district, and economic activities are the main contributors, with Umhlatuze having the highest level of industrialisation, and air pollution. A number of policy initiatives are proposed to address environmental problems, especially waste and pollution generation. Umhlatuze local municipality has progressed on the matter of addressing air quality issues by emphasising monitoring and using pollution concerns to influence land use planning. An emphasis on air quality investigations is also noted in the IDP, suggesting both capability in and consideration of pollution control by decision-makers.

5.2.2 Air Quality Issues identified by Analysis

In addition to the issues identified by municipalities, the study aimed to identify further issues that municipalities may not regard as directly influencing air quality or may have overlooked through lack of expertise in the field. Pollution issues and sources that may present hindrances to the municipalities' compliance with the AQA regulations, as well as influencing the overall structure of AQM, were differentiated into significant categories. The issues are listed in Table 5.2.

Manufacturing and other industrial activities were noted in all municipalities, with various sectors of production prevalent. Uthungulu had very significant emissions from manufacturing industries and the presence of highly polluting industries such as primary aluminium manufacturing. Biomass burning was common, with numerous motivating factors across municipalities, including veld, grazing and forest fires. A combination of intentional and accidental burning was evident. Uthukela noted a high incidence, especially in the Drakensberg mountainous regions, where burning was linked to visibility problems. Domestic fuel burning was an issue in all districts and linked to the lack of electricity provision; fuelwood was a common choice of biofuel. Uthukela district had air pollution issues close to urban centres due to the proximity of informal settlements, which were unserviced and used biofuels.

Table 5.2: Current air pollution sources and issues identified from IDP analysis (Sources: Emnambithi/Ladysmith Municipality, 2002; Emnambithi/Ladysmith Municipality, 2005; Hibiscus Coast Municipality, 2002; Hibiscus Coast Municipality, 2005; Ugu District Municipality, 2002; Ugu District Municipality, 2005; Umhlatuze Municipality, 2002; Umhlatuze Municipality, 2005; Umtshezi Municipality, 2002; Umtshezi Municipality, 2005; Uthukela District Municipality, 2002; Uthukela District Municipality, 2005; uThungulu District Municipality, 2002; and uThungulu District Municipality, 2004)

Sources	Ugu	Uthukela	Uthungulu
Industrial: manufacturing, combustion	◦ Manufacturing ◦ Cement production & transportation, paper mills, sawmills	◦ Manufacturing ◦ Chemical, timber, clothing & textile	◦ Manufacturing ◦ Paper mill, iron & steel manufacturing ◦ Harbour – bulk handler
Biomass burning	◦ Veld, forest fires	◦ Game hunting, grazing, cultivation, accidental & arson veld fires	◦ Grazing fires
Domestic fuel burning	◦ Households not electrified – fuelwood	◦ Urban informal settlements - biofuels	◦ Rural – not electrified – fuelwood
Transportation, Motor vehicles	◦ National road ◦ Low rail use - decline - road congestion ◦ Airport upgrade ◦ High volume tourist inseason ◦ Public transport improvement planned	◦ National road ◦ Road – heavy haulage ◦ Rail under-used ◦ Airport - renovated	◦ National road ◦ Road – heavy haulage ◦ Harbour ◦ Rail under-used ◦ Transport industry – export-driven ◦ Thoroughfare to other districts
Landfills	◦ Rural – solid waste management needed	◦ Mainly individual sites	◦ Rural – no disposal ◦ Regional vs. local site
Agriculture	◦ Cane burning & transport, timber ◦ Erosion ◦ Uncontrolled grazing, unsustainable cultivation	◦ Livestock ◦ Soil erosion – rural ◦ Extensive fertiliser application ◦ Veld fires ◦ Woodlots	◦ Cane burning, transport ◦ Forestry ◦ Soil erosion – dust ◦ Traditional agriculture growth ◦ Unsustainable grazing
Implied from Land Use Management	◦ Landscape favours high concentrations – steep gorges, 42 rivers ◦ Unsurfaced rural roads ◦ Tourism – high traffic, need pristine environment ◦ Reserves – vegetation emissions ◦ Illegal sandwinning – uncontrolled dust ◦ Increase in development	◦ Mountains, river valleys – inversions ◦ Tourism promotion ◦ 'Berg – conservation ◦ Dense urban informal settlements ◦ Dispersed rural settlements – services ◦ Towns densely populated ◦ Marshes, wetlands ◦ Bedrock exposed by erosion	◦ High rural population ◦ Clustering of populations ◦ Inland – dry, hilly ◦ Large wetlands ◦ Nature reserves & forests ◦ Untarred roads
Mining	◦ Limestone mining	◦ Coal, sand mining ◦ Rock & gravel quarry	◦ Heavy mineral extraction - dunes ◦ Sand
Construction	◦ Access roads ◦ Water provision ◦ Sewerage ◦ Community centres	◦ Access roads ◦ Electricity provision	◦ Housing ◦ Activities concentrating in urban areas

A number of transport-related issues were identified in districts, with the presence of a major national road raising concerns in all districts, especially the heavy haulage noted in Uthukela and Uthungulu.

Good road networks promoted vehicle use, with the under-utilisation of rail networks observed in all districts, although coal transport by rail was significant in Uthungulu. Intermittent high tourist volumes in Ugu, airport upgrades in Ugu and Uthukela, and a busy harbour and export-driven transport activities in Uthungulu are additional concerns for air quality in the districts.

The lack of solid waste management, especially in rural areas, presents a pollution issue due to the lack of control on emissions. Poorly managed communal or household dumpsites present an environmental health hazard, particularly through the emissions from the decomposing material that is not vented or burnt off as is done at landfill sites. Agriculture is a major activity in Uthukela and Uthungulu districts. Sugar cane cultivation and forestry are dominant in Ugu and Uthungulu, with cane burning, VOC emissions from forests and materials transportation being pollution sources. Soil erosion, and the resultant windblown dust, is an issue in all districts, being common in rural areas and associated with poor farming practices. Unsustainable cultivation and uncontrolled grazing contribute significantly to the high incidence of soil erosion experienced in the rural areas of municipalities.

Atypical factors influencing air pollution that are linked to land use management include the topography, which inhibits dispersion of pollution in Ugu and Uthukela, especially Ladysmith, and the large wetland system in Uthungulu. Wetlands are associated with notable pollutant emissions, due to biological processes, and the presence of a large system in proximity to an area experiencing elevated pollution levels can alter pollutant load. The concentration of population in urban areas can cause localised pollution and contribute to impacts, as well as increasing the level of exposure. The impact of tourism and tourism promotion can alter pollution levels, as experienced in Ugu during vacation periods, by increasing transport-related emissions, energy use and construction of attractions and accommodation. Nature reserves and conservation areas also contribute to pollutant load through vegetation emissions, although this is dependant on the size of reserves and their relative proportion to the municipal area.

Mining is considerable in all districts, with different foci. Coal mining in Uthukela could factor into fuel availability in the area by making coal available cheaply and encouraging its use, as opposed to cleaner fuels and electricity use. The mining activities carried out in municipalities also raise particulate matter concentrations. The construction projects underway in the district have implications for elevating dust levels and transport movements. In addition to the construction phase, the creation of access road promotes motor vehicle use and can increase transport-related emissions.

5.2.3 Potential Air Quality Issues

The analysis also identified planned activities in the IDP that may affect air quality at a later stage. The activities are detailed in Table 5.3. Direct and indirect impacts on air quality were differentiated.

Direct impacts affect air quality by carrying out the activity and influence the emissions profile of the municipality. Indirect impacts were seen as altering air quality by other means than directly through performing the activity. These impacts were observed more frequently, although, generally, have lower associated pollutant levels.

Several economic development activities were noted that had the potential to alter air quality in the districts, partially due to the development focus of the IDP's. In addition, consideration of potential air quality impacts of these developments was lacking in the IDP's. Road construction and the promotion of local economic development activities, such as agriculture and mining, were common direct impacts across districts. In Uthungulu, economic development was industrially-focused, emphasising the provision of bulk services and expanding the manufacturing thrust of the district. Uthukela shared the growth of industrial output as an impact arising from economic development. Facilities development, local economic development activities including tourism, and work towards the provision of services was uniformly emphasised across municipalities. The construction phases of these projects present the greatest impact on air quality, although developments that increase travel can cause elevated levels of transport-related pollution.

Housing development was also uniformly emphasised although a strategic analysis of environmental impacts from the development were not indicated. The expansion of informal settlements, which are associated with air pollution from domestic fuel burning, was the only direct impact observed in IDP's. Indirect impacts from construction and habitat destruction, as well as necessary transport infrastructure, are associated with housing provision. Waste management presents a possible major air pollution source; landfill developments in Uthukela and Uthungulu could lead to unexpected additions to emissions in these districts. Air quality deterioration could be observed in areas neighbouring landfills and sewerage plants, and changes to waste management, as proposed in Ugu, could result in improvement or decline of air quality. Indirect impacts were not identified from waste management developments in the IDP's.

Basic services provision is resource-intensive and carried out at significant scales in municipalities; major projects implemented without consideration of the strategic scale of environmental impacts have the potential to alter the pollutant load of a municipality. Construction activities can directly increase pollution, as well as sanitation improvements planned across districts. Crematoria have been associated with elevated concentrations of pollutants, and transport improvements have an impact on air pollution. Other basic services, such as water and electricity provision, affect air quality indirectly through construction, on a local scale, and natural resource use, on a strategic scale.

Table 5.3: Potential air pollution sources and issues identified in IDP (Sources: Emnambithi/Ladysmith Municipality, 2002; Emnambithi/Ladysmith Municipality, 2005; Hibiscus Coast Municipality, 2002; Hibiscus Coast Municipality, 2005; Ugu District Municipality, 2002; Ugu District Municipality, 2005; Umhlatuze Municipality, 2002; Umhlatuze Municipality, 2005; Umtshezi Municipality, 2002; Umtshezi Municipality, 2005; Uthukela District Municipality, 2002; Uthukela District Municipality, 2005; uThungulu District Municipality, 2002; and uThungulu District Municipality, 2004)

Sources	Ugu	Uthukela	Uthungulu
Economic development: Direct	◦ Upgrade rural roads ◦ Develop community mining ◦ Promote agriculture, woodlots	◦ Promote agriculture ◦ Revitalise industrial sector ◦ Develop urban areas – Ladysmith ◦ Construct new highway ◦ Create rural service centres, corridors	◦ Planned SDI initiative, IDZ ◦ Expand coal-handling facilities, construct container facility ◦ Develop transport corridor, upgrade roads, access roads ◦ Develop coastal zone ◦ Develop possible airport, abattoir ◦ Construct direct route to Gauteng ◦ Promote growth of small growers
Indirect	◦ Increase telecommunications density ◦ Develop tourism inland ◦ Introduce community environmental management ◦ Understand urban-rural development link ◦ Create youth facilities	◦ Construct major dam ◦ Prioritise electricity provision ◦ Improve access to communication ◦ Improve schools, create possible technikon, university ◦ Develop public, sports facilities ◦ Develop new tourism ventures, promote rural tourism, craft centre ◦ Has high erosion risk – limits development	◦ Maximise tourism ◦ Promote rural SMME, service delivery, public works, transfer of technology ◦ Develop community facilities, youth services ◦ Improve school, clinic infrastructure ◦ Develop possible market ◦ Promote community natural resource use
Housing: Direct	◦ Has expanding informal settlements		
Indirect	◦ Has dispersed settlement ◦ Has services backlog	◦ Construct housing	◦ Construct housing ◦ Has large backlog
Waste management: Direct	◦ Plans for waste management	◦ Construct sewerage plant ◦ Construct landfill ◦ Construct industrial waste site ◦ Construct rural disposal site	◦ Construct regional landfill
Indirect	-	-	-
Basic services provision: Direct	◦ Provide sanitation	◦ Improve sanitation	◦ Improve sanitation ◦ Expand crematorium ◦ Develop rural public transport
Indirect	◦ Provide water to rural ◦ Build rural schools ◦ Has intervention from national government	◦ Proceed with land reform, service delivery ◦ Provide water – households ◦ Conduct electrification	◦ Conduct rural electrification ◦ Possibly construct dam

Related aspects of governance and environmental management were identified by the study as additional issues. The issues were viewed as influences on the implementation of AQM in the districts. Ugu district had identified governance and capacity-building issues, including a lack of enforcement of existing legislation. Environmental management and protection in the district was also necessary for tourism development. Hibiscus Coast local municipality specifically, identified a need for a Land Use Management System and the integration of Local Agenda 21 principles into activities. The need for work on institutional capacity to achieve environmental objectives and the recognition of the IPWM policy were further issues.

Uthukela district considered NEMA as relevant legislation in addressing environmental issues, and recognised the change in the role of local government from a funding and development institution to a self-supporting sphere of government. Ladysmith/Emnambithi local municipality raised the additional perspective of the environment as a major asset and identified significant environmental organisations in the municipality. The development of an EMP, and plans to conduct a SEA and draft an Open Space System, were also identified in the IDP. Uthungulu district identified constraints of a lack of environmental-based capacity, ill-defined environmental processes, and the absence of strategic planning and implementation. The IDP was viewed as a core function of the district municipality, with environmental management identified as a crosscutting function. Umhlatuze local municipality had made plans for the preparation of an EMS, and the implementation of a Metropolitan Open Space System and Coastal management Zone.

5.3 Capacity of Municipalities

The capacity of municipalities reflects directly on their ability to implement AQM and provides an implicit measure of their readiness, both current and future, to turn legislation into real-world outcomes. Interviews with relevant personnel, and those identified as being key in the implementation, generated responses that are indicative of the capabilities of the municipalities selected as case studies. These allow for judgements on capacity to be made on issues pertinent to implementing AQM, including familiarity with the AQA, the skills present, and ability to develop AQM capabilities in the future. The following sections comprise the outcomes of the qualitative data collected and are presented according to the interpretation of AQA relevant requirements of AQM. The section on the interpretation of the AQA is split to address the familiarity of the municipalities with the requirements, the aspects of AQM implemented, and the challenges. The section on human resources capacity examines the staffing and training characteristics of municipalities for AQM. AQM technical requirements of emissions inventories, monitoring, modelling and source identification, as well as management capabilities of planning and communication are presented in detail subsequently. Lastly, the use of success indicators by municipalities for assessing progress in control is addressed.

5.3.1 AQA Interpretation

The interpretation of the AQA is fundamental to the successful implementation of the legislation, as both the responsibilities of various tiers of government and the approach to AQM are described therein. Understanding of the act should extend to the detailed responsibilities, with regard to the relevant tier of government, their expression in the authorities' implementation, and the challenges facing the enactment of the AQA. The responsibilities of local government, for AQM, have been detailed in Section 3.3.2.2. The responses of municipalities have been compared to these and assessments made of the awareness of the municipalities. AQA implementation activities were observed together with the responsibilities to indicate the actions that followed the identification of responsibilities. The challenges, as listed by respondents, served to identify the difficulties facing local government specifically and highlighted areas where improvements can be made and possible actions focused. These are detailed in Table 5.4.

Table 5.4: AQA Interpretation by Municipalities

Issue	Identified Component & Corresponding Percent of Responses
Responsibilities under AQA	Monitoring (94%) Enforcement (53%) Developing an AQMP (12%) Appointing an AQO (6%) Licensing (35%) Advisory and audit role (12%)
Implementation	Development of AQMP (17%) Appointment of AQO (56%) Monitoring (28%) Conducting an emissions inventory (11%) Modelling (6%) Inspections (11%) Within Uthukela: Staff transfer (67%)
Challenges	Funding (78%), separated into staffing (61%), equipment (50%), training (33%), and monitoring (44%) Social concerns (39%) Legislative issues (28%) Lack of legislative clarity (22%) Industrial co-operation (28%)

5.3.1.1 Familiarity with Requirements of AQA

Familiarity with the AQA expressed by knowledge of the requirements for local government implementation was lacking in municipalities. A general responsibility for the provision of clean air in the area was recognised, as well as the monitoring and enforcement of air quality standards. Ninety-four percent of respondents (16 of 17) listed monitoring and 53% (9 of 17) listed enforcement as local government responsibilities as stated in the AQA, illustrating a strong emphasis on technical capabilities and implementation activities, as discussed later in Section 5.3.3. There was an emphasis on monitoring in all municipalities sampled; however, with regard to enforcement responsibilities, Umhlatuze local municipality and Umtshezi local municipality failed to identify this aspect. Both monitoring and enforcement reflect actions that are currently undertaken, which can be correlated to the high degree of recognition of responsibility.

Provisions for the development of a guideline document to guide air quality management (12%, or 2 of 17), the licensing of emitters (35%, or 6 of 17), and the appointment of an AQO (6%, or 1 of 17), as legislated by the AQA, were not widely acknowledged. The need for an AQMP was solely recognised by the district and local municipalities in Ugu; and Umtshezi local municipality identified the requirement for an AQO in the Act. Uthukela district municipality and Umhlatuze local municipality listed licensing as a responsibility. Ugu and Uthungulu district municipalities did not recognise this responsibility although the AQA specifically states licensing to be a metropolitan or district municipality responsibility. Responsibilities of licensing, planning for AQM and appointing a single individual responsible for AQM, all of which are delegated to municipalities upon the promulgation of the AQA are, largely, unfamiliar measures to municipalities. The unfamiliarity, as well as limited training and awareness of municipalities on the implementation of the AQA, are contributing factors to the generally low response figures.

Respondents in Uthukela district municipality emphasised the advisory and audit role of authorities (12%, or 2 of 17), expecting industries to conduct self-monitoring and record incidents of non-compliance. An inventory of industries in the area and sampling of emissions, with prosecution of offenders if necessary, were additional responsibilities raised by Uthukela district municipality.

An ambiguity in the AQA, which exists regarding the level of municipality responsible for AQM at local government level, limited the recognition of responsibilities, and further influences implementation activities. The aforementioned conflict arises from the definition of municipality given in the 'definitions' section under the 'Interpretation and Fundamental Principles' section of Chapter 1 in the AQA, stating, "“municipality” means a municipality established in terms of the Local Government: Municipal Structures Act, 1998 (Act No. 117 of 1998)". Respondents in the Uthungulu district raised the issue most frequently, as a conflict in the performance of the function is experienced between the Uthungulu district municipality and Umhlatuze local municipality. In light of the developments regarding air pollution control in the AQA, a service level agreement is being discussed between the authorities to determine where the function will be performed, especially as no significant air pollution is experienced outside of the local municipality area.

5.3.1.2 Progress towards Implementation

Municipalities have progressed in the implementation of some AQM measures and did not repeat these as responsibilities, which caused a degree of variance between the responses on AQA responsibilities and implementation (Table 5.4). Districts have made some progress towards implementation of the AQA and a number of elements of AQM are planned or have been carried out. The contrast between responses on responsibilities and implementation indicate unfamiliarity with the AQA, while a general need for action is recognised.

AQMP

Hibiscus Coast local municipality and Uthukela district municipality are developing implementation plans to give effect to the AQA through AQM activities in the municipality. Ugu district municipality proposes to conduct an assessment to identify necessary actions such as drafting of an action plan. Uthukela is intending to prepare an AQM policy as an accompaniment to the implementation plan and has drafted by-laws, which are awaiting promulgation, to give effect to the AQA. Umhlatuze local municipality has drafted a planning document, which can be extended to form an AQMP; however, issues surrounding the municipalities' functions and possible priority area declaration are hampering the extension. Umtshezi local municipality is awaiting guidance on the development of the AQMP from provincial government. Uthungulu district municipality has not progressed in this regard, due to the AQM function being currently located with Umhlatuze local municipality. In summary, planning measures for the implementation of the AQA are not well represented by responses, as only 17% of respondents (3 of 18) were aware of developments towards an AQMP.

AQO

AQO appointment has been completed, or anticipated, in all municipalities, with the exception of Uthungulu district municipality. This is echoed by the identification of the appointment of an AQO as an implementation activity by 56% of respondents (10 of 18). Uthukela district municipality is planning the designation of an AQO, with the delay attributed to the employment of additional EHP's, while Ugu district municipality, and Hibiscus Coast, Umtshezi, and Umhlatuze local municipalities have completed AQO designation. However, during the research period the post in Umhlatuze local municipality fell vacant and is currently undergoing review. The AQA does not stipulate the need for a dedicated AQO and municipalities have opted to designate an officer from the existing number of EHP's with additional AQM duties, in the majority of instances. The progress in the appointment of an AQO is partly the result of pressure from provincial government for an individual responsible for the co-ordination of AQM activities in the municipalities.

Monitoring

Monitoring is undertaken in all districts to differing extents; Umhlatuze municipality in Uthungulu, in partnership with the Richards Bay Clean Air Association (RBCAA), has a monitoring network in place, whereas monitoring data are available in Ugu and Uthukela districts from individual stations recently donated to local municipalities by the provincial Department of Agriculture and Environmental Affairs (DAEA). Umtshezi local municipality in Uthukela is in the process of collecting monitoring data for common pollutants to quantify pollutant levels in Estcourt and intends using the data to identify threshold limits. Monitoring of ambient air quality was only regarded by 28% of respondents (5 of 18) as an aspect of implementing the AQA.

Emissions Inventory

An emissions inventory, as an implementation tool of the AQA, was listed by Hibiscus Coast local municipality and Uthukela district municipality, and regarded by 11% of respondents (2 of 18) as an aspect of AQA implementation. Umhlatuze local municipality has carried out an inventory independently. A number of factors, foremost being the lack of familiarity with the AQA, conflicts in functions between local and district municipalities, and notably, the lack of communication on air quality issues at an intra-departmental level explain the poor awareness overall. Monitoring and emission inventory functions are discussed in detail in Section 5.3.3 on technical capabilities.

Umhlatuze municipality in Uthungulu district has facilitated implementation of the AQA by conducting dispersion modelling, carrying out routine inspections to assess compliance, and issuing notices for cases of non-compliance. Overall, only 6% of respondents (1 of 18) identified modelling as a component of AQA implementation and 11% (2 of 18) identified inspections. Uthungulu district municipality was the only municipality that listed AQM training as an aspect of implementation. The transfer of staff from the Environmental Health division of the provincial Department of Health to supplement current staff numbers at municipalities was an aspect of implementation stated by Uthukela and identified by 67% of respondents within the municipality, as this represented the fulfilment of an anticipated, legislated relocation. An interim memorandum of understanding between Uthukela district municipality and the Department of Health allows the district access to a larger number of EHP's. The re-allocation of staff consolidates the environmental health function, of which air pollution control is a category, at the local level. The relocation is motivated by the conditions stipulated in the National Health Act, which provides for environmental pollution control to be situated at local government level.

In addition, some degree of conflict is present within the municipalities, as local and district municipalities within the sample lacked coordination in AQM efforts. Currently, Uthukela district municipality is not implementing the AQA conditions, however, ambient air monitoring, AQO appointment, AQMP and emissions inventory development are proposed by the municipality. At the time of the interview, Ugu district municipality had not made any progress toward carrying out the environmental health function. In a follow-up interview, Ugu district municipality had maintained the designation of AQO's transferred from Hibiscus Coast municipality and was planning an assessment, together with the DAEA, to guide further AQM actions. Uthungulu district municipality has not progressed in pollution control implementation and, future implementation plans extend to negotiation of an agreement with Umhlatuze municipality to allocate the function effectively.

Umtshezi local municipality in Uthukela district is responsible for running the monitoring station in the town of Estcourt, as well as having appointed an AQO. The municipality is awaiting guidance from the DAEA on developing an AQMP, and is in discussion with industries in the town on conducting an emissions inventory. Assistance in carrying out these AQM functions is provided by the provincial Department of Health. Hibiscus Coast local municipality in Ugu district carries all responsibility for AQM in the local municipal area, although within the study period the Environmental Health Department was transferred to the district municipality. The local municipality was charged with the operation of the monitoring station in Port Shepstone, had appointed two AQO's, and was in the process of drafting implementation plans and conducting an emissions inventory.

Umhlatuze local municipality in the Uthungulu district is currently implementing the AQA and using AQM tools, with no input from the district municipality. As mentioned, negotiations to develop a service level agreement are in progress; however, a large degree of uncertainty surrounds the AQM function in the district. The highly industrialised nature of Umhlatuze municipality necessitated the introduction of pollution control measures prior to the passing of the AQA, and substantial progress on inventory, monitoring, and modelling functions are evident. In addition, under APPA legislation, an Air Pollution Control Officer (APCO) was appointed although the post is vacant at present. An APCO is the position created under APPA legislation, which is similar to the AQO post, to use the relevant term in AQA. The development of an AQMP for Umhlatuze is currently proposed. Duplication of effort, lack of consultation, and limited co-ordination were observed in the relationship between local and district municipalities.

Figure 5.1 summarises the implementation of local and district municipalities graphically, indicating the total number of respondents, together with the proportion that indicated the implementation of the activity. Further, a tick is added to indicate that the activity is currently carried out, or an arrow to indicate that the activity is planned. The figure also displays the lack of communication within the Environmental Health Department, as there are frequent observations of low correlation between level of response and implementation.

5.3.1.3 Challenges

Numerous challenges (Table 5.4) face municipalities in the implementation of the AQA, and, by far, the most significant remains the lack of funding for the various components that are necessary for successful AQM. These include capable staff, project funding and equipment purchasing.

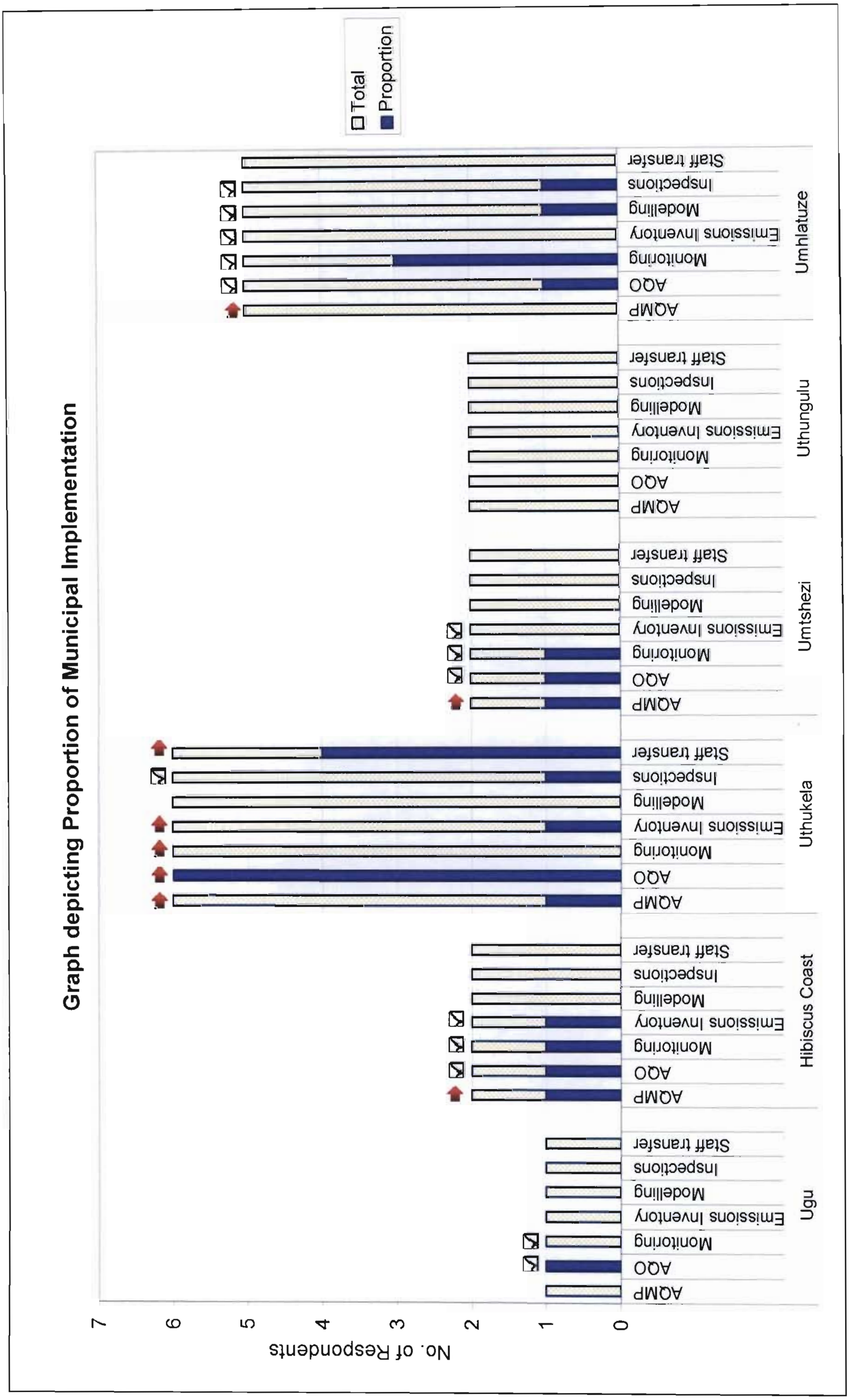

Figure 5.1. Summary Graph of Municipal Implementation

It was also noted by a third of respondents (6 of 18), principally in Uthukela, Umtshezi and Hibiscus Coast municipalities, that individuals have limited qualifications in AQM and further training is inhibited by the lack of funding to facilitate this. The inability to secure qualified individuals, as municipalities cannot offer competitive salaries, was raised in the Umhlatuze municipality. The number of individuals that carry out AQM functions is seen as inadequate to address air quality issues; however, funding is not available to allocate further staff. Monitoring activities were most restricted by the lack of funds, cited by 44% of respondents, in Uthukela, Hibiscus Coast and Umhlatuze municipalities. While the majority stressed the resource limitations, Umtshezi local municipality and Ugu district municipality did not view these as significant challenges.

Various social (39%, or 7 of 18) and legislative (28%, or 5 of 18) concerns were raised as challenges to implementation. The social aspects to implementing AQA included the need for greater transparency in decision-making and the inclusion of more interested and affected parties by Umhlatuze, co-operation across departments, and consultation and communication within the municipality by Uthukela, and employee awareness, and co-ordination of efforts across municipalities by Umtshezi municipality. Local municipalities challenging the ceding of the Environmental Health function to district municipalities, as well as the competency of district and metropolitan municipalities to implement the AQA, were seen as challenges in some cases. Elements of political interference, community resistance and industrial resistance were identified as well, especially in Ugu district. Legal issues pertained to the lack of legislative clarity (22%, or 4 of 18), with the conflict between the National Health Act and the AQA, as well as the ambiguity in the definition of municipality in the AQA identified by the Uthungulu district. The lack of by-laws in municipalities, the slow implementation of the AQA, and lenient permit conditions present challenges to municipalities and were raised by respondents in Umhlatuze local municipality. Contradictions between APPA and the AQA were envisaged as a challenge by Umtshezi local municipality.

Securing the co-operation of industries in the municipality presented a challenge to 28% (5 of 18) of respondents. Specific issues raised were resistance of industries to the siting of monitoring stations, the acceptance of certain agricultural practices by all stakeholders, greater consultation and information provision by industries as advocated in the AQA, and non-compliance with emission regulations. An expected increase in workload related to licensing emitters and, practically, the need to measure accurately were also identified as less significant challenges.

With particular reference to Umhlatuze, the division of powers and functions between the municipality and the RBCAA in view of the promulgation of the AQA was seen as a challenge. The partnership between the Umhlatuze local municipality and the RBCAA involves industries in Richards Bay and local representatives of the DAEA as well. The RBCAA has no regulatory powers and includes government structures to enable decision-making to be influenced and informed by its activities. It is a recognised Section 21 company, making it a non-profit organisation, and is funded by industries on the polluter pays principle, where contributions are calculated in proportion to the contribution of the industry to total SO_2 emissions, as well as membership fees.

The membership is divided equally between industry and non-corporate entities, consisting of six members each, with the local municipality, DAEA, ratepayer's association, Bay Hospital, and the Zululand Environmental Alliance (ZEAL) represented on the management structure and sub-committees. Through the co-management of the RBCAA, a monitoring system was set up in Richards Bay, and funded by industry, and further, an avenue for the public to raise air quality concerns was provided. Ecoserv consultants are contracted to the RBCAA to conduct technical activities, including the operation and maintenance of monitoring stations and dispersion modelling. In light of the AQA, the relationship between the RBCAA and the local authority may require further definition to prevent contradictions with the AQA.

5.3.2 Human Resources Capacity

Table 5.5 summarises the findings on the human resources capacity of municipalities, addressing aspects of staff and training specifically. The availability of personnel, and their capacity, to carry out AQM functions is critical to implementing the AQA. Understanding the staffing resources available to municipalities, as well as plans to improve or augment these, are indicative of functions that will be performed and the level of competency achieved.

Table 5.5: Human Resources Capacity in Municipalities

Issue	Identified Component & Corresponding Percent of Responses
Staff and Training	Air pollution control in Environmental Health Department or Community Services sector (100%) Personnel for pollution control (89%) Personnel responsible solely for air pollution control (6%) Employment of additional staff (28%) Re-evaluate need for additional staff later (56%) Uncertainty over staff transfer (56%) AQM training received (67%) Short course (44%) Tertiary qualifications in pollution control (22%) Pollution control concepts in environmental health studies (72%)

The significant portion of municipalities used the Environmental Health Department to implement pollution control, including air pollution issues. Umtshezi local municipality was an exception, as there was no Environmental Health Department at local level; the broader Social and Community Services Department carried the pollution control function. Uthungulu district municipality had few available resources for carrying out environmental health functions, with Umhlatuze local municipality addressing the majority of pollution control issues. Eighty-nine percent of respondents

(16 of 18) indicated that personnel were available to address pollution control; however, only 6% (1 of 18) indicated that their sole responsibility pertained to air pollution control. In all municipalities, EHP's carried out a pollution control function in addition to their other duties relating to environmental health, with Umhlatuze local municipality employing a specialist APCO to address air pollution specifically and supported by other EHP's, and management-level individuals. Uthukela and Ugu district municipalities have separated tasks by designating geographical areas within which EHP's address all environmental health issues that arise. In contrast, Hibiscus Coast local municipality has designated fields of expertise, where EHP's deal specifically with a field of interest and carry out other general duties as well.

The employment of additional staff was planned according to 28% of respondents (5 of 18), with indications from 56% (10 of 18) overall that with clarity on implementation and the finalisation of staff transfers, the issue would be re-evaluated. Uncertainty over the transfer of staff, either from local to district municipal level or from the provincial Department of Health to district level, was expressed by 56% of respondents (10 of 18) as a cross-cutting issue at all municipalities besides Umtshezi local municipality. Delays related to the transfers, which are legislated by the National Health Act, resulted in implementation of the AQA requirements being postponed.

With regard to specialist training in AQM, two thirds of the sample (67%, or 12 of 18) had received some degree of training in AQM, with 44% (8 of 18) having attended a short course and 22% (4 of 18) possessing tertiary qualifications in pollution control. The relatively large number of individuals trained in AQM is due, largely, to the efforts of a national programme to provide training on AQM, and implemented by DAEA and DEAT using short courses. All municipalities, except Ugu district municipality, had made provision for an individual to attend a short course on AQM or AQA implementation. Ugu municipality had subsequently obtained individuals who had received AQM training following the transfer of staff from Hibiscus Coast. Individuals tasked with the operation of monitoring stations, in Hibiscus Coast and Umtshezi local municipalities, were targeted with more specialised training. A greater proportion (72%, or 13 of 18), which was well represented across districts, was introduced to concepts of pollution control while pursuing environmental health qualifications as most municipalities required a minimum qualification of a National Diploma in Environmental Health as a prerequisite for employment.

5.3.3 Air Quality Management Technical Capabilities

Table 5.6 summarises the technical capabilities of municipalities in the sample, focusing on emission inventory, monitoring, modelling and source identification capabilities. The technical capabilities associated with AQM are often the easiest to implement as they represent tangible outcomes upon which to base planning for action and budgets. In addition, the absence of technical ability seriously hampers the implementation of AQM and the measures that have been developed to improve air quality. Emissions inventories, monitoring, and modelling have been identified as the necessary tools for implementing AQM, whether incorporated into an AQMS or used intuitively, and following is a collation of the efforts of the municipalities sampled.

Table 5.6: AQM Technical Capabilities of Municipalities

Issue	Identified Component & Corresponding Percent of Responses
Emissions Inventory	Conducting emission inventories (47%) Industry participation a factor in inventories (18%)
Emission Sources	Industrial sources (78%) Domestic fuel burning (17%) Motor vehicles (17%) Sugarcane burning (11%)
Emission Types	SO_2 (33%) Particulate matter or dark smoke (28%) Dust (22%) NO_x (11%) Odours (11%)
Monitoring	Monitoring (89%) SO_2 monitoring (22%)
Modelling	Modelling air pollution dispersion (28%)

While inventory processes were being developed or undertaken in all districts, two local municipalities, Hibiscus Coast and Umhlatuze, were carrying out emission inventories within their jurisdictions with no reciprocal activity from the district municipalities of Ugu and Uthungulu. Hibiscus Coast municipality had made progress in inventorying industrial activity, despite limited participation from industries and expected completion within the study period. Umhlatuze municipality had carried out emission inventories previously in collaboration with consultants, with the current inventory informing a baseline assessment and the identification of buffer areas for planning. Inventory development was facilitated by the electronic relay of emissions data from major industries, and regular updates were necessary due to the changes in emissions. The advanced nature of the inventory in Umhlatuze municipality was necessary for the validation of modelling exercises as discussed later. Uthukela district municipality was planning an emission inventory, and Umtshezi local municipality had initiated the process in Estcourt by beginning data collection and entering into discussions with industries for the provision of data.

The inventories conducted for the first time in Hibiscus Coast, Uthukela, and Umtshezi were at the request of DAEA. Overall, three local municipalities and a single district municipality had initiated an emissions inventory; however, only 47% of respondents (8 of 17) indicated the process was being carried out. This discrepancy was highlighted in other aspects of the study as well, where poor correlation between responses and actual activities was evident, and will be analysed in the following chapter. Eighteen percent of respondents (3 of 17) identified industry participation as a factor in conducting the inventory. In addition, the municipalities indicating processes for inventories focused solely on industrial emissions, with the exception of Umhlatuze, which indicated that other non-industrial activities were examined and found to be insignificant in magnitude in the municipal area.

Industrial sources were the primary sources of emissions identified across the sample, with 78% of respondents (14 of 18) listing these as significant in the municipality. Domestic fuel burning (17%, or 3 of 18), motor vehicles (17%, or 3 of 18) and sugarcane burning (11%, or 2 of 18) were identified to a lesser degree as emission sources. Domestic fuel burning is a significant source in Uthukela district municipality, with vehicles presenting a major source in Umtshezi local municipality. Sugarcane burning and the traffic associated with increased vehicle numbers were significant sources in the Ugu district. Veld fires and refuse burning were identified sources of emissions in Umtshezi and Ugu municipalities respectively.

SO_2 was listed as a specific pollutant by 33% of respondents (6 of 18), and particulate matter or dark smoke identified by 28% (5 of 18), and dust by 22% (4 of 18). SO_2 was identified uniformly well across municipalities, with associated particulate matter or dark smoke emissions identified most frequently in Uthukela district. Dust was most prevalent in industrial activities in Umhlatuze municipality, and a less noteworthy source in Hibiscus Coast and Uthukela municipalities. Eleven percent of respondents (2 of 18) viewed NO_x, with a similar proportion listing odours, as a significant emission, these being Umtshezi and Umhlatuze municipalities. Noise was raised as an additional consideration in Ugu district.

Eighty-nine percent of respondents (16 of 18) stated monitoring of ambient air quality was carried out in the municipality, with 22% (4 of 18) specifying that to be SO_2 monitoring. Within Uthukela and Ugu districts, the local municipalities in Port Shepstone (i.e. Hibiscus Coast) and Estcourt (i.e. Umtshezi) each operate a monitoring station, which were donated by the DAEA. The DAEA-donated stations comprise automatic analysers for SO_2, NO_2, PM_{10}, O_3 and monitor meteorological variables as well. In Uthungulu district, Umhlatuze local municipality in partnership with the RBCAA operates a network of monitoring stations, which consists of five SO_2, one PM_{10}, and one O_3 analysers and monitors meteorological variables at seven stations, with three outside of the network. Spores and pollen are also monitored in the municipality but are operated by the University of the Witwatersrand (WITS) and not the municipality. Limited monitoring of benzene, toluene and other carcinogenic hydrocarbons were conducted recently in Umtshezi municipality by WITS to allay concerns raised by communities. The DAEA also donated a station for placement in Empangeni in the Uthungulu district; however, the responsible authority for operating this station remains unclear.

The data from Umtshezi and Hibiscus Coast municipalities are automatically transmitted daily to the WITS Climate Research Group for analysis, with local data handlers receiving training in operation and maintenance. The analysed data are available on-line to the municipalities running the stations, as well as other authorities. Monitoring data from the Umhlatuze network are available on-line continuously and are updated automatically. Additionally, public access is allowed, and encouraged, to the monitored data although the public is not able to freely access the raw datasets. Calibration is carried out at all stations, with Umtshezi municipality focusing on producing better quality data to obtain SANAS (South African National Accreditation System) certification and aid decision-making, and Umhlatuze municipality obtaining SANAS certification regularly. Consultants are responsible for running the monitoring and modelling programmes in Umhlatuze municipality.

Twenty-eight percent of respondents (5 of 18) indicated that air pollutant dispersion modelling was carried out. These respondents were exclusively from the Umhlatuze local municipality in Uthungulu district, with no other respondents giving an indication of an intention to undertake modelling in the near future. Umhlatuze municipality, using the RBCAA, conducts modelling of SO_2 plumes using the emission inventory and meteorological data. The HAWK model is used, and validation is done with monitored data. Modelling of PM_{10} is expected to follow; however, the lack of monitoring data for validation is preventing this project from moving forward.

5.3.4 Management Capabilities

Technical capabilities should be supported by a management framework that enables activity in real-world scenarios, such as aiding decision-making and effectively communicating the outcomes of technical activities. Within the context of the study, communication and planning were identified as critical components for successful implementation of the AQA and follows on from measures and responsibilities listed in the AQA.

5.3.4.1 Communication

Table 5.7 highlights the significant means used for communication with tiers of government and the public by municipalities, as well as the nature of the relationship in the case of inter-governmental communication. Communication is necessary for successfully realising the aims of policy, and the means for communication should be directed to effecting these. Inter-governmental communication, where a defined process and cross-flow of information are present, and a clear method for including the public and facilitating their participation in AQM processes were examined.

Communication with provincial government on air quality was observed to be erratic and generally limited to problem situations or information needs, with 53% of respondents (8 of 15) acknowledging communicating on an ad-hoc basis with the provincial tier and only 7% (1 of 15) reporting regular contact. The responses of an EHP currently employed by the provincial Department of Health, who is actively involved in the AQM activities of the local municipality was excluded from the total responses on inter-governmental communication, causing the lowering of total responses on the subject. Uthungulu and Uthukela district municipalities and Umhlatuze and Hibiscus Coast local municipalities had limited communication with the DAEA, while Umtshezi local municipality had regular communication. Ugu district municipality recognised the relationship as good, extending to verbal and written communications. Meetings attended or reports submitted on a quarterly basis were the primary means of contact with provincial authorities as listed by 40% of respondents (6 of 15), with 7% (1 of 15) submitting monthly reports. Hibiscus Coast used meetings, Uthukela submitted reports, and Umhlatuze submitted monthly reports to communicate with the DAEA.

Table 5.7: Communication Capabilities of Municipalities

Issue	Identified Component & Corresponding Percent of Responses
Tiers of Government	Regular contact with provincial government (7%) Ad-hoc communication (53%) Communication through reports (33%), or meetings (13%) Assistance from provincial authorities (27%) Provincial communicated with national on municipal behalf (13%)
Public	Complaints (67%) Various media (56%) Fora (22%) Councillors (22%)

Umhlatuze local municipality also extends invitations to the DAEA officials in the district to attend meetings and industry fora, although participation is limited. Similarly, Umhlatuze also felt EIA's were an opportunity for communication with provincial authorities. Hibiscus Coast municipality used the meetings organised by provincial government to share experiences and communicate with other municipalities. Twenty seven percent of respondents (4 of 15) indicated that provincial authorities had provided assistance to the municipality on AQM. Ugu, Hibiscus Coast, and Umtshezi municipalities acknowledged assistance in a number of areas, and Umhlatuze municipality emphasised assistance in deriving solutions to pollution problems. No respondents indicated having communicated with national government, i.e. DEAT, on air quality issues; however, 13% (2 of 15) understood that provincial authorities communicated on their behalf.

In communicating with the public on air quality issues, over two-thirds of the sample (67%, or 12 of 18) used complaints as the primary means of communication. Uthukela district municipality and Hibiscus Coast, Umtshezi, and Umhlatuze local municipalities use complaints from members of the public on air pollution problems as a vehicle for communication. Umhlatuze complements complaints through the activities of the RBCAA, where members of the public can sit on the board or sub-committees, or attend meetings to obtain information on the actions of the municipality for controlling air pollution. The organisation also runs a website where real-time air quality information is available to the public and is responsible for setting up a complaint system, including a 24-hour complaint line, which has resulted in greater public involvement. Other municipalities are only able to receive complaints during office hours, which was viewed as a shortcoming, especially in Uthukela and Umtshezi municipalities where excessive industrial emissions at night were an issue.

Municipalities also used other forms of media (56%, or 10 of 18) to a limited extent, including newspapers, newsletters, radio broadcasts, pamphlets, posters, and municipal account statements to convey air quality messages. Information provided addressed developments in AQM, such as monitoring station installation and establishment of programmes to improve air quality, as well as general advisories on air quality such as health warnings for vulnerable groups during incidents. All municipalities used media to inform and include the public regarding air quality issues, with the exception of Uthungulu district municipality, as they are not performing an AQM function. However, they indicated that upon transfer of the function, arrangements instituted by the Umhlatuze municipality would remain in place.

Participation in air quality fora (22%, or 4 of 18), where industries are included, and public participation during EIA's were opportunities for municipalities to raise awareness and obtain the views of the public. Health education programmes are conducted as a public communication exercise as well. Uthukela and Ugu district municipalities implement health education, with Uthukela also using fora. Local municipalities use varied communication methods, with Umtshezi and Umhlatuze municipalities using fora; Hibiscus Coast implementing health education; and EIA participation being used exclusively by Umhlatuze. Community representative committees were being formed in the Uthukela district, and ward committees were highlighted as a separate mechanism for filtering health messages to communities, using councillors to carry air quality information to communities, with the system also used in Ugu district. Additionally, Umhlatuze local municipality cited industry open days in the municipality as a means for involving the public, and Ugu district municipality hosted a stand at the Lion Show, an annual agricultural show in the municipality, as a health education exercise.

5.3.4.2 Planning

Table 5.8 summarises the significant responses with respect to planning measures to be implemented by municipalities to address air quality issues. Planning measures were included as a distinct category to identify in detail the actions of municipalities with respect to forecasting future air quality issues or the escalation of minor issues into major air pollution problems. The AQMP is included as a tool to address planning in the AQA; however, as indicated in Section 5.3.1, the use of AQMP's requires greater input. Municipalities were asked to identify control strategies and planning tools that are directed at addressing air quality issues before a problem develops.

A large portion of the sample (69%, or 11 of 16) indicated the use of planning measures to address air quality issues, with municipalities employing a range of measures. Planning and control measures proposed by municipalities include, AQMP drafting and zoning as general planning tools, as well as elements of control implemented include, *inter alia*, monitoring, follow-up of EIA conditions, and by-law development.

Table 5.8: Planning Capabilities of Municipalities

Issue	Identified Component & Corresponding Percent of Responses
Planning measures	Use of planning measures (69%) Development of an AQMP (50%) Elements of town planning and zoning of areas (38%)

Ugu district municipality has not progressed with regard to planning measures, although other municipalities have processes in place to develop tools or are currently using a planning tool. Fifty percent of respondents (8 of 16) listed the development of an AQMP as a significant strategy, and Uthukela district municipality, and Umtshezi, Hibiscus Coast, and Umhlatuze local municipalities are looking toward AQMP development. Uthungulu district municipality intends to pursue a strategy of technical mitigations for minimising air pollution as a means of control and planning, with further action remaining to be defined. Town planning and zoning of areas was included as a planning measure, mentioned by 38% of respondents (6 of 16). The general philosophy of grouping industries together and away from residential and business areas was evident in the Uthukela district. Umhlatuze local municipality had conducted an air quality study that identified buffer areas where development guidelines are proposed, in addition to town planning.

Further elements of planning and control that are anticipated in Umhlatuze local municipality are a health risk study, dispersion modelling of particulate matter, follow-up of EIA conditions, and the compulsory drafting of emission reduction plans by industries. Monitoring data was an important component of identifying pollution problems in Umtshezi municipality, and in developing the AQMP, and included as an overall planning tool in Hibiscus Coast municipality. The development of by-laws in Hibiscus Coast municipality is expected to address planning measures as well, such as the siting of boilers and other appliances and control of emissions. An element of control in Hibiscus Coast that may have incidental benefits for air quality is the licensing of hazardous substances, where a register of users of certain chemicals is drawn up. Liaison with industries, in an advisory or regulatory capacity, is a component of control for reducing potential emissions that is implemented in the Uthukela district.

A further consideration noted was the lack of involvement of the Planning Department of municipalities in developing AQMP's or other planning measures. The exception to this scenario was Umhlatuze local municipality, where an Environmental Planning Department is situated, which liaises with Environmental Health, on air pollution impacts and the influence on town planning. In Uthukela district municipality and Umtshezi and Hibiscus Coast local municipalities, although AQMP's were proposed as planning tools, no effort to incorporate town planners was made. In addition, the Planning Department of Uthungulu district municipality is responsible only for spatial planning and did not input into environmental planning. Ugu district municipality has not proposed planning or control measures and therefore it is unclear as to their consultation with the Planning Department.

5.3.5 Success Indicators

An additional factor that required consideration in implementing AQM was the need for using success indicators as an assessment and benchmark of progress in improving air quality, which would influence future development of AQM in the managed area. Table 5.9 summarises the use of assessments in determining air quality improvements.

Table 5.9: Use of Success Indicators by Municipalities

Issue	Identified Component & Corresponding Percent of Responses
Assessment of Air Quality Improvements	Using a means of assessment (63%), of which Formal (38%) Informal (25%) Emission reductions as an indicator (25%)

Sixty-three percent of respondents (10 of 16) indicated that a means of assessment was used to determine the success of implemented measures in terms of air quality improvements, of which 38% (6 of 16) applied a formal method and 25% (4 of 16) informal means. Formal indicators were employed by Umhlatuze local municipality. These include the introduction of emission reduction programmes as the result of RBCAA and the local municipality pressuring industry, a system of annual goal assessment at the RBCAA, and the assessment of the municipality's performance by provincial authorities. Umhlatuze municipality is planning a health study and dispersion modelling of particulate matter as strategy improvements and for the refinement of future actions, and together with the RBCAA promotes air quality research.

Uthungulu district municipality relied on the assessments of Umhlatuze local municipality as a measure of success. Uthukela district municipality used informal indicators to assess the success of implementation, with reduction in emissions following discussions with industry management used as an indicator; and Umtshezi local municipality using a decreasing trend in complaints and a visual reduction in emissions for assessment. Hibiscus Coast local municipality planned to introduce assessment in the form of enforcing control conditions stipulated for compliance, and both Ugu district municipality and Hibiscus Coast local municipality are awaiting data outputs from the monitoring station to guide assessment.

5.4 Summary

A mixed set of results was obtained on the range of categories used to indicate the capacity of municipalities. The awareness of responsibilities, according to the AQA, is inadequate, with an emphasis on activities that municipalities have previously been implementing as duties or areas of technical capability. Enforcement represents the former category, whereas, monitoring falls into the latter in the results. Requirements introduced into the municipal realm by the AQA were poorly recognised, although in terms of implementation, advances were evident. The designation of AQO's and introduction of ambient monitoring were examples of the contradiction in responses. Municipalities are also in the midst of processes for initiating AQMP development; however, emission inventories display limited implementation. Numerous challenges face municipalities in implementing the AQA, the foremost being financial and human resources. Various social and legislative concerns were raised, together with industrial co-operation as limitations on implementation. The human resources available to municipalities, and the skills capacity thereof, showed the availability of personnel, although those dedicated to AQM activities were severely lacking. Short courses were a common form of supplementary training used to introduce AQM at municipal level, with pollution control concepts encountered in environmental health diplomas being the dominant form of AQM understanding.

With regard to technical capabilities, emission inventories and source identification was well represented, with monitoring to a lesser degree, and dispersion modelling limited in application. SO_2 was the most common pollutant identified across municipalities, and industries, the most common source. Inter-governmental communication was poorly expressed in results, generally limited to problem-solving or information provision on an ad-hoc basis. Meetings and reports were the frequent communication tool, although assistance was noted in some municipalities. Public communication showed greater reach, although complaint response was the dominant tool, with media, fora and councillors used to varying extents. In both governmental and public contexts, communication was reactionary and poor on air quality issues. Planning measures are widely used, with AQMP's and town planning and zoning, noted as a tool. Municipalities, with a mix of formal and informal success indicators, assess the progress towards air quality goals. Concerns that are evident in the results are the discrepancies that exist between the implementation of district and local municipality levels of local government, uncertainties in the transfer of environmental health staff catalysed by the National Health Act, and a general lack of awareness about the requirements of the AQA and the AQM strategy placed on local government. A summary table of municipalities' implementation efforts and the challenges facing them is presented in Table 5.10.

Table 5.10: Summary of Municipal Implementation and Challenges

	Current Activities	Planned Activities	Challenges
Umtshezi Local Municipality	◦ Monitoring ◦ AQO	◦ AQMP ◦ Emissions inventory	◦ Employee awareness ◦ Industrial co-operation ◦ Inter-municipal AQM co-ordination ◦ Contradictions in transition from APPA to AQA ◦ More training
Uthukela District Municipality	-	◦ Monitoring ◦ Licensing ◦ Enforcement ◦ AQO ◦ AQMP ◦ Emissions inventory ◦ Approve by-laws ◦ Memorandum of Understanding with provincial Department of Health	◦ Funding for staff and equipment ◦ Intra-departmental and intra-municipal communication and consultation ◦ Industrial co-operation
Umhlatuze Local Municipality	◦ Monitoring network ◦ Emissions inventory ◦ AQO ◦ Dispersion modelling of SO_2 ◦ Compliance inspections ◦ Notice issue for non-compliance	◦ Licensing ◦ AQMP ◦ Enforcement ◦ Health study ◦ PM_{10} modelling	◦ Transparency in decision-making, inclusion of more stakeholders ◦ Funding for staff and equipment ◦ Lack of by-laws ◦ Lenient permit conditions ◦ AQA implementation delays ◦ Lack of clarity on municipality definition ◦ Division of powers and responsibilities between RBCAA and municipality
Uthungulu District Municipality	-	◦ Service level agreement with Umhlatuze	◦ Lack of clarity on municipality definition ◦ Transfer of staff ◦ Funding for staff and equipment
Hibiscus Coast Local Municipality	◦ AQO ◦ Monitoring ◦ Emissions inventory	◦ AQMP	◦ Funding for staff and equipment ◦ Community resistance and awareness ◦ Political interference ◦ Industrial resistance
Ugu District Municipality	◦ AQO ◦ Monitoring	◦ AQM needs assessment	◦ Funding ◦ Industrial resistance ◦ Community resistance

CHAPTER SIX
ANALYSIS OF AQA IMPLEMENTATION

6.1 Introduction

A number of issues have arisen from the results of the in-depth study of the AQM capacity of municipalities and an analysis of these issues provides insight into the challenges and opportunities presented to municipalities in the implementation of the AQA. An analysis of the capacity findings attempts to identify the underlying motivations constraining effective implementation by municipalities and together with the identified strengths displayed by municipalities sampled and the significant theoretical concepts in AQM develop a systematic framework aimed at guiding municipalities as they embark on implementing the AQA.

6.2 Analysis of Capacity Findings

The results of the study of municipal capacity, in the light of the AQA, can be analysed with respect to the overall representation of municipalities, and on the merits of individual issues raised in municipalities. Specific themes were identified within the context of results that present a broader analysis of the specific responses provided by interview respondents. These encompass technical and management issues, as well specific issues arising from the analysis that did not correspond to the broader categories. An in-depth examination of responses is attempted with the motivating factors for responses unpacked and possible ameliorating actions identified in some cases.

6.2.1 Structural Issues

Significant issues have been identified relating to the structural arrangements that serve pollution control, including the relationship between local and district municipalities, departments and structures within the municipality, and that of provincial and local government. Roles and responsibilities require further definition, and flexibility surrounding authority that leads to co-operative working are some of the outcomes of the analysis.

6.2.1.1 Local and District Municipalities

One of the most critical challenges in the implementation of the AQA relates to the relationship between local and district municipalities in the local government tier. In the municipalities sampled, local municipalities conducted AQM activities independent of district municipalities, and duplication of activities and fragmentation of results was observed. The development of various planning tools and documents, including AQMP's, implementation plans and by-laws, demonstrate the piece-meal approach to AQM practiced by municipalities, with 17% of respondents indicating the development of such tools and three local and a single district municipality indicating the intention to draft a variation of the tools mentioned.

Hibiscus Coast and Uthukela are developing implementation plans, with the latter also producing by-laws and an AQM policy; Umtshezi is awaiting further guidance on AQMP development and Umhlatuze has produced an air quality study to extend into an AQMP. Umtshezi and Uthukela municipalities are located in the same district, with Uthukela district municipality having the overall jurisdiction although the municipalities' plans for implementing the AQA have not been reconciled. The planned implementation by Uthungulu and Ugu district municipalities has not been detailed in planning documents although the associated local municipalities have made progress in their municipal areas. Implementation, especially of AQM tools, illustrates great contrast; in areas where local municipalities have been capacitated, the AQM function is carried by that authority and, in some cases, to a greater extent than district municipalities. In all districts, local municipalities have taken on greater responsibility for AQM, including running monitoring networks, developing, or making provision for, AQMP's, and planning, or conducting, emission inventories. Umhlatuze, Umtshezi and Hibiscus Coast local municipalities have progressed on monitoring, AQMP's and emission inventories, while Uthukela district municipality has made some progress on these tools, and Uthungulu and Ugu district municipalities are experiencing difficulties.

Successes are isolated in areas where expertise is located, with the greater municipal area having limited exposure. Occasions were encountered where district municipalities could have benefited from interactions with local municipalities. The location of equipment and specialised training offered to local municipalities were not mirrored in the responses of individuals at district level. Hibiscus Coast and Umtshezi received a donation of a monitoring station set up in the municipality, with training in the operation and maintenance of the equipment, and Umhlatuze operates a network of stations with the RBCAA. District municipalities appear, largely, to have been excluded from these processes, with the exception of Ugu, where Environmental Health was consolidated late in the study period and some degree of functioning has been taken over. Uthukela has not accessed monitoring information or assistance from Umtshezi and has focused on the Ladysmith area. The municipality is experiencing difficulties in conducting inventories as equipment is unavailable to obtain detailed emissions data and EHP's have limited AQM training. Currently, Uthungulu has no capabilities for carrying out AQM and the function is located solely at Umhlatuze and only upon the transfer of staff, can advances towards implementing the AQA be planned.

Consultation between the municipal levels and initiatives aimed at harmonising efforts for implementing the AQA would have enabled greater gains to be obtained for limited input of personnel and training. There is a need for a broader forum where interactions and experiences are fostered and exchanged, especially at district level. Appointing individuals responsible for the co-ordination of AQM activities in municipalities, being AQO's, has aided communication and improved the implementation of AQM, compared to municipalities where the designation has been delayed. The absence of rural local municipalities is not an oversight on the part of the study but rather evidence of the absence of personnel and resources for environmental functions. The nature of AQM, and pollution control, indicates that industrial or urban emissions present major pollution problems, however, rural areas can host distinct problems such as agricultural and domestic fuel emissions.

The extension of expertise to all areas of municipal influence is a process of dissolution rather than expedited uniformity, and realistic timeframes are necessary in addition to the political will and commitment, from upper tiers of government as well, to achieve the objectives of the AQA in the local government tier. Co-ordination and communication improvements between local and district municipalities should extend to informing, and including other municipal levels where possible, in the development of policy and decision-making on implementation activities. The concepts are further illustrated in Figure 6.1, showing the need for greater communication and consultation between local and district municipalities and co-operative working. A culture of participatory governance and sustained communication should be instilled in the local government tier, as the governance mechanism in closest proximity to civil society and responsible for the majority of service delivery, in the broader definition.

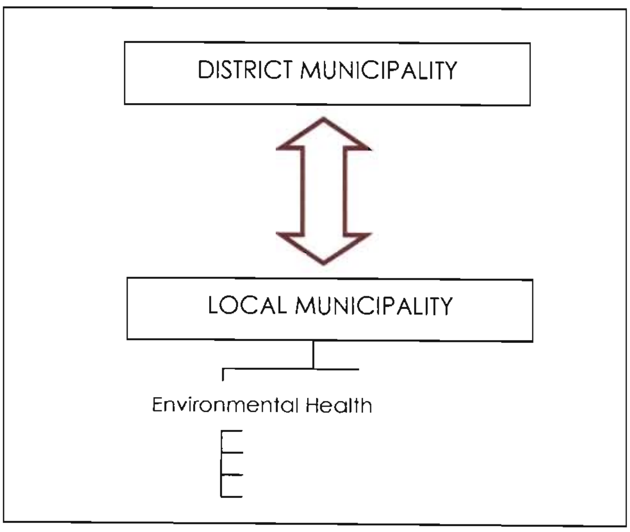

Figure 6.1. An Illustration of Improvement to the District – Local Municipality Relationship

Channels of communication were not evident, and the uncertainty surrounding environmental health functions severely hampered improvements to the situation. Although the resolution of the transfer of the Environmental Health department from local to district municipalities was experienced at a single district during the period of research, other municipalities continue to debate over the schedule of transfer. Doubt over the movement of staff, the dates, and details regarding financial implications of the shift, affected responses on responsibilities, implementation and the personnel requirements for

AQM. Neither management nor employees could provide clarity on the details of transfer, and further attention to this aspect of implementation, as it affects the rollout of the AQA, is needed to ensure its resolution. The implications of the Constitution and the National Health Act affect Environmental Health as a division of municipal functioning, which includes air pollution control in the majority of municipalities; however, negligible consideration has been given to the organisation of transferrals and management of the interim situation. In this case, a defined strategy is needed, with timeframes and expected conditions as well as the functioning of Environmental Health in the period prior to amalgamation. Incorporating the transfer into the IDP mechanism may present a solution, as it allows for a strategic approach to moving staff and allocating financial resources to facilitate the transfer.

The lack of communication between the municipal levels, i.e. local and district municipalities, contributes to the confusion resulting from the legislative ambiguity in the AQA regarding the level of municipality responsible for implementing the AQA. 'Municipality' is defined in the AQA, under definitions, according to the Municipal Structures Act, which does not further distinguish except to refer to the types of municipalities established, *viz.* metropolitan, district and local municipalities. It is only with respect to allocating licensing responsibilities in the AQA that metropolitan and district municipalities are specified as the implementing authority, with all other local government AQM responsibilities remaining open to discussion. It is hoped that further guidance from DEAT will clarify the definition and responsibilities, with preliminary arrangements dissected across municipal authorities. However, the issue of municipality definition is peculiar to Uthungulu district, and the motivation for the isolation in response may arise from as Respondent 12 expressed it, "the stronger municipality challenge". The quote refers to local municipalities with greater competency and more resources in the Environmental Health function possibly challenging the transfer of the function to district municipalities, as is the case between Umhlatuze and Uthungulu. An alternative motivation is the limited progress made by other municipalities in implementing AQM and therefore, the current absence of conflict in functions. The latter explanation is marginal as the resources of other district municipalities in the sample exceed that of the constituent local municipalities, and have the ability to incorporate local departments effectively.

6.2.1.2 Intra-municipal Communication

Difficulties in communication were experienced within the municipalities as well, with intra-departmental communication on AQA implementation being poor, as the Environmental Health department conducted activities with no awareness of some individuals on progress in this regard. Responses to various areas, especially the implementation conducted and the nature of activities planned, suggested the lack of communication and consultation most strongly. Individuals responsible for management and those directly involved in implementation expressed the greatest knowledge on pollution control concepts and practices, whereas other individuals were not informed or updated on developments in air pollution control. In Ugu and Uthukela district municipalities, all EHP's carry the responsibility for pollution control within designated areas although selected individuals were informed of and involved in AQM activities. Inventories displayed the most significant degree of miscommunication, with Hibiscus Coast and Uthukela both indicating the activity was planned or currently implemented and individuals within the department expressing a lack of awareness, and similarly for plans for appointing an AQO in Uthukela district municipality.

The novelty of AQM in some municipalities, with the quick effecting of the AQA described by Respondent 9 as "a new phenomenon for local government", can explain to some degree the limited awareness of individuals regarding the changes to pollution control in the municipality. The Environmental Health department in municipalities, prior to the promulgation of the AQA, performed air pollution control and, thus, there is an existing organisational framework and trained personnel responsible to address revisions in the approach. Under APPA, local authorities were charged with the control of small smoke-producing appliances, and are, currently, enforcing pollution control in this sector, while the complete approach under the AQA is being devised. All municipalities used the Environmental Health department, or the Community Services sector, which includes environmental health, to implement air pollution control and a large percentage of the sample indicated the availability of personnel (89%) and AQM training (67%). Implementing AQM, following the shift in strategy, is a question of building on the foundation of pollution control available to municipalities, and expanding and enhancing that capacity to fulfil the objectives and requirements of the AQA gradually, in its entirety, as far as applicable to local government.

Employee awareness is linked to inter-departmental communication and training and information provision and skills training can enhance delivery allowing the public and other departments to reach individuals that can address their particular concern, as well as receive advice on suitable actions. Addressing these elements would facilitate the department working as a functional unit to deliver services in a manner consistent with the department's and municipality's vision, as well as reducing the reliance on a single individual to act as the driver and co-ordinator of activities and policy processes. Umtshezi municipality raised employee awareness, specifically, as a challenge to implementing the AQA as the responsibilities and, training to carry these out, were lacking. Respondent 1 stated, in response to enquiries on department challenges, that, "At the outset, I would think awareness, employees need to be aware that they have responsibility in terms of the Act…need to be, probably, trained in various aspects of air pollution control, monitoring…". The sharing of expertise, assistance of higher authorities such as provincial agencies, and an approach that encourages co-operative governance will aid in raising the profile of the AQA with regard to municipal responsibilities.

Within the municipality, communication regarding air pollution control was limited, as plans for AQM implementation as determined by higher authorities were not filtered to individuals who address day-to-day issues, and consultation with these individuals was not evident. The overall impression of municipalities was that, with the exception of Umhlatuze, which experiences well-publicised pollution problems, there was a minimal level of awareness regarding air pollution control functions. Frequently, in initial communications an individual was identified that drove the pollution control process, or in the absence of such an individual, a number of departments and individuals were consulted before the function could be well placed. In addition, funding mandates were often the domain of councillors, with input from managers of pollution control divisions, which muted the perspectives of EHP's and AQO's on the strengths and shortcomings of applying decisions and municipal laws and conditions, and reducing the prospects for improving efficiency and effectiveness in decision-making. Co-ordination at a level that exceeds the district can provide many advantages to the implementation of the AQA. By extending mechanisms for co-ordination to a regional or national municipal level, with participation of other tiers of government if practical, shared expertise and experience can multiply the benefits across a larger scale, and rapidly advance AQM implementation and the success of the implemented measures. A national action plan to implement AQM is also facilitated by this approach.

6.2.1.3 Provincial Authorities and Municipalities

Local government is designated as an autonomous tier of government, having powers and functions independent of other tiers; however, with respect to AQM, municipalities rely on provincial government to transfer skills and guidance from national government. Local government is limited in terms of resources and is therefore reliant on provincial and national government, and the limitations presented to local government over the options available to other tiers of government are discussed further in Section 6.2.3. Provincial authorities have, in addition to financial resources, greater capacity and skills available than local government and there is a need to share with municipalities and incorporate them into activities undertaken by provincial authorities. By ignoring opportunities to capacitate municipalities, it constitutes a wasted effort on the part of both authorities. Environmental Management Co-operation Agreements (EMCA's) as described in NEMA may provide a mechanism for national, provincial and local authorities to work collaboratively to implement the AQA, together with civil society and the private sector, as alluded to by Respondent 19, a provincial government representative (Republic of South Africa, 1998). The development of mechanisms and tools for the tiers of government to interact meaningfully encourages skills transfer and resource provision, where, not gifting, but active involvement and collaborative working come about. Figure 6.2 provides an illustration of the development of the relationship between provincial and local government, representing the need for assistance from provincial authorities to cultivate capacity and growing into collaborative working for the improvement of air quality.

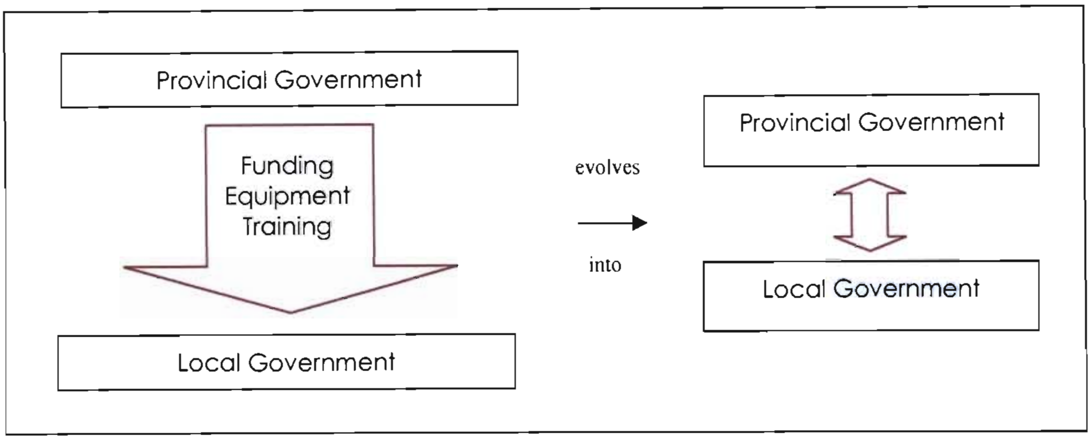

Figure 6.2. The Proposed Relationship between Provincial and Local Authorities

An apt example is that of the monitoring stations donated by the DAEA, provincial authority in KZN, to municipalities. Currently, local officials are trained to operate the stations, data undergoes third-party analysis, and analysed data are available locally via an internet website. An interim settling period of one year was suggested to reduce error and establish good quality data from stations, which has not passed, after which data can be used for planning and other decision-making exercises. A favourable scenario would be to have local authorities trained during the rollout of the AQA in further capabilities such as data analysis and other aspects of monitoring capabilities, and the gradual transfer of all aspects of station operation to local authorities. In this way, the transfer of skills is achieved, although this approach might necessitate introducing more personnel into municipalities that are responsible for AQM activities, which raises complications of funding and employee relations. The latter relates to issues such as job stability, as budgets may fluctuate, monitoring needs may diminish with minimal pollution, and municipalities may be unable to afford the long-term implications of monitoring operations, and employee turnover, considering training in a technically advanced environment, shortage of suitably trained individuals and attractive opportunities for technically skilled individuals in the private sectors.

It was evident that resources provided by provincial government structures assisted understanding and implementation of AQM concepts, with 27% of respondents in the study indicating that assistance was received from provincial authorities on AQM. Umtshezi municipality acknowledged the contribution of the DAEA in setting up a number of elements of the AQM programme, including training, inventories and developing an AQMP. The DAEA is assisting the Ugu district municipality in the assessment of AQM needs and is compiling a task team with individuals from the municipality and provincial authority. Hibiscus Coast municipality noted more limited involvement, with the provincial authority acting as more of a facilitator, which was further highlighted in Umhlatuze municipality, with the DAEA assisting in finding solutions to problem situations. The DAEA is beginning to work actively in municipalities to implement the AQA effectively at local level and with limited resources, especially personnel, effect positive changes in the AQM capacity of municipalities.

Satellite offices of the DAEA, located regionally, were viewed as less involved in the AQM processes of municipalities, as seen in Umhlatuze, where the RBCAA, as the vehicle for controlling air pollution in the municipality, experienced limited participation from provincial authorities. Enforcement was viewed as the primary action of the provincial authorities, resulting in management-level positions in the RBCAA being discharged. In the light of the Constitution and the call for co-operative governance, deliberation and greater inclusion of local authorities in the decisions of provincial authorities should be pursued, with the regulator-regulated relationship of the past relegated. Governance embraces fluid relationships and non-institutionalised forms of decision-making outside of traditional structures to reach equitable, sustainable solutions (Hajer and Wagenaar, 2003). The spirit of democracy and governance instilled in South African policy needs to be filtered to every tier of government to effect the changes in structure and function that are envisioned for sustainable development.

An intuitive conflict between the functions of Environmental Health and Environmental Management departments was observed during the course of the study, where air pollution control is deemed an activity of environmental health in municipalities, although nationally and provincially the mandate has been given to environmental management departments, i.e. DEAT and DAEA respectively. In addition, some environmental health capacity and responsibility also rests with the provincial Department of Health. It is unlikely that the situation at local level will be changed as progress with Environmental Health officials has been made; therefore, there is the need for compromise between provincial departments to ascertain the best scenario for implementation. The transfer of provincial environmental health staff is a component of the National Health Act's action to consolidate Environmental Health at district municipalities as well, and will at some future date, avoid the need for agreement between the authorities. Subsidiarity is an important guiding principle in regard to resolving conflicts of function, locating functions where they are most appropriately carried out and granting authority to the designated party, as well as the principle of a 'lead agent', who is given the mandate for the function, requiring consultation with cross-cutting interests but retaining the fundamental guidance and authority.

6.2.2 Planning for AQM

The IDP mechanism, though embraced at national policy level and in the AQA as an application, is largely ignored by municipalities as the long-term planning tool it is designed to be. The AQMP, as the driver of AQM at all tiers of government, is legislated as a necessary component of the municipal IDP, indicating the financial and resource allocation together with expected air quality improvements.

It is the blueprint for activity on AQM, and while, the period lapsed following the promulgation of the AQA is relatively short, municipalities are, for the large part, ignorant of the necessity of the planning tool. With only 12% of respondents recognising the AQMP as a responsibility under the AQA, representing those located at local and district municipalities in the Ugu district, awareness of the responsibility and the need for a comprehensive planning document, in line with national directives, is poor.

In addition, guidelines on developing an AQMP and necessary impetus from the national ministry have not been forthcoming; however, awareness is a prerequisite for action. The guidance given in the AQA on AQMP content promotes a strategic approach to control, using objectives and goals to develop an understanding of the desirable quality of air for the managed area and, thereafter, developing controls in various pollution sectors leading to the achievement of the objectives. Consideration is also given to practices that are regarded highly in the management of air quality, to set objectives high and adopt incremental progress in their achievement. By using best practice, confidence is instilled in the public the authority serves and regulated emitters, as the approach is recognised as performing well in other contexts and is well accepted amongst peers. As such, an AQMP is seen as the tool that will influence the use and conditions of use for other AQM tools, as well as defining the approach of the municipality as a whole. The AQA has situated the AQMP as the critical component of an AQM strategy around which the tools for control develop.

An AQMP is, simply, a plan, and without the guidance on the direction a strategy should develop in, municipalities are in danger of implementing a melange of controls, at great expense, and not reaping the desired improvements in air quality. When considering implementing the AQA, 17% of respondents stated the development of an AQMP as an aspect, and when addressed as a specific category with regard to planning measures, 50% of respondents listed that an AQMP would be drafted. Umtshezi, Hibiscus Coast and Umhlatuze local municipalities and Uthukela district municipality indicated that AQMP development was an objective, realising the need for guidance on strategy before progressing in implementation. Uthukela is using the AQMP as the initial step of the control strategy, and has not made progress in other areas of AQM, such as monitoring emissions, whereas Umtshezi and Hibiscus Coast have already begun implementing tools and are using monitoring data as an information provider for shaping the development of the strategy. Umhlatuze is significantly further along in control, assisted by the partnership with the RBCAA, and as a result of the AQA is looking at an AQMP as a document to lead future developments.

Additionally, Umhlatuze was the only municipality consulting with the Planning department on progressing with an AQMP. Although the Environmental Planning department together with consultants prepared the initial phase leading to the AQMP resulting in the identification of buffer areas according to air quality concerns, the involvement of Environmental Health is expected to be significant in the AQMP drafting. Other municipalities in the sample did not view the involvement or consultation of the Planning department as necessary. However, the influence of planning outcomes on air quality is not negligible, and as such, incorporating planners into decision-making and planning for AQM enhances the effectiveness of measures adopted, as well as making a greater array of possible controls available to AQM managers.

Planning determines the landscape of the built environment, including settlements, and the transport arrangements that service the area. Town planning is responsible for defining the areas for residential, commercial and industrial activity, and transport planning shapes the road, rail, air and sea transportation routes and infrastructure. By including Planning departments, AQM managers are capable of indirectly influencing air quality and the exposure of the population. While, in many countries internationally, the most significant pollution problems revolve around transportation and, especially, the motor vehicle, South Africa's initial AQM controls have focused on industrial activity. In developing AQMP's, it would be a significant oversight to allow these recognised, and quite intractable, pollution problems to escalate unchecked when controls can be introduced pre-emptively to curb future pollution (Longhurst, 2006). Involving Planning is, therefore, a means of influencing the air quality that will be experienced in the future by developing appropriately now, and will be an invaluable boon in hindsight.

6.2.3 Funding AQM Implementation

An AQM strategy is regarded as resource-intensive, requiring inputs into tools to determine the state of the air and implement controls to improve air quality. Local government in South Africa is dealing with a major service backlog, where many areas of the country do not have access to basic services such as potable water and sanitation, and is charged with local economic development of their jurisdiction to revitalise previously disadvantaged regions. However, local government remains the most appropriate level of government to situate the majority of AQM activities, and the imperative is accompanied by difficulties in bringing policy to fruition. Access to financial and human resources are the greatest challenge to municipalities, and are a severe constraint to implementing the AQA. Funding is needed for equipment, such as monitoring devices and the associated upkeep, training of staff in aspects of pollution control and AQM, and supplementing the current staffing quota to carry out technical duties, such as sample analysis and maintenance of monitoring stations.

Municipalities should examine all avenues of funding available, as there are a number of different agencies that are currently involved in implementing the AQA, as well as provisions in the AQA itself for implementing authorities to acquire revenue for implementation. National government is the level of government with the greatest access to resources, being directly funded by the National Treasury but also being able to receive international aid from donor agencies and international governments.

These resources may be channelled for local application from the higher authority. Provincial government, the DAEA in KZN, has more limitations in terms of accessing funding than national, nevertheless is ably funded as well and possibilities exist for receiving assistance from this source as well. The donation by the DAEA of five complete monitoring stations with automatic analysers and cellular phone communication capabilities demonstrates the ability of provincial government to allocate funds capably and access resources.

Some municipalities may also form partnerships with donor agencies independently and receive assistance, of both monetary and technical resources, to set up their AQM programmes. Ethekwini municipality in KZN has established a working relationship with Norwegian authorities and has established a programme with laudable results in air quality improvements in the South Durban Basin. In addition, Section two of NEMA makes provision among its principles for using the 'polluter pays' principle and is carried through to the AQA, although the development of economic instruments for AQM is still at its conception. Economic taxes and atmospheric user charges are possible expressions and intend to incur costs upon emitters and make emissions to the atmosphere an economic good with associated costs.

The concept of an 'unfunded mandate' was raised in Umhlatuze municipality as a number of functions have been re-assigned from other tiers of government to local government, and the likelihood exists that the funding to carry out these new responsibilities has not been transferred as well. A more in-depth analysis of the situation by authorities may be necessary to determine the level of responsibilities now given to local government and the nature of funding resources available to municipalities to implement them. A viability assessment with recommendations and tools for municipalities, and other government tiers to assist, is a possible format.

Related to funding and staffing needs is the compounding factor of the limited pool of qualified personnel to address AQM. South Africa has a shortage of individuals suitably trained in the management and technical capabilities of air pollution control, with limited opportunities for training and skills transfer. Tertiary institutions offer isolated programmes at higher levels for individuals looking to attain knowledge in AQM, and industry remains the most significant avenue in which to train and obtain technical expertise. Further initiatives for training need to be developed and available opportunities increased. Bursaries and scholarships are a means of improving the capabilities of individuals entering the pollution control field. There is a need, especially, for technically skilled personnel to operate and maintain monitoring stations, including calibration and equipment maintenance, conduct modelling runs and validation, carry out inventories and maintain the information systems of the programme.

In the study, respondents carried environmental health qualifications but had limited exposure to air pollution control concepts, with 72% receiving instruction in air pollution-related coursework while pursuing environmental health diplomas. Increasing funding to air quality-related initiatives promotes AQM qualifications as an opportunity for individuals and presents a distinct method of increasing capacity in the necessary fields, thereby, making more personnel available to municipalities for inclusion in AQM programmes. Provided that necessary funding can be made available by municipalities for securing personnel, this measure could also provide a means for reducing the reliance on consultants and improving the sustainability of municipal programmes.

An innovative approach, proposed by Uthukela municipality, was the use of self-regulation by industries, with reporting of incidences of non-compliance and municipalities auditing the emissions records. This approach addresses funding limitations and can be implemented by less-funded municipalities, as fewer resources are needed and a limited amount of monitoring. Emitters are charged with monitoring stack and other emissions resulting from their activities and keeping records of emissions, both compliant and non-compliant, and making note of the latter. The regulating authorities regularly review the records to determine the performance of the emitter and make regulatory decisions accordingly. The approach can be expanded to place an emissions minimisation and cleaner technology responsibility on larger, or more environmentally conscious, emitters to show continual improvements in records. These measures are frequently adopted by industries that trade internationally or serve a sector where environmental concerns are an issue; the improvements and introduction of new technology also provide a public relations opportunity.

Enforcement is the critical component of employing this approach, as industries can easily manipulate records to portray a more agreeable scenario without the knowledge of regulators. The installation of source monitoring devices and the analysis of raw data is a method of discouraging misrepresentations in reports, as well as the establishment of affable relationship between emitters and regulatory agencies, where healthy communication leads to outcomes that are workable for both parties. Authorities that are perceived as uncooperative or unreasonable may receive far greater resistance from polluters in terms of participation and voluntary compliance. On the part of regulators or municipalities, resources for the greater number of AQM tools and activities are unnecessary as the emitters subsume these functions, together with the costs of conducting them. A reasonable number of well-trained individuals, in proportion to the number of emitters in the area, that are capable of auditing records, maintaining relationships with emitters and with an understanding of pollution control concepts can provide the core for implementing AQM. Ambient monitoring, to a far lesser degree, that addresses general areas of exposure and with an element of compliance monitoring is needed to demonstrate compliance with regulations.

The investment of large resources in assessing and controlling air pollution should be accompanied by a means of determining the degree of success enjoyed by introducing each measure, ensuring that the benefits are consistent with the costs involved in running an AQM programme. Consideration is given to the incremental benefits of introduction, where initial controls capture greater improvements and subsequent controls achieve incremental gains comparatively. An element of justification should be found in investing in the measures against improvements in air quality. Aside from control measures and tools, the functioning and efficiency of management should be assessed as an aspect of success, or default, and improvements in that area sought. Poor management with little relevance to practically experienced scenarios, as well as being far removed from other stakeholders, can have greater effect on a programme of pollution control than actual controls. Assessment of management can be done using more established methodologies borrowed from business administration and related disciplines. Therefore, following the assignment of funding, an important component is assuring the viability of the venture as well. Research and development can present a significant part of determining the efficiency of measures, and increasing the efficiency over time. New measures can be developed to achieve greater gains for less funding input; an example is emissions trading and other economic instruments that have been favoured in innovative legislation internationally. A portion of funding should be allocated for the development of improvements in strategy.

An additional observation on the funding of municipal AQM initiatives was the instances of greater capability evident in larger municipalities with more available financial resources as compared to smaller municipalities. This was juxtaposed against the lack of significant deterioration in air quality in smaller municipalities that was noted in the larger, and more industrialised, municipalities. The observation highlights the local context of the contrast and relationship between increasing economic output and environmental degradation that is the accepted outcome of development (Atkinson, 1997). While developed countries have attempted the decoupling of increased economic growth from the destruction of environmental quality, including the atmosphere, the path of industrialisation has been seen as the norm. Municipalities can expect to challenge this established model of development, by pursuing sustainable development through activities such as eco-tourism and sustainable communities, and placing an emphasis on the maintenance of natural stock and suitable forms of development for the local setting (Tietenberg, 2004). By avoiding, or minimising, the degradation of the environment altogether, the allocation of resources for management, monitoring, and rehabilitation are significantly less than municipalities where the benefits and costs of industrialisation are clear.

Umhlatuze local municipality is highly industrial in nature, having a number of industrial plant and other activities emitting a varied mix of pollutants into the atmosphere. It is also well funded and has a large tax base of both residential and commercial entities. In contrast, other municipalities in Uthungulu, for example Umlalazi, are rural or peri-urban in character, with agricultural activity dominating the economy of the area, with contributions from tourism and other activities associated with a low pollutant load (uThungulu District Municipality, 2002). These economies are not developed to the extent of Umhlatuze, having limited resources available for allocation to municipal services. In terms of pollution, Umhlatuze has high ambient concentrations with exceedances of standards, and other municipalities have no recorded pollution episodes, with the exception of sugar cane burning and associated emissions occasionally; Umhlatuze has significant resources allocated for monitoring the effects on the ambient pollutant effects whereas other municipalities have little to none allocated. The illustration provides detail on the statements made earlier; however, a balanced approach to pollution control is needed in view of the developments of the AQA, where the *absence* of monitored incidents does not indicate compliance with standards. All municipalities should be able to provide evidence on the ambient concentrations of pollutants relative to standards and develop a programme of action following the assessment.

6.2.4 The Public as Stakeholders

The shift in perception regarding inter-governmental interaction extends to the relationship with the wider public as well. Complaints dominated as a means of communication with the public by municipalities, noted as a significant tool by 67% of respondents. Besides highlighting the necessity of improving communication, complaints are an important component of current municipal capability as they aid officials in identifying problematic sources and associating these with elevated levels of exposure. The public, in essence, assist the municipality in source identification, which is a municipal responsibility, and in recognition of their assistance, efforts should be made by municipalities to facilitate their participation through all available means. Budgetary and capacity constraints place restrictions on the methods that authorities have at their disposal. Hence, initiatives such as the monitoring website with real-time updates and contact details or 24-hour complaints line operated by Umhlatuze municipality are not applicable by all municipalities. Other more conventional means, such as broadcasting or publishing news content on pollution control developments and making contact details more visible to members of the public can be easily implemented at municipal level.

However, the unavailability of officials after hours when excessive emissions are observed in some municipalities is a concern and innovative measures are needed for municipalities to address the issue of after-hours non-compliance. As Respondent 2 indicated, "the first step is monitoring, to be vigilant, industry (has) free rein in small towns… (require) monitoring station to counter air pollution", with monitoring playing a role in securing the co-operation of emitters, in compliance with permit conditions. Municipalities should attempt to initialise monitoring in problem areas by urging decision-makers of the necessity for compliance monitoring in a successful strategy, and allocating funds and requesting financial assistance from other sources for the earliest possible interventions. The encouragement of public effort in pollution identification and an attitude of corroborative working should be fostered, especially, in municipalities lacking in AQM capabilities and in other municipalities to the extent that the overall goal of protecting public health is realised.

The benefits wrought from greater inclusion of the public in AQM extend beyond filling in the gap for municipalities lacking in capacity. Addressing the needs of the public in decision-making, participation, consultation and communication creates an informed civil society able to actively participate in decision-making and contribute meaningfully to its outcomes. Communication is an important aspect of empowering the public to claim the desired environmental quality, creating an awareness of the choices that influence public policy and government action, with participation expanding the ambit of influence to introduce mechanisms where change can be affected by public choice and encouraging civil society to define an identity and opinion on issues. Consultation is a means whereby stakeholder communication can be maintained during processes, where although decisions may not necessarily be made, attitudes and perspectives can be proffered. All these tools can be utilised to coax civil society to assume an active role, which facilitates transparent and inclusive decision-making, and possibly leading to greater public support for implementation and improved perceptions of authorities and their initiated projects. It is a means of fostering buy-in for, even unpopular, measures as the risks and necessity can be transmitted adequately and fairly, and relying on the understanding imparted to individuals to motivate further.

Care must be taken to create a flow of information, and not simply conduct episode management, and requires on-going effort to keep the public 'in the loop' of communication. A public committee or board presents the most-readily implemented measure; however, the formal structure may prove too cumbersome and restrictive to allow good communication flow and the individual circumstances of municipalities should dictate the ideal implementing tool. The funding mechanism and co-management approach of the RBCAA in Umhlatuze municipality offers a promising option for other municipalities. The organisation is funded by contributions from industries in the municipality, in proportion to individual contributions to the total pollutant load, re-iterating the concept of economic incentives and, specifically, the atmospheric user charge mentioned briefly in the implementation funding section. The local municipality also contributes to the costs of monitoring and other AQM activities, including the employment of a dedicated AQO. A management board of directors runs the RBCAA and individual programmes are under the authority of sub-committees, with emitters, authorities and the public constituting the membership. Gathering stakeholders together in a non-aligned forum, leads to greater participation of all stakeholders, and a greater degree of interaction produces more effective outcomes.

In examining the mechanisms currently in use by municipalities, 56% of respondents used various media as a communication tool, and although this signifies a high percentage of use, these are generally restricted to ad-hoc communiqués for episode management and awareness. There was no consistent means of communication used by municipalities, with the exception of the RBCAA in Umhlatuze and there is room for improvement in these municipalities as the profile of air quality issues can be raised effectively using pre-existing methodologies.

Fora present an interesting option, similar to that of the public board discussed, and presents a multi-stakeholder platform for issues affecting any group to be discussed and allows for solutions to be developed and reconstructed by individuals affected by pollution impacts, authorities responsible for regulation and regulated emitters. It is used by 22% of respondents although there are possibilities for extending the reach of municipal education initiatives using fora as the vehicle for increasing awareness, capability and interaction on air quality. Umhlatuze holds fora with major industries, Umtshezi had an environmental forum with local industries and Uthukela uses a district health forum and municipal health committees. The membership of these fora were principally industries and authorities, with the public allowed to address the forum and attend meetings. By expanding the membership of fora and incorporating the public in a tangible way, the effectiveness can be increased and a dialogue created. There are difficulties in sustaining interest in fora though, as Respondent 1 commented, "Generally, forums start out with a bang, [and are] not sustained well or not what we expected". Mechanisms to sustain interest and adapt processes to address issues better are needed to elevate fora to a useful tool for effecting change.

6.2.5 Technical Capability Emphasis

Evident throughout the respondent comments is the stress on technical components of AQM above other functions related to planning and decision-making, where enforcement and monitoring especially, were listed more often than responses on AQMP development and AQO appointment. To illustrate further, identified responsibilities from the AQA were monitoring and enforcement at 94% and 53% respectively, with licensing identified by 35% of respondents. In contrast, the responses were negligible relating to non-technical aspects with AQMP's listed by 12% and AQO appointment by 6%. The emphasis on technical capabilities can be explained perhaps, by the outcomes, as monitoring and other technically associated AQM activities produce tangible outcomes that can be implemented in a visible manner. Monitoring stations, compliance inspections and licence documents are results that can be publicised, produced to emitters and motivated for in budgeting exercises. An AQMP is a planning document, and while it provides invaluable insight in determining the direction of an AQM programme, it requires deliberation and is essentially a policy-making exercise; therefore, generating less interest and publicity. The appointment of an AQO is a similar process, with the bureaucracy of these exercises stifling their importance in AQM. Non-technical activities necessitate innovation and inquiry and are inherently more intensive to develop than technical skills.

However, an AQM programme that lacks the elements of policy and planning addressed by AQO appointment and an AQMP is remiss in the guidance and planning of action and can deliver outcomes that could be futile with regard to the issues they were intended to ameliorate. Poor quality data and incorrect locations are examples of an improperly planned monitoring programme, and the targeting of the wrong emitters for reduction, the result of incorrect data or poorly considered control measures. Ignoring or implementing a substandard QA/QC protocol can deliver poor quality data, and incorrect locations can mean an oversight on the part of micrositing details such as a shadow from nearby trees or in the broader perspective, figures that fail to indicate the maximum ground-level or exposure concentrations. Targeting motor vehicles over industries, when the latter are the emitters of concern, illustrates well the instance of ill-advised control measures, where success in control will not achieve air quality objectives.

The emphasis on monitoring, and the data produced, as the basis for decision-making and planning is a positive aspect of the technical focus of municipalities, and refers to Hibiscus Coast, Umtshezi, and Umhlatuze local municipalities specifically. Hibiscus Coast intends using monitoring data as an overall planning tool and in particular in the development of an AQMP to identify problem areas and determine strategies to address them. Umtshezi has not initiated formal processes of decision-making and planning although monitored data will be used to examine the air quality in the area in detail, identify pollution problems and control solutions. Monitoring is an important component of the AQM strategy in Umtshezi. The air quality study conducted in Umhlatuze made extensive use of monitored and modelled data in the delineation of buffer zones for development (Liebenberg-Enslin and Jordan, 2005). Other municipalities did not express interest in using monitoring data as a component of the planning and decision-making processes. This may be motivated by the lack of data to utilise, as these municipalities are not currently monitoring air quality. In the future, as municipalities become increasingly aware of their responsibilities for AQM and are able to allocate resources accordingly, monitoring may be more commonplace and a greater number of municipalities will be able to access data and utilise these datasets for decision-making.

The existing level of awareness signals that municipalities realise the importance of obtaining the baseline characterisation of air quality in the municipality using actual measurements before embarking on planning a strategy for control. Measured concentrations provide a significant advantage when planning an AQM programme as they can be regarded as evidence of the extent of pollution and a solid foundation for decision-makers to base actions upon. Monitoring that is conducted well and at representative sites can prove useful for strategic decisions, and highlights the role of monitoring as an essential component of an AQMS, although not at the expense of other tools in the system. The quality of data influences the integrity of decisions based upon monitored data and QA/QC must be stressed, as an integrated function with monitoring, as well as to other stakeholders and decision-makers.

Good quality data is a significant a factor as obtaining monitoring data, and SANAS certification in Umhlatuze and the attempts at Umtshezi give direction for other municipalities to place their focus. Independent assessment of monitoring facilities, such as those offered through SANAS certification, allows for confidence in the quality of data produced from both users and stakeholders, such as the public and industry, should issues of credibility of measurements arise. The latter condition is particularly relevant where industry sponsorship of monitoring or the datasets from industrial self-monitoring are used, as all possibility of bias is excluded. In order to achieve accreditation, exacting standards of data quality, which are comparable to international norms, must be demonstrated. In the absence of assured data quality, further inputs into the AQMS are questionable and compromises all control measures implemented. While obtaining equipment and implementing AQM dominate the current outlook of municipalities, an understanding of errors and uncertainties and their quantification, where possible, through QA/QC procedures is a necessity as these tools form the basis upon which decision-making and policy rest. Therefore, the emphasis on technical capabilities should extend to ensuring that the data produced are adequate for the purposes envisioned before confidently placing it at the heart of a strategy.

The modelling of air pollution dispersion was poorly represented across the study, with little implementation or technical capability noted in responses, with Umhlatuze municipality being the exception using modelling to track non-compliant sources, especially in relation to complaints received. Dispersion modelling is useful for planning and the identification of problem areas, singling out areas for focused AQM intervention using the various model categories. Screening models are basic, working with simple assumptions and operating in isolation; however, for a relatively unpolluted area, can assist in identifying the impacts of development on air quality. Complex models allow for detail in inputs through the consideration of more variables in calculations, and can determine concentrations for units across a managed area, interpolating monitored data for a more complete picture of air quality. A grasp of the uncertainties and assumptions made by models is essential for the correct use of modelling data.

Internationally, control agencies and private companies have developed a number of models, and some well-developed and researched models are available without charge on the websites of agencies such as the US EPA. Municipalities could access these models and ascertain the impacts of planned developments, of existing emitters on air quality, and the spatial and temporal extent of impacts using simple screening models or more complex models such as Gaussian puff models. The level of input data and time and computing power necessary to run the models does increase with complexity. An agency with greater funding resources and AQM capabilities should carry the responsibility for modelling rollout, such as provincial or national authorities, as it provides a central structure as well as being able to generate more capacity internally to support the project. An element of training is necessary; however, upon designation of a responsible individual, training can progress quickly with only very complex models being inhibitive in their use. Expertise can be developed over time though continual exposure to modelling concepts and viewing the capability as a progressive skill. Modelling is an invaluable tool in an AQMS, and should be incorporated into municipal programmes wherever possible as it provides coverage over a greater spatial extent than monitoring, allowing for a more accurate assessment of compliance, and extends the reach of monitoring investments through interpolation.

Overall observations on AQM capabilities revealed that municipalities with the perception of good air quality placed less emphasis on the challenges to implementation and implementation as a whole, as well as relative to municipalities with identified air pollution problems. However, perceptions are, largely, value-based judgements, and the AQA is based on scientific proof of compliance. As such, the basis for an assessment of air quality is ambient air quality standards, for which interim values are available, with revised standards currently in process. The emphasis placed on standards as the concluding authority was weak throughout the study, with visual observation and complaints enjoying greater influence on issues of compliance. Although monitoring and non-compliance were mentioned often as issues by municipalities, 11% of respondents mentioned standards as an aspect of AQM and in relation to compliance. Umtshezi local municipality was in the process of identifying the threshold pollutant limits experienced in the town of Estcourt using monitoring data, and Uthukela district municipality recognised the existence of standards and levels, which were exceeded by local industries in Ladysmith.

Standards are the guideline for action and exceedances, or the risk of, indicate the need for controls on emitters and polluting activities. Judgements on poor air quality should be based on comparisons to standards, and following confirmation, action can be taken. Ambient air quality standards require greater emphasis as they are recognised as the fundamental premise of AQM, and the necessity should be communicated to municipalities as currently, air pollution issues are identified based on other criteria and following a stronger drive for enforcement by national authorities, based on standards, municipalities might be caught unaware on some issues. The stringency of standards proposed by the AQA coupled with the relative inexperience of municipalities indicate the possibility of NO_x and CO being exceeded in highly trafficked areas and SO_2 and PM_{10} shorter-term standards being exceeded in industrialised areas of municipalities or in settlements reliant on domestic fuel burning.

For example, Estcourt in Umtshezi municipality focused on SO_2 and particulate matter as control issues, however, the presence of a major national road in the municipality may result in exceedances of NO_x and CO; and Ugu district experiences high traffic volumes during vacation periods and NO_x exceedances may be unexpected by the municipality. Additionally, Ladysmith in Uthukela district highlighted particulate matter, SO_2 and dust as problem pollutants without further elaboration through monitoring or other means. Empangeni in Umhlatuze municipality has large traffic volumes of goods vehicles, especially diesel-powered trucks on a highly trafficked major highway and PM_{10} exceedances are a possibility although Richards Bay and surrounds captures the greatest attention in terms of relative air quality. The examples provide illustrations of the importance of using standards as a foundation for judgement and not perceptions. The comparison of measured values against standards to identify exceedances according to the AQA may surprise municipalities and require significant adjustments to the current management strategy.

6.2.6 Focus on Industrial Activities

There is a general focus on industrial emissions and behaviour, both at local implementation and national policy-making levels, and that is to be expected in view of a historical lapse in control and the significant contribution of industries to the total pollutant load in South Africa. Industrial emissions are seen as point sources, where a minimal comparative investment can lead to significant gains in air quality, and are targeted in the initial phases of pollution control. Evidence to support this approach can be found in the internationally recognised control programmes of countries such as the USA and UK, and in the earliest examples of control in the use of emission standards (Elsom, 1992; Jacobson, 2002). While the targeting of industries may be necessary to achieve large short-term, or immediate, gains, there is an obvious need to expand this focus in the long-term to procure sustainable air quality improvements. Additionally, attainment for these sources may not be as straightforward as officials, legislation or policies suggest and creative measures may be needed to bring industrial emitters into conformance with expected reductions. A reasonable programme of emission reduction and controls such as emissions trading can aid industrial compliance.

All municipalities placed the focus on industries when addressing implementation and responsibilities, frequently identifying the activities in relation to industries, e.g. licensing of industries or the identification of polluting industries for input into an emissions inventory. Emission inventories being conducted in Umtshezi, Uthukela and Hibiscus Coast municipalities exclusively addressed industrial emissions, expressing an oversight of other pollutant sources. Umhlatuze municipality was the exception as the only municipality that had addressed emissions other than those from industrial sources in the inventory, although other sources were found to be inconsequential in comparison to industry, in the context of the highly industrialised environment of Richards Bay. Monitoring activities in municipalities were also a response to industrial emissions and siting of stations were in relation to proximity and dispersion characteristics of problematic industrial emitters. Industries influenced the challenges facing municipalities, such as the resistance and non-cooperation of industries in AQM activities, the planning strategies of municipalities by zoning areas suitable for industries, and the control strategies by making them directly relevant to industrial control.

Industrial emissions represent a source of concentrated emissions in time and space, as large concentrations are emitted in a short time-scale, but other emitters may prove significant on other time-scales with respect to ambient air quality standards. According to the results regarding source identification, other sources are present in municipalities and will require quantification in the longer-term to attain compliance with standards in the fuller sense. Respondents identified domestic fuel burning, motor vehicles, veld fires and agricultural emissions as significant sources in municipalities. Although industrial emissions dominated the category, listed by 78% of respondents, as industrial emissions are brought under control, caution must be taken not to allow unfettered growth in emissions from other sectors. The characteristics of municipalities provide an indication of the types of sources and emissions, as well as related pollution issues, to expect.

Examples of indicators were discussed under Section 6.2.5 on technical capability emphasis, with the tourist-oriented economy of Ugu district being conducive to pollution from motor vehicles and noise, and the proximity of a major national road having possible consequences for air quality in Estcourt in Umtshezi municipality. Association with sources can then identify pollutants, which may present future problems or require addressing with increased significance following industrial compliance, and create a general impression of air quality issues. Assumption is unreliable in AQM, however, the intuitive assessment provides a basic assemblage of suggestions to be elaborated on and verified by AQM tools.

With the prevailing focus on industry, participation and co-operation are necessary factors for AQM activities as emissions data, compliance reports, licensing applications and other mechanisms require industry to be forthcoming and approach their involvement as a stakeholder as opposed to the regulated polluter. With specific reference to emissions inventories, the participation of industries was listed as a necessary component by 13% of respondents. Given the status of AQM in municipalities as preliminary and tentative, the difficulties being experienced suggest that industries should take cognisance of their responsibilities and municipalities should begin to engage with industries and increase their awareness of provisional and prospective requirements and control measures. As an illustration, Umtshezi local municipality has proceeded with discussions with industries on the provision of data and has communicated to polluting industries the strict enforcement that will be applied as implementation of the AQM programme advances.

The AQA provides assistance to AQO's regarding information provision by instituting the requirement for Atmospheric Impact Reports at the discretion of the AQO, where, on reasonable suspicion of non-compliance, any person is obligated to provide relevant details to the AQO (Republic of South Africa, 2005). This is an empowering tool, enabling officials to request information on demand from emitters and legally facilitating emitter participation; however, respondents in the sample showed no awareness of this provision. The finer details of AQA implementation have not been emphasised by authorities in lieu of the greater challenges in introducing an altogether new approach to air pollution control though it can be expected that upon securing the means and mechanisms for the fundamental elements of the strategy, the entire strategy can be promoted and applied.

6.2.7 Additional Issues

An issue arising from a respondent's comments and specific to Umhlatuze municipality concerns the possible conflict in responsibilities between Umhlatuze local municipality and the RBCAA as the current division of powers and functions could be construed as contravening the AQA in its current form or at some future date. As the local municipality is not completely responsible for monitoring and other AQM activities in the municipality, this may contradict the conditions of the AQA and action may be necessary to redefine the relationship. An agreement or similar document may be drawn up following the negotiating of the functioning of the RBCAA relative to the municipality, stipulating the responsibilities of both parties. The document may include, possibly, the ceding of functions to ensure infringements of the AQA are limited and the legality of the process is maintained.

Umhlatuze regards the RBCAA concept as a good model for other municipalities, as funding responsibility for AQM does not rest solely with the municipality, but encompasses emitters. Co-management allows municipalities to incorporate stakeholders into the management process, although the legislative powers remain the exclusive domain of the municipality. When the legislative queries surrounding the arrangement are clarified, further research into the organisational concept may provide insight into AQA mechanisms for other municipalities, especially innovative municipalities with a strong industrial base and good relations between authorities and emitters.

The need for by-laws was not expressly addressed in pollution control legislation or policy and clarity is necessary on the issue. Uthukela municipality has developed by-laws and is in the process of passing it into municipal law, while Umhlatuze raised the lack of pollution control by-laws in the municipality as a challenge to their implementation. Other municipalities placed no acknowledgment of the need, or lack of, for by-laws. National legislation is universally applicable throughout South African territory and therefore the AQA should be jurisdictionally superior to by-laws as stated in the act. Special consent is given for municipalities to implement more stringent measures locally as the need arises, and remains within the extent of the AQA.

6.3 Developing an Implementation Framework

In the development of a framework to guide the implementation of the AQA by the local government tier, practical considerations have emerged from the analysis of data and various theoretical concepts inform the implementation. These include the necessary development of an AQMP as a guidance tool for structured implementation; an AQMP allows for a baseline characterisation of air quality in the managed area and the assignment of tools accordingly. A noteworthy aspect of an AQMP for local government is the inclusion of budgetary and time allocations, as these ensure streamlining with the current and planned activities of the municipality. The latter refers specifically to the IDP mechanism in South Africa, which is the planning tool of choice for municipalities, and is given consideration in the AQA structure.

The expansion of the AQMS concept, incorporating the significant AQM tools, to address policy-relevant components and accommodate stakeholder information and public participation is in line with current models for AQM (Elsom, 1992; Fedra, 2002). Strictly scientific implementation removed from societal influences has not effectively ameliorated pollution problems, but transferred them across media or displaced them into another activity; therefore, pollution control is forced, increasingly, to address the behaviour that causes pollution through awareness and engagement. In a developing country context, partnerships are a key concept, whether with the private sector or civil society, bolstering the capability of authorities and enabling governance to remain relevant (Cloete, 2002).

Sustainable development is the current paradigm for environmental management policy, and South African policy is no exception; however, sustainability provides an innovative means of incorporating the concept into a practical expression. Sustainable development is regarded as a pathway and principles guide progress towards improved sustainability, providing a means of measurement. The principles guiding policy can be incorporated into the implementation of policy as well. The Bellagio principles for assessment comprise ten principles of a guiding vision and goals, holistic perspective, essential elements, adequate scope, practical focus, openness, effective communication, broad participation, on-going assessment and institutional capacity (Hardi and Zdan, 1997). The principles are intended only as guidelines for implementation, provide no guarantees and are suggestive of best practice. Sustainability is a particularly relevant concept in the light of this study, in addition to the motivations presented, as it purports a holistic perspective, incorporating ecological, economic and social factors and outcomes. Analysis has exposed the need for stakeholder consultation and participation, and balancing ecological and economic needs in the broader view.

Further elements that aid in the development of the framework and successful implementation include the reliance on AQM tools as these provide a scientific basis for decision-making and action, and the importance of governance to guide AQM implementation and define an organisational structure. Related is an essential systematic approach, highlighted in the AQMS, as AQM necessitates a strategic approach to demonstrate compliance with ambient standards. There is a need for a combination of approaches, both in control measures and strategy; although AQM is the defining strategy, emission standards and economic incentives strategies have been implemented successfully in other countries to improve cost-effectiveness and ease of control (Elsom, 1992). The last statement emphasises the assistance of case studies for authorities introducing AQM, making it unnecessary to repeat errors in implementation or policy and use innovation and policy guides developed by authorities advanced in AQM.

The USA has a long record of experience implementing AQM and has conducted research into improving the strategy and addressing the shortcomings, and has made freely available, through the US EPA, a variety of AQM tools (Elsom, 1992). The UK has undergone a similar experience to the current scenario in South Africa, having used a 'best practicable means' strategy and introducing AQM over a decade ago. The review and assessment framework for determining AQMA's offers particular insight in the development of the framework, resulting from the systematic nature of the process and the development of action plans as an outcome (Beattie *et al.*, 2001). A concluding observation on theory is the focus of an AQM strategy on implementation, with all elements of the strategy reflecting this characteristic, affecting guidance by stressing the importance of implementation, visible in the use of tools and emphasis on standards as the defining feature of the strategy.

6.3.1 A Framework for Implementation of AQA

A framework diagram has been prepared to guide municipalities through the implementation of the AQA at local government level and is presented in Figure 6.3. Implementation has been divided into three steps, which are intended to indicate increasing levels of complexity, as well as, with reference to step two and three, an increasing level of pollution. In the framework, Step one is mandatory in the AQA; Step two represents an additional mandatory phase and deals with the implementation of AQM in local government; Step three is a detailed approach necessary for municipalities where significant air pollution problems are present.

An important note is the consideration of stakeholder perspectives at various levels of implementation, and the effort to engage with them throughout the implementation process. Stakeholders are envisaged as a party or individual directly affected by air quality interventions, or the lack of, and include the communities located in proximity to a problem emitter, as well as the emitters. Authorities and structures within authorities should be included as stakeholders to enable control solutions with a large degree of acceptability to be developed, although it should be noted that some measures, inevitably, would remain unpopular though necessary. The inclusion of structures within authorities extends to working groups and other deliberative arenas to allow air quality to be viewed as a crosscutting issue, carrying influence in various areas that affect the quality of ambient air in a municipality; areas such as transportation and town planning are obvious examples.

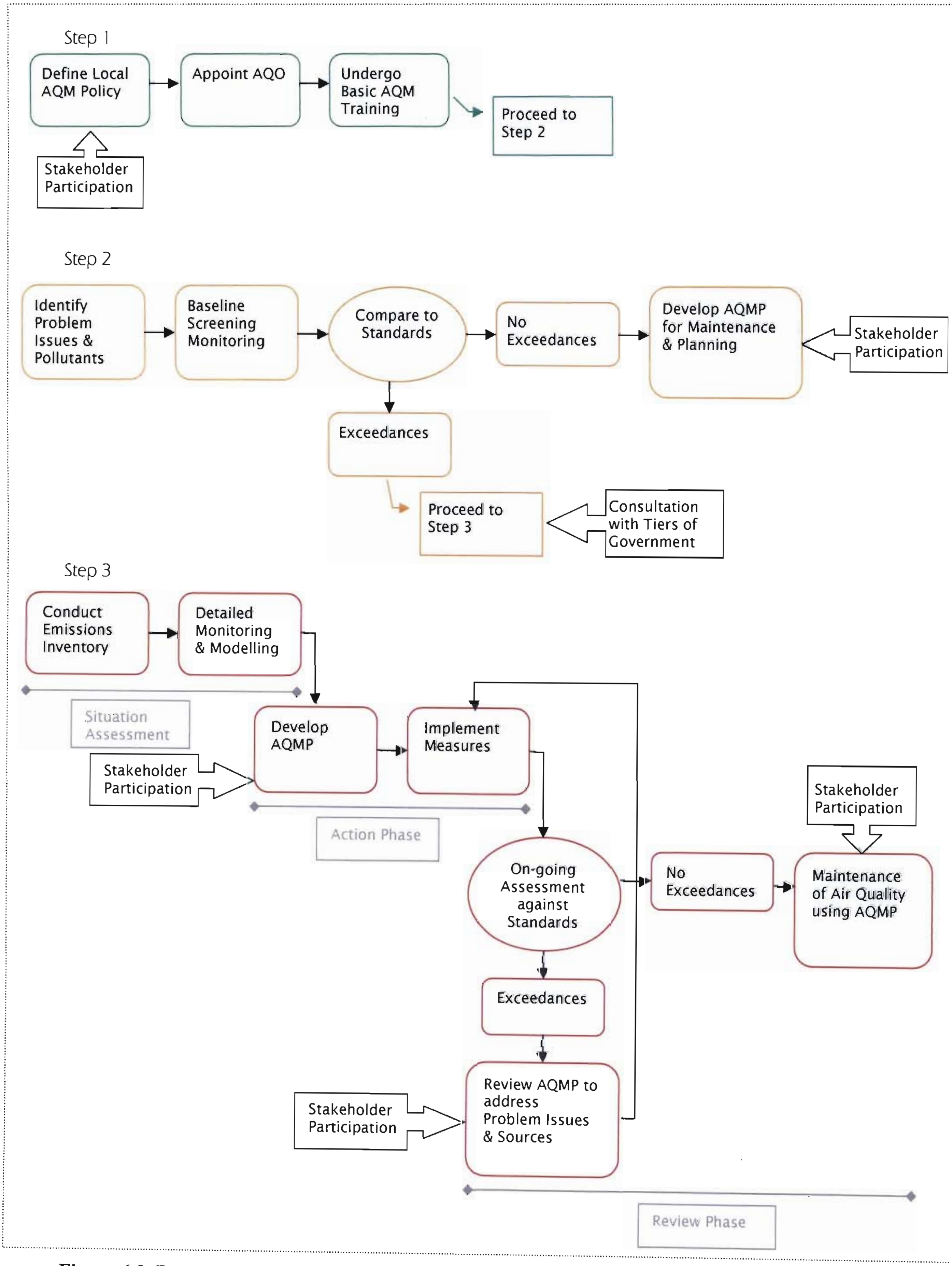

Figure 6.3. Framework for Implementation of the AQA

Non-technical participation and consultation with stakeholders is the ideal for enabling constructive outcomes and obtaining an accurate understanding of the issues that are motivating stakeholder concerns. Consistent information provision in an understandable format and a mechanism for response indicates facilitation on the part of authorities and promotes trust and co-operation between authorities and the public. Deliberation is an intensive consultation with stakeholders, where parties are involved in the development of solutions and directly influence these; deliberation may be necessary in instances of an aggressive civil society or the persistent offending by particular large emitters, as amenable solutions are determined around indicated limitations and often leads to increased support and improvements in compliance. An additional consideration in stakeholder consultation is the placement of the period of consultation; consulting stakeholder perspectives after discussions have occurred and policy or actions have been prepared undermines the value of stakeholder input and suggests a token of consultation. This is a commonality in dealing with the public, as the non-technical, and occasionally uninformed, civil society cannot contribute meaningfully and are not in a position to demand necessary air quality improvements. Authorities, dealing with the shift to AQM for pollution control, do have additional responsibilities to the communities in the municipality regarding communication and participation.

Step one and Step two represent mandatory phases in the implementation, however, Step one is distinguished for setting the initial conditions that are necessary to approach AQM strategically. The development of an AQM policy allows municipalities to incorporate relevant elements of the AQA and the aims of the legislation and overarching policy into the local setting, and determine goals and objectives for a local AQM programme. The local AQM policy serves as a statement of intention and shapes the activities in the municipality that are designated as discretionary or legislated. Stakeholder consultation and participation is necessary to correlate the vision of the citizenry and enterprises with that of authorities, and develop a common understanding of the expected outcomes of the AQM approach, as well as introducing the new approach. The policy-development activity has been designed as the first step to set a platform before AQM, as a pollution control exercise, is started and should describe policy for various subsequent activities.

The appointment of an AQO follows the description of policy and necessitates the designation of a single individual with duties and responsibilities outlined in the AQA. The individual may be supported by a team or hold sole responsibility for AQM activities, and in cases of limited human resources, the individual may be expected to carry out other functions in addition to air pollution control, as observed in the sample. The number and level of complexity of activities to be carried out influences the assignment of personnel and the need for additional staff. A job description, supplementary to the AQA, is needed to outline the deliverables of the AQO in the municipality and for performance assessment in the future. These should be a combination of technical and management skills and responsibilities. In the current municipal setting, it is viewed as necessary to provide AQM training to all officials designated as AQO's, and this action immediately follows AQO designation. The current AQM skills shortage and the limited avenues available for training suggest that few officials would have exposure to AQM concepts and activities and a blanket requirement for training is necessary.

Step two follows the policy-making and initial condition setting of Step one with implementation actions and actively develops the AQM approach for control in municipalities. The identification of problem areas and pollutants is based on previous experience in control, and the complaints register can be included as an information source. Based on the prioritised areas identified, screening monitoring is conducted to determine the ambient concentrations of the pollutants of concern. The monitoring exercise is intended to be a low-cost method of determining the existence of pollution problems and quantifying pollution in the municipality; short-term monitoring using inexpensive sampling methodologies is advised for the majority of less-industrialised municipalities. Monitoring data indicates areas of focus, and more importantly, in the comparison to standards, a decision is made based on exceedances measured. Therefore, standards are used as the benchmark to identify the need for action and determine the level of air quality experienced in the municipality, over and above subjective impressions.

The absence of observed exceedances, across all measured pollutants, leads to the development of an AQMP, with the primary aims of maintenance of the current air quality and planning to ensure future developments do not compromise air quality, in terms of standards. The AQMP provides an opportunity to increase the awareness of air quality issues in the municipality, through stakeholder consultation in the formal drafting and by instituting communication pathways for implementation. Guidelines for the development of an AQMP are characterised in the AQA although detailed notes on the structure, controls and procedure have not been produced. Exceedances of the standard for any measured pollutant necessitate advancing to Step three for the pollutant. At this juncture, consultation with provincial and national authorities is advised, as the exceedance of a standard is grounds for the declaration of a priority area, however, the authority for declaration is not vested with local government. In the interim period of the AQA implementation, priority area declaration as an AQM activity has yet to be fully implemented, with a single pilot priority area announced by DEAT. Municipalities can act in anticipation of priority area declaration or on indications from AQM tools.

The AQA provides some guidance on the management of priority areas, with no practical procedures or activities detailed currently. In Step three, the identification of problem areas and pollutants is formalised by conducting an emissions inventory to determine significant sources and the extent of emissions. Detailed monitoring and modelling is carried out based on the inventory in the areas of concern. The tools aid in the development of a representative picture of ambient concentrations in the municipality as a whole. These activities form a situation assessment, dictating the status quo of the municipality, which serves a dual function of informing control actions and assessing them post-implementation. The action phase involves developing an AQMP and implementing the measures contained therein. The AQA guidelines prescribe conditions for priority area AQMP's but is not specific regarding compliance, penalties, review or funding. The AQMP at this step is seen as more detailed than the maintenance AQMP drawn up in Step two, incorporating all AQM tools and advocating for their continuous use. The tools being emissions inventories, ambient monitoring, dispersion modelling, stricter air quality standards where deemed necessary, and emission control measures. General principles for other aspects of AQM should be included as well, including public participation, episode management, and emitter licensing. Stakeholder consultation and participation is a necessary component of AQMP development.

Following the implementation of measures set out in the AQMP, a review phase is necessary to determine the state of compliance, or non-compliance, of the managed area through on-going comparison with ambient standards. If the area is found to comply with standards, the AQMP can be revised to maintain the level of air quality and following the passage of no less than two years with compliance, the priority area designation may be withdrawn according to the AQA. Exceedances require a review of the AQMP to determine areas of weakness in planning and implementation and counter these through innovation and enforcement. The advised reviews of the AQMP also require stakeholder input. Penalties for not meeting priority area AQMP's should be addressed as well, ensuring the inclusion of a responsible party and timeframes for compliance.

While the framework has been structured to be systematic and easily implemented by local municipalities, both with existing air quality capabilities and not, officials must consider the influence of social factors on the management of air quality. Organisational culture, funding limitations, delays in implementation, and the lack of staff or an individual to drive the process are contributors to poor implementation that are not directly addressed by the framework, although they should be conceived at a strategic level for individual municipalities. On-going stakeholder engagement is necessary, including the defined stages in the framework, to facilitate support for control measures and resource allocation by municipalities. Cultivating skills and resources capacity can alleviate some pressure on the organisation of the municipality.

CHAPTER SEVEN
CONCLUSION

7.1 Introduction

Air pollution has a record of control dating back centuries, with innovation in strategy leading to improved ways of reducing the impact of anthropogenic emissions to the atmosphere. The previous control legislation under APPA employed the 'best practicable means' approach using emissions standards and led to the development of pollution 'hotspots' around South Africa (Barnard, 1999; UNEP/WHO, 1996). In terms of the environmental right enshrined in Section 24 of the Constitution, guaranteeing a non-harmful environment as well as purporting pollution prevention and minimisation, the out-dated approach of APPA required reform. The resulting legislation on air pollution control, AQA, was ushered in in September 2005 and altered the control of air pollution in the country, *inter alia*, by shifting the approach to AQM and placing the significant responsibility for control activities with local government. Examining the capacity of local government to implement the AQA is therefore pertinent, related to the control responsibilities as well as concerns raised over the capacity of local government prior to the AQA (Cloete, 2002; Scott *et al.*, 2005).

District municipalities, as a component of local government, were selected as the setting for the study, specifically in KwaZulu-Natal and recommendations made to facilitate the implementation by local government. The identification of responsibilities, from the AQA and theory on air pollution control, informed the role of local government in implementation, and air quality issues from the respective IDP's provided a baseline assessment and an indication of municipal plans to address air pollution. Capacity of authorities to fulfil the responsibilities was determined and the analysis of responses allowed recommendations to be succinctly presented in a systematic framework to guide implementation.

7.2 AQM, Local Government and the AQA

AQM is favoured in internationally recognised programmes, having ambient air quality standards that are the fundamental premise for control, and supported by AQM tools that aid air quality characterisation and control. Emissions inventories, monitoring, modelling and emission control measures support standards, with AQMP development, planning and transportation controls adjunct to the process. Local government is the vehicle of choice for the majority of AQM measures introduced, identified as the most effective tier of government to address air quality issues as they arise. AQA assigns a number of responsibilities to local government, including management and technical capabilities, and these are now coupled with the development challenges facing South African local government.

The securing of the environmental right has had far-reaching implications for environmental policy, influencing environmental management, waste management, and air pollution control through policy and legislation. The consolidation of environmental health functions at district municipalities through health legislation has also influenced pollution control at municipalities. Governance is the new approach to managing the interactions by public authorities, embraced by policy-makers and regulators on a broad scale globally. Interactions with stakeholders and policy and regulatory decisions are affected by the shift, and local government has to place air pollution control within this context as well. Internationally, bodies such as the UN and EU, together with individual countries' experiences of the USA and the UK, as good examples, provide valuable guidance and can act as case studies for South Africa to consider in developing the AQM programme.

7.3 Local Government Capacity

A mixed set of results was obtained on the range of categories used to indicate the capacity of municipalities. The awareness of responsibilities, according to the AQA, is inadequate in municipalities, with an emphasis on technical or previously implemented activities. Requirements introduced by the AQA were poorly recognised, although advances in implementation were evident. Numerous challenges face municipalities in implementing the AQA, the foremost being financial and human resources, identified by 78% of respondents. Municipal implementation and the challenges to implementation of the AQA are presented in Table 7.1. The human resources available to municipalities, and the skills capacity thereof, showed the availability of personnel, with 89% indicating available personnel. Although those dedicated to AQM activities were severely lacking, as only 6% of respondents indicated their sole responsibility to be pollution control.

With regard to technical capabilities, emission inventories and source identification were well represented, with 47% indicating processes for an emissions inventory. Monitoring capabilities were present to a lesser degree, although 89% of respondents were carrying out monitoring. Dispersion modelling is limited in application as 28% indicated the use of models. SO_2 was the most common pollutant identified (33%), and industries, the most common source (78%). Inter-governmental communication was, generally, ad-hoc, as indicated by 53% of respondents. Public communication showed greater reach, with complaint response the dominant tool, used by 67%. In both governmental and public contexts, communication was reactionary and poor on air quality issues.

Planning measures are widely used (69%), and there is evidence of the use of success indicators in the assessment of progress towards air quality goals (63%). Concerns are the discrepancies that exist between the implementation of district and local municipality levels, uncertainties in the transfer of environmental health staff catalysed by the National Health Act, and a general lack of awareness about the requirements of the AQA and the AQM strategy placed on local government.

Table 7.1: Summary Table of Municipal Implementation and Challenges

	Current Activities	Planned Activities	Challenges
Umtshezi Local Municipality	◦ Monitoring ◦ AQO	◦ AQMP ◦ Emissions inventory	◦ Employee awareness ◦ Industrial co-operation ◦ Inter-municipal AQM co-ordination ◦ Contradictions in transition from APPA to AQA ◦ More training
Uthukela District Municipality	-	◦ Monitoring ◦ Licensing ◦ Enforcement ◦ AQO ◦ AQMP ◦ Emissions inventory ◦ Approve by-laws ◦ Memorandum of Understanding with provincial Department of Health	◦ Funding for staff and equipment ◦ Intra-departmental and intra-municipal communication and consultation ◦ Industrial co-operation
Umhlatuze Local Municipality	◦ Monitoring network ◦ Emissions inventory ◦ AQO ◦ Dispersion modelling of SO_2 ◦ Compliance inspections ◦ Notice issue for non-compliance	◦ Licensing ◦ AQMP ◦ Enforcement ◦ Health study ◦ PM_{10} modelling	◦ Transparency in decision-making, inclusion of more stakeholders ◦ Funding for staff and equipment ◦ Lack of by-laws ◦ Lenient permit conditions ◦ AQA implementation delays ◦ Lack of clarity on municipality definition ◦ Division of powers and responsibilities between RBCAA and municipality
Uthungulu District Municipality	-	◦ Service level agreement with Umhlatuze	◦ Lack of clarity on municipality definition ◦ Transfer of staff ◦ Funding for staff and equipment
Hibiscus Coast Local Municipality	◦ AQO ◦ Monitoring ◦ Emissions inventory	◦ AQMP	◦ Funding for staff and equipment ◦ Community resistance and awareness ◦ Political interference ◦ Industrial resistance
Ugu District Municipality	◦ AQO ◦ Monitoring	◦ AQM needs assessment	◦ Funding ◦ Industrial resistance ◦ Community resistance

7.4 Analysis of AQA Implementation

The analysis of the capacity findings highlights the opportunities and challenges to the implementation of the AQA by local government. Structural issues related to the relationship between different authorities were strongly emphasised, and range from intra-municipal to inter-governmental level. Communication and consultation was the greatest challenge, manifested in difficulties in harmonising strategies, sharing expertise, and resource provision in the case of provincial authorities. Local and district municipalities experienced duplication of AQM efforts, with local municipalities often having greater expertise and access to resources than their respective district municipalities. Difficulties in implementation were related to legislative conflicts as well; with the ambiguous definition of 'municipality' in the AQA highlighted, and the transfer of the environmental health function to district municipalities according to the National Health Act.

Within municipalities, communication on air quality issues was poor as well, ignoring the crosscutting nature of AQM by locating the function solely within the Environmental Health Department, to the exclusion of town and transport planners. However, there is potential for successful implementation of the AQA as personnel and organisational structures exist to initialise development. Provincial authorities are charged with skills transfer and resource provision by channelling national action into local efforts, although limited application was evident in municipalities. The development of mechanisms and tools for provincial government to interact meaningfully with local structures is needed to foster active involvement and collaborative working. A summary illustration of the improvements to structural arrangements necessary for AQM is given in Figure 7.1, showing the need for improved communication and consultation within municipalities, between municipal levels and tiers of government. The red arrows highlight identified areas where significant improvements are necessary for successful implementation by local government. In the figure, the Environmental Health Department is abbreviated to Env Health, and similarly the Environmental Management Department is abbreviated to Env Mgmt.

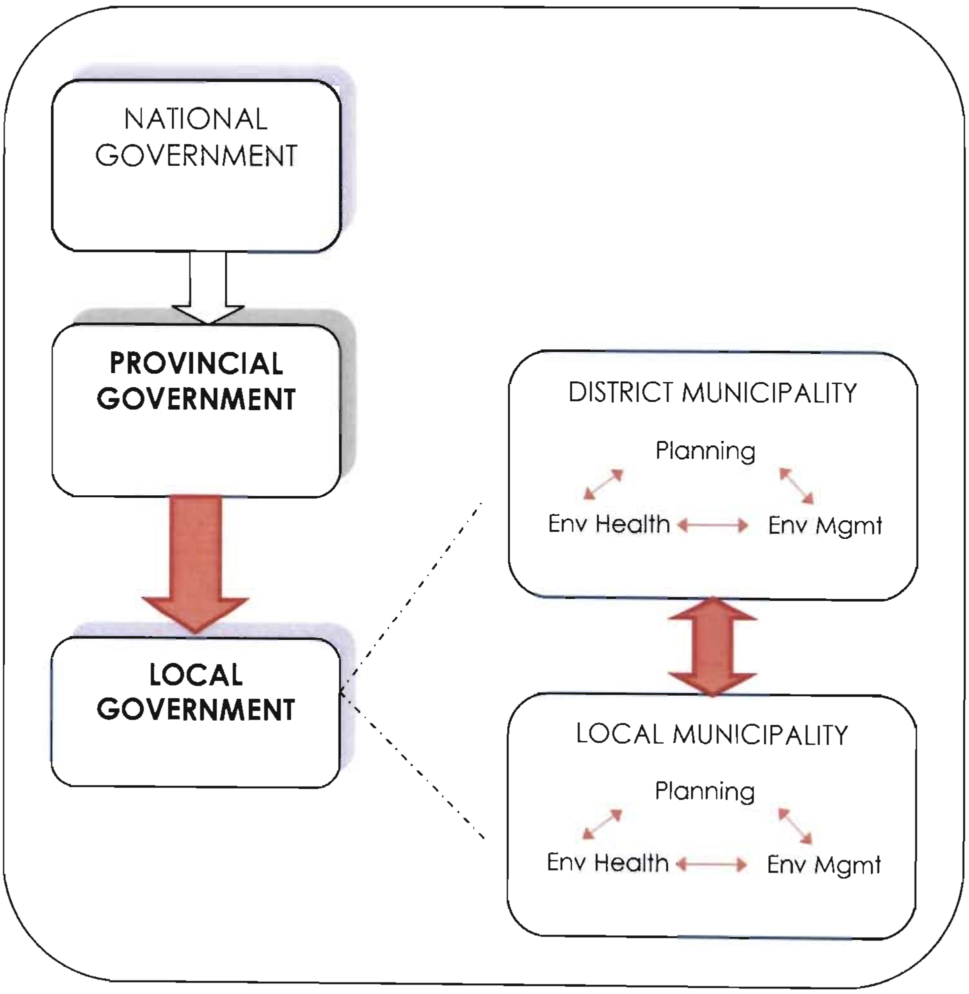

Figure 7.1. Summary Illustration of Improvements to Structural Relationships for AQM

Largely, planning for the implementation of AQM in municipalities was lacking. There was a need for consideration of the IDP mechanism and integrating AQMP drafting into the process, as well as the inclusion of the Planning Department. Funding AQM implementation has emerged as the greatest challenge to municipalities, and available avenues of access to resources should be explored, including assistance from provincial and national authorities. Placing a greater burden of pollution costs on emitters through economic incentives or regulatory imperatives such as self-regulation is advised, together with measures for securing continual strategy improvement and refinement.

Recognising the public as stakeholders in AQM and facilitating their participation is an important outcome of the study, indicating that the complaints mechanism should be emphasised and further efforts to maintain an informed civil society be made. Technical capabilities are strongly emphasised by municipalities and a holistic approach to managing air quality is necessary, while improving on the range and quality of tools and data production. Using standards as the basis of all AQM action in municipalities is an additional area of consideration for local government. Throughout the study, industrial activities have been the focus of AQM and the AQA provides the means to address major sources, although other sources that may be significant in an individual municipality should not be allowed to increase unchecked.

A framework for guiding the implementation of the AQA by local government was an outcome of the study, summarising significant theoretical AQM concepts and capacity findings, and informed by the requirements of the AQA for local government. The framework was presented in Section 6.2.3. It is divided into three steps and systematic in nature; step one and two are mandatory according to the AQA, with step three applicable to municipalities with considerable air quality issues. Stakeholder engagement is seen as on-going, although designated steps where interaction is necessary are indicated.

7.5 Looking Forward

By addressing the systemic nature of AQM, and coupling this with the structural issues raised, it is envisaged that the major challenges presented to municipalities by the AQA can be adequately resolved; however, factors such as a shift in organisational culture, funding limitations and individual 'champions' of AQM in municipalities are beyond prescription. It is clear that municipalities are progressing toward AQM implementation, although the nature of the implementation is variable, with some municipalities having greater access to resources and others lacking guidance in the approach. While creating technical and management AQM capacity is a national challenge, as indicated by Respondent 20, "Capacity is the most important issue to the implementation of AQA"; in the local government microcosm, the proximity to regulated emitters and the public amplify these needs. Following the addressing of the issue of capacity of municipalities, guidance in implementation is necessary to begin a structured and uniform application of the AQA in South Africa. The ordered rollout of the AQA, and the entire NAQMP, by national authorities, and improved inter-governmental working can influence the implementation of the AQA positively. This study has successfully highlighted noteworthy areas in municipal implementation, and in moving forward, the cultivation of capacity in line with the significant outcomes, as well as the active propagation of guidance from well-equipped national and provincial authorities, support the attainment of air quality improvements through municipal action.

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Appendix 1

Interview Schedule for Local Government regarding Implementation of the Air Quality Act (AQA)

Interviewee details: Name, Qualifications, Position, Role/Description of duties

1. How many staff currently carry out air quality functions?
   a) Are there plans for additional staff?
2. What do you see as the responsibilities of the Municipality in terms of the AQA?
3. What steps has the Municipality taken with regard to the implementation of the requirements of the AQA?
4. What challenges do you face in the implementation of the AQA?
5. Has an emissions inventory been done?
6. Is monitoring undertaken in the Municipality?
7. Is modelling carried out?
8. What are major emission sources in the Municipality?
9. How do you liaise with the public on air quality issues?
10. How does the Municipality communicate with national and provincial government on air quality issues?
11. Regarding potential/future air pollution problems, what control strategies or planning tools have been implemented?
12. Is the success of air pollution control measures assessed, with a view to improvements?