Department of Environment
and Resource Management

Clean and Healthy Air

For Gladstone

Final Report

November 2011

#29910

Tomorrow's Queensland: strong, green, smart, healthy and fair

Toward Tomorrow's Queensland

Queensland Government

Status of the Report

Environmental Protection Act 1994

For the purposes of section 73C of the *Environmental Protection Act 1994*, and in the context of the administering authority adding, changing or cancelling a development condition of a development approval that is necessary or desirable because of a matter or recommendation contained in this report; this is a report made by a recognised entity, being the administering authority, in accordance with section 73C(g)(i).

The administering authority in this instance is the Chief Executive of the Department of Environment and Resource Management, which is responsible for the administration of the *Environmental Protection Act 1994.*

Prepared by: Operations and Environmental Regulator, Department of Environment and Resource Management

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Executive summary

The Clean and Healthy Air for Gladstone (CHAG) Project has been undertaken in response to community concerns about the cumulative impact of industrial air emissions on the wellbeing of the community in the Gladstone region on the Central Queensland coast.

The region is a significant industrial centre with heavy industry moving to the area to take advantage of the port and transport infrastructure, energy supplies, close proximity to mineral resources export facilities, and an increasingly skilled industrial workforce. The continuing expansion of industrial activity has been accompanied by increasing community concern about potential impacts from current and future industrial activity on community wellbeing and specifically impacts on health from industrial air emissions.

The aims of the CHAG Project were:

- to assess the impact of contaminant emissions on the ambient air quality in the Gladstone area
- to assess potential risks to human health associated with those emissions
- to assess whether the community has experienced adverse health outcomes as a result of the emissions
- to develop a contemporary approach to the management of emissions in the Gladstone area, including better targeted conditions for development approvals, improved planning and forecasting capability, and targeted regulatory compliance activities
- to identify whether further health monitoring or evaluation is required.

The project was undertaken by the Department of Environment and Resource Management (DERM) in collaboration with Queensland Health. This report has been accepted by the Chief Executive of DERM as the administering authority pursuant to section 73C(g) of the *Environmental Protection Act 1994*. This empowers the administering authority to add, change or cancel a development condition of a development approval if it considers the addition change or cancellation is necessary or desirable because of the report.

This report summarises the methodology, scope of work and key findings of earlier reports for the CHAG Project which were completed by DERM or Queensland Health. This report advances that body of work to outline recommendations that will be implemented by both DERM and Queensland Health.

A project plan was developed in consultation with the community and industry of the Gladstone region. The project plan was based on environmental health risk assessment principles and included the following key tasks:

- development of an air emissions profile for the region and identification of key contaminants for detailed investigation
- implementation of a comprehensive ambient air quality monitoring program
- development of a regional air quality model
- community health assessment and health risk assessment
- review of regional air quality management.

At the time the CHAG Project commenced, there were no specific contaminants, sources of pollution or health conditions that had been identified as a particular concern to be targeted by the investigation. However, there was a general community concern about emissions of coal dust from stockpiles and its potential impact.

The CHAG Project has focused on the quality of the ambient air environment. This is the typical air quality that the general community is exposed to. The project did not set out to deal with the potential exposure of any individuals to key contaminants or with exposures of individuals in particular industrial settings.

The ambient air quality monitoring program, community health assessment and human health risk assessment focused on a suite of ‘key contaminants’ which were selected based on the potential for adverse health outcomes when associated with significant exposure.

The air quality monitoring program was one of the most comprehensive undertaken in Australia to date. It has provided the data needed for detailed and rigorous assessment of air quality and potential exposure of the Gladstone community to health risks from contaminant emissions to air.

The potential for contaminants in the air to have an adverse effect on health in the region was investigated through a detailed assessment of the health status of the Gladstone population. The assessment focused on conditions that may be aggravated or caused by contaminant emissions to air, and a human health risk assessment based on the results of the air quality monitoring program.

Air quality and health risks—key findings

Review of all available results from the air monitoring program carried out for the project during 2009—and in the case of fluoride and cyanide the first part of 2010—has identified no key contaminants were present at levels that either consistently exceeded the relevant health-based standard or guideline, or otherwise could be considered to pose unacceptable risks to health.

Results for many of the key contaminants were very low, and many were below the reporting level of the available analytical techniques. For the majority of results that exceeded the reporting level, there was a substantial margin between the results and the relevant health-based standard. In response to specific concerns raised during the project, levels of particulates, metals, benzene and fluoride in the ambient air were measured and found to be well below health-based standards—apart from levels of particulates which were elevated during the regional dust storms or local bush fires. In regard to concerns about cancers and reproductive effects, there is no obvious basis from air quality data for concluding that the ambient air in Gladstone poses unacceptable health risks.

The community health assessment found an excess of self-reported symptoms of asthma in both adults and children. As a number of common atmospheric contaminants are recognised to be respiratory irritants, the health risk assessment took into account potential for individual and cumulative impacts of these contaminants. The study concludes that the excess of self-reported symptoms of asthma is not explained by the levels of respiratory irritants in the ambient air in Gladstone. The contribution of household smoking and occupational exposure to contaminants to the reported levels of asthma in Gladstone could not be quantified in this study.

The summary assessment of air quality, based on the results of the air monitoring program supplemented by modelling on a smaller number of contaminants, is that the ambient air quality in the Gladstone area meets current health-based standards or guidelines. The findings are consistent with expectations for an urban Australian airshed with an industrial base. The air is not pristine, nor can it be in such an environment. However, no obvious health risks were identifiable in the ambient air assessment.

The Human Health Risk Assessment makes seven recommendations from the public health perspective, which are detailed in that report. While the air quality as measured in the course of the project is considered to meet guidelines or standards, and is acceptable from a population-based perspective, the recommendations address the need for ongoing ambient air quality monitoring; collaboration with the community and industry; and impact assessments to consider additional impacts on air quality. In addition, the Health Risk Assessment acknowledges the incremental benefits to human health of improvements in air quality generally, and control of particulate matter specifically, and recommends continuous improvements in emissions control. These recommendations are further discussed in the body of this report. The health risk assessment also makes recommendations regarding asthma management and smoking cessation, in response to the findings of the community health survey.

Managing contaminant emissions from existing sources

While no significant health risks were identified in the ambient air quality assessment, the nature of the existing concentration of heavy industry in the Gladstone region presents ongoing risks to air quality that need to be managed. The final report of the human health risk assessment carried out during the project recommended that industry, government and the community seek opportunities to reduce discharge of contaminants into the ambient air with the aim of improved amenity, reduced potential health risks and improved health status on a population-wide basis.

Development approval conditions relating to the release of contaminants to air are generally expressed as upper limits on the concentration or mass of contaminants that can be released. The various ways that emission limits are expressed has evolved over the years and is now inconsistent between facilities and, in some cases, specified sampling and averaging times for contaminants are inconsistent with achieving the air quality objectives of the Environmental Protection (Air) Policy 2008.

There is also now substantial inconsistency among development approvals in relation to the quality control, quality assurance, monitoring and reporting requirements that relate to emissions to air. Variations in sampling and reporting requirements contained in development approvals compromise the potential for the information collected to be a valuable data bank on regional emissions.

Recommendation

1. That current development approvals be amended to bring about an integrated approach to regulating air emissions and emission monitoring across the Gladstone area. The amendments should ensure:
    a. emission limits on particulates, sulfur dioxide (SO_2) and nitrogen oxides (NO_x) include a consistent short-term averaging time based on the ambient concentration objectives in the Environmental Protection (Air) Policy 2008 and the potential acute health impacts of these contaminants
    b. monitoring by the holders of development approvals for emissions of particulates, SO_2 and NO_x be undertaken on a continuous basis
    c. where industry monitoring is undertaken on a continuous basis it be reported to DERM on that basis
    d. monitoring of air emissions be undertaken in accordance with appropriate standard methods by organisations accredited by the National Association of Testing Authorities (NATA) for the relevant method
    e. the results of all emissions monitoring is reported to DERM in a format required by DERM on an annual basis
    f. emission limits in development approvals be amended to reflect best practice environmental management as defined in the *Environmental Protection Act 1994*
    g. new approvals reflect these requirements.

Sulfur dioxide emission limits

Sulfur dioxide is a significant respiratory irritant with the potential to impact on human health. Levels of sulfur dioxide in the Gladstone airshed during the sampling period for the health risk assessment were all within the relevant health-based guidelines or standards. However, the modelling work undertaken during the course of the CHAG Project showed that, if all industrial facilities in Gladstone were releasing sulfur dioxide at the maximum concentration permitted by their existing development approvals it is likely that ambient concentrations would be greater than current air quality objectives set in the Environmental Protection (Air) Policy 2008.

Recommendation

2. That the current limits on the release of sulphur dioxide from industrial facilities in the Gladstone region be reviewed to ensure that ambient concentrations are maintained at the minimum that is reasonably achievable with available fuel sources and technology installed.

Maintenance and operation of plant and equipment

The maintenance and operation of plant and equipment is a significant factor influencing the quantity and quality of contaminant releases to air. This is dealt with in most development approvals through conditions that require operators to install, maintain and operate plant and equipment in a proper and efficient manner. During the course of the CHAG Project, the environmental risk posed by incidents that result from poor maintenance and operation of plant was highlighted by a number of incidents that resulted in uncontrolled release of contaminants.

The development approval conditions relating to the maintenance and operation of plant and equipment are inconsistent between facilities and ambiguous in terms of the standard of performance required.

Recommendations

That development approval conditions relating to the maintenance and operation of plant and equipment be amended to ensure consistency, and include requirements for rigorous auditing processes that minimise the potential for environmental harm occurring through poor maintenance and operation of equipment.

3. That development approval conditions similar to the following be applied where facilities rely on the pollution control equipment to avoid environmental harm:
    a. A current inventory of design data and maintenance requirements, including maintenance history for all pollution control devices operated at the site must be kept and maintained on a weekly basis.
    b. All pollution control devices must be operated within design and maintenance specifications.
    c. Where monitoring of pollution control equipment indicates impaired operational performance, standby systems are to operate and corrective measures must be undertaken.
    d. The plant(s) serviced by the pollution control equipment with impaired operational performance must be safely shut down as soon as practicable, unless otherwise agreed by the administrating authority.
    e. In the event of significant process change that may directly affect atmospheric emissions or process operations that could lead to unplanned atmospheric emissions (for example, alterations to process or capacity) the final design of the process change or addition will be subject to a formal hazard and operability study to identify and mitigate process risks.

Incident response

In the event of uncontrolled releases to air, the first priority is to ensure community exposure to potentially harmful contaminants is minimised.

The Queensland Government has a comprehensive emergency management system to respond to emergencies in a coordinated manner. These actions are guided by Queensland's Chemical/HazMat Plan 2004 and Disaster Management System which operate at all levels of the community.

There is also potential for incidents to occur where an emission to air may cause environmental harm, but not trigger an emergency response because there is no apparent or reported serious risk to the life or health of individuals.

During the course of the CHAG Project, community concern was raised over possible gaps in incident response, handling and post-incident information dissemination protocols used by industry and government. The community considered that government and industry were not adequately responding to incidents or communicating responses relating to the release of emissions.

Separately, the Government has amended the *Environmental Protection Act 1994* to extend the obligations of operators of all activities to report and communicate incidents that have the potential to cause environmental harm.

Recommendations

4. That DERM seek assurances from existing operators that they have recently undertaken site risk assessments that adequately identify potential incident scenarios, state the likelihood of occurrence, list the hazards that may occur as a result of any incident, and model the potential impact of an incident.
5. That operators of significant sources of air pollutant emissions have regard to the DERM Procedural Guide on Industry Incident Contingency Planning and establish incident response plans that ensure:
    a. specific procedures to respond to incident scenarios identified through the risk assessment process exist
    b. response procedures are regularly tested, reviewed and evaluated.
6. That operators of significant sources of air pollutant emissions develop procedures to adequately report and communicate incidents, investigate incidents, record incident data and review incident response plans.
7. That current development approvals be amended to include incident response conditions that:
    a. provide consistency and clarity of requirements to notify the administrating authority
    b. have incident response plans that are based on the requirement of the Emergency Preparedness and Response provisions of ISO14001.

Air quality monitoring

The comprehensive air quality monitoring program undertaken for the CHAG project provided the data needed for a rigorous assessment of air quality and potential exposure of the Gladstone community to air contaminants.

The scope of the ambient monitoring program, in terms of the number of sites and variables measured, was significantly greater than would usually be required in a regional centre with industrial sources. This ensured that it provided a comprehensive basis for the review of ambient air quality characteristics.

The scale of ongoing monitoring required needs to reflect the findings of the intensive monitoring program undertaken as part of the CHAG Project, and the emergence of new industrial sources in the Gladstone region.

DERM has largely met the cost of ongoing monitoring of ambient air quality in the Gladstone region with some limited capital contributions from particular industries. Consistent with the 'polluter pays principle' adopted in the Intergovernmental Agreement on the Environment, future ambient air quality monitoring costs should be shared with industry operating in the region.

Recommendations

8. That DERM continues to operate the ambient air quality monitoring network in the Gladstone region and review the list of monitored contaminants as new major industries are established.
9. That the Department enter into arrangements with existing and new industries operating in the region to contribute to the capital and operating costs of the ambient air quality monitoring network in the Gladstone region.

Air quality model and emissions inventory

The air quality model developed during the project is a tool that supports decision-making about the best location of development in the region and, in particular, the location of new development and its impact on the potential cumulative effects on the ambient air environment.

The CHAG Project developed an emissions inventory to provide input data for regional air quality modelling. Compilation of the detailed regional emissions inventory required a significant investment from government and industry to ensure that it contains reliable estimates of contaminant emissions from the many sources in the Gladstone region.

Recommendations

The following recommendations are aimed at ensuring modelling tools can be maintained and developed to support decisions regarding management and ongoing development of the region.

10. That DERM maintains a comprehensive inventory of air emissions for the Gladstone region.
11. That new industries (of sufficient scale to materially change the air emissions profile) be required to verify and report their emissions profiles to the department within two years of beginning operations.
12. That when existing facilities currently included in the inventory make changes to plant and equipment that require an amendment to a development approval, verification of emissions from the plant and equipment affected should be carried out.
13. That existing industry works with the department to address shortcomings in emissions data for particulates, mercury and organic compounds.
14. That each facility operating an environmentally relevant activity (ERA) that releases contaminants to air undertakes an evaluation that determines a complete list of release points, and on the basis of a risk assessment, identifies release points that should be included in the emissions inventory.
15. That existing development approvals be amended to require facilities operating ERAs to limit releases to specific release points.

Best practice management

Currently, there is no specific policy requirement for new or expanding developments to adopt low-emission technologies. However, best practice environmental management must be considered when making environmental management decisions under the Environmental Protection Act.

Environmental impact statements currently require an assessment of alternatives to a proposed project. However, this assessment rarely extends to an assessment of proposed technologies against available alternatives.

Recommendation

16. That the terms of reference for environmental impact statements for projects in the Gladstone region include a requirement that the proponent of a project identifies contaminant emissions and alternative available technologies for their management to achieve best practice environmental management.

Land-use planning

Gladstone is an expanding industrial centre with a large industrial land bank, port facilities and government support for continued development of heavy industry. The region is at a stage where significant rapid growth is occurring. This expansion will lead to an increase in, and changes to, the nature of contaminant emissions to air. An appropriate approach to planning for the location of new sources will ensure that the cumulative effects of current and future development do not compromise ambient air quality.

Land-use planning is a major factor in achieving acceptable ambient air quality and protection of public health and wellbeing. The outcomes of land-use planning that are of interest in managing ambient air quality are the separation of heavy industry and residential or other areas that may be adversely affected by industrial activities; avoiding the concentration of polluting activities with similar air emissions characteristics; and protecting industrial development from encroachment by residential and other sensitive land uses.

In determining the location for a new facility, regard should be given to the cumulative impacts of emissions to air from the facility. New industry should be located to ensure adequate dispersion of air emissions, and limitation of the opportunity for cumulative interactions.

Recommendations

17. That decisions regarding the location of new industrial development in the Gladstone region be evaluated for the potential for cumulative impacts on air quality.
18. That priority be given to locations that avoid cumulative impacts and the degradation of ambient air quality.

Community expectations regarding air quality

Community expectations regarding air quality and the potential impacts of industrial development are generally outlined in section 2. The community expects the ambient air quality in the Gladstone region will not be compromised by existing and future industrial developments.

During the course of the project, the joint community-industry-government reference group has been a necessary and productive forum for dissemination of ideas and provision of feedback and opinion.

In addition to this forum, the Gladstone Industry Leadership Group was formed in 2008. Members of this group are:

- Boyne Smelters Limited
- Cement Australia
- NRG Gladstone Operating Services
- Queensland Alumina Limited
- Rio Tinto Alcan – Yarwun.

The group's member companies have publicly committed to continuous improvement in areas of concern to the community such as the environment as well as to openly sharing information with the Gladstone community.

More recently, the Gladstone Region Environmental Advisory Network (GREAN) has been established under the auspices of Gladstone Regional Council. The membership of GREAN is drawn from the regional community. The functions of the group as identified in its terms of reference include acting 'as a community reference group for projects as considered appropriate by the committee (e.g. Clean and Healthy Air for Gladstone Project)'.

Recommendation

19. That DERM continues to maintain a working relationship and regularly consult with the community, industry and local government in relation to the department's regulatory oversight of air quality management in the Gladstone area.

1 Project outline

This report documents the outcomes and findings of the Clean and Healthy Air for Gladstone (CHAG) Project. The project was an investigation into the quality of air in the Gladstone region, the factors influencing air quality, management of air pollution and the potential for adverse impacts on the health of the Gladstone community due to air pollution.

The CHAG Project was initiated in mid 2007 in response to community concerns about emissions to air in the Gladstone region and the potential for those emissions to have an adverse impact on the health of people in the Gladstone community.

The project was undertaken by DERM in collaboration with Queensland Health. This report documents the findings of the CHAG project and has been accepted by the Chief Executive of the DERM administering authority pursuant to section 73C(g) of the *Environmental Protection Act 1994*.

This report summarises the methodology, scope of work and key findings of earlier reports for the CHAG Project which were completed by DERM or Queensland Health. This report advances that body of work to outline recommendations that will be implemented by both DERM and Queensland Health.

1.1 Project aims

The aims of the CHAG Project were to:

- assess the impact of air emissions on the ambient air quality in the Gladstone area
- assess the potential risks to human health associated with those emissions
- assess whether the community has experienced adverse health outcomes as a result of those emissions
- develop a contemporary approach to the management of emissions in the Gladstone area, including better targeted conditions for development approvals, improved planning and forecasting capability, and targeted regulatory compliance activities
- identify whether further health monitoring or evaluation is required.

1.2 Project methods

The project was a joint venture DERM and Queensland Health, with DERM leading the project and contributing expertise in air quality, and Queensland Health contributing expertise in toxicology and population health. The project plan was based on accepted environmental health risk assessment principles and guidelines as articulated in current Australian guidelines (enHealth Council, 2002) and included the following key components to inform subsequent policy interventions:

- development of an air emissions profile for the region and identification of key contaminants for detailed investigation
- implementation of a comprehensive air quality monitoring program
- development of a regional air quality model
- community health assessment and health-risk assessment
- review of regional air quality management.

The emissions profile identified sources and quantities of air contaminants released in the Gladstone area. A list of key contaminants of particular interest in regard to their potential health impact was identified from the full emissions profile, and was used to guide the air quality monitoring and health investigations completed as part of the project. The emissions inventory is also a fundamental dataset to support air quality modelling for the region. This component of the project is discussed in section 3.

The assessment of residents' exposure to air contaminants in the Gladstone region was based primarily on a detailed air quality monitoring program that measured the concentrations of over 160 contaminants in the air from late 2008 until July 2010. The results of the monitoring program were supplemented by an air quality model developed specifically for the region. The monitoring program is described in detail in section 4 and the air quality model in section 5.

An assessment of the health of people in the region was carried out to determine if there was evidence that the region had an unusual prevalence of diseases that can be caused or exacerbated by air pollution. The health assessment had two main components, an analysis of data from existing health datasets and a structured community health survey. The health assessment is described in detail in chapter 6. The results of the air quality monitoring program and health assessment were analysed in the final health risk assessment report and summarised in chapter 6.

Current air quality management was reviewed against the management hierarchy in the Environmental Protection (Air) Policy 2008 and contemporary best practice to identify strategic improvements. This is detailed in chapter 7.

1.3 Project governance and consultation

At the outset of the CHAG Project, the Queensland Government made a commitment that the investigation would be undertaken in a rigorous and transparent way so that the findings and outcomes could be relied upon by the community, government and industry in the region.

To ensure that this occurred, the project included the following project governance arrangements:

- The project was managed through a whole-of-government steering committee including senior representatives of Queensland Government, including Queensland Health, DERM, Department of Transport and Main Roads, the Department of Employment, Economic Development and Innovation and the local government, Gladstone Regional Council.
- A Community Reference Group was established to provide the community with a means to effectively contribute to and participate in the planning and progress of the project. The former Gladstone City and Calliope Shire Councils, which are now part of the Gladstone Regional Council, facilitated the formation of this group.
- An Industry Reference Group was established to ensure that there was effective involvement of industry in the implementation of the project, and to provide a forum for implementation of project recommendations. Formation of this group was initially facilitated by the Gladstone Area Industry Network.
- Recognised non-Queensland Government experts in environmental toxicology, population health and air quality science were engaged to undertake independent reviews of key project processes and findings. Dr Neville Bofinger from the Queensland University of Technology reviewed the air quality components of the project and Professor Brian Priestly, Head of the Australian Centre for Human Health Risk Assessment at Monash University (Victoria, Australia) was responsible for reviewing the health assessment and health risk assessment components of the project.
- A series of community forums were held during the course of the project to ensure that the people and industry in Gladstone were kept up to date with progress and were presented with project findings on an ongoing basis.

Associated with the release of each report from Queensland Health, a number of activities were undertaken, including information sessions for community members, community leaders and health practitioners; and media conferences. Each report but the last was followed by a public forum providing opportunity for responses to each report. The independent reviewer for the health components of the study, Professor Brian Priestly participated in these activities.

2 Context

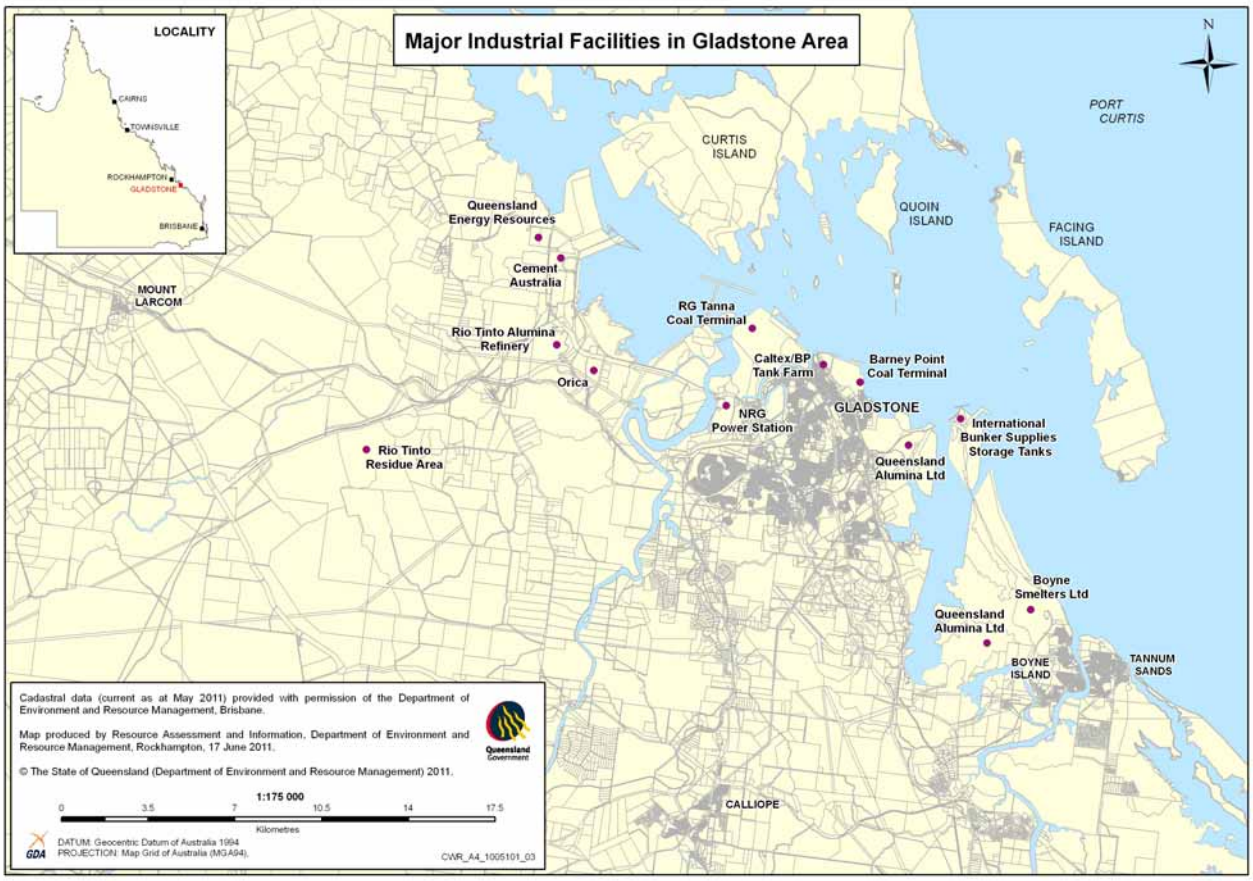
2.1 Regional context

The study area was centred on the city of Gladstone, a city of approximately 60 000 people located on the Central Queensland coast in north-eastern Australia. The area included the satellite townships of Mount Larcom, Calliope and Boyne–Tannum as shown in Figure 1.

The region is a significant industrial centre with heavy industry moving to the area to take advantage of the port and transport infrastructure, energy supplies, close proximity to mineral resources and an increasingly skilled industrial workforce.

Major industries include Queensland's largest coal-fired power station, two alumina refineries, Australia's largest aluminium smelter and cement kiln, one of Queensland's major ports, a chemical manufacturing plant which is one of the largest producers of sodium cyanide in Australia, and various other engineering fabrication facilities.

Figure 1: Major industrial facilites in the Gladstone area



2.2 Projected regional growth

Further development of large industry is planned for the region and an industrial land bank of approximately 28 000 hectares has been established by the Queensland Government to secure and reserve a large area of suitable land with ready access to the harbour for large-scale industrial development over a 30–50 year timeframe (Queensland Government 2008). In addition to this, a large area of the harbour foreshore has been set aside as port-strategic land under control of the Gladstone Ports Corporation Limited.

The resident population of the Gladstone Region was 57 587 at the end of 2008. The region's rate of population growth exceeded the Queensland average over the five years to 2006 with an average annual growth rate of 3.1 per cent since 2001, compared to Queensland's average annual growth rate of 2.4 per cent over the same period. This trend is expected to continue with the region's population anticipated to grow to around 90 000 by 2031 under a low-growth scenario and as high as 115 000 under a high-growth scenario.

2.3 Community concerns

The expansion of industrial activity in the region has been accompanied by increasing community concern about the potential for impacts from current and future industrial activity on community wellbeing and health.

Dust and other air contaminants from industrial and commercial activities around Gladstone have been a concern to some members of the Gladstone community for some time. In certain areas, coal dust has been of particular concern.

In response to questions asked in Queensland Parliament in April 2007, Queensland Health completed an analysis of data on asthma, miscarriages, total cancers and leukaemia in Gladstone. The initial results showed no differences between Gladstone and the Queensland average except in the case of one particular type of leukaemia, called chronic lymphoid leukaemia, or CLL. In the period 1996 to 2004, 19 cases of CLL were reported in Gladstone, when, according to the state average, just nine cases were expected in a population the size and age make-up of Gladstone.

This apparent high incidence of CLL was investigated in further detail and the findings published (Queensland Health, 2007). The investigation found 22 people with CLL in the study period who lived in Gladstone City or Calliope Shire at the time of their diagnosis. According to Cancer Registry data, if the Gladstone–Calliope region had the same rate of CLL as the state average, 14 cases would have been expected during the years 1996–2004. The investigation concluded that no environmental factor could be identified as a possible cause. An unusually high number of cases in the area were pre-disposed to CLL based on genetic risk and this may have explained part of the excess. The elevation of cases could otherwise have been the result of random variation in time and place.

Ongoing community concerns about air quality have been well documented by a series of contemporary investigations that have canvassed community attitudes within the region. These include the following:

- A survey undertaken by Queensland Health as a part of the current investigation included questions relating to perceptions of industry (QH February 2009). Three-quarters of all respondents expressed some level of concern about potential impacts of industry on health; 30 per cent were highly or extremely concerned. Of those who were concerned about potential impacts of industry on health, nearly 70 per cent were concerned about air pollution and dust. Nearly 600 respondents expressed high or extreme concern that air pollution may be affecting their health. Nearly half the Gladstone respondents said they felt they had very little control over risks to their health. This survey is discussed further in chapter 6.
- In May 2007 the Central Queensland Ports Authority (now the Gladstone Ports Corporation) released a report on qualitative research regarding public perceptions of dust in Gladstone (Rowland 2007). Health was identified as 'the primary concern of the focus group participants, with many participants concerned about the perceived potential impact of coal dust on their health'.
- These findings were reinforced through a community visioning process (Philips & McGrail 2008) that identified significant concern about environmental management and consultation processes and scepticism about the accuracy and independence of environmental monitoring data and reports.

2.4 Summary of geographical issues

Gladstone is an established industrial centre with a significant land bank, port facilities and Queensland Government support for continued expansion of industrial activity. The region is at a stage where significant rapid growth is anticipated through the establishment of a liquefied natural gas (LNG) processing and export industry and other proposed projects.

The local community has concerns regarding the growth of the region and in particular the potential for impacts on health and lifestyle. A lack of trust in the decision-making processes of government and industry that are guiding this expansion has been reported in industry-sponsored studies.

The presence of nuisance dust and odours has been a long-standing issue for people in the region. However, past air quality monitoring and the understanding of industrial emissions at the outset of the project had not identified specific contaminants that should be of specific concern in regards to community health. Neither had specific health issues been identified that needed to be targeted by the investigation.

3 Regional emissions profile

At the time the CHAG Project commenced, there were no specific contaminants, sources of pollution or health conditions that had been identified as particular concerns to be targeted by the investigation. The first stage of the project involved developing a comprehensive list of contaminants likely to be released to air in the region.

The initial list of contaminants was based on reports to the National Pollutant Inventory (NPI) and comparable datasets and literature reviews for industrial sources and potential releases from other non-industrial activities. The final list comprised 187 potential contaminants including 22 metals and metal compounds, 145 organic substances and 20 inorganic substances.

3.1 Key contaminants

To focus the project on contaminants with known health outcomes, the initial list was reviewed to identify those contaminants for which significant exposure could be associated with adverse health outcomes.

A combined Queensland Health and DERM group with expertise in environmental analysis and monitoring, analytical chemistry, industrial process engineering, environmental health and toxicology, public health medicine and health risk assessment was formed to review the initial list.

The following criteria were used to select a subset of key contaminants for investigation:

1. The availability of good-quality toxicological and scientific evidence in regard to potential health risks.
2. The potential for significant community exposure, according to current emissions data.
3. The availability of ambient air standards against which results of monitoring could be compared. Standards were selected in the following order of priority: Australian National Environmental Protection Policy for Ambient Air Quality and Queensland Environmental Protection (Air) Policy; World Health Organization; and international standards from the USA and Canada. The absence of a standard, however, was not a criterion for excluding a contaminant from consideration.
4. The potential for significant variations in exposure under a range of operating conditions.
5. Whether the contaminant was a marker representative of exposure to a range of other substances; for example, the detection of heavy metals in unusual quantities could indicate the presence of other contaminants.
6. The ready availability of validated measurement and analytical techniques.
7. The potential level of community concern.

Once selected, a paper identifying the proposed key contaminant list and preliminary health measures was prepared for consultation and discussion (QH2008). The paper was presented to the project reference groups and the external independent health reviewer, Professor Brian Priestley. As a result of the consultation process, coal dust and PM_1 (particulates with a mass median aerodynamic diameter of 1 micrometre or less) were added to the proposed list. The final list of key contaminants is provided below.

Table 1. List of key contaminants for investigation

Category of contaminants	Contaminants included in the category
acidic / caustic aerosols	ammonia, acidic vapours, hydrogen sulphide, sodium hydroxide
carbonyl compounds	acetaldehyde, acrolein, formaldehyde
carbonyl sulfide	
coal and coal dust	
criteria gaseous contaminants	carbon monoxide, oxides of nitrogen, ozone, sulfur dioxide
cyanides	
fluorides	hydrogen fluoride and fluoride compounds
metals	arsenic and compounds, beryllium and compounds, cadmium and compounds,

Category of contaminants	Contaminants included in the category
	chromium (III) and compounds, chromium (VI) and compounds, lead compounds (inorganic), lead compounds (organic), manganese and compounds, mercury and compounds, nickel and compounds, zinc and compounds
polychlorinated biphenyls	
polycyclic aromatic hydrocarbons (PAHs)	anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, naphthalene, phenanthrene
radionuclides	internally deposited radionuclides (uranium/thorium)
volatile organic compounds (VOCs)	volatile organic compounds (total), benzene, carbon tetrachloride, ethylbenzene, methyl ethyl ketone, methyl isobutyl ketone, toluene, 1,1,1-trichloroethane, trichloroethylene, xylenes
particulate matter (PM)	total particulate matter, PM_{10}, $PM_{2.5}$, PM_1
polychlorinated dioxins and furans	

The key contaminant list was used to guide an expansion of the existing air quality monitoring program, a community health assessment, and a comprehensive health risk assessment.

3.2 Detailed emissions profile

The Clean and Healthy Air for Gladstone Project identified the need for a complete inventory of emissions to air to support development of an up-to-date air quality modelling tool.

Estimates of the quantities of each contaminant released in the region were initially of variable quality, prompting a process of refining these estimates to support air quality modelling work. This process is described in the following sections.

3.2.1 Emissions sources

Particular sources of emissions were included based on the:

- chemical species emitted
- scale and intensity of emissions generated or emitted by the source
- potential for direct human exposure to the source
- availability of a technique to estimate emissions.

Major industrial sources included in the emissions profile were:

- Boyne Smelters Limited aluminium smelter, Boyne Island (BSL)
- Queensland Alumina Limited alumina refinery (QAL)
- Rio Tinto—Alcan alumina refinery at Yarwun (RIO)
- NRG Gladstone Power Station (NRG)
- Cement Australia (CA)—Fishermans Landing
- Orica chemical plant
- Gladstone Ports Corporation Limited (GPCL) operations
- International Bunker Supplies South Trees storage tanks
- Caltex–BP fuel storage facility.

In addition to the major industrial sources, a range of other emission sources was included in the inventory. These are termed ‘aggregated emissions’ and include the sources that are generally found in urban areas. Individually such sources are not of regional significance, but can be when aggregated.

Aggregated emission sources included in emissions profile were:

- aircraft
- commercial boating
- recreational boating
- commercial shipping
- railways
- architectural surface coatings
- barbecues
- cutback bitumen
- domestic aerosols and solvents
- dry cleaning
- gaseous fuel combustion (domestic)
- industrial solvents
- lawn mowing (domestic)
- motor vehicle refinishing
- paved and unpaved roads
- printing and graphic arts
- service stations
- motor vehicles.

3.2.2 Quantifying emissions

There are several methods that can be used to obtain an estimate of the quantity of contaminants being emitted from a specific source. Direct and continuous measurement will provide the most robust estimate. However, data of this sort are only available for a small number of contaminants at a few sites.

The emissions estimation techniques applied in this project to determine emissions for the majority of sources were based on methods recognised by the National Pollutant Inventory (NPI) and published in emission estimation technique manuals (DSEWPC).

The methods identified in the manuals generally include a variety of estimation techniques such as direct measurement, use of mass balance equations, fuel analysis or other engineering calculations and emission factors. The actual method selected for a particular source is guided by data availability and the degree of precision required.

The information used to compile the inventory was derived from a range of sources including:

- direct requests to industry for detailed information (NPI reporting methods and existing stack test reports based on direct measurements)
- direct information requests to local government (NPI reporting; sub-threshold substance usage; traffic flow data)
- NPI database searches (detailed studies of NPI reporting from specific industries operating in the study region)
- benchmarking studies comparing emissions reported by specific industries in the study region with emissions reported by similar industries elsewhere in Australia and overseas
- estimations of per-capita contributions (scaling national or state statistical data according to the regional population)
- statistical data from the Australian Bureau of Agricultural and Resource Economics (estimations of per-capita contributions)
- statistical data from the Australian Bureau of Statistics.

3.2.3 Industry benchmarking

The available emissions data for each of the larger industrial sites in Gladstone were subject to verification through an industry benchmarking process.

The benchmarking studies for this project examined reported emissions to air for Gladstone's industrial activities, with those of industries that are similar or identical in other parts of the world. Studies used publicly available information sourced from Australia, Canada, the European Union, Japan and the United States of America.

International databases also included additional suites of contaminants not included in the National Pollutant Inventory. As a result, each benchmarking study was used to develop a broader understanding of emissions from each type of industrial facility.

By standardising the operations for production process and annual plant capacity, comparisons could be drawn for each of the contaminants reported as being emitted by a site. This also provided an indication of the reliability of emission estimates for each site.

- Benchmarking studies were completed by DERM for the following major industries in the study region:
- Boyne Smelters Limited (aluminium smelting operation) (EPA 2008a)
- NRG Gladstone Power Station (black-coal fired electricity generation) (EPA 2008b)
- Queensland Alumina Limited and Rio Tinto Yarwun (alumina refining) (DERM 2010)
- Cement Australia (cement clinker production) (EPA 2008c).

Where an industry was found to report emissions outside of an expected range, clarification was sought on how the particular operator determined the reported emissions.

In the case of Boyne Smelters Limited, apparent discrepancies were identified in emission estimates (the reported data were much lower than expected). As a result, DERM issued a notice under sections 323 and 324 of the *Environmental Protection Act 1994* to undertake an environmental investigation into the generation and treatment of contaminants released to the atmosphere by the aluminium smelter and the environmental impact of those contaminants. This assessment resulted in a detailed emissions inventory for the site as well as changes to the development approval under which the smelter operates. Changes to the development approval included stricter air emission limits for a range of contaminants, enhanced monitoring and incident response procedures. The findings of the detailed assessment confirmed the initial benchmarking conclusions in that the data were indeed significantly under-reported.

3.3 Findings

3.3.1 Sources for selected contaminants

Nitrogen oxides and sulfur dioxide

Figures 2 and 3 below show the relative contributions to emissions of nitrogen oxides (NO_x) and sulfur dioxide (SO_2) in the study area. These compounds are mainly generated by burning fossil fuels. The Gladstone Power Station is the largest source of each of these contaminants producing 43 000 tonnes of NO_x and 35 000 tonnes of SO_2 annually. On the graphs, the data represented by category 'AGG' are the aggregated emission sources as listed in Section 3.2.1. The category 'REST' represents industries which contributed a relatively small component of emissions and therefore have not been identified separately.

Figure 2. Annual regional emissions of nitrogen oxides by source (%)

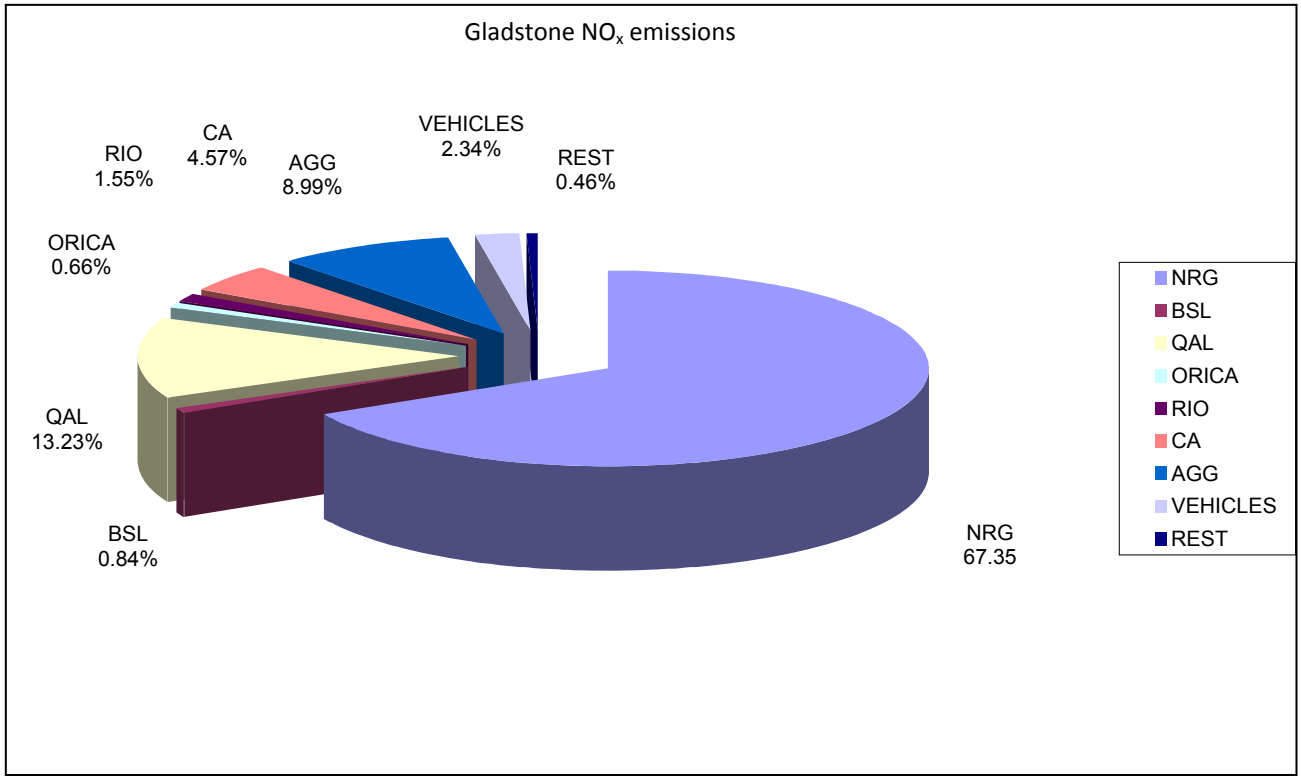
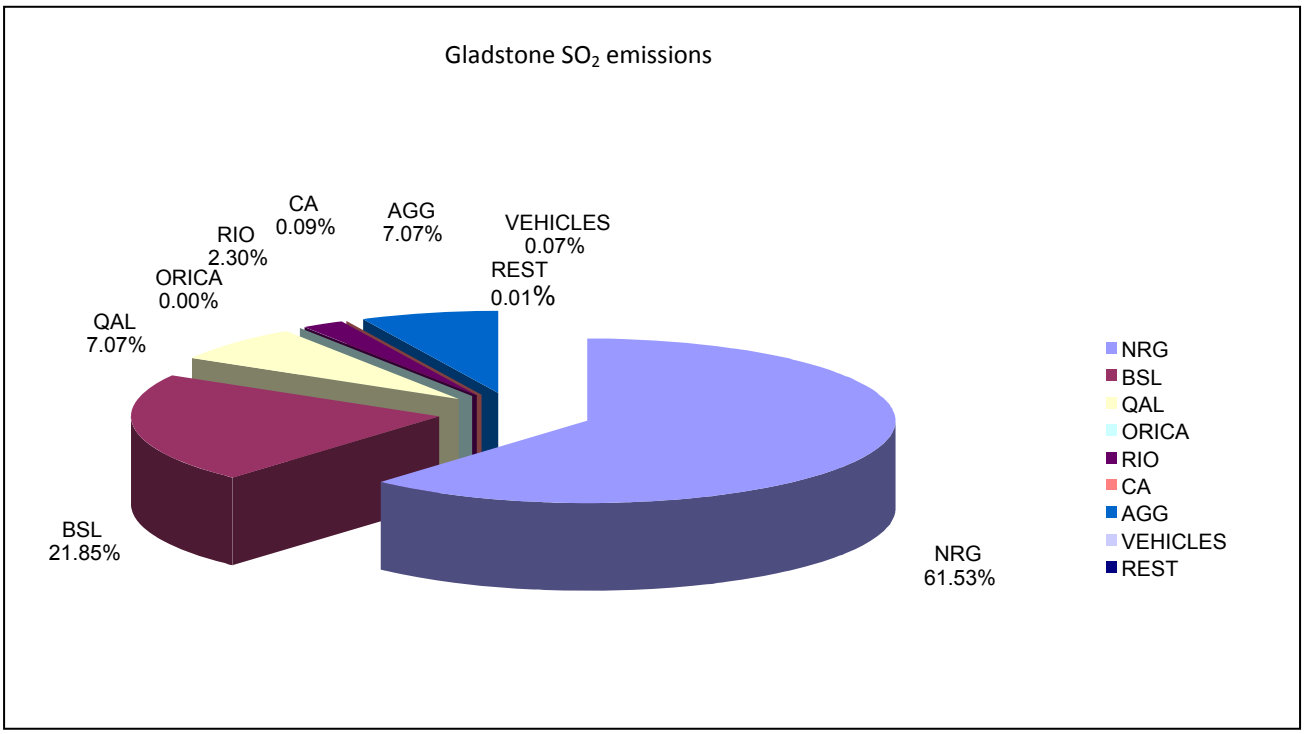


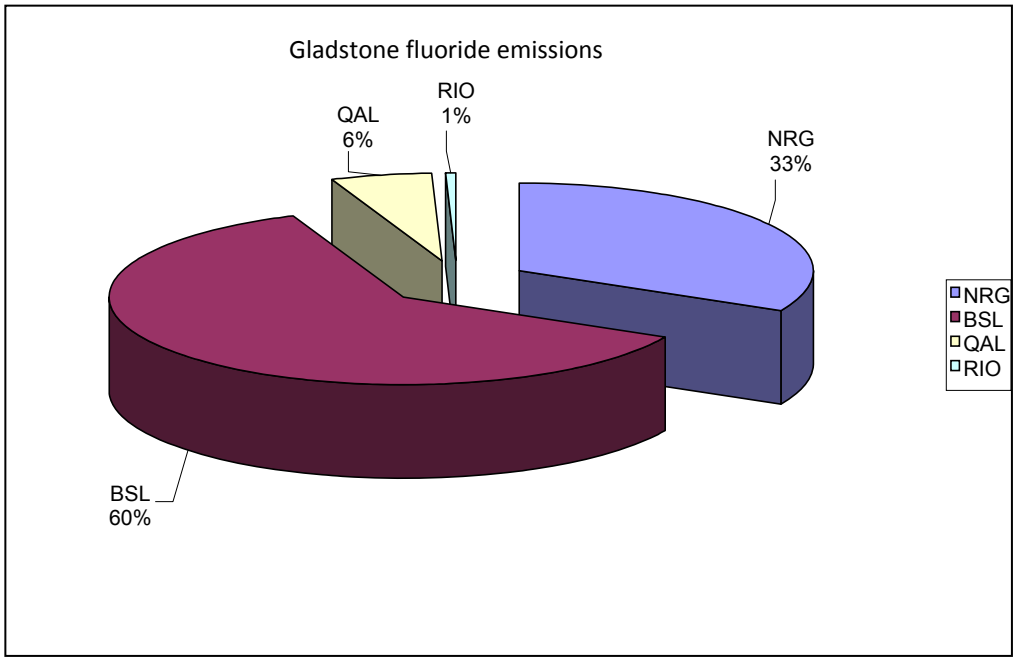
Figure 3. Annual regional emissions of sulfur dioxide by source (%)



Fluoride compounds

Boyne Smelters Limited releases the greatest quantity of fluoride and fluoride compounds with annual emissions of approximately 472 tonnes. Fluoride is also a component of coal that is released on combustion. Facilities with coal-fuelled boilers make a significant contribution to total fluoride emissions in the region. Figure 4 presents the contributions to fluoride emissions in the region

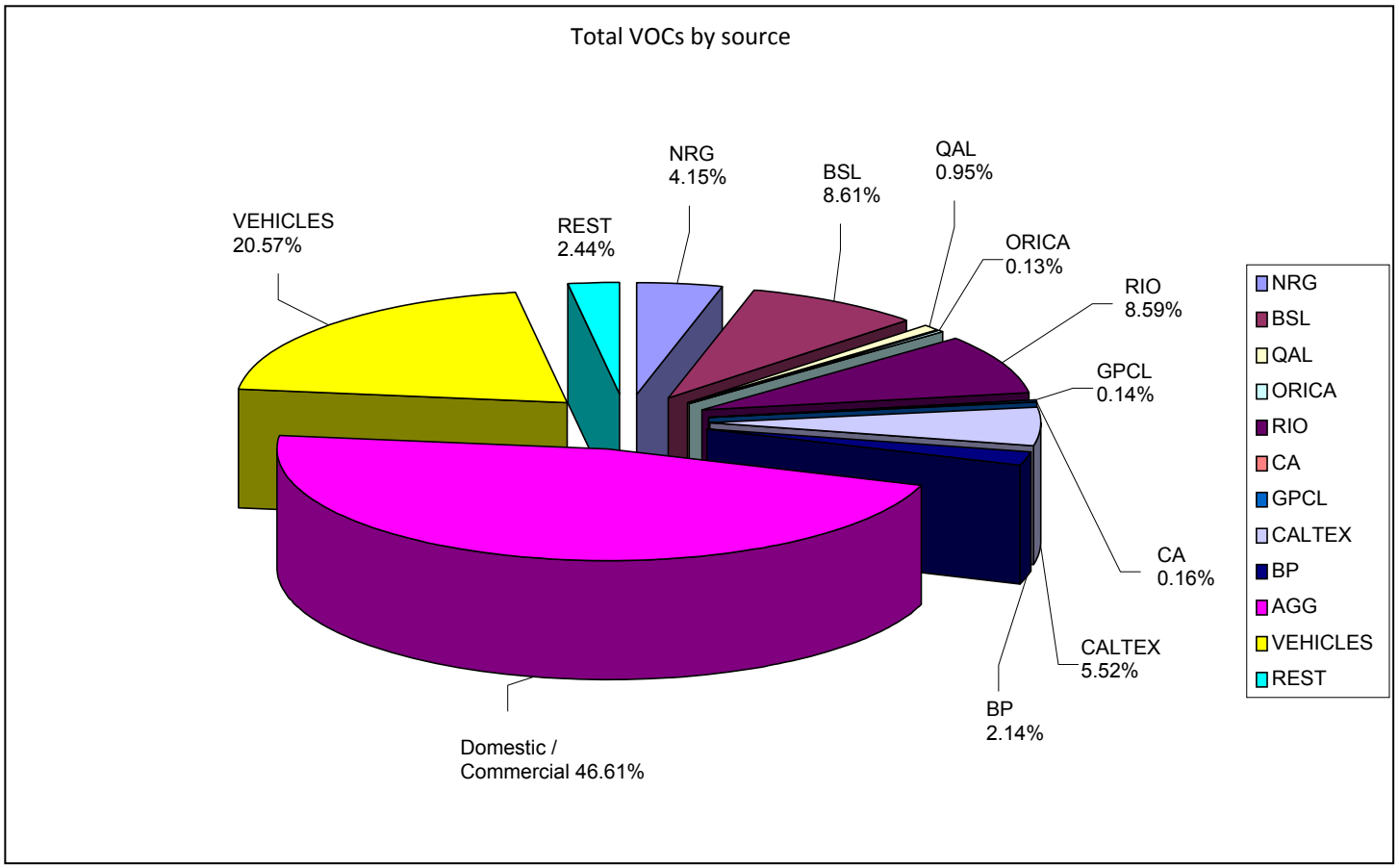
Figure 4. Annual regional emissions of fluoride and fluoride compounds by source (%)



Volatile organic compounds

The aggregated non-industrial emission sources make the greatest contribution to emissions of volatile organic compounds in the region with commercial shipping and boats contributing nearly six per cent of emissions indicated in figure 5.

Figure 5. Annual regional emissions of volatile organic compounds by source (%)



3.3.2 Further work

There is always a degree of uncertainty in an emissions inventory due to limitations in the accuracy of the raw data collected, in the methods used for processing those data and variations over time in the rate of emission of contaminants. The degree of precision required is determined by the end use of the data. The following are aspects of the current inventory where further work is warranted.

Particulate matter

The results of particulate monitoring across all monitoring sites shows that ambient air consistently met the current health-based standards for PM_{10} and $PM_{2.5}$. However, as discussed in section 6, further work by industry to reduce community exposure to particulates is warranted from a public health perspective.

The current emissions inventory suggests that Boyne Smelters Limited is the largest single source of particulate matter in the region. This finding is not consistent with the results of DERM's enhanced monitoring program and reflects the fact that Boyne Smelters Limited has undertaken the most comprehensive emissions monitoring program in the region and consequently, emissions estimates from Boyne Smelters are of higher quality than estimates of emissions from other sources because it has undertaken this comprehensive analysis.

Further work to more reliably quantify particulate emissions across the region is required to inform ongoing management actions.

Mercury

Mercury was not detected in any ambient air samples and this result is consistent with the small amounts of mercury identified as being emitted into the air in the Gladstone region.

Mass balance calculations were carried out as part of the project to verify estimated mercury emissions. This work identified approximately 1470 kg of mercury per year is being imported into the region as a trace element in raw materials, principally in coal and bauxite. Approximately 643 kg per year can be accounted for as outputs to waste, water and air. Mercury is problematic to reliably quantify due to both the difficulty of analysis and its volatile nature.

The department completed an audit of reporting of mercury emissions at the two alumina refineries which were identified as potential key sources of such emissions. The audit found that there are shortfalls and uncertainties in the data for emissions and transfers of mercury and cadmium reported from both sites. However, while improvements can be made to the reporting, they are unlikely to result in any significant adjustment in the data currently presented in the benchmarking report for the alumina refineries.

Further work by the aliminia refineries, to more reliably quantify the contribution of mercury and cadmium to the emission inventory, is warranted.

Organic compounds

The benchmarking reports identified gaps and uncertainties around the release of various organic compounds. While organic compounds do not currently present an air quality issue, verification of emissions by industry will ensure that reliable predictions of exposure can be made when planning new development in the region. It should also be noted that the aggregated non-industrial emissions of organic compounds in the region are generally of comparable magnitude to industrial emissions, and can be expected to increase with the anticipated urban and commercial growth of the region.

4 Ambient air quality

At the outset of the Clean and Healthy Air for Gladstone project, there were four monitoring sites in the region that provided continuous data on sulfur dioxide, nitrogen dioxide, visibility-reducing particles and PM_{10}.

The expanded ambient air monitoring program carried out as part of the CHAG Project had a number of aims including:

- measuring community exposure to key air contaminants to inform the human health risk assessment component of the project
- obtaining information on ambient concentrations of an expanded range of airborne contaminants
- providing a basis for assessment of ongoing ambient air monitoring requirements for the Gladstone region.

The monitoring program was designed to provide a more comprehensive understanding of air pollution in the Gladstone region and, in particular, the detailed understanding of ground-level concentrations of air contaminants required for the Human Health Risk Assessment conducted by Queensland Health.

The air monitoring plan was independently reviewed by Dr. Neville Bofinger who concluded that monitoring site selection, the suite of contaminants and the sampling and analysis methods chosen were appropriate for the purpose of the health risk assessment. Suggested changes to the site of the Boyne Island monitoring station were adopted in determining the final location for this station.

4.1 Expanded monitoring program

4.1.1 Monitoring sites

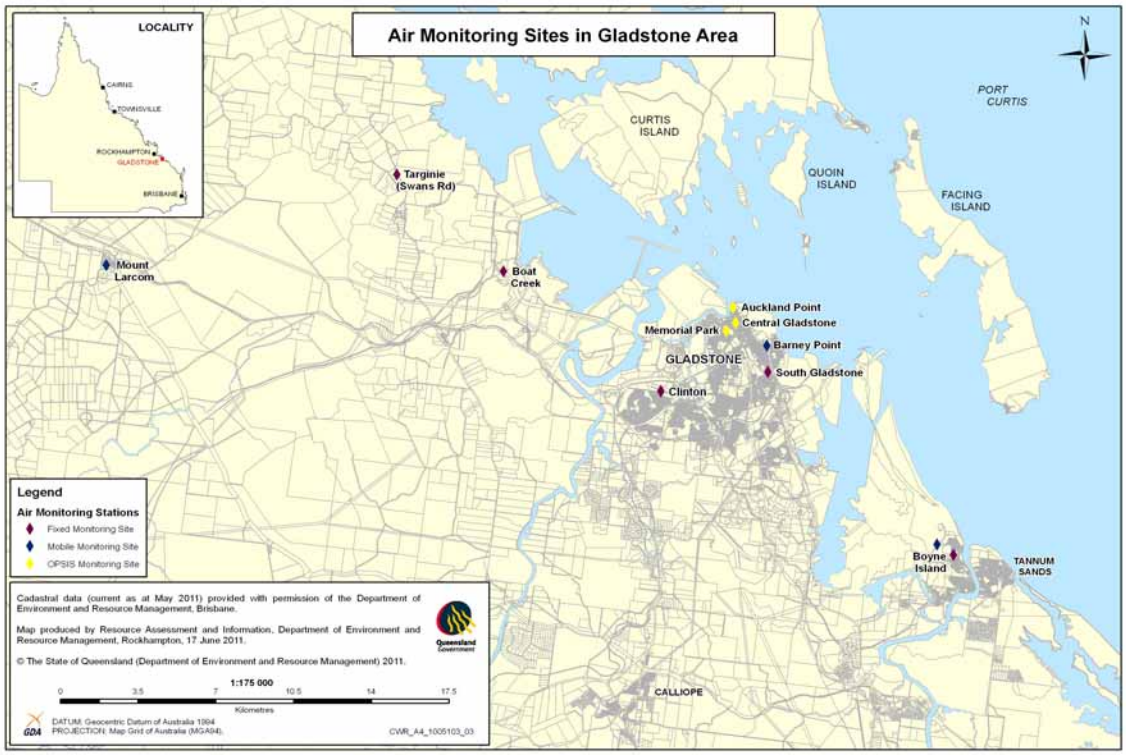
The number and location of monitoring stations for the CHAG Project was determined from a consideration of historic monitoring data, an analysis of prevailing winds, location of industries and residential areas and modelling of industrial emissions in the region.

Six fixed monitoring stations and one mobile unit were established to provide the required coverage of the region. The fixed sites were located at Targinie, Boat Creek, Clinton, South Gladstone, Boyne Island and Central Gladstone as shown in figure 6. The Central Gladstone station is an optical instrument with two light paths, one emitting from Auckland Point and the other from Memorial Park.

The mobile unit was used to gather information on air quality in locations not covered by the fixed monitoring network. Locations and time periods were chosen to gather information on maximum contaminant levels based on expected prevailing winds and industrial source locations. The mobile monitoring station was located at Boyne Island from August 2008 to January 2009, Mount Larcom from January to May 2009, Barney Point from June 2009 to March 2010, and Calliope from April to July 2010.

To the greatest extent possible, monitoring stations were sited to conform to the requirements of Australian/New Zealand Standard 3580.1.1:2007 ‘Methods for sampling and analysis of ambient air – Guide to siting air monitoring equipment’. Site compliance with AS/NZS 3580.1.1 is documented in the report titled Clean and Health Air for Gladstone – Ambient Air Monitoring Program June 2008 – July 2010 (DERM 2011).

Figure 6. Locations of CHAG Project ambient air quality monitoring stations



4.1.2 Contaminants measured

The specific contaminants measured at each monitoring site were selected based on an understanding of the contaminant emissions likely to have an impact at the site. Measurements of over 160 separate contaminants were carried out during the course of the monitoring program in order to provide a comprehensive assessment of air quality in the region.

An overview of the contaminants monitored and the period of monitoring at each monitoring location from the commencement of the expanded monitoring network in June 2008 to March 2010 is provided in figure 7.

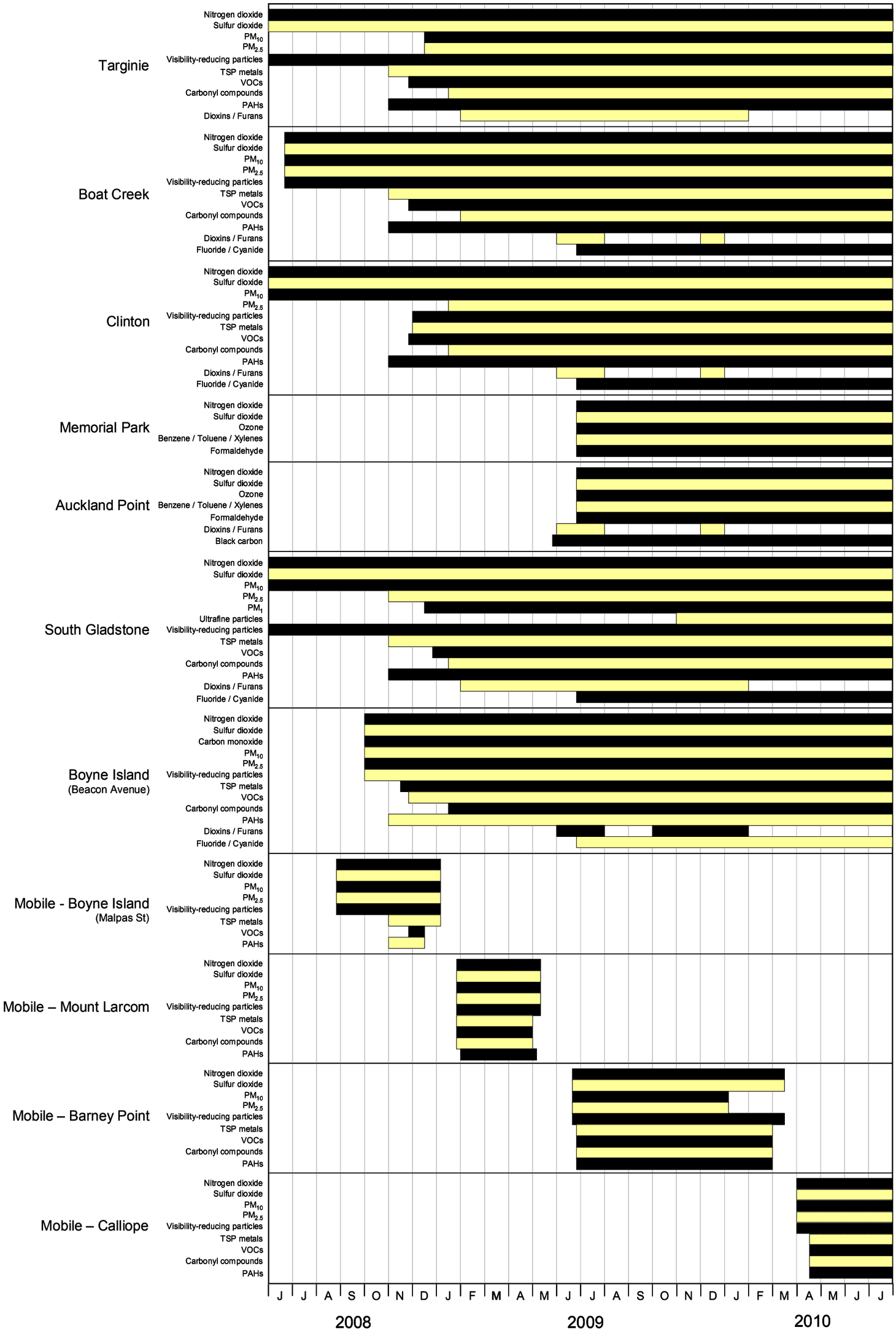


Figure 7. Air contaminants monitored at CHAG Project monitoring sites

4.1.3 Sampling methods

Sampling and analysis was carried out in accordance with the relevant Australian or international standard or equivalent method (DERM 2011).

Particulates (PM_{10}, $PM_{2.5}$ and PM_1) and the criteria gases (sulfur dioxide, nitrogen dioxide and carbon monoxide) were measured on a continuous basis. The Central Gladstone sites also provided continuous measurements of ozone, benzene, toluene, xylenes and formaldehyde.

For contaminants measured on a continuous basis, instrumentation and data-logging devices at the monitoring stations logged measurements from the instruments every ten seconds and processed these measurements to 30-minute averaged concentrations. The 30-minute averaged values from the logging devices were automatically retrieved by DERM's central air monitoring data management system and subsequently converted to contaminant concentrations over averaging periods specified in relevant air quality standards or guidelines.

Measurement of volatile organic compounds, metals, carbonyl compounds, polycyclic aromatic hydrocarbons, cyanide, fluoride and ionising radiation was carried out by taking samples from the air using a variety of standard techniques over a 24-hour period every six days. These samples were then sent to a laboratory for analysis.

Monitoring of polychlorinated-dibenzo-p-dioxins (PCDDs), polychlorinated-dibenzo-p-furans (PCDFs), and polychlorinated biphenyls (PCBs) was carried out by the University of Queensland's National Research Centre for Environmental Toxicology (EnTox). The samples collected for PCDD, PCDF and PCB were also analysed for polycyclic aromatic hydrocarbons (PAH) content. The continuous sampling performed for the dioxin, furan and PCB samples at the South Gladstone and Targinie monitoring sites provided a more precise measurement of annual average PAH concentrations at these two sites, particularly for those PAH species which were often present at concentrations below the minimum measurable concentration of the 24-hour sampling method.

The independent review of the air monitoring program by Dr Bofinger recommended that an assessment of volatile organic compounds (VOC) emissions from the coal stockpiles at the Gladstone Port be undertaken. VOC monitoring was undertaken using passive diffusion samplers at five sites within the Gladstone Port over a 32-day period in October–November 2009. The passive diffusion samplers were fixed to points on the coal conveyors above the coal stockpiles.

4.1.4 Performance of the monitoring program

For most contaminants, data availability rates were 80 per cent or greater. Lower data availability was experienced at two sites, South Gladstone and Memorial Park, due to instrumentation problems. Data availability was also low for carbonyl compounds across the monitoring network because high humidity resulted in moisture accumulating in the sorbent tubes and caused analysis difficulties. A summary of the data availability for each contaminant during the period of monitoring at each location can be found in Gladstone Ambient Air Monitoring Program (DERM 2011).

4.2 Discussion of results

The enhanced air quality monitoring program was one of the most comprehensive monitoring programs undertaken in Australia. It has provided the data needed for a detailed and rigorous assessment of air quality and exposure of the community to air contaminants in the region. The data obtained allow unequivocal conclusions to be drawn about current air quality and provide a valuable basis for informing air quality management decisions into the future.

Measured concentrations for many of the key contaminants were low and many were less than the level of analytical reporting limit for the available analytical techniques. For the majority of results that exceeded the level of analytical reporting limits, ambient concentrations were much less than the relevant health-based standard.

Health-based guidelines for particulate matter were exceeded on a number of occasions, each of which was associated with a specific bush fire or dust storm event.

The overview of findings from the expanded monitoring program summarised below is based on the results of ambient air monitoring in the Gladstone region performed between June 2008 and July 2010. These data are presented in detail in Gladstone Ambient Air Monitoring Program (DERM 2011).

The assessment of air quality monitoring and modelling results is based, in the first instance, on a comparison of measured levels of contaminants in ambient air, with published national or international health-based standards or guidelines. These standards or guidelines are in turn based on available scientific evidence regarding potential adverse health or environmental effects of these substances, and adopt a conservative approach to define an acceptable level for various substances in ambient air. Details of the standards and guidelines against which air quality has been assessed can be found in the Human Health Risk Assessment Final Public Health Report (QH August 2010).

4.2.1 Particulate matter

The results from particulate monitoring at the various sampling sites show the ambient air in the Gladstone airshed were generally within the current 24-hour average standards for PM_{10} and $PM_{2.5}$.

Individual 24-hour results that exceeded the relevant air quality standard were associated with the presence of additional sources of particulate matter from dust storms and/or smoke from fires as detailed in table 2.

As discussed in the health risk assessment report (QH Aug 2010), current knowledge of the dose–response relationship between ambient particulate levels and adverse health effects indicates that the effects of ambient particulate levels within the Gladstone population are low. However, there is no known concentration threshold for potential effects from exposure to ambient particulates and it cannot be concluded that there are no health effects as a consequence of the particulate levels measured during the expanded monitoring program. For a populated community with a range of diverse industrial and commercial operations, the results are considered to be within acceptable limits from a health-risk perspective.

Total suspended particulates (TSP)

There were no exceedences of the EPP (Air) annual average air quality objective for TSP at any of the Gladstone region monitoring sites during the period November 2008 to March 2010. The highest annual average TSP concentration was 38.0 $\mu g/m^3$ (42 per cent of the EPP (Air) objective) at South Gladstone for the 12-month period ending January 2010. The highest 24-hour average TSP concentration was 138 $\mu g/m^3$ at Clinton on 25 September 2009 during a major dust storm that affected much of Queensland.

PM_{10}

Between June 2008 and July 2010 there were 68 exceedences of the NEPM (Air Quality) 24-hour average PM_{10} standard of 50 $\mu g/m^3$ across the Gladstone air-monitoring network, with most occurring between August and October 2009. All of these exceedences were associated with the presence of transient sources of PM_{10} in the region including dust storms and/or smoke from bushfires.

$PM_{2.5}$

Between June 2008 and July 2010 the NEPM (Air Quality) 24-hour average advisory $PM_{2.5}$ standard of 25 $\mu g/m^3$ was exceeded on 43 occasions across the Gladstone air-monitoring network, with most occurring between July and October 2009. The NEPM (Air Quality) annual average advisory $PM_{2.5}$ standard was also exceeded at the Boat Creek and South Gladstone monitoring sites from September 2009 to July 2010, and at the Clinton monitoring site from September 2009 to February 2010. As was the case for PM_{10}, all of the 24 hour exceedences could be associated with the presence of additional sources of $PM_{2.5}$ in the region from dust storms and/or smoke from bushfires

The impact of the bushfires and dust storms in August and September 2009 on annual average $PM_{2.5}$ concentrations can be seen in the measurements at Boat Creek. The 12-month average $PM_{2.5}$ concentrations at Boat Creek were less than 6 $\mu g/m^3$ prior to August 2009, 7.5 $\mu g/m^3$ in August 2009, 8.1 $\mu g/m^3$ in September 2009 and 9.0 $\mu g/m^3$ or higher from October 2009. The highest annual average $PM_{2.5}$ concentration was 9.4 $\mu g/m^3$ [118 per cent of the NEPM (Air Quality) advisory standard] at South Gladstone for the 12-month periods ending February 2010 and April 2010.

Analysis of the $PM_{2.5}$ data suggests that annual average $PM_{2.5}$ concentrations are likely to be in the range of 4 $\mu g/m^3$ to 6 $\mu g/m^3$ at most monitoring site locations in the absence of the impacts of bushfire smoke and major dust storms.

PM_1

There are no ambient air quality standards or guidelines for PM_1 particles. Monitoring was undertaken only to obtain information on current PM_1 concentrations in Gladstone. South Gladstone was chosen as the site for PM_1 monitoring because this site was likely to experience higher PM_1 concentrations than some of the other monitoring locations due to its proximity to industrial and motor vehicle sources. The highest 24-hour average PM_1 concentration was 10.9 $\mu g/m^3$ on 21 April 2009. The average PM_1 concentration was 5.3 $\mu g/m^3$. Over the period of monitoring, PM_1 particles were found to comprise approximately 70 per cent of the $PM_{2.5}$ particle fraction and approximately 30 per cent of the PM_{10} particle fraction at South Gladstone.

Visibility-reducing particles

Between June 2008 and July 2010 there were a total of 136 exceedences of the EPP (Air) one-hour average visibility objective due to atmospheric particles across the Gladstone air-monitoring network, with most occurring between July and October 2009. All of these exceedences could be associated with the presence of smoke from bushfires or grassfires in the region.

Table 2. Particle standard exceedences in the Gladstone region between June 2008 and July 2010

Date	Standard	Number of exceedences						Contributing factors
		Targinie	Boat Creek	Clinton	Barney Point	South Gladstone	Boyne Island	
28 Sept 2008	Visibility		1			1		Smoke from bushfires west and south-west of Gladstone
6 Mar 2009	PM_{10}	1	1					Wind-blown dust caused by strong westerly winds
3 May 2009	PM_{10}	1						Smoke from burning of roadside verge 1 km south of the Targinie monitoring site
	$PM_{2.5}$	1						
	Visibility	5						
5 May 2009	PM_{10}	1						Smoke from burning of roadside verge 1 km south of the Targinie monitoring site
	$PM_{2.5}$	1						
20 June 2009	$PM_{2.5}$						1	Smoke from a bushfire south of Tannum Sands
	Visibility			2		1	4	
3 July 2009	Visibility						1	Smoke from a large bushfire at O'Connell
14 July 2009	$PM_{2.5}$			1				Boat Creek, Clinton, South Gladstone—smoke from a large bushfire in the Targinie area Boyne Island—smoke from a grassfire in the Wurdong Heights area
	Visibility		1	3		1	1	
15 July 2009	Visibility	3						Smoke from a large bushfire in the Targinie area
17 July 2009	Visibility		3					Smoke from a large bushfire in the Targinie area
18 July 2009	$PM_{2.5}$		1					Smoke from a large bushfire in the Targinie area
	Visibility		3					

Date	Standard	Number of exceedences						Contributing factors
		Targinie	Boat Creek	Clinton	Barney Point	South Gladstone	Boyne Island	
19 July 2009	$PM_{2.5}$		1					Smoke from a large bushfire in the Targinie area
	Visibility		3					
20 July 2009	Visibility		3					Smoke from a large bushfire in the Targinie area
4 Aug 2009	PM_{10}		1					Smoke from a bushfire in the Targinie area carried over the Boat Creek site by westerly winds in the early morning and late evening
	$PM_{2.5}$		1					
	Visibility		3					
5 Aug 2009	PM_{10}		1					Smoke from a bushfire in the Targinie area carried over the Boat Creek site by westerly winds in the early morning and late evening
	$PM_{2.5}$		1					
	Visibility		9					
6 Aug 2009	PM_{10}		1					Smoke from a bushfire in the Targinie area carried over the Boat Creek site by westerly winds in the early morning and late evening
	$PM_{2.5}$		1					
	Visibility		5					
7 Aug 2009	PM_{10}		1					Smoke from a bushfire in the Targinie area carried over the Boat Creek site by westerly winds in the early morning and late evening
	$PM_{2.5}$		1					
	Visibility		5					
9 Aug 2009	Visibility		3					Smoke from a bushfire in the Targinie area carried over the Boat Creek site by westerly winds during the night
5 Sept 2009	Visibility						1	Smoke from a bushfire south of Tannum Sands
7 Sept 2009	$PM_{2.5}$		1					Smoke from a bushfire in the Targinie area carried over the Boat Creek site by westerly winds during the early morning.
	Visibility		4					

Date	Standard	Number of exceedences						Contributing factors
		Targinie	Boat Creek	Clinton	Barney Point	South Gladstone	Boyne Island	
10 Sept 2009	Visibility		1					Smoke from a bushfire in the Targinie area carried over the Boat Creek site by westerly winds during the night
12 Sept 2009	Visibility						1	Smoke from a large grassfire at Broadacres south of Tannum Sands
13 Sept 2009	PM_{10}						1	Smoke from a large grassfire at Broadacres south of Tannum Sands
	$PM_{2.5}$			1		1	1	
	Visibility			1		3	6	
14 Sept 2009	PM_{10}			1			1	Smoke from a large grassfire at Broadacres south of Tannum Sands
	$PM_{2.5}$			1		1	1	
	Visibility					2	9	
15 Sept 2009	PM_{10}			1				Smoke from a large grassfire at Broadacres south of Tannum Sands
	Visibility						1	
23 Sept 2009	PM_{10}	1	1	1	1			Major dust storm reached the Gladstone region in the late evening
24 Sept 2009	PM_{10}	1	1	1	1	1	1	Major dust storm
	$PM_{2.5}$	1	1	1	1	1	1	
25 Sept 2009	PM_{10}	1	1	1	1	1	1	Residual dust from dust storm and smoke from a large bushfire near Mount Morgan
	Visibility					1		
26 Sept 2009	PM_{10}	1	1	1	1	1	1	Residual dust from dust storm and smoke from a large bushfire near Mount Morgan
	$PM_{2.5}$				1		1	
27 Sept 2009	PM_{10}	1	1	1	1	1	1	Residual dust from dust storm and smoke from a large bushfire near Mount Morgan
	$PM_{2.5}$	1	1	1	1	1	1	
	Visibility	3	3	2		5	2	

Date	Standard	Number of exceedences						Contributing factors
		Targinie	Boat Creek	Clinton	Barney Point	South Gladstone	Boyne Island	
28 Sept 2009	PM_{10}	1	1	1	1	1	1	Residual dust from dust storm and smoke from a large bushfire near Mount Morgan
	$PM_{2.5}$				1	1		
29 Sept 2009	PM_{10}			1				Residual dust from dust storm and dust from airport runway extension works near the Clinton site.
1 Oct 2009	PM_{10}		1					Targinie—smoke from a large bushfire at Bajool Boat Creek—smoke from a large grassfire at West Stowe
	$PM_{2.5}$		1					
	Visibility	1	8					
2 Oct 2009	PM_{10}		1					Smoke from a large grassfire at West Stowe
	$PM_{2.5}$		1					
	Visibility		7					
4 Oct 2009	PM_{10}			1				Wind-blown dust caused by strong westerly winds coupled with dust from airport runway extension works near the Clinton site
5 Oct 2010	PM_{10}			1				Wind-blown dust caused by strong westerly winds coupled with dust from airport runway extension works near the Clinton site
7 Oct 2009	PM_{10}			1				Wind-blown dust caused by strong westerly winds coupled with dust from airport runway extension works near the Clinton site
14 Oct 2009	PM_{10}			1				Dust from runway extension works near the Clinton site
15 Oct 2009	PM_{10}	1	1	1	1	1	1	Wind-blown dust caused by strong westerly winds
16 Oct 2009	PM_{10}	1	1	1	1	1	1	Wind-blown dust caused by strong westerly winds and smoke from a large bushfire between Gin Gin and Miriam Vale
	$PM_{2.5}$		1	1	1	1		

Date	Standard	Number of exceedences						Contributing factors
		Targinie	Boat Creek	Clinton	Barney Point	South Gladstone	Boyne Island	
17 Oct 2009	PM_{10}			1	1		1	Smoke from a large bushfire between Gin Gin and Miriam Vale
	$PM_{2.5}$			1	1	1	1	
	Visibility		2	2		3	5	
3 Nov 2009	Visibility	1						Smoke from a large grass fire at Wooderson, south-west of Gladstone, was carried over the Targinie area by southerly winds
18 Jun 2010	Visibility	1						Smoke from local fire in vicinity of monitoring station

Since September 2009, 12-month average $PM_{2.5}$ concentrations at the Boat Creek, Clinton and South Gladstone monitoring sites have exceeded the NEPM (Air Quality) annual average advisory air quality standard for $PM_{2.5}$.
The National Environment Protection (Ambient Air Quality) Measure air quality standard for PM10 is a 24-hour average of 50 $\mu g/m^3$ (not to be exceeded on more than five days per year).
The National Environment Protection (Ambient Air Quality) Measure advisory air quality standards for $PM_{2.5}$ are an annual average of 8 $\mu g/m^3$ and a 24-hour average of 25 $\mu g/m^3$.
The Queensland Environmental Protection (Air) Policy 2008 air quality objective for visibility-reducing particles is 20 km visibility averaged over a 1-hour period.

4.2.2 Criteria gaseous contaminants

Four gaseous criteria contaminants—nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone and carbon monoxide—were included in the monitoring program. There were no exceedences of the NEPM (Air Quality) standards for the gaseous criteria contaminants at any of the Gladstone region monitoring sites during the period June 2008 to July 2010. Table 3 shows the maximum concentration measured for each of the criteria contaminants.

Concentrations of nitrogen dioxide are unlikely to pose risks to health other than in those members of the community who are most susceptible to the irritant effects of NO_2 on airways. From the context of protection of population health in a developed urban environment, ambient concentrations are considered to be acceptable.

Sulfur dioxide concentrations are highly correlated with winds coming from the direction of major industrial sources at all monitoring locations. Concentrations of SO_2 were well below the relevant NEPM (Air Quality) standards. The levels reported for Gladstone are comparable to the levels reported in South East Queensland over the same time period. From the context of protection of population health in a developed urban environment, ambient concentrations are considered to be acceptable. It remains possible that some people with a high degree of sensitivity to sulfur dioxide might experience irritation or exacerbation of asthma or other pre-existing chronic airways disease symptoms during short-term episodes corresponding to the higher levels reported during the monitoring period.

Concentrations of ozone are considered to be acceptable from the perspective of the protection of population health in a developed urban environment. Present levels of precursor contaminant emissions, coupled with local meteorology, appear to be unlikely to result in significantly elevated ground-level ozone concentrations.

Monitoring results indicate that exposure to carbon monoxide from ambient air in Gladstone is unlikely to pose any risk to human health.

Table 3. Maximum measured concentration for each of the criteria contaminants

Contaminant	NEPM (Air Quality) Standard (ppm)	Averaging period	Maximum recorded concentration	Site
Nitrogen dioxide	0.03	12 months	0.006	Boat Creek
	0.12	1 hour	0.059	Boat Creek
Sulfur dioxide	0.2	12 months	0.003	Central Gladstone
	0.08	24 hours	0.019	Boyne Island
	0.2	1 hour	0.155	Clinton
Ozone	0.08	4 hours	0.043	Central Gladstone
	0.1	1 hour	0.048	Central Gladstone
Carbon monoxide	9.0	8 hours	2.1	Boyne Island

4.2.3 Metals

Nine metallic elements were included in the key contaminant list. These were arsenic, beryllium, cadmium, chromium, lead, manganese, mercury, nickel and zinc. Sampling and analysis carried out included these key contaminants plus a further 16 metals.

Ambient concentrations of manganese were less than 6.3 per cent of the relevant standard and concentrations of nickel were less than five per cent of the relevant standard. For all other metals, ambient air levels were less than two per cent of the relevant standard.

Concerns about exposure to metals in ambient air have been specifically raised by sections of the Gladstone community. The air monitoring results for arsenic, beryllium, cadmium, chromium, lead, manganese, mercury, nickel and zinc indicate that exposure to these metals in ambient air in the Gladstone region does not pose an unacceptable risk to human health.

4.2.4 Volatile organic compounds

The concentrations of volatile organic compounds (VOCs) were found to be very low across the Gladstone region.

Nine VOCs were included in the key contaminant list. These were benzene, carbon tetrachloride, ethylbenzene, methyl ethyl ketone, methyl isobutyl ketone, toluene, 1,1,1-trichlorethane, trichloroethylene and xylenes. The sampling and analysis carried out included these, plus a further 93 VOCs.

The minimum concentration of carbon tetrachloride capable of being detected with the sampling and laboratory equipment used was above the required air quality criterion. Air modelling studies were used to assess compliance with the criterion for carbon tetrachloride. The results of the modelling indicate that the maximum 24-hour average level of carbon tetrachloride is less than 20 per cent of the carbon tetrachloride exposure standard. Based on modelled levels, levels of carbon tetrachloride in the ambient air are considered unlikely to pose a risk to human health.

Some members of the Gladstone community have raised specific concerns about exposure to benzene in ambient air. Ambient levels of benzene across all monitoring sites were below 25 per cent of the relevant standard. The Gladstone results are similar to concentrations measured in the Brisbane urban airshed. The levels are considered acceptable from a health risk assessment perspective.

For all other VOCs, measured and modelled levels in ambient air were typically less than two per cent of the relevant air quality guideline. The results indicate that exposure to VOCs from ambient air in the Gladstone region does not pose an unacceptable risk to health.

4.2.5 Carbonyl compounds

Three carbonyl compounds were included in the key contaminant list. These were acetaldehyde, acrolein and formaldehyde. Data on a further ten carbonyl compounds were collected by the expanded monitoring program.

Acetaldehyde

The calculated mean levels of acetaldehyde at all sites were less than 10 per cent of the relevant standard. These levels are well below exposure levels that have been shown to cause mucous membrane irritation in humans. These results indicate that exposure to acetaldehyde from ambient air does not pose an unacceptable risk to health.

Acrolein

Acrolein was not detected in carbonyl compound air samples at any of the Gladstone region monitoring sites. However, the minimum concentration of acrolein capable of being detected with the sampling and laboratory equipment used was greater than the relevant air quality criterion, so air modelling studies were used to assess compliance with the criterion for acrolein.

Results of the modelling undertaken by DERM indicate that community-based exposure to acrolein in ambient air is less than 30 per cent of the relevant standard. It is concluded that acrolein does not pose an unacceptable risk to health, from either an acute or a chronic perspective.

Formaldehyde

For formaldehyde, calculated mean levels in ambient air across the monitoring sites were all less than 4.5 per cent of the relevant standard. At these levels, odour and adverse effects such as mucous membrane irritation would not be expected. The results indicate that formaldehyde does not pose an unacceptable risk to health.

4.2.6 Polycyclic aromatic hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a group of more than 100 carbon-based chemicals which contain at least two benzene (six-sided) rings. PAHs may irritate the eyes, skin and respiratory tract. Acute exposure to high levels may cause headaches, nausea, vomiting and abdominal pain.

The principal health concerns associated with PAHs generally relate to chronic exposure rather than acute exposure.

Based on the health risk assessment conducted by Queensland Health and the complementary report by EnTox, concentrations of PAHs in the ambient air in Gladstone are within relevant health-based guidelines for both chronic and acute effects and are considered unlikely to pose a risk to public health.

4.2.7 Polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzo-p-furans (PCDFs) and polychlorinated biphenyls (PCBs)

PCDDs, PCDFs and PCBs are environmentally persistent halogenated aromatic hydrocarbon chemicals. These chemicals are often present as complex mixtures with varying toxicity due to the different congeners having a wide range of toxicities. As a means of estimating the toxicity of such mixtures, the World Health Organization (WHO) has assigned a toxic equivalency factor to individual congeners. Instead of simply reporting the mass concentration of a mixture of variously toxic compounds, dioxin levels are usually reported as toxic equivalents (TEQs), the toxicity-weighted mass, in order to provide added information on the toxicity of the mixture.

Using the WHO05 toxic equivalence values, an estimate was made of the human intake from air of PCDD/Fs and 'dioxin-like' PCBs at each monitoring location. These intake estimates can be compared with the human intake standard of 70 picograms/kg body weight/month recommended by the National Health and Medical Research Council. At all monitoring locations the intake of PCDD/Fs and PCBs via air is less than 0.1 per cent of the exposure standard.

Monitoring of PCDDs and PCDFs and 'dioxin-like' PCBs has been previously undertaken in Australia as part of the Commonwealth National Dioxins Program (DEH 2004). The PCDD/F and PCB concentrations found in the Gladstone region are consistent with the very low levels (by world standards) of these compounds in air in Australia.

Based on the health risk assessment conducted by Queensland Health and the complementary report by EnTox, levels of PCBs in air do not contribute significantly and do not exceed available international exposure standards for intake of 'dioxin-like' PCBs recommended by the National Health and Medical Research Council within Australia (NHMRC 2002). The levels of PCBs are consistent with, if not somewhat lower than, levels measured in other parts of Australia. The results indicate that exposure to PCBs from ambient air is not likely to cause an unacceptable risk to human health.

4.2.8 Cyanide compounds

There are no national or international ambient air quality standards or guidelines for cyanide. Monitoring was intended only to obtain information on current ambient concentrations in Gladstone. Monitoring of cyanide compounds was carried out at Boyne Island, South Gladstone, Clinton and Boat Creek from June 2009 to July 2010. Cyanide compounds were only present at levels above the minimum measurable cyanide concentration of 0.008 $\mu g/m^3$ in one 24-hour sample collected at Clinton on 11 March 2010.

4.2.9 Fluoride

Concerns about exposure to fluoride in ambient air have been specifically raised by sections of the Gladstone community. The monitoring results indicate that the contribution of fluoride in ambient air to total intake of fluoride is very low, and that adverse effects on human health from fluoride in ambient air are unlikely.

Monitoring of fluoride compounds was carried out at Boyne Island, South Gladstone, Clinton and Boat Creek from June 2009 to July 2010. There were no exceedences of any of the EPP (Air) air quality objectives for fluoride at any of these monitoring sites during this period. The highest 90 day average fluoride concentration was 0.148 $\mu g/m^3$ [29.6 per cent of the EPP (Air) objective] at Boyne Island for the 90-day period ending 28 May 2010. The highest 30 day average fluoride concentration was 0.275 $\mu g/m^3$ [32.7 per cent of the EPP (Air) objective] at Boyne Island for the 30-day period ending 22 April 2010. The highest 24 hour average fluoride concentration was 0.695 $\mu g/m^3$ [24.0 per cent of the EPP (Air) objective] at Boyne Island on 10 April 2010. These results are well within the standards set for the protection of sensitive vegetation and ecosystems. At these levels, exposure from ambient air is approximately 0.2 per cent of the estimated daily intake from reticulated water that has been fluoridated to optimal levels. Because the fluoride level in drinking water is based on achieving positive health effects without adverse consequences, it is concluded that the estimated additional intake from ambient air is inconsequential from a human health perspective.

4.2.10 Acidic and caustic aerosols

Sections of the TSP sample media filters from the South Gladstone, Clinton and Boat Creek monitoring sites were chemically analysed for pH and a range of ions by CSIRO Marine and Atmospheric Research to determine if the particulate matter on the filters was alkaline. Unfortunately no conclusions could be drawn about the alkalinity of the particulate matter from the chemical analysis results due to large uncertainties introduced by background pH and ion concentrations arising from compounds present in the filter matrix as a result of the filter manufacturing process.

Further investigations are being carried out to determine if a successful method can be developed to quantitatively measure the alkalinity of particulate matter.

4.2.11 Ionising radiation

Ionising radiation was included in the expanded air monitoring program for completeness. Community exposure to ionising radiation occurs from a variety of sources, including naturally occurring radioactive minerals and human activities involving the use of radiation and radioactive materials. The annual average radiation dose from all sources at the five monitoring sites was 0.8 microsvert (mSv) or less. These values are indistinguishable from natural background radiation and do not show a significant contribution from industry emissions. It is considered that exposure to ionising radiation in the Gladstone community is due to natural background and does not pose an unacceptable risk to public health.

5 Air quality modelling

Air dispersion modelling is an important tool for developing and implementing air quality management strategies. Regulatory applications of air dispersion modelling include assessing the local and cumulative regional impacts of proposed industries. Modelling results are also used to supplement air quality data collected by the fixed monitoring network in order to achieve a higher resolution in space and time of concentration and exposure levels. Once validated, air dispersion models can be used as predictive tools. They can also identify where impacts of emissions are likely to be highest. This information can be used for optimal siting of ambient air monitoring stations to provide most useful information on air quality in the region. Data from monitoring stations are used to validate the model output by carrying out statistical comparisons of predicted and observed concentrations.

The air dispersion modelling module of the EnviMan Air Quality Management System was used to supplement the air quality monitoring data used in the CHAG Project health risk assessment.

Ground-level concentrations were predicted for a number of contaminants. Some of these predictions were used in place of direct measurements, when the ambient contaminant concentrations or the recognised health criteria were less than detection limits of the analytical methods. Further details can be found in the final health risk assessment report (QH August 2010).

5.1 Air dispersion modelling in the Gladstone region

5.1.1 History

A variety of air dispersion modelling studies have been undertaken in the Gladstone region (including the 1992–1993 Gladstone Industrial Land Study [Connell Wagner 1995]) and in assessing potential locations for proposed industrial development. In 2002 the government implemented a Gladstone Airshed Modelling System (GAMS) to assist in air quality management. GAMS included US and Australian air dispersion models, CALPUFF and TAPM. The strongest feature of GAMS is the graphical user interface that allows non-specialist modellers to quickly assess the impact of new industries using the CALPUFF model pre-configured for the Gladstone Region.

5.1.2 EnviMan air quality management system

For the CHAG Project, DERM has used the OPSIS EnviMan modelling system as a complete air quality management system that integrates air quality monitoring, air emission inventories and air dispersion modelling for Gladstone. This has been done with a view to extending it more broadly as the preferred air quality management tool for other industrial regions in Queensland. EnviMan provides air emissions estimation tools, regional emissions databases and an air dispersion model. The EnviMan emissions databases are designed to include air emissions from all relevant activities in the Gladstone region, as well as industrial point sources discussed in chapter 3. EnviMan's modelling software uses the emissions databases together with an in-built meteorological database management module to run air quality simulations for the region.

The combination of emissions inventory databases and an air dispersion module in the same software package provides a powerful air quality management tool. EnviMan employs a grid-based advection diffusion dispersion modelling system that is widely used throughout Europe by air quality management authorities. Plumes from elevated point sources are mapped onto the emissions grid using an air dispersion model called AERMOD. AERMOD is the current USEPA-recommended regulatory model for short-range dispersion from stationary industrial sources. It includes the most up-to-date algorithms for dispersion in both convective and stable boundary layers.

5.2 CHAG modelling

5.2.1 Contaminant emission sources modelled

Modelling was undertaken with an emissions database that included emissions data provided by stack test results, continuous monitoring data, NPI data, benchmarking reports and Information Request submissions from major industries. The emissions inventory for Gladstone does not yet incorporate emissions data for all sources, such as transport. Transport sources include motor vehicles, rail, shipping and aircraft and they are typically relevant sources of carbon monoxide, hydrocarbons, nitrogen oxides and particulate matter emissions in urban areas. A new vehicle emissions inventory for Gladstone that will include emissions from transport is currently being developed, and will be incorporated into the EnviMan system by the end of 2011.

5.2.2 Meteorological input

The meteorology of the Gladstone area is characterised by the coastal meteorology and diurnal changes at surface level. The meteorology is characterised by a diurnal wind cycle, involving land breezes at night and sea breezes during the day, which typically occur on coastlines due to differences in land and sea temperatures. The wind direction in these breezes is influenced by large-scale pressure systems and air flows. Nocturnal cooling of the atmosphere near the surface leads to the formation of a (thermally) stable surface layer with reduced (thermal) turbulence. The atmospheric stability and depth of the surface layer is also dependent on the degree of cloud cover. Thermal heating of the land surface in the morning leads to turbulent mixing and the formation of the unstable ‘planetary boundary layer’ (PBL). The depth of the PBL varies between 500 m and 2500 m between late morning and early afternoon and also depends on other meso-scale and large-scale processes, such as advection and subsidence of warm air aloft. The PBL is ‘undercut’ in the late morning by the advancing sea breeze, whose thermal internal boundary layer is generally 400–600 m deep.

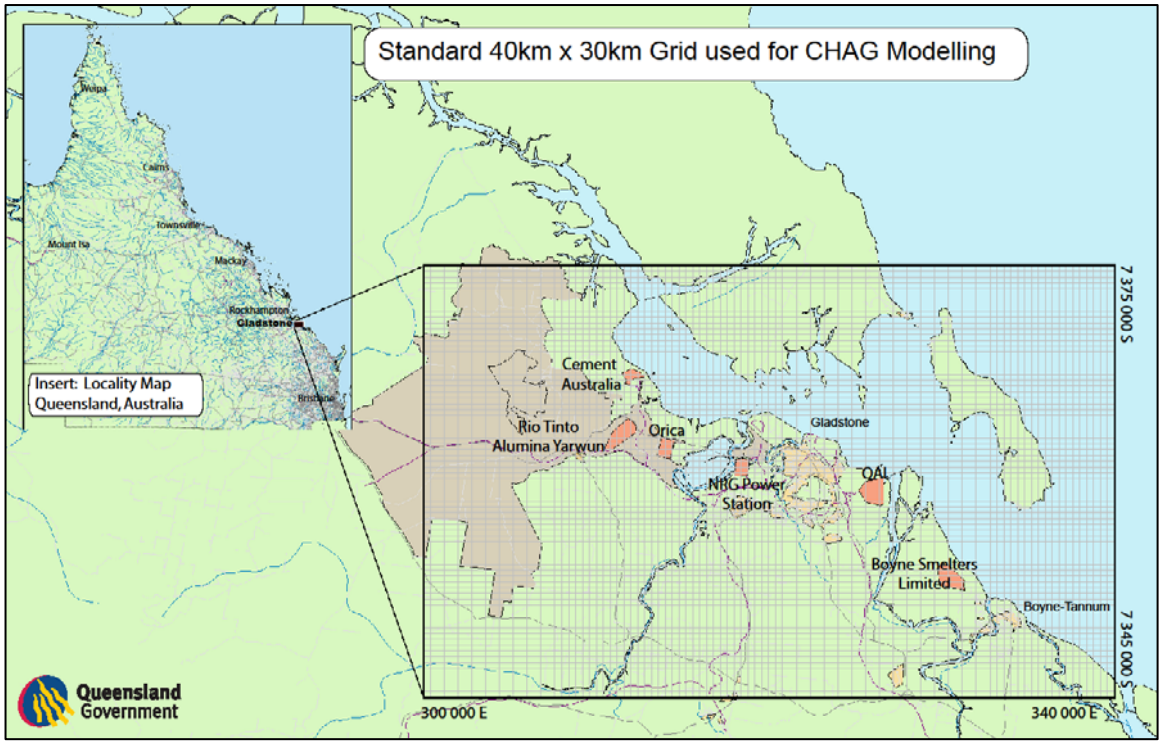
For EnviMan modelling, hourly meteorological data including temperature, radiation, wind speed, wind direction, precipitation and global radiation from the South Gladstone monitoring station were used for all the modelling simulations. The EnviMet module incorporates scaling algorithms for setting up the boundary layer parameters for air dispersion modelling.

Meso-scale and boundary layer processes generally lead to temporally (hourly, sub-hourly) and spatially (3–5 km) varying wind direction and atmospheric stability and vertically varying wind profiles and turbulent mixing. It is noted that simplified representation of meteorology in a Gaussian dispersion model like AERMOD has limitations. For instance, it is unable to simulate recirculation of contaminants and simplifies modelling of turbulent mixing over heterogeneous terrain.

5.2.3 Grid size and resolution

All model simulations used a grid size of 40 km × 30 km and a grid resolution of 400 m × 400 m (i.e. 100 cells × 75 cells). The modelling grid area is shown in figure 8.

Figure 8. Modelling grid area



Model configuration and run-time options

Each model simulation was run for the period 1 January 2009 to 31 December 2009 in hourly time steps. The simulation height for receptors was set at 2 m.

5.2.4 Receptors

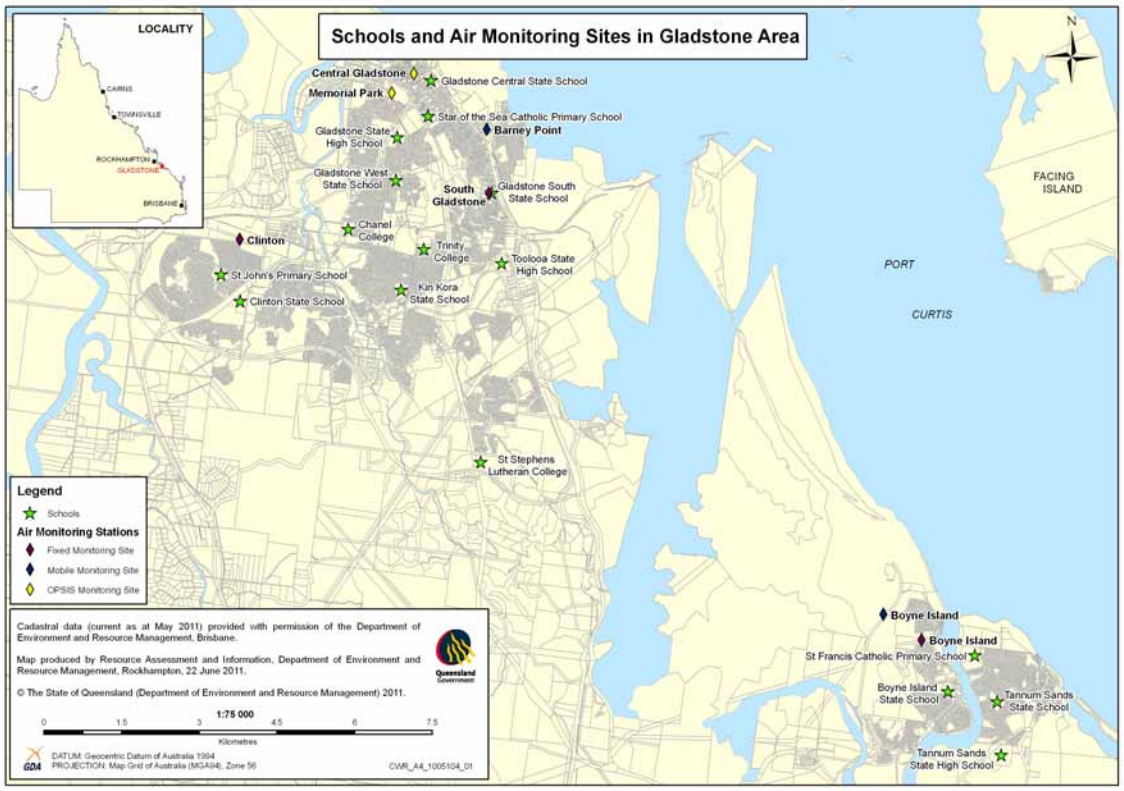
Receptors in EnviMan are predefined locations (point, line or regional) for which contaminant concentrations are predicted. This was primarily done for model validation purposes, where each Gladstone monitoring station was defined as a receptor point and the modelled output substance concentration was compared to actual substance concentrations measured at the monitoring station. Air quality should also be evaluated for sensitive receptor locations such as schools, aged care facilities, and hospitals. Table 4 shows an example of prediction results for sulfur dioxide at selected sensitive receptor locations.

Table 4. Impact of current reported emissions of sulfur dioxide on sensitive receptors

Site number	School receptor	NEPM (Air Quality) Standard for SO_2 (annual average) (g/m^3)	Predicted annual average SO_2 concentration (Jan–Dec 09) (g/m^3)
1	Gladstone Central Preschool and Primary	57	3.7
2	Gladstone West Preschool and Primary	57	3.1
3	Boyne Island Primary School	57	2.2
4	Clinton Primary School	57	3.7
5	Gladstone South Primary School	57	4.5

Site number	School receptor	NEPM (Air Quality) Standard for SO_2 (annual average) (g/m^3)	Predicted annual average SO_2 concentration (Jan–Dec 09) (g/m^3)
6	Kin Kora Primary School	57	3.2
7	St John's Primary School	57	4.8
8	Gladstone High School	57	2.9
9	Tannum Sands High School	57	0.6
10	Tooloola High School	57	5.2
11	Chanel College	57	3.0
12	St Stephens Lutheran College	57	3.2
13	Star of the Sea School	57	3.5
14	Trinity College	57	3.5
15	St Francis Catholic Primary School	57	0.4

Figure 9. Map of Gladstone schools



5.3 Evaluation of model performance

5.3.1 Current limitations

It is important to evaluate model performance and to understand the uncertainties in predicted contaminant concentrations. The output and performance of air dispersion models depends both on the quality of the input information and how well the model algorithms represent the actual physical processes occurring in the atmosphere. Atmospheric mechanisms are complex and, even if all inputs are exactly known, there are still uncertainties in the results due to the nature of atmospheric turbulence.

Annual emissions estimates for sulfur dioxide were considered to be the most accurate because there are no significant natural sources of sulfur dioxide in the region and estimates of industrial emissions are based on readily available information on the consumption of fuels and their sulfur content. An initial satisfactory validation of model performance based on its predictions of sulfur dioxide concentrations provides confidence for using it to model the dispersion of other non-reactive contaminant gases.

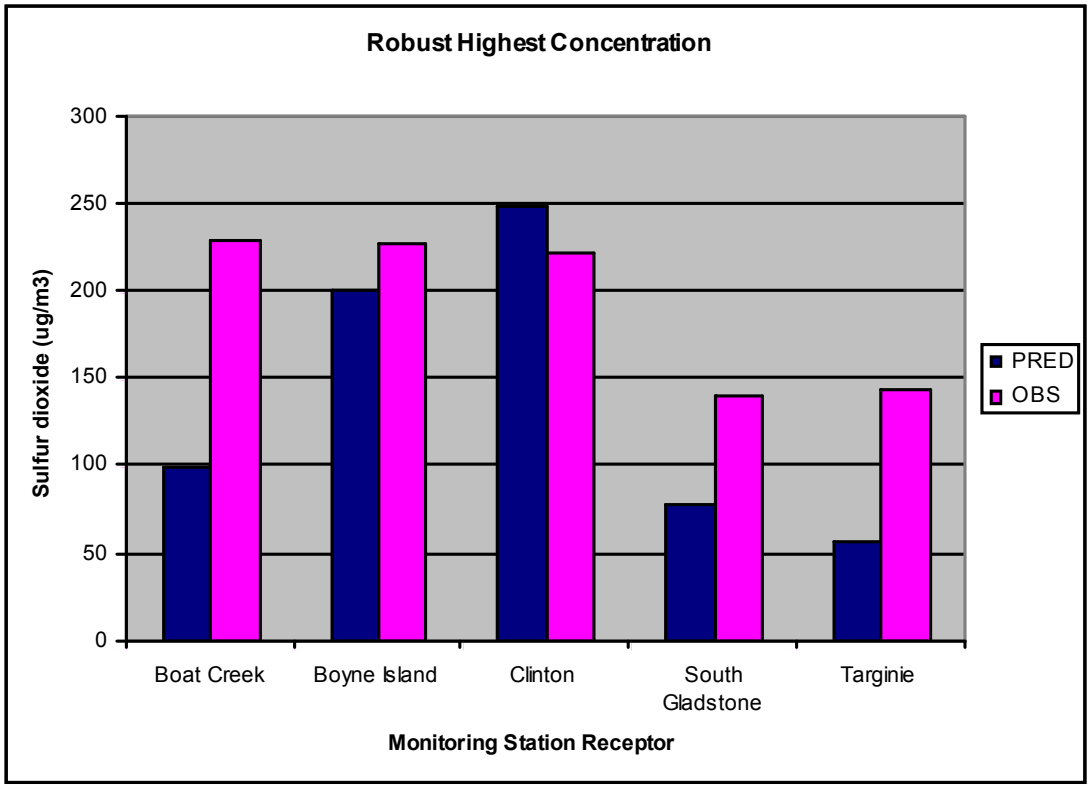
5.3.2 Comparison of model predictions and measured observations

The main purpose of the initial implementation of the model for the CHAG Project was to assess ambient air quality against air quality objectives and standards. Consequently, the main interest is in performance of the model in predicting the upper range of concentrations in the observed distributions of contaminant concentrations. In this case, validation involves comparing the upper tails of cumulative frequency distributions of observed and predicted contaminant concentrations. A model with such proven capability answers questions of interest to regulators such as the probability that a certain concentration is exceeded.

Model simulations for 2009 were analysed to compare predicted sulfur dioxide concentrations with observed concentrations at the monitoring stations.

Figure 10 summarises model performance by comparing predicted and observed robust highest concentrations of ne-hour sulfur dioxide concentrations for five air quality monitoring stations. The robust highest concentration (RHC) is a statistic based on information contained in the upper end of the distribution of concentrations and represents a smoothed estimate of peak concentrations. A method for calculating the RHC based on the Rth value (R=26) and the average of the R-1 largest values is described by Cox and Tikvart (1990).

Figure 10. Robust highest concentration predicted and observed 1-hr sulfur dioxide concentrations at South Gladstone, Boyne Island, Clinton, Boat Creek, Targinie 2009



The RHC plot shows that overall, the model predicts higher concentrations reasonably well. The ratios of modelled RHC to observed RHC are 0.39, 0.44, 0.56, 0.88 and 1.12 for Targinie, Boat Creek, South Gladstone, Boyne Island and Clinton respectively. The predicted RHC is within a factor of 2.0 of the observed RHC for three of the monitoring sites, South Gladstone, Boyne Island and Clinton.

5.3.3 Modelled sulfur dioxide concentrations

Model simulations were performed for three (industry) emission scenarios for sulfur dioxide:

- Best estimates of emissions based on NPI data, benchmarking reports, direct measurements by industries such as stack tests and continuous monitoring results and completed information request submissions
- Emissions at development approval release limits for existing industry
- Emissions at development approval release limits for existing industry plus proposed release limits for a future sulfuric acid plant associated with the Gladstone Nickel Project.

The scenarios are summarised in table 5.

Table 5. Sulfur dioxide emissions used in scenario modelling

	Actual reported emissions (tonnes/year)	Development approval release limits (tonnes/year)	Development approval release limits plus future industry emissions (tonnes/year)
Industry	**Emissions scenario 1**	**Emissions scenario 2**	**Emissions scenario 3**
Queensland Alumina Limited	4420	70 000	70 000
NRG Gladstone Power Station	26 100	66 000	66 000
Rio Tinto Alcan Yarwun	760	5080	5080
Boyne Smelters Limited	12 211	14 600	14 600
Future Industry	0	0	4800

Table 6 shows the predictions of sulfur dioxide from the model simulations compared to the National Environment Performance Measure for Ambient Air Quality (NEPM [Air Quality]) standards for sulfur dioxide. Clearly if industries were operating with emissions of sulfur dioxide at their development approval release limits, exceedences of the NEPM (Air Quality) standards for sulfur dioxide would occur at the Clinton and South Gladstone monitoring stations.

Table 6. Predicted sulfur dioxide concentrations (annual average, maximum 24-hour average and 99.9th percentile of hourly predictions) for three emission scenarios

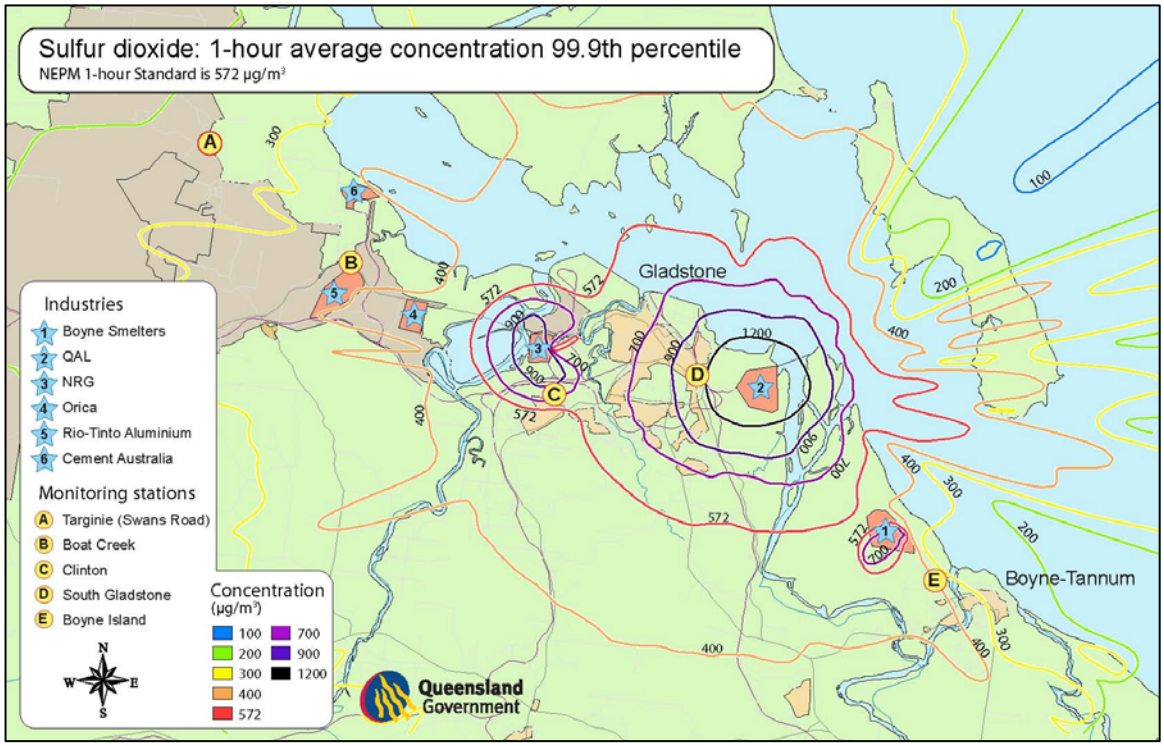
Annual Averaging period (Annual average)	NEPM (Air Quality) Annual Standard = 57 µg/m^3				
Monitoring stations	Boat Creek	Boyne Island	Clinton	South Gladstone	Targinie
Reported emissions	2.1	0.9	5.3	4.8	1.1
Emissions from industry running at maximum approval conditions	9.1	2.2	22.3	40.4	6.1
Additional hypothetical industry emissions with current Industry running at maximum approval conditions	15.8	2.2	22.4	40.4	7.6
24-hour Averaging period (24-hour average, maximum)	NEPM (Air Quality) 24-Hour Standard = 229 µg/m^3				
Monitoring Stations	Boat Creek	Boyne Island	Clinton	South Gladstone	Targinie
Reported emissions	19	47	60	17	12
Emissions from industry running at maximum approval conditions	74	81	164	282 (exceed)	74
Additional hypothetical industry emissions with current Industry running at maximum approval conditions	92	81	164	282 (exceed)	76

1-hour Averaging period (1-hour average, 99.9th percentile*)	NEPM (Air Quality) 1-Hour Standard = 572 µg/m^3				
Monitoring Stations	Boat Creek	Boyne Island	Clinton	South Gladstone	Targinie
Reported emissions	92	222	285	81	56
Emissions from industry running at maximum approval conditions	341	396	761 (exceed)	1192 (exceed)	251
Additional hypothetical industry emissions with current Industry running at maximum approval conditions	345	397	761 (exceed)	1192 (exceed)	252

* A percentile is the value of a variable below which a certain percentage of observations fall. In this case, the 99.9th percentile represents the SO_2 concentration level below which 99.9% of the hourly observations or predictions fall for one year of data. The 99th percentile value has been selected to avoid the risk of basing the results on invalid outliers if the maximum value was used.

Figure 11 shows the peak one-hour averaged ground level concentration that would be expected to occur if each of the facilities were operating at the upper limit of permissible sulfur dioxide emissions.

Figure 11. Predicted maximum one-hour average (99.9th percentile) sulfur dioxide concentrations for facilities operating at their development approval release limits



5.4 5.4 Findings

The emission inventory and dispersion modelling component of the EnviMan system has provided a sound basis for extrapolating monitoring results for the CHAG Project. DERM is further developing the monitoring module of the EnviMan system and is updating the emission inventories for all relevant emission sources (including industry, motor vehicles, rail, shipping, bushfires, soil and vegetation). This will allow DERM to have a fully integrated air quality management system that is operational by the end of 2011. The integration of air quality modelling and monitoring will allow the two functions to complement each other easily. Further work will be conducted to determine if even more advanced dispersion models such as TAPM and CALPUFF can be utilised by the EnviMan system.

Modelling the impact of sulfur dioxide emissions shows the potential for exceedences of ambient air quality standards for one-hour and 24-hour averages if current industry chooses to operate at maximum emissions allowable under the current development approval conditions.

6 Population health and health risk assessments

6.1 Health study introduction

The aims of the CHAG project that Queensland Health addressed, in partnership with DERM and in consultation with industry and community groups, were:

- to assess the potential risks to human health associated with those contaminants in ambient air
- to assess whether the community has experienced adverse health outcomes as a result of ambient air pollution
- to identify whether further health monitoring or evaluation is required.

The first two Queensland Health reports (QH 2008, QH November 2008) provide a comprehensive and detailed description of the health status of the Gladstone community, with a focus on health outcomes that may be aggravated or caused by air contaminants. The health assessment was guided by the potential health outcomes associated with the set of identified key contaminants as discussed in section 3.1. Health outcomes studied included respiratory, cardiovascular, cancer, irritant, reproductive, infectious and endocrine conditions. Some of these conditions (especially asthma, some cancers and adverse birth outcomes), had been raised as specific concerns to members of the community during the consultation process.

The second two reports (QH February 2009, QH August 2010) particularly the final health risk assessment, provide detailed analysis of air quality and associated health risks, based on actual measures of contaminants in ambient air.

6.2 Population health assessment

The health assessment consisted of two studies:

- an analysis of data from existing health datasets
- a survey to measure self-reported health outcomes potentially associated with air pollution in the Gladstone area.

6.2.1 Analysis of existing health datasets

Data were extracted and analysed from hospitalisation, death, cancer and perinatal (birth) registries for the Gladstone area. Where possible, comparisons are made within Queensland and across Australia. For each condition, either seven or eight years of data are provided (from 1999 to 2006 or 2007), providing an overview of these conditions over time. The full report was published in November 2008 as Health Assessment Phase 1: Summary of data analysis from existing health datasets.

The key findings from the analysis of health datasets are:

- Rates of deaths in Gladstone from all causes are similar to rates of deaths in Queensland and Australia.
- For heart disease and diabetes, rates of deaths in Gladstone are similar to rates in Queensland and Australia.
- For deaths due to respiratory diseases, the Gladstone rates in most years are similar to the Queensland rates.
- Hospitalisations for the following conditions fluctuated without any consistent pattern; in some years being lower and in some years being higher than the Queensland rate:
  - heart attack and abnormal heart rhythms
  - chronic airways disease and respiratory tract infections
  - diabetes
- Hospitalisations for the following conditions are similar to the Queensland rates:
  - angina and heart failure
  - asthma

- Foetal deaths (stillbirths) and deaths due to congenital malformations and chromosomal abnormalities occur in Gladstone at rates that are similar to or slightly lower than the Queensland rates.
- Cancers of the lung and major airways, prostate, liver, stomach and ovary, and acute myeloid leukaemia all occur in Gladstone at rates that are similar to the Queensland rates.

6.2.2 Community health survey

The community health survey was undertaken by Queensland Health specifically as a component of the CHAG Project. The findings of the survey are published in the report titled Gladstone Community Health Survey (QH February 2009).

The objectives of the community health survey were:

- to measure self-reported health outcomes potentially associated with air pollution in the Gladstone area
- to measure self-assessed health and well-being
- to measure other factors that may contribute to health outcomes and assist in describing the community, including marital status, education status, household income, occupation, smoker status
- to describe concerns about possible impacts of industry on health.

The Gladstone community health survey obtained information from telephone interviews and included information on self-reported health outcomes, again with a focus on conditions that may be aggravated or caused by air contaminants; information on other factors that can contribute to health outcomes; and descriptions of levels of concern about industry.

Many health-related survey questions were derived from the 2004–2005 National Health Survey (Australian Bureau of Statistics 2005), providing validated questions and enabling direct comparison from NHS results, thereby negating the need for a project-specific control group.

Questions relating to concerns about industry and its impacts on health were derived from or informed by a small number of existing environmental health studies. Questions relating to wheeze, rhinitis and eczema in children were derived from The International Study of Asthma and Allergies in Childhood (Asher et al 1995), again providing validated questions and enabling comparisons with studies elsewhere in Australia and overseas. Comparisons for smoking prevalence rates are taken from the 2007 National Drug Survey (Australian Institute of Health and Welfare 2008).

The survey was conducted by computer assisted telephone interviewing through the Office of Economic and Statistical Research, in September and October 2008. Random digit dialling using Gladstone area telephone prefix numbers was employed to access households in the Gladstone area. Completed interviews were obtained from 2183 adults and on behalf on 822 children, representing in total 5.9 per cent of the Gladstone area population. The survey population reasonably represents the age and gender structure of Gladstone, except for young adults, especially males. This is likely to reflect reduced use of fixed landline telephones in this age group. The median duration of residence in Gladstone was 17 years and the median number of years that the respondent had lived at the current address was five years.

To enable comparisons between areas of residence, the suburbs were grouped into clusters called ‘localities’ that made geographical and demographic sense, and were also sensible in terms of relationship to industries.

The key findings of the survey were:

- Participants expressed a high level of concern about potential impacts of industry generally, and air pollution specifically, on their health and the health of their households.
- Participants expressed a slightly poorer perception of their health than Queensland and Australian comparisons, and nearly half the Gladstone respondents said they felt they had very little control over risks to their health.
- The self-reported prevalence of asthma in adults is 12 per cent, which is two per cent higher than in Queensland and 1.5 per cent higher than across Australia. Several measures indicate higher use of medication and access to health services, and greater impacts on activity and participation in the workforce, compared with Queensland and Australia.

- The overall reported prevalence of wheezing or whistling in the chest, as an indication of asthma, in the Gladstone children in the last 12 months is 32.6 per cent. In children aged 6–7 years, the reported prevalence reached 38 per cent, which is higher than that found in other ISAAC (International Studies of Asthma and Allergy in Children) studies in Australia, and is statistically significant.
- The reported prevalence of severe episodes of wheeze in children is similar in Gladstone to other Australian studies.
- The reported prevalence of symptoms of eczema and allergic rhinitis in the Gladstone children is similar to other Australian studies.
- The reported prevalence of conditions related to heart and circulatory disease are similar to or lower in Gladstone than in Queensland and Australia, with the exception of self-reported prevalence of fast or irregular heartbeat, which is higher in both Gladstone and Queensland, compared with Australia.
- Overall self-reported cancer prevalence in Gladstone is lower than the Queensland prevalence, and the same as the Australian prevalence.
- There is no difference in the reported prevalence of diabetes between Gladstone, Queensland and Australia.
- The survey measured a range of irritant effects. More than 40 per cent of respondents experienced itchy eyes in the last 12 months. Comparison data for this and other irritant symptoms are limited.
- The self-reported prevalence of smoking in Gladstone (21.9 per cent) is four per cent higher than latest available data for Queensland.
- Analysis by locality across the Gladstone area was performed where sensible. There were no statistically significant differences between the various localities for prevalence of asthma in adults or children; emphysema/bronchitis; hay fever, sinusitis and other allergy; and itchy eyes.

As a result of these findings, the health risk assessment included close attention to contaminants that can exacerbate symptoms of asthma and an evaluation of the potential cumulative impacts of air contaminants that are respiratory tract irritants.

The findings of the health assessment were reported to the general community, community and industry leaders, and health workers in the Gladstone area through information sessions, published reports and summary documents. During the consultation period surrounding the health assessment, other concerns identified by sections of the community included potential harms from ‘heavy’ metals, fluoride and benzene. The Results section of this health risk assessment includes detailed discussion on these substances.

6.2.3 Findings of population health assessment

In conclusion, the outstanding findings of the population health assessment were:

- Overall, the health of the population of the Gladstone area as measured by these key health outcomes and presented, does not show consistent variation from Queensland as a whole.
- Deaths and cancers generally occurred at rates similar to the Queensland rates.
- There were fluctuations for some health conditions in some years which indicated rates for hospitalisations higher than the Queensland rates. There was no consistent pattern in these fluctuations. Higher rates of hospitalisations do not necessarily indicate higher rates of disease as hospitalisations can also reflect hospital access.
- There was a high degree of expressed community concern about industrial air pollution.
- There was a modest but statistically significant increase in the reported prevalence of asthma and its burden of disease in adults.
- There was an increase in the reported prevalence of asthma symptoms in children under the age of 10 years.
- Reported severe episodes of wheeze, hospitalisations for asthma and deaths due to asthma and respiratory disease occur in Gladstone at rates that are similar to Queensland. That is, while asthma symptoms generally are reported at higher rates, available evidence suggests that severe manifestations of asthma occur in Gladstone at rates similar to Queensland.

- The contribution of potential workplace exposure to respiratory irritants and higher rates of tobacco smoking in Gladstone to these findings are unknown.

6.3 Human health risk assessment

The purpose of the human health risk assessment was to:

- characterise the overall quality of the Gladstone airshed, based on data obtained on the key contaminants through the expanded monitoring program
- assess the potential risks to human health associated with these air contaminants.

The risk assessment was based, in the first instance, on comparison of measured levels of contaminants in ambient air, with published national or international health-based standards or guidelines. These standards or guidelines are in turn based on available scientific evidence regarding potential adverse health effects of these substances, and adopt a conservative approach to define an acceptable level for various substances in ambient air. This means that levels below the standard or guideline are unlikely to pose a significant risk to public health.

Most environmental exposure guideline values or standards are derived on the basis of the substance being present in isolation of other chemicals. However, in many circumstances, including ambient air, there will be a mixture of substances present. A commonly used method to assess the overall impact of some specific groups of chemicals is based on the sum of the toxicity equivalent values for each chemical in the group.

One group of chemicals that is frequently assessed together using this method are polycyclic aromatic hydrocarbons (PAHs) because they have a similar mode of toxicological action in the human body. Two other specific groups that can be assessed on the basis of similar modes of toxicological action are dioxin-like polychlorinated biphenyls (PCBs) and polychlorinated dibenzodioxins and dibenzofurans (dioxins).

For each of these chemical groups, an assessment of the overall impact of the components of the chemical group can be based on summing the toxicity equivalents for each component in the group. In this report, the toxicity equivalent values for PCBs and dioxins were based on toxic equivalent factors published by the World Health Organization and for PAHs from the California Environmental Protection Agency.

Most key contaminants considered in this study fall outside those specific groups for which toxicity equivalents can be calculated. In addition, most of the key contaminants, if present at adequate concentrations, cause adverse health outcomes by different modes of action on the human body. It is appropriate for the health risk assessment to consider each of these contaminants independently.

Because the community health survey identified self-reported symptoms of asthma in both adults and children as a significant finding, the health risk assessment considered the mixture effects of the contaminants that can cause respiratory irritation if present at adequate concentrations: nitrogen dioxide, sulfur dioxide, ozone, formaldehyde, acetaldehyde and acrolein. To assess the human health risks of the combinations of these contaminants, a Hazard Index method has been used. This is a commonly used method to assess the impacts of mixtures of different contaminants that have potential to cause adverse health effects through a similar mode of action in the human body.

For each substance, the amount present in the applicable averaging period (1 hour or 24 hours) is expressed as a proportion of its reference standard or guideline value for that averaging period. The individual ratio values for that specific time period are then summed to provide a measure of the cumulative impact of all the substances assessed during that specific time period.

When the hazard index was calculated for the respiratory irritants, the results for 1-hour averaging periods indicate that simultaneous exposure to sulfur dioxide, nitrogen dioxide and ozone does not represent a significant public health risk. The results for 24-hour averaging periods indicate that simultaneous exposure to sulfur dioxide, acetaldehyde, acrolein and formaldehyde does not represent a significant public health risk.

6.4 Findings

Chapter 4 provides an assessment of air quality in Gladstone against current standards and guidelines. Further detail can be found in the final health risk assessment report (QH August 2010).

Review of all available results has identified no key contaminants that were present at levels that either consistently exceeded the relevant health-based standard or guideline, or otherwise would be considered to pose unacceptable risks to health.

Results for many of the key contaminants were very low and many were below the level of reporting of the analytical techniques. For the majority of results that exceeded the level of reporting, there was a substantial margin between the results and the relevant health-based standard.

Significantly, in response to specific concerns raised during the project, levels of particulates, metals, benzene and fluoride in the ambient air are well within health-based standards, apart from circumstances where regional dust storms or local bush fires raised particulate levels.

In regard to concerns about cancers and reproductive effects, there is no obvious basis from the air quality data for concluding that the ambient air in Gladstone poses unacceptable health risks.

In the case of particulate matter, a key contaminant that would be expected to be found in ambient air, the reported levels have been consistently within relevant standards. Short-term excursions above the relevant standards have been associated with events such as documented dust storms and fires in bushed or grassed areas. As particulate matter may exacerbate symptoms of chronic cardiovascular and respiratory disease, it is likely that these short-term excursions have exacerbated asthma symptoms in sensitive individuals. The overall particulate matter results are consistent with what would be expected in a populated airshed such as Gladstone.

A number of contaminants are recognised as respiratory irritants. Levels of each of these individual contaminants in ambient air in the Gladstone area are below standard or guideline levels. At these levels, these contaminants are not considered to pose unacceptable risks to health other than in those who are most susceptible to their irritant effects on airways. Mixture effects of contaminants that are respiratory irritants are considered using a Hazard Index method. The cumulative impacts of these contaminants are still below health-based thresholds, and are considered acceptable from a public health perspective.

The excess of self-reported symptoms of asthma in both adults and children is not explained by the levels of respiratory irritants in the ambient air in Gladstone.

While a proportion of asthmatics may be particularly sensitive to one or more of the respiratory irritant contaminants, these contaminants are present at levels that are comparable with levels in other urban communities. Similarly, while particulates may provoke asthma symptoms, overall levels in the Gladstone airshed are within current standards and are similar to other urban communities in Queensland. The contribution of occupational exposure to symptoms in adults, and the contribution of cigarette smoking by adults to symptoms in both adults and children, to the reported rates of asthma symptoms cannot be quantified.

The summary assessment of air quality, based on the results of the air-monitoring program supplemented by modelling on a smaller number of contaminants, is that the ambient air quality in the Gladstone area meets current health-based standards or guidelines. The findings are consistent with what would be expected in an urban Australian airshed with an industrial base. The air is not pristine, nor can it be in an environment with a significant industrial base. However, there are no obvious health risks identifiable in the ambient air.

While the air quality is considered to meet guidelines or standards that are acceptable from a population-based perspective, it is possible that some people with particular susceptibilities, including asthma, may be affected by current air quality, at least on an intermittent basis. However, this is considered to be no different from the experience of people with similar susceptibilities in other urban locations such as Brisbane.

6.4.1 Recommendations from the human health risk assessment

Ongoing air quality monitoring

The ongoing air quality monitoring program implemented by DERM in the Gladstone area should continue to include the criteria gaseous contaminants and particulate matter. Many contaminants monitored during the course of the project and included in this extensive health risk assessment have been present at very low or undetectable levels, so periodic monitoring of additional contaminants should take into account data captured during the course of this project. The ongoing air quality monitoring program should have capacity to include additional contaminants as indicated by the development of new industries or changes to existing industries.

Ongoing collaboration

The joint community/industry/government reference group established for the CHAG project has been a necessary and productive forum for dissemination of ideas and provision of feedback and opinion. The establishment of an ongoing reference group with similar representation is recommended as a forum to review the air quality monitoring program and its results, as industrial expansion across the area continues.

Impact assessments consider additional impacts on air quality

It is recommended that impact assessments for new developments include baseline air quality data and consider additional impacts on air quality. While many impact assessments do include this information, it needs to be explicit, given the large industrial base in the area.

Continuous improvement in control of particulate matter

While the current particulate levels are below health-based guidelines, and the contribution of dust storms and bush fires is noted, there is no accepted level of exposure to PM_{10} or $PM_{2.5}$ below which exposure is considered completely without potential for adverse health effects. On this basis, it is recommended that efforts to manage emissions of particulate matter into the environment are encouraged, within industry, government and the community.

Continuous improvement in control of emissions generally

Air that is as clean as possible is the goal from the human health perspective; small improvements in many areas can have incremental benefits which, at least theoretically, can lead to improved amenity, reduced potential health risks and improved health status on a population-wide basis. It is therefore recommended that industry, government and the community seek opportunities to reduce discharge of contaminants into the ambient air.

Management of asthma

Peaks of air contaminants, including particulate matter and the respiratory irritant contaminants, may be responsible for exacerbation of asthma in sensitive individuals. At a population level, air contaminant levels do not explain the excess of symptoms of asthma reported by members of the Gladstone community. The contribution of occupational exposure to respiratory irritants to asthma symptoms in workers is unknown. However, it is recommended that all people with asthma have an asthma management/action plan that is developed in consultation with their GP or health care provider. Asthmatics with uncontrolled symptoms should consult their GP or health care provider. Good resources are available from the National Asthma Council Australia and the Asthma Foundation of Queensland.

Continue smoking prevention and cessation programs

A finding of concern from the community health survey is the high rate of smoking identified in Gladstone (21.9 per cent of adults, compared with 17.9 per cent for Queensland). Smoking aggravates asthma and is a direct cause of chronic respiratory illness, and can increase the respiratory impacts of some occupational contaminants. Exposure to tobacco smoke contributes to respiratory illness including asthma in children. At a community level and within industry groups, Queensland Health encourages ongoing commitment to smoking prevention and cessation programs.

7 Air quality management

7.1 Introduction

One of the aims of the Clean and Healthy Air for Gladstone Project was 'to develop a contemporary approach to the management of emissions in the Gladstone area, including better targeted conditions for development approvals, improved planning and forecasting capability, and targeted regulatory compliance activities'.

The key issues for air quality management in the Gladstone region at present are:

- community concerns regarding air quality
- managing contaminant emissions from existing sources
- future industrial and urban development of the region.

The following is a review of current air quality management in the Gladstone region that draws on the findings and outputs of the project and makes a series of recommendations to enhance air quality management to meet these challenges.

7.2 Community concerns regarding air quality

7.2.1 Community consultation

Community expectations regarding air quality and the potential impacts of industrial development generally are outlined in chapter 2. The community expects that the ambient air quality in the Gladstone region will not be compromised by existing and future industrial development.

During the course of the project, the joint community–industry–government reference group has been a necessary and productive forum for dissemination of ideas and provision of feedback and opinion.

In addition to this forum, the Gladstone Industry Leadership Group was formed in 2008. Members of this group are Boyne Smelters Limited, Cement Australia, NRG Gladstone Operating Services, Queensland Alumina Limited and Rio Tinto Alcan – Yarwun. The group's member companies have publicly committed to continuous improvement in areas of concern to the community such as the environment, health and safety, employment and infrastructure as well as to openly sharing information with the Gladstone community.

More recently, the Gladstone Region Environmental Advisory Network (GREAN) has been established under the auspices of Gladstone Regional Council. The membership of GREAN is drawn from the regional community. The functions of the group as identified in its terms of reference include acting 'as a community reference group for projects as considered appropriate by the committee (e.g. Clean and Healthy Air for Gladstone Project)'.

Continued transparency in decision-making is needed to provide the regional community, government and industry with confidence that decisions about the air environment are consistent, equitable and informed.

Recommendation

1. That DERM continues to maintain a working relationship and regularly consult with the community, industry and local government in relation to the department's regulatory oversight of air quality management in the Gladstone area.

7.2.2 Ambient air quality monitoring

The comprehensive air quality monitoring program undertaken provided the data needed for a rigorous assessment of air quality and potential exposure of the Gladstone community to air contaminants.

Ongoing ambient air quality monitoring in the region is required to deliver the following outcomes:

- to determine ambient concentrations of and exposure of the community to particular air contaminants, with emphasis on the criteria contaminants

- to provide the data necessary to assess compliance with the NEPM (Air Quality) and NEPM (Air Toxics) and other applicable air quality standards and guidelines
- to provide air quality information to the public
- to assess the effectiveness of air pollution control policies and strategies and provide scientific support for policy-making on contaminant emission control and industrial development
- to be able to determine whether there has been a significant change in the key parameters of ambient air quality
- to validate and calibrate air pollution dispersion models.

The network of six fixed monitoring stations and mobile monitoring unit used in the project will form the basis of the ongoing monitoring program. The air quality monitoring program is currently operated in accordance with quality assurance procedures that have been developed to meet NATA requirements. During 2011–12 the department will seek NATA accreditation for the air quality monitoring program. This level of independent accreditation is desirable to develop community trust in the results of the monitoring program.

Based on the results of the enhanced monitoring program presented in chapter 4, it is justifiable to discontinue routine measurement of the contaminants that require collection of samples and subsequent analysis by laboratories (that is, all contaminants other than sulfur dioxide, nitrogen oxides, carbon monoxide, ozone and particles).

A capacity for rapid deployment of additional sampling equipment is being established in the region to provide support responses to incidents where localised impacts on air quality are anticipated.

The DERM live air monitoring data website will continue to provide access to current and historical air quality data from continuous monitoring. Additionally, results of the ongoing monitoring program will continue to be reported in a monthly ambient air quality bulletin for Central Queensland.

Monitoring of the black carbon content of the PM_{10} and $PM_{2.5}$ particle fractions at the Auckland Point monitoring site was carried out during the project. Further investigation of the use of black carbon as an indicator of dust sources will be carried out through monitoring of the black carbon content of the TSP particle fraction.

The initial investigation of particulate matter alkalinity was inconclusive. Further particle sampling using a revised method will be conducted as part of ongoing ambient air quality monitoring.

Periodic reviews of the monitoring program will be conducted. In the period between such reviews, it may also be necessary or prudent to make changes to the monitoring program in response to changed local conditions. Triggers for such changes could include:

- significant changes in the regional emissions profile through addition or removal of sources
- changes in regulation such as environmental protection policy, NEPM or Environmental Protection Act that require additional data
- monitoring results that identify a need for more detailed investigations.

The scope of the ambient monitoring program in terms of the number of sites and variables to be measured is significantly greater than would be required in a similar regional centre in the absence of large industrial sources. The scale of monitoring required is a direct consequence of the potential for cumulative effects on air quality from current and future industry in the region.

DERM has largely met the cost of ongoing monitoring of ambient air quality in the Gladstone region with some limited capital contributions from particular industries.

It is consistent with the ‘polluter pays’ principle adopted in the Intergovernmental Agreement on the Environment for industry operating in the region to contribute to the cost of operating and maintaining the monitoring network.

Recommendations

2. That DERM continues to operate the ambient air quality monitoring network in the Gladstone region and review the list of monitored contaminants as new major industries are established.
3. That the Department enters into arrangements with existing and new industries operating in the region to contribute to the capital and operating costs of the ambient air quality monitoring network in the Gladstone region.

7.3 Managing contaminant emissions from existing sources

The investigations carried out during the CHAG Project consistently showed that ambient air quality in the Gladstone area meets current health-based standards or guidelines. The findings are consistent with what would be expected in an urban Australian airshed with an industrial base. The air is not pristine, nor can it be in an environment with a significant industrial base.

The nature of the existing concentration of heavy industry in the Gladstone region presents ongoing risks to air quality that need to be managed. The final report of the human health risk assessment carried out during the project recommended that industry, government and the community seek opportunities to reduce discharge of contaminants into the ambient air with the aim of improved amenity, reduced potential health risks and improved health status on a population-wide basis.

The project identified opportunities for improving air quality management to provide greater security that air quality objectives will continue to be met. These are discussed below.

7.3.1 Emission limits, monitoring and reporting

DERM regulates emissions to air from industrial facilities through conditions listed in each operation's development approval. The conditions in development approvals for new operations have undergone continual improvement over time to help meet current best practice management, incorporate the provisions of the Environmental Protection (Air) Policy (2008) and address the potential for cumulative impacts. Under the current provisions in the *Environmental Protection Act 1994*, development approval conditions may only be amended without agreement of the holder under limited triggers. Some environmental authorities have not had conditions updated since they were issued so do not necessarily reflect current knowledge or best practice management.

Development approval conditions relating to the release of contaminants to air are generally expressed as upper limits on the concentration or mass of contaminants that can be released. In the case of the operations of the Gladstone Ports Corporation Limited, pollution control objectives are in the form of maximum particulate concentrations that must be achieved at specified ambient monitoring locations.

Table 7 provides a summary of contaminant release limits included in current development approvals for the major industrial facilities in the Gladstone region. The ways that emission limits are expressed is inconsistent between facilities. In some cases, the development approvals specify monthly sampling and averaging times for contaminants that have acute effects, while the Environmental Protection (Air) Policy (2008) specifies hourly averaging times.

Table 7. Summary of development approval conditions relating to contaminant emission limits

Facility	Contaminants regulated	Limit type	Monitoring requirements
Orica	NO_2, HCN, C_l, NH_4, NO_3	Maximum concentration Different limits for normal operating and start-up conditions	Continuous NO_2 and chlorine Daily HCN Weekly other compounds
RTA-Y	SO_2, NO_x, particulate	12-month rolling average mass emission rate for NO_x, SO_2 and particulates Maximum hourly average mass emission rate for SO_2	Continuous NO_x, SO_2 and particulate on boilers Continuous particulate and quarterly NO_x at calciners
BSL	F, SO_2, CN, NH_4, particulates, PAH	Mass emission limits for specified sources and site-wide mass emission limits for fluoride and PAH.	Monthly (fluoride and particulate) Quaterly (PAH) Yearly (CN, NH_4)
QAL	Particulate, SO_2	Maximum rolling 24-hour average concentration for particulate SO_2 limited by 3 % sulfur limit on coal	Continuous monitoring of particulate from annual NO_x sampling for boilers and calciners
CA	NO_x, particulate, SO_2	24-hour average concentration of oxides of nitrogen as NO_2 (at 0º C and 101.325 kPa when correct to a reference level of 7 % by volume of 0_2) SO_2 limited by 3 % sulfur limit on coal Exemptions on release limits for start-up, power failure, trial burns and instrument calibration.	NO_2 Continuous SO_2, TSP once per year
NRG	NO_2, particulate and obscuration	Concentration limits for different percentiles of operating time Monthly averaged obscuration value.	Continuous NO_x on nominated boiler and monthly samples for other boilers
GPCL	Particulate	Concentration limits at boundary of port activities	Ambient monitoring sites on boundary

There is also substantial inconsistency among development approvals in relation to the quality control, quality assurance, monitoring and reporting requirements that relate to emissions to air. Variations in sampling and reporting requirements contained in development approvals compromise the potential for the data collected to become a valuable data bank on regional emissions.

Table 8. Summary of development approval conditions relating to different aspect of monitoring and reporting of releases to air

Site	Quality control	Records	Reporting	Methods
Orica	Equipment must be calibrated, and appropriately operated and maintained. Operators must have appropriate qualifications.			
BSL	Standard sample points required NATA-accredited operators	Relevant operational parameters at time of sampling	Annual monitoring report with specified content. Monthly Fluoride results reporting	Test must be representative of emission rates.
QAL	Standard sample points required Appropriate qualifications	Production rate at time of sampling		Must be representative of normal conditions where practicable

Site	Quality control	Records	Reporting	Methods
CA	Instruments calibrated and appropriately operated		When limits are exceeded and in annual return	Must be representative of the contaminants discharged under normal operating conditions
NRG			Results available on request or when emission limits are exceeded	
RTA-Y	Standard sample points required Actual test methods and the accuracy of each method must be recorded.		The results notified to the administering authority within ten (10) working days	Where technically practicable, samples must be taken when emissions are expected to be at maximum rates.
GPCL	Competent person with calibrated equipment		When requested or in the event of a visible coal dust complaint.	

Recommendation

4. That current development approvals be amended to bring about an integrated approach to regulating air emissions and emission monitoring across the Gladstone area. The amendments should ensure that:
   a. emission limits on particulates, sulfur dioxide (SO_2) and nitrogen oxides (NO_x) include a consistent short-term averaging time based on the ambient concentration objectives in the Environmental Protection (Air) Policy 2008 and the potential acute health impacts of these contaminants
   b. monitoring by the holders of development approvals for emissions of particulates, SO_2 and NO_x be undertaken on a continuous basis
   c. where industry monitoring is undertaken on a continuous basis it be reported to DERM on that basis
   d. monitoring of air emissions be undertaken in accordance with appropriate standard methods by organisations accredited by the National Association of Testing Authorities (NATA) for the relevant method
   e. the results of all emissions monitoring is reported to DERM in a format required by DERM on an annual basis
   f. emission limits in development approvals be amended to reflect best practice environmental management as defined in the *Environmental Protection Act 1994*
   g. new approvals reflect these requirements.

7.3.2 Sulfur dioxide emission limits

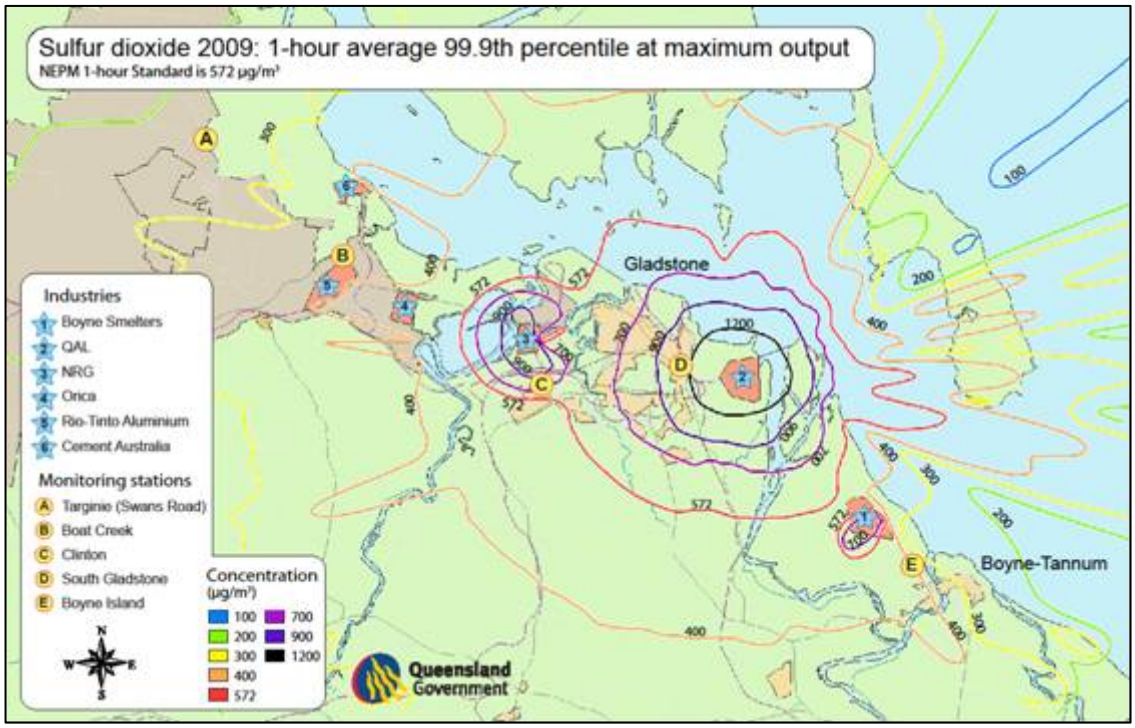
In recent years, the potential cumulative impacts of sulfur dioxide emissions from new development in the region has been assessed using air quality modelling of a proposed source and estimated emissions of sulfur dioxide from existing sources in the region. One of the findings of the modelling work discussed in chapter 5 is that, if all industrial facilities in Gladstone were releasing sulfur dioxide at the maximum concentration permitted by development approvals it is likely that ambient concentrations would be significantly greater than current air quality objectives.

Sulfur dioxide emissions from combustion processes are commonly limited by limiting the sulfur content of fuels. This restriction is included in the development approval conditions for QAL and Cement Australia where development approval conditions require a maximum of three per cent sulfur in coal. In contrast, the Gladstone Power Station is limited to a sulfur concentration of 0.8 per cent for coal and 1.8 per cent for fuel oil. Rio-Tinto Alumina has a sulfur dioxide emission limit for each of the boilers on site in the form of a twelve-month rolling

average of 161 grams per second and a one-hour average of 258 grams per second while Boyne Smelters Limited has effectively a twelve-month average sulfur dioxide release limit of 14,600 tonnes/year.

Figure 12 shows the peak one- hour averaged ground level concentration that would be expected to occur if each of the facilities were operating at the upper limit of permissible sulfur dioxide emissions. This modelling clearly shows that if all facilities operated at the upper level of permitted sulfur dioxide emissions, the cumulative impact would cause relevant health-based standards to be exceeded.

Figure 12. Predicted 99.9th percentile one-hour average sulfur dioxide concentration with industrial facilities, each of the facilities operating at the upper limit of permissible sulfur dioxide emissions.



It should be noted that the sulfur content of coal generally used in the region is well below that allowed in development approval conditions and this is reflected in the ambient monitoring results, which show that sulfur dioxide concentrations are substantially less than that indicated by modelling of maximum permissible concentrations.

Recommendation

5. That the current limits on the release of sulphur dioxide from industrial facilities in the Gladstone region be reviewed to ensure that ambient concentrations are maintained at the minimum that is reasonably achievable with available fuel sources and technology installed.

7.3.3 Maintenance and operation of plant and equipment

The maintenance and operation of plant and equipment is a significant factor influencing the quantity and quality of contaminant releases to air. This is dealt with in most development approvals through conditions that require operators to install, maintain and operate plant and equipment in a proper and efficient manner.

A caustic emission incident at the QAL refinery on 15 January 2009 is an example where a lack of appropriate of maintenance resulted in contaminants being released in an uncontrolled manner. In Department of Environment and Resource Management vs QAL, Magistrate Carroll in his findings regarding the incident stated, ‘The important point here is that there is no evidence that a formal routine maintenance had been implemented by QAL to ensure that the butt weld and the patching were in good repair’ and, ‘I take into account that this incident occurred due to lack of maintenance.' (Magistrates Court July 2010)

The risk assessment carried out for the environmental evaluation of BSL air emissions (Kriznic, Ingram & Forster 2009) also highlights the importance of proper maintenance and operation of equipment.

The risk assessment identified sources in the minor risk category as 'primarily those that are operating all the time and have emission control systems in place to mitigate their risk of off-site impact. These are the well maintained bag houses, gas treatment centres and fume scrubbers that mitigate the majority of emissions from continuous processes at the BSL site' while the medium risk category included sources 'from the bath cleaning, cell lining and green carbon processes whose impacts off-site appear to be substantial in the event of failure of the dust emissions control systems. In the cell de-lining processes from the reduction lines, there are some issues that have been raised which have driven up the risk. In particular the fact that these processes used poorly maintained and/or instrumented bag houses make it very difficult to determine if they are operating correctly.'

As changes to plant and operating parameters are made over time, pollution control equipment can be operating outside of original design specifications. This situation was encountered during the BSL environmental evaluation as reported to DERM where original design specifications for pollution control equipment were sometimes no longer available and some items were operating outside of known specifications.

Consideration of these matters led to additional conditions being amended to the BSL development approval. These conditions specifically require a current inventory of design data and maintenance requirements, including maintenance history for all air pollution control devices operated at the site to be maintained. The conditions also specify the responses to be undertaken in the event of failure of pollution control equipment.

Detailed investigations similar to the BSL environmental evaluation have not been carried out at other facilities and so no conclusion can be drawn as to the current adequacy of pollution control equipment design criteria or maintenance regimes. However, given the known potential for failure of pollution control equipment it is recommended that similar conditions be included as standard in the development approvals of facilities operating pollution control devices.

Most current development approvals for industrial facilities include the following standard condition:

The holder of this Development Approval must:

a. install all measures, plant and equipment necessary to ensure compliance with the conditions of this Development Approval; and

b. maintain such measures, plant and equipment in a proper and efficient condition; and

c. operate such measures, plant and equipment in a proper and efficient manner.

The development approval for QAL includes an abbreviated version of this condition and the approval for RTA-Y does not explicitly include a requirement on maintenance and operation of equipment. The development approval for RTA-Y implements a risk-based approach to regulation, the efficacy of which is currently being questioned by both the company and DERM.

Overall, the development approval conditions relating to maintenance and operation of plant and equipment are inconsistent between facilities and ambiguous in terms of what would constitute a breach of such conditions.

Recommendations

6. That development approval conditions relating to the maintenance and operation of plant and equipment be amended to ensure consistency, and include requirements for rigorous auditing processes that minimise the potential for environmental harm occurring through poor maintenance and operation of equipment.

7. That development approval conditions similar to the following be applied where facilities rely on the pollution control equipment to avoid environmental harm:

    a. A current inventory of design data and maintenance requirements, including maintenance history for all pollution control devices operated at the site must be kept and maintained on a weekly basis.

    b. All pollution control devices must be operated within design and maintenance specifications.

    c. Where monitoring of pollution control equipment indicates impaired operational performance, standby systems are to operate and corrective measures must be undertaken.

    d. The plant(s) serviced by the pollution control equipment with impaired operational performance must be safely shut down as soon as practicable, unless otherwise agreed by the administrating authority.

e. In the event of significant process change that may directly affect atmospheric emissions or process operations that could lead to unplanned atmospheric emissions (for example, alterations to process or capacity) the final design of the process change or addition will be subject to a formal hazard and operability study to identify and mitigate process risks.

7.3.4 Incident management

In the event of uncontrolled releases to air, the first priority is to ensure that community exposure to potentially harmful contaminants is minimised.

The Queensland Government has a comprehensive emergency management system to respond to emergencies in a coordinated manner. These actions are guided by Queensland's Chemical/HazMat Plan 2004 and Disaster Management System which operate at all levels of the community.

There is also potential for incidents to occur where an emission to air may cause environmental harm, but not trigger an emergency response because there is no apparent or reported serious risk to the life or health of individuals.

During the course of the CHAG Project, community concern was raised over possible gaps in incident response, handling and post-incident information dissemination protocols used by industry and government. The community considered that government and industry were not adequately responding to incidents or communicating responses relating to the release of emissions.

Separately, the Government has amended the *Environmental Protection Act 1994* to extend the obligations of operators of all activities to report and communicate incidents that have the potential to cause environmental harm.

Examples of such events that have occurred during the course of the CHAG Project include the uncontrolled release of caustic vapour from QAL and a fire in the fume treatment centre for the carbon bake 3 furnace at BSL noted above.

In March 2008, a number of industries in the Gladstone region were asked by the then Environmental Protection Agency (EPA) to submit their incident/emergency response procedures relating to air emissions. The purpose of the request was so the EPA could assess whether gaps existed in the response procedures and to what extent those gaps affected incident responses. The incident response plans varied greatly in nature and content. Review of the plans found that some focused solely on disaster management related to natural disasters whereas others had detailed procedures to cover a wide range of incidents including scenario-specific plans.

There is significant variation in the requirements placed on industry to report incidents and in planning for incident management. Recent amendments to the development approval conditions for Boyne Smelters include comprehensive requirements around management of incidents that has been informed by the considerations identified above.

The following recommendations are aimed at providing clarity in regards to responsibilities during uncontrolled releases to air and confidence that such incidents will be managed in an effective way.

Recommendations

8. That DERM seek assurances from existing operators that they have recently undertaken site risk assessments that adequately identify potential incident scenarios, state the likelihood of occurrence, list the hazards that may occur as a result of any incident, and model the potential impact of an incident.
9. That operators of significant sources of air pollutant emissions have regard to the DERM Procedural Guide on Industry Incident Contingency Planning and establish incident response plans that ensure:
    a. specific procedures to respond to incident scenarios identified through the risk assessment process exist
    b. response procedures are regularly tested, reviewed and evaluated.
10. That operators of significant sources of air pollutant emissions develop procedures to adequately report and communicate incidents, investigate incidents, record incident data and review incident response plans.
11. That current development approvals be amended to include incident response conditions that:
    a. provide consistency and clarity of requirements to notify the administrating authority

b. have incident response plans that are based on the requirement of the Emergency Preparedness and Response provisions of ISO14001

7.4 Appropriate location of future industrial and urban development of the region

Gladstone is an expanding industrial centre with a large industrial land bank, port facilities and government support for continued development of heavy industry.

The region is at a stage where significant rapid growth is occurring through expansion of the RIO alumina refinery, the establishment of a liquefied natural gas (LNG) processing and export industry, expansion in port facilities, a proposed nickel and cobalt refinery and the expansion of urban development that will necessarily accompany these developments.

This expansion will lead to an increase in and changes in the nature of contaminant emissions to air. An appropriate approach to planning for the location of new sources will ensure that the cumulative effects of current and future development do not compromise ambient air quality.

7.4.1 Air quality modelling

The air quality model developed during the project is a tool to support decisions regarding the ongoing development of the region and, in particular, to inform decisions regarding the location of new development and potential cumulative effects of contaminant sources within the region.

7.4.2 Regional emissions inventory

The principle purpose of developing the emissions inventory was to provide input data for the regional air quality model. Compilation of the detailed regional inventory has required a significant investment from government and industry due to incomplete data on contaminant release points and lack of reliable emission estimates for all but a few contaminants.

Development approval conditions generally specify the height, exit velocity and maximum contaminant concentration for identified release points at a facility. The release points to which development approvals apply have generally been identified through the development assessment process as the highest risk in terms of potential for environmental harm. In general, monitoring is only required at these specified release points.

Development approvals for RTA-Y, Cement Australia, Boyne Smelters Limited and Orica limit releases to air to specified release points, although it is known that releases to air occur from other locations at RTA-Y. The development approval for QAL applies limits to releases from the boilers and calciners but does not limit releases to only those sources. Several other potentially significant release points and fugitive sources exist on the QAL site including a thermal oxidiser and process vents. Similarly, the development approval for NRG does not recognise release points other than the main stacks.

Boyne Smelters Limited developed a comprehensive inventory of release points as the first stage in the environmental evaluation process discussed in section 7.3.3. The evaluation identified 330 potential sources of emissions to air which were then analysed through a risk assessment to identify those release points where further investigation was warranted. This process provided a reliable and transparent inventory of contaminant sources on site and confidence that an appropriate level of regulation is now being applied.

Recommendations

The following recommendations are aimed at ensuring modelling tools can be maintained and developed to support decisions regarding management and ongoing development of the region.

12. That DERM maintains a comprehensive inventory of air emissions for the Gladstone region.
13. That new industries (of sufficient scale to materially change the air emissions profile) be required to verify and report their emissions profiles to the department within two years of beginning operations.

14. That when existing facilities currently included in the inventory make changes to plant and equipment that require an amendment to a development approval, verification of emissions from the plant and equipment affected should be carried out.
15. That existing industry works with the department to address shortcomings in emissions data for particulates, mercury and organic compounds.
16. That each facility operating an environmentally relevant activity (ERA) that releases contaminants to air undertakes an evaluation that determines a complete list of release points, and on the basis of a risk assessment, identifies release points that should be included in the emissions inventory.
17. That existing development approvals be amended to require facilities operating ERAs to limit releases to specific release points.

7.4.3 Low emission technologies

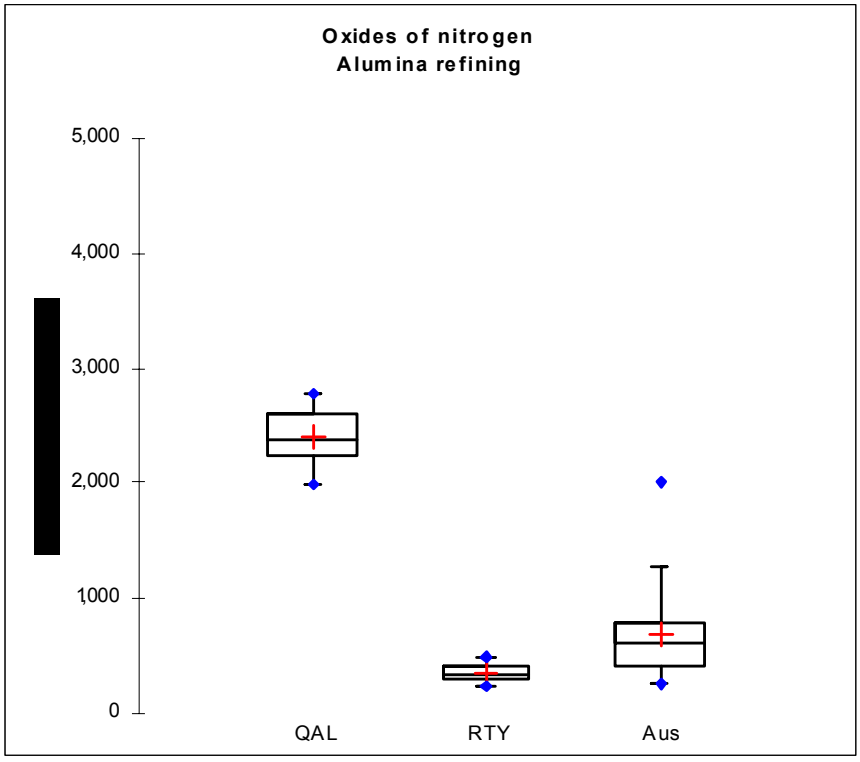
There is currently no specific policy requirement for new or expanding developments to adopt low emission technologies. However, best practice environmental management must be considered when making environmental management decisions under the Environmental Protection Act. The Act defines best practice environmental management of an activity as 'the management of the activity to achieve an ongoing minimisation of the activity's environmental harm through cost-effective measures assessed against the measures currently used nationally and internationally for the activity.'

Note that this does not imply that the lowest achievable emission rate must be adopted but that it must be considered.

A locally relevant example of the difference that selection of technology can make to air emissions can be identified from the Alumina Refining Benchmarking Report (DERM 2010) that includes reported emissions of nitrogen oxides per tonne of alumina produced as shown in figure 13.

QAL produces three times as much alumina as RTA-Y but the QAL facility releases 11 times the quantity of nitrogen oxides. This disproportion arises from the technologies used in the production process with RTA-Y implementing low NO_x-producing technology in boilers and calciners, effectively avoiding the generation of approximately 2 million tonnes per year of NO_x.

Figure 13. Specific emission of oxides of nitrogen for Australian alumina refineries



Another example of where choice of technology constrains air quality management can be found in the coal-loading operations at Port Curtis. In 2008, the then Central Queensland Ports Authority commissioned The RG Tanna Dust Benchmarking Study. The study found that 'the majority of dust emanating from the RG Tanna Coal Terminal is associated with the stockpiling configuration of the terminal.'

'Generally the terminals utilising Stackers and Reclaimers are scoring better across the sample group. In this context, RG Tanna Coal Terminal represents compromises with initial design and operating methodologies which other terminals are not constrained by.'

Environmental impact statements currently require an assessment of alternatives to a proposed project. However, this assessment rarely extends to an assessment of proposed technologies against available alternatives.

Recommendation

18. That the terms of reference for environmental impact statements for projects in the Gladstone region include a requirement that the proponent of a project identifies contaminant emissions and alternative available technologies for their management to achieve best practice environmental management.

7.4.4 Land-use planning

Land-use planning is a major contributing factor to the achievement of acceptable air quality and protection of public health and wellbeing. The main outcomes of land-use planning that are of interest in managing air quality are the separation of heavy industry and residential or other areas that may be adversely affected by industrial activities, avoiding a concentration of polluting activities with similar contaminant emissions from establishing in the same locality and protecting industrial developments from encroachment by residential and other sensitive land uses that would adversely affect industry viability.

Buffers or separation distances are not an alternative to source control and cleaner production methods. They are a means of reducing the effects of residual emissions and, in exceptional circumstances, the emissions of a plant operating under less-than-optimum conditions.

Decisions regarding the location of new industrial development in the region are made under the *State Development and Public Works Organisation Act 1971* or the *Sustainable Planning Act 2009*.

Many of Gladstone's major air emitters are located in Gladstone State Development Area where land-use planning is carried out according to the Development Scheme. The development scheme is established under the *State Development and Public Works Organisation Act 1971* and so assessment of development proposals is carried out through the Coordinator General.

Assessment criteria outlined in the Development Scheme and associated policy is generally aimed at ensuring that the principles of ecological sustainable development are achieved in the assessment stage and through management of existing industries. However, air quality management issues can more easily be managed through the assessment process if air quality is a consideration when the location of a new facility is determined.

Where a proposed facility involves a similar emission profile to an existing industry or an emission profile that has the capacity to interact and contribute to photochemical pollution, this places significant pressure on the airshed to assimilate contaminants and maintain air quality. An example of this is the proposed location of the Gladstone Pacific Nickel plant which is approved for development at a site in close proximity to the Gladstone Power Station. Both developments have substantial sulfur dioxide emissions.

In determining the location for a new facility, regard must be given to the cumulative impacts of that facility in relation to existing facilities both in and outside the region. The new industry should be located to provide sufficient separation to ensure adequate dispersion of its emissions and limit the opportunity for cumulative interactions.

Recommendations

19. That decisions regarding the location of new industrial development in the Gladstone region be evaluated for the potential for cumulative impacts on air quality.
20. That priority be given to locations that avoid cumulative impacts and the degradation of ambient air quality.

Glossary

AERMOD	atmospheric dispersion model for short-range dispersion of air pollution emissions from stationary industrial sources
BSL	Boyne Smelters Limited
CA	Cement Australia
CALPUFF	integrated Gaussian puff model is an advanced non-steady-state air quality modelling system developed by TRC Companies Inc
CHAG Project	Clean and Healthy Air for Gladstone Project
DERM	Department of Environment and Resource Management
DOAS	differential optical absorption spectroscopy
EPP (Air)	Environmental Protection (Air) Policy 2008
ERA	environmentally relevant activity
GAMS	Gladstone Airshed Modelling System
GPCL	Gladstone Port Corporation Limited
ISAAC	International Studies of Asthma and Allergy in Children
LNG	liquefied natural gas
NATA	National Association of Testing Authorities
NEPM (Air Toxics)	National Environmental Protection (Air Toxics) Measure
NEPM (Air Quality)	National Environment Protection (Ambient Air Quality) Measure
NHS	National Health Survey
NPI	National Pollutant Inventory
NRG	NRG Gladstone Power Station
PBL	planetary boundary layer
QAL	Queensland Alumina Limited
RHC	robust highest concentration
RIO	Rio Tinto Alcan alumina refinery at Yarwun
TAPM	The Air Pollution Model - A combined predictive meteorological and non-steady-state air quality modelling system developed by CSIRO
TEQs	toxic equivalents
VOCs	volatile organic compounds

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DERM see Queensland Department of Environment and Resource Management

EPA see Queensland Environmental Protection Agency

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