



Ministry for the
Environment
Māori Airi Te Taiao

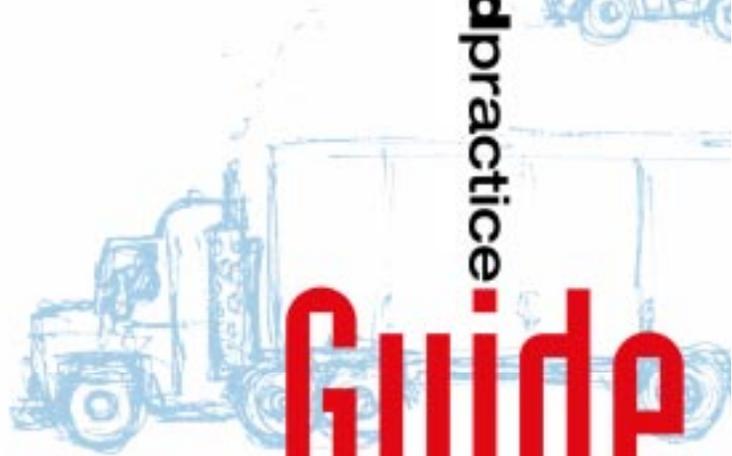
Sustainable Management Fund

good practice

Guide

for preparing

**emission
inventories**



The Ministry for the Environment does not endorse or support the content of the publication in any way

© The Crown (acting through the Minister for the Environment), 2001.

Prepared by Emily Wilton
Environet Ltd
11 Lachie Griffin Rise
Governors Bay
Banks Peninsula
Ph - 021 296 8900
Email - Environet@inet.net.nz

Acknowledgements

This guide was funded by the Minister for the Environment's Sustainable Management Fund, which is administered by the Ministry for the Environment.

Environet would like to thank the following people for their contribution: Phillip Millichamp (Sinclair Knight Mertz), Caroline Austwick (MfE), Sarah McDermott (MfE), Ian Moncrief (Fuel and Energy Group), Leif Piggot (Environment Waikato), Perry Davy (Wellington Regional Council), Prue Harwood (Otago Regional Council), Bob Ayrey (Environment Canterbury) and Gary Bedford (Taranaki Regional Council).

Contents

1	Introduction	1
1.1	About this manual.....	1
1.2	Air quality management in New Zealand.....	2
1.2.1	<i>Key air quality indicators.....</i>	<i>2</i>
1.2.2	<i>Air quality guidelines in New Zealand</i>	<i>3</i>
1.2.3	<i>Air quality monitoring.....</i>	<i>3</i>
1.2.4	<i>Emission inventories and source studies</i>	<i>4</i>
1.2.5	<i>Atmospheric dispersion modelling</i>	<i>4</i>
1.2.6	<i>Integrating emission inventory data with other tools to manage air quality.....</i>	<i>5</i>
1.3	Why prepare an emission inventory?.....	8
2	Managing an emission inventory project.....	11
2.1	Contracting the project.....	11
2.2	Conducting the inventory in-house.....	13
3	Emission inventory design.....	15
3.1	Identify key issues	15
3.2	Identify contaminants to be included.....	17
3.3	Identify sources to be included	18
3.4	Define the area to be included	20
3.5	Spatial distribution	22
3.6	Temporal distribution	23
4	Data Collection	25
4.1	Domestic Heating	25
4.1.1	<i>Survey method.....</i>	<i>26</i>
4.1.2	<i>Design the survey questionnaire.....</i>	<i>26</i>
4.1.3	<i>Design the sampling regime</i>	<i>27</i>
4.1.4	<i>Train the interviewers.....</i>	<i>28</i>
4.1.5	<i>Conduct the survey</i>	<i>28</i>
4.1.6	<i>Analyse and present results</i>	<i>28</i>
4.2	Industrial sources	29
4.3	Motor vehicle emissions	32
4.4	Other sources.....	34
5	Obtaining emission data.....	36
6	Calculating emissions	39
7	Assessing the uncertainty.....	41

7.1	Ignoring the uncertainty	41
7.2	Qualitative acknowledgement of the uncertainty	42
7.3	Certainty rankings.....	42
7.4	Quantifying the uncertainties for individual components	43
7.5	Combining the uncertainties	43
8	Quality assurance	45
9	Back-casting for previous emission inventories.....	48
9.1	Identifying differences.....	48
9.2	Re-evaluating data	48
9.3	Presenting results.....	49
10	Presenting Data.....	51
10.1	Report format and content.....	52
10.2	Report presentation.....	53
10.3	Communicating emission inventory data to the public	53
11	Apply to air quality management.....	54
	References	56
	Appendices.....	57
	Appendix one: Example domestic heating questionnaire.....	57
	Appendix two: Example industrial use questionnaire	61
	Appendix three: Example tender document.....	66
	Appendix four: Example fact sheet.....	69

List of figures

Figure 1.1: Emission inventories can show the contributing sources of emissions of a particular contaminant, in this case PM ₁₀	9
Figure 1.2: Emission inventories can show the breakdown of contributing sources within a major source group e.g., domestic burning or industrial practices	9
Figure 1.3: Emission inventories can be used in conjunction with meteorological data to assess priorities for air quality monitoring.....	10
Figure 1.4: Changes in annual NO ₂ emissions Lower Fraser Valley, British Columbia .	10
Figure 2.1 Ghant Chart illustrating task scheduling for an emission inventory	14

List of tables

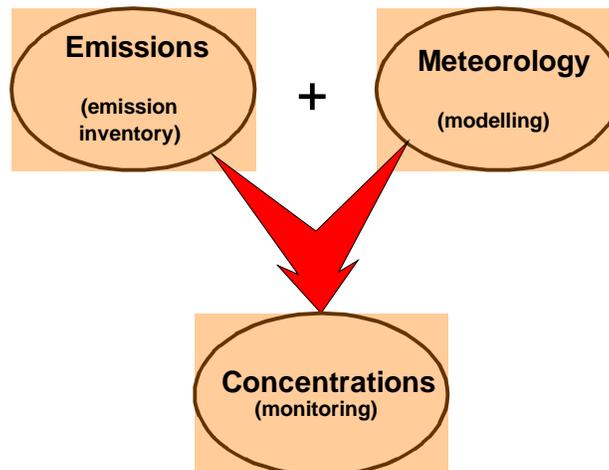
Table 1.1 EPI Air Quality Categories.....	2
Table 1.2: Draft proposals for revised ambient air quality guidelines and EPI categories	3
Table 3.1: Summary of air quality issues.....	16
Table 3.2: Summary of major sources in New Zealand.....	18
Table 3.3: Additional sources of emissions	19
Table 3.4: Options for spatial resolution of study area.....	23
Table 4.1: Volume capacity ratios for different level of service categories.....	33
Table 4.2: Potential sources of activity data	34
Table 8.1: Types of data that may be able to be used to validate inventory inputs	47
Table 9.1: Summary data of back-cast changes (from Levelton, 1998)	49
Table 9.2: Comparison of original to back-cast (adapted from Levelton, 1998)	50
Table 9.3: Options for presenting emission inventory results	52
Table 10.1: Structure and content of an emission inventory	52

1 Introduction

1.1 About this manual

This report is a step by step guide to preparing emission inventories in New Zealand. It contains information on the purpose, process, methodology and application of emission inventory investigations in New Zealand. It aims to help those commissioning and participating in emission inventories to produce quality documents with useable information.

The main objective of an emission inventory is to assess sources of discharges to air. Thus emission inventories are an important component of most air quality management strategies. Other key components of an air quality management strategy include monitoring, establishing air quality targets, assessing the impacts of meteorology (modelling), assessing management measures and cost/ benefit analyses. There are strong linkages between the disciplines of monitoring, modelling and emission inventories.



Similarly, emission inventories play a significant role in the development of an air quality strategy, generally forming the basis of the assessment of the effectiveness of management measures. This manual details these linkages and relationships giving an overall perspective of the application of an emission inventory as an air quality management tool.

Outputs from this project complement other work commissioned by the Ministry for the Environment, to assist in air quality management in New Zealand. In particular, the Good Practice Guide for Monitoring and Data Management (MfE, 2000) describes methods for collecting and managing air quality monitoring data. Reports on air quality indicators (MfE, 1998) and draft national guidelines (MfE, 2000) are also available. The application of these guidelines and indicators to air quality management in New Zealand is also detailed in this report.

Other components of this Sustainable Management Fund (SMF) project include a review of New Zealand inventories; an emission factor database that can be used to source emission factors and a software programme for conducting an emission inventory. These resources are available from the project sponsor, Environment Waikato.

This guide uses the “task schedule” system to outline the process for preparing an emission inventory. The schedules and subsequent flowcharts illustrate the key tasks, their relative ordering and the steps and decisions required to achieve each task. Additional material that could be used to assist in preparing inventories and other sources of emission inventory guidance material are included in the references. In particular, a number of guidance documents have been prepared by the USEPA and these can be accessed through the EPA’s CHIEF web site at <http://www.epa.gov/ttn/chief/>.

1.2 Air quality management in New Zealand

Since the introduction of the Resource Management Act (RMA) in 1991, air quality management in New Zealand has been the responsibility of Regional Councils and Unitary Authorities.

The purpose of the RMA as is stated in section 5 of the Act and, as it relates to air, is as follows:

1. To promote the sustainable management of air;
2. “Sustainable management” means managing the use, development, and protection of air in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural well being and for their health and safety while:
 - a) sustaining the potential of air to meet the reasonably foreseeable needs of the future generations; and
 - b) safeguarding the life-supporting capacity of air; and
 - c) avoiding, remedying, or mitigating any adverse effects of the discharge of contaminants to the air on the environment.

Furthermore, sections 35 and 30 of the RMA specifically require councils and unitary authorities to monitor and manage air quality. Guidance on the use of different tools to measure and manage air quality is provided in a number of documents prepared by the Ministry for the Environment. In particular, the Ministry’s draft *Good Practice Guide for Ambient Air Quality Monitoring and Data Management* and draft *Proposals for Revised and New Ambient Air Quality Guidelines for New Zealand* are key tools that can be integrated with emission inventory data to manage air quality.

1.2.1 Key air quality indicators

The *Environmental Indicators for Fresh Water, Air and Land*, prepared by the Ministry for the Environment in 1998 as a part of the Environmental Performance Indicators (EPI) programme, identifies the following indicators for air quality:

- Class one indicators: carbon monoxide (CO), suspended particulate (PM₁₀), nitrogen dioxide (NO₂), sulphur dioxide (SO₂) and ozone (O₃).
- Class two indicators: visibility.

The EPI programme also identifies the categories for reporting these indicators. These are detailed in table 1.1.

Table 1.1 EPI Air Quality Categories

Category	Measured Value
Action	Exceeds the guideline
Alert	Between 66% and 100% of the guideline
Acceptable	Between 33% and 66% of the guideline
Good	Between 10% and 33% of the guideline
Excellent	Less than 10% of the guideline

1.2.2 Air quality guidelines in New Zealand

In 1994, the Ministry for the Environment released national air quality guidelines for what were then referred to as the “common air contaminants”. These contaminants included suspended particulate (PM₁₀), carbon monoxide (CO), sulphur dioxide (SO₂), nitrogen dioxide (NO₂), ozone (O₃), lead (Pb), fluoride (F) and hydrogen sulphide (H₂S). The Ministry is presently reviewing these guidelines and a draft document *Proposals for Revised and New Ambient Air Quality Guidelines for New Zealand* has been prepared. In addition to revising the guideline values, guidance is given in that report on how the guidelines should be applied to both ambient air quality monitoring and to the processing of resource consent applications.

The EPI air quality categories have been integrated into the draft guideline document and recommendations made regarding the use of these categories for air quality management. These recognise that regional councils and unitary authorities may wish to develop their own region-specific objectives, based on community aspirations, and provide a consistent framework for setting such objectives. The recommendations include:

- maintaining air quality within the “acceptable” category in locations where the air quality is generally recognised as being clean
- aiming to maintain air quality at measured levels where measured concentrations are in the alert category
- that councils and unitary authorities adopt regional criteria for specific contaminants based on air quality monitoring data where air quality is within the alert category
- that management measures be implemented to reduce concentrations of contaminants to at least the guideline level in locations where air quality falls within the action category

The contaminants and guidelines proposed in the Ministry’s draft *Proposals for Revised and New Ambient Air Quality Guidelines for New Zealand* and the relative values for each EPI category are detailed in table 1.2.

Table 1.2: Draft proposals for revised ambient air quality guidelines and EPI categories

	Action >100%	Alert 66% -100%	Acceptable 33% - 66%	Good 10% - 33%	Excellent <10%
	Averaging Period	Guideline	66% of Guideline	33% of Guideline	10% of Guideline
PM₁₀	24 hour	50 µgm ⁻³	33 µgm ⁻³	17 µgm ⁻³	
SO₂	1 hour	350 µgm ⁻³	230 µgm ⁻³	115 µgm ⁻³	35 µgm ⁻³
SO₂	24 hour	120 µgm ⁻³	80 µgm ⁻³	40 µgm ⁻³	12 µgm ⁻³
CO	1 hour	30 mgm ⁻³	20 mgm ⁻³	10 mgm ⁻³	3 mgm ⁻³
CO	8 hour	10 mgm ⁻³	7 mgm ⁻³	3 mgm ⁻³	1 mgm ⁻³
NO₂	1 hour	200 µgm ⁻³	132 µgm ⁻³	66 µgm ⁻³	20 µgm ⁻³
NO₂	24 hour	100 ug/m ³	66 ug/m ³	33 ug/m ³	10 µgm ⁻³
O₃	1 hour	150 µgm ⁻³	100 µgm ⁻³	50 µgm ⁻³	15 µgm ⁻³
O₃	8 hour	100 µgm ⁻³	66 µgm ⁻³	33 µgm ⁻³	10 µgm ⁻³

1.2.3 Air quality monitoring

Air quality monitoring is an integral component of managing air quality as the need for management intervention should stem from data on concentrations of contaminants. These

monitoring data can be compared to guideline values and EPI categories (described above) to determine the need for measures to reduce contaminant concentrations. In addition to comparing values to guidelines alone, trends in concentrations and emission sources can provide an indication of the potential for future problems.

Air quality monitoring programmes implemented by regional councils and unitary authorities in New Zealand range from extensive telemetered monitoring networks to short term investigations into concentrations of one or two contaminants. Both types of programmes provide useful data for air quality management. Guidance on how to conduct air quality monitoring including different types of air quality monitoring sites is presented in the Ministry for the Environment publication *Good Practice Guide for Ambient Air Quality Monitoring and Data Management*.

1.2.4 Emission inventories and source studies

Emission inventories can be used to identify sources of emissions and to assist in the assessment of options for managing air quality. They provide an estimate of the quantity of a contaminant emitted by a particular source and the combined emissions from all sources. Other types of source studies include elemental analysis of suspended particulate and subsequent identification of sources using principal component analysis or chemical mass balance techniques. While potentially more robust than an emission inventory, this method requires the collection and analysis of many samples and is limited to assessing contributors to particulate as well as being limited to assessing contributions at a specific location.

The basic methodology of an emission inventory is use of an average emission rate for each activity, based on the quantity of material used e.g., fuel burnt, paint consumed. For some activities actual source data are used e.g., some industrial activities measure stack emissions. However, generally data are based on average test data, obtained typically from overseas sources, often derived from limited testing and not necessarily suited to New Zealand conditions. Thus the uncertainty associated with emission factor data could be more than five times the emission factor used for some processes.

Other potential sources of uncertainty include assessing the level of activity resulting in the discharge. In this regard it is important to note that emission inventories represent an estimate of the average emissions for a particular time period and are not necessarily indicative of actual emissions for a given day. For example, actual motor vehicle emissions are likely to be higher than emission inventory estimates on special occasions that result in larger than normal motor vehicle use e.g., events such as Christmas in the Park.

Clearly there are uncertainties associated with using emission inventory methodologies to assess sources of air pollution. It is important therefore, that in preparing emission inventories that uncertainties are reduced so that the resulting inventory can be used as an effective air quality management tool.

1.2.5 Atmospheric dispersion modelling

Atmospheric dispersion modelling is used to assess variations in concentrations of contaminants across a study area. This is done by assessing the impact of meteorology and topography on emissions of contaminants and thus requires detailed meteorological data across the study area. Detailed emission inventory data is also a necessary input parameter for atmospheric dispersion modelling.

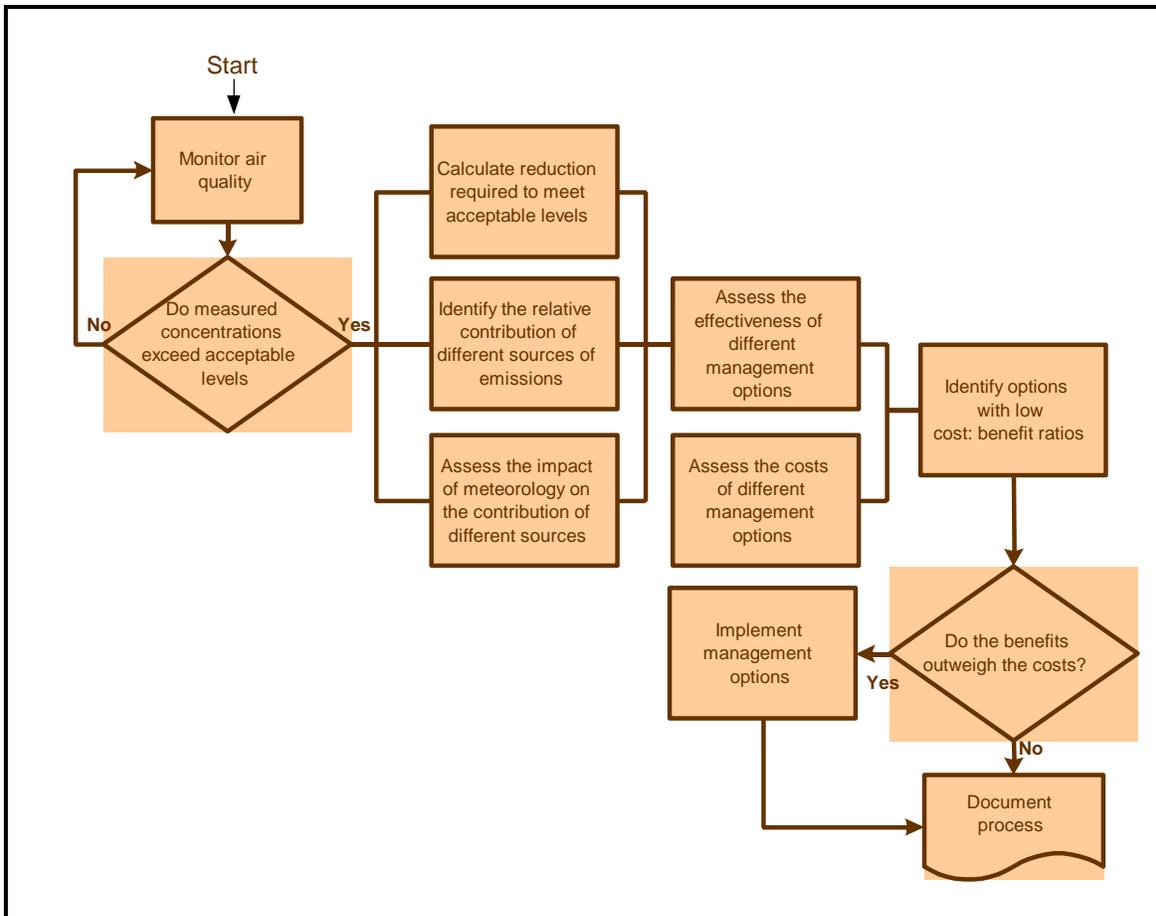
Atmospheric dispersion modelling has a number of uses as an air quality management tool. These include:

- assessing the extent of an air-shed or the area to which management intervention should be applied
- assessing the impact of variations in emissions on concentrations of a contaminant e.g., as a results of air quality management strategies
- estimating concentrations of contaminants in locations where monitoring is not conducted

The latter purpose, to estimate concentrations in areas where monitoring is not conducted, has many uses from an air quality management perspective. It provides an indication as to the suitability of monitoring sites and the extent to which concentrations measured at existing sites are typical of the area of interest. It can also be used in assessing the exposure of a population to ambient air concentrations of contaminants and could be used as an input parameter to health studies.

1.2.6 Integrating emission inventory data with other tools to manage air quality

In the absence of other air quality management tools, an emission inventory can provide an indication of pressures on the air environment and the maintenance of existing air quality. In conjunction with other tools, however, an emission inventory can be used to identify the sources of an air quality problem and can assist in the identification of management options to resolve the problem. This involves integration of the inventory data with other air quality tools such as monitoring data, meteorology, air quality targets and guidelines as well as other tools such as cost/effectiveness assessments. The use of an emission inventory in managing air quality, and the integration with other methods, is illustrated in the following flowchart:



Details of how to monitor air quality are outlined in the Ministry for the Environment publication *Good Practice Guide for Monitoring and Data Management* (MfE, 2000). Air quality monitoring can be used in conjunction with guideline data to assess the impact of emissions on the environment. Management intervention is likely if monitored concentrations exceed acceptable levels. However, the definition of acceptable could vary in different areas depending on community aspirations. Acceptable levels could refer to national guidelines (MfE, 1994) or draft guidelines (MfE, 2000) or a region or area specific value as discussed in section 1.2.2. These data should be defined by the value (acceptable level), the averaging period and the frequency with which it can be exceeded. For example, a Council might set an acceptable level for PM₁₀ of 50 µgm⁻³, 24-hour average, which is allowed to be exceeded no more than once per year.

The reduction required to meet the acceptable level can be calculated using the following formula:

$$\text{Reduction required} = \frac{C - \text{target}}{C}$$

The value of C depends on the distribution of data and the number of occasions per year when the guideline can be breached. For the example used above, which allowed a 24-hour average guideline for PM₁₀ of 50 µgm⁻³ to be breached on one occasion per year, the value for C would be the 99.7 percentile concentration. This is because one day per year represents 1/365 or

approximately 0.3%. To calculate the percentile value required, divide the number of allowable exceedences by the total number possible.

For air quality issues relating to ambient air quality, an emission inventory could be used to estimate the contribution of different sources to emissions of the contaminant of concern. If guideline values were exceeded at a peak (as opposed to ambient) air quality monitoring site, other tools may be more appropriate. For example, it may be more appropriate to use atmospheric dispersion modelling of a selection of major point source discharges to determine the most effective management strategies at a peak industrial monitoring site.

If an emission inventory has been used to assess sources of emissions, consideration of the impact of meteorology is required. This is because concentrations of contaminants in the air depend on both the emissions and the effect of meteorology. In selecting management measures to reduce concentrations, the effect of meteorology should be considered. Detailed modelling of the impacts of meteorology on emissions of contaminants is a major task, which requires comprehensive meteorological data. Other options include a simplified box-model assessment or a qualitative assessment of the impact of meteorology on emissions. However, these methods would not be suitable in many locations.

Before management options can be implemented the area to be managed needs to be identified. Options for assessing the area to which management intervention will be applied include:

- using the emission inventory area
- using some existing definition of urban area e.g., zoning or TLA boundary
- conducting a detailed meteorological assessment of the area contributing to the problem

Factors to consider include justifying the selection of the areas to be included and excluded as well as the practicality of applying any rules to different areas.

The effectiveness of different options in resolving the problem will depend on a number of factors, including projections in activity data and emission factors. Projections in activity data include changes in VKT, industry and domestic heating appliance numbers with time. Projections in VKT data are integrated into most road network models and are based on data relating to predicted changes within the study area such as population and layout of households. Projections in industry and domestic heating patterns are not so easy to quantify. Factors influencing home heating include the cost of heating, household numbers and types, lifestyle factors and values and perceptions of those making heating choices. Predicting the impact of these components on the changes in the number of solid fuel burners with time is therefore, very difficult. Moreover, the extent to which different factors may influence home heating choices may vary from location to location. Assessing the effectiveness of different management options requires an assessment of:

- changes in emissions with time, without management intervention (status quo)
- the net reduction in emissions associated with proposed measures
- any potential side-effects of proposed measures that might influence emissions e.g., increases in other emissions
- an assessment of the impact that reducing emissions will have on concentrations

Calculating the net reduction in emissions associated with different management options can be done within the emission inventory framework for most types of management measures. However, it is recommended that separate spreadsheets or models be used for these assessments. Management measures based on road network management can be assessed using the

Environmental Capacity Analysis (ECA) tools developed by the Ministry of Transport for the Vehicle Fleet Emission Control Strategy (VFECS). Other transport related measures could be assessed by manipulating variables within the NZTER emissions model.

Management options for domestic heating can be assessed using a simple spreadsheet incorporating emission factors, household numbers, fuel use and projected home heating methods. For example, if the management option were to prohibit the use of open fires, the reduction in emissions would be calculated by reducing the number of households using open fires to zero (if you want to assume 100% compliance). It should be noted, however, that a proportion of households that were previously using open fires would be likely to convert to another form of solid fuel heating, and therefore increases in other solid fuel methods would be required.

Assessing the costs associated with different management options includes identifying all costs associated with the measure and involves techniques such as discounting. It is recommended that an economist be involved in the process of establishing the costs associated with management options.

The cost-effectiveness of different options is assessed by comparing the costs to the benefits. For the purpose of assessing the relative effectiveness of different options, the benefits can be expressed as the reduction of the contaminant concentrations compared to the status quo option. Management measures can be ranked in order of most, to least effective, and decisions can be made regarding the implementation of measures.

1.3 Why prepare an emission inventory?

An emission inventory is an estimate of the quantity of emissions discharged to air for a given area. It can include a variety of contaminants and should include estimates from all major sources of those contaminants. An inventory of emissions can be prepared for a range of areas from a single industrial site with multiple discharge sources, to an assessment of urban, regional or national emissions. The focus of this report is on urban emission inventories. However, techniques described could be used to assess emissions for larger or smaller geographical areas. Emission inventories are a useful air quality management tool both in locations with and without known ambient air quality problems.

In locations where air quality is a problem, emission inventories can be used to identify the main contributors to emissions of a contaminant concern (figure 1.1) and can identify key contributors within major sources (figure 1.2). Thus an inventory can be a powerful tool for identifying the specific sources that could be targeted if a reduction in emissions is required and can be used to identify trends in those sources with time.

Note:

An emission inventory is an assessment of the quantity of contaminants discharged to air and provides no indication of the impact of these contaminants on the environment.

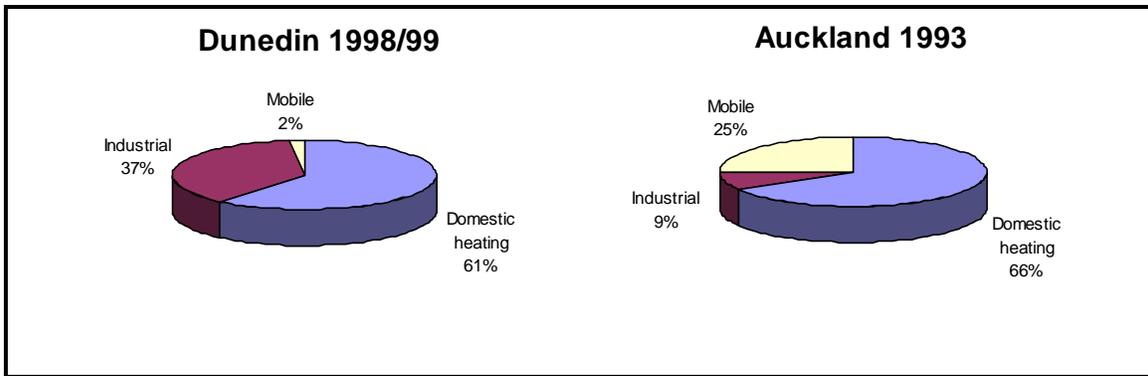


Figure 1.1: Emission inventories can show the contributing sources of emissions of a particular contaminant, in this case PM₁₀

Even in locations where poor ambient air quality isn't believed to be a major concern, emission inventories have many uses. These include:

- assessing priorities for air quality monitoring (figure 1.3)
- indicating the state of the environment
- determining any major sources of emissions of which the regulatory authorities are unaware
- assessing relative contributions to emissions to assist processing of industrial resource consent applications
- indicating potential trends, such as growth in transport emissions (figure 1.4)
- identifying potential policy and regulatory options

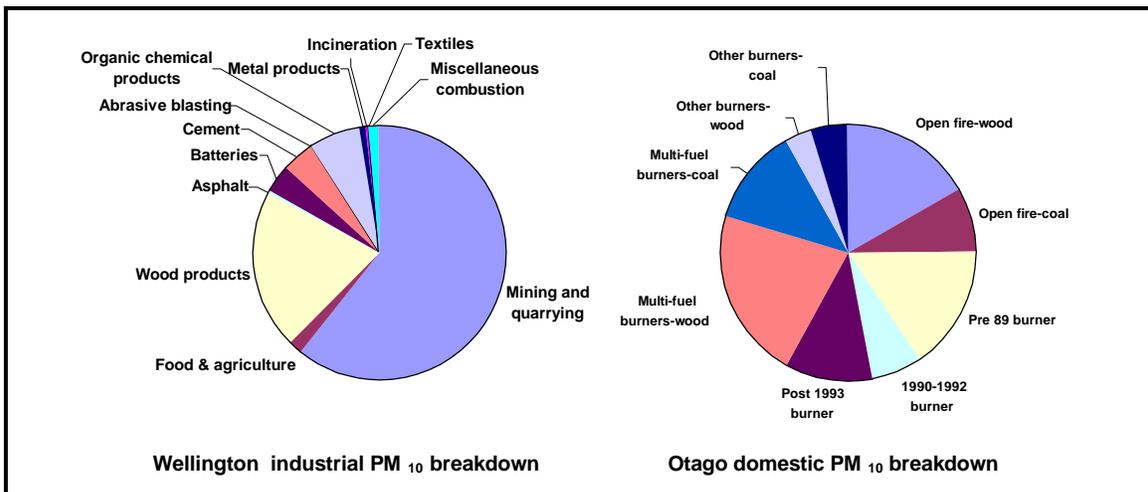


Figure 1.2: Emission inventories can show the breakdown of contributing sources within a major source group e.g., domestic burning or industrial practices

In such locations, detailed inventory data may not be required and a less comprehensive approach to emissions assessment may be appropriate. Thus a screening level approach to an emission inventory can be used in some locations. A screening approach is a simple version of an emission inventory that uses largely existing data e.g., census data on home heating fuels, and is presented as annual emissions, often collated for whole regions or large subsets of regions.

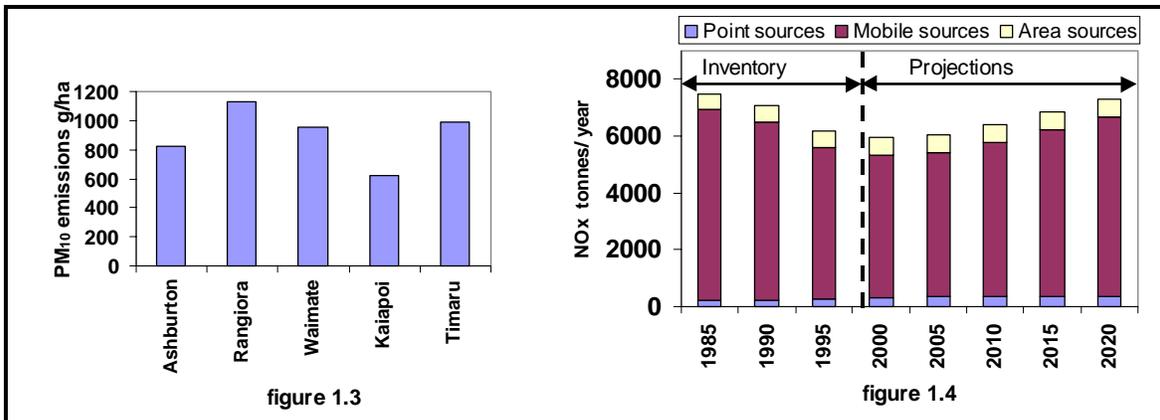


Figure 1.3: Emission inventories can be used in conjunction with meteorological data to assess priorities for air quality monitoring

Figure 1.4: Changes in annual NO₂ emissions Lower Fraser Valley, British Columbia

Case study – preparing an emission inventory in an area without major air quality problems - Taranaki

Air quality in Taranaki is not a major concern for the region. Some air quality monitoring has been conducted for most of the air quality indicators and no exceedences of ambient air quality guidelines have been recorded. Natural emissions such as sea-spray and agricultural activities may at times result in amenity issues and there is some concern at the use of domestic backyard incinerators. However, generally air quality in the region is considered to be excellent.

In 1998 the Taranaki Regional Council commissioned NIWA to conduct an emission inventory for the Taranaki region. The purpose of the inventory was:

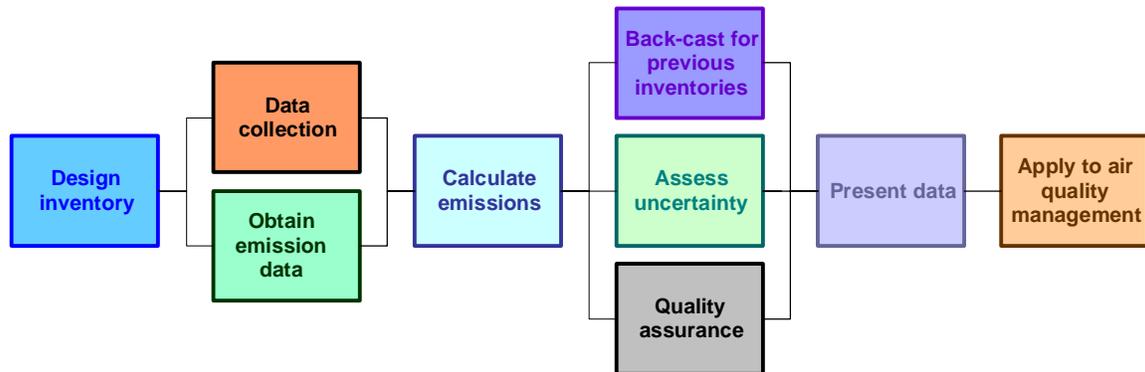
- to provide an overview of major sources of air discharges in the region
- to provide an independent objective assessment of emissions
- to determine if there were any major sources that they had not accounted for
- an objective basis for the further development of air quality management strategies

Because detailed data were not required, a screening approach to the inventory was taken. The region was divided into four areas. These were New Plymouth & Bell Block Urban Area (the main urban areas of the region), Mt Egmont National Park ('pristine'), Eastern Hill Country (main land uses drystock, reverting scrub and bush) and the remaining pastoral land. Sources examined included industrial combustion, motor vehicles, home heating, vegetation/ land and farm animals. The four key ambient air contaminants of interest were identified as PM₁₀, CO, NO_x and VOCs. Additional data were collected for subsets of these e.g., PM_{2.5}, PAHs, NMHC, CH₄. Data are presented as annual emission estimates.

Overall the inventory provides a useful tool both in establishing a baseline of emissions for comparison for future estimates and in identifying the relative contribution of different sources to emissions of contaminants. Key findings were that for most classes of contaminants, emissions from natural sources were much greater than from anthropogenic sources, and that transport, and home heating sources were more significant than industry. These data can be used in the development of air quality monitoring strategies if required and provide useful information on the areas within the region that are more susceptible to air quality problems.

2 Managing an emission inventory project

The process of preparing an emission inventory is illustrated below as a task schedule. This breaks the process down into nine key components and indicates the relative order in which the tasks should be conducted. Tasks listed in parallel can be carried out simultaneously. For example, the collection of data and the obtaining of emission factors could be carried out at the same time. However, both must be completed before the calculation of emissions can begin.



Councils in New Zealand have taken a number of different approaches to conducting emission inventories, including:

- contracting the work out to a consultant
- conducting the work internally
- managing the project internally but contracting out specific components to a specialist

Other options include commissioning a consultant to conduct a scoping study prior to conducting an inventory and employing a professional project manager to manage the contract. With the exception of the latter option, project management by the Council responsible for the emission inventory is required.

This guide aims to provide sufficient detail to assist with both the preparation of an emission inventory in-house and to assist with the management of an emission inventory project if much of the work is being contracted to an external agency.

2.1 Contracting the project

Contracting out the emission inventory is an attractive option if you have limited staff time available. However, this option will still require in-house resources. In addition to the standard project management requirements, it is likely that there will be additional expectations for your time. These depend on the way the project is contracted. Some options include:

- select consultants before designing the project and involve the consultants in the design phase
- invite expressions of interest prior to a full tender to ensure tenders are limited to qualified consultants
- commission preliminary work for scoping or designing the study
- employ an independent project manager
- commission a technical review of tenders

A common approach is to conduct the project management in-house but to contract out other aspects. The project management requirements may vary between Councils but will generally include:

- project initialisation
- preparing to contract the work out e.g., tender document
- selecting a consultant
- preparing a contract
- reviewing deliverables
- authorising payments

Project initialisation means defining the scope of the project in terms of expected outputs, time, resources, budget and goals, and determining the feasibility of the project with respect to each of these e.g., is it realistic to expect the project goals to be met by the proposed budget?

Preparing to contract the work out e.g., a tender document, is one of the major project management tasks under this regime. Tender documents will vary depending on project expectations. Some design aspects of the inventory may need to be established in the initialisation phase, prior to releasing the tender document. For example, the cost and work content of the inventory will vary significantly depending on the spatial resolution required. An example of a tender document for conducting a basic emission inventory is illustrated in appendix three. This includes an example of selection criteria for assessing tenders that gives a greater weighting to experience and methodology than to cost when selecting a successful tenderer. The reasons for tenders that are priced more competitively should be assessed to ensure that they are not understating the work involved. Another option to assist in obtaining a quality product is to specifically invite tenders from suitable personnel.

In addition to these project management components it is important that relevant staff are involved in a number of key inventory design tasks. These include identifying the key air quality issues, selecting the study area and spatial resolution, assessing the sources to be included and determining an appropriate temporal resolution. The purpose of this involvement is to enhance the investigation with local expertise and knowledge.

Other tasks that you may be expected to be involved in include:

- identifying industrial processes within the study area
- extracting information relating to industrial discharges from consent files
- obtaining vehicle kilometer travelled (VKT) data from a road transport model
- classification of land use for biogenic emissions assessment
- peer review and proofing of the report

The benefit of being involved in these latter tasks include cost savings and the accessibility of internal systems – for example, GIS for identifying industries and land use classifications within the study area, and transport models and modellers for the extraction of vehicle data information.

The depth of involvement in any of these tasks should be made clear prior to establishing the contract and the release of tender documents. This allows for an even playing field when assessing tenders and ensures best value for money.

This guide recommends that you:

Require that tender briefs specify which tasks Council staff will assist with and the degree of assistance that will be provided.

Give greater weighting to experience when selecting a consultant to conduct the emission inventory.

Require consultants to outline any additional or conflicting assumptions regarding Council input.

Negotiate any differences prior to establishing a contract.

2.2 Conducting the inventory in-house

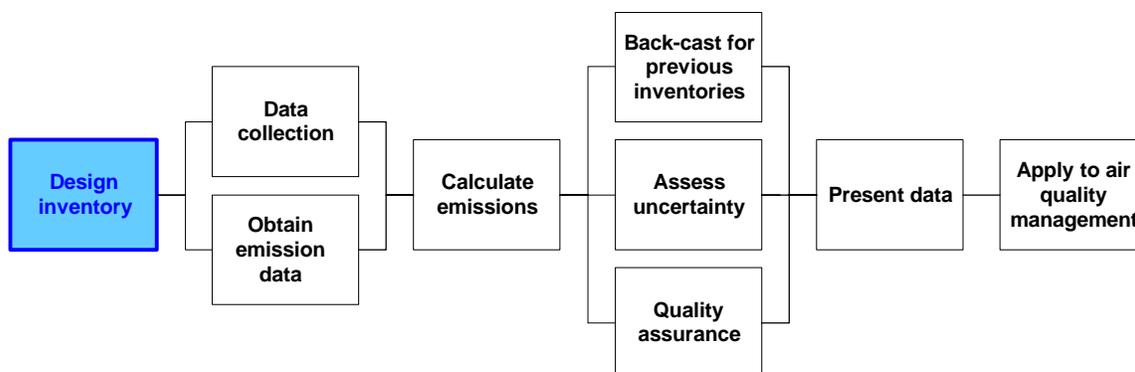
A primary focus of this document is to provide a guide for those giving consideration to carrying out an emission inventory in-house. In addition to providing a hands on familiarity with inventory data for future application, it also provides for greater co-ordination of the outputs throughout the process. Components of the project can still be contracted out, particularly if specialist expertise is required.

Under this regime project management includes project initialisation, planning, implementation, controlling and closing the project:

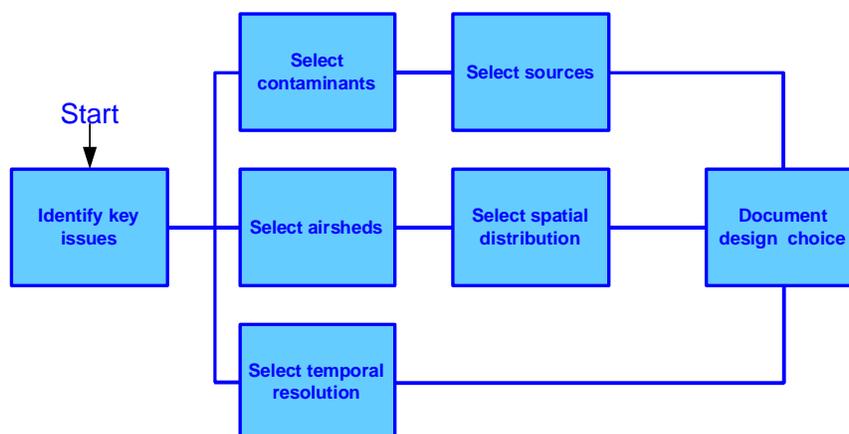
The **initialisation** process requires the same tasks as the contract management scenario i.e., defining the scope of the project in terms of time, resources, budget and goals and assessing the feasibility of the project. The time required to conduct an emission inventory will vary depending on the resources available, the size of the study area, and the proposed project outputs. These may be estimated initially and refined during the **project-planning phase**. The project-planning phase involves task identification and scheduling, and refining time and cost estimates.

Figure 2.1 illustrates how the tasks identified for the emission inventory process can be scheduled. It provides an indication of the relative time associated with each task for a typical emission inventory, shortened for ease of presentation. Actual times will depend on the scale of the inventory, the experience of the personnel, and the availability of data. This could be more than three times the duration illustrated in figure 2.1. For a smaller urban area (e.g., population less than 50,000) a timeframe of approximately two times that indicated in figure 2.1 could be expected. Another factor that will influence the duration of the project when conducted in-house will be other demands on the project team's time.

3 Emission inventory design



The first major task in preparing an emission inventory is the design phase. This comprises a number of subtasks, identified below in preferred order of achievement, and detailed in sections 3.1 to 3.6 of this chapter.



Documentation procedure – the recording of major decisions and key points for later inclusion in the emission inventory report – should be conducted in accordance with quality assurance procedures detailed in chapter eight.

Note: this order may be reversed for some components e.g., the spatial distribution may be selected prior to identifying the exact air-shed if a large area is to be covered and the need for fine resolution is identified from the outset. However, in most instances, particularly for smaller towns, air-shed selection should occur first.

3.1 Identify key issues

An emission inventory is a useful air quality management tool in both locations with and without existing air quality issues. Identifying key air quality issues in locations where problems exist has four main benefits:

- assessing the scope and objectives of an emission inventory
- identifying the sources that should be included
- presenting the report in a meaningful context
- identifying contaminants to be included

Key air quality issues and potential issues in most areas of New Zealand are generally well recognised. Table 3.1 identifies a number of air quality issues, key indicators and common sources. As indicated in the table an emission inventory is not the most appropriate method for investigating all of these issues. For example, if the only air quality issues for a particular location were spraydrift and odour, then a detailed emission inventory is unlikely to be a useful tool in resolving these issues. An emission inventory is also unlikely to be of use if the problem is known to arise from a specific source e.g., hydrogen sulphide concentrations in Rotorua, or fluoride emissions from a single industrial source.

Table 3.1: Summary of air quality issues

Common air quality issues	Typical locations where it's an issue	Key indicators of the issue	Use of emission inventory as a management tool
PM ₁₀ or PM _{2.5}	Mostly urban/ industrial	Monitoring, observations	➤
SO ₂ , NO ₂ , CO	Urban/ industrial	Monitoring	➤
Odour	Urban/ rural/ industrial	Complaints, observations, survey	x
Dust	Rural/ urban/ industrial	Complaints, observations, survey	Possibly depending on circumstances
Visibility	Urban/ coastal/ forestry	Survey, observations, monitoring	x Some limited use e.g., modeling of photochemical pollution
Tropospheric ozone	Urban/ near to urban areas	Monitoring, observations of photochemical haze	➤ In conjunction with modelling
Greenhouse gases	Global	National directive, regional directive e.g., RPS	➤
Hazardous air pollutants	Urban/ industrial	Monitoring	➤
Hydrogen sulphide	Geothermal - dependent on geography	Monitoring, complaints, observations	x
Fluoride	Industrial	Observations, monitoring	x
Spraydrift	Horticultural/ Agricultural	Complaints	x

Air quality issues relating to dust emissions are often a localised problem arising from one or two sources that can be identified based on observation. If the sources of the dust can not be identified by visual observation an emission inventory may be an appropriate tool. However, quantification of dust emissions from different source types is difficult and this could be a limiting factor in using an emission inventory approach.

Sources of visibility degradation can be assessed only to a very limited extent using an emission inventory. This is because factors such as particle size and composition, which are not assessed using an emission inventory, play a big role in visibility degradation. Moreover, secondary particles, relative humidity and temperature, all of which can impact on visibility, are not accounted for in emission inventories. However, an emission inventory can provide emissions data for input into a photochemical pollution model to simulate the construction and transport of photochemical pollution. Further details regarding visibility monitoring and management are contained in the Ministry for the Environment's *Visibility in New Zealand, Amenity Value, Monitoring, Management and Potential Indicators* report (MfE, 2000).

This guide recommends that you:

- Assess whether an emission inventory is an appropriate air quality management tool for the local air quality issues.
- Include an overview of air quality issues in the emission inventory report.
- Have regard to air quality issues and the inventory objectives and purpose when designing the inventory.

3.2 Identify contaminants to be included

The main limiting factor in the selection of contaminants to be included is the availability of emissions data. Provided emission factors or other emissions data are available a number of approaches to the selection of contaminants are possible:

- all encompassing – collect as much data as possible on all contaminants
- collect data for any local air quality issues plus data for key indicator contaminants¹
- collect data relevant to current and potential future air quality issues

An emission inventory would typically include emission estimates for suspended particulate (PM₁₀), carbon monoxide (CO), sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), and carbon dioxide (CO₂).

Other contaminants that could be included are hazardous air pollutants, additional greenhouse gases, such as N₂O and methane, and a breakdown of particulate into smaller size fractions e.g., PM_{2.5} or PM₁. Particulate size fraction data for the latter are limited to overseas studies and can be found on the USEPA AP-42 website: <http://www.epa.gov/ttn/chief/ap42.html>. In areas where secondary particles are likely to be a significant contributor the inventory should include the precursor emissions SO₂, NH₃, VOCs and NO_x. If the inventory data is to be used to assess photochemical pollution model the inventory should include VOCs, NO_x, PM_{2.5}, NH₃ and SO_x.

Hazardous air pollutants include a wide range of gaseous and particle bound contaminants. Hazardous air pollutants which may be an ambient air quality concern in New Zealand include benzene, polycyclic aromatic hydrocarbons (PAHs) and dioxins. An emission inventory could be designed to include a limited number of HAP, such as benzene, PAHs and dioxins, or a more comprehensive range such as those included in the Air Emission Inventory for the Port Phillips region (EPA, 1998) or the USEPA Great Lakes Regional Air Toxic Emission Inventory (USEPA, 1999).

¹ See Ministry for the Environment (1997) for description of air quality indicators.

This guide recommends that you:

Include emission estimates for PM₁₀, CO, SO_x, NO_x, VOCs, and CO₂.

Consider the inclusion of a selection of hazardous air pollutants and PM_{2.5}.

3.3 Identify sources to be included

The key air quality issues identified in section 3.1 may play some role in determining the sources and level of detail to be included in the inventory. For example, if particle concentration were identified as a key issue, a detailed assessment of home heating fuels and appliances would be necessary for most New Zealand locations. Moreover, inclusion of additional sources of particle emissions should be considered. Table 3.2 provides a summary of the common major sources for different air quality issues. The prevalence of domestic heating, motor vehicles and industry indicate that the inclusion of these sources should form the basis of any emission inventory. Additional sources that could be included if detailed examination of specific contaminants was required are contained in table 3.3.

Where adequate resources are available it is appropriate to investigate sources relevant to all issues, as priorities may change. A comprehensive assessment also provides greater opportunity for trend analysis of potential future issues.

Table 3.2: Summary of major sources in New Zealand

Air quality issue	Source focus
PM ₁₀ / PM _{2.5}	Main sources are typically domestic heating, industry, motor vehicles and outdoor burning. These should be examined in detail. However, the contribution of additional sources such as those listed in table 3.3 could be significant in some locations.
SO ₂	Main sources are typically diesel vehicles, coal combustion (collect data on coal name and source) and specific industries (e.g., manufacturing fertiliser).
NO ₂	Main source is typically motor vehicles. Gas power stations are also a potentially major source.
CO	Main source is typically motor vehicles although domestic heating may be a major contributor in some locations.
Tropospheric ozone	Ozone forms as a result of the reactions involving volatile organic compounds (VOCs) and nitrogen oxides (NO _x). The main sources of these contaminants are domestic heating, industry and transport. However, the contribution of additional sources such as those listed in table 3.3 could be significant in some locations.
Greenhouse gases	Include motor vehicles and agricultural activities e.g., methane from livestock, as well as large industrial processes such as power plants.
Hazardous air pollutants	Sources depend on the pollutant in question. Main sources typically include domestic heating, transport, industry, and open burning/ incineration.

Table 3.3: Additional sources of emissions

Additional combustion	Particles	Volatile organic compounds
<ul style="list-style-type: none"> – marine (commercial and pleasure craft) – aircraft – railway – off-road vehicles – lawn mowers – leaf blowers, weed eaters, chainsaws – outdoor burning (e.g., backyard burning, stubble burning, forest fires) 	<ul style="list-style-type: none"> – marine aerosol – dust from tilling – wind erosion of soils – wearing of tyres and brake linings – resuspended road dust – cigarette smoke – meat cooking – pesticide and fertiliser application – railway – coal shipping 	<ul style="list-style-type: none"> – service stations and bulk fuel users – storage tanks – bakeries – cutback asphalt – solvent evaporation from consumer products – dry cleaning – glues, adhesives and sealants – surface coatings – pesticides – printing inks – biogenic sources
<p>Nitrogen oxides</p> <ul style="list-style-type: none"> – fertiliser application – vegetation 	<p>Greenhouse gases</p> <ul style="list-style-type: none"> – livestock/ wildlife – landfills – wetlands 	

Identifying the additional sources to be included requires an assessment of which might make a reasonable contribution. Observing the contribution of that source to total emissions data for another area is a useful way of assessing whether a source might be worth including. For example, if cutback bitumen contributes only 0.1 tonnes per day of VOCs for the whole of Auckland, it is unlikely to be a notable contributor in other locations. Local knowledge of the relative prevalence of an activity is another factor that contributes to the assessment.

In selecting sources to be included in the inventory, a decision regarding the extent of inclusion of industrial discharges is required. Options for selecting industries include:

1. all activities requiring a resource consent for a discharge to air
2. all existing activities described as controlled, discretionary, or non-complying in the air plan
3. all processes defined as part A and B or part A, B and C under the Clean Air Act
4. all activities requiring a resource consent for a discharge to air, plus specific industries relevant to the local situation
5. all identifiable industrial discharges within the study area

The first two categories will vary in content across New Zealand as the definition of what requires consent or constitutes a particular activity type will be defined by each region's air plan.

For many areas, activities that require a resource consent may be all that need to be included in the inventory. Situations where additional sources may need to be added include:

- Situations where the discharge has been classified as a permitted activity but the sheer number of discharges result in a significant contribution to total emissions. Examples include

spray-painting and school boilers. In Christchurch the contribution of these sources to total VOC and PM₁₀ emissions from industry respectively is 72% and 5%.

- If a specific issue is identified as a major concern then inclusion of some “permitted activities” may be necessary. A good example with respect to industry is VOC emissions, as a number of contributing sources have not traditionally required resource consents. These include dry-cleaners, surface coating activities, bakeries and other activities detailed in table 2.3.
- In small towns and areas where industrial activity is limited, inclusion of the smaller scale industry, e.g., activities classified as part C processes under the Clean Air Act, is useful as these are likely to constitute a significant proportion of the industrial discharges in these situations.

For the purpose of presenting results it is necessary to categorise some sources together. The extent to which sources require categorising will depend on the number and types of sources included in the inventory. Common categories used include transport (motor vehicles, aircraft, off-road vehicles, rail and marine), industry (classified by the standard international classification (SIC) code), biogenic sources and area sources.

An area emission source is any of the stationary and non-road sources that are too small and/or too numerous to be counted as point sources (USEPA, 1994). One difference between the area sources and other sources is the magnitude of assumptions that are made regarding the spatial distribution of the area sources. Including domestic heating as an area source is not appropriate for most places in New Zealand because this source can be a major contributor to air emissions.

An alternative classification system for industrial discharge is by discharge type. It is likely that this categorisation system would provide more useful information for air quality management purposes. However, classification of industry by SIC code is the standard practice. This guide recommends that software used for calculating emissions allows for industrial emissions to be categorised both in terms of discharge type and SIC codes.

This guide recommends that you:

Select sources based on existing and potential air quality issues.

Include a minimum of industry, home heating and motor vehicle emissions.

Categorise sources for ease of presentation (e.g., motor vehicles, rail, aircraft, off-road vehicles and marine classified as transport).

Do not treat domestic heating as an area source unless it is unlikely to be a major contributor.

Classify industrial sources by both SIC codes and by discharge type in the software.

3.4 Define the area to be included

Selecting an appropriate boundary for an emission inventory will depend on the purpose of the inventory and its intended application. For example, if the purpose was to assess the potential for regional air quality issues then it would be important to consider all sources within the region, both rural and urban, and it is likely that the area to be included would be defined based on

territorial boundaries. If the purpose, however, was to determine sources of high PM_{10} concentrations observed in an urban township then the emission inventory area should have a more narrow focus. In this case the area included may reflect some definition of the urban area e.g., based on census area units, or residential zoning as per the district plan.

A major consideration in determining the area to be included is the local topography and meteorology. These characteristics help define an air-shed, which is the area within which emissions travel or reside. Characterisation of an air-shed is beyond the scope of an emission inventory investigation. However, it is necessary when designing the inventory to consider the air-shed concept and the extent to which emissions that occur outside of an urban area may or may not contribute to concentrations in the area being examined. Figure 2.1 illustrates the air-shed concept in a valley situation. In this illustration the air-shed is defined by the ridges of the hills and includes the slopes and the basin of the valley.

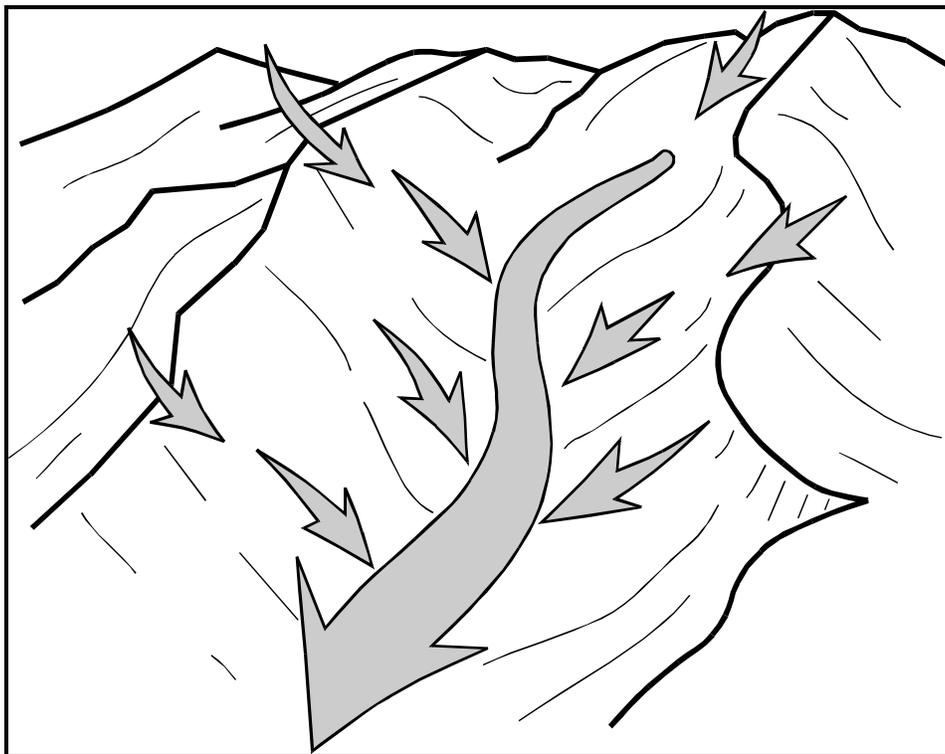


Figure 3.1: Illustration of air-shed concept (Sturman, 2000)

This guide recommends that in selecting the study area regard be had to:

Obvious air-sheds – valleys and hills.

Major wind directions, particularly at times of high pollution.

The potential for contribution of major sources outside of the urban area based on examination of the air-shed and wind directions.

The practicality of using the different types of area definitions.

Previous inventories and back-casting.

3.5 Spatial distribution

Once the boundary for the emission inventory is established, the need for further spatial distribution can be assessed. Selecting an appropriate spatial resolution for an inventory depends on a number of factors including size of the area, distribution of major sources, geography and meteorology and intended use of the inventory. A major limitation in determining the spatial resolution, however, will be the cost associated with collecting data. Options for spatial distribution include:

- entire study area (no additional spatial distribution)
- split based on separate air-sheds
- grid cells placed over entire study area
- spatial distribution based on census area units or mesh blocks

Urban areas with a population of less than 50,000 are unlikely to require further spatial breakdown unless emissions are spread across different air-sheds (in which case a spatial distribution based on separate air-sheds is a good option). If rural areas are included in the inventory, and the size of the air-shed is large, a rural/ urban split should be considered.

The grid cell approach is common when the inventory covers a large area, particularly if detailed atmospheric modelling of emissions is an intended application. The grid cell method involves breaking the study area up into adjacent cells of equal size and estimating emissions originating from the area within each cell.

The main limitation with the grid cell approach is obtaining reasonable data for each cell. This is problematic, particularly in locations where emissions from domestic heating are a major concern. This could include not only areas where PM_{10} / $PM_{2.5}$ concentrations are of concern, but also areas where photochemical smog is an issue during the winter months. This is because domestic heating can be a major source of volatile organic compounds (VOCs), which are precursors to photochemical smog. The preferred method for estimating emissions from domestic heating is a household survey (section 4.1). Thus the limitation is the number of households that would need to be sampled to give a reliable estimate of emissions from each grid cell. For example, the required sample size for a 3-km by 3-km grid cell containing 1700 households (assuming a 7% sample error at 95% CI) would be 160. Thus the overall required sample size for an area the size of urban Christchurch (approximately 100,000 households within 60 3-km² grids) would be 9600.

Alternative approaches to gathering data from domestic heating for input into the grid emission estimate include:

- a random survey across the whole study area and assuming an equal distribution or a distribution based on the spread of population
- estimating emissions for each grid cell based on census data relating to home heating methods

The first method is equivalent to having no spatial breakdown for this source. This is unrealistic, as emissions from domestic heating will vary across a city with changes in house age and style and with socio-economic and demographic characteristics. The second method has been limited by the types of home heating questions asked in the census. For example, the 1996 census included a question relating the type of fuel and combinations of fuels burnt, irrespective of the type of appliance used or frequency of use. This method also requires the subsequent allocation of emissions data from the census area units into the grid cells.

Another spatial distribution method common in New Zealand is distribution based on suburbs defined by combining census area units. This approach could be used in the larger urban areas that do not contain multiple air-sheds or where air-sheds can be characterised using suburb definitions. Suburbs generally encompass much larger areas than grid cells and can be selected to encourage similarities in factors such as the age of dwelling. For example, a suburb boundary that separates a relatively new housing area from an older area might be of interest. This approach provides some indication of the distribution of emissions, although not at an ideal resolution for input into atmospheric dispersion modelling.

Another consideration in determining the spatial distribution is ensuring some consistency with previous inventories for the same area. For example, a subsequent inventory may determine that a finer spatial resolution is required or that an additional area should be included. However, some definition of the study area or part thereof needs to remain the same as the previous inventory, if comparisons from one inventory to the next are to be made.

The method chosen to spatially refine emissions estimates will be location dependent.

Table 3.4: Options for spatial resolution of study area

	Suitable for:	Examples of NZ locations
1. Entire study area	Small towns – mostly one air-shed	Ashburton, Nelson, Reefton
2. Split based on separate air-sheds	More than one air-shed	Wellington, Dunedin
3. Grid cells placed over entire study area	Large area, data able to be collected at required resolution	Wellington, Auckland*
4. Spatial distribution based on census area units or mesh blocks	Large area, additional spatial distribution required	Christchurch

*Note: Most NZ cities would not fall into this category

3.6 Temporal distribution

Data could be represented for a number of different timeframes including hourly, 24-hourly, monthly, seasonally and annually. These all represent periods during which emissions may vary for a number of reasons. The temporal distribution for the inventory should be selected to complement the key air quality issues identified previously and the intended application of the inventory. For example, if 24-hour average PM₁₀ concentrations were the main concern, having emission data for a 24-hour period would be necessary.

Another factor to consider when selecting the temporal resolution, for example over a 24-hour period, is the variability in meteorological conditions that occur at different times of the day, and the subsequent effect on concentrations. Thus it might be appropriate to include further breakdowns within the 24-hour period to coincide with variances in meteorological conditions. An example of where this is appropriate is Christchurch, where temperature inversions restrict the

dispersion of pollutants during the evening and early morning periods. The temporal breakdown used for Christchurch was 6am-10am, 10am-4pm, 4pm-10pm and 10pm-6am.

It should be recognised, however, that as the temporal resolution gets smaller the degree of confidence in the result decreases. An emission inventory with a fine temporal resolution, e.g., one hour, is potentially more useful from an air quality management perspective. However, there are currently huge limitations in collecting data at a resolution as fine as one hour. This is because of the uncertainties associated with the activity data collection methods as well as the real life variability in emissions.

This guide recommends that you:

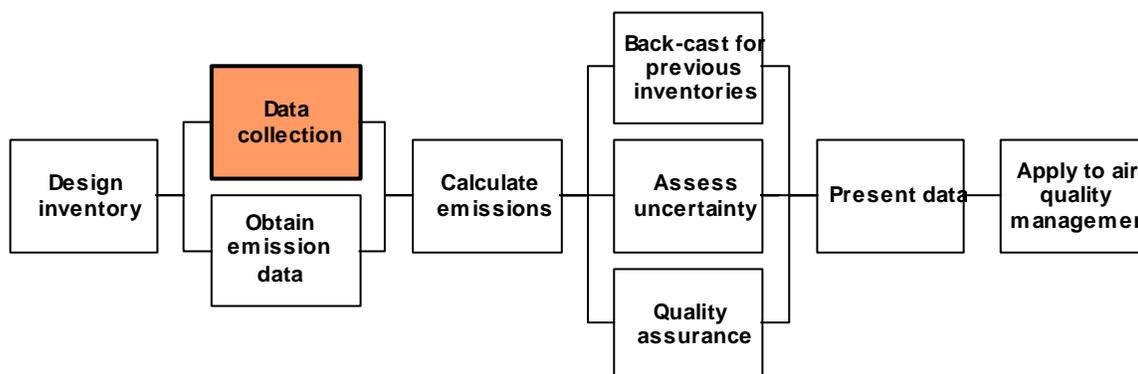
Use a 24-hourly temporal resolution with a breakdown into further groupings if the effect of varying meteorology over this period is likely to be significant.

Collect summer and winter variations in daily emissions, with the optional inclusion of spring and autumn e.g., in areas where stubble burning or other seasonal sources may be significant.

Collect data relating to one year only i.e., emissions estimates are all for the same year.



4 Data Collection



Section 3.3 identified three major sources that should be included in all emission inventories prepared for urban areas in New Zealand. These sources are domestic heating, motor vehicles and industry. The collection of data from these sources is detailed in sections 4.1 to 4.3. Data collection for other emissions is discussed in section 4.4.

An important aspect of collecting data is ensuring adequate representation at the spatial resolution determined during the design of the inventory. One method that has been used when data are difficult to define spatially has been the classification of sources as an area source. Emissions from area sources are estimated for the whole study areas and are generally spatially distributed based on population density. The use of the area source classification, however, can lead to error if population or any other distribution method used is not a good indicator of the actual variation in emissions.

4.1 Domestic Heating

The activity data required for domestic heating includes:

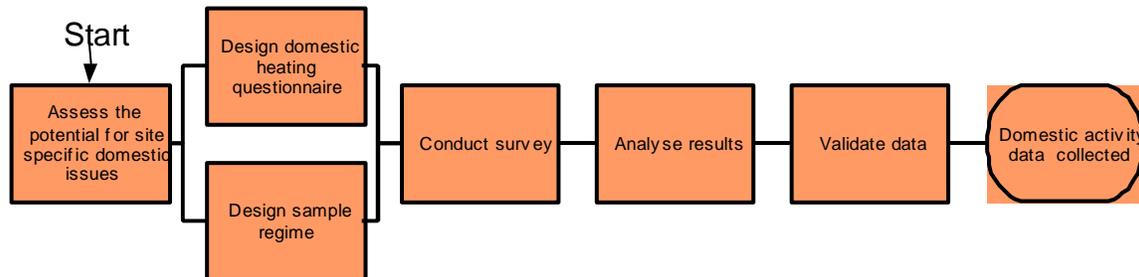
- type of fuel burning equipment
- type of fuel
- quantity of fuel burnt – per day
- distribution of fuel use over a typical 24-hour period
- seasonal variations in fuel use

Other factors that influence emissions from solid fuel burners include the operation of the burner and qualities of the fuel burnt. Activity data for these factors are not currently collected because these factors have a variable impact on emissions and this impact has not been well quantified. Moreover, collecting activity data for these factors would be problematic owing to lack of household knowledge about fuel quality and potential reluctance to admit to habits such as banking down. The latter is more likely an issue in locations where educational campaigns have advised against banking down the fire.

Activity data for domestic heating habits can be collected using a household survey, which should be conducted during the winter months when households are most familiar with their fuel use patterns. It is preferable to contract a survey specialist to be responsible for the survey component of the inventory. However, even this approach will require significant input from the

project manager. In particular, it is important that the survey questionnaire is relevant to the specific location, the sampling regime is designed in accordance with the spatial resolution of the inventory and the outputs required are specified.

The process for conducting a household survey is illustrated below.



Some limited guidance on conducting a survey for an emission inventory is available at www.epa.gov/ttn/chief/eiip/techreport/volume03/iii24.pdf

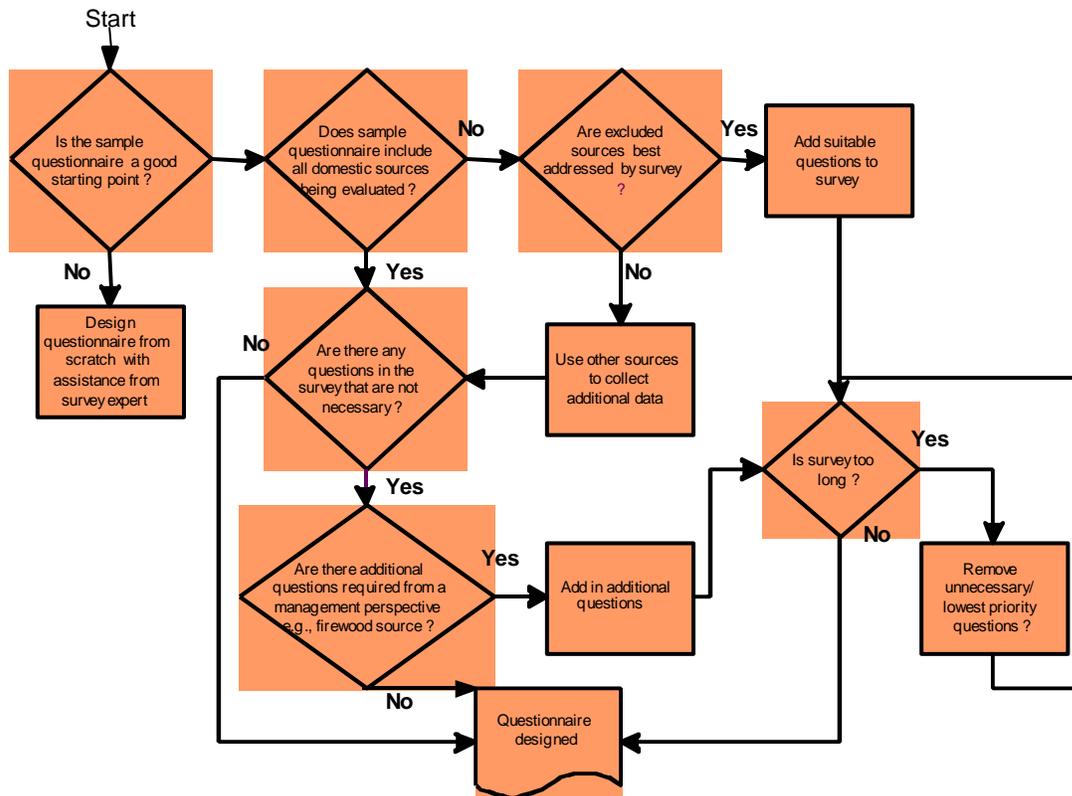
4.1.1 Survey method

The survey could be conducted using either a telephone or door-to-door methodology. The door-to-door survey method has the advantage of the interviewer being able to assist more readily with difficult questions such as estimating fuel quantities. Another advantage is that it is possible to match a non-response household with a similar household. A door-to-door survey, however, is generally more expensive than a telephone survey.

4.1.2 Design the survey questionnaire

Conducting the domestic heating survey is often one of the most expensive components of the emission inventory process. Thus the consequences of getting it wrong are significant. Identify the information required from the survey, i.e., the output data and tables, and work backward from them to ensure that the questionnaire will deliver the required data.

A questionnaire that could be used to assess emissions from domestic heating is included in appendix one. This can be adapted for any location as illustrated in the following flow chart. The flow chart includes reference to other domestic sources or questions related to management measures that may be included in the survey. Examples of each include use of lawn mower, and whether firewood is bought or obtained free of charge. The latter may be necessary in assessing factors such as the cost associated with potential management options. However, priority should be given to the domestic heating data should the survey questionnaire become lengthy. Other methods for collecting data from additional domestic sources are detailed in section 4.5.



4.1.3 Design the sampling regime

The first step in designing the sampling regime is to establish an acceptable sample error for the overall survey and for each spatial representation e.g., grid cell, census area unit. A good survey would aim for a sample error around 3.5%. However, sample errors up to about 7% would generally be acceptable.

Having established the sample error for the survey, the number of households required to be surveyed can be established using the following formula for surveying from a finite population (Lamb, 1999):

$$\text{Equation 4.1} \quad n = \frac{NZ_{\alpha/2}^2 p \cdot q}{(N-1)e^2 + Z_{\alpha/2}^2 pq}$$

without replacement.

- where
- n = sample number
 - $Z_{\alpha/2}$ = confidence interval estimate
 - N = population (number of households in each survey area)
 - p,q = component of sample proportion variance estimate
 - e = tolerable error level

On-line calculators are also available at the following sites:

<http://www.au.af.mil/au/hq/selc/samplsiz.htm>

<http://www.surveysystem.com/sscalc.htm>

This formula should be used to determine the survey requirements for each spatial representation within the study area. For example, if the spatial resolution was defined by eight suburbs within

the study area, the number of households required to be surveyed for each of the eight suburbs would need to be assessed. When the survey responses for the individual suburbs are combined, data may need to be weighted to give a representative sample for the study area.

A protocol for dealing with non-respondents should be developed. This should include a callback procedure to be used when a respondent chosen is unable to be contacted and a procedure for replacing that respondent if repeated callbacks are unsuccessful. In the case of a door-to-door survey interviewers should match the selected respondent's residence with an identical house i.e., number of chimneys, age etc and ensure it is in the same geographical location.

4.1.4 Train the interviewers

Training the interviewers consists of:

- outlining the purpose of the inventory
- ensuring they understand the types of appliances that fit into the different appliance classifications
- providing information on fuels including average weights, sources, and quantities. For example, the average weight of wood burnt on a burner in Christchurch is about 17 kg per day.
- explaining each question and the style of answers that are required
- explaining the intended meaning of any terminology used e.g., “typical winter's night”
- outlining the survey methodology, timeframe and protocol for dealing with non-respondents

4.1.5 Conduct the survey

As indicated above, the survey should be conducted during the winter months and should be completed within a specified time period.

4.1.6 Analyse and present results

Surveys should be checked for completeness, coded and entered into a database. Results should be analysed in accordance with the data output specifications previously identified (section 4.1.2). Suitable analysis packages include SPSS, SASS and Systat.

This guide recommends that you:

Use a domestic heating survey to obtain activity data for domestic heating.

Ensure that a survey expert conducts the survey or that the survey methodology is peer reviewed by an expert prior to conducting the survey.

Correspond with building inspection offices to establish a database of solid fuel burner installations, including burner makes and models, installation date and a map reference.

In conjunction with other Councils, seek a variation to the census questionnaire that provides better domestic heating data for emission inventory purposes.

4.2 Industrial sources

Activity data for the industrial sector can be collected using data from resource consent files, a survey of industry or a combination of both.

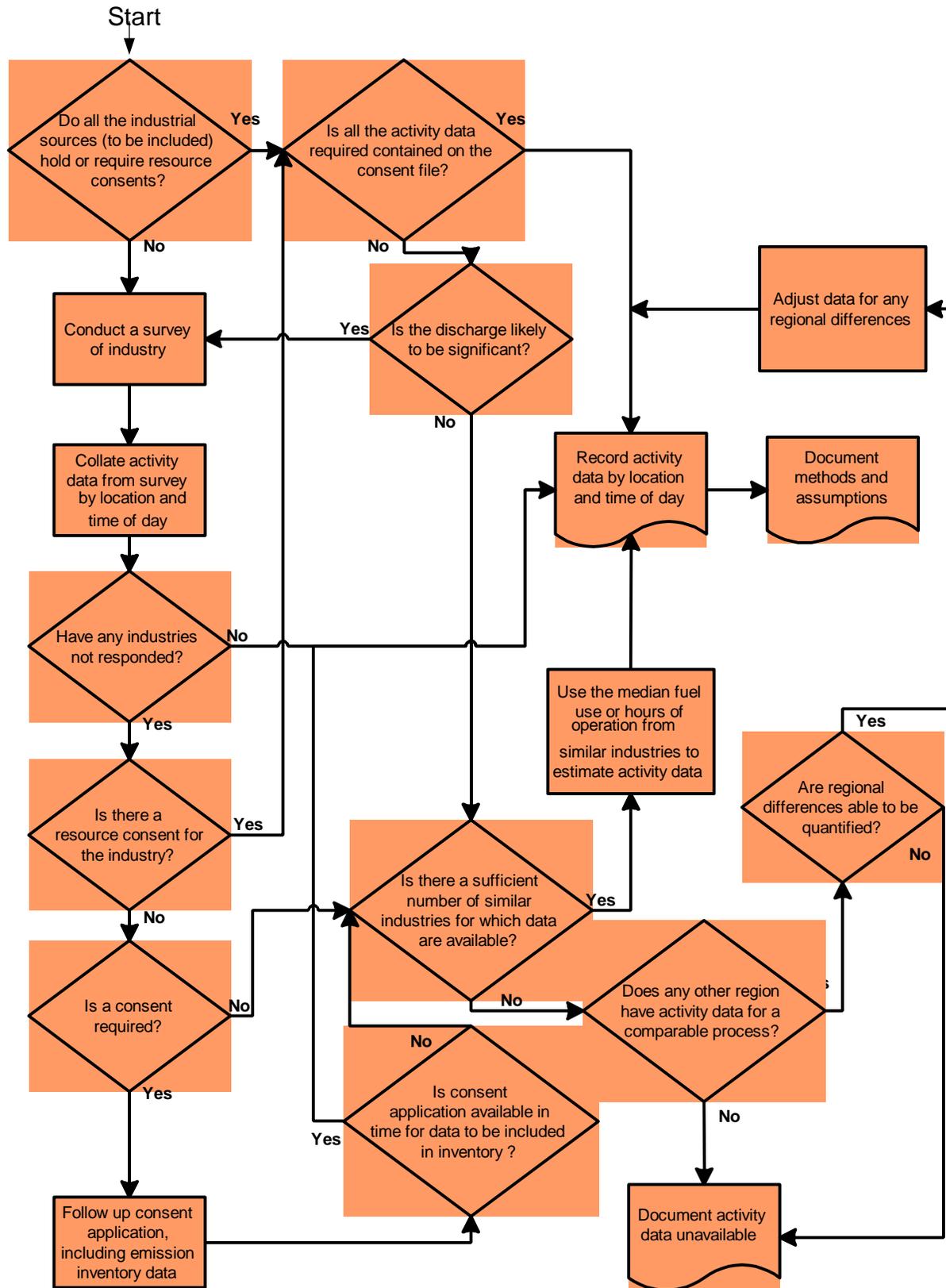
One limitation with using data from resource consent files is that in some instances data are limited to the maximum allowable fuel or material used. If these data are to be used, assumptions are required as to what proportion of the maximum allowed are actually used. The advantage of using this method is that all information used is publicly available. Consequently there are no restrictions on the presentation of this information. In contrast, persuading industries to participate in an industrial survey, which has no immediate legislative support, may require assurances regarding the presentation of results.

The preferred approach is therefore the collection of data from resource consent applications where possible. Thus the first step in collecting activity data for industry is to examine the resource consent files, extract the data where possible and compose a list of industries that require the use of other methods to obtain activity data. This list will include industrial activities that need to be included in the inventory (see section 3.3) that do not hold resource consents e.g., Part C processes.

A list of potentially relevant industrial sources activity data that is required is detailed in appendix two, which also serves as a questionnaire that can be used to collect data from industry. Details such as industry name, file number (if applicable), and grid reference should be entered prior to sending out the survey. An accompanying letter should include details of the information required, the contact number for further clarification and the date the survey should be returned by. Follow-up phone calls for non-respondents will improve the response rate.

The process for collecting activity data from industry is illustrated in the following flowchart.





The industrial sources to be included in the inventory are determined during source selection phase of the inventory design (see section 3.3). This recommends a minimum approach of including all activities that require a resource consent for a discharge to air.

The most effective way of identifying these activities within the study zone is using a Geographic Information System (GIS). If these data are not available in the GIS system it is recommended that systems be implemented to rectify this. If this activity falls outside of the emission inventory timeframe, ensuring consented industries are within the study area should be based on local knowledge and checking street addresses against a map.

If additional activities require inclusion i.e., industrial discharges that do not hold a resource consent, these can be identified using local knowledge, information from suppliers and the yellow pages where necessary.

The type of activity data required will depend on the form of the emission factor or emission test results i.e., whether it specifies an emission rate based on the quantity of fuel burnt, material consumed, product produced or some other factor. For combustion processes, with the exception of generators, the quantity of fuel burnt is the activity data that is required. For processes such as abrasive blasting, spray-painting or printing, it is the amount of blasting material, paint applied or ink used. With seed cleaning, meat smoking and foundries it is the total weight of the seed to be cleaned, the meat to be smoked, or the metal to be melted that is the required activity data. The emission factor description will indicate the type of activity data required. Thus sourcing an appropriate emission factor is necessary prior to obtaining activity data for some discharge types.

Additional data may be collected during this phase of the inventory. This includes annual fuel use, which can be used for consistency checks described in chapter eight. Data relating to physical characteristics of the discharge may be useful if modelling of emissions is an identified output. These data include chimney height, flue diameter, and discharge velocity and temperature.

The flowchart for obtaining activity data from industry suggests that it is possible to speculate about the activity data based on the median amount for the same type of discharge within the study area or comparable industries in another region. These methods should only be used as a last resort and for minor discharges only.

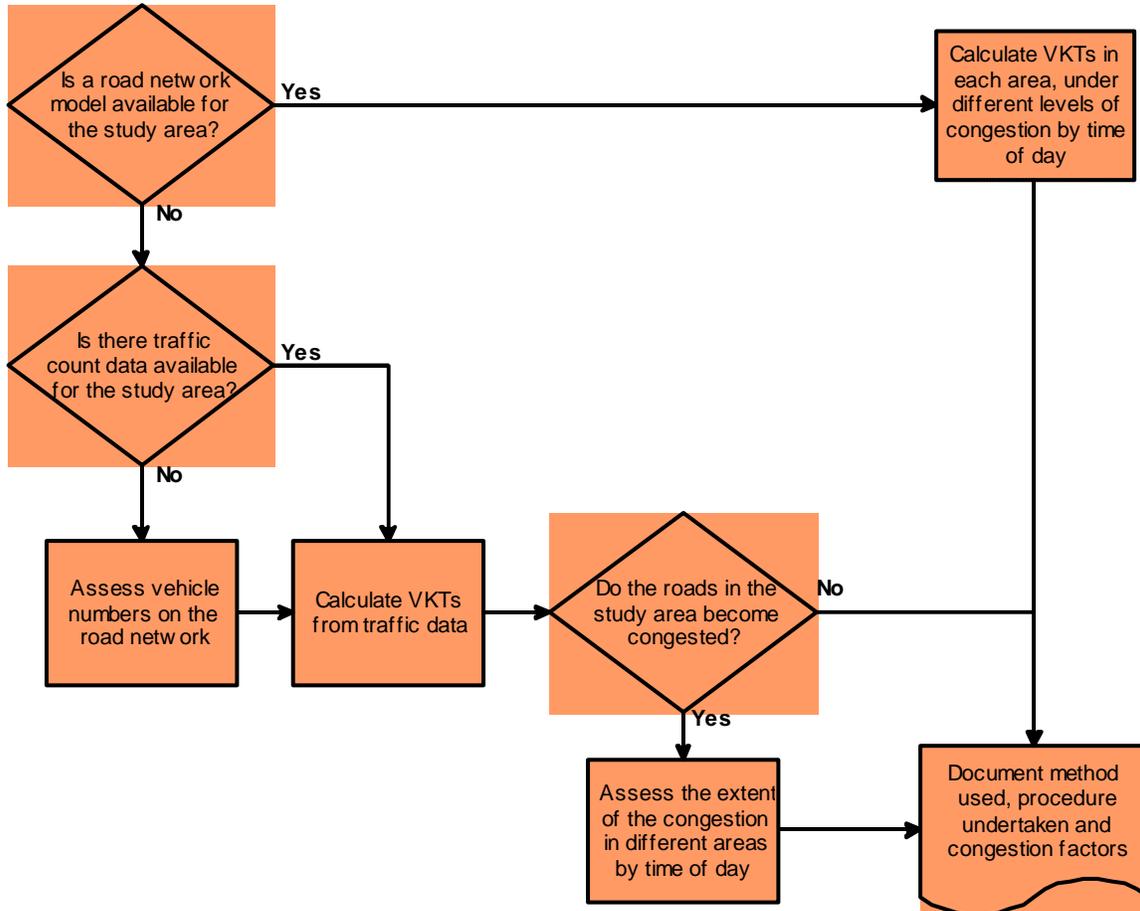
This guide recommends that you:

- Obtain activity data using resource consent information where possible.
- Integrate emission inventory data requirements into the resource consent process.
- Include a layer for discharge to air consents in your GIS system and use this to identify the appropriate industries within the study area.
- Document any industries excluded from the analysis.
- Document assumptions in detail.

4.3 Motor vehicle emissions

The activity data required for motor vehicles are an assessment of the average vehicle kilometers travelled (VKT) for each portion of the study area and their associated level of congestion for each of the time periods defined in the inventory design. Subsequent emission estimates are expressed as mass of contaminant per kilometer travelled.

The process for collecting activity data for motor vehicle emissions is illustrated in the following flowchart.



As indicated above, one of two methods is typically used. Estimating VKT and congestion using a road network model, or estimating VKT from traffic count data and congestion based on observation. To assess the availability, accessibility and limitations of a local road transport model, contact the appropriate local authorities. Regular contact with these road transport modellers and engineers may also assist with further air quality management issues.

In the road network models congestion is defined by the level of service (LOS), which ranges from A to F. A LOS value of A represents free flowing traffic and the other extreme, highly congested traffic, is represented by a LOS value of F. The NZTER emission factor database provides emission estimates for three levels of congestion based on groupings of LOS. These are based on the ratio of volume of traffic to the capacity of the road (volume/ capacity ratio) and are referred to as level of service (table 4.1).

Table 4.1: Volume capacity ratios for different level of service categories

LOS	Volume/ capacity ratio
A-B	<35
C-D	>35<70
E-F	>70

Extracting VKT data from the road network model requires specialist expertise in the operation of the road network model. For some Councils this expertise may be available in-house, or through the territorial local authority. Others, however, may need to contract consultants to extract the VKT data from the road network model.

The steps involved in obtaining appropriate data are outlined as follows:

1. extract model output data for VKT and the road capacity value for each link within the study area for each different hour²
2. allocate each link and corresponding data to the appropriate area (grid, census area unit, other) within the study area
3. classify VKT into one of three levels of congestion (table 4.1) based on the volume/ capacity ratio
4. calculate VKT for each level of congestion for each study area for each different hour
5. calculate VKT for each time period specified in the inventory design by selecting the appropriate hours

The environmental capacity analysis (ECA) is a framework that has been designed for calculating emissions from motor vehicles and is compatible with all road transport models used in New Zealand. The ECA model uses the VKT outputs from the road transport model and emission factor data from the New Zealand Emission Model, NZTER, and calculates emissions based on different levels of congestion and time of day as described above. For less complex assessments, where detailed spatial distribution are not required, a simple spreadsheet is an effective methods of calculating emissions. The application of the ECA approach is described in the Ministry of Transport reports (1998; 2000) prepared for the vehicle fleet emission control strategy (VFECS).

In small urban centers where traffic models are not available and where motor vehicle emissions are unlikely to provide a significant contribution to emissions, a simpler approach to assessing emissions can be used. A method for estimating VKT based on traffic data is outlined as follows

1. establish vehicle numbers for each road or portion of road
2. determine street length (km) for each road/ portion of road
3. multiply vehicle numbers by road length

In obtaining activity data for motor vehicles, consideration should be given to any differences in methodology for assessing motor vehicle emissions from one inventory to the next. This is because it may be necessary to obtain the data for both the year of the current inventory as well as the years of previous inventories. This is discussed in more detail in chapter nine.

² The model will define traffic data for each hour based on one of a number of categories. Each category will represent VKT for an hour for a selection of hourly periods throughout the day. For example one category might represent data for the hours 2pm-3pm, 10pm-11pm and 6am-7am if all these time periods experienced approximately the same number of VKT across the road network.

4.4 Other sources

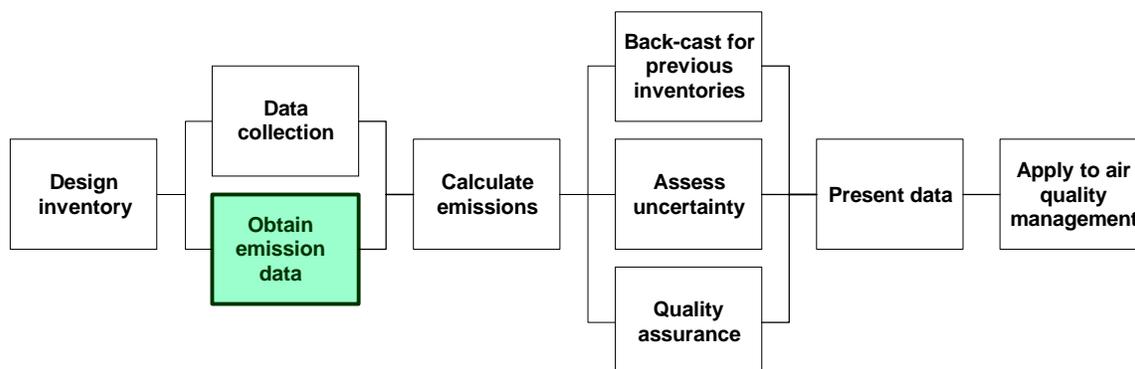
Other sources of emissions may also be included in the inventory. The type of activity data required depends on the activity. Table 4.2 summarises the types of activity data required for a number of miscellaneous sources of emissions and indicates potential sources of these data. Activity data are required for each temporal resolution identified in section 3.6.

Table 4.2: Potential sources of activity data

	Activity data required	Potential Sources	Emission type
Aircraft	No. of landings/ take offs, aircraft type, engine type	Local airports	Combustion
Architectural/ decorative coatings	Quantity of paint used	Manufacturers/ distributors	VOCs
Bakeries	Quantity of bread (kg) consumed per capita	Major producers e.g., Tip Top, Norths etc.	VOCs
Cigarette smoke	No. of smokers	Health department	Particulate
Cutback asphalt	Quantity of bitumen	NZ Bitumen Contractors Association	VOCs
Dry cleaning	Solvent consumption	Perc sales, survey	VOCs
Dust from tilling	Area tilled (hectares)	Councils	Particulate
Glues, adhesives and sealants	Quantity used	Survey/ resource consent files	VOCs, HAPs
Landfills	Tonnes of material land filled	Local authority	VOCs, Greenhouse gases
Lawn mowers	Hours of use, 2 stroke or 4 stroke	Survey or per capita	Combustion
Leaf blowers, weed eaters, chainsaws	Hours of use, 2 stroke or 4 stroke	Survey or per capita	Combustion
Livestock/ wildlife	No. of animals	Statistics NZ	VOCs Greenhouse gases
Marine (commercial and pleasure craft)	Fuel consumption, hours of use, work output	Survey (domestic), local port company (commercial)	Combustion
Marine aerosol	Length of coast, wind speed	Meteorological data, maps	Particulate
Meat cooking	Weight of meat cooked	MAF	Particulate
Off-road farm vehicles	Engine type, fuel consumption	Survey	Combustion
Outdoor burning	Quantity burnt	Survey, fire department (forest fires)	Combustion

	Activity data required	Potential Sources	Emission type
Pesticides and fertilisers	Average application rate per kg of active ingredient, area (ha) of crop types	MAF/ Agribase	NO _x , Particulate
Printing inks	Quantity of ink used	Survey/ resource consent files	VOCs
Railway	Fuel consumption, fleet composition	NZ Rail inventory available from MOT.	Combustion
Railway – coal shipping	Tonnes shipped	Tranz Rail	Particulate
Resuspended road dust	Kilometers of road	Road network model, map	Particulate
Service stations and bulk fuel users	Fuel consumption	Councils	VOCs
Solvent evaporation from consumer products	Kg per person per year	Statistics NZ	VOCs
Surface coatings (industrial)	Quantity of paint used	Survey/ resource consent files	VOCs
Vegetation & soil	Land use categories, area and temperature	GIS or other mapping systems with land use classifications, MAF, National Rural Fire Authority, Agribase – Councils.	VOCs, NO _x
Wearing of tyres and brakes	VKT	See section 4.3	Particulate
Wind erosion of soils	Land classifications, soil erodibility factors, wind velocity, moisture in surface soil and surface roughness	Councils	Particulate

5 Obtaining emission data



Emission data are available in a number of forms, the most common of which is an emission factor. Real data on the emission rate from the activity being assessed is another form of emission data and is preferable to using an emission factor. This data is generally only available for some industrial discharges and may relate to testing done at the time of application for consent or may be a requirement of the granting of the consent.

Different methods for obtaining emission data, listed in order of decreasing confidence, include:

- continuous emissions data – equipment which measures the concentration of pollutants on a continuous basis
- stack sampling data – involves the insertion of a sampling probe into a stack, the extraction of a sample and the analysis of discharge rate
- material balance calculations – based on knowledge of the amount of material entering a process and consumed by the process
- emission factor – estimate of average emission rate for a particular process
- published correlations or equations (GVRD, 1998)

The emission factor is the most commonly used method in New Zealand. An emission factor is the rate of emission per unit of activity for a particular process. The unit of activity varies with the discharge type, but would typically be one of the following:

- weight of fuel burnt e.g., g/kg
- hour of discharge occurring e.g., g/hour
- quantity of product produced e.g., g/tonne of product produced
- quantity of product used e.g., g/tonne of product used
- kilometer of road travelled

Emission factors are established based on results of, preferably extensive, emission testing and are intended to represent typical emissions under standard operating conditions. In most cases they are an average of all available data of acceptable quality and are generally assumed to be representative of long-term averages of all facilities in the source category (USEPA, 1995). However, in many instances emission factors have been derived based on limited data. Moreover, most emission factor data is derived from overseas situations, where factors that influence emissions, such as control technologies, fuel types and specifications and operational factors may differ.

Material mass balance emission data are typically used for processes consuming VOCs, for example the application of surface coatings or metal cleaning and degreasing. For these types of compounds this method provides greater confidence than use of emission factors.

In New Zealand, the Ministry of Transport has released an emission factor database for motor vehicle emissions as a part of the Vehicle Fleet Emissions Control Strategy (VFECS). This database, referred to as NZTER, contains emission factors based on exhaust emission testing of the New Zealand vehicle fleet and projections of future emission factors. Integration of emission factors from NZTER into the emissions calculation is illustrated in section 6.2.

Many inventories within New Zealand will need to present detailed data on particulate emissions, particularly from domestic solid fuel burning. Two major problems in deriving appropriate emission factors for PM₁₀ are the difficulties in conducting tests and consequent lack of test data and the differences in operational factors that can significantly influence emissions.

Difficulties in conducting measurements of particulate relate to the need to measure both the filterable and condensable particulate matter. For domestic heating emissions this involves the use of a purpose built set-up that includes a dilution tunnel. Consequently emission tests carried out in New Zealand have been limited to laboratory situations and simulations of operating conditions. Emission test data from open fires and some older appliances is limited.

A comprehensive assessment of emission factors for industrial sources is the USEPA AP-42 emission factors available at <http://www.epa.gov/ttn/chief/ap42.html>

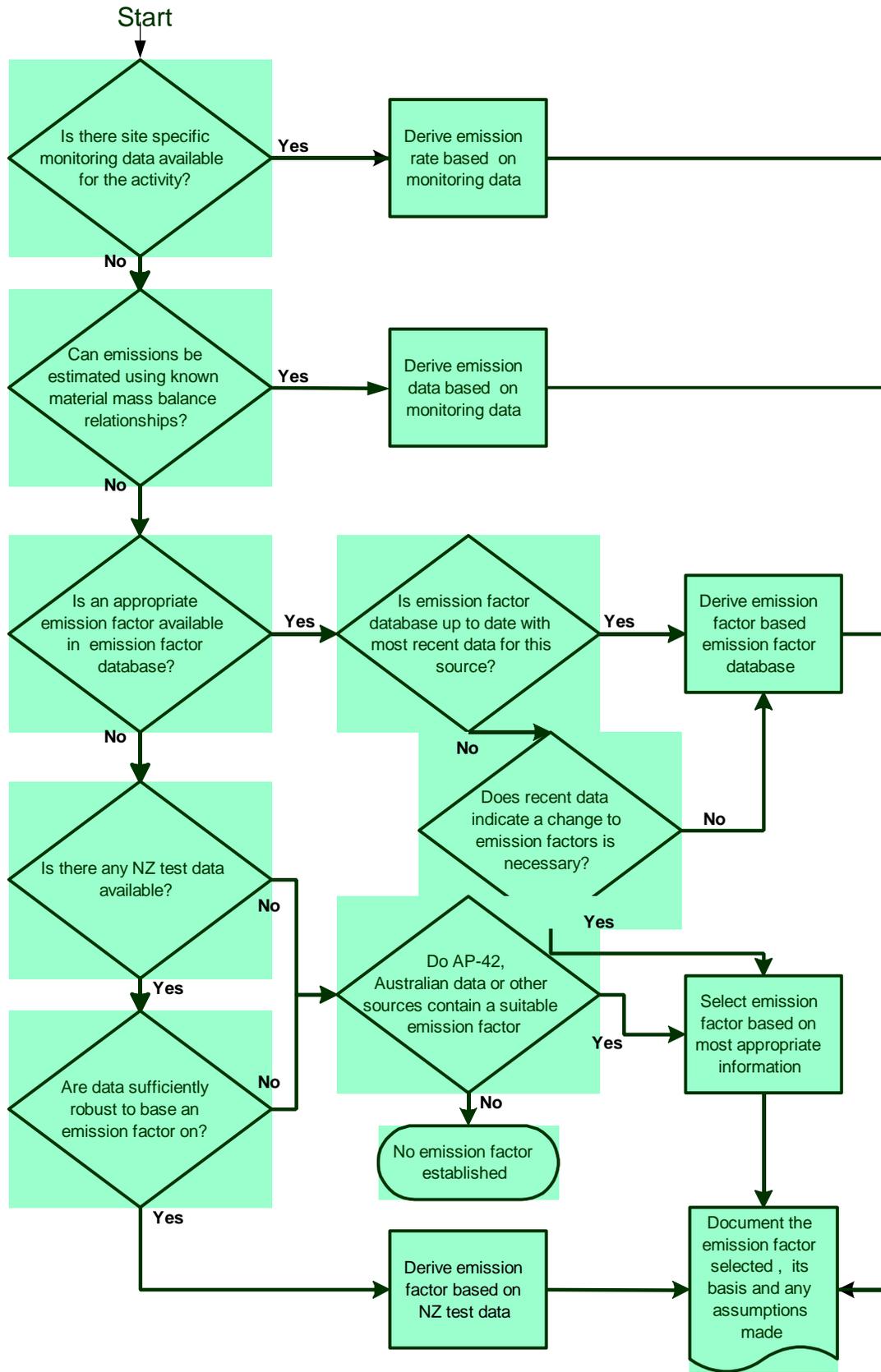
Other sources of emissions data include:

<http://binary.eea.eu.int:80/g/>

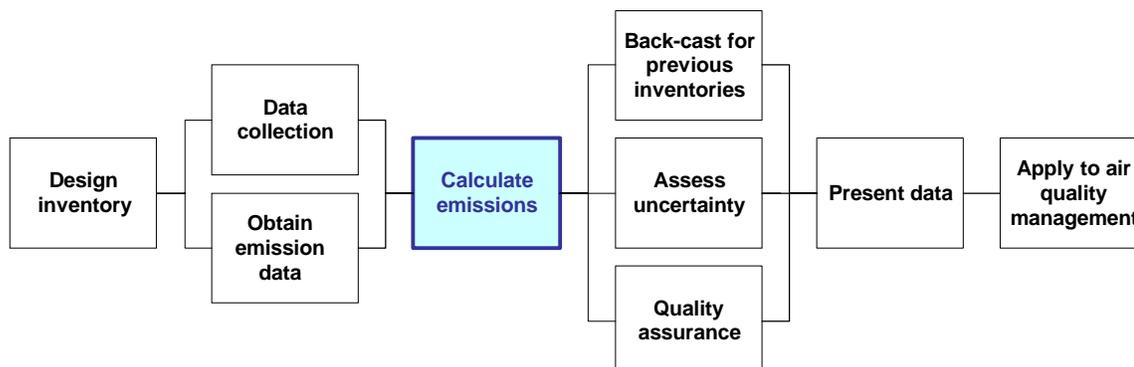
<http://www.environment.gov.au/epg/npi/handbooks/>

<http://www.environment.detr.gov.uk/airq/laqm/tg298/index.htm>

Emission factors for domestic heating and a selection of other sources are available from the emission factor database, developed for New Zealand as a component of this SMF funded project. These data are selected based on overseas emissions testing and New Zealand data available at the time of establishment and may not necessarily represent the most current information at any time. These data have been collated to assist in the preparation of emission inventory. However, no additional testing was undertaken where emission test data were limited. Additional emission testing to further develop emission factors for emissions from solid fuel burning in New Zealand is recommended. The process for establishing emission data for any activity is illustrated in the following flow diagram.



6 Calculating emissions



Calculating the emissions is in fact one of the easiest and least time-consuming components of the emission inventory, particularly if purpose designed software or existing calculation spreadsheets can be used.

For combustion processes, both domestic and industrial (excluding generators), emissions for each time period are calculated as follows:

$$\text{Contaminant emissions (g)} = \text{weight of fuel burnt (kg)} \times \text{emission factor (g/kg)}$$

For most other industrial processes emissions can be calculated using one of the following, depending on the activity specified in the emission factor:

$$\text{Contaminant emissions (g)} = \text{amount of product consumed (kg)} \times \text{emission factor (g/kg)}$$

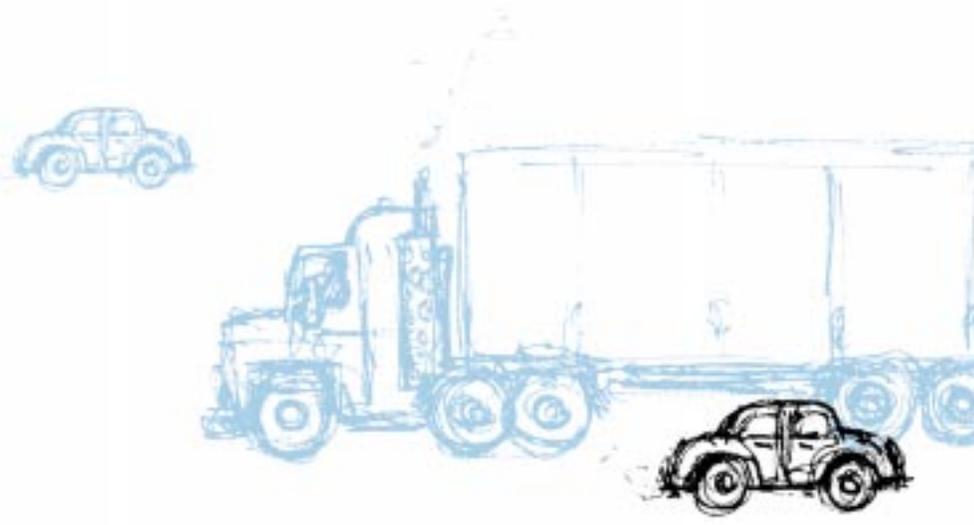
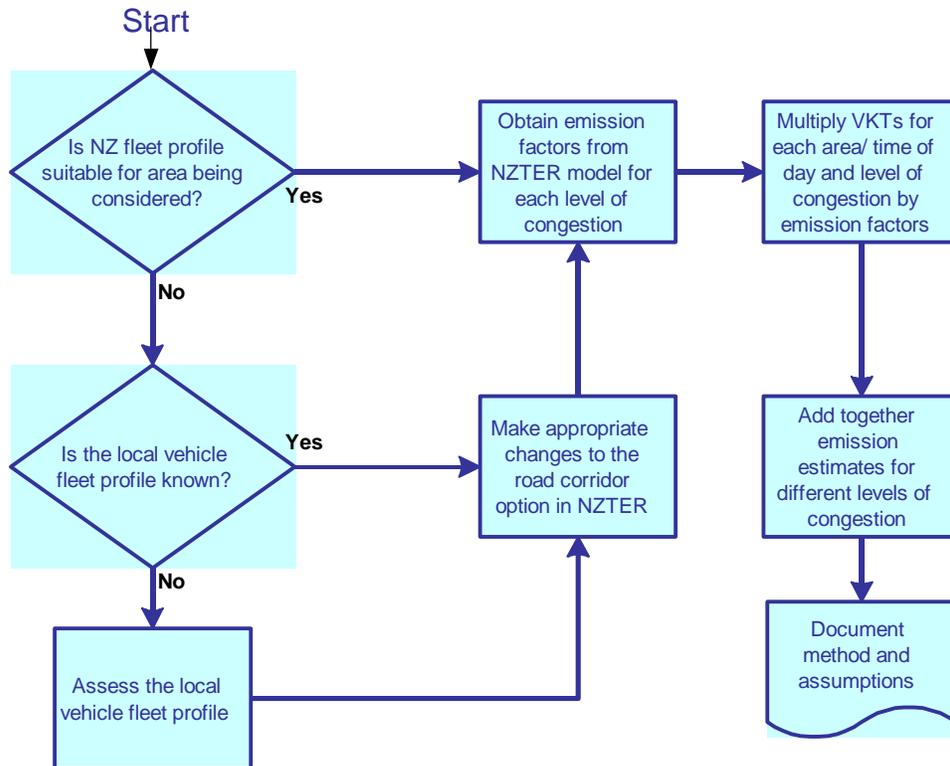
$$\text{Contaminant emissions (g)} = \text{amount of product produced (kg)} \times \text{emission factor (g/kg)}$$

$$\text{Contaminant emissions (g)} = \text{no. of hours of discharge (hr)} \times \text{emission factor (g/hr)}$$

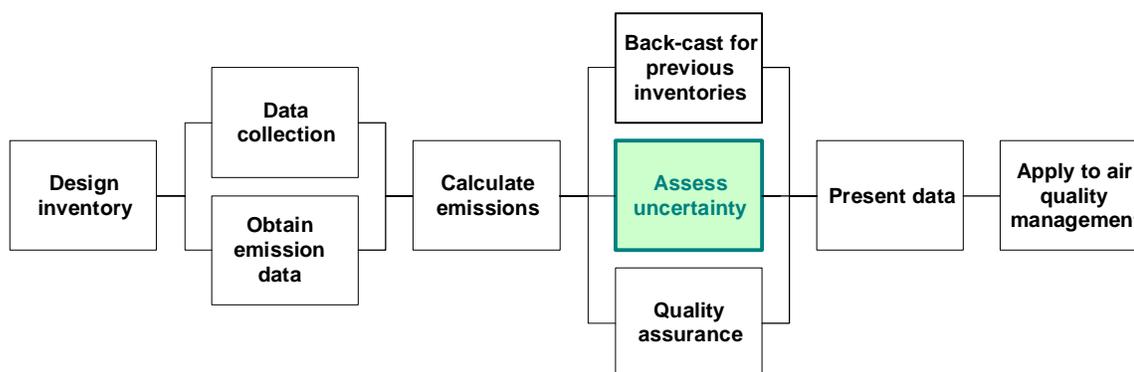
The process for selecting emission factors and making subsequent calculations for motor vehicle emissions is illustrated in the following flowchart. The equation for converting the activity data (VKT) for each congestion level and time-period into emissions is as follows:

$$\text{Contaminant emissions (g)} = \text{VKT (km)} \times \text{emission factor (g/km)}$$

Further detailed information on calculating emissions from different activities can be found at the following website www.epa.gov/tn/chief/eiip/techreport/volume03/index.html



7 Assessing the uncertainty



Even the most well conducted emission inventories are subject to uncertainty. Errors are inevitable at the base level of data collection e.g., the activity data (e.g., fuel use or VKTs) and emission factors. This is because it is not possible to measure and incorporate fuel use, VKTs or emission factors for all conditions under which these factors may vary. Thus the methodology uses activity data based on average consumption or in the case of transport emissions, modelled results for VKTs. Similarly, emission factors are based on average values derived from emission testing of often a limited number and variety of activities that discharge to air.

There are a number of options to choose from when deciding how to deal with the uncertainty associated with making estimates of emissions using emission inventory methodologies. These include:

- ignoring the uncertainty
- qualitative acknowledgement of the uncertainty
- certainty rankings
- quantifying the uncertainty for individual components, where available e.g., sampling error
- combining the errors for individual components

An emission inventory should contain a discussion detailing sources that have been excluded from the assessment because of lack of data and the potential significance of the exclusion, irrespective of the approach chosen for dealing with uncertainty. Similarly, the number of significant values used when reporting the emission estimates should be considered, under any uncertainty assessment regime. This is because it is inappropriate to report results to a high level of accuracy e.g., to indicate that industry contributes 1,952 kilograms of NO_x per day, when average emission factors and fuel use data are used.

7.1 Ignoring the uncertainty

Ignoring the uncertainty associated with the preparation of emission inventory investigations is the easiest but least ideal way of addressing the issue. The main problem with this approach is the lack of certainty associated with the emission inventory outputs. This can be particularly important if the inventory is being used to justify regulatory measures to improve air quality. In this situation it may become less of an issue when a single source is a very dominant contributor (for example, if the measures proposed were to address CO concentrations and motor vehicles

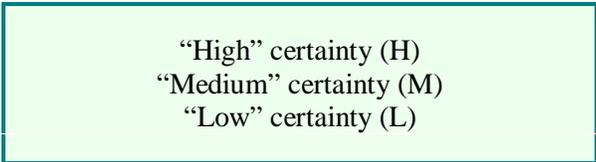
were by far the greatest contributor). In this case the inventory results should be able to be defended on the basis of a basic sensitivity analysis.

7.2 Qualitative acknowledgement of the uncertainty

Qualitative acknowledgement in the emission inventory report of the potential uncertainty surrounding the estimates of emissions is another method of addressing the uncertainty. This method is marginally better than ignoring the uncertainty as readers are made aware that some limitations exist and that data should not be treated as providing the exact estimate of emissions at any given time. However, as with the previous approach there is a lack of certainty associated with the emission inventory outputs.

7.3 Certainty rankings

Certainty rankings provide a qualitative indication of the certainty of each estimate. It is recommended that the approach taken be similar to that taken for the national inventory of dioxin emissions (Ministry for Environment, 2000). This requires assigning one of the following certainty rankings to each activity and emission factor estimate:



“High” certainty (H)
“Medium” certainty (M)
“Low” certainty (L)

The definition of each assign is outlined below. The definitions have been modified from those presented in the national inventory of dioxin emissions to make them more applicable to a wider range of sources and emission factors.

Activity statistic

- If the statistic was actual industry-compiled data (e.g., the amount of fuel combusted or product consumed), or was derived from comprehensive surveys, an “H” certainty ranking is assigned.
- If limited industry or survey data were available, or the data were modified to account for changes with time then an “M” certainty ranking is applied.
- If there was no data available and the level of activity was based on expert judgement then an “L” certainty ranking is applied.

Emission Factor

- If extensive emission testing data are available, including New Zealand specific data, and are used to derive emission factors, an “H” level of certainty is assigned.
- If a reasonable amount of emission test data are available from overseas sources and no major differences between overseas sources and local sources are identified then an “M” level of certainty is assigned.
- If emission estimates are reliant on a limited amount of overseas data or no emission testing data are available and engineering judgement is used the level of certainty assigned is “L”.

7.4 Quantifying the uncertainties for individual components

This method of addressing the uncertainty could include quantifying the errors for all components of the inventory or just a few major sources.

The first step in using this method is to decide what confidence intervals are to be applied to the error estimate. A common selection is 95% CI, which means that there is a 95% probability that the value will lie within the range specified. For example, if the value of an emission factor was 10 ± 5 g/kg (95% CI) it would mean that there was a 95% probability that the value would be between 5 and 15 g/kg. It should be noted, however, that these data are often not available and the assessment may therefore be limited.

Sources such as surveys are relatively easy to quantify as methods exist for assessing the error associated with the sample size. However, this component of the error relates to the sample size only and does not include any uncertainties associated with the questions themselves e.g., the quantity of fuel burnt. A method for assessing the sample error associated with a survey for a finite population is detailed in section 4.1.3.

The estimated standard error associated with emission factors and other aspects of the inventory can be based on examination of the distribution of the data from which the emission factor, or activity data, is drawn. For example, if test data shows that emissions from a burner average at 10 g/kg and 95% of the actual values are between 5g/kg and 15g/kg then the estimated standard error (95%, CI) is $10\text{g/kg} \pm 50\%$.

In some instances distribution data may not be available. In such cases it is often not appropriate to make an assessment of the potential uncertainty surrounding the calculation. However, in some instances the author may have good knowledge of the reliability or otherwise of the data and may choose to estimate an uncertainty based on this experience. If an uncertainty is reported based on such scientific judgement this should be acknowledged in the report.

An example of quantifying some but not all uncertainties is the “Source Apportionment of Airborne Particulate Matter in the United Kingdom” (Airborne Particles Expert Group, 1999) which is available at the following address: [Http://www.environment.detr.gov.uk/airq/](http://www.environment.detr.gov.uk/airq/)

7.5 Combining the uncertainties

The ideal way of assessing uncertainty is to quantify the error associated with each component of the inventory, then combine these errors using statistical formulae. For example, the contribution of motor vehicles to total carbon monoxide concentrations might be found to be $68\% \pm 10\%$. However, the use of this option is restricted by the availability of error estimates for all components of the inventory. Consequently examples of the application of this technique are not available. It is possible, however, that as the knowledge and understanding of emission factors and activity data increases this option may be more viable.

Despite current limitations it is still possible to calculate uncertainties for some emissions estimates as this gives a general indication of the magnitude of the uncertainty associated with the estimates. Example 7.1 illustrates the level of uncertainty associated with emission inventory estimates.

The first stage in quantifying the uncertainty for all components is to quantify the errors for the individual components, as per section 7.4.

The second stage is to use statistical formulae relevant to the type of mathematical calculation being performed to quantify the error. Equations 7.1-7.4 detail methods of estimating error (α) based on formulae described in Topping (1971).

Equation 7.1 multiplication ($m_1 m_2 \dots m_n$) $\alpha = \sqrt{(m_1 m_2 m_3)^2 \left(\left(\frac{\alpha_1}{m_1} \right)^2 + \left(\frac{\alpha_2}{m_2} \right)^2 + \left(\frac{\alpha_3}{m_3} \right)^2 \right)}$

Equation 7.2 multiplication ($m_1 m_2$) $\alpha = \sqrt{m_1^2 \alpha_2^2 + m_2^2 \alpha_1^2}$

Equation 7.3 division (m_1/m_2) $\alpha = \sqrt{\frac{\frac{\alpha_1^2}{m_2^2} + \frac{\alpha_2^2}{m_1^2}}{m_2^4}}$

Equation 7.4 addition/ subtraction ($m_1+m_2+m_3$) $\alpha = \sqrt{\alpha_1^2 + \alpha_2^2 + \alpha_3^2}$

Example 7.1

To calculate the error associated with PM_{10} emissions from open fires burning wood based on an average emission factor of 10g/kg $\pm 50\%$, a daily fuel quantity of 15kg ± 5 kg for 2541 households assuming a sample error of 3.5%:

<i>m1</i>	<i>m2</i>	<i>m3</i>	<i>α1</i>	<i>α2</i>	<i>α3</i>
2541	10	15	89	5	5

Equation 7.1 applies $\alpha = \sqrt{(m_1 m_2 m_3)^2 \left(\left(\frac{\alpha_1}{m_1} \right)^2 + \left(\frac{\alpha_2}{m_2} \right)^2 + \left(\frac{\alpha_3}{m_3} \right)^2 \right)}$

Daily PM_{10} emissions from open fires for the above example = 381 kg ± 229 kg (60%)

This guide recommends that you:

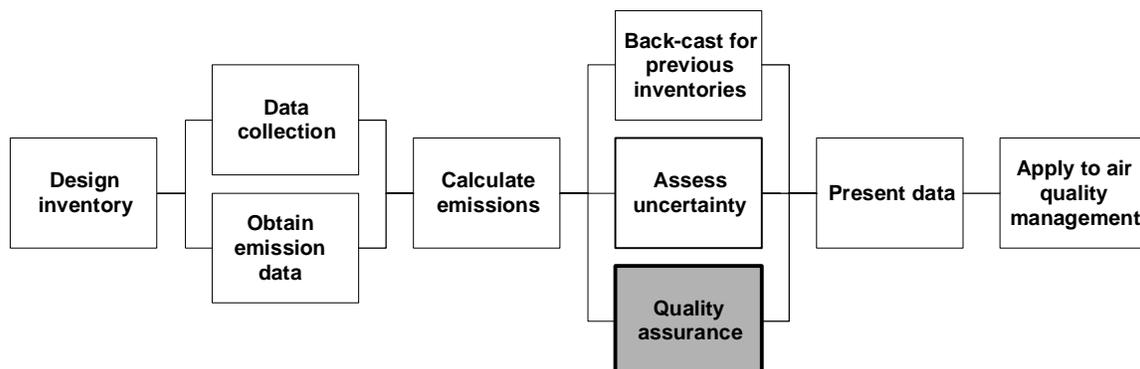
As a general rule of thumb, report emission estimates for overall results to two significant figures.

Include a discussion on potentially significant sources that have been excluded from the assessment.

Indicate any particular components of the inventory for which estimates are relatively uncertain when using a qualitative approach to dealing with uncertainties.

Quantify and combine uncertainty estimates where possible.

8 Quality assurance



The purpose of quality assurance is to provide an accurate and consistent emission inventory. Good quality assurance gives confidence in the inventory and any resulting regulatory provisions.

Quality assurance is integrated into the process of preparing an emission inventory at all stages. In that sense, it includes the documentation of the process undertaken, the methods used and the assumptions made. Additional quality assurance techniques that should be applied at this stage in the process include:

- checks on the accuracy of data entry
- identifying outliers
- peer review of emissions calculations
- validation of data using consistency checks

Checks on accuracy of data entry and identifying outliers involve checking values are within an acceptable range. Examples of this include:

- annual fuel use is not > daily fuel use times 365
- daily hours of operation are not >24
- values for activity data are entered for each industrial process

In addition to this, processes for checking data entry accuracy should be developed. These processes will depend on the type of software used. Other data handling and transfer errors are minimised through the development of software that does not duplicate data input requirements and presents outputs in the format required for reporting.

Large or complex projects often require careful and methodical management of quality assurance. In some cases the appointment of a quality assurance manager to ensure checks are undertaken at all levels may be appropriate. Another option is to engage an external “peer reviewer” to specifically consider quality assurance issues for all aspects of the emission inventory preparation. Similarly, quality assurance checks conducted by external consultants should be reviewed by Council staff.

Examples of consistency checks

Check that the distribution of emissions with time of day is consistent for all contaminants - if not examine why and determine whether it is a genuine difference or an error.

Check for consistency between areas - if one or more areas have unusual emissions compared to the rest, assess the reasons for the high or low emissions. If high emissions occur because of industrial discharges and the calculation appears correct check the basis for the emission factor and the activity data to ensure they are appropriate.

Emission calculations should be peer reviewed once completed. Samples of the emission calculations for each source category should be verified using manual calculations.

Validation of data is the use of any relevant information as a check that the data used is not inconsistent with other available data. It is common that the validating data-set will differ from the inventory information in some way and thus the two data-sets should not be expected to be the same. Differences between data-sets should be considered and accounted for where possible. Validation of input data should occur wherever possible.

Example 8.1: Validating the quantities of coal used on domestic coal burning appliances

A household survey indicates that the 5000 households burning coal use an average of 10 kg of coal per day in the study area.

Validation: Annual domestic coal sales in the study area equate to 5000 tonnes.

Conclusion: The two data-sets are not inconsistent. The survey data also indicates that the majority of households burnt coal throughout the period May-August and do not use that method every night of the winter. If every household burnt every day the annual total would be 6000 tonnes. The actual total burnt is less. However, the difference is likely to be attributed to households using other methods or no heating on some nights.

Example 8.2: Validation of VKT data using vehicle registrations and odometer readings

A road transport model indicates that the daily average VKT for an area is 663877, giving an annual VKT estimate of 2,423,151,415.

Validation: The number of vehicles registered for the area is 283365. Using an annual average odometer reading of 10,000 km gives an estimated annual VKT for these vehicles of 2,833,650,000.

Conclusion: The vehicle registration and odometer data indicates a greater number of VKT, by 15%. However, some of these are likely to occur outside of the study area. Similarly, however, some VKT will occur in the study area from vehicles registered that are not registered within the area. Other potential sources of differences in the datasets include the definition of the study area relative to the postal area (from which the vehicle registration data are derived). Overall there are some differences in the data sets, which may or may-not be explained by these factors.

Table 8.1: Types of data that may be able to be used to validate inventory inputs

Data source	Validation method
Domestic wood use	Based on fuel sales by local merchants (needs to be adjusted for the proportion of wood that is self-collected).
Domestic coal sales	A survey of coal merchants (needs to account for coal obtained privately if likely) or data may be collated by other sources e.g., Coal Research Limited.
Industrial coal	Annual industrial coal consumption data e.g., Coal Research Limited.
Surface coatings/ solvent evaporation	Total paint/ solvent sales for the area.
Vehicle kilometers travelled	Annual average odometer readings (needs to account for proportion travelled outside of study area) or fuel sales

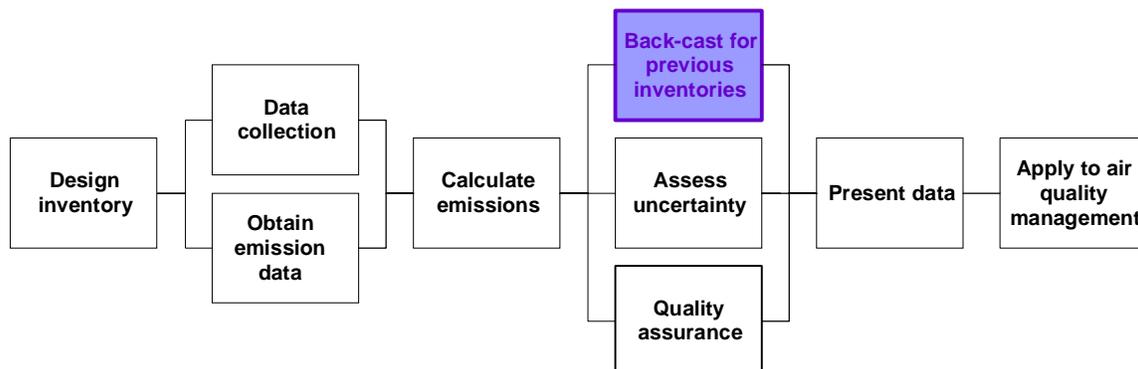
This guide recommends that you:

Document assumptions made throughout the production of the emission inventory.

Integrate data entry checks and outlier checks into the process.

Validate data where possible.

9 Back-casting for previous emission inventories



“Back-casting” for previous emission inventories means applying the methodology used in preparing the current emission inventory to previous inventories carried out for the same general location. For example, if an inventory were prepared in 1995, then repeated in 2000 with some changes in methodology, the back-cast would apply the changes in methodology to the 1995 data. The original 1995 inventory should be referred to as the “original” and the revised version the “back-cast”. The purpose of back-casting is to allow valid comparisons between two emission inventories e.g., the 1995 back-cast and the 2000 inventory, to assess changes in emissions with time.

The key stages involved in preparing the back-cast include:

1. identifying the differences in methodology between the inventories
2. re-evaluating data from the original study in accordance with new methodologies
3. presenting the results of the back-cast

9.1 Identifying differences

Identification of differences in the methodologies requires both inventories to have adequate documentation of the methods used. Types of differences include:

- study area
- emission factors
- categorisation of sources
- types of sources included
- method of assessing activity data
- assumptions in collecting activity data

9.2 Re-evaluating data

The process of re-evaluating the data will vary depending on the form of the differences in methodology. If the changes are to the study area, data can either be compared for areas common to both inventories or the original area could be adjusted to be consistent with the area used in the recent inventory. The latter approach, however, would require assumptions regarding factors such as home heating methods in additional areas as it would not be possible to retrospectively survey these areas.

Differences such as changes in emission factors or categorisation of sources are not major tasks provided emission inventory software has been well designed. However, changes in the methods of assessing data could require substantial resources, particularly if this required, for example, the re-evaluation of transport models outputs or the inclusion of congestion factors.

In some cases, where the original inventory design has been poor or changes between the two inventories have been significant, it may not be possible or practicable to present a back-cast.

9.3 Presenting results

Presentation of the results of the back-cast can range from a summary of the relative contribution of different sources to emissions of each contaminant, and how this differs from the original assessment, to presenting detailed tables including time of day and source breakdowns.

The following should be included as a minimum:

- the purpose of the back-cast and the associated terminology
- summary table of changes and the reason for improvement/change e.g., table 9.1 (Levelton, 1998))
- table comparing original emission estimates to back-cast estimates for each contaminant e.g., table 9.2 (Levelton, 1998)
- methodological differences that were not able to be back-cast and the potential significance
- text detailing the significant differences between the original and the back-cast

Table 9.1: Summary data of back-cast changes (from Levelton, 1998)

Source	Change for 1990	Reason for improvement
Area Sources		
Space heating	Higher CO, VOC, Lower SO ₂	Updated emission factor, assumption
Open burning	Much lower overall	Lower 1990 estimate for waste burned
Agriculture	NOx higher	NOx from fertilizer added for 1990
Solvent evaporation	VOC updated	Much improved detail and methodology
Landfills	VOC lower PART higher	Improved methodology Base quantity change
Bakeries		New source
Biogenics	VOC halved	Improved methodology
Mobile Sources		
Motor vehicles	All pollutants updated	Updated VKMT by speed, vehicle type; switched MOBILE 3C to MOBILE 4.1C; adjusted road dust factor (reduced)
Rail/Air/Marine Off-road	Updated Emissions 50% less	Emission factor updates Improved base quantity

Table 9.2: Comparison of original to back-cast (adapted from Levelton, 1998)

	Common pollutant emissions (tonnes)				
	CO	NOx	PM ₁₀	SOx	VOC
Point sources					
Original 1990	10511	9501	15149	3860	8933
Backcast 1990	7097	8807	10952	4326	7991
% change from original	-32	-7	-28	+12	-11
Area sources					
Original 1990	5896	3775	3954	402	43512
Backcast 1990	5807	3765	6903	223	44155
% change from original	-2	0	+75	-45	+1
Mobile sources					
Motor vehicles					
Original 1990	386270	28911	3678	1828	41625
Backcast 1990	324499	38114	1094	1863	24651
% change from original	-16	+32	-70	+2	-41
Non-road mobile					
Original 1990	23008	17138	1610	2349	4887
Backcast 1990	17106	12513	1590	1574	3199
% change from original	-26	-27	-1	-33	-35

This guide recommends that you:

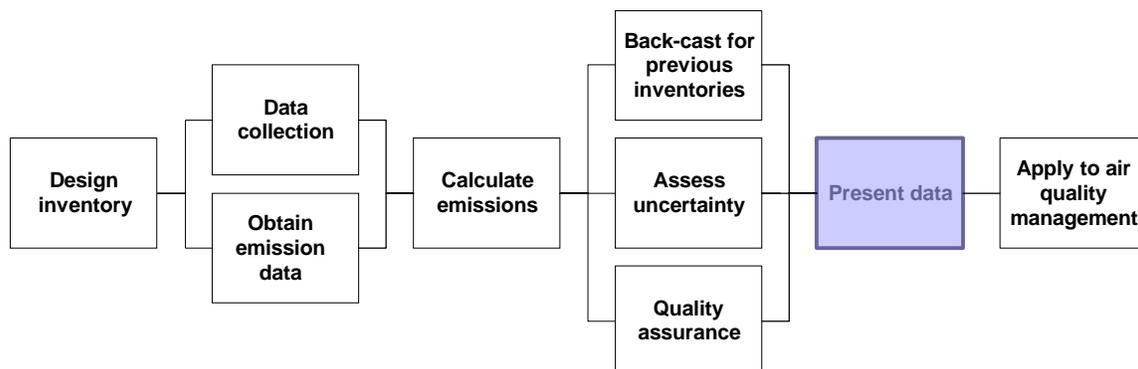
Present a back-cast of emissions where practicable.

Specify details of differences in methodology.

Include, as a minimum, in the content of the back-cast report:

- the purpose of the back-cast
- summary table of changes in methodology
- table comparing original estimates to back-cast estimates
- methodological differences not able to be back-cast
- discussion of main differences between the original and the back-cast.

10 Presenting Data



Emission inventory outputs can be presented in a number of formats listed in order of increasing technicality:

- fact sheets
- web page
- summary report
- inventory report
- back-casting report
- technical appendices

A fact sheet is a one page visually attractive summary of the key points of the emission inventory. It summarises the results and integrates the use of graphics. A fact sheet is an effective way of communicating the results to the public.

Presenting a summary of the emission inventory data on a web page could be an effective media for communicating the results of an inventory. A web page should detail the purpose of the inventory and a summary of results. It should contain graphics and be linked into other relevant data such as air quality monitoring results where possible.

A summary report is a good option if the main report is lengthy or has been prepared for a technical audience. The target audience is those primarily interested in the results of the inventory, but not interested in the detail. The benefits of a summary report are that it reduces cost by minimising the printing required to replicate the lengthier inventory report and it presents the results in more easily digestible form.

The inventory report is the main output from the emission inventory and is the primary focus of this section of the guide. This report should contain data from all sources included in the inventory and a summary of the total emissions from all of these sources. It is not recommended that separate reports be used for different sources. Guidance on the content and format of the inventory report is contained in sections 10.1 to 10.2.

A back-casting report is a method of addressing changes in methodology from one inventory to another and is detailed in chapter nine. These data can be presented as a separate chapter within the inventory report or as a separate report. The latter option is appropriate in situations where the inventory report is lengthy. It is important, however, to make reference to the back-casting report in the inventory report.

Technical appendices are a detailed explanation of the methodology used and the assumptions made. Like the back-cast report, it is optional whether these data are contained within the inventory report or presented as a separate report. Table 9.2 details three options for presenting the results of the emission inventory.

Table 9.3: Options for presenting emission inventory results

Option one	Option two	Option three
Summary report – most readily available report <u>plus</u> Inventory report – contains back-cast and technical detail Fact sheets optional	Inventory report – most readily available report <u>plus</u> Separate back-cast and technical appendices reports Fact sheets optional	Inventory report contains technical detail and back-cast Fact sheets optional

10.1 Report format and content

Information that should be included in the inventory is detailed in table 10.1. A sample framework within which this content could be presented is also illustrated in table 10.1. However, these data could be presented using other frameworks if desired. For example, a collation of emission factors from all sources could be presented as a separate chapter or the uncertainty estimates for each source could be collated and presented in a single chapter.

Table 10.1: Structure and content of an emission inventory

Structure	Content
Executive summary	Outline why the inventory was prepared, methodology used, key results and their significance and any potential implications.
Introduction	Purpose and scope of the inventory – why the inventory was prepared. Overview of air quality issues. A description and illustration of the study area. Any background information including previous inventories, relevant legislation, air quality management issues and meteorology.
Design of the inventory	Detailed description of design of the inventory, including the study area, spatial distribution, contaminants and sources included and the temporal resolution.
Emissions data using a separate chapter for each activity type or category of activity types	Activity data, emission factors, methodology used in obtaining activity data, assumptions, emissions estimates summary data, discussion, and uncertainty assessments. Plus additional data which could be extracted into the appendices or a separate technical appendices report including: detailed emission estimates, minor assumptions, how emission factors were derived, procedures for obtaining activity data

	from industry, details of industries or other sources not included.
Total emissions	The quantity of emissions from each source and their contribution to the total, uncertainty assessment.
Appendices	Domestic heating questionnaire

10.2 Report presentation

One of the most important aspects of presenting the results of the emission inventory is to convert the data gathered into meaningful information. This involves exploring the implications of the data presented, particularly in the context of any local air quality issues. A good example of data presented as meaningful information is the emission inventory for Waikato (Environment Waikato, 1998)

In addition, the emission inventory should be prepared having regard to the following:

- an illustration of the study area should be included in the inventory
- reports should be proofread prior to release
- graphics need to be effective in black and white, unless the report is generally available in colour
- geographical representation of variation in emissions levels across the study area
- reports should be prepared in accordance with the appropriate Council's technical report format
- ability to reproduce as an internet document or on CD to minimise publishing costs

10.3 Communicating emission inventory data to the public

Methods used to communicate the results of an emission inventory to the public could include public presentations, the preparation of fact sheets, pamphlets or summary documents, inclusion of material on the internet and a media campaign.

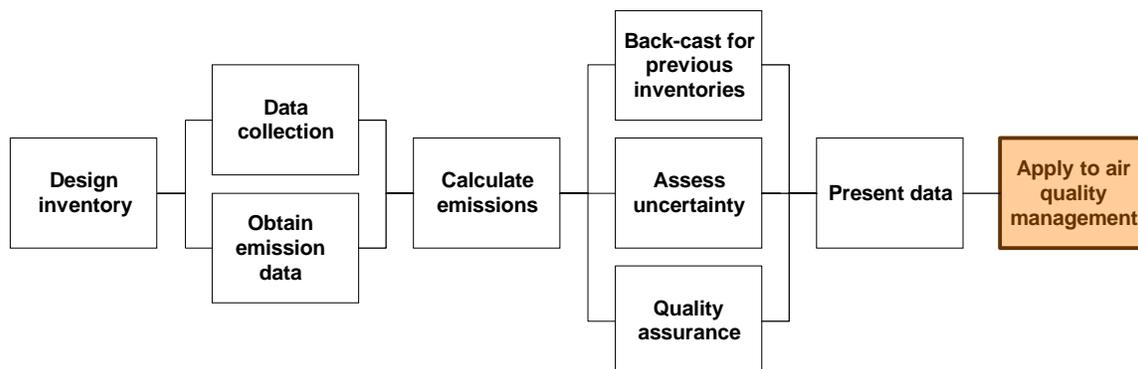
Professional communications and design support can be helpful.

A public presentation should contain an overview of air quality issues and an outline of the role of the emissions inventory in determining sources of emissions to air. It should answer the questions relevant to the audience: why was this work carried out and what does it mean to me? The implications of the results for future air quality management decisions should be outlined.

Media campaigns should aim to answer the same questions. Technical accuracy is paramount, but care must be taken that information is not presented in an overly technical manner. The use of simple pie charts, graphs, maps and photographs that can be provided in both electronic or hard copy form is recommended, along with the use of plain English press material.

In-house briefings to staff who are not directly involved with the project, may help an organisation's air quality initiatives gain wider acceptance. A sample fact sheet, outlining the results of the 1996 Timaru emission inventory is illustrated in appendix four.

11 Apply to air quality management



The final task in the emission inventory process is applying the results to air quality management. Section 1.3 of this report summarises the way that an emission inventory can be used as an air quality management tool and section 1.2.6 details how an emission inventory can be used in conjunction with other tools to manage air quality.

One aspect of the application of an emission inventory to air quality management is the projection of the emission estimates into the future. Such projections are very useful to the management of air quality as they can provide indicators of potential problems and can assist in the assessment of the effectiveness of regulatory options. However, projections rely on predictions of trends and are no substitute for conducting a proper inventory. The case study below is an example of the application of an emission inventory as a management tool. This case study also highlights the need for the ongoing assessment of emissions via an emission inventory.

Case Study – Air quality management in Christchurch

Key issues: In Christchurch concentrations of PM₁₀ regularly exceed guideline concentrations and have been identified by Environment Canterbury as the priority air quality issue.

Monitoring sites: The main air quality monitoring site in Christchurch is in St Albans and is a neighbourhood/ residential site (table 1.3).

Air quality target: 24-hour average PM₁₀ concentration of 50 µg m⁻³, not to be exceeded on more than one occasion per year.

Reduction required: The reduction required was calculated based on reducing the 99.7 percentile concentration measured at the St Albans monitoring site during the years 1988 to 1997 to 50 µg m⁻³. This indicated a 74% reduction in PM₁₀ concentrations was required.

1996 Inventory results: An emission inventory was prepared in 1996 by NIWA (CRC, 1998). This examined emissions from motor vehicles, industry and domestic heating. Results indicated that domestic heating contributed 83% of the PM₁₀ emissions. Open fires burning wood and coal contributed almost half of the emissions from domestic heating.

Assessment of the effect of meteorology: A box model was prepared by NIWA (CRC, 1997) that showed the relationship between emissions and concentrations under meteorological conditions conducive to high pollution.

Assessment of the effectiveness of different management options: The effectiveness of different management options relative to the status quo option were assessed based on projections of existing trends and information on factors that might influence emissions, such as increases in electricity prices. Weighting factors were used to account for the effect of the time of day that emissions occurred relative to meteorological conditions. From this analysis it was determined that the solid fuel burner emission standard should be lowered to 1.5 g/kg, that open fires should be banned, that non-complying burners should be replaced 15 years after installation and that, combined with an education campaign encouraging households away from solid fuel burning, these measures should be adequate to meet the air quality target (Foster, 1998).

Cost/Benefit analysis: The costs associated with different management options were assessed and compared to the benefits (expressed as a percentage reduction in PM₁₀ compared to the status quo option). Options were then ordered in terms of most to least cost effective (Ball, 1998).

Draft plan preparation: In 1998 a draft plan was prepared that included the regulations indicated above. Submissions on the plan were received and heard during 1999.

1999 emission inventory: In 1999 the emission inventory for Christchurch was repeated. Results showed an increase in the number of households using solid fuel burning from 42,000 in 1996 to 52,000 in 1999. Re-analysis based on these data indicated that the management options proposed in the draft air plan would no longer be adequate to reduce PM₁₀ concentrations to meet the target (Wilton, 2000).

Plan preparation: Additional measures to reduce the number of households in Christchurch using solid fuel burning are to be integrated into the air plan.

This guide recommends that you:

Conduct an emission inventory every 3-5 years

References

Ball R., 1998. An economic analysis of options to reduce suspended particulate from domestic burning in Christchurch. Canterbury Regional Council report R98/9.

Canterbury Regional Council, 1998. Christchurch inventory of total emissions. Canterbury Regional Council report R98/20.

Environment Waikato. 1998, Emission inventory for domestic heating. Environment Waikato.

EPA, 1998. Air emissions inventory for the Port Phillips Region. Environmental Protection Authority publication number 632.

Foster E, 1998. Reductions in suspended particulate concentrations in Christchurch. Canterbury Regional Council report R98/2.

Lamb C, 1999. Christchurch home heating survey, A survey of domestic home heating methods and fuels in the Christchurch metropolitan area. Environment Canterbury report U00/34.

Ministry for the Environment, 1997. Environmental Performance Indicators, Proposals for air, fresh water, and land. Ministry for the Environment.

Ministry for the Environment, 2000. New Zealand inventory of dioxin emissions to air, land and water, and reservoir sources. Ministry for the Environment.

Ministry for the Environment, 2000. Good Practice Guide for Monitoring and Data Management. Ministry for the Environment.

Ministry of Transport, 1998. Traffic network analysis; development of an integrated environmental capacity analysis procedure. A technical report compiled by the Ministry of Transport in support of the Vehicle Fleet Emission Control Strategy. Ministry of Transport.

Ministry of Transport, 2000. Environmental Capacity Analysis; Case Study Application to Christchurch. Ministry of Transport.

Topping, J, 1971. Errors of observation and their treatment (3rd Ed.). Chapman and Hall Ltd, England.

USEPA 1994. Emission inventory quality assurance system users manual, <http://www.epa.gov/ttn/chief/nti/index.html> 6 December 2000.

USEPA, 1999. Great Lakes Regional Air Toxic Emission Inventory Report, Initial inventory using 1993 data. USEPA.

USEPA, 1999. Emission inventory guidance for implementation of ozone and particulate matter national ambient air quality standards (NAAQS) and Regional Haze regulations. USEPA.

Wilton E, 2000. Comparison of 1996 and 1999 Emission Inventory Survey Results. Canterbury Regional Council, U00/24.

Appendices

Appendix one: Example domestic heating questionnaire

(adapted from 1999 Christchurch emission inventory questionnaire (Lamb, 1999))

Home Heating Questionnaire

Good morning / afternoon/evening my name is _____ and I am calling on behalf of the _____ Council. May I please speak to an adult in your household who knows about your home heating?

We are currently undertaking a survey in your area on methods of home heating. We wish to know what you use **to heat your main living area, on a typical winter's day, and night.**

TICK THOSE WHICH APPLY & WHERE APPLICABLE PLACE THE NUMBER IN BRACKETS

(BY THE ANSWER) IN THE BOX.

1. MAP CODE _____
MAP ZONE _____
2. (a) Do you use an open fire (**includes a visor fireplace**) in your **MAIN** living area on a **TYPICAL Winter's day or night**? YES (1) [] NO(0) [] *If NO GO TO Question 3.*
 - (b) Do you use it
 - i. In the morning (between 6am and 10 am) YES (1) [] NO (0) []
 - ii. Day time (between 10am and 4pm) YES (1) [] NO (0) []
 - iii. Evening (between 4pm and 10pm) YES (1) [] NO (0) []
 - iv. Overnight (between 10pm and 6am) YES (1) [] NO (0) []

(c) Which months of the year do you typically use your open fire ? (*tick boxes for months indicated*)

<input type="checkbox"/> Jan	<input type="checkbox"/> Feb	<input type="checkbox"/> March	<input type="checkbox"/> April	<input type="checkbox"/> May	<input type="checkbox"/> June
<input type="checkbox"/> July	<input type="checkbox"/> Aug	<input type="checkbox"/> Sept	<input type="checkbox"/> Oct	<input type="checkbox"/> Nov	<input type="checkbox"/> Dec

- (c) Do you use wood on your open fire? YES (1) [] NO (0) [] *If NO GO TO Part (f).*
- (d) How much wood do you use per day during the winter? (*ask them how many pieces of wood (logs) they use on an average winter's day*) _____
- (e) Do you buy your wood from a wood merchant or collect it yourself ? BUY IT(1) [] COLLECT IT (2) [] BOTH (3) [] *If BOTH ask %Collected _____ % Bought _____*

If NO summer months (Nov – Jan incl.) are indicated in question (c) GO TO Question (g).

- (f) How much wood do you use per day during the summer? (*ask them how many pieces of wood (logs) they use on a typical summer's day*) _____
- (g) Do you use coal on your open fire? YES (1) [] NO(0) [] *If NO GO TO Question 3.*

- (g) How much coal do you use per day during the winter ? (*ask them how many buckets of coal they use on an average winter's day*) _____
- (h) What type of coal do you use? _____

If NO summer months (Nov – Jan incl.) are indicated in question (c) GO TO Question 3.

(i) How much coal do you use per day during the summer? (*ask them how many buckets of coal they use on a typical summer's day*) _____

3. (a) Do you use **any type** of electrical heating **in your MAIN living area on a TYPICAL winter's day or night**? **YES (1)** [] **NO(0)** [] *If NO GO TO Question 4.*

- (b) Do you use it
- | | | | |
|------|--|---|--|
| i. | In the morning (between 6am and 10 am) | YES (1) [<input type="checkbox"/>] | NO (0) [<input type="checkbox"/>] |
| ii. | Day time (between 10am and 4pm) | YES (1) [<input type="checkbox"/>] | NO (0) [<input type="checkbox"/>] |
| iii. | Evening (between 4pm and 10pm) | YES (1) [<input type="checkbox"/>] | NO (0) [<input type="checkbox"/>] |
| iv. | Overnight (between 10pm and 6am) | YES (1) [<input type="checkbox"/>] | NO (0) [<input type="checkbox"/>] |

4. (a) Do you use **any type** of gas heating **in your MAIN living area on a TYPICAL winter's day or night**? **YES (1)** [] **NO (0)**[] *If NO GO TO Question 5.*

(b) Is it **flued or unflued** gas heating? **FLUED (1)** [] **UNFLUED(2)** [] **BOTH (3)** []

- (c) Do you use it
- | | | | |
|------|--|---|--|
| i. | In the morning (between 6am and 10 am) | YES (1) [<input type="checkbox"/>] | NO (0) [<input type="checkbox"/>] |
| ii. | Day time (between 10am and 4pm) | YES (1) [<input type="checkbox"/>] | NO (0) [<input type="checkbox"/>] |
| iii. | Evening (between 4pm and 10pm) | YES (1) [<input type="checkbox"/>] | NO (0) [<input type="checkbox"/>] |
| iv. | Overnight (between 10pm and 6am) | YES (1) [<input type="checkbox"/>] | NO (0) [<input type="checkbox"/>] |

(d) How much gas do you use? (*ask them for the size of the gas bottles(s) and how often they would refill them*)-(sizes are 2kg, 2.5kg, 3kg, 4.5kg, 9kg, 18kg, 20kg, 45kg, 90kg)

Size#1 _____ Freq#1 _____
 Size#2 _____ Freq#2 _____

5. (a) Do you use a log burner? (*This is not a multi fuel burner ie does not burn coal*) in your MAIN living area on a TYPICAL winter's day or night. YES (1) [] NO (0) [] *If NO GO TO Question 6.*

(b) How old is your log burner? Pre 1990 (1) [] 1990-95 (2) [] Post 95 (3) []

(c) Do you use it

- i. In the morning (between 6am and 10am) YES (1) [] NO (0) []
- ii. Day time (between 10am and 4pm) YES (1) [] NO (0) []
- iii. Evening (between 4pm and 10pm) YES (1) [] NO (0) []
- iv. Overnight (between 10pm and 6am) YES (1) [] NO (0) []

(d) Which months of the year do you typically use your log burner ? (*tick boxes for months indicated*)

<input type="checkbox"/> Jan	<input type="checkbox"/> Feb	<input type="checkbox"/> March	<input type="checkbox"/> April	<input type="checkbox"/> May	<input type="checkbox"/> June
<input type="checkbox"/> July	<input type="checkbox"/> Aug	<input type="checkbox"/> Sept	<input type="checkbox"/> Oct	<input type="checkbox"/> Nov	<input type="checkbox"/> Dec

(e) How much wood do you use per day during the winter? (*ask them how many pieces of wood (logs) they use on an average winter's day*) _____

(f) Do you buy your wood from a wood merchant or collect it yourself ?
 BUY IT (1) [] COLLECT IT (2) [] BOTH (3) []
If BOTH ask %Collected _____ % Bought _____

If NO summer months (Nov – Jan incl.) are indicated in question (5d) GO TO Question 6.

(f) How much wood do you use per day during the summer? (*ask them how many pieces of wood (logs) they use on a typical summer's day*) _____

6. (a) Do you use a burner which burns coal as well as wood - ie a multi fuel burner (*This includes incinerators, pot belly stoves, McKay space heaters etc.*) in your MAIN living area on a TYPICAL Winter's day or night? YES (1) [] NO (0) [] *If NO GO TO Question 7*

(b) How old is your multi fuel burner? Pre 1990 (1) [] 1990-95 (2) [] Post 95 (3) []

(c) What type of multi fuel burner is it? _____

(d) Do you use it

- i. In the morning (between 6am and 10 am) YES (1) [] NO (0) []
- ii. Day time (between 10am and 4pm) YES (1) [] NO (0) []
- iii. Evening (between 4pm and 10pm) YES (1) [] NO (0) []
- iv. Overnight (between 10pm and 6am) YES (1) [] NO (0) []

(e) Which months of the year do you typically use your multi fuel burner ? (*tick boxes*)

<input type="checkbox"/> Jan	<input type="checkbox"/> Feb	<input type="checkbox"/> March	<input type="checkbox"/> April	<input type="checkbox"/> May	<input type="checkbox"/> June
<input type="checkbox"/> July	<input type="checkbox"/> Aug	<input type="checkbox"/> Sept	<input type="checkbox"/> Oct	<input type="checkbox"/> Nov	<input type="checkbox"/> Dec

(f) How much wood do you use per day during the winter? (*ask them how many pieces of wood (logs) they use on an average winter's day*) _____

(g) Do you buy your wood from a wood merchant or collect it yourself ?

BUY IT (1) [] COLLECT IT (2) [] BOTH (3) []
If BOTH ask %Collected _____ % Bought _____

If NO summer months (Nov – Jan incl.) are indicated in question (6e) GO TO Question (i).

(h) How much wood do you use per day during the summer? (*ask them how many pieces of wood (logs) they use on a typical summers day*) _____

(i) Do you use coal on your multi fuel burner? **YES (1) [] NO (0) []** ***If NO GO TO Question 7.***

(j) How much coal do you use per day during the winter? (*ask them how many buckets of coal they use on an average Winters day*) _____

(k) What type of coal do you use? _____

If NO summer months (Nov – Jan incl.) are indicated in question (6e) GO TO Question 7.

(h) How much coal do you use per day during the summer? (*ask them how many buckets of coal they use on a typical summer's day*) _____

7. (a) Do you use an oil fired heating system **in your MAIN living area on a TYPICAL Winter's day or night?** **YES (1) [] NO(0) []** ***If NO GO TO END.***

(b) Do you use it

- i. In the morning (between 6am and 10 am) **YES (1) [] NO (0) []**
- ii. Day time (between 10am and 4pm) **YES (1) [] NO (0) []**
- iii. Evening (between 4pm and 10pm) **YES (1) [] NO (0) []**
- iv. Overnight (between 10pm and 6am) **YES (1) [] NO (0) []**

(c) How much oil do you use? _____

(END)

THANK YOU VERY MUCH FOR YOUR HELP WITH THIS SURVEY.

Appendix two: Example industrial use questionnaire

Emissions Inventory - Industrial Questionnaire

Company Name _____

Resource consent No: _____

Map reference: _____

Plant Address: _____

Postal Address _____

Person completing Questionnaire _____

Contact Phone No. _____ Fax No. _____

Q1. Nature of business: _____
(e.g., textile manufacture, fertiliser production)

Q2a. Please tick box for each type of discharge

- | | | |
|---|---|--|
| <input type="checkbox"/> Coal boiler | <input type="checkbox"/> Foundry | <input type="checkbox"/> Fibre glassing |
| <input type="checkbox"/> Diesel boiler | <input type="checkbox"/> Automotive spray painting | <input type="checkbox"/> Powder coating |
| <input type="checkbox"/> LPG boiler | <input type="checkbox"/> Architectural spray painting | <input type="checkbox"/> Adhesive coatings |
| <input type="checkbox"/> LFO boiler | <input type="checkbox"/> Printing | <input type="checkbox"/> Manufacture rubber products |
| <input type="checkbox"/> Wood burner | <input type="checkbox"/> Quarrying | <input type="checkbox"/> Seed cleaning |
| <input type="checkbox"/> Incinerator | <input type="checkbox"/> Meat smoking | <input type="checkbox"/> Seed handling |
| <input type="checkbox"/> Waste oil burner | <input type="checkbox"/> Abrasive blasting | <input type="checkbox"/> Can coating |
| <input type="checkbox"/> Diesel generator | | <input type="checkbox"/> Other _____(specify) |

Q2b. For coal combustion please indicate the type of boiler e.g., chain grate, vekos, underfeed stoker, low ram etc. _____

Q2c. For a diesel generator please specify the heat output: _____

Q3. Attachment one details the type of information required for each discharge type listed in **Q2**. For each discharge from your operation, please estimate the annual amount of materials consumed/ produced etc. as per attachment one. *(tonnes/year, litre/year, kilogram/year, etc.)*

Discharge type e.g., spray painting	Type of control equipment (if applicable) e.g., baghouse filter	Material type e.g., paint consumed	Annual Quantity e.g., 500 litres/year
1.			
2.			
3.			
4.			
5.			
6.			

Q4. Seasonal variation:

If the quantity indicated in **Q3** varies throughout the year, please indicate the percentage of the total that occurs in each of the four periods below *e.g. Sept-Nov 10%, Dec-Feb 10%, Mar-May 30%, Jun-Aug 50%*

Discharge type	Sept - Nov	Dec-Feb	Mar-May	Jun-Aug
1.				
2.				
3.				
4.				
5.				
6.				

Q5. If the emissions from any processes have been measured please outline below and attach emission test data if available.

Discharge type	Compounds measured	Discharge rate	Tested by:
<i>e.g, coal boiler</i>	<i>particles (TSP)</i>	<i>0.2 kg/hour</i>	<i>ESR</i>
1.			
2.			
3.			
4.			
5.			
6.			

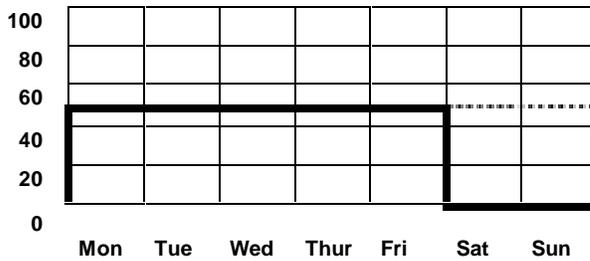
Q6. For each discharge type indicated in Q2, please fill in the following form indicating variations in the quantity of material (e.g., paint used) identified in Q3.

Discharge type _____
 (e.g., spray painting, diesel boiler, seed cleaning)

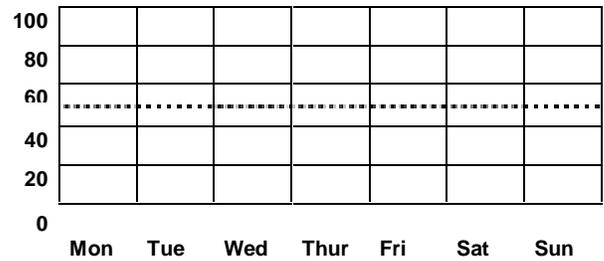
Q6a. What is the typical daily quantity of material used/ produced (i.e., units used in Q3)

If this varies throughout the week please illustrate this variation in the following pictures assuming the value given in Q6a represents 50%. If variations occur, but are not consistent from one week to the next, show a constant use for those periods.

The example shown indicates a constant use Monday to Friday with no weekend usage.

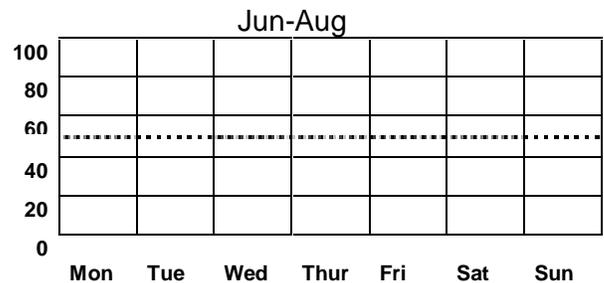
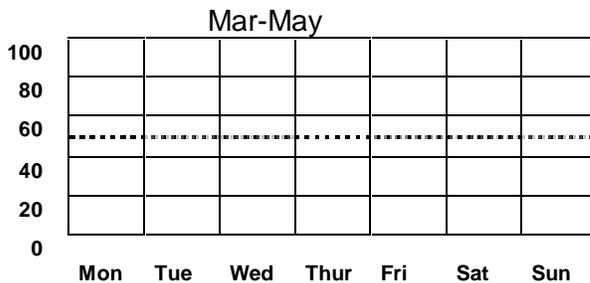
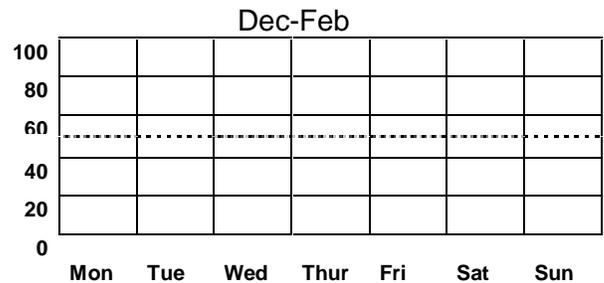
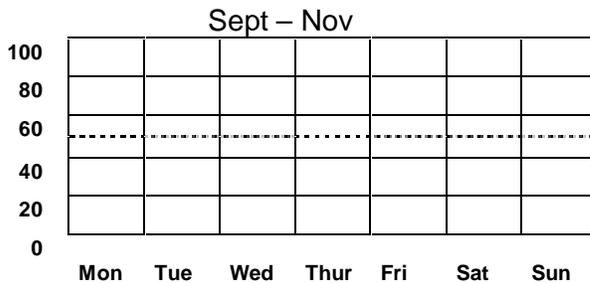


EXAMPLE



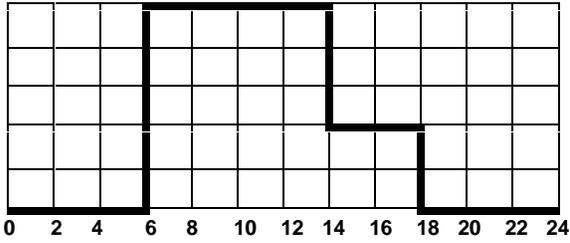
ACTUAL

If this weekly use pattern varies with season please indicate the weekly pattern for each season in the following diagrams.

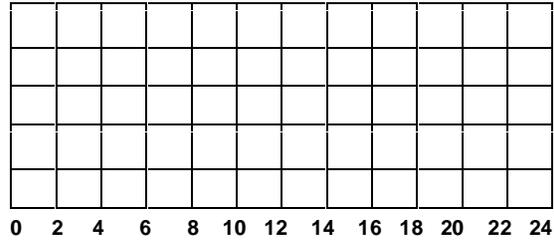


Q6b. Daily variations

Please estimate the variation throughout the day. The example shown indicates a constant use rate for the hours 6am to 2pm with a reduced use rate from 2pm to 6pm (time is given at the bottom of the diagram in 24 hour clock).



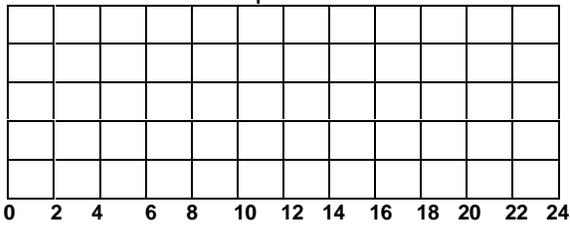
EXAMPLE



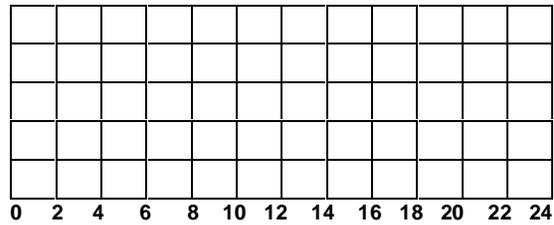
ACTUAL

If this daily use pattern varies with season please indicate the pattern for each season in the following diagrams.

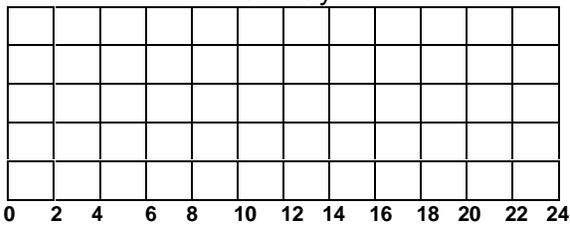
Sept – Nov



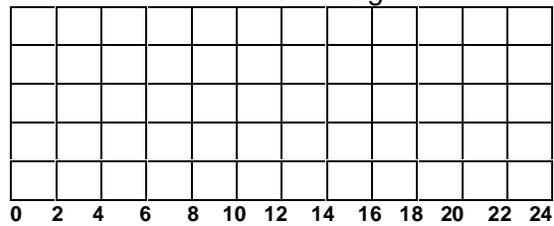
Dec-Feb



Mar-May



Jun-Aug



Industry survey information - attachment one

Discharge type	Type of activity data required	Other data required
Abrasive blasting	Quantity of abrasive material used	Type of material e.g., sand, garnet or metal
Adhesive coatings	Tonnes of adhesive used	Proportion that is solvent
Aggregate handling and storage piles	Tonnes of material transferred	Type of material, mean wind speed
Asphalt plants	Tonnes of product produced	Process type e.g., batch mix or drum mix, type of control equipment e.g., venturi scrubber
Brewing of beer	m ³ of beer produced	
Can coating	Tonnes of solvent used and not recovered	Type of can e.g., two or three piece
Coal fired boiler	Tonnes of coal burnt	Type of boiler e.g., chain grate, vekos, underfeed stoker etc
Diesel boiler	Litres or tonnes of diesel burnt	
Diesel generator	Heat output of the generator (kW or kVa)	
Fibre glassing and polymeric coatings of substrates	Tonnes of coating applied	Solvent content or coating type, and control technology e.g, condenser
Foundary	Tonnes of metal melted	Type of metal, type of furnace, type of control equipment (e.g., baghouse filter)
Incinerators	Quantity of material burnt	Type of material, control equipment
Light fuel oil (LFO) boilers	Litres or tonnes of LFO burnt	
LPG boilers	Tonnes of LPG burnt	
Manufacture of PET (polyethylene Terephthalate)	Tonnes of product	Use of spray condensers
Meat smoking	Tonnes of wood used to prepare smoke	Batch or continuous process, control equipment e.g., wet scrubber and de-mister
Pneumatic conveying	Hours conveying occurs and quantity (m ²) of material conveyed	Type of material e.g., wood
Powder coating and other metal coating methods	Area coated	Object being coated i.e., large appliance, metal furniture or miscellaneous, control technology
Printing	Tonnes of ink applied	Type of printing process e.g., web, rotogravure (if available)
Quarrying	Quantity of material processed	Type of material e.g., coal, lime etc, control equipment,
Rubber cement spraying for type retreading	Quantity of material sprayed	Solvent content
Rubber processing	Tonnes of rubber produced	Type of rubber e.g., styrene, spandex etc
Seed cleaning and handling	Tonnes of seed cleaned/ handled	Type of control equipment
Spray painting	Litres of paint applied	Type of activity e.g. automotive, architectural
Textile printing	Tonnes of fabric printed	Proportion of fabric that is printed
Waste oil burners	Litres of tonnes of waste oil burnt	Ash content (note ash content for no. 5 & 6 oils is 15%, waste oil is higher)
Wood fired burners	Tonnes of wood burnt	Type of control equipment, moisture content, fuel type (wood or bark)

Appendix three: Example tender document

Ambient Air Quality

CALL FOR TENDERS

EMISSIONS INVENTORY

Tenders Close _____(time, date, year)

OBJECTIVE:

To produce a comprehensive emissions inventory of discharges to atmosphere from sources within the _____ Region. Pollutants inventoried are to include at least the following contaminants:

- Particulate matter (PM₁₀)
- Carbon monoxide (CO)
- Carbon dioxide (CO₂)
- Sulphur dioxide (SO₂)
- Nitrogen oxides (NO_x)
- Volatile organic compounds (VOCs)



Figure 1: Emission inventory study area

EXPECTED OUTCOMES:

- 1 A report including details of the contribution from different sources to pollutant emissions in ambient air within the area illustrated in figure 1.
- 2 A database containing details of emissions from all sources to an agreed spatial resolution and with capabilities for estimating future emissions.

SPECIFIC TASKS:

1. Design an emission inventory for the area illustrated in figure 1, in consultation with staff of the _____ Council.
2. Obtain activity data, appropriate emission factors and calculate emissions for the agreed sources documenting assumptions and methodology, in accordance with the Ministry for the Environment's good practice guide for preparing emission inventories.
3. Assess changes in methodology since the previous inventory and these changes to the original inventory data where possible to enable an assessment of emission trends.
4. Compile a database of activity data and emissions estimates that will enable the Council to retrieve and illustrate information as needed, for the agreed spatial distribution.

RESOURCES AVAILABLE:

1. Information held by ___ Council relating to land use categories, GIS databases and resource consent files.
2. Approximately ___ days of staff time associated with assistance with the following tasks: _____.

TIMETABLE:

1. The project is required to be completed by _____. Tenders should nominate a specific timetable including commencement and completion dates with provision for progress reports at specified intervals.

BUDGET:

1. The budget for this project is in the range of \$_____ for a lump sum contract.

TERMS OF ENGAGEMENT:

1. It is envisaged that the contract will be let on the basis of the IPENZ Short Form Conditions of Engagement or similar. Alternatives or modifications to the terms of engagement should be specified as part of the tender.

GENERAL INFORMATION REQUIREMENTS

2. Statement of company capability and experience
3. Project Personnel
 - qualifications
 - experience
 - background

- timetable commencement date
- completion date

4. General methodology including database format, data presentation, and proposed sources to be included

5. Costing Information Requirements

Project Labour Fees	hourly rate for personnel
	total labour fees
Other Costs	
Total Cost	

(Please note that this is a lump sum contract, personnel rates have only been requested in case of a need to commission work beyond the scope of the project.)

PRESENTATION OF COSTING

Costing must be presented in tabular form as follows:

Total Cost (excl. GST)	\$
Rates for additional work (excl. GST)	\$
Labour component	\$
Disbursements (itemised)	\$

CRITERIA FOR ASSESSING TENDERS

The tenders will be assessed on the basis of a number of criteria. Each criterion will be rated from 1 to 10 (10 being the best score from the Council’s perspective, i.e. cheapest cost, most experienced personnel and best methodology and outputs). Weightings will be applied to provide a total value for each tender. The criteria and their weightings are as follows:

Company experience and personnel	0.4
Tendered total cost and costs for additional work	0.2
General methodology and outputs (including timetable)	0.4

TENDER SUBMISSION

Tenders must be in a sealed envelope, clearly marked “Tender for Emissions Inventory”, and submitted to _____ before _____ (*time, date, year*)

Appendix four: Example fact sheet

The sources and amounts of

AIR POLLUTANTS

The Timaru emissions inventory identifies the sources and estimates the amounts of contaminants discharged into the air. The study was conducted for Environment Canterbury by NIWA (National Institute of Water and Atmospheric Research). It looked at six common air contaminants: suspended particulate (PM₁₀), carbon dioxide, sulphur oxides, nitrogen oxides, carbon monoxide and volatile organic compounds.

The contaminant of most concern is suspended particulate because of the frequency and extent to which it exceeds health guidelines.

Health effects associated with high concentrations of PM₁₀ range from minor irritations of the eyes and nose to the premature death of people with serious heart and lung conditions. Small children and the elderly are particularly sensitive.

The Timaru emissions inventory made the following findings:

- Domestic home fires and woodburners are the major source of PM₁₀ in Timaru.
- On a typical winter's day, 90 tonnes of wood and 12 tonnes of coal are burned in Timaru. Home fires pump out an average of over a tonne of suspended particulate every day.
- Research shows that in the urban areas of Timaru, 88 per cent of PM₁₀ emissions come from home heating, six per cent from industry and six per cent from vehicles.
- The emissions inventory identified how Timaru people heat their homes. It discovered most people use more than one source: electricity (63%); woodburners (43%); gas (24%) and open fires (10%).
- Some 72 per cent of solid fuel users burn wood or coal on woodburners; 17 per cent on open fires and the rest on other solid fuel burners.

For more information about air pollution, contact customer services on (03) 365 3828 or 0800 EC INFO (32 4636). Leaflets and other printed information can be obtained from Environment Canterbury's office at 75 Church Street, Timaru. You can also visit the council's Internet site at www.ecan.govt.nz. The website contains an air quality educational section.