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COMPONENT 2

DATA COLLECTION & PROCESSING

Component 1: Project Management & Communication

Component 2: Data Collection & Processing

Component 3: Data Integration & Interpretation

Adaptive Management

Module 2.1 Air Quality Measurements

Module 2.2 Meteorological Measurements

Module 2.3 Emissions Studies

Module 2.4 Soil, Water, Plant and Animal Impacts

Module 2.5 Community Data Collection & Processing

Module 2.6 Stakeholder Database Development

Module 2.7 Contextual Database Development & Maintenance
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COMPONENT 2 – DATA COLLECTION & PROCESSING

Proposal Module 2.1: Air Quality Measurements

1. Rationale

A. The Wagerup Refinery is a source of gaseous and particulate (aerosol) emissions. A careful and detailed monitoring study is required to accurately assess the impact of emissions from the Refinery on air quality in the surrounding areas (in particular, the Yarloop township), and whether such emissions are associated with resident complaints of odour, and adverse effects on health and lifestyle. Because both aerosol and gaseous emissions may potentially influence the composition of rainwater, through the scavenging of pollutants by clouds or falling rain drops, monitoring of rainwater composition will be undertaken.

B. The current study will seek to investigate all the major meteorological, physical, chemical pathways through which refinery emissions could potentially influence aerosol, gas and rainwater composition in the area. These include dispersed stack and fugitive emissions, uplifting of dust from the residue drying area (RDA), degassing from water bodies, as well as scavenging of pollutants by precipitation.

C. Whilst there have been previous attempts to study the potential influence of Wagerup on air quality in the Yarloop area, the current study will seek to more comprehensively characterise the composition of aerosol, gas, rainwater and dustfall samples using a larger suite of techniques with higher sensitivities. This should characterise the chemical mixture that occurs during events. In addition, the collection of samples during the study over a greater period of time than has occurred previously will enable a more statistically robust assessment to be made about the contribution and potential impacts of refinery emissions on air and rainwater quality in Yarloop.

D. An important issue that needs to be addressed by any monitoring study in the Yarloop area is that air pollution events are often reported by residents to be highly transitory in space and time. The current study will seek to monitor the physical and chemical characteristics of individual plumes using a variety of “online” instruments capable of collecting data at very high time resolution.

E. There can be no guarantee that the study will identify the pollutants associated with residents’ complaints of odour, and adverse effects on health and lifestyle. What can be achieved is a far more extensive and thorough study as outlined in paragraphs B, C and D above.

2. Define Inputs and Outputs

A. Inputs: Results from the modelling (see Module 3.1 "Meteorological and Pollutant Dispersion Modelling") and community input (Module 2.5 “Community Data Collection & Processing”) will be used to guide the selection of appropriate sites for the aerosol, gas, rainwater and dustfall sampling.
Interaction and input from a toxicologist and other relevant health professionals will be used to inform the measurement program from their perspective. Activation of wind-direction aerosol and gas samplers will be based on meteorological measurements (see Module 2.2 “Meteorological Measurements”).

B. Outputs: An extensive, mainly continuous, data set on air quality covering aerosol and gases of 1-minute resolution, rainwater and dustfall measurements for four sites south of and two sites north of the Wagerup Refinery, with approximately two months data at each site. (Outputs to Modules 2.4 “Soil, Water, Plant and Animal Impacts”, 3.1 “Meteorological and Pollutant Dispersion Modelling”, and 3.4 “Integrated Current Assessment”).

3. Objectives

A. To provide chemical analysis of air pollution events identified by the community
B. To provide chemical analysis of the pollutants in the air in the region originating from the Wagerup Refinery
C. To provide information on these pollutants in the air in the region originating from other natural and human-induced sources

4. Methodology

Previous studies in the Wagerup/ Yarloop district have not identified the pollutants causing the odour and adverse effects on health and lifestyle. This study will use the most modern measurement techniques available to CSIRO to search for the pollutants, but it is the nature of scientific research that there cannot be a guarantee that pollutants in the air of the district around Wagerup causing these effects will be identified.

Key aspects of this study

The key aspects of the methodology are:
- the pollutants to be measured
- the meteorological processes involved in the pollution events
- the methods to be used to identify sources
- the frequency of measurements
- the locations of measurements

The measurement program is to be evolving and adaptive, taking into account new information as it progresses. The following outline is based on our understanding of the knowledge currently available about this problem.

The pollutants that we recommend to be measured are:

- Gases: An extensive range of volatile and semi-volatile organic compounds (gases) including hydrocarbons, carbonyls, alcohols, acids, halogenated
species, sulfur and nitrogen containing compounds. This will be done using multi-compound techniques, such as mass spectrometry, that can detect whole suites of species, not necessarily anticipated prior to the analyses. Air samples may also be collected in bags during events for the measurement of odour intensity if suitable facilities for odour intensity measurement in Western Australia are available.

- **Aerosol**: Continuous monitoring of aerosol scattering and PM10 to provide data on aerosol loadings at a very high time resolution. This may be important given the transitory nature of the irritant/odorous plumes. Collection of aerosol samples for detailed examination of aerosol composition, including the PM2.5 aerosol fraction, which is the most efficient at penetrating the human respiratory system and, therefore, potentially the most dangerous to human health. A range of organic species (including adsorbed compounds) will be investigated.

- **Other**: Collection of dust and rainwater samples with analyses for organic and inorganic compounds.

These measurements should characterise the chemical mixture that occurs during events.

To thoroughly investigate the impact of emissions to the atmosphere from the Wagerup Refinery on the surrounding region, the meteorological pathways of transport from the Refinery to the region should be identified. From a preliminary examination of the available observations and other information, six possible pathways have been identified. These are:

- stack emissions plus atmospheric fumigation via convection
- stack emissions plus entrainment in escarpment flows
- stack emissions plus plume meandering
- fugitive emissions from the plant on water bodies near ground level plus atmospheric dispersion
- wind driven emissions from the RDA plus atmospheric dispersion
- entrainment of the plume into rain-bearing clouds and subsequent transport of pollutants to the surface in rainwater

This list is not exclusive, however it does highlight the major pathways to be investigated at the commencement of this study. The methodology and measurement program presented here are designed to maximise the possibility that adequate information is obtained to quantify the pollutants in the region that arrive by each of these pathways.

The identification of the sources that are contributing to any air pollution event observed at a sampling site will be based on a combination of appropriate meteorology (wind direction, wind shear, mixing) and chemical emissions indicators. The primary indicators will be nitrogen oxides (NOx), carbon dioxide (CO2), a nephelometer and tapered element oscillating microbalance (TEOM) for aerosol detection with carbon monoxide (CO) as a secondary indicator. These gases are not thought to be the cause of any odour or health effects but are convenient chemical
markers of the emissions into the air. The method used for indicators is to measure the concentrations of the three gases and to determine the ratio of the enhanced concentrations of these gases that contribute to peaks in concentration. From source studies such as result in the data in Table 1, the typical ratios from different sources are known, and the likely source or sources contributing to a pollution event can be identified. There will be interference of other local sources for these gases including emissions from bushfires, combustion heaters, motor vehicles and other internal combustion engines. However, as shown in Table 1, the different sources can be identified if measurements with adequate precision are made. This technique, combined with meteorological observations, should provide an identification of the emission sources contributing to any significant air pollution events in the district around Wagerup.

<table>
<thead>
<tr>
<th>Source</th>
<th>CO₂/NOₓ</th>
<th>CO/NOₓ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calciner 1 to 3 &amp; Liquor Burner</td>
<td>1540</td>
<td>3.4</td>
</tr>
<tr>
<td>Boilers 1 to 3</td>
<td>530</td>
<td>0.1</td>
</tr>
<tr>
<td>Motor vehicles</td>
<td>210</td>
<td>15</td>
</tr>
<tr>
<td>Biomass burning</td>
<td>280</td>
<td>22</td>
</tr>
</tbody>
</table>

The duration of sampling depends on the frequency of occurrence of pollution events at a fixed location and the number of events that are to be sampled. Preliminary meteorological modelling (Module 3.1 “Meteorological and Pollutant Dispersion Modelling”) indicates that there will be between five events per two months (with indicator concentrations of NOₓ 8 ppb or greater; CO 20 ppb or greater; CO₂ 14 ppm or greater) and two events per week (the latter with indicator concentrations of NOₓ 4 ppb or greater; CO 10 ppb or greater; CO₂ 7 ppm or greater) at fixed locations selected in the vicinity of Yarloop. A large fraction of these events will occur mid-morning and others in the late afternoon and evening. Given this infrequency in encountering events, our opinion is that continuous measurements are necessary to capture the composition of the pollution events. Six to eight months of fully operational continuous measurements in the vicinity of Yarloop and four months continuous measurements north of the refinery near Hamel would provide an unequivocal record of the chemical composition of the pollution events both south and north of the Refinery with 15 to 20 and 10 events characterised, respectively. Not all events will be captured, as even with routine monitoring a data loss of 10% is acceptable.³⁷

Four sites around Yarloop are being considered as measurement locations. The three sites closer to the Refinery are in areas known to have a significant record of air pollution events. The fourth site is within the Yarloop township. The locations of the sites are: one due south of the Refinery at the northern end of the Yarloop community; one on the edge of the escarpment south east of the Refinery, and two on

³⁷ National Environmental Protection Measure for Ambient Air Quality, 1998.
the western side of the Highway, one closer to the Refinery and one in the Yarloop township. The locations where the continuous measurements are to be conducted should have a clear fetch in the direction of the Refinery, without houses or major roadways for around 100m upwind in the direction of the Refinery. One set of monitoring equipment would be used and located for two months under full operation at each location.

A key objective of this study is the relating of this air quality data to community identification of air pollution events. Given that the plume footprint is narrow and short-lived, it is essential that there are a number of residents maintaining community air quality diaries (Module 2.5 “Community Data Collection & Processing”) within the close vicinity of the monitoring station. Modelling studies (Module 3.1 “Meteorological and Pollutant Dispersion Modelling”) along with statistical design will be used to determine the optimum number of residents required within a specified area. At the end of each two months of monitoring, the Community Diaries and the air quality data will be analysed along with the meteorological data and air pollution modelling for the period to produce an understandable account of the air pollution for that period.

**Specific methodology**

A. The study will involve the use of a relocatable air quality station fitted with a suite of state-of-the-art sampling devices. The purpose, sampling resolution and detection limit of the instruments are summarised in Table 2, and the post-sampling chemical analyses are detailed in Table 3. The mobile monitoring station will sample at the six different locations in the Wagerup-Yarloop area referred to above over a period of one year (ca. 2 months at each site). Two staff will be based locally to operate the equipment and will be supported by frequent visits by other specialist staff from CAR.

B. The collection of continuous NOx, CO and CO2 data will provide information to assist with the identification and characterisation of air pollution events, and to assess the origin of short-lived air pollution events reported by residents. The available continuous CO monitors that can be reliably operated in the field do not measure as low concentrations, (or have high precision) as would be desirable for this study. The measurements of NOx, CO2 and aerosol will define significant events and provide an indication of their source, including the Refinery, motor vehicle and biomass burning sources, through the observed CO2/NOx ratios. The expected CO/NOx ratios from the measurements will further identify emissions from motor vehicles or biomass burning, thus providing further evidence for these events to be excluded from set the refinery based events. The expected contributions to CO concentration from the Refinery emissions are expected to be at the limit of detection of the CO instrument, and so the Refinery would be identified through the absence in change in the CO/NOx ratio or a decrease in this ratio due to an enhanced NOx signal and negligible change in the CO signal.

C. The collection of an extensive VOC data set will enable us to identify periods when concentrations of any of the measured VOC species are elevated and to determine whether these coincide with any of the following: i) plume events indicated by characteristic CO2/NOx/CO signals, ii) plume events perceived by
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Residents (diary record of nearby residents), iii) periods of high aerosol loadings (as indicated by the nephelometer and TEOM), iv) periods when wind is from the refinery sector, and iv) periods of drizzly overcast conditions. This will assist in determining measured chemical species that are associated with odour and/or health effects or other impacts reported by residents, and determine whether these chemicals are associated with refinery emissions. Initially, VOC sampling will occur via flasks, adsorption tubes, and DNPH filters. This intermittent sampling will be activated by the chemical, meteorological and community indicators. As soon as possible a Proton Transfer Reaction Mass Spectrometer will be bought on line for continuous, high precision measurement of VOCs including hydrocarbons, alcohols, carbonyls, organic acids, and other halogenated, sulphur and nitrogen containing organic compounds.

If chemical species relevant to this study are identified that were not part of the original calibration plan, then calibration tests will be developed where possible.

D. The TEOM and nephelometer measurements will enable the detection of short-lived events with high concentrations of particles, which cannot be achieved using the filter sampling techniques. This data coupled with the diary information from nearby residents will enable an assessment of whether any of the reported short-term health effects (e.g. eye irritation) are associated with elevated concentrations of particles.
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Table 2: Instrumentation to be installed in mobile air quality station

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Purpose</th>
<th>Sampling resolution</th>
<th>Nominal Limit of detection (LOD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO monitor</td>
<td>Continuous measurement of CO</td>
<td>1 min</td>
<td>25 ppbv</td>
</tr>
<tr>
<td>CO2 monitor</td>
<td>Continuous measurement of CO2</td>
<td>1 min</td>
<td>0.1 ppmv</td>
</tr>
<tr>
<td>NOx monitor</td>
<td>Continuous measurement of NOx</td>
<td>1 min</td>
<td>0.2 ppbv</td>
</tr>
<tr>
<td>Proton Transfer Reaction Mass Spectrometer (PTR-MS)</td>
<td>Continuous measurement of VOCs</td>
<td>1 min</td>
<td>200 pptv</td>
</tr>
<tr>
<td>DNPH cartridges</td>
<td>Sampling of gaseous carbonyl compounds</td>
<td>10 min</td>
<td>1 ppbv</td>
</tr>
<tr>
<td>Adsorbent tubes</td>
<td>Sampling of VOCs</td>
<td>10 min</td>
<td>0.4 ppbv</td>
</tr>
<tr>
<td>Acid impingers</td>
<td>Sampling of acidic gases</td>
<td>Multiple event-based (weekly samples)</td>
<td>0.04–0.4 µg m⁻³</td>
</tr>
<tr>
<td>Nephelometer</td>
<td>Continuous measurement of aerosol light scattering coefficient</td>
<td>1 min</td>
<td>1 Mm⁻¹</td>
</tr>
<tr>
<td>Tapered Element Oscillating Microbalance (TEOM)</td>
<td>Continuous measurements of PM10 aerosol mass loading</td>
<td>1 min</td>
<td>3 µg m⁻³ for 1-min avg.</td>
</tr>
<tr>
<td>Electron microscope grid sampler</td>
<td>Collection of aerosol samples during pollution events for elemental/morphological analysis of single particles</td>
<td>10–30 min</td>
<td>Particle Diameter ≥ 0.5µm, elements ≥ 1% of mass</td>
</tr>
<tr>
<td>High volume aerosol samplers (2)</td>
<td>Collection of bulk PM10 aerosol samples on filters for chemical analysis of organic components</td>
<td>Multiple event-based (weekly samples)</td>
<td>See Table 3 for analytical LODs</td>
</tr>
<tr>
<td>Dichotomous Partisol aerosol samplers (2)</td>
<td>Collection of bulk fine and coarse aerosol samples on filters for mass determination and chemical analysis of inorganic components</td>
<td>Multiple event-based (weekly samples)</td>
<td>See Table 3 for analytical LODs</td>
</tr>
<tr>
<td>Automated rainwater sampler</td>
<td>Collection of rain samples</td>
<td>Single rain events (≥ 20 ml)</td>
<td>See Table 3 for analytical LODs</td>
</tr>
</tbody>
</table>
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Table 3: Chemical analyses to be performed on aerosol and rainwater samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Analysis</th>
<th>Limit of detection *</th>
</tr>
</thead>
<tbody>
<tr>
<td>HiVol filters</td>
<td>Organic carbon (OC) and elemental carbon (EC) by thermal combustion</td>
<td>0.31 ( \mu )g OC m(^{-3}), 0.07 ( \mu )g EC m(^{-3})</td>
</tr>
<tr>
<td></td>
<td>Water-soluble organic carbon (WSOC) by thermal combustion</td>
<td>0.06 ( \mu )g WSOC m(^{-3})</td>
</tr>
<tr>
<td></td>
<td>Organic speciation by gas chromatography-mass spectrometry (GC-MS)</td>
<td>0.1 – 6 ng m(^{-3})</td>
</tr>
<tr>
<td>Partisol filters</td>
<td>Mass by gravimetry</td>
<td>5 ( \mu )g m(^{-3})</td>
</tr>
<tr>
<td></td>
<td>Soluble ions by ion chromatography (IC)</td>
<td>0.04 – 0.4 ( \mu )g m(^{-3})</td>
</tr>
<tr>
<td></td>
<td>pH of aqueous extracts</td>
<td>± 0.01 pH units</td>
</tr>
<tr>
<td></td>
<td>Elements by inductively-coupled plasma mass spectrometry (ICP-MS) or Particle-Induced X-ray Emission (PIXE)</td>
<td>7 ng m(^{-3}) for ( Z &gt; 22 ), 90 ng m(^{-3}) for ( Z &lt; 22 )</td>
</tr>
<tr>
<td>Rainwater samples</td>
<td>Soluble ions by IC</td>
<td>0.004 – 0.07 ( \mu )M</td>
</tr>
<tr>
<td></td>
<td>PH of collected rainwater</td>
<td>± 0.01 pH units</td>
</tr>
<tr>
<td></td>
<td>Water-soluble organic carbon WSOC by thermal combustion</td>
<td>0.3 ( \mu )M</td>
</tr>
<tr>
<td></td>
<td>Carboxyls by HPLC</td>
<td>0.1 ( \mu )M</td>
</tr>
</tbody>
</table>

* The reported detection limits for the HiVol and Partisol filter samples are based on a sampling time of 4 h. This equates to a week's worth of refinery-sector sampling in which wind is in the refinery sector 2% of the time.

E. The collection of aerosol samples on electron microscope grids will enable the examination of the morphology and elemental composition of the particles during three types of events: i) plume events indicated by characteristic \( \text{CO}_2/\text{NO}_x/\text{CO} \) signals, ii) events perceived by residents, and iii) periods of high aerosol loadings (as indicated by the TEOM and nephelometer). In order to help assess whether the Refinery is the source of the pollution, samples of calciner dust, alumina and dust from the RDA will also be analysed to see if particles with the same morphology and composition are identifiable in the ambient air samples.

F. One HiVol and one Partisol sampler will sample during periods when wind direction is from the refinery sector, while the other pair of samplers will be activated when wind direction is in the remaining sector. Coupled with the detailed chemical characterisation, this will enable an objective and statistically robust assessment of the extent to which refinery emissions contribute on
average to the measured concentrations of aerosol pollutants in the areas surrounding the Refinery, and whether reported long-term health effects or other impacts may be associated with these emissions.

G. The rainwater sampling and analysis program will enable an objective and statistically robust assessment of the extent to which refinery emissions impact on the chemical composition of rainwater falling in the areas surrounding the Refinery (through scavenging of pollutants). Together with gas monitoring data, the results will be used to test the hypothesis that rain borne transport of pollutants from Wagerup is the cause of reported odour problems during drizzly overcast conditions in Yarloop.

H. In addition to the mobile monitoring station, a series of fixed dustfall sampling devices will be deployed to collect monthly dustfall samples at selected monitoring sites for the duration of the study. The samples will be weighed to determine dustfall rates, and selected samples analysed by electron microscopy to determine their morphology and mineralogical composition. This will enable an assessment of whether emissions from the Refinery complex contribute significantly to dust fall in the surrounding area.

5. Equipment required, operating requirements

A. 1 x Mobile monitoring station  
B. 1 x NOx gas monitor  
C. 1 x CO2 gas monitor  
D. 1 x CO gas monitor  
E. 1 x gas calibrator/zero air generator  
F. 1 x Proton Transfer Reaction Mass Spectrometer (PTR-MS)  
G. 2 x PM10 High-volume aerosol sampler  
H. 2 x Dichotomous Partisol aerosol samplers  
I. 1 x PM10 Tapered Oscillating Microbalance (TEOM)  
J. 1 x Nephelometer  
K. 1 x Automatic rainwater collector  
L. 1 x Electron microscope grid sampler  
M. 2 x DNPH sampling units  
N. 2 x Acid impinger sampling units  
O. 2 x VOC adsorbent tube sampling units  
P. 6 x Dustfall gauges  
Q. 1 x Computer/data acquisition/communications system  
R. 240 V Mains power

6. Staff required

A. Ian Galbally, Rob Gillett, Bim Graham and Simon Bentley will jointly manage this module, install instruments, undertake QC visits, and perform data analysis and interpretation.
B. A research scientist (CSOF4M level) and field technician (CSOF3M level) will help with the installation of equipment, and operate and maintain the samplers for the duration of the study.

C. A visiting scientist (equiv. CSOF6M) will assist with installation and initial operation of the PTR-MS instrument.

D. Paul Selleck will perform the IC, HPLC and pH measurements, Kate Boast will perform the gravimetric analyses, Tom Firestone will perform the thermal analyses, and Ian Weeks and Sarah Lawson will perform the VOC analyses.

7. **Time line**

A. Installation of samplers: week 1 – week 4  
B. Sampling at Hamel site 1: week 5 – week 12  
C. QC visit 1: week 12 – week 13  
D. Sampling at Hamel site 2: week 13 – week 20  
E. QC visit 2: week 20 – week 21  
F. Sampling at Yarloop site 1: week 21 – week 28  
G. QC visit 3: week 28 – week 29  
H. Sampling at Yarloop site 2: week 29 – week 36  
I. QC visit 4: week 36 – week 37  
J. Sampling at Yarloop site 3: week 37 – week 44  
K. QC visit 5: week 44 – week 45  
L. Sampling at Yarloop site 4: week 45 – week 52  
M. Analyses of samples: week 8 – week 56
COMPONENT 2 – DATA COLLECTION & PROCESSING

Proposal Module 2.2: Meteorological Measurements

1. Rationale

Meteorology provides the connection between the emissions and the impact of the plume at the ground; the wind direction determines the direction of travel of the plume and the turbulence in the atmosphere the rate of dilution (mixing) of the plume. Meteorological measurements are a necessary part of the study in order to:

- assist in validating the events detected in the township and at the Air Quality site and relating these back to the refinery emissions;
- use the wind direction to provide an input for triggering the sampling of some compounds at the Air Quality site;
- provide a ground truth for meteorological and pollution modelling;
- provide data input via data assimilation into the modelling (if necessary).

The purpose of this activity is to characterise the meteorology during the various conditions considered likely to be associated with the air pollution events, namely fumigation, downslope flow from the escarpment, plume meandering, the dispersion of fugitive emissions, wind rise of dust from the residual drying areas, and (if feasible) rainfall through the plume.

A. Continuous meteorological measurements at a site yet to be finalised will provide near-surface meteorological data. These are important for determining the local wind direction when events are detected by Yarloop residents (diary entries) or members of the CAR study team. They will also be used for validating the TAPM modelling during both the forecast and hindcast (i.e. data integration) parts of the study.

B. Continuous meteorological measurements at the Air Quality site will provide basic near-surface data, particularly the local wind direction when events are detected by the sampling equipment but also humidity/rainfall/wind speed and temperature. The wind direction measurements will also provide an option for triggering the sampling of some compounds, e.g. turning on specialised sampling equipment when the wind is blowing from the refinery.

C. Radiosonde releases will provide upper-air meteorological data. The radiosondes will be released on a campaign basis (18 days) when synoptic conditions are favourable for odour events. The profiles from the sondes will provide the meteorological data at plume release height, the height of the inversion and wind shear through the boundary layer.

2. Define Inputs and Outputs

A. Inputs: Predictions from TAPM forecasts of conditions likely to be conducive to pollution events. These will be used to plan the radiosonde release times to maximise the amount of relevant data collected by the radiosondes.
B. Outputs:
(i) From the fixed meteorological site: validated meteorological data (wind speed, wind direction, temperature, differential temperature (between 2m and 10m), relative humidity, barometric pressure, rainfall, solar radiation, and net radiation) as 1-minute averages. The differential temperature, radiation and wind speed will be used to estimate the atmospheric stability.
(ii) From the mobile Air Quality site: validated meteorological data (wind speed, wind direction, temperature, relative humidity, and rainfall) as 1-minute averages.
(iii) Processed vertical profiles of wind direction, wind speed and temperature at the times of the radiosonde releases.
(iv) Interpretation of the surface and upper-level meteorological data to describe the meteorological mechanisms associated with the pollution events.

3. Objectives

A. To provide continuous near-surface meteorological data during the study from the fixed meteorological site. This fixed site will include relevant meteorological measurements with data recorded at 1-minute intervals.

B. To provide continuous near-surface meteorological data during the study from the Air Quality site. Data to be recorded at 1-minute intervals.

C. To provide vertical profiles of wind speed, wind direction, temperature, and relative humidity on 18 selected days when meteorological conditions are expected to favour the detection of plume based air pollution events at the AQ sampling site. The focus will be on the first few hundred metres above the ground to include meteorology at plume release height and up to the temperature inversion. This will provide data for describing the mechanisms believed to be associated with plume based pollution events, namely fumigation, downslope flow from the escarpment plume meandering, and (if feasible) rainfall through the plume.

4. Methodology

A. Meteorological data will be collected continuously at the fixed meteorological site. The location, yet to be chosen, will be selected to meet the Australian Standard for the siting of meteorological sensors. Calibrated sensors will be installed for wind speed and direction (at 10 m above ground level), temperature, relative humidity (at 2 m above ground level), differential temperature (between 2 m and 10 m), barometric pressure, rainfall, solar radiation, and net radiation. Data to be recorded continuously throughout the field experiment as 1-minute averages using a data acquisition system with a GSM dial-up connection. Regular data back-up. Validation of data to be performed on a monthly basis and to include inter-comparison with meteorological data from the Air Quality site. All meteorological instruments will be calibrated and operated to Australian Standards where appropriate.
B. A limited set of meteorological parameters will be collected at the (mobile) Air Quality site. Calibrated sensors will be installed for wind speed and direction (at 10 m above ground level), temperature and relative humidity (at 2 m above ground level) and rainfall. Data to be recorded continuously throughout the field experiment as 1-minute averages using the data acquisition system of the AQ site. Regular data back-up as part of the AQ system. Validation of data to be performed on a monthly basis and to include inter-comparison with meteorological data from the Yarloop site. All meteorological instruments are to be calibrated and operated according to Australian Standards where appropriate.

C. Radiosonde ascents (using equipment available from DEWCP) will be made from a suitable site during synoptic conditions favourable to plume based air pollution events as determined from TAPM forecast modelling. Plan radiosonde ascents on 18 suitable days with an initial sounding around sunrise (e.g. 7 am), one at about 11 am, and a final one in the early evening (e.g. 7 pm). A decision on whether to launch the latter two sondes (11 am and 7 pm) will depend on whether or not the wind direction and air quality information from the sampling sites is favourable. Sonde ascent rates will be chosen to be as low as possible to maximise the vertical resolution of data in the first few hundred metres, which is critical for assessing the dispersion of the refinery plumes. The aim is to collect upper-level data for conditions corresponding to 4 of the 6 possible meteorological transport mechanisms (fumigation, downslope flow from the escarpment, plume meandering, the dispersion of fugitive emissions, dust from the residual drying areas, and (if feasible) rainfall through the plume) as only 4 involve the elevated plume. Radiosonde releases are planned for occasions when the AQ site is located to the south and to the north of the refinery, i.e. there are a total of 8 different conditions that need to be characterised. Each of these will require 4 good profiles to give confidence in the results. Assuming a two-thirds success rate for the releases (i.e. allowing for incorrect forecasts, equipment malfunctions, operator error), gives the total number of required releases as 54. Assuming 3 releases per day, this requires 18 days with radiosonde flights.

Results will be processed to produce validated profiles of wind speed, wind direction, temperature and relative humidity. Analysis and interpretation of the results will be undertaken to characterise the meteorological mechanisms associated with the pollution events.

5. Equipment and operating requirements

A. At the Yarloop meteorological site, calibrated sensors will be installed for wind speed and direction (at 10 m above ground level), temperature, relative humidity (at 2 m above ground level), differential temperature (between 2 m and 10 m), barometric pressure, rainfall, solar radiation, and net radiation. The wind sensor will be mounted on top of a pump-up mast with other equipment bolted to the mast. Data acquisition as 1-minute averages with a dial-up data acquisition system and communications module housed in a weatherproof box. Regular data back-up. Site to be surrounded by a mesh fence, 240V power required.
B. At the mobile Air Quality site, calibrated sensors will be installed for wind speed and direction (at 10 m above ground level), temperature and relative humidity (at 2 m above ground level) and rainfall. The 10-m mast for the wind sensor will be attached to the side of the AQ van/hut. Data acquisition as 1-minute averages, integrated with data acquisition equipment in AQ site, regular back-up.

C. Radiosonde equipment from DEWCP including receiver and decoder, storage PC. Approximately 54 radiosondes, balloon gas, equipment and personal for filling and releasing the radiosondes, training in safe use of equipment, approval from CASA for radiosonde releases.

6. Staff required
   
   A. Mark Hibberd to organise meteorological site equipment and installation, and check installation and operation.

   B. Mark Hibberd for logistics of the radiosonde soundings, 2 persons for radiosonde releases.

   C. Simon Bentley for quality control and validation of meteorological data.

7. Time line
   
   A. Meteorological sites – the duration of the study.

   B. Radiosondes – Campaign on 18 selected days during the study.
COMPONENT 2 – DATA COLLECTION & PROCESSING

Proposal Module 2.3: Emissions Studies

1. Rationale

A. As a result of the review of the operating licence for 2002/2003 for the Wagerup Alumina Refinery the Minister for the Environment has imposed a number of requirements on the monitoring of emissions from the Refinery. Previous to this an independent Environmental Audit had identified a number of problems relating to the emissions monitoring that was taking place.

A condition of community acceptance of the outcomes of this Air Quality Study is the development of an independent emissions program that operates for the duration of the proposed Study, complements the monitoring required under the Licence conditions and measures any other compounds that may contribute to the odour/health problem.

B. While the Refinery operation is continuous there are peaks and troughs during its day to day operation. These fluctuations in production could result in varying rates and varying composition of the emissions that are hidden if only occasional sampling is used.

2. Define Inputs and Outputs

A. Inputs. The current Alcoa emissions inventory, the Environmental Audit and the operating licence from the Western Australian Department of Environmental Protection.

B. Outputs: Detailed plan of complementary emissions measurements as a component of the Wagerup Air Quality Study (Modules 1.1 “Independent Management & Coordination”, 1.2 “Project Evaluation”, 1.3 “Project Communication”).

3. Objectives

A. To undertake the design of an air emissions study that will be conducted in coordination with the ongoing emissions monitoring program to ensure that the emissions data obtained during the period of this study is accepted and trusted by

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42 EPA WA (Sept 2002). Conditions of Licence Alcoa World Alumina Australia Pty Ltd. Licence No 6217/6. File No L80/83
the regional community

4. Methodology

A. Review the refinery processes to confirm the existing emissions sampling program, identify opportunities for understanding the day to day variations in the rate and composition of the emissions, and identify tasks required to quantify any significant poorly known sources and poorly or unquantified compounds emitted. Identify the sampling regime necessary to reliably quantify the emissions from the operational range of plant conditions. Produce an integrated emissions sampling design that takes into account Alcoa’s ongoing emissions measurement program and meets the requirements of the local community as well as Alcoa.

5. Equipment required, operating requirements

A. Consistent with health and safety requirements there will be a need to inspect as much of the Refinery as possible in order to be familiar with the process and identify possible emission sources and sampling points.

6. Staff required

A. A CAR team of three scientists expert in air pollution and emissions studies.

7. Time line

A. Within four weeks of the signing by the parties concerned of the agreement to undertake the proposed Air Quality Study two CAR staff members will visit the Wagerup plant site for a period of up to one week. They will undertake a site inspection to familiarise themselves with all aspects of the plant operation and in particular the process sources that require emissions monitoring under the current licence and any other sources of emissions.

B. The two CAR staff members will then spend up to two weeks preparing an air emissions program with the assistance of the senior CAR officer concerned with this aspect of the Study.

C. The plan will be submitted to both the Community Evaluation Group (CEG) and the Study Evaluation Team (SET) no later than one month after the Refinery site visit for feedback.
COMPONENT 2 – DATA COLLECTION & PROCESSING

Proposal Module 2.4: Soil, Water, Plant and Animal Impacts

1. Rationale

A recent report from the Chamber of Mines and Energy of Western Australia Inc noted that:

The Australian public demands a high standard of environmental protection and community consultation. It is only by fulfilling these demands that the minerals industry can hope to have continued access to the resources it needs to continue operating.

A. Air pollution is known to result in the degradation of non-economic parameters such as native plants and animals. A loss of numbers and types of animal or plant species may result in a loss of biodiversity over small areas downwind of major industrial complexes. Alcoa has been operating at Wagerup since 1986, and during that time there has been little or no work to establish baseline data for animal and plant numbers and species type and distribution.

B. As well as effects on native wildlife, air pollution can have negative impacts on domestic animals such as chickens, cattle, and sheep, and on crops and garden plants. This is an issue that is of pressing concern to members of the local community since it directly affects the economic viability of local farms.

C. Changes to soil composition due to the refinery activities and emissions are possible. If such changes to soil composition are real they may have consequences for the local community.

D. The local community have requested a study to measure the extent of contamination of water. Alcoa has an existing programme to monitor groundwater including an extensive network of bores where a range of indicator species are currently monitored. However, there are questions about the current monitoring raised by the community and these concerns need to be evaluated by an independent assessment team, as well as evaluation of surface and rainwater.

2. Define Inputs and Outputs

A. Inputs: Existing surveys with information on diversity and numbers of native fauna and flora, health of domestic and wild animals, soil properties and composition and groundwater, surface water and rainwater compositions. Community based Input from Modules 2.5 “Community Data Collection & Processing” and 3.3 “Retrospective Interpretation”.

B. Outputs: A plan of a program for the scientific evaluation of environmental impacts on soil, water, plants and animals in the region surrounding the Wagerup Refinery. Presentation of this plan to the CEG and SET.

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41 Mining and the Community: A Growing Relationship. Volume 2. The Chamber of Mines and Energy of Western Australia Inc.
3. Objectives

A. To investigate information and concerns, both existing and as identified in Modules 2.5 “Community Data Collection & Processing” and 3.3 “Retrospective Interpretation”, on the environmental impacts on soil, water, plants and animals in the region surrounding the Wagerup Refinery. To assess from studies elsewhere what environmental concerns may be relevant. To design a program for the scientific evaluation of environmental impacts on soil, water, plants and animals in the region surrounding the Wagerup Refinery. To present this design to the CEG and the SET for consideration and ratification.

4. Methodology

A. The areal extent and deposition of emissions from the refinery to the soil need to be established. Any existing soil data including soil types and composition will be reviewed in order to determine if additional soil sampling and analysis is required. If additional soil sampling is required as may be identified in Modules 2.5 “Community Data Collection & Processing” and 3.3 “Retrospective Interpretation”, the sampling design, location choices including relationship to those sites chosen for the fauna and flora survey, depths and chemical species and properties analysed for need to be established.

B. Existing data gathered on the chemical composition of ground water, surface water and rainwater will be reviewed. To develop a program to monitor groundwater, surface water and rainwater composition in the vicinity of the Alcoa refinery, data from groundwater samples from the existing bores and dams, surface water from lakes and ponds and runoff water from rain will be reviewed. The range of chemical species measured will be reviewed and recommendations made on these. This will include a range of elements and organic species including elements in issue such as fluoride, selenium uranium. Associated data from Modules 2.5 and 3.3 will also be incorporated. A sampling design including locations, type and frequency of measurements will be developed.

C. Existing scientific and community derived data on native fauna and flora into a database will be reviewed along with those studies that are appropriate to assess impact on native fauna and flora in a mixed rural/bush environment. If additional surveys are required, the sampling design, location choices including relationship to those sites chosen for the soils survey, diversity of species of flora and fauna to be surveyed would be established. Such a subsequent study could be carried out in the footprint of the Alcoa refinery and in an adjacent area not impacted by the refinery.


D. A methodology for assessing impacts of the refinery emissions on domestic animals, such as chicken, cattle and sheep, crops and garden plants will be designed to determine any adverse effects that may have resulted from the refinery emissions. A process to develop advice on the seriousness of any such effects and how they can be prevented or ameliorated will also be designed.

E. The plans developed under sections A, B, C and D above, including the associated costs, will be presented as an integrated report to both the CEG and SET.

5. Equipment required, operating requirements

Nil.

6. Staff required

A. Suitably qualified staff from CSIRO.

7. Time line

A. Study plan delivered to both the CEG and SET for consideration and ratification three months from signing of contract.
COMPONENT 2 – DATA COLLECTION & PROCESSING

Proposal Module 2.5: Community Data Collection & Processing

1. Rationale

A. This module covers the mechanisms for collecting and processing community data. Because of the potential demands on the community, as much data for as many modules as possible will be collected at one time. This will also assist in keeping the cost to a minimum.

B. The rationales behind the community data collection requirements are shown in the individual modules in Components 1 “Project Management” and 3 “Data Integration & Interpretation”.

2. Define Inputs and Outputs

A. Inputs: Design requirements to achieve the desired outcomes for modules in Component 3 “Data Integration and Interpretation”, Module 1.2 “Project Evaluation” and Module 1.3 “Project Communication”.

B. Outputs: Reliable data for the following modules: Geographic Information Systems (GIS) data assessments – retrospective and current in Module 2.7 “Contextual Database Development & Maintenance” and Module 3.3 “Retrospective Interpretation” respectively; interpretation of air quality monitoring findings (see Module 2.1 “Air Quality Measurements”); Module 3.2 “Defining the Impact on Amenity”; reliable data for Module 1.2 “Project Evaluation”; indications of requirements for further data collection for Module 2.4 “Soil, Water, Plant and Animal Impacts”; background and demographic information for the stakeholder data base and communication requirements as noted in Module 1.3 “Project Communication”.

3. Objectives

A. To collect, process and store accurate and reliable data for input to the various modules in Components 1 to 3.

B. To provide indicators of further requirements for physical scientific data collection as may assist the achievement of the study objectives and the interpretation of data overall.

4. Methodology

A. On commencement of the study, advertisements will be placed in local newspapers to cover the region (Yarloop/Hamel and surrounds, Waroona, Pinjarra and locations to the coast) that advise that the ARCWIS Field Team will
be visiting residents of Yarloop and Hamel and anyone else who would like to be involved in the study to do an initial survey, collect other information and provide Community Diaries (see below) for completion. Anyone outside the immediately impacted area who would also like to have input to or be kept informed about the study will be invited to contact ARCWIS.

B. Soon after the commencement of the study, the ARCWIS Field Team will visit all households in the impacted area with the following:
- information about the study and details of confidentiality (participants will be assigned a number for use throughout the study);
- a telephone number to call for enquiries or to provide any ongoing information;
- two copies of the Community Diary (to be completed by as many as have experiences in the household);
- blank maps of the area and sheets for additional comments;
- a survey to be completed with the interviewer (one person per household);
- a number of replied paid envelopes.

C. The Community Diaries will request brief information on the following:
- Date, time, person making the entry, impact (from a list and provision for “other”), intensity rating (from a provided scale), description.

Because people will complete the diaries at a different rate, households will be provided with two diaries at any time. When one is completed, it is to be returned to ARCWIS in a replied paid envelope. Another will then be sent.

Diary information will be coded and processed initially for storing and analysing in SPSS\textsuperscript{47} format, but can be converted to Excel for importing to the GIS and whatever other form as may be required by Modules 2.1 “Air Quality Measurements”, 2.7 “Contextual Database Development & Maintenance”, 3.4 “Integrated Current Assessment”, and 3.5 “Data Interpretation and Synthesis”.

D. GIS assessment and collection of other data will be ongoing. Initially, people will be supplied with a number of blank maps of the area. They will firstly be asked to note any past experiences on one, including their perceptions of the area impacted by the Wagerup emissions (see Module 3.3 “Retrospective Interpretation”). They will be encouraged to note any ongoing information on other copies of maps as may be useful to the study (see Module 2.7 “Contextual Database Development & Maintenance”). Additional comments and notes will also be encouraged. These can be returned to ARCWIS with the reply paid envelopes.

The data will be forwarded to Module 2.7 “Contextual Database Development & Maintenance” and also to inform the ongoing physical scientific data collection (see Modules 2.1 “Air Quality Measurements” and 3.4 “Integrated Current Assessment”).

\textsuperscript{47} Statistical package for Social Science
People will also have the ability to contribute to the mapping at the Feedback Field Days where information can be directly stored to the GIS maps (see Module 1.3 “Project Communication”).

Telephoned information will also be collected and referred to the appropriate CSIRO Study Team members (see Module 1.3 “Project Communication”).

E. **Project and process evaluation measures** will be taken at the survey interview. One person per household will be asked to complete the survey as best as possible for the whole household. Measure of procedural, distributive and interactional justice will be taken. The base line measure will include both aspirations and expectations for the study. Measures will be taken again after 6 months and again at the completion of the study. Similar evaluation surveys of other major stakeholders will be conducted by mail.

This data will be coded, processed and stored on SPSS. Analysis of the data will be reported to the SET and CEG for consideration (see Component 1 “Project Management & Communication”).

F. **Impact definition measures** will also be taken at the time of the original survey interview. These will measure lifestyle and amenity to try to determine any impacts that emissions may be having in this regard (see Module 3.2 “Defining the Impact on Amenity”).

Psychological scales to measure considerations of amenity and quality of life will be developed based on extensive research on empirical psychological and planning literature. Cognitive, affective and behavioural components will be considered in an appropriate scale development (see Module 3.2 for greater detail of the variables). The scales will be pre-tested with Perth respondents.

The measures will be asked of all participating households in the impacted area. These measurements will then be compared with a sample of residents in similar locations but not experiencing concerns with air quality. A total of 120 comparison households will be interviewed: 30 in each of northern Waroona, Pinjarra, Harvey and Australind.

Both respondents group will be asked the same questions after 6 months and again at the conclusion of the study. This will provide an indication of the reliability of the measures. Some open-ended, non-prompted questions will be included.

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This data will be coded, processed, stored and analysed using SPSS. It will be made available in whatever form is required by the various modules in Component 3.

G. **General stakeholder information** will also be collected at the first survey interview. This will include demographics such as location; length of residence; intended length of residence; age; family structure etc. and requirements for information and communication.

Demographic data will be used in the analysis of the evaluation and impact data to allow comparisons of groups. This will inform the need for any other data collection as well as ensure that no particular group is being disadvantaged by the process.

Communication and location data will be used in the Stakeholder Database as described in a separate module in this component.

5. **Equipment required, operating requirements**

   A. The ARCWIS Field Team; diaries; surveys; reply paid envelopes; maps; comment sheets; data processing requirements; coordination with the CSIRO Study Team.

6. **Staff required**

   A. The ARCWIS Team (CSOF 6; 4; 3; 2 & ARCWIS Field Team).

7. **Time line**

   A. Newspaper advertisements in the first month after commencement of the study.
   
   B. Visit to households in the second month after commencement of the study.
   
   C. Mapping and community input of data ongoing throughout the study.
   
   D. Remeasure of evaluation and impact definition questions six months after commencement of the study.
   
   E. Remeasure of evaluation and impact definition questions twelve months after commencement of the study.
COMPONENT 2 – DATA COLLECTION & PROCESSING

Proposal Module 2.6: Stakeholder Database Development

1. Rationale

A. It is essential to the smooth and integrated conduct of the study that all participants and stakeholders, their involvement and their communication requirements can be tracked. Data (not identifiable to specific people) from this will form part of the final evaluation and evidence of accountability of the process – that is, that everyone who was interested had the opportunity for involvement in all aspects of the study and its data collection and were kept informed.

2. Define Inputs and Outputs

A. Inputs: Newspaper advertisements; household surveys; telephone calls; Community Diaries; written comments and maps etc. (see Modules 1.3 “Project Communication”, 2.5 “Community Data Collection & Processing” and 3.3 “Retrospective Interpretation”).

B. Outputs: An accurate record of every person involved in the study in a non-identifiable coded form, their requirements for information and communication; the details of their type of input etc. This information will be used by Modules 1.2 “Project Evaluation”; 1.3 “Project Communication” and all modules in both Components 2 and 3.

3. Objectives

A. To keep track of all participants and stakeholders involved in the study, their requirements for information and the type of involvement to allow for evaluation for accountability of the process and to ensure that no groups have been disadvantaged by the process.

4. Methodology

A. A central database will be maintained by ARCWIS that records participants’ and stakeholders’ numbers, their locations (not addresses), affiliations (if applicable), how contacted (e.g. advertisement; door knock; word of mouth etc.), type of input (e.g. whether completed diaries; surveys; maps; comments; attended Field Days; made phone calls etc.), requirements for information, information provided to them by the Study Team etc.

Participants’ numbers and personal details will be stored separately and kept in a secure location.

Summaries will be reported regularly to the SET and CEG and will form part of
the final reporting of the study (see Modules 1.2 “Project Evaluation”, 3.4 “Integrated Current Assessment” and 3.5 “Data Interpretation and Synthesis”).

5. **Equipment required, operating requirements**
   
   A. Study coordination processes that ensure all of the above is recorded and accurately maintained.

6. **Staff required**
   
   A. Research Assistant - ARCWIS.

7. **Time line**
   
   A. The 18-months duration of the study.
COMPONENT 2 – DATA COLLECTION & PROCESSING

Proposal Module 2.7: Contextual Database Development & Maintenance

1. Rationale
   
   A. In order and to conduct an integrated analysis of physical and social data and to provide meaningful interpretations of study outcomes, a framework of spatially referenced data needs to be developed. This will be achieved through the development of Geographic Information Systems (GIS) that depicts regional infrastructure data in digital form.

   B. Provision of study outcomes in a familiar local context will assist the community and other stakeholders to reach an understanding of these outcomes. The database will also be utilised in the communication of the results of social and physical data collection and analysis.

2. Define Inputs and Outputs
   
   A. **Inputs:** Digital datasets of environmental and cultural data that characterise the regional setting.

   B. **Outputs:** Extensive GIS database to provide base maps for Modules 3.3 “Retrospective Interpretation”, 3.4 “Integrated Current Assessment” and 3.5 “Data Interpretation and Synthesis”.

3. Objectives
   
   A. To develop a geo-referenced database of biophysical and cultural data for use throughout the study.

4. Methodology
   
   A. Digital data for biophysical and cultural themes will be imported into the GIS. It is expected that much of the digital spatial data will be available from Alcoa. Additional data not available from this source will be purchased or obtained from relevant custodians. Datasets to be included are:
      
      - transportation network (e.g. road & rail)
      - population centres
      - cadastre
      - topography
      - hydrography (streams, lakes, coastline)
      - areal photography
      - shire boundaries
      - town planning schemes
      - monitoring sites
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0 feature locations e.g. local schools, hospitals, Alcoa refinery ... etc.

B. A data dictionary will be maintained with details of all datasets in the database. Metadata statements will reside with datasets.

C. A database structure will be established to accommodate the variety of datatypes that may be incorporated in the database.

5. Equipment required, operating requirements

A. GIS Software, PC, Computer network services and support

6. Staff required

A. GIS Operator; Lorraine Bates; ARCWIS Field Team

7. Time line

A. This work will commence immediately in order to develop an adequate resource for use in Modules 2.5 “Community Data Collection & Processing”, 3.3 “Retrospective Interpretation” and 3.4 “Integrated Current Assessment”. The majority of the work will be completed by mid-January 2004.
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