AIRWATCH – Primary CD "WHAT'S UP WITH OUR AIR?"

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How to use this CD

Loading the home page

The AirWatch CD should automatically load on your computer however if this does not happen please open the CD folder (usually your 'D' drive) and double-click on the file titled 'index.htm' to open the home page.

Navigating the website

Click on the buttons across the top of the site to open up the page you require.
Click on the links in the yellow box on the right of the Lesson and Extension pages to open more detailed documents in Adobe Acrobat Reader format.

How to complete the activities

Introduction

- Read the scope and sequence document
- Send the introductory letter home to parents

Lessons

- Commence with Lesson 1 and complete through to Lesson 5. Please note that each Lesson has two activities and only one activity needs to be completed to get an understanding of the topic.
- Complete the two Lesson Assessment activities

Extensions

- Complete one or more Extension activities to gain a deeper understanding of the topic
- Complete the Extension Assessment for each Extension activity

Other

- Filler tasks are available if you need some extra work for students, for example if they finish an activity early.
- Air Facts can be used in school newsletters, community projects and general communications to highlight the issue of air pollution.
- A selection of Photos is available for each Lesson topic. Click on the photo within the website in order to open up a high-resolution printable version of the image. You can also access the photos by opening up the 'Photos' folder on the CD.
- The Links page contains a series of web links that you can use to conduct further research on the topic of air quality in Perth and around the world. Remember you need to ensure you are connected to the Internet before accessing these sites.

Evaluation

What's up with our air?

We hope that you have enjoyed using the AirWatch CD 'What's up with our air?" and found it beneficial to planning your work.

Please find time to provide feedback about the CD by completing the survey below - your comments will allow us to continually improve our program.

We would like your help to find out:

- How you used the CD
- Best bits/worst bits!
- What you and your students learned

Part 1 – Design and content

1) How did you hear about the CD?

AirWatch website
AirWatch school visit
colleague
word of mouth
workshop
other, please state:

2) Why did you decide to use it?

3) How easy did you find the CD to use?

very easy
easy
about right
not that easy
much too confusing

4) Which year level was it best suited to?

5) Which curriculum areas did you find it most relevant to?

6) How did you use the lessons from the CD?

sequentially
independently as needed
core lessons only
extension only
extra resources only
all or combination

7) Which parts did you find most valuable and why?
core activities
extensions
assessments
extra resources and activities
Why? ____

8) How did you find the extension activities?
too difficult
difficult
just right
very good

9) What was the least useful aspect and why?

10) What would you suggest we could do to improve the design or content of the CD?
Please be specific:

Part 2– Knowledge, attitude and behaviour

11) How would you rate your knowledge of air quality issues before using the CD?
no knowledge
little knowledge
some knowledge
good knowledge

12) How would you rate your knowledge of air quality issues AFTER using the CD?
about the same
some knowledge
more knowledge
much more knowledge

13) Which of these issues do you now feel better equipped to teach about?
common pollutants
haze
photochemical smog
greenhouse effect
air pollution & health
transport issues

14) Which lesson plan or extension provided the most notable change in knowledge
a) for you b) for students
Please state:

15) How would you rate your students' understanding of air quality issues BEFORE using the lesson plans?

little or no understanding
some understanding
satisfactory
good

16) How would you rate your students' understanding of air quality issues AFTER using the lesson plans?

little understanding
some understanding
satisfactory
good
very good

17) Has using the CD contributed to a change in students' ATTITUDE to air quality?

yes
a lot
a little
unsure
no
about the same

18) Has the CD contributed to a change in students' BEHAVIOUR to air quality?

yes
a lo
a little
unsure
no
about the same

If yes, please state specific behaviour/s:

19) Any other comments:

Please send me information about future AirWatch projects on:

Local air pollution   *Greenhouse*   *Indoor air*   *Air monitoring projects*

Click this link to return this form with your comments to:

Kim.braimbridge@environment.wa.gov.au or Fax: 6364 6513

www.airwatch.gov.au

CORE LESSONS

	Aim	Students will be able to:	Activity	Curriculum outcome	Resources needed
Lesson 1 What's in the air?	Introduce students to the basic properties of air and typical pollution types	• Describe the make-up of air. • Identify common sources of pollution. • List examples of global, local and indoor pollution.	1) Edible air – use food stuffs to make up the proportion of different gases in the air. 2) Spot the polluter – find as many polluters in the poster as possible. 3) Class discussion: what is global, local and indoor pollution. Find 3 examples of each in the Smogsville poster.	Science: Earth and Beyond 2,3,4 Society and Environment: Place and Space 2.2, 2.3, 2.4	*AirWatch manual 2.1* Smogsville poster
AirWatch School Visit	Introduce students to typical pollution problems in Perth and brainstorm how we can all make less pollution.	Explain the difference between haze and smog. Describe how haze and smog are formed (in general) List common health problems caused by air pollution Select actions that they can do to reduce pollution they and their families cause.	School visit.	Science: Earth and Beyond Society and Environment: Place and Space, Care of Places Values: Environmental Responsibility	Coordinator to run School incursion
Lesson 2 Let's stop the haze craze!	Understand what haze is, and how weather can make it worse	Explain the difference between visible (particle) pollution and invisible (gas) pollution Identify particles in the air Explain why haze is worse	1) Visible and invisible pollution – make up mixtures to show the difference between particle (visible) and gas (invisible) pollution. *AirWatch manual 3.1* 2) Bring in particle collectors, view with a magnifying glass, and count particles per sq cm ??? 3) Create an inversion – add	Society and Environment: Place and Space 2.1, 3.1, 4.1; 2.2, 3.2, 4.2; 2.3, 3.3, 4.3 Science: Earth and Beyond 2,3,4	Plastic cups, water, milk, pepper cooking oil. *AirWatch manual 3.1* Cardboard, sticky tape, magnifying glasses

		for us in winter (temperature inversion).	cooking oil to the pepper, watch what happens – how is the atmosphere like this? What happens to the pepper? What time of year would haze have the most impact on us? 4) Draw a picture to show winter haze in your neighbourhood.		
Lesson 3 Cars and Smog	Understand what smog is, and that cars and factories are the major cause of smog.	Students explain diagrammatically how smog is formed. Students understand the connection between car use and the amount of pollution produced.	1) 'Draw what you know" Draw a diagram that depicts hows smog is formed in Perth. 2) Car costs and pollution Input data and calculate the environmental and financial cost of owning a car.	Society and Environment: Place and Space Mathematics: Number	Colour pencils, calculator, worksheet
Lesson 4 Your health and pollution	Understand that poor air quality can affect health. Understand that pollution affects each of us differently.	Identify parts of the body affected by polluted air. Identify physical and emotional effects of poor air quality on individuals. Explore attitudes towards Asthma.	1) "Stay outside please!" - Students use a poster to identify affected body parts. 2) "Is that how it really feels?" - restricted breathing activity using straws.	Health & PE: K&U 3.4; SMS 3 Attitudes & values Science: L&L 2,3,4 EB2	Upper body diagram *Asthma foundation fact sheets* Plastic straws
Lesson 5 It's how you get there that counts!	To examine the use of car travel to school	Understand that the way we get to school can influence air quality Investigate and realise there are different constraints on travel to school. Explore feelings, attitudes and values towards personal journeys.	1) Travel to school survey – greenhouse gases. 2) Debate - the pros and cons of car pooling/public transport to school. (PMI activity).	Society and Environment: ICP 2.1,2.3, 2.4, 3.3, 3.4, 4.3 Place & Space 2.2, 2.3, 3.3, 4.2,4.3 Science: EB 2,3,4	Walk to school activity worksheet Walk to school activity worksheet

Lesson 1 “What’s up with our air?”

Introduction

Air is our most important natural resource, without it we’d be dead in four minutes! This lesson introduces students to the topic of air and air pollution. They will investigate the composition of air and the concepts of ‘pollutants’ and ‘pollution’. Your students will identify common sources of pollution, and reflect on how their lifestyles affect the air.

Activity 1.1 “What’s in the air?” - Students simulate the composition of air.

Common foodstuffs are used to create ‘edible air’. Students make up a mixture in the same proportion as the gases in the air, enabling them to ‘visualise’ the air and helping them to realise that air is not homogeneous but made up of different types of molecules which do not interact.

Activity 1.2 “Spot the polluter” - Students look at ‘Smogsville’ and try to find as many sources of pollution as possible.

Pollution is all around us, and comes from all sorts of things we do in our day-to-day lives. The place pollution comes from is called its ‘source’. Students use the cartoon of ‘Smogsville’ to identify as many sources of pollution as they can find and relate those to their own lifestyles.

Activity 1.1 "What's in the air?" - Students simulate the composition of air.

Aim
Introduce students to the basic properties of air and the concept of pollution.
Students will be able to:
- Identify the gases that make-up the air
- Describe the proportion of each gas in the atmosphere
- Explain the difference between 'a pollutant' and 'pollution'

Background
This activity enables students to 'visualise' air, helping them to realise that air is not homogeneous but made up of different types of molecules which do not interact. It also highlights the difference between a compound and a mixture.

A mixture is where different substances are mixed together which can be separated. For example, muesli is a mixture with different components that can be separated.

A compound is where different substances can be mixed together and cannot be separated into their individual parts again. For example, the ingredients in a cake.

Materials
Jar or clear container = 1 per group

Enough of these foodstuffs so that each group has:
- 78 dried peas
- 21 peanuts
- 1 piece of popcorn
- 1 raisin
- 1 fruit loop
- 1-3 walnut pieces

Student worksheet

Activity

"What's in the air?" - Students create a 'model' to simulate the composition of air.

Pre-task discussion
The topic of air could be introduced by asking some questions to stimulate curiosity...

What's all around us, but we can't see it?
What's inside us, but we can't taste it?
What's touching us, but we can't feel it (usually)?
What's the most important thing we do, and we can't stop it?
What do you share with everyone in this room, but you can't own it?

How much air do we breathe every day? (about 10,000 litres)
How much air can our lungs hold? (3-4 litres)

How much air is left inside us, even when we breathe out as fully as we can? (about 1 litre)
How many breaths do we take each minute, usually? (13 – 17 while resting, up to 80 during exercise)
If you could take your lungs out and spread them out on the ground, how big would they be? (about the size of a tennis court)

Imagine you could see all the gases that are in the air, what do you think it would look like?

The task:
We are going to make up a mixture that can show us what is in the air. Work in your group to fill you jar with:

- 78 dried peas
- 21 peanuts
- 1 piece of popcorn
- 1 raisin
- 1 fruit loop
- 1-3 walnut pieces

Mix them evenly together.

Which gas do you think each 'food' represents? Draw a line connecting the food with the gas:

Oxygen	Raisin
Carbon Dioxide	Dried peas
Pollutants	Pop corn
Trace gases	Peanuts
Water vapour	Fruit loop
Nitrogen	Walnut pieces

Answers:
Dried peas = nitrogen gas
Peanuts = oxygen
Piece of pop corn = carbon dioxide
Raisin = water vapour
Fruit loop = trace gases
Walnut pieces = pollutants

This is called a mixture. How would you describe a mixture?
A mixture is where different substances are mixed together which can be separated. For example, muesli is a mixture with different components that can be separated.

How is this mixture different to the ingredients in a cake?
A compound is where different substances can be mixed together and cannot be separated into their individual parts again.

Looking at the mixture, which is the most abundant gas in the air?
Nitrogen

Which of these gases is the most important to our survival?

Oxygen

Does it make up most of the air?
No

What is the name of the gas we breathe out?
Carbon Dioxide

The amount of oxygen in the air is always about the same. What keeps it that way?
Plants continually produce oxygen through photosynthesis.

Predict what might happen if the amounts of these gases changed.

The walnuts represent pollutants. Take them out, so the air is pure, and break a tiny piece off one walnut piece and put it in jar.

This walnut piece is a pollutant, but would it cause problems?
If a pollutant is present in very small quantities it may not cause a problem as it can be dispersed in the air. It may become a problem depending on how toxic it is, and how sensitive an individual is to it.

Now add 10 walnut pieces to the jar.

The walnuts are pollutants, do you think now they would be likely to cause problems now? If you do we would call it 'pollution'.

What is the difference between a 'pollutant' and 'pollution'?
Pollution occurs when 'pollutants' build up to levels that could cause problems to sensitive groups of people. The Department of Environment sets acceptable levels that common pollutants must stay below. To find out what the common pollutants and their acceptable levels are visit www.environment.wa.gov.au and look at the Air Quality pages.

Curriculum Links

Society and Environment
Place and Space, People and Places (Levels 2, 3, 4)
Key content (from Curriculum Framework Curriculum Guide):

- Natural features influence human activities
    - The landscape provides natural resources that people use
    - People adapt to the landscape in which we live

- Human activities influence natural features
    - People's activities have planned and unplanned impacts on the natural features of a particular landscape

- Natural landscapes and human activities are interrelated
    - The interaction between people and the wider environment can be measured

Natural and Social Systems (Levels 2,3,4)

- Elements and interrelationships in natural systems

- Changing, adding or removing one element in a natural system impacts on the whole community

Science
Earth and Beyond, (Levels 2, 3, 4)
Key content (from Curriculum Framework Curriculum Curriculum Guide):

Sustainability of life and wise resource use

- Renewable and non-renewable resources
    - Resource use can change the physical environment

- Physical and natural systems and sustainability
    - Human impact on natural systems results in changes to the environment and consequently impacts on humans

Earth forces and materials

- The characteristics and origins of a variety of materials

Activity 1.2

"Spot the polluter!" - Students look at 'Smogsville' and try to find as many sources of pollution as possible.

Aim

After this activity you will be able to:

- Identify common sources of pollution.
- Explain how the location can affect pollution at a particular place

And also possibly

- Explain the difference between 'pointsource' and 'non-pointsource' pollution.
- List examples of global, local and indoor pollution

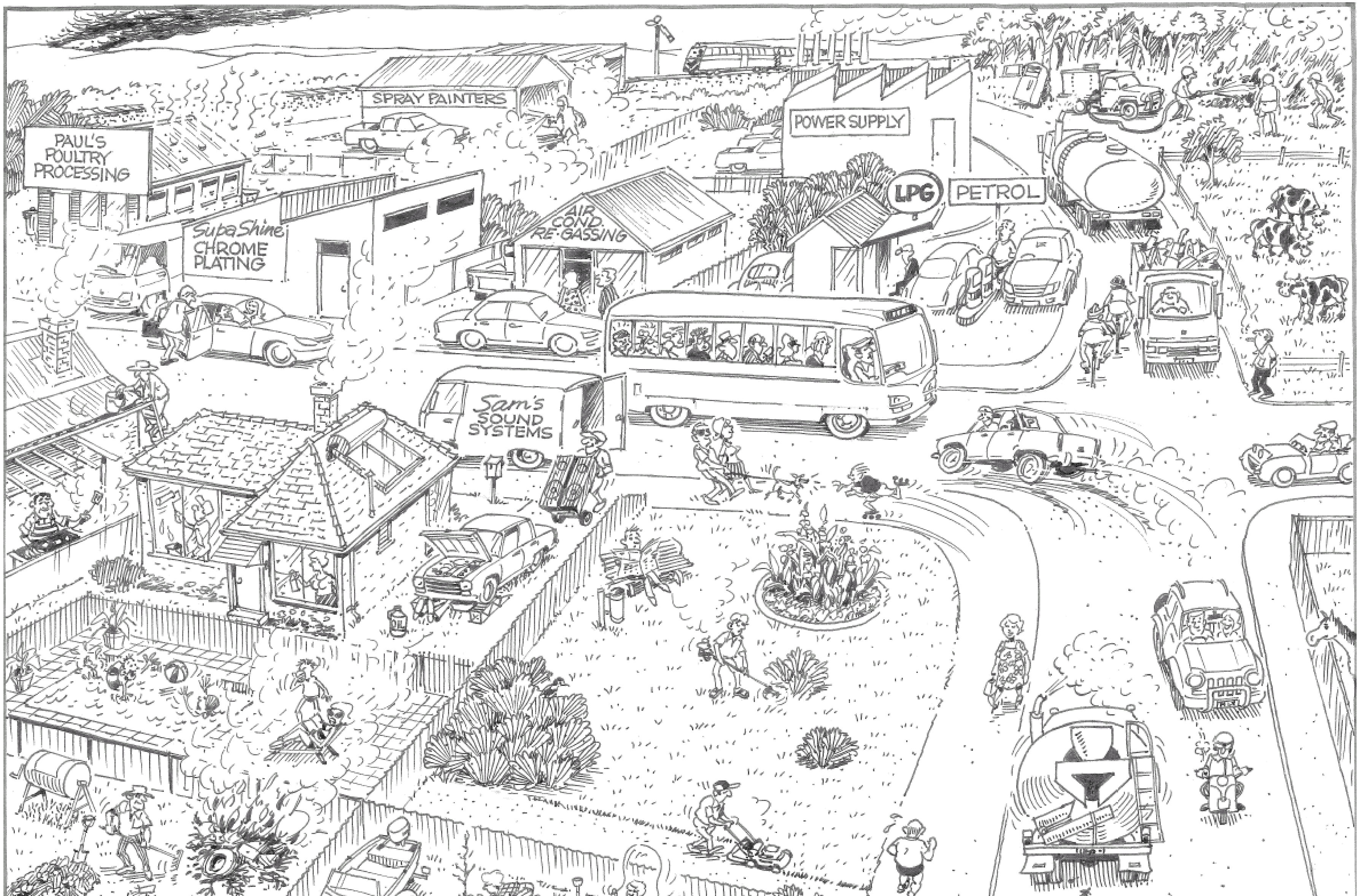
Background

It is a common belief that most air pollution comes from large sources like industry. Certainly a large proportion does come from industry, but the main sources of air pollution in Perth (and most cities) come from our everyday activities, particularly vehicles and wood fires in winter. In this activity students identify common sources of pollution and think about how the location and weather conditions can affect it.

Students can go on to classify the 'sources' of pollution as either 'pointsource' or 'non-pointsource' (see teacher notes) or as either global (ie likely to affect the whole planet's atmosphere as in Greenhouse gases or depleting the ozone layer) local (ie air pollution within a city) or indoor (as in chemicals that are used within our homes).

Materials

See the cartoon 'Smogsville' following page.


PAUL'S POULTRY PROCESSING
SPRAY PAINTERS
POWER SUPPLY
LPG
PETROL
SupaShine CHROME PLATING
AIR COND. RE-GASSING
Sam's SOUND SYSTEMS
walter

Activity 1.2 "Spot the polluter!"

The task:
Pollution is all around us, and comes from all sorts of things we do in our day-to-day lives. The place pollution comes from is called its 'source'.

Look at the picture of 'Smogsville' and work with your partner to find as many sources of air pollution as you can. Hint, you should be able to find at least 20.

(Students work in pairs to spot the polluters).

Answers:
Pollution sources:

1. *Car exhausts (note the 'Hoons' car – how you drive can affect how much pollution comes from your car, aggressive acceleration is worst)*
2. *Burn-off in backyard*
3. *Wood heaters - Chimneys*
4. *Lawn mower*
5. *Whipper Snipper*
6. *Boat*
7. *Cigarette smoke*
8. *Petrol fumes from service station*
9. *Fumes from Spray Painters*
10. *Gas from Air Conditioning Re-gassing workshop*
11. *Emission from Power Station, most people believe that electricity is clean, but power generation is a major source of CO_2, a 'Greenhouse gas'*
12. *Trucks – diesel engines produce more pollution than a petrol engine*
13. *Fumes from the BBQ*
14. *Fumes from the paint (indoors)*
15. *Bush fires*
16. *Cows – methane*
17. *Scooter*
18. *Bus*
19. *Fumes from Chrome Plating*
20. *Fumes from poultry processing*
21. *Spray can*

Follow up questions

Which of these activities have you or your family done in the last week?

Can you think of any other types of pollution that would affect the environment?

In Perth where do you think most of our air pollution comes from?

How do you think the weather affects the pollution...where would the worst pollution in this town be, if:

- The wind was blowing from the North (top of picture)? *It would be worse at the bottom of the picture.* Why? *All the pollutants from the industrial area and the other activities would be carried there by the wind.*

- The wind was blowing from the West (left of picture)? *It would be worse at the right of picture (cows and horses).* Why? *All the pollutants from the industrial area and the other activities would be carried there by the wind.*
- There was no wind it was perfectly still? *In the middle of the town.* Why? *There is no wind to disperse the pollutants and they would collect around the houses.*

How would you feel if?

- You were a country kid who just moved to this town? (How would a city kid feel? Why do you think they would react differently?)
- You were the family by the pool, and the wind was blowing from the South? What could you do about it?

What can you see in this picture that show 'good' things for our environment?
Answers:

1. *Roller skates*
2. *Bicycles*
3. *LPG*
4. *Train*
5. *Bus*
6. *Composting*
7. *Solar water heater*
8. *Car pooling*
9. *Walking*
10. *Running*
11. *Scooter*

What can you see in the picture that shows other things that can cause environmental problems?
Answers:

1. *Oil spills*
2. *Old fridge – rubbish dumping and CFC's*
3. *Noise pollution*
4. *Dog poo*

Extension

Introduce the concepts of 'pointsource' and 'non-pointsource' pollution.

When pollutants come from a large single source (eg a factory), scientists call them 'pointsource' pollutants. When they come from a large number of small sources spread over a wide area they are called 'non-pointsource'. While 'pointsource' pollution is often more visible to most people, it is often easier to deal with, as it is economical to fit large factories with pollution controlling technology. On the other hand, 'non-pointsource' pollution is often harder to control.

Ask students to find three examples of 'pointsource' and 'non-pointsource' pollution in the cartoon. Which do they think would be harder to control? Why?

Curriculum Links

Society and Environment

Place and Space, People and Places (Levels 2, 3, 4)
Key content (from Curriculum Framework Curriculum Guide):

- Natural features influence human activities
  - The landscape provides natural resources that people use
  - People adapt to the landscape in which they live

- Human activities influence natural features
  - People's activities have planned and unplanned impacts on the natural features of a particular landscape

- Natural landscapes and human activities are interrelated
  - The interaction between people and the wider environment can be measured

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- Changing, adding or removing one element in a natural system impacts on the whole community

Science
Earth and Beyond, (Levels 2, 3, 4)
Key content (from Curriculum Framework Curriculum Guide):

Sustainability of life and wise resource use

- Renewable and non-renewable resources
  - Resource use can change the physical environment

- Physical and natural systems and sustainability
  - Human impact on natural systems results in changes to the environment and consequently impacts on humans
  - Strategies to protect local environments

Earth forces and materials

- The characteristics and origins of a variety of materials

Lesson 1 Background Notes

Air is made up of a mixture of gases, some of which are essential for life.

Nitrogen ($N2$)	78%	Inert gas
Oxygen ($O2$)	21%	Used for respiration by plants and animals
Argon (Ar)	~1%	Inert gas
Carbon Dioxide (($CO2$)	~0.03%	Used by plants to make their own food
Trace gases		methane, oxides of nitrogen

Water can exist in our air in varying amounts as a gas; as it comes from evaporation from water bodies, rainy weather, and is given off from plants during the day. The air also contains tiny particles such as dust, sea salt, volcanic ash and soot, all of which are small enough to float in the air for a long time.

Pollutants

The air can contain other gases and particles which are not normally found in the air. These usually come from some human activity such as car usage or factories. When they reach a high enough level of concentration, they become an air pollution problem.

When pollutants come from a large single source (eg a factory), scientists call them 'pointsource' pollutants. When they come from a large number of small sources spread over a wide area they are called 'non-pointsource'. While 'pointsource' pollution if often more visible to most people, it is often easier to deal with, as it is economical to fit large factories with pollution controlling technology. On the other hand 'non-pointsource' pollution is often harder to control.

Perth has two main pollution types: photochemical smog and haze. Smog is a result of exhaust gases from vehicles (both petrol cars and diesel commercial vehicles) and industry mixing to form the dangerous gas ozone (in the stratosphere ozone protects the earth's surface from UV rays, but at ground level it is a reactive and harmful gas). Haze consists of particles which we see as smoke. The main sources of smoke are fires, either bush fires or burn-offs and in winter wood heaters. Smokey vehicles such as diesels also contribute to haze.

Pollution can cause health problems, especially in the young and the elderly and also damage plants and materials.

Activity 1.2 Spot the polluter! student notes

Introduction

Pollution is all around us, and comes from all sorts of things we do in our day-to-day lives. The place pollution comes from is called its 'source".

Aim

After this activity you will be able to:

- Identify common sources of pollution.
- Explain how the location can affect pollution at a particular place

And also possibly

- Explain the difference between 'pointsource' and 'non-pointsource' pollution
- List examples of global, local and indoor pollution

Look at the picture of 'Smogsville' and work with your partner to find as many sources of air pollution as you can. Hint, you should be able to find at least 20.

Which of these activities have you or your family done in the last week?

Can you think of any other types of pollution that would affect the environment?

In Perth where do you think most of our air pollution comes from?

How do you think the weather affects the pollution…where would the worst pollution in this town be, if:

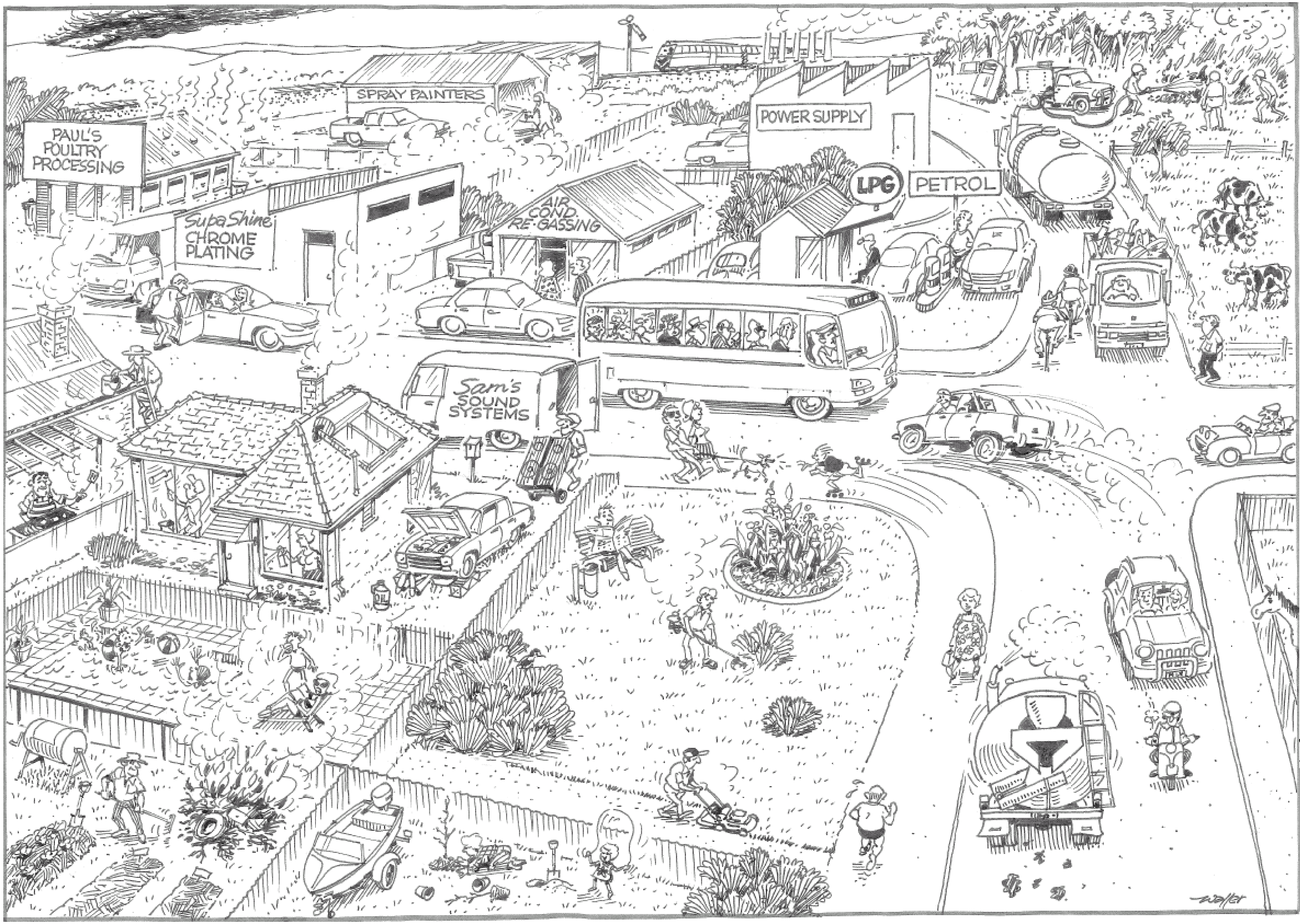
- The wind was blowing from the East? Why?
- The wind was blowing from the South? Why?
- There was no wind, it was perfectly still? Why?

How would you feel, if?

- You were a country kid who had just moved to this town? (How would a city kid feel? Why do you think they would react differently?)
- You were the family by the pool, and the wind was blowing from the South? What could you do about it?

What can you see in this picture that show 'good' things for our environment?

What can you see in the picture that shows other things that can cause environmental problems?



AirWatch
BREATHE EASY™

Activity 1.1 “What’s in the air?” student notes

Aim

At the end of this activity you will be able to:

- Identify the gases that make-up the air.
- Describe the proportion of each gas in the atmosphere
- Explain the difference between ‘a pollutant’ and ‘pollution’

Materials

Container
78 dried peas
21 peanuts
1 popcorn
1 raisin
1 fruit loop
1-3 walnut pieces.

Activity - “What’s in the air?”

We are going to make up a mixture that can show us what is in the air. Work in your group to fill your jar with:

- 78 dried peas
- 21 peanuts
- 1 piece of popcorn
- 1 raisin
- 1 fruit loop
- 1-3 walnut pieces

Mix them together evenly.

Which gas does each ‘food’ represent? Draw a line connecting the food with the gas:

Oxygen	Raisin
Carbon Dioxide	Dried peas
Pollutants	Pop corn
Trace gases	Peanuts
Water vapour	Fruit loop
Nitrogen	Walnut pieces

This is called a mixture. How would you describe a mixture?

How is this mixture different to the ingredients in a cake?

Looking at the mixture, which is the most abundant gas in the air?

Which of these gases is the most important to our survival?

Does it make up most of the air?

The amount of oxygen in the air is always about the same. What keeps it that way?

Predict what might happen if the amounts of these gases changed.

The walnuts represent pollutants. Take them out, so the air is pure, and break a tiny piece off one walnut piece and put it in jar.

This walnut piece is a pollutant, but would it cause problems?

Now add 10 walnut pieces to the jar.

The walnuts are pollutants, do you think now they would be likely to cause problems now? If you do we would call it ‘pollution’.

What is the difference between a ‘pollutant’ and ‘pollution’?

Lesson 2 “**Let's stop the Haze craze**”

Introduction

There are 160,000 wood heaters in Perth. Every winter they are responsible for haze levels in our city. Haze is made up of tiny particles that can get into our lungs causing health problems. Students will explore the physical properties of particle and gaseous pollution, collect particles in the air around the school and use their interpersonal skills to deal with the tricky problem of a ‘smokey’ neighbour.

Activity 1. “Visible and invisible pollution”

Students do a simple simulation putting a little milk and pepper into glasses of water to recreate how gas and particles behave in the air.

Activity 2. “Collecting particles”

Students make a particle collector from cardboard and sticky tape to investigate particles levels around the school. They will compare different sites and think about sources of particle pollution and how the weather could affect particle levels. If you’d like the students to analyse the particle collectors on the same day they do the other haze activities, then they will need to make and set up their collectors one week in advance.

Activity 3. “A Social Problem – smoking out the neighbours!”

Students tackle the issue of smoky fires and a difficult neighbour. After working out how to best use a wood fire, students work in groups and use their interpersonal skills to deal with the problem of a neighbour who has a very smoky fire that is causing distress to some people in their street.

Activity 2.2 Collecting particles

Introduction

With the pepper in the water we looked at a 'model' of particles, now we are going to look at the real thing! Fine particles in the air can come from natural sources or from human activity such as woodheaters and burning off. We will make simple particle collectors and find out which part of the school has the most particles in the air.

If you wish to do this at the same time as Activity 2.1, you will need to set up the particle collectors one week in advance.

Particles can be harmful to our health and affect plant and animal life around us.

Aim

At the end of this lesson students will be able to identify particles in the air and suggest where these particles may have come from.

Teacher notes

To get an idea of what the particle levels are like around your area, students can try this simple way of collecting them. Particle testers can be made using cardboard or plastic from an ice-cream container lid. They are put outside for a few days but make sure they are not obvious as they may disappear! They can then be analysed for particles.

The trick to making these testers useful is to ensure you are putting them somewhere that you think the particle levels may be high, such as near roads, incinerators or cleared land. **When looking at the results ensure students use a white background so the particles can be easily seen.**

Materials

Particle collectors, made and set up one week in advance.
They require (for each group):

- Two cardboard strips 5cm wide and 25 cm long with 5 holes about the size of a 20 cent piece in them
- Sticky tape
- String

Magnifying glasses (1 per group – if you'd like to look more closely at the particles)

Activity

Making a particle collector

To collect particles you need to make a particle tester, using the instructions below**.**

1. Cut a strip of cardboard that is 5cm wide and 25cm long and cut 5 holes, each about the size of a 20 cent piece, evenly spaced along the cardboard strip.

2. Cover all holes with sticky tape. The sticky side of the tape will collect particles from the air. Make sure that you do not touch the sticky side over the holes.

3. Select three locations around the school and tie it with a piece of string to a suitable 'anchor', write your group name, date and location on the cardboard. Keep one tester in a plastic bag, this is called a control.

4. Two or three days later, remove the testers and record information in the table below.

Note: This activity really works best if you cut off one cirlce every day as then you can compare the different weather conditions, wind etc to decide if it's weather or location that makes the difference

Questions:

1. Compare your tester to those of other students; were some areas around your school dirtier than others?

2. Can you explain why these locations would be dirtier?

Date	Location	Tester Description

Discussion Questions:

1. In which area did your tester collect most particles?

2. Does the tester you made pick up all the pollutants in the air? Explain.

3. List the possible sources of these particles.

4. Why do you think particles are bad for you?

An alternative method

Store 5 testers in a plastic bag and hang a new one out each day. After all 5 have been collected, compare them. Students can observe which days were high pollution days and look for weather patterns and their effect on pollution.

Curriculum Links

Society and Environment

Place and space; People and places (Levels 2,3,4)

Human activities influence natural features

- People's activities have planned and unplanned impacts on the natural features of a particular landscape

Natural landscapes and human activities are interrelated

- The interaction between people and the wider environment can be measured

Science

Earth and Beyond, Sustainability of life and wise resource use

Renewable and non-renewable resources

- Resource use can change the physical environment

Physical and natural systems and sustainability

- Human impact on natural systems results in changes to the environment and consequently impacts on humans

Activity 2.1 Visible and invisible pollution

Introduction

This activity uses a simple simulation to demonstrate the difference between visible (particle) and invisible (gaseous) pollution.

Aim

Students will be able to describe the physical properties of particulate and gaseous pollution.

Teacher Background Notes

This lesson focuses on more detail on particles, the pollutant responsible for haze, and builds on the concepts that were introduced in the AirWatch 'school visit.'

Materials

Clear plastic cups (2 per group)
Water
Milk (1 tablespoon per group)
Pepper (1 teaspoon per group)

Particle collectors, made and set up one week in advance.
They require (for each group):

- Two cardboard strips 5cm wide and 25 cm long with 5 holes about the size of a 20 cent piece in them
- Sticky tape

Magnifying glasses (1 per group)

Activity

What's in the air?

Do you remember at the AirWatch visit we learnt about haze, what can you tell me about it? (Elicit particles, smoke, woodheaters, cars, trucks, how to reduce smoke from wood heaters and vehicles). What about smog? (Elicit gas, cars, trucks, buses, factories)

Today we are going to do an activity to show the difference between these two important types of pollution.

Pollutants (get cartoons form page 23 of Primary Manual)

The **visible pollutants** we call particles (or particulates) are tiny particles of solid or drops of liquid which can float in the air. These can be natural like pollen or dust, or man-made from sources such as wood fires, wood heaters, industry, power plants or from cars or trucks.

Invisible pollution is gases, which mix with air and, at times, even react with it to form other gases. An example of this is the invisible gases from car exhausts.

The task: The difference between visible and invisible pollution.

1. Half fill two clear disposable cups with water
2. Add one teaspoon of milk to one cup, stir to mix
3. Add one teaspoon of pepper to the other cup, stir
4. Observe the differences between the milk and the pepper

Questions:

1. What kind of pollutant(s) did the milk act like in the water? (Gases)

2. What kind of pollutant(s) did the pepper act like in the water? (Pariculates)

3. Would it be easier to get the milk or pepper out of the water? (Pepper)

4. Would it be easier to remove the gases or particles from the air? (In a controlled area particulates can be removed by filtering the air, removing gases is more difficult, but some gases can be removed by using industrial 'scrubbers')

5. Suggest how you could get the pepper out of the water.

Discussion Questions:

1. In winter we can often see a brown 'smudge' over the city or in the distance. What do you think this is?
   (Particles in the air) – See photos on CD

2. What can cause particles to be present in the air, particularly in winter?
   (Woodfires, burning off, car and truck exhausts)

3. Cars put a lot of pollutant gases into the air. Can you always see them? (no) Why not? (They are invisible)

Follow up:
Have another look at the cartoon of 'Smogsville' (Lesson 1, activity 2), find 5 examples of each type of pollution, particulate and gaseous.

Curriculum Links

Society and Environment: Place and Space, Features of Places (Levels 2,3,4)

Key Content (from Curriculum Guide)
Natural and Built Features

- Natural processes and/or human processes create and/or change particular landscapes

Human activities influence natural features

- People's activities have planned and unplanned impacts on the natural features of a particular landscape

Natural landscapes and human activities are interrelated

- The interaction between people and the wider environment can be measured

Science: Earth and Beyond, Sustainability of life and wise resource use (Levels 2, 3, 4)

Key content (from Curriculum Guide):
Renewable and non-renewable resources

- Resource use can change the physical environment

Physical and natural systems and sustainability

- Human impact on natural systems results in changes to the environment and consequently impacts on humans

Activity 2.3 A social problem – smoking out the neighbours!

Introduction

Particles can be harmful to our health, affect plant and animal life and discolour buildings and other structures. In winter one of the main sources of particles are wood heaters in our homes; Perth has around 160,000 wood heaters. Diesel engines are a major source of particles on our roads.

Aim

At the end of this lesson students will be able to:

- Encourage a 'neighbour 'to use their wood heater correctly
- Evaluate solutions to dealing with a neighbour with a smokey fire that is causing them distress
- Deal sensitively with a difficult interpersonal situation

Materials

Cartoon 'Smogsville'
Cartoon 'Good and Bad Woodheaters' – see p 26 'Air Pollution and You'

Activity

Teacher notes:
You could begin this activity using the 'Smogsville' cartoon from Lesson 1. Point out the person burning off and ask them to suggest how that would be affecting the neighbours.

Explain that burning off is not permitted in many suburbs now, but there can be other 'smoky' problems. Elicit wood heaters and explain that Perth has 1600,000 wood heaters. Brianstorm the kind of problems these can cause (Asthma, coughing, eye/nose irritation, smokey smells in neighbours houses, smelly washing on the line).

Task one:

Give the groups copies of the two cartoons showing correct and incorrect wood heater use; ask them to tell you what you should do to run a wood fire that doesn't create too much smoke.

Answers:
Seasoned (not green) wood
Wood stored out of the rain
Open flue
Chimney at least 1 metre above the roof
"Parallel Excluder" at top of chimney rather than "Chinamans Hat"
Smaller pieces of wood in the fire

Task two:

Ask students to brainstorm how they would deal with the problem of having a 'smoky' neighbour; this neighbour has a wood heater which they use all day everyday during winter. The chimney is always producing high levels of smoke which frequently blows over neighbours houses, many neighbours are getting upset and they believe it is contributing to health problems (including asthma) in their children. Students could consider the following questions:

1. State clearly what the problem is and how it is making the neighbours feel.
2. Decide on the goal, what do you want the outcome to be?
3. Think of as many solutions to the problem as you can. At this stage no-one may comment on the ideas suggested. Just accept them and write them down.
4. Take each idea one at a time and think about the consequences if that idea was adopted. Think about the consequences in terms of whether it will meet the goal as well as in terms of other peoples' actions, thoughts and feelings. Cross off any ideas that have unacceptable consequences.
5. Negotiate to select the best action.
6. Decide how you would go about doing that action.

As a class discuss each group's solution, which would be the most effective way to deal with the problem? Would they feel comfortable about doing that?

If you have a wood heater, how can you make sure you don't upset your neighbours?

Curriculum Links:
Society and Environment: Place and Space, Features of Places (Levels 2,3,4)
Key Content
Natural and Built Features
- Natural processes and/or human processes create and/or change particular landscapes

Human activities influence natural features
- People's activities have planned and unplanned impacts on the natural features of a particular landscape
- The impact of one group of people on a particular landscape or the environment may affect other people and may cause conflict over its use
- Competing uses for natural resources may cause conflict over its use

Natural landscapes and human activities are interrelated
- The interaction between people and the wider environment can be measured

Society and Environment; Care of Places
Significance of Places
- The importance of a particular landscape to an individual reflects their thinking about the environment

Science: Earth and Beyond, Sustainability of life and wise resource use (Levels 2, 3, 4)

Key content (from Curriculum Guide):
Renewable and non-renewable resources
- Resource use can change the physical environment

Physical and natural systems and sustainability
- Human impact on natural systems results in changes to the environment and consequently impacts on humans
- Strategies to protect local environments

Lesson 2 Background Notes

Haze and particles

The major source of particles in the air comes from burning. This may be from using our wood heaters, our backyard incinerators, burning off garden refuse, natural bush fires or a controlled burn such as those done in our forests to control leaf litter build up to avoid wild bushfires. Vehicles are also an important source of particles and approximately 60 – 80% of particles from vehicles come from diesel engines.

Smoke consists of very fine particles of carbon and also grit, ash, and soot which tend to be larger in size. The larger particles settle to the ground or are washed out of the air by rain and can cause problems because they make buildings, plants, clothes and other things dirty when they fall.

At the same time, smaller particles remain in the air for some time and are more dangerous to health because they can be inhaled deep into the lungs making conditions such as bronchitis and asthma worse. The elderly, young children, and those with existing lung or heart disease are most at risk from high haze levels.

In winter haze can be worse in our towns and cities, partly because of the popularity of slow combustion wood heaters and partly because the cold clear still nights we sometimes experience cause the smoke to be trapped close to the ground (due to the formation of a temperature inversion in the lower atmosphere). At these times smoke particles can be seen as a brown haze above the horizon.

To reduce the number of particles in the air produced by our wood heaters and vehicles we can follow these guidelines:

- Avoid using open fires and woodheaters where possible
- Burn a hot fire with bright coals so that it produces as little smoke as possible
- Use small pieces of untreated and well-dried wood
- Never use green wood
- Keep your wood dry during winter
- If your chimney is smoking a lot, open up the flue and give the fire more air
- Don’t burn household rubbish, particularly plastics
- Don’t burn your garden rubbish
- Service your vehicle regularly (especially diesel engines)

Activity 2.2 **Collecting particles!** **student notes**

Introduction

With the pepper in the water we looked at a 'model' of particles, now we are going to look at the real thing! Tine particles in the air can come from natural sources or from human activity such as woodheaters and burning off. We will make simple particle collectors and find out which part of the school has the most particles in the air.

Particles can be harmful to our health and affect plant and animal life around us

Aim

At the end of this lesson you will be able to identify particles in the air and suggest where these particles may have come from

Materials

Particle collectors, made and set up one week in advance
You require (for each group):

- Two cardboard strips 5cm wide and 25 cm long
- Sticky tape
- String
- Scissors

Magnifying glasses (1 per group)

Activity

Making a particle collector

To collect particles you need to make a particle tester, using the instructions below.

1. Cut a strip of cardboard that is 5cm wide and 25cm long and cut 5 holes, each about the size of a 20 cent piece, evenly spaced along the cardboard strip.

2. Cover all holes with sticky tape. The sticky side of the tape will collect particles from the air. Make sure that you do not touch the sticky side over the holes.

3. Select three locations around the school and tie it with a piece of string to a suitable 'anchor', write your group name, date and location on the cardboard. Keep one tester in a plastic bag, this is called a control.

4. After each tester has been exposed for the same amount of time, remove the testers and record information in the table below. (Or you can cut one section with a hole off each day and keep it in a plastic bag to compare with all other sections at the end of the week)

Questions:

1. Compare your tester to those of other students; were some areas around your school dirtier than others?

2. Can you explain why these locations would be dirtier?

Date	Location	Tester Description

Activity 2.1 Visible and invisible pollutants! student notes

Introduction

The **visible pollutants** we call particles (or particulates) which are tiny particles of solid substances or drops of liquid which can float in the air. These can be natural like pollen or dust, or man-made from sources such as wood fires, wood heaters, industry, power plants or from cars or trucks.

Invisible pollution are gases which mix with air and, at times, even react with it to form other gases. Examples of this are the invisible gases from car exhausts.

Aim

You will be able to describe the physical properties of particulate and gaseous pollution.

Materials

Clear plastic cups (2 per group)
Water
Milk (1 tablespoon per group)
Pepper (1 teaspoon per group)

Activity

"Spot the polluter! "

The task: The difference between visible and invisible pollution

1. Half fill two clear disposable cups with water
2. Add one teaspoon of milk to one cup, stir to mix
3. Add one teaspoon of pepper to the other cup, stir
4. Observe the differences between the milk and the pepper

Questions:

1. What kind of pollutant(s) did the milk act like in the water?

2. What kind of pollutant(s) did the pepper act like in the water?

3. Would it be easier to get the milk or pepper out of the water?

4. Would it be easier to remove the gases or particles from the air?

5. Suggest how you could get the pepper out of the water.

Activity 3.2 - Car Costs and Pollution Worksheet

Vehicles are a major source of air pollution in Perth. Unfortunately we rely on our cars too much and the average car drives 15000 kilometres every year. Emissions from vehicle exhausts include carbon dioxide, carbon monoxide, nitrogen oxides, hydrocarbons and particulates. Vehicle emissions are responsible for producing SMOG, a gas that is very dangerous to people's health, and for increasing global warming. Each kilometre the average car drives it releases 7 grams of carbon monoxide, 0.3 grams of nitrogen oxides and 0.18 grams of hydrocarbons into the environment.

Section 1

A Average kilometres a car drives each year ______________

B Average grams of carbon monoxide (CO) a car releases each kilometre ______________

C Average grams of nitrogen oxides (Nox) a car releases each kilometre ______________

D Average grams of hydrocarbons (HCs) a car releases each kilometre ______________

Car Type	FUEL		TOTAL	
	E	**F**	**G**	**H**
	Avg cents/km	Cost($)/year ((AxE) /100)	Avg cents/km	Cost($)/year ((AxG) /100)
Small	11.57		59.68	
Medium	12.82		79.28	
Large	16.79		88.12	
4WD Medium	18.48		90.45	
4WD Large	22.67		98.84	

Note: Total expenses for a car include petrol, insurance, maintenance, depreciation, loan payments and more. Average cents per litre and grams of pollution are indicative only.

Section 2

My home car is a… ______________ (if two or more use the biggest)

Which means its car type is… ______________

My family's average fuel cost / year is… ______________ (F)

My family's average total cost / year is… ______________ (H)

My family's average cost / week is… ______________ (H / 52)

Section 3

In one week our car produces the following: ________ grams of CO ((A/52)xB) ________ grams of Nox ((A/52)xC) ________ grams of HCs ((A/52)xD)

In one month our car produces the following: ________ grams of CO ((A/12)xB) ________ grams of NOx ((A/12)xC) ________ grams of HCs ((A/12)xD)

In one year our car produces the following: ________ kilograms of CO (AxB) ________ kilograms of NOx (AxC) ________ kilograms of HCs (AxD)

There are approximately 1,000,000 cars in Perth. How many kilograms of CO, Nox and HC's do all the cars in Perth produce?

Did you know that the average car also produces 245 grams of carbon dioxide (CO2) per kilometre. How many kilograms of CO2 does your car produce each year?

Lesson 3 Cars and smog

Introduction

This lesson aims to enable students to understand one of the main causes of Perth's air pollution – photochemical smog. Students will look at causes, effects on health, and propose possible solutions to the problem.

Activity 3.1 Draw what you know – SMOG

Students investigate what they believe are the causes of smog and draw a diagram to illustrate their understandings. They then explain why it may affect personal heath, and describe different activities they can undertake to reduce smog levels.

Activity 3.2 Car costs and pollution

By investigating running costs, maintenance etc. students calculate the full cost of owning a vehicle. They will calculate the amount of air pollution produced when using their family car and report results in graphical form.

Activity 3.1 Draw what you know – SMOG

Aim

To enable students to understand the causes of smog and its effects on our health and the environment. Students will be able to:

- Describe what smog is
- Identify what are the major causes of smog production
- Understand why smog is bad for them
- List different activities they can undertake to reduce smog levels

Materials

Paper and coloured pencils

Activity

Students create a drawing to describe what they know about smog and how it is formed.

Discussion

1. Discuss smog and air pollution. Sample questions could include:
   Has anyone ever seen air pollution? If yes, what did it look like and where were you at the time?
   Do you think we can see all the pollution in the air? (Smog is invisible)
   What do you think causes more air pollution in Perth than anything else? (Cars – the worst, Industry – the second worst)
   When do you think the most smog would occur in Perth? (Late spring to early autumn)
   What elements of our lifestyle and our metropolitan area contribute to Perth having lots of smog? (Almost everybody owns a car, long hot summers, moderate winds, blue skies that makes us think the air is clean)
2. Students individually draw a picture to describe what they know about smog, its formation and the effects on people.
3. Review drawings, are everyone's drawing correct?
4. Discuss what people can do to reduce the formation of smog in Perth.
5. Discuss the effects of smog on our health and the environment.
6. Choose students to write the responses on the board.

Curriculum Links

Society and Environment

Place and space; People and places (Levels 2,3,4)

Human activities influence natural features

- People's activities have planned and unplanned impacts on the natural features of a particular landscape.

Natural and Social Systems (Levels 2,3,4)

Elements and interrelationships in natural systems

- Changing, removing one element in a natural system impacts on the whole community

Science

Communicating Scientifically; Communicate scientific understandings (Level2 2,3,4)

Access and organise information

- Organisers for information

Activity 3.2 Car costs and pollution

Aim

To allow students to understand:

- The true cost of owning a vehicle.
- How much pollution a vehicle produces.

Materials

Car cost and pollution worksheet, paper, calculator and pencil

Activity

Students calculate the cost of owning a vehicle and the amount of pollution produced by the family car, and then graph the pollution.

1. Discuss car use and its link to pollution. Sample questions could include:
   What do you think causes more air pollution in Perth than anything else? (Cars – the worst, Industry – the second worst)
   Is pollution still coming out of an exhaust even when you can't see smoke? (Yes)
   What expenses are there when you own and use a car? What do Mum and Dad have to pay for? (The car, petrol, mechanics, insurance, batteries, tyres, parking, roadside assistance, depreciation of the car's value price)
2. Students read the black section at the top of the Car Cost and Pollution Worksheet
3. Under Section One students input average information data in points A to D and then fill in the table for each car type at point F and H. This will calculate the cost of buying and running an unleaded petrol car, one column is purely fuel costs, the other includes all expenses including maintenance, depreciation and insurance.
4. Complete Section Two about their family car to work out how much it costs to run their car each week.
5. Complete Section Three and calculate the how much pollution (CO, NOx and HC) is generated in one week, one month and one year by their parent's car(s).
6. Create a graph that illustrates the pollution levels produced by their parent's car over one year. (CO, NOx and HC)
7. As a class work out how much CO, NOx and HC is produced by all cars in Perth. (Remember this does not include buses, trucks, motorbikes etc).
8. As a class work out how much carbon dioxide (CO_2) is produced by one car in a week, month and year.
9. Discuss what people can do to reduce the amount of pollution that comes from cars in Perth. What alternatives are there to petrol cars?
10. Brainstorm other impacts from overusing cars, environmental and non-environmental. (traffic jams, time delays, anger, stress, accidents, hospital expenses, destruction of nature for roads and carparks, health effects)

Curriculum Links

Society and Environment

Place and space; People and places (Levels 2,3,4)

Human activities influence natural features

- People's activities have planned and unplanned impacts on the natural features of a particular landscape.

Natural landscapes and human activities are interrelated

- The interaction between people and the wider environment can be measured

Place and space; Care of places (Levels 2,3,4)

Key Content:

The significance of places

- An individual's point of view about the environment is based on a range of factors that influence personal values.

People care for places and the wider environment

- Current decisions about the care of particular landscapes and the wider environment affect people's future well-being.

Natural and Social Systems; Natural systems (Levels 2,3,4)

Key Content:

Elements and interrelationships in natural systems

- Changing, adding or removing one element in a natural system impacts on the whole community

Mathematics

Number; Understand Numbers (Level 2,3,4)

Whole numbers and decimals

- Numbers with one or two decimal places can be rounded to the nearest integer or tenth
- A decimal point separates whole units from a part of the same unit in money and metric measurements

Number; Calculate (Level 2,3,4)

Multiplication and division

- Multiplication and division of decimals
- Division problems where a remainder exists
- Division problems can be calculated by using a calculator and how to interpret decimal point answers

Lesson 3.1 Draw what you know – SMOG student notes

Aim

You will be able to:

- Describe what smog is
- Identify what are the major causes of smog production
- Understand why smog is bad for them
- List different activities they can undertake to reduce smog levels

Materials

Paper and coloured pencils

Activity

Create a drawing to describe what you know about smog and how it is formed.

Discussion

1. Discuss smog and air pollution. Sample questions could include:

   Has anyone ever seen air pollution? If yes, what did it look like and where were you at the time?

   Do you think we can see all the pollution in the air? (Smog is invisible)

   What do you think causes more air pollution in Perth than anything else? (Cars – the worst, Industry – the second worst)

   When do you think the most smog would occur in Perth? (Late spring to early autumn)

   What elements of our lifestyle and our metropolitan area contribute to Perth having lots of smog? (Almost everybody owns a car, long hot summers, moderate winds, blue skies that makes us think the air is clean)
2. Students individually draw a picture to describe what they know about smog, its formation and the effects on people.
3. Review drawings, is everyone's drawing correct?
4. Discuss what people can do to reduce the formation of smog in Perth.
5. Discuss the effects of smog to our health and the environment.
6. Choose students to write the responses on the board.

Lesson 3.2 Car costs and pollution student notes

Activity

Calculate the cost of owning a vehicle and the amounts of pollution produced by the family car and then graph the pollution.

1. Discuss car use and its link to pollution. Sample questions could include:
   What do you think causes more air pollution in Perth than anything else? (Cars – the worst, Industry – the second worst)
   Is pollution still coming out of an exhaust even when you can't see smoke? (Yes)
   What expenses are there when you own and use a car? What do Mum and Dad have to pay for? (The car, petrol, mechanics, insurance, batteries, tyres, parking, roadside assistance, depreciation of the car's price)
2. Students read the black section at the top of the Car Cost and Pollution Worksheet.
3. Under Section One students input average information data in points A to D and then fill in the table for each car type at points F and H. This will calculate the cost of buying and running an unleaded petrol car, one column is purely fuel costs, the other includes all expenses including maintenance, depreciation and insurance.
4. Complete Section Two about their family car to work out how much it costs to run their car each week.
5. Complete Section Three and calculate how much pollution (CO, NOx and HC) is generated in one week, one month and one year by their parent's car(s).
6. Create a graph that illustrates the pollution levels produced by their parent's car over one year. (CO, NOx and HC).
7. As a class work out how much CO, NOx and HC is produced by all cars in Perth. (Remember this does not include buses, trucks, motorbikes etc).
8. As a class work out how much carbon dioxide (CO_2) is produced by one car in a week, month and year.
9. Discuss what people can do to reduce the amount of pollution that comes from cars in Perth. What alternatives are there to petrol cars?
10. Brainstorm other impacts from overusing cars, environmental and non-environmental (traffic jams, time delays, anger, stress, accidents, hospital expenses, destruction of nature for roads and carparks, health effects).

Lesson 3 Background Notes

Cars and smog

Photochemical smog is a pollutant produced when the gases emitted from vehicles and industry react with heat in the air. This chemical reaction creates a colourless and odourless gas known as photochemical smog.

The cars that we drive every day emit carbon dioxide, carbon monoxide, nitrogen oxides, lead, hydrocarbons and particulate matter from their exhausts. The nitrogen oxides released react further under the influence of heat and sunlight to form ozone, which is the major component of the invisible pollution known as smog. Ozone is formed when oxides of nitrogen and reactive organic compounds come together for a few hours under the influence of sunlight and high temperatures.

Ozone in the stratosphere is good and helps protect the earth from damaging ultra violet radiation, eg the ozone layer, however ground level ozone can be very damaging to our health and can also affect the yields and growth rate of plants.

Perth typically has over 10 days per year when ground level ozone exceeds the World Health Organisation goal of 80 parts per billion. These high levels have been recorded as far south as Rockingham, north as Two Rocks, east as Rottnest and west as Rolling Green.

Ozone causes health problems such as eye, nose and throat irritations and damages the respiratory system. When people come in contact with higher levels of ozone they may feel tightness in the chest and experience wheezing. There is also evidence that higher ozone levels can trigger asthma attacks and increase our susceptibility to infection.

The young, the elderly and those with lung and heart disease are most at risk. For an average person, exercising on a day when ozone levels are high can also damage their health. This is because the volume of air that they breathe increases due to the exercise and therefore smog inhalation also increases exacerbating its harmful effects.

The actions that occur to create smog are:
- Lots of cars are on the road and there may be traffic jams
- Exhaust fumes are expelled into the air as people drive
- It is a hot day, typically late spring through to early autumn
- Smog is created in a chemical reaction over a few hours

There are many ways to reduce the formation of smog such as:
- Choose not to drive
- Walk
- Catch the bus
- Ride a bike
- Carpool
- Drive smoothly
- Buy a fuel efficient car
- Keep the car well tuned
- Avoid peak hour traffic
- Keep your tyres correctly inflated

Lesson 3.2 Background Notes

Vehicles

In WA there are over 1 million cars and each day we drive approximately 40 million kilometres in total. That is enough to drive to the moon 100 times.

The cars that we drive every day are the major source of photochemical smog generation in Perth.

Health and Environmental Effects

Carbon Monoxide (CO)

- CO reduces the ability of the blood to carry oxygen and is particularly dangerous to smokers, persons with heart disease and those with anaemia. CO can also cause permanent damage to the nervous system.

Nitrogen Oxide (NOx)

- NOx exacerbate asthma, reduce lung function and can lead to chronic lung damage. NOx also increases the susceptibility of young children and the elderly to respiratory infections.
- NOx also reacts in the presence of Volatile Organic Compounds and sunlight to form ground-level ozone, a major component of smog. Ozone irritates the eyes, damages the lungs and aggravates respiratory problems. It is our most widespread and intractable urban air pollution problem. Ozone also reduces agricultural production and the growth rate of trees.
- NOx contributes to the formation of acid rain. Acid rain acidifies the soils and waters where it falls, killing plants, fish and the animals that depend on them. Acid rain also causes property damage through the corrosion of buildings and monuments.
- NOx also contributes to nitrification (i.e. over fertilisation) of wetlands and bays, leading to algal blooms and fish kills.

Hydrocarbons (HCs)

- HCs react in the presence of nitrogen oxides and sunlight to form ground-level ozone just like NOx.
- A number of exhaust HCs are also toxic, with the potential to cause cancer, nerve damage and other health effects. Benzene, a known human carcinogen, is an example of a toxic HC found in vehicle exhaust.

Lesson 4 Air pollution and your health!

Introduction

This lesson identifies some common health effects of air pollution. Students identify how and where the body may be affected and investigate what happens to their lungs under different situations. Students will reflect on how they feel about air quality in relation to personal health and lifestyle.

Activity 4.1 "Stay outside please!"

We often think that only our lungs are affected by poor air quality. In completing this activity students recognise other parts of the body affected by poor air, and look at some common effects of pollution.

Activity 4.2 "Is that how it really feels?"

By conducting a simple breathing activity using straws, students identify the physical and emotional effects of asthma on individuals and those around them. Students explore attitudes towards breathing difficulties caused by poor air quality.

Activity 4.1 "Stay outside please!"

Students use a poster to identify affected body parts.

Aim

Students recognise parts of the body affected by poor air, and differentiate between them. Students will understand how poor air quality may affect themselves and others individually.

Materials

Upper body diagram – supplied

Extras; General information about pollution and health
www.hhmi.org/coolscience - info and fun activities for students to make their own air testing kits
http://www.lungnet.org.au/education/learn-health.html - Australian Lung Foundation, how the lungs work, causes and treatments of asthma, bronchitis, indoor outdoor air pollution
www.davidsuzuki.org - Canadian environmental site looking at air pollution, health effects, global warming

Activity

Using the diagram, students are asked to identify which parts of the body pollution affects, and say what those effects may be.

1. Use the diagram of the body to identify which parts can be affected by poor air quality.
2. Name the ways that fine particles enter the body.
3. Describe how pollution can affect each of the parts of the body you have identified above.
4. Working in groups, describe some common allergies or illnesses made worse by air pollution.
5. If the air was really bad, how would this affect your daily life?

As a class discuss:
Which parts of the body are most at risk – were you surprised by what you found out?
Do you know anyone who has difficulty breathing?
Why is personal health and exercise important to you?
If the air was badly polluted in Perth describe how this would affect your body and exercise.

Curriculum Links

Science; Life and living
Key content:
Structure and life processes

- All living things have a number of life processes
- External and internal factors can impact on living things eg. pollution

Health and Physical education; Knowledge and understandings
Key content:
The meaning and dimensions of health

- people can enhance their health by developing positive attitudes towards it and taking positive action

Cross curricular links: English, listening, speaking, writing

Activity 4.2 "Is that how it really feels?"

A simple breathing activity using straws.

Aim

To identify physical and emotional effects of asthma on individuals and those around them. Students explore attitudes towards breathing difficulties caused by poor air quality.

Materials

Straws (2 per student), Asthma WA website: www.asthmawa.org.au, factsheets.

Teachers' note:
Asthma is airway narrowing, which varies in severity over short periods of time. When sensitive bronchioles (small tubes in the windpipe) are exposed to certain 'triggers' they narrow, making it harder to breathe. Narrowing of the airways may be due to; inflammation, excess mucus, or muscle spasm. Many people are born with a tendency to develop asthma, and it usually occurs with family history and in association with allergies.

- Currently 1 in 6 children in Australia suffer from asthma
- 220,000 Western Australians have asthma (2002)
- the elderly and young children are most at risk

There is no evidence that air pollution can actually cause any respiratory disease including asthma. In fact some research in Europe shows more allergies and asthma in less polluted cities. Australia and New Zealand have the highest levels of asthma in the world despite having fairly good air quality.

There are two main forms of air pollution which could make asthma worse
1. Particles from combustion e.g. car and diesel engines, industry, domestic coal and wood and bush fires as well as dirt and sand.
2. Nitrogen dioxide and ozone are formed in summer smog and in high concentrations cause airway inflammation in people with and without asthma.

Common triggers can be: viral infections eg. colds/flu, pollens, moulds, dust, air pollutants, some food preservatives, exercise, emotions.

Doing the activity:
Emotional and physical feelings; anxious, scared, short of breath, tired, heavy feeling, flushed, no problem!

Things at home that could affect our breathing:
dust mites, carpets, unflued gas heaters, chemicals in cleaning products, paints, volatile organic compounds (voc's) found in new furnishings and more. Information about indoor air quality www.epa.gov/iaq/ia-

Activity

Before doing each activity please check for any pre-existing medical conditions or otherwise which may affect students carrying out the activity.

Each student receives 2 straws. Students are asked to participate in two experiments:
a) AirWay narrowing

1. Place both straws in mouth side by side and breathe through the straws with noses pinched
2. Remove one straw and breathe through the remaining straw
3. Join two straws together and breathe through the end to end straws

Students recognise through progressive steps, an increasing difficulty in breathing.

b) Narrowing – how does it feel

1. Students cut their straw (from first experiment) in half
2. Students jog on the spot for 1 minute
3. Put half a straw in mouth and pinch nose. Breathe through straw while jogging on the spot for the next 10 seconds.

Students recognise that there is increased difficulty in breathing when exercising.

As a class or in groups discuss:
What happened to their body physically?
How they felt emotionally with restricted breathing, eg. scared, worried.
If this happened often how would you feel?
Make a list of things at home or school which may affect your breathing.

Curriculum links

Health & Physical education; Knowledge & understanding
Key content:
The body's response to physical activity

- different components of a physical activity (type, frequency, intensity, duration)

The meaning and dimensions of health

- people's attitudes to health are varied

Health and physical education; Self management skills

Key content:

Reviewing the situation

- how to identify risks in issues, situations, environments or lifestyles

Science; Life and living

Key content:

- an organism's structure of body system enables it to carry out life processes (eg. lungs and breathing)

Science; Earth and beyond

Key content:

- Student understands how some change in the observable environment influence life (eg. breathing)

Activity 4.1 **student notes**

"Stay outside please!" - Students use a poster to identify affected body parts.

Activity

Using the diagram of the upper body students identify which parts of the body pollution affects, and say what those effects may be.

1. Use the diagram of the body, identify which parts can be affected by poor air quality.
2. Name the ways that fine particles enter the body?
3. Describe how pollution can affect each of the parts of the body you have identified above.
4. Working in groups, describe some common allergies or illnesses made worse by air pollution.
5. If the air was really bad, how would this affect your daily life?

As a class discuss:
Which parts of the body are most at risk – were you surprised by what you found out?
Do you know anyone who has difficulty breathing?
Why is personal health and exercise important to you?
If the air was badly polluted in Perth describe how this would affect your body and exercise.

Activity 4.2 “Is that how it really feels?”

A breathing activity using straws.

Each student receives 2 straws. Students are asked to participate in two experiments:

a) AirWay narrowing
1. Place both straws in mouth side by side and breathe through the straws with noses pinched
2. Remove one straw and breathe through the remaining straw
3. Join two straws together and breathe through the end to end straws

Students recognise through progressive steps, an increasing difficulty in breathing.

b) Narrowing – how does it feel
1. Students cut their straw (from first experiment) in half
2. Students jog on the spot for 1 minute
3. Put half a straw in mouth and pinch nose. Breathe through straw while jogging on the spot for the next 10 seconds.

Students recognise that there is increased difficulty in breathing when exercising.

Discussion:
As a class or in groups discuss:
- What happened to their body physically?
- How they felt emotionally with restricted breathing, eg. scared, worried.
- If this happened often how would you feel?
- Make a list of things at home or school which may affect your breathing.

Lesson 4.1 Background Notes

Health effects of air pollution

Most of us associate our lungs with pollution related illness, as air pollution lessen the lung's ability to exhale air, and can damage lungs even after minor irritation disappears. However there are a range of symptoms and other body parts that can be affected by short term exposure to high pollution levels. Eyes nose and throat can be irritated; other common symptoms include headache, lethargy, dizziness, allergies, asthma, and in extreme cases blood noses.

Long-term contact with polluted air can have permanent health effects, like rapidly aging the lungs, decreasing lung capacity and function, causing diseases like asthma, bronchitis, emphysema, and cancer and shortening life span.

People who are most affected by air pollution include:
Children younger than 14, those with heart or lung disease, those with respiratory diseases such as asthma or emphysema, pregnant women , outdoor workers and athletes who exercise vigorously.

Notes on activity 4.1 (identify parts of the body, and symptoms)

1. Eyes, nose, throat, chest, skin
2. Most common are absorption via the skin and inhalation
3. Eyes – watery and stinging, sensitive to changes in atmosphere
   Nose – nasal hairs damaged, itchiness, loss of smell/nose bleeds in extreme cases
   Sore throat
   Head – headaches, dizziness, sickness
   Chest – wheezing, coughing, tightness
   Skin – itchy, or sometimes rashes due to allergies

4. Asthma – may trigger asthma attacks, shortness of breath, wheezing, indoor pollutants may cause it eg. house dust mite.
   Bronchitis - is usually caused by a viral infection of the bronchi, causing swelling and more mucus than usual. This causes a cough, and sometimes pain which is felt in the throat or upper chest when the child coughs.

   Chronic bronchitis occurs long term and is usually caused by long-term inhalation of irritants, such as cigarette smoke. Over a long term it can cause scarring of the small airways making breathing more difficult.

5. Think of the things you usually do in the day eg. walk to school, play games at recess, eat lunch outside, go to a friend's house or play sport after school. How would these be different?

Emphysema - may develop after long-term exposure when the irritants also promote destruction of the alveolar air sacs. This makes it hard for the lungs to support any kind of exertion without the person becoming breathless. Bronchitis and emphysema may occur separately but often occur together.

Activity 4.2 Background Notes

Asthma

Asthma is airway narrowing, which varies in severity over short periods of time. When sensitive bronchioles (small tubes in the windpipe) are exposed to certain ‘triggers’ they narrow, making it harder to breathe. Narrowing of the airways may be due to; inflammation, excess mucus, or muscle spasm. Many people are born with a tendency to develop asthma, and it usually occurs with family history and in association with allergies.

- Currently 1 in 6 children in Australia suffer from asthma
- 220,000 Western Australians have asthma (2002)
- the elderly and young children are most at risk

There is no evidence that air pollution can actually cause any respiratory disease including asthma. In fact some research in Europe shows more allergies and asthma in less polluted cities. Australia and New Zealand have the highest levels of asthma in the world despite having fairly good air quality.

There are two main forms of air pollution which could make asthma worse;

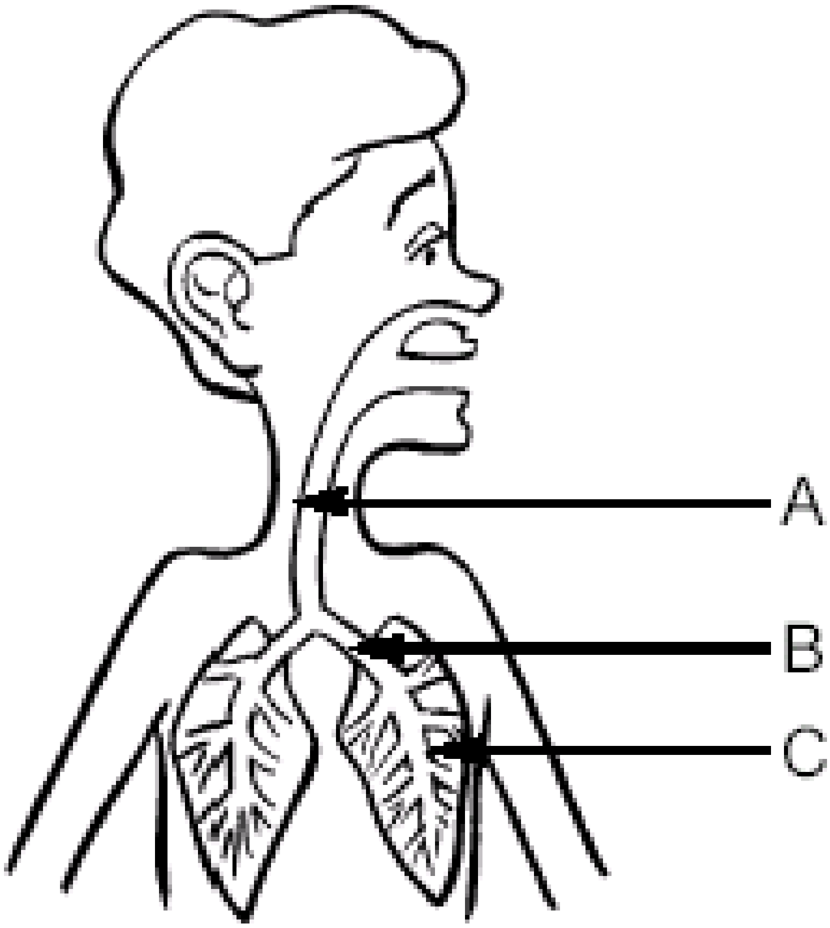
1. Particles from combustion e.g. car and diesel engines, industry, domestic coal, wood, and bush fires as well as dirt and sand.
2. Nitrogen dioxide and ozone are formed in summer smog and in high concentrations cause airway inflammation in people with and without asthma.

Common triggers can be viral infections eg. colds/flu, pollens, moulds, dust, air pollutants, some food preservatives, exercise, emotions.

‘Feelings’ when doing the activity:

- Emotional and physical feelings: anxious, scared, short of breath, tired, heavy feeling, flushed, no effects for some.
- Things at home that could affect our breathing or indoor air quality include:
dust mites, carpets, unflued gas heaters, chemicals in cleaning products, paints, volatile organic compounds (VOC's) found in new furnishings and more. Information about indoor air quality www.epa.gov/iaq/ia-

Use the diagram to decide which parts of the body can be affected by air pollution



1) Please name A, B, and C
2) Which other body parts can be affected and say how?

Lesson 5 Journeys we make

Introduction

This lesson investigates local greenhouse gases. Students identify sources and calculate personal and class contribution to greenhouse gases. They explore personal travel choices by investigating options to reduce car usage, such as public transport and car pooling.

Activity 5.1 "It's how you get there that counts!"

Students calculate their personal contribution to greenhouse gases. They will recognise that travel to school choices can influence their local environment's air quality.

Activity 5.2 Debate - the pro's and cons of car pooling/public transport

Students explore attitudes and values towards personal travel. This involves recognising issues involved, and suggesting strategies to overcome barriers.

Activity 5.1 **"It's how you get there that counts!"**

Aim

Students recognise that travel to school choices can influence their local environment's air quality. Students calculate their contribution to greenhouse gases.

Materials

Handouts; travel to school activity showing greenhouse gas calculation

Extra resources: Australian Greenhouse Office fact sheet 2
www.greenhouse.gov.au/publications, Greenhouse, questions and answers;
www.dar.csiro.au/publications/gh_faq.htm CSIRO air quality research organisation
Greenhouse gas calculator activity - www.milleniumkids.com.au

Activity

How do we get to school?

Activity: Complete the class tally sheet 'travel to school'

Class__________ Date___________

	Number of students travelling this mode	Total distance travelled by this mode (km)	Total amount of greenhouse gases p/day (0.2g per km)
Number of people coming to school by car			
Number of people coming to school by public transport			
Number of people coming to school by bicycle			
Number of people coming to school by walking			

Every 1km travelled by car = 0.2 grams of greenhouse gases

1. Which method was most & least popular?
2. What does this tell us about cars and local air quality?
3. Calculate the amount of greenhouse gases emitted by your travel to school, each day and weekly.
4. Which method of travel is most difficult to do and why?
5. Where do four other common greenhouse gases come from?

Discussion
Is it what we expected?
Do we think our results typical of the school? If so what are the implications for local air quality and health?
What are the positives and negatives about travelling in the car?
Plan accurately the steps needed to reduce class emissions from car travel.

Curriculum Links
Society and Environment; Place & space, People and places
Key content:
Human activities influence natural features
- People's activities have planned and unplanned impacts on the natural features of a particular landscape
- People's beliefs and values affect their impact on the landscape

Natural landscapes and human activities are interrelated
- The interaction between people and the wider environment can be measured

Science; Earth and beyond

Key content:
Renewable and none-renewable resources
- Resource use can change the physical environment

Physical and natural systems and sustainability
- Strategies to protect local environments

Mathematics; Understand Numbers
Whole numbers and decimals
- Numbers with one or two decimal places can be rounded to the nearest integer or tenth
- A decimal point separates whole units from a part of the same unit in money and metric measurements

Mathematics; Calculate
Addition and subtraction
- Strategies for solving addition and subtraction of money and measurements to two decimal places

Multiplication and division
- Multiplication and division of decimals
- Division problems where a remainder exists

Activity 5.2 Debate - the pro's and cons of car pooling/public transport

Aim

Students explore attitudes and values towards personal travel. This involves recognising issues involved, and suggesting strategies to overcome barriers.

Materials

AirWatch primary manual 'vehicle counts' p.69
Local bus/train timetable.

Activity

Activity:
Divide into groups to discuss positive, minus, and interesting (PMI) points about:

a) car pooling b) public transport

1. What are the main positives and negatives for both?
2. Does it matter if we don't car pool or use public transport? Clarify your personal thoughts.
3. Describe the main reasons that make us not want to use public transport.
4. Propose solutions to overcome the negative reasons you found.

Discussion:
Are our assumptions about public transport based on fact or on what we think is true?
Investigate how you could set up car-pooling in your class.

Curriculum Links

Society and Environment; Place & space, People and places
Key content:
Human activities influence natural features

- People's activities have planned and unplanned impacts on the natural features of a particular landscape
- People's beliefs and values affect their impact on the landscape
- The impact of one group of people on the environment may affect other people

Natural landscapes and human activities are interrelated

- The interaction between people and the wider environment can be measured

The significance of places

- The importance of the wider environment to an individual influences thinking about how it should be cared for and used
- An individual's point of view about the environment is based on a range of factors that influence personal values

Science; earth and beyond
Key content:
Renewable and none-renewable resources

- Resource use can change the physical environment

Physical and natural systems and sustainability

- Human impact on natural systems results in changes to the environment and impacts on humans
- Strategies to protect local environments

Health and Physical education; Knowledge and understandings
Key content:
The meaning and dimensions of health

- people can enhance their health by developing positive attitudes towards it and taking positive action

Assessment
Use a rubric to identify the main issues involved in car pooling, demonstrating an understanding of the positives and negatives for them as individuals, and for the environment.

Activity 5.1 " It's how you get there that counts!" student notes

Aim

Students recognise that travel to school choices can influence their local environment's air quality. Students calculate their contribution to greenhouse gases.

How do we get to school?

Activity: Complete the class tally sheet 'travel to school'

Class__________ Date___________

	Number of students travelling this mode	Total distance travelled by this mode (km)	Total amount of greenhouse gases p/day (0.2g per km)
Number of people coming to school by car		Eg. 26	Eg. 26 x 0.2
Number of people coming to school by public transport			
Number of people coming to school by bicycle			
Number of people coming to school by walking			

Every 1km travelled by car = 0.2 grammes of greenhouse gases.

1. Which method was most & least popular?
2. What does this tell us about cars and local air quality?
3. Calculate the amount of greenhouse gases emitted by your travel to school, each day and weekly.
4. Which method of travel is most difficult to do and why?
5. Where do four other common greenhouse gases come from?

Discussion

Is it what we expected?
Do we think our results typical of the school? If so, what are the implications for local air quality and health?
What are the positives and negatives about travelling in the car?
Plan the steps needed to reduce class emissions from car travel.

Activity 5.2 Debate - the pro's and cons of car pooling/public transport

Aim

Students explore attitudes and values towards personal travel. This involves recognising issues involved, and suggesting strategies to overcome barriers.

Materials

AirWatch primary manual 'vehicle counts' p.69
Transperth local bus/train timetable
.

Activity

Activity:
Divide into groups to discuss positive, minus, and interesting (PMI) points about:

a) car pooling b) public transport

1. What are the main positives and negatives for both?
2. Does it matter if we don't car pool or use public transport? Clarify your personal thoughts.
3. Describe the main reasons that make us not want to use public transport.
4. Propose solutions to overcome the negative reasons you found.

Further discussion:
Are our assumptions about public transport based on fact or on what we think is true?
Who gives us our information about public transport?
Do we feel safe using public transport?
How could you set up car-pooling in your class?

Activity 5.1 Background Notes

Cars, pollution and greenhouse gases

Travel to school by car is one of the leading causes of air pollution in many cities, especially in school areas themselves. The most significant natural greenhouse gas is carbon dioxide ($CO2$).

An average car produces 0.2g of $CO2$ for every km travelled. $CO2$ concentrations have risen by about 30% since pre-industrial times. Road transport emissions in 2003 were 1% higher than in 2002, and 31% higher than in 1990 (Australian Greenhouse Office).

On average diesel vehicles generate more emissions than petrol vehicles per km travelled.

The greenhouse effect is a natural process. Sunlight passes through the atmosphere, warming the Earth's surface. In turn, the land and oceans release heat, or infrared radiation, into the atmosphere, balancing the incoming energy. Water vapour, carbon dioxide and some other naturally occurring gases can absorb part of this radiation, allowing it to warm the lower atmosphere.

This absorption of heat, which keeps the surface of our planet warm enough to sustain us, is called the greenhouse effect. Without heat-trapping greenhouse gases, average global surface temperature would be -18°C rather than the current average of 15°C.

Main causes of greenhouse gases

Activity	**Greenhouse gas produced**
Burning fossil fuels eg. cars, industry	Co2
Clearing land	Co2
Agriculture eg. cattle, fertilizers, rice paddies	Methane
Producing waste eg. sewage, rubbish	Nitrous oxide (NOx)
Household products eg. fridges, furniture	Hydrocarbons (CFC's and volatile organic compounds)

Where do greenhouse gases come from?
Most of the increase in carbon dioxide comes from burning of fossil fuels such as oil, coal, and natural gas for energy, and from deforestation.
Cows, sheep and other ruminant animals 'burp' methane into the air. Rice paddies also generate methane. Other sources of methane are landfills, burning vegetation, coal mines, and natural gas fields.

How long do they stay in the air?
Carbon dioxide persists for more than a century in the air. Methane's average lifetime is about 11 years. Nitrous oxide and some of the CFCs stay in the air for more than a century.

How much greenhouse gas does Australia produce?
In 2001, Australia produced 528.1 million tonnes of carbon dioxide equivalent -- this was mainly carbon dioxide (69.9%) as well as methane (22.9%), nitrous oxide (6.3%) and other gases. Of Australia's total net emissions in 2001, the production of energy accounted for 68.0%, 19.5% came from agriculture, emissions from industrial processes contributed 4.6%, and waste emissions contributed 3.1%. More details about Australia's emissions is available from the Australian Greenhouse Office's National Greenhouse Gas Inventory

Activity 5.2 Background Notes

Vehicle use and costs!

All over the world planners are finding it increasingly impossible to meet the growth in motor vehicle use just by building new roads. Planners from the UK have stated that if we can't reduce car use, we'll just run out of space, our roads will become choked with traffic and our air will become unfit to breathe.
West Australians would be horrified to think that they were contributing to such a heritage for their children and grandchildren.

Studies have found that it is not industry that is the largest polluter in Perth, it is community behaviour, such as vehicle use, that is causing most of Perth's air pollution.

- Car use in Perth is climbing, at a significant cost to the community. We all need to start being responsible and recognise that our individual behaviour can reduce the air pollution problem.
- Currently (2002), there are 2.8 million driver-only car trips made per day in Perth.
- If present trends continue, this will increase to 4.7 million in 2029.
- 8 out of 10 journeys are made by car (2002).
- The average trip length is 8km.

Driving costs!

- Perth spends 17% of its collective earnings on transport, mostly on running cars and providing and maintaining roads.
- Keeping a car on the road can put a dent in your wallet. NRMA Motoring & Services has worked out and regularly updates the weekly running costs for the most popular models.
- For example, keeping a Toyota Corolla hatch on the road can cost an average of $135 per week.
- Visit Transperth's savings calculator from the links page to see how much you could be saving by catching public transport instead of driving your car every day.
- Did you know that using public transport eliminates almost 20 per cent of your car emissions and helps you save money.

Health and Environment

Cars are a health hazard. Not only do we replace healthy active alternatives such as walking and cycling with sitting behind the wheel, but our cars pollute the air with carbon monoxide, nitrogen oxides and air toxics. There is increasing evidence that vehicle emissions contribute to major respiratory problems, cancer and premature death.

What can be done?

- A car pool can be organised for every day or just once per week, depending on your needs.
- Cheap car pooling car parks in Perth are located in Mayfair Street in West Perth, and Queens Gardens in East Perth.
- Join Travelsmart schools - **Example Manning Primary school.**
  In 2000, the year 7 class at Manning Primary School reduced their car use by 53%! Even after the program, they took the car to school a third less than before the program (31%). The school won a $500 cheque for the greatest improvement.

Extra resources

Travelsmart schools program www.dpi.wa.gov.au/travelsmart/schools.html
Calculate your car emissions and fuel costs at: www.motoring.racv.com.au
www.greehnouse.gov.au/tdm/publications/carsharing
Vehicle operating costs: www.mynrma.com.au/operatingcosts

Assessment – Your health and pollution!

Perth's air is under threat from a mysterious disease. People are getting sick and you need to find out why….

Task: Working as undercover agents you must find out what is posing the risk to Perth's air. You are to go 'inside' the human body to find out just how it is being affected. Your mission will include identifying causes of illness and planning an emergency response to treat all those affected.

Health and physical education; Knowledge and understandings
Science; Life and living

ELEMENTS	Level 2	Level 3	Level 4
External and internal factors can impact on living things eg. pollution	I know that air pollution may cause lung damage	I understand that it has other health effects such as headaches, dizziness, allergies, eye and nose irritations	I know it has other symptoms and can lead to long-term illness such as asthma and bronchitis
Decision making - ways to deal with a problem (eg own, share, ignore or respond to it)	I can recognise people breathing with difficulty	I can recognise exactly what the problem is	I recognise and know how to respond by treating the situation or seeking further help
Physical and social-emotional benefits associated with physical activity	I know that some people don't feel well and others are not affected because of pollution	I know that everyone has different sensitivities and this may be why some are affected more than others	I know why some are affected more than others and I can suggest ways to minimise the risk for some people

Rubric

This rubric represents our understanding of air pollution in our cities

Science

Earth and Beyond

Task: Look at the picture of 'Smogsville'. The city council wants to build a **Daycare Centre** on the vacant block in the middle of the picture.

Write a letter to the **Mayor** explaining how air pollution could be a problem at this site. You can cover the sources of pollutants, the main types of pollution and what people and the city council can do to reduce pollution.

	Below expected level Level 2	Expected level Level 3	Above expected level Level 4
Resource use can change the physical environment	I can name the main sources of pollutants.	I can name the main sources of pollutants, describe how these form two main types of pollution and explain how weather makes these worse.	I can name the main sources of pollutants, describe in detail how these form two main types of pollution and explain how weather makes these worse. I can explain how this will affect where to build the day care centre.
Human impact on natural systems results in changes to the environment and impacts on humans	I described some of the ways that air pollution affects people.	I described most of the ways that different types of air pollution affect people.	I described all the ways that the main types of air pollution affects life
Strategies to protect local environments	I suggested some actions people can do to care for their air.	I suggested some actions people can do to care for their air and realise that some people do and some don't care about their environment.	I suggested some actions people can do to care for their air and realise that some people do and some don't care about their environment. I suggested what the city can do to help people change.

Rubric

This rubric represents our understanding of air pollution in our cities

Society and Environment

Place and Space

Task: Look at the picture of 'Smogsville'. The city council wants to build a **Daycare Centre** on the vacant block in the middle of the picture.

Write a letter to the **Mayor** explaining how air pollution could be a problem at this site. You can cover the sources of pollutants, the main types of pollution and people and the city can do to reduce pollution.

	Below expected level Level 2	Expected level Level 3	Above expected level Level 4
Features of places	I can name the main sources of pollutants.	I can name the main sources of pollutants, describe how these form two main types of pollution and explain how weather makes these worse.	I can name the main sources of pollutants, describe how these form two main types of pollution and explain how weather makes these worse. I can explain how this will affect where to build the day care centre.
People and Places	I understand that most people don't realise they create pollution.	I understand that most people don't realise they create pollution and that our pollution affects other people.	I understand that most people don't realise they create pollution and that our pollution affects other people and what they do in a place.
Care of places	I suggested some actions people can do to care for their air.	I suggested some actions people can do to care for their air and realise that some people do and some don't care about their environment.	I suggested some actions people can do to care for their air and realise that some people do and some don't care about their environment. I suggested what the city can do to help people change.

BE COOL - CAR POOL TO SCHOOL!

Task: In order to be "role model students" for your community, you are to develop and promote a plan for car-pooling to parents of students in your class.

You must clearly explain the benefits to your parents of signing up to this new idea. You will need to have a plan to make it work. Explain that it will save them time and money while also helping to protect the environment.

Society and environment; place and space, resources

	Level 2	Level 3	Level 4
Human activities influence natural features	I understand that most people don't want to create pollution	I understand that the pollution we cause affects other people and places	I understand that air quality around our school can be changed by the actions of individuals, and that we can do something about it
Significance of places	I suggested some actions people can do instead of driving to school	I understand the benefits of car pooling and suggested some actions people can do to care for their air. I realise that some people would not want to do this	I suggested a plan for parents to be involved in car-pooling, gave them good reasons for doing so, and offered suggestions on how we could do it as a class
Resource availability and distribution	I realise that cars use fuels which are non renewable	I realise that people have choices about which kind of car they drive and if we use cars to travel to school we will continue to use limited resources	Making decisions on the type of car and method of travel to school, we can use resources more efficiently

Science; earth and beyond

	Level 2	Level 3	Level 4
Human impact on natural systems results in changes to the environment and impacts on humans	I understand that driving our car all the time might not be a good thing	I can explain how driving cars all the time can make air quality worsen, and may cause health effects	I can give some alternatives to driving to school and reasons why they are better for the environment
Strategies to protect local environments	I suggested some actions people can do to car pool	I suggested a plan for people to car pool and realise that some people do and some don't care about their environment	I made a plan for car-pooling, saw that some people find it difficult to do, and I suggested ways we can overcome these problems
Resource use can change the physical environment	I recognise that cars use a lot of fuel, which may not be a good thing.	I recognise that car exhausts can cause air pollution, and that if we don't do something about it our future air quality might be worse	I recognise that cars run of fossil fuels and suggested alternative forms of fuel and transport for the future

WHAT'S UP WITH OUR AIR?

Introduction

Teachers' resource

AIMS: Students will develop an understanding of the importance of air quality in their lives with consequent behavioural changes for themselves and their families.

RATIONALE: An understanding of environmental issues is essential for all students. This course will encourage students to understand how air quality affects society and how their behaviour can have an impact. Student action at home, at work and in the community is central to the idea of 'Active Citizenship' in the Society and Environment learning area and the value of Environmental Responsibility. The course offers a practical, investigative component that will, it is expected, engage and motivate.

APPROACH: There is an opportunity for students to excel as an individual and as part of a group. Choices of topics are available so that students may investigate issues of interest to them.
During the course, the student will have the opportunity to obtain the following essential knowledge and skills:

Students will be able to improve their level of questioning to a higher level depending on their understanding. Material is aimed at level 2,3, and 4 so students can understand concepts, begin to as questions about the topic, and to apply knowledge learned.

ESSENTIAL KNOWLEDGE:
Students will develop understandings about:
(From S+E Curriculum Guide)

- The features of and processes operating in natural environments
- People's activities have planned and unplanned impacts on the natural features of a particular landscape
- People's beliefs and values affect their impact on the landscape
- The impact of one group of people on a particular landscape or the environment may affect other people and may cause conflict over its use
- Competing uses for natural resources may cause conflict over the use of a particular landscape

(From Science Curriculum Guide)

- Human impact on natural systems results in changes to the environment and consequent impacts on humans
- Strategies to protect local environments

SKILLS:

- Creating questionnaires relevant to an inquiry
- Collecting and interpreting data
- Mapping data and presenting conclusions to audiences
- Working as an individual and as a part of a group

STRANDS FOCUS

Society and Environment

- Investigation Communication and Participation
- Place and Space
- Resources
- Active Citizenship

Science

- Working Scientifically
- Earth and Beyond (Sustainability of Life and Wise Resource Use)

Health and physical education

- Knowledge and understandings
- Self management skills

Cross Curricular

- English
- Art
- Technology and Enterprise
- Mathematics

Acknowledgements

The Department of Environment and AirWatch would like to thank the following people in production of the CD lesson plan 'Whats up with our air?'

For advice and material relating to curriculum design and extension writing;
Susan Brenchley, Gibbs St Primary school
Muriel Jefferson, Challis Primary school
Bev Stevens, Parkwood Primary school

Production;
Justin Mowatt, Executive Officer, Environmental Education, Department of Environment

Contact

AirWatch, Department of Environment, Level 4, Atrium, 168 St George's Terrace, Perth
WA 6000, Ph: 6364 6500/6463 www.airwatch.gov.au

Justin – format and design to be same as Community display posters where possible.
Please use common theme where you can eg. colour/imagery/skyscape etc. Can you access this easily?
I've got JPEGS of cartoons except the 1st two but not the display .

FRONT COVER

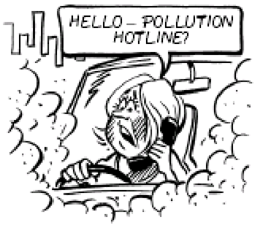
AIRWATCH (curved ?)

"WHAT'S UP WITH OUR AIR?" (curved?)

Teachers resource – an introduction to air quality issues.

In captions dotted around if not too crowed;
BE COOL AND CAR POOL
NO FUSS.... CATCH THE BUS
DON'T BE A PAIN....RIDE THE TRAIN
AIR POLLUTION.... WHATS YOUR SOLUTION?

IMAGES: – fade into background if looks better. Boy to be large in the middle, other images either side of him and smaller.

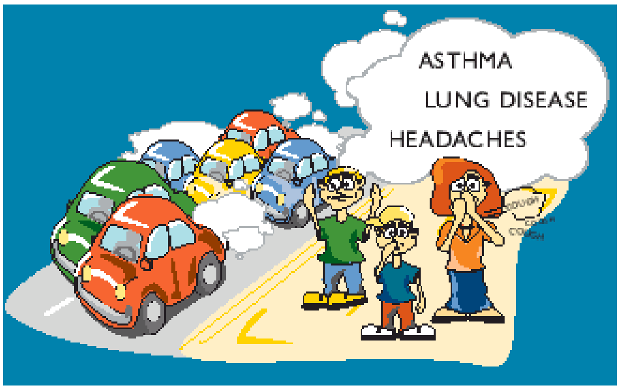


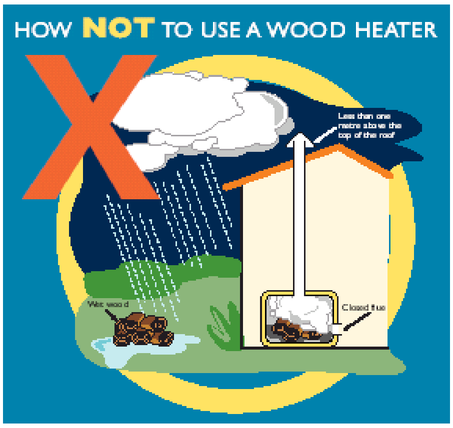
Logos:
DOE – bottom left
AirWatch/ - bottom right
Air Quality branch TBC

BACK COVER:

- How to use the CD…. (explained earlier)
- AirWatch address and website….
- This CD course will encourage students to understand how air quality affects society and how their own behaviour can have an impact.
  Student action at home, at work and in the community is central to the idea of 'Active Citizenship' in the Society and Environment learning area and the value of Environmental Responsibility.

Image:



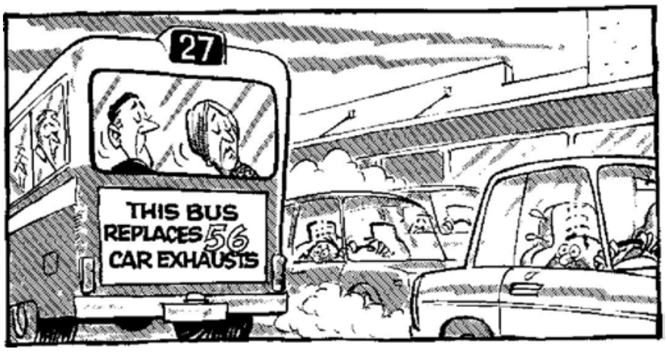


CD FACE:

Wording:

- AirWatch
- "What's up with our air?"
- A community education initiative under the Perth Air Quality Management Plan
- An average adult breathes 10,000 litres of air each day (in bubble or capsule)

Logos: AirWatch / DOE
Image:



Extension 1 A car free inner city Perth!

BACKGROUND NOTES

This page includes an extension on the basic task based on Multi-intelligences and Bloom's taxonomy. Feel free to use it in addition to or instead of the webquest.

__**Students**__: If you are accessing this page it is because your teacher has directed you to. Here's how it works: complete all 6 activities from your strongest intelligence. Remember that we all use a unique blend of a number of intelligences, so you may wish to complete one or more of the other intelligences.

Air pollution

MI		**Bloom's**	**Taxonomy**			
	Knowledge	**Comprehension**	**Application**	**Analysis**	**Synthesis**	**Evaluation**
Verbal Linguistic	List all types of Air pollution	Prepare a talk on one of the pollutants from your list	Design a vehicle that uses alternative fuel	Explain why your vehicle meets the needs of ensuring cleaner air	Plan a worksheet for another student to do on your pollutants	Discuss how a successful alternative fuel might contribute to a healthier cleaner environment. Or check out other discussions you may wish to lead. Discussion

Logical Mathematical	Complete the brain teasers	Compile a graph of pollutants showing their impact on our air	Classify different pollutants into their different types	Analyse the threat to our health & environment and explain your number one reason.	Design new signs for the city and put signs & or symbols on a map of the city	Discuss if everyone feels the same way about air pollution. You may need to survey first.
Visual Spatial	Draw one of the pollutants in the environment it is polluting	Design and make a 3D model of the city to show photochemical smog	Categorise your pollutants and add them to a wall display	Compare your pollutant to another in a venn diagram	Make a collage of pollutants	Check what pollutants others have chosen to study. Establish why people have chosen different pollutants.
Body Kinesthetic	Get a group together to present the role play	Devise a play based on the role play presented to the class		Devise and evaluate an alternative fuel that could be used instead of petrol/diesel	Design and make a vehicle that could use an alternative fuel	Play Cars & Buses
Musical Rhythmic	Learn an environmental song	Listen to the different environmental sounds on tape	Create a tape of environmental sounds of your own	Devise a dance to go with the tape	Create your own environmental song	Perform songs & dance for the class
Interpersonal	Brainstorm what 'conservation'	Hold a group discussion on the	Values clarification	Investigate three pollutants and their	Plan a program for reducing pollutants	Moral dilemmas Investigate the

	means; how have people changed the environment	main threats to our air quality		effects	in Perth	problem of imposing restrictions when they conflict with people's lifestyles
Intrapersonal	Find out all you can about one of the air pollutants	Describe your feelings about this pollutant (you could choose a poetry format)	Tell us what is so alarming about your pollutant	What would you change in Perth to reduce this pollutant & why?	Complete a chart showing the pollutant and its effect	Write a report on this pollutant
Naturalistic	Create a diorama of your chosen pollutant in the environment	Explain what special problems are associated with it	Suggest improvements for Perth	Justify why you think Perth needs these improvements	Design plans for a new city	Explain to the class why your design is better
Existentialistic						

Discussion topics

- Fossil fuel combustion, particularly by motor vehicles, has been identified as the largest single contributor to air pollution. Discuss how you feel about this.
- Cars which have been altered, and no longer conform to the original specifications, tend to put out considerably more pollution into the air. Such modifications include non-standard cylinder heads, pistons, valves, camshafts, fuel systems, or exhausts. What can be done to overcome this?
- Many vehicles run on diesel. Discuss what else we could use instead of diesel or petrol to fuel our vehicles.
- Ozone also damages susceptible materials such as rubber, plastics, concrete, stone, cloth, dyes, and paint work. Discuss how we can overcome this problem.
- What is City Diesel? In the United Kingdom a new type of fuel called City Diesel is being developed. While City Diesel is more expensive than regular diesel, it is a cleaner fuel with a considerably lower sulphur content. Vehicles using this fuel will have reduced sulphur dioxide emissions. Discuss how this could be beneficial for our health.
- To improve the quality of the air we breathe we must think about our individual contribution to pollution. Each of us add to the air pollution in some way or another. Discuss what an individual can do to reduce air pollution.
- Every kilometre you don't drive will make the air a little bit healthier for you and your family to breathe. Discuss when & where you could choose to not drive.

Brain Teasers

- Perth emits 680 tonnes of carbon monoxide a day, how much will we have emitted by 2025?
- For every 1% increase in population it is expected that there will be a 1.6% increase in car usage. If our population increases by 17% by 2025, what will be the increase in car usage?
- If the car usage is increased by your figure from number 2, how much more carbon monoxide will we emit in 15 years time?
- If health costs $2.5 million dollars per year to our health system, what is that cost over 15 years?
- If your car is well maintained, it produces 25% less carbon monoxide. How much carbon monoxide would Perth emit daily if all cars were well maintained?
- If you own a Toyota Landcruiser and it costs you $9.53 per kilometre for fuel and you travel 15000 km per year how much does it cost in total?
- If the total cost for your Landcruiser including registration, tyres etc is $83.61 per km, how much does it cost you per year?

Role Play

Purpose: To understand the pressures placed on the environment and the need for ecologically sustainable development.

Scene: A public meeting has been called regarding an important project to reduce the air pollution in Perth. Ie cleaner fuel regulation changes. Many different interest groups have ideas on how this should be implemented.
You need to do this simulation in front of the class. So you will need to make sure you understand the issues involved.

Profiles:

Name : Mr James Pimpernel –Pugh
Occupation: Doctor
Argument: I treat breathing illnesses and I want to support the Department of Environment in its efforts to reduce air pollution. I am also worried that if nothing is done more people will die from air pollution related diseases.

Name: Mr and Mrs Van Hire
Occupation : Inner city lawyers
Argument: We work in the city and we are extremely opposed to the thought of not being able to drive into work each day as we often work long hours outside public transport options.

Name: Jim Jones
Occupation: Local councillor
Argument : Local council wants the inner city to be vehicle free apart from council public transport using alternative fuel. The money it brings will inject capital into our flagging urban economy.

Name: Ms Sandy Miner
Occupation: Petroleum mining owner
Argument: Rich deposits of petroleum have been discovered off the coast and it would be profitable for our company if cards continue using this type of fuel. We want to continue with our Government contract to supply fuel for public transport.

Name : Mr Redmund Wine
Occupation: Pub owner
Argument: We, the Shop Keepers, want to see vehicles continue to be allowed into the city. It is good for business in the short term, and will be more profitable in the longer term as people will continue to come into the city at night.

Name: Trevor Yallingup
Occupation: Member of the local Aboriginal community
Argument: This area has special cultural significance and we don't want to see any further destruction of our environment.

Other roles could be introduced eg. Student group - opposed to current environmental practises

Values
Find out about alternative fuels. Why are they beneficial?
What will be the impacts of such actions?
Identify what different groups of people value or believe to be important

- Using this fuel will have reduced sulphur dioxide emissions. Discuss how this could be beneficial for our health.

- To improve the quality of the air we breathe we must think about our individual contribution to pollution. Each of us adds to the air pollution in some way or another. Discuss what an individual can do to reduce air pollution.
- Every kilometre you don’t drive will make the air a little bit healthier for you and your family to breathe. Discuss when & where you could choose to not drive.

Extension 1 A car free inner city Perth!

AirWatch Webquest

Introduction

Across the world, greenhouse gases are increasing, the climate is getting warmer, and Perth's precious air is getting worse and is set to cause serious health effects by 2025. What will be the cost to you, your family, the health of our city, and the environment overall? Perth's City Council have been looking at the current situation and analysing the threat to Perth's air. They realise that motor vehicles have been identified as the single largest contributor to emissions in Perth contributing to photochemical smog, Perth's principal summertime air quality issue. They need your help to propose a plan to ban all vehicles from Perth's inner city.

Aim

Students analyse the quality of Perth's air, and investigate the role of car emissions. They research, plan, devise and present a method of transportation for the inner city that is environmentally friendly.

Activity

Your task is to provide details to the council to support their plan for a vehicle free inner city. You must analyse the quality of Perth's air, investigate the role car emissions play and devise a method of transportation around the city that is environmentally friendly. You may work with other experts but each of you must take on a different role to fulfil. **The roles are**:

AirWatch Coordinator: Your role is to investigate and analyse the quality of Perth's air. You must analyse current smog levels from the DoE website and investigate data from monitoring stations across the metropolitan areas. Think about what might be the reasons why Perth's air quality differs from place to place and use these findings to justify the council's proposal. You will need to include a prediction of the air quality in 2025 if we do not take action now!

Environmental scientist: Your role is to be the DoE expert on vehicle emissions both exhaust emissions and evaporative emissions. You will need to investigate both petrol and diesel vehicles and use this data to support the council's proposal. Use the information on the Cleaner Fuel Initiative from the Department of Environment's website to support your findings. You will need to include a prediction should our population continue to grow (and of course the number of vehicles), on the situation as you think it will be in 2025. You may recommend the council have a 'clean fuel' clause in their proposal, in which case you will need to investigate alternative fuels.

Health Department doctor: Your role is to investigate the health effects of poor quality air. You will need to link lung diseases (asthma, bronchitis, emphysema etc) to the social and economic costs. You will need to establish that poor health relating to poor air quality places a huge cost on our health system and promote the benefits of clean air to support the council's plan.

City Council planner: Your role is to map out the inner city area that is intended to be vehicle free. You will need to use the information from your environmental scientist to establish what transport will be available to the public (possibly buses run on one of the alternative cleaner fuels investigated). It will also be your role to put the final proposal to the public at the council's meeting. You must liaise with the rest of your group to provide a detailed final submission.

Process

To complete your assignment you will need to do the following:

- **Planning** phase: You must get your team together and discuss who will take on the different roles and how you will each approach the task. (It is no good if two of you end up doing the same work, so share your strategies.) You have 1 day to complete this phase.
- **Research** phase: Where you gather the information you need to complete the task. You may use all resources supplied at school, books, encyclopaedia (in class & library), Internet (at home & school), Airwatch resources. You have 1 week to complete this phase.
- **Information processing** phase: This is where you decide what information you have is useful & what isn't. You must decide what you are going to do with the information. Based on the information gathered you must be ready to make your recommendations to the group and be able to justify your decisions. You have 3 days for this phase.
- **Decision-making** phase: As a group you will need to hear all recommendations and decide what is the best action to take and how you will present this to the other groups. You have 1 day for this phase.
- **Construction** phase: You must begin assembling your presentations; possible formats are:

  A written report with graphs, diagrams, illustrations etc
  A power point presentation
  A model of the inner city with oral report
  Story book or pamphlets produced on Publisher
  Charts produced on Inspirations

  You have 2 weeks to prepare this.
- **Presentation** phase: Your group will need to present your findings to the class, your buddy class, and possibly other interested parties that may be invited to attend. You MUST have your presentation ready for Week 6 of the term.

Resources

Here are some websites that will be useful to you in your search:

DOE site home: this site is the Department's home site and has links to other pages that will be helpful.

http://portal.environment.wa.gov.au/portal/page?_pageid=233,1&_dad=portal&_schema=PORTAL

Air publications page: this page is also the DOE and has all the initiatives currently in progress, including the cleaner fuel initiative.

http://portal.environment.wa.gov.au/portal

Booklet: This booklet on Air Pollution and You is also available at school in hard back form.

http://portal.environment.wa.gov.au/pls/portal/docs/PAGE/DOE_ADMIN/TECH_REPORTS_REPOSITOY/TAB1019688/AIR_POLLUTION.PDF

CSIRO Airwatch site : **http://www.cmar.csiro.au/ar/airwatch/**

Better Health Channel:

http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/LFourPagesMoreInfo/Smog

Airwatch site: www.airwatch.gov.au

Bureau of meteorology: **http://www.bom.gov.au/weather/wa/**

Asthma WA: **http://www.asthmawa.org.au/**

Dept of Health **http://www.health.wa.gov.au/**

Diesel net: **http://www.dieselnet.com/**

Perth city council: **http://www.cityofperth.wa.gov.au/**

Maps: **http://www.mapimage.net/city_of_perth/**

Assessment

You will be assessed on the following criteria

	Beginning to Develop	At Expected Level	Above Expected Level
References	Evidence of research from less than 4 sources	Evidence of research from at least 4 sources	Evidence of research from more than 7 sources
Originality	Text has simply been copied and pasted from other sources	Text from other sources has been paraphrased	Student has used reference material but constructed original text
Drawings	Drawings absent, irrelevant or difficult to interpret	Drawings are neat but simple and summarise the text	Drawings are neat and enhance the text
Individual effort	Only gave minimum effort required	Worked hard and contributed an equal portion of the work	Worked over and above expected level, contributed more than was asked for
Presentation	Made minimum requirements but lacked detail	Given with confidence, full detail, but simple style	Given confidently, full detail with clear justification and style enhanced ideas

Conclusion

Congratulations you have successfully completed the Airwatch Webquest!

Extension 2 The greenhouse and you

Introduction

Extension two is focused on greenhouse activities, investigating local greenhouse gases via simple experiments done in the classroom and by asking students to investigate their own contribution towards greenhouse gases. Students are expected to use their understandings to propose solutions to issues they explore.

Aim

Using simple science experiments students understand how the greenhouse effect works, and investigate different scenarios (Activity 1.1).
Students examine restricted use of the family car/cars and develop a plan of action to manage the situation (Activity 1.2).

Activity 1.1

Conduct a Greenhouse experiment

Lesson 1:
Purpose: To see how the greenhouse effect works.

Teacher demonstration or small group activity

One large jar with screw on lid (available from Bunnings) per group
River stones, rocks or similar
Green leaves from grounds – don't pick off trees
.

- Assemble stones (representing the earth) and, leaves (representing life) on lid of jar.
- Cover lid with water (representing oceans).
- If available, put airwatch suction thermometers inside the jar. Otherwise, record temperature.
- Secure jar (representing greenhouse gases) to lid.
- Record starting temperature inside jar.
- Class to discuss the purpose of the experiment and write down their prediction of what will happen.

- Place jar outside in sun. If channel 7 or 9 weather watch equipment available, check current outside temperature. If not, record temperature and leave thermometer near jar.
- Students begin to write up experiment, under the headings**: Purpose, Equipment, Method, Prediction**.
- Draw & label **diagram.**
- Check jar after 20 mins. Record **observations** – what do you see? (Any condensation? Where?). What can you feel? Is any part of the outside of the jar warmer than any other part? (don't forget top of lid as this has contact with ground)
- Record temperatures inside and outside jar.
- Repeat after 1 hour and every 30 mins thereafter as desired.
- Record observations (field notes) in table form
- Discuss what this showed us and write a **Conclusion** (what I learnt or demonstrated))

Variation:
Set up second jar as above and add ice blocks (representing the poles). Add to prediction re any difference you expect to see in jars.

Lesson 2 Working Scientifically
Purpose: to discover how changes in the greenhouse gases will effect conditions (temperatures) on Earth.

Small groups.

- Students **brainstorm** changes they can make to alter the greenhouse effect.
- Each group selects **ONE** variable. **Predict** changes expected.
- One group is set up as the **control group** (as Lesson1).
- Groups set up jars as for Lesson 1, incorporating variable).
- Students set up a **table** to record each jar's temperature and physical appearance at 20 mins, 1 hour etc.
- In workbook, students write up new **Purpose** and individual group's variable and why they made that change (eg We varied ………………………………. We didn't vary ……………………………….).
- Discuss results. Are they what you expected – If not? Why Not? What was demonstrated / learnt from this investigation?
- Write up **Observations** and **Conclusions**

Teacher's Note:
Some possible variables are :-----

- Cover jar with black cloth or paper
- Cover jar with white cloth or paper
- Cover jar with foil

- Place in shade, etc.
- The variation of adding ice (polar caps) could be done here also. Non-variables are Earth, life and oceans.

Activity 1.2

Debate – "What if cars were like sprinklers"

Conduct a debate that all cars can only be used twice per week.
Begin by conducting a whole class or small group session – *"What if cars were like sprinklers".*

Complete a "**What If**" sheet OR conduct a **PMI** (Plus Minus Interesting) table (**samples attached**).

Form teams of 4 or 6.
Divide groups into 2 teams of 2 or 3 students an affirmative and a negative team.
Each student chooses 2 points from the brainstorm session and expands this. Add arguments, illustrations examples etc . Be passionate, be expressive.
You do not have to believe what you say, you just need to convince the class that your side is right.

If working in teams of 2, concentrate just on presenting a strong argument to support your case.

If working in teams of 3, the third speaker does **NOT** introduce any new material but tries to rebut the arguments of the opposition and sums up his/her team's case. Speaker 3 prepares by considering the likely arguments of the opposition.

This activity can be done in one session with a 20 minute preparation time OR set-up as a formal debate with a given time for research and team practice

Teacher's note:
Encourage children to think outside the square and consider the "Interesting" aspects as well as the +ves and –ves.

Extension:
Consider planning and public transport issues which may arise from less car usage.
Should car use days be rostered like sprinklers or would this create new problems. Conduct a CAF (Consider All Factors).

Variations:

Use the same format to debate such topics as:

“Global warming would benefit Australia” **OR** “ The Greenhouse Effect is great”.

Resources

Greenhouse activities: http://rise.org.au/EandP/schools/act/greenhouse.html
Kid’s site: http://www.epa.gov/globalwarming/kids/greenhouse.html
Airwatch primary manual ‘Who cares about our air?’ & CD
Environmental Studies Extension, Ric publications (Blackline)

UNIT OF STUDY: The Greenhouse Effect & You Upper Primary (levels 2 /3 /4)

Eight ways to be smart	**Bloom's Taxonomy: Six Thinking Levels**					
	Knowing	Understanding	Applying	Analysing	Creating	Evaluating
<u>Verbal</u> I enjoy reading, writing & speaking	Read information on greenhouse & global warming	BROW Discuss ramifications – what changes will there be? Make a list	Complete map of Australia in 2050, detailing key changes for each capital city of a warmer world	In groups, conduct a PMI related to climate changes & global warming	...Write a poem about a warmer Australia	Debate: Global warming would be good for Australia See sample lessons
<u>Mathematical</u> I enjoy working with numbers & science	Read information on energy emissions and the role of CO2 on the greenhouse effect and global warming	Create a T CHART to show the positive effects of a balanced greenhouse effect and the results of too much greenhouse gas in the atmosphere	Find out your school's gas, electricity waste disposal, and energy costs for the year. Conduct an experiment to clean up mould without using chemicals or bleach	TREC Calculate how much your school could save based on a 5%,10%, 20% reduction in each	Draw a diagram to show the levels of the atmosphere. Include levels: planes fly, weather is formed, and greenhouse gases and pollution are found in the Troposphere (10-15 kms) (Stratosphere 15-50 kms) etc	How does your school rate? What does your school recycle? What could be done better? Who can make a difference – How?
<u>Visual/Spatial</u> I enjoy painting, drawing & visualising	Watch video "Saving Hieronymous"	Complete Greenhouse diagram, labelling key factors or picture	Conduct an energy audit at home. How many appliances / energy sources were in use between 5 & 6 in	Draw floor plan of your house. Mark in the energy being used during audit and number of occupants.. Circle those which are	Produce an advertisement (script for radio /tv) OR visual for magazine or newspaper to promote the saving of energy	How could my family reduce energy, saving money and CO2 emissions? (and Hieronymous) Assess media stories/ images

			each home on ….. Indicate on survey sheet the number of people in each room "using" the energy	unnecessary and/or wasteful eg light on in empty room	in the home or school and the benefits. EVALUATION Sample Rubric attached	/cartoons which could relate to greenhouse and energy conservation
<u>Kinaesthetic</u> I enjoy doing hands-on activities, sports & dance	Visit Energy museum in Fremantle for the Greenhouse Visit. Complete activities in booklet	Role play effect of increased CFC and CO2 in atmosphere Create a dance to show effects of global warming	Conduct a greenhouse experiment. See Sample Lesson	Grow plants inside and outside a terrarium (use drink bottles) How would an increase in temperature eg 2 degrees affect plants and animals that live here?	Mime scenarios where energy is wasted/or used wisely. Emphasise what is happening and how you feel about this environmentally (groups of 3 – 4) Create dioramas of future cities – The "nightmare city" or "the ideal future city"	Evaluate mimes from other groups. Award appropriate medals
<u>Musical</u> I enjoy making & listening to music	Watch appropriate video related to topic "The last Rainforest", "Saving Hieronymous? etc	As a group, create a sound picture for some aspect of this topic. You can use any natural source of noise or music to tell your story. You have 20 minutes to complete the task	LEAP Listen to music to select backing music for play. What mood are you trying to create?	Listen to group stories. Identify the story/topic. Did the group successfully portray the scenario selected?	Create a rap, jingle, song etc to promote some aspect of greenhouse you have studied	Produce play for assembly for other classes (see Air Watch booklet / CD for types of pollutants plays or song books, environment resource books etc)
<u>or</u>						

Interpersonal I enjoy working with others	Tally how many trips were made in the car by each member of the family for each class member yesterday. As a group, decide which of these trips in the car were: a) essential, b) could have been combined c) could have been avoided etc. (students can decide categories) Make lists	What if cars were like sprinklers *See sample lessons* Find out about The levels of the atmosphere. Which is most important to us and why? What are trade winds, jet streams & the Coriolis force? If rockets are travelling into colder atmospheric conditions, why do they need heat protection shields?	ARC Using the car costs and pollution data, work out how much CO2 was produced by the class and their families yesterday	TAP How much CO2 could be prevented by: a) eliminating non-essential trips b) walking or riding to school	TAP Design a posters advertisement, storyboard OR power point presentation to promote an alternative to using the family car EVALUATION Sample rubric attached	Develop a plan to encourage children to walk safely (in groups / parent roster as accompanying adult etc) to school. Write an article for the school newsletter outlining your proposal. Be sure to include the data supporting the need for this
Intrapersonal I enjoy working by myself	Research one aspect of the greenhouse topic Use note taking grid	Complete a **KWL** on the Greenhouse Effect and global warming	**A&R** Compile a written, illustrated report from your research – 5 w's plus analysis. Include diagrams	Conduct a home heating survey – How many homes have solar, gas, electricity for heating? Do the same for products containing chemicals	Interview your parents as to why they have these heating options.. Include water and room heating choices. Share with class Make a poster explaining the difference	Create a table to show economic, environmental and any other advantages/ disadvantages of each type. Consider all information from all interviews plus what you have learnt. Come to an "on

				(nasties) OR investigate your families contribution to ozone depletion	between good and bad ozone	balance" recommendation
Naturalist I enjoy caring for plants & animals	List disasters caused by weather.	Explain how global warming contributes to natural disasters	How can we prevent global warming in our little part of the world?	**SCRAM Substitute, conduct, report, analyse, make** Repeat greenhouse experiment in groups with one group as control and each other group varying one aspect of the greenhouse effect. (eg cover with black cloth, white cloth, foil. Place in shade etc). Record as previously. Draw conclusions from comparisons.	Create a disaster landscape (after the warming) using bark/leaves/ objects from nature	**TAP** How might my life be different in a warmer world? Show in a mind map/power point presentation/cartoon etc NB Refer to health section of CD for reference to health issues

Thinking Skills Acronyms:

A&R	Action/Reaction
ARC	Action/Reaction/Consequence
BROW	Brainstorm/Read/Organise/Write
Concept Maps	Makes explicit the links between cells on a map & explains the connection between ideas. (Not to be confused with spider webs, flow diagrams etc)
KWL	What I Know/What I want to Know/What I Learnt
LEAP	Listen/Enjoy/Arrange/Perform
TAP	Think All Possibilities
T Chart	Simple structure enabling students to extract & record information in 2 lists of opposing characteristics e.g. fact/opinion
TREC	Think/Read/Estimate/Calculate

Curriculum outcomes

Overarching Learning Outcomes: 1, 2, 3, 4. 5, 6, 7, 10, 12

Learning Areas:
Society & Environment
Science
English
The Arts
Technology & Enterprise
Mathemamatics
Values: 1, 4, 5

Integration: This unit can stand alone as an Environmental Studies unit or be integrated into an Airwatch unit (S&E focus), an Energy unit (Science focus) or a Disaster & Survival theme (English focus)

Overarching Learning Outcomes: 1, 3, 4, 5, 6, 7, 10, 12

Values: Ecological Sustainability

Air Watch Integrated Assessment Assignment: (1)

Task: Research alternatives to using the family car and produce a **poster, advertisement, storyboard OR power point** presentation to promote one or more of these alternatives. The benefits of doing so must be inherent in your presentation.
Submit your research notes with your completed assignment

Name:_______________________ Due Date:_________________

	Level 2 (1 mark per pointer)	Level 3 (2 marks per pointer)	Level 4 (3 marks per pointer)
S & E Place & Space Resources	Identifies ways people can conserve energy Suggests means of co-operating to protect our air quality	Identifies impact people's actions may have on air quality Identifies issues which may arise fas a result of a decision to use alternatives to the car	Acknowledges varying positions individuals & groups may hold re car use Identifies wider impacts of less car use
ICP	Given the focus questions, identifies some of the factors to be considered and makes limited , factualnotes/observations	Gathers information from more than one source and makes simple predictions/ conclusions based on personal experience.	Identifies the types of observations, data & sources appropriate to the investigation and collects accurate information from a variety of sources
English Writing	Devises an advertisement including several reasons for choosing alternatives to the car. **OR** Places set of pictures into logical narrative	Writes an advertisement which includes relevant details to support case presented **OR** Creates a storyboard or power point presentation which gives 3 or more related reasons to support argument Integrates symbols to construct	Advertisement or poster has powerfully presented message with reasons **OR** Writes an persuasive case for car alternatives with a general statement followed by a series of logical & developed points Designs advertisement/

Viewing	sequence & includes captions Identifies the importance of colour in advertisement/presentation	meaning and links advertisement/presentation to target audience	presentation clearly emphasising the image/message rather than just promoting an activity
Comments:	**NB Rubric could include T&E boxes**	**Values criteria, or different assessment**	Total score /15 = % **Criteria depending on class focus.**

Overarching Learning Outcomes: 1, 3, 5, 6, 7, 10, 11, 12
Values = Ecological Sustainability

Air Watch Integrated Evaluation Assignment: (2)

Task: Produce an advertisement—either a script (radio / TV) OR print version (newspaper / magazine) to promote ways in which you or your family could change your usual habits in order to be more green house friendly.

Your advertisement must clearly demonstrate what action is proposed, why it is desirable and how it will make a difference.
You also need to indicate the intended audience and suggest suitable timetable slots or publications for your proposed advertisements.

	Level 2	**Level 3**	**Level 4**
Science E&C	Identifies how greenhouse gases are produced from everyday activities	Identifies appliances or habits which waste energy/ create greenhouse pollution	Compares different sources of energy and decides which is least polluting and wasteful
English	**V.1** Recognises the importance of colour in advertisements or posters **V2.2** Identifies the significance of music in TV or radio script or colour in print media	**V3.1** Suggests sound effects relevant to sequence of shots or events in script (radio / tv) OR recognises information may be portrayed in different forms (graphs, diagrams, pictures for print media) **V 3.2** Links commercial to target audience	**V 4.1** Recognises that narrative is the principal structural element in most media texts **V 4.2** Links commercial to target audience and identifies best screening time or print type

Viewing	Place set of pictures into logical narrative sequence and include captions Identifies the importance of colour in advertisement/presentation	Integrates symbols to construct meaning and links advertisement/presentation to target audience	Designs advertisement/presentation clearly emphasising the image/message rather than just promoting an activity
Comments:	NB Rubric could include T&E boxes	Values criteria or different assessment	Total score /15 = % Criteria depending on class focus
S&E Resources **ICP**	Suggests ways to conserve or improve resource use in home or community Given the focus questions, identifies some of the factors to be considered and makes limited, factual notes or observations	Outlines choices people make about the use of limited resources Describes & justifies personal choices Gathers information from more than one source and makes simple predictions/ conclusions based on personal experience	Identifies how technology will impact or has impacted on our use of resources Identifies the types of observations, data & sources appropriate to the investigation and collects accurate information from a variety of sources
T & E Information	Record & present information and ideas, using graphics, words &/or symbols to convey key information re proposal(s)	Considers the target audience when using techniques which will maximise the effectiveness of a simple but significant message related to family practices	Prepares an advertising /promotional campaign which reflects a variety of forms and combines modern and traditional technologies
	Alter / add / delete boxes as required. Add points for numerical scoring if desired?		

Extension 2 Background Notes

The Greenhouse and you

It's important for students to realise that whilst scientists talk about changes on a global scale, they / we need to think of what might happen in our little corner of the world, and how we might be affected. If we take care of our backyard first, it will be easier to take care of the whole world.

The Greenhouse Effect is great. Without it, the earth would be much colder than the average 15 degrees centigrade which makes life on earth possible. The greenhouse effect is important, but if it becomes stronger, it could make the earth warmer than usual. Even a little extra warming could create problems for all life forms.

How it works:
A greenhouse traps heat to allow plants to grow well. The Greenhouse effect is when the sun's heat is trapped close to the earth's surface by the atmosphere.

In the natural cycle, the sun's energy reaches the earth as short wavelength radiation which passes through the atmosphere and is absorbed into the earth's surfaces (land, water, vegetation, buildings etc).
Some heat is then radiated back towards the atmosphere as long wavelength radiation and is absorbed by certain atmospheric gases – the greenhouse gases. Some of this absorbed energy is then reflected back towards the earth in all directions giving us our +15degrees C **average** temperature
(N.B. read this paragraph to the students and ask them to interpret it in diagram (labelled) or picture form)

The Problem:
The problem is that the concentration of these gases (mainly carbon dioxide, water vapour and ozone [CO2, H2O and O3) in the atmosphere has been increasing so that more energy than normal is being trapped and reflected back to earth.

During the last 2 centuries, humans have been developing technologies that use engines and require the burning of fossil fuels, such as coal, timber, oil, gas etc. When these materials are burnt, they emit large quantities of carbon dioxide in the form of smoke and exhaust fumes. This is trapped in the atmosphere where it in turn traps increasing amounts of long wavelength radiation and reflects more heat back to earth, (like turning up a heater).
(N.B. A discussion of feudal systems and the changes initiated by the development of the engine – ie. Industrial and Agrarian revolutions are relevant here)

Possible Climatic Consequences for Australia:
Taking 2050 as a reference point, the following "guesses" as to the consequences of global warming emerge:

- Rise in global mean temperature of 4 degrees C
- Latitudinal weather systems will be pushed towards the poles. In Australia, this means the tropics and sub tropics would extend further south, and the wet & windy weather of Victoria, Tasmania and Southern WA would be pushed so far south that only Tasmania would still experience this type of weather
- Less rain in the south
- 50% more rain in the north of the continent

- The areas affected by tropical cyclones will be extended 200 -400 km to the south
- Less snow in Australian snow fields
- Wind speeds north of 36 degrees latitude will lessen by 20% and increase elsewhere
- Sea level will rise 20 -140 cms

("Greenhouse & You" Tim Lowson Ready Ed Publications 1989)

Capital City Summary

Warmer cities: *Sydney, Melbourne, Brisbane, Adelaide, Perth, Hobart, Darwin*
Wetter Cities: *Sydney, Brisbane, Darwin*
Drier cities: *Melbourne, Adelaide, Perth*
Rainfall will remain about the same in *Hobart*
Windier cities: *Melbourne, Hobart*
Less windy cities: *Sydney, Brisbane, Adelaide, Perth, Darwin*

(**N.B. Research into El Nino and its relationship to the greenhouse effect is relevant here.)**

<u>Global Warming: Good News / Bad news (debatable points)</u>

Plants will be bigger because CO2 encourages plant growth	Rising sea levels
Cyclones move further south	Flash flooding
Drier soils in some areas	More rain
More exotic crops grown	Hotter temperatures
Bigger crop yields	Reduced snow fields
Increase in skin cancers (people & animals)	
Increased eye disease (people & animals)	
Less impact on plants from air pollution	
Less irrigation required for cropsetc Insert background notes here.	

Petrol Vehicles & Air Pollution – Background Information for Teachers

Air pollution and vehicles

Vehicles are a major source of air pollution and can be harmful to human health and the environment. The amount of air pollution (emissions) from a vehicle depends on a number of different things such as the type of vehicle, the age of the vehicle, how well the vehicle is maintained, the way the vehicle is driven and the type of fuel used in the vehicle.

Petrol vehicles

Petrol is a flammable liquid which is obtained from petroleum, a dark-coloured thick crude oil that is extracted from under the ground. Crude oil is formed over millions of years.

Petrol vehicles are powered by energy that is created by the combustion of petrol fuel in the engine. Petrol engines operate by air and petrol mixing and being compressed prior to being ignited via a spark plug.

Petrol vehicles and emissions

There are two types of vehicle emissions; exhaust emissions and evaporative emissions. Exhaust emissions come out of the vehicles exhaust pipe and are created by the combustion of fuel in the engine. Evaporative emissions are vapours of fuel that are released into the air from the vehicles fuel tank without being burnt (often when filling up at the service station).

Individually, vehicles release only low levels of emissions and may not impact on air quality. However, large number of vehicles on our roads causes emissions to become concentrated in the air at a level that can be harmful to human health and contribute to photochemical smog, particle haze and the greenhouse effect.

The air pollutants of most concern from petrol vehicles are particles, carbon monoxide, oxides of nitrogen, hydrocarbons and carbon dioxide. These pollutants can contribute to many health problems in our community, especially for the very young and the elderly. Health effects can range from eye, nose and throat irritation, to breathing problems and chronic illness. Hydrocarbons and oxides of nitrogen also contribute to the formation of photochemical smog in Perth (for more information on photochemical smog refer to Lesson 2).

How is air pollution from petrol vehicles being managed in Australia?

In Australia, the Government has been able to reduce the emissions from petrol vehicles through a number of measures. This includes introducing new vehicle emission design standards and cleaner fuel. In 1975, all new cars sold in Australia were fitted with basic anti-pollution equipment, but these cars were designed to run on leaded petrol (airborne lead can affect the human central nervous system, particularly of young children). Since 1986 all new cars have been built with catalytic converters and have been designed to run on unleaded petrol. The Government also introduced legislation in 2002 to regulate fuel quality in Australia which sets limits on the levels of certain pollutants permitted in fuel. Improved petrol quality and advanced technologies mean that today's new cars produce less pollution than those only a few years old.

How is air pollution from petrol vehicles being managed in Western Australia?

The Perth Air Quality Management Plan has been developed to ensure that the people of Perth have clean air now and in the future, and includes programs for the reduction of emissions from all vehicles. The Government is implementing a number of programs, including further improvements to petrol quality, a smoky vehicle reporting program, vehicle emission testing programs and education programs to encourage people to use alternatives such as public transport, cycling and walking instead of their cars. More information on the programs being implemented under the AQMP is available in the latest AQMP Progress Report under "Air Quality Information" on this CD.

Further information on air pollution and how it is being managed in WA is available on the DoE website at www.environment.wa.gov.au (look under "Air").

What can petrol vehicle owners do to reduce pollution from their vehicles?

- Minimise vehicle use by using alternatives such as cycling, walking and public transport.
- Regularly service and maintain your vehicle to manufacturer standards.
- Improve driving techniques such as avoiding unnecessary accelerating and braking and stopping the engine whenever your car is stopped or held up for an extended period of time.
- Travel lightly by removing unnecessary weight from the vehicle such as roof racks, toolboxes etc when not required.
- Avoid spilling fuel and overfilling your vehicle when re-fuelling at the service station.

Extension 3 "My new car's a diesel!"

Aim

Students understand that fuel types are different and that they have different impacts on the environment. Students analyse the differences between diesel, LPG and petrol vehicles, and which vehicle is best for particular purposes.

Activity

- Students examine the use of diesel, LPG and petrol vehicles when deciding which one to buy in future.
- Students put forward a case why they would chose a diesel, LPG or petrol vehicle as their next car based on what it will be used for.

Mock Trial

Place students into teams of 4 with 2 teams to look at each statement (8 students).
Each group will research independently of the other.

<u>My next cars going to be a...</u>

Team A – to consist of: Prosecutor (Lawyer)
Assistant (Lawyer)
Witness
Witness

Aim: To prove that my next car should be a diesel

Team B – to consist of: Defence (Lawyer)
Assistant (Lawyer)
Witness
Witness

Aim: To prove that my next car should be petrol or LPG (students to choose only one).

The students are given the following two scenarios and Team A is asked to choose the scenario their case will be based on.

Scenario 1: The car you have had for many years is getting very run down and you decide to buy a new one. You are married with two children, and this is the second car of the family that you mainly use just to drop the kids at school and to run small errands in your local area.

Scenario 2: You and your elderly partner have both retired from work, and have decided to go on a long trip around Australia. You decide to buy a new vehicle for the trip, and intend on towing a caravan, as well as taking the family dog.

Considerations

Positives versus negatives
Benefits versus limitations
Types and amount of emissions generated eg. particulate matter (PM_{10}), carbon dioxide (CO_2)
Health and economic costs
Time and effects
What the vehicle is to be used for
When the vehicle was last serviced

Fuel efficiency of the vehicle
Vehicle load
Model and year of manufacture
Any pollution control mechanisms – eg catalytic converter

Each group must know of the opposition's points so that they can try to refute them in court.

It may be preferable to have only one scenario being looked at over 2-3 weeks.
This could be done as part of Oral English or SOSE or as part of group activities.

When the students are ready (this needs to be monitored) select a jury of 12 students and a judge from the students who have now researched this topic. This could be done as per a real-life court, i.e., with the lawyers allowed to select the jurors from a given list with perhaps the teacher to select the judge. The jurors then select their Chief. Four (4) students to act as witnesses with "specialist knowledge" (such as mechanic, car buyer, traveller, scientist, doctor) and the remainder of students as the audience.

Court Case

1. Prosecution presents the case for.
2. Defence present the case against.
3. Prosecution calls the first witness (see suggestion list of specialist areas above).
4. Defence cross examine this witness.
5. Prosecution call the second witness (with a different specialist background).
6. Defence cross examine this witness.
7. Defence call their first witness.
8. Prosecution cross examine this witness.
9. Defence call their second witness.
10. Prosecution cross examine this witness.
11. Prosecution sums up directed to the jury.
12. Defence sums up directed to the jury.
13. Judge offers his **succinct** advice to the jury.

Jury go outside or elsewhere to decide on the verdict. (Do not allow too much time – approx how long?)

Resources

http://www.greenvehicleguide.gov.au
http://www.dpi.wa.gov.au
http://www.greenhouse.gov.au
http://www.ephc.gov.au
http://www.deh.gov.au
http://www.epa.wa.gov.au

Curriculum outcomes:

Society and Environment:

Place and space; People and places

Human activities influence natural features
People's activities have planned and unplanned impacts on the natural features of a particular landscape.

Resources; resource availability and distribution

Science

Communicating Scientifically; Communicate scientific understandings

Extension 4 Interview – "Changing faces"

Aim

Students examine and make observations on how people's daily lives have changed over time. They develop and conduct an interview with people they know in their local community. Results should show that people's beliefs, values, and actions may have planned or unplanned impacts on the environment.

Activity

Students to write to or contact senior groups in the local community and either invite some to the school or arrange for individual students to visit them. Students could also contact their parents and grandparents.

Questions which could be asked (More questions will develop as students become more familiar with this technique):

1. What changes have you seen in your lifetime (environmentally)?
2. How did you get to school?
3. What sports did you play?
4. What did you do after school?
5. Did you have a car?
6. What was it like?
7. How was your home heated?
8. How was your home cooled?
9. What illnesses seemed to be the most prevalent?
10. What types of illnesses did people die from when they were your age that people no longer die from?
11. What do you like about modern life?
12. What don't you like about modern life?

- Students should listen to the recordings and decide for themselves what they like or dislike about modern living.
- Would they have preferred to live in their parents' or grandparents' time? Why or Why not?
- List the things that, in your opinion, are available currently that make our lives better.
- List the things that, in your opinion, are available currently that make our lives worse.

Assessment

Each student should complete an oral and written report on an aspect of this topic.
The oral reports could be assessed as a class exercise with students deciding on the criteria. For example: spoke clearly, did not rush, looked at the audience when speaking, used descriptors and detailed sentences, was accurate.

Curriculum Outcomes:

English
Health and PE
SOSE

‘”Changing faces” - oral interview assessment

Society and environment

	Level 2 Remember/Understand	**Level 3** Apply/Create	**Level 4** Analyse/Evaluate
Investigating, Communication and Participation (all aspects)	ICP 2 When given a focus question, the student can identify aspects to be considered and use simple data gathering techniques to collect information; and can select and compare relevant, literal, factual information in presenting findings and comparing own interpretation with those of others.	ICP 3 The student plans an investigation by devising questions, identifying and using information from more than one source; and makes inferences from the information collected in order to justify personal decisions.	ICP 4 The student identifies appropriate sources and data-gathering techniques for an investigation; records information from these sources accurately; considers various perspectives and begins to generalize beyond the immediate context when presenting findings.
Place and Space (People and Places)	2.2 Understands that people make choices in their use of places.	3.2 Understands that the use people make of different places is affected by natural and built features.	4.2 Understands that people and places are interdependent.
Resources (People and work)	2.3 Understands that there are similarities and differences in the way people work.	3.3 Understands that individuals and groups value different forms of work.	4.3 Understands that people act in various ways to make workplaces more effective.
Time, Continuity and Change (all aspects)	TCC 2 The student understands that the passage of time creates differences in people’s lives and in the environment and that people endeavour to retain what they consider important.	TCC 3 The student understands that the stories of people; important people and events are woven into the narrative history of particular time periods.	TCC 4 The student understands that people and events in a time period are linked through the impact each has on the other and that there are different perspectives on people and events of the past.

Teachers may also be able to use Outcomes from other Learning Areas such as English and Technology and Enterprise to be considered for assessment as they work through the topic.

NB Teachers may prefer to use English as the main assessment feature for this task.

Extension 5 “Let’s be healthy-air!”

Aim

Students conduct community based research to obtain specific information about local air quality. Main topics considered for research will be community understanding and perceptions about air quality, and health effects of air pollution. Skills learned include selecting a target audience, survey design to meet specific objectives, and survey analysis and report writing.

Activity

Developing a Survey on Pollution in the Community using Multiple Intelligences/Bloom’s Planning Matrix

Remember	1. Discuss in pairs or groups of four – what is already known about pollution – in the community – affecting the health of the community. All students to take part. 2. Brainstorm in the groups – then blackboard words or phrases for class discussion. 3. What is a survey? Discuss.
Understand	1. Where does pollution come from? Who is affected? How are they affected? What problems can be attributed to pollution? 2. Use the brainstorm vocabulary to create a mindmap placing like words and phrases into groups. 3. Discuss confidentiality and why it is necessary.
Apply	1. Use the knowledge that students have remembered and understand to discuss in groups the topics that may have arisen from the mindmap. e.g.,. people, illnesses, vehicles, using public and private transport, walking versus cycling, home heating and cooling. 2. Understand the difference between simple and complex questions. 3. Decide on the format for a survey.
Create	1. Create either a simple or more complex survey for an investigation into the opinions of the local community. 2. Decide whether it is to be a class only survey or full-scale school/district survey. 3. Each group in the class to select a topic from the list decided from the mind mapping activity.

	4. Create a question or questions to match the topic selected. 5. Organize a letter to accompany the survey emphasizing the confidentiality aspect.
Analyse	1. Allow time for distribution and collection/return of surveys – approx. two weeks. 2. Each group that set the question to conduct their own recording and analysis. A second group re-analyse the same question i.e. each group to analyse a second question – explain that this gives the survey more accuracy and reliability.
Evaluate	1. Evaluate data and results from the analysis – first in groups then as a class so that there is general consensus. 2. Write a report for each section – including graphics or photographic evidence if possible. 3. Decide on whether more research is needed on certain topics. 4. Report to the community in some way – school newsletter, local newspaper.
Assessment	1. Formative – as groups and topics develop. Some individuals may stand out during this time. 2. Summative – final presentation for each question.

Curriculum Outcomes:

Health and PE:

- Interpersonal skills, Self-management skills

SOSE:

- Investigation, Communication and participation, Resources, Natural and social Systems, Active citizenship

English:

- Listening and speaking, Reading, Writing

Technology and Enterprise:

- Information, Systems, Enterprise

Science:

- Investigating, Acting Responsibly, Earth and beyond, Energy and change, Life and living, Natural and processed materials

"Let's be healthy-air!" - survey assessment

SOCIETY AND ENVIRONMENT

	Level 2 Remember/Understand	**Level 3** Apply/Create	**Level 4** Analyse/Evaluate
Investigating, Communication and Participation (all aspects)	ICP 2 When given a focus question, the student can identify aspects to be considered and use simple data gathering techniques to collect information; and can select and compare relevant, literal, factual information in presenting findings and comparing own interpretation with those of others.	ICP 3 The student plans an investigation by devising questions, identifying and using information from more than one source; and makes inferences from the information collected in order to justify personal decisions.	ICP 4 The student identifies appropriate sources and data-gathering techniques for an investigation; records information from these sources accurately; considers various perspectives and begins to generalize beyond the immediate context when presenting findings.
Natural and Social Systems (Natural Systems)	2.1 Understands that elements of natural systems form communities in which each element depends on another.	3.1 Understands that elements of natural systems link to form cycles of which people are a part.	4.1 Understands that different elements respond and attempt to adapt to changes in natural systems.
Active Citizenship (Ecological Sustainability)	Use Emerging phase • Helps to manage the environment in the classroom, school and home. • With direction, takes action to	>>>>>> moving to	Developing phase • Initiates action/devises strategies to conserve the school's resources. • With guidance, helps to

	conserve and protect the surroundings and to use resources in a sustainable way.		conserve/preserve resources in the wider community. • Articulates values pertaining to ecological sustainability.

Teachers should use 'on balance' judgement for the Active Citizenship outcome

SCIENCE

	Level 2 Remember/Understand	**Level 3** Apply/Create	**Level 4** Analyse/Evaluate
Investigating (all aspects)	I 2 When given a focus question and a familiar situation, the student contributes elementary ideas about variables and procedures, collects and makes records of data and can say whether what happened was expected.	I 3 The student shows some awareness of the need for fair testing and makes simple predictions; collects and organizes numerical data and descriptive information using simple tables, diagrams and graphs; and identifies main features, patterns and difficulties in the investigation.	I 4 The student plans and conducts different types of investigations, taking account of the main variables; collects data using repeat trials or replicates; explains patterns in data or information prepared in different formats; and makes general suggestions for improving the investigation.

Teachers may also be able to use Outcomes from other Learning Areas such as English and Technology and Enterprise.

Diesel Vehicles & Air Pollution – Background Information for Teachers

Air Pollution & Vehicles

Vehicles are a major source of air pollution and can be harmful to human health and the environment. The amount of air pollution (emissions) from a vehicle depends on a number of different things such as the type of vehicle, the age of the vehicle, how well the vehicle is maintained, the way the vehicle is driven and the type of fuel used in the vehicle.

Diesel vehicles

Diesel vehicles are powered by energy that is created by the combustion of diesel fuel in the engine. Diesel fuel is a flammable liquid which is obtained from petroleum, a dark-coloured thick crude oil that is extracted from rocks under the ground. Crude oil forms over millions of years. Diesel fuel is heavier and oilier than petrol.

Diesel engines, or compression ignition engines, operate by air being compressed in the combustion chamber before diesel fuel is injected and ignited due to the high pressure and temperature.

Did you know?
A German engineer named Rudolph Diesel invented the diesel engine in 1892.

Diesel vehicles and emissions

There are two types of vehicle emissions; exhaust emissions and evaporative emissions. Exhaust emissions come out of the vehicles exhaust pipe and are created by the combustion of fuel in the engine. Evaporative emissions are vapours of fuel that are released into the air from the vehicles fuel tank without being burnt (often when filling up at the service station).

Individually, vehicles release only low levels of emissions and may not impact on air quality. However, the large number of vehicles on our roads causes emissions to become concentrated in the air at a level that can be harmful to human health and contribute to photochemical smog, particle haze and the greenhouse effect.

While there are less diesel vehicles on our roads than petrol vehicles, they create more air pollution. The air pollutants of most concern from diesel vehicles are fine particles, visible smoke and oxides of nitrogen (NO_x). These pollutants can contribute to many health problems in our community, especially for the very young and the elderly. Health effects can range from eye, nose and throat irritation, to breathing problems and chronic illness. The fine particles emitted by diesel vehicles are particularly of risk as they can be breathed into our lungs and cause permanent damage.

Visible smoke emissions from diesel vehicles can be odorous and visibly offensive and unpleasant for pedestrians, cyclists and other road users. Fine particles, visible smoke and oxides of nitrogen can also contribute to the formation of photochemical smog and haze in Perth (for more information on photochemical smog and haze refer to Lessons 2 and 3).

Diesel vehicles are generally more fuel-efficient than petrol vehicles and therefore cheaper to run. Because of this, the number of diesel vehicles and the total distance travelled by diesel vehicles is increasing in Australia.

How is air pollution from diesel vehicles being managed in Australia?

In Australia, the government has been able to reduce the amount of pollution from diesel vehicles through a number of measures. This includes introducing new vehicle emission design standards and cleaner diesel fuel. However, even the best-designed diesel vehicle using the cleanest fuel will still create high levels of emissions if the vehicle isn't serviced regularly or is poorly maintained.

The National Environment Protection Council (NEPC) made the National Environment Protection (Diesel Vehicle Emissions) Measure (Diesel NEPM) on 29 June 2001. This Measure provides Australian States and Territories with guidelines for developing programs to improve the maintenance and operation of in service (in use) diesel vehicles to help reduce air pollution.

How is air pollution from diesel vehicles being managed in Western Australia?

The Perth Air Quality Management Plan (AQMP) has been developed to ensure that the people of Perth have clean air now and in the future, and includes programs for the reduction of emissions from all vehicles. The Government is implementing a number of programs, including further improvements to fuel quality, a smoky vehicle reporting program, vehicle emission testing programs and education programs to encourage people to use alternatives such as public transport, cycling and walking instead of their cars. More information on the programs being implemented under the AQMP is available in the latest AQMP Progress Report under "Air Quality Information" on this CD.

The Department of Environment (DoE) is also implementing the Diesel NEPM in Western Australia.

Further information on air pollution and how it is being managed in WA is available on the DoE website at www.environment.wa.gov.au (look under "Air").

What can diesel vehicle owners do to reduce pollution from their vehicles?

- Minimise vehicle use by using alternatives such as cycling, walking and public transport.
- Regularly service and maintain your vehicle to manufacturer standards.
- Improve driving techniques such as avoiding unnecessary accelerating and braking and stopping the engine whenever your car is stopped or held up for an extended period of time.
- Travel lightly by removing unnecessary weight from the vehicle such as roof racks, toolboxes etc when not required.
- Avoid spilling fuel and overfilling your vehicle when re-fuelling at the service station

Liquefied Petroleum Gas (LPG) Vehicles & Air Pollution – Background Information for Teachers

Air Pollution & Vehicles

Vehicles are a major source of air pollution and can be harmful to human health and the environment. The amount of air pollution (emissions) from a vehicle depends on a number of different things such as the type of vehicle, the age of the vehicle, how well the vehicle is maintained, the way the vehicle is driven and the type of fuel used in the vehicle.

What is Liquefied Petroleum Gas (LPG)?

Liquefied petroleum gas (LPG) is a fuel that can be used in vehicles. It contains a mixture of propane and butane gases. It is obtained from natural gas extracted from under the ground.

LPG is often referred to as an 'alternative fuel'. It can be used as an alternative to petrol or diesel fuel in vehicles. LPG is the third most widely used transport fuel after petrol and diesel.

LPG vehicles and air pollution

There are two types of vehicle emissions; exhaust emissions and evaporative emissions. Exhaust emissions come out of the vehicles exhaust pipe and are created by the combustion of fuel in the engine. Evaporative emissions are vapours of fuel that are released into the air from the vehicles fuel tank without being burnt (often when filling up at the service station).

Individually, vehicles release only low levels of emissions and may not impact on air quality. However, large number of vehicles on our roads causes emissions to become concentrated in the air at a level that can be harmful to human health and contribute to photochemical smog, particle haze and the greenhouse effect.

The air pollutants of concern from LPG vehicles are particles, carbon monoxide, oxides of nitrogen, hydrocarbons and carbon dioxide. However, because LPG contains only small amounts of carbon, it has lower carbon dioxide emissions than petrol or diesel vehicles (the main pollutant contributing to the greenhouse effect). LPG also emits fewer particles than diesel vehicles.

Did you know?
LPG now powers over four million vehicles worldwide.

How is air pollution from LPG vehicles being managed?

While the Australian government has introduced standards to
Control the quality of LPG used in vehicles, it is still considered a 'cleaner fuel' than diesel or petrol. A number of programs have been introduced in Australia to encourage greater use of LPG fuel for motor vehicles.

LPG vehicles can be purchased from new, or alternatively petrol and diesel vehicles can be easily converted to LPG. Programs such as the Western Australian 'LPG subsidy scheme' give members of the public $500 towards the cost of purchasing a new vehicle that is LPG powered, or towards converting their petrol or diesel vehicle to LPG.

What can LPG vehicle owners do to reduce pollution from their vehicles?

- Minimise vehicle use by using alternatives such as cycling, walking and public transport.
- Regularly service and maintain your vehicle to manufacturer standards.
- Improve driving techniques such as avoiding unnecessary accelerating and braking and stopping the engine whenever your car is stopped or held up for an extended period of time.
- Travel lightly by removing unnecessary weight from the vehicle such as roof racks, toolboxes etc when not required.
- Avoid spilling fuel and overfilling your vehicle when re-fuelling at the service station.

What's up with our air?   Extension activities

Introduction

Some previous knowledge of air quality issues is expected in order to complete the extensions, eg. completion of core lessons 1-5 "What's up with our air?", but is not a pre-requisite. These extensions cover a range of topics related to air quality, the majority of which focus on the Perth or WA environment. Areas of investigation include greenhouse gases, health effects of pollution, transport choices, and lifestyle changes. The topics are explored via discussion, investigation, debate, and research.

Each extension has clear aims, suggested activities, and an assessment component. These extensions are non-sequential and have been designed that way to allow for individual programming.

Aim

The extensions build on knowledge and skills learned from core lessons 1-5 "What's up with our air?" They are designed to provide a more challenging investigation of air quality issues by further engaging students in both individual and group activity and assessment.

Extensions

The table summarises each extension activity, identifying aims, technique, and assessment.

TITLE	STUDENTS WILL	TOPIC	TECHNIQUE USED	ASSESSMENT
A vehicle free inner city	Plan research, design, and present findings to support a plan for a vehicle free inner city	Alternative transport	Webquest Multiple intelligences Blooms taxonomy 6 thinking levels	Rubric
The greenhouse and you	Understand how the greenhouse effect works, and discover how changes in greenhouse gases will effect conditions on earth.	Greenhouse	Blooms taxonomy 6 thinking levels Science experiment	Design an advertisement to promote ways your family could change habits to become more greenhouse friendly
Cars are like sprinklers!	Develop a plan of action realising that all cars can only be used twice per week	Examines car use	What if… PMI debate	Produce a poster/ad/PowerPoint/presentation to promote alternatives to the car
My new car's a diesel!	Realise that not all fuel types are the same and that they have different impacts	Examines fuel types	Mock trial	Rubric
Changing faces	Design and conduct interviews. Understand that technological changes take place all the time.	Lifestyle changes	Interview	Rubric
Let's be healthy-air!	Design and conduct surveys to elicit specific information about air pollution and health	Air pollution and health	Survey Multiple intelligences Blooms taxonomy 6 thinking levels	Rubric

Resources

Refer to each extension for specific texts, booklets, and websites.

Curriculum Links

All material has been developed to meet requirements of the WA Curriculum Framework 2005.

Overarching learning outcomes: 1, 3, 5, 6, 7, 10, 11, 12
Values: Ecological sustainability

Outcomes

The extension activities have been designed with a S&E/Science focus but are cross-curricular in nature. Links to other areas include English, mathematics, technology and enterprise, health and physical education and the arts. Specific outcomes are described for each extension and following is a summary of main curriculum outcome areas served:

Society and Environment

Place and space; People and places (Levels 2,3,4)

Natural and social systems (Levels 2,3,4)

Science

Communicating Scientifically; Communicate scientific understandings (Level 2,3,4)

Health and Physical Education

Knowledge and understandings; the meaning and dimensions of health (Level 2,3)

“Scary airy facts”

(Format needs to be lively and random moving eg. in bubbles or capsules etc and be appealing to students & include images...)

Around Perth.....

1) Our lungs are a very delicate interface that separates us from our environment. They have an enormous surface area, so large, that if they were spread out they would cover the area of two tennis courts.
Our Amazing Lungs - www.2.nature.nps.gov/air/edu

2) Several factors influence Perth’s air quality; large population over a large area, high private vehicle use, location of industrial centres, and last but not least - the weather of the Perth region eg. sea breeze, hot summer days and cold calm winter nights.
Department of Environment, Air Quality website www.environment.wa.gov.au/airquality

3) Every day Perth drivers travel the equivalent of 500 times around the world (more than 20 million km) in their cars.
WA Greenhouse Strategy 2004

4) Most carbon monoxide in Perth comes from motor vehicles. Carbon monoxide depletes oxygen in the blood stream causing drowsiness and headaches, and affecting nervous system and heart function.
Greenhouse Gas Inventory 1995 data from the Australian Greenhouse Office

5) “The car is the technology which involves the biggest number of employees, the highest advertising budget, the largest accidental death rate and the biggest contribution to global warming”
Peter Newman, The Internationalist, June 99

6) Based on the results from the Department of Environment’s 2004 pilot Home Heating Survey Report it is estimated that there were 134,000 wood heaters in Perth and 88,000 (65.7%) of those wood heaters were in use during the winter 2004.
Dr. John Todd, Eco energy options Pty Ltd. May 2005

7) The Perth Haze Study identified wood smoke particles emitted from domestic wood heaters. Wood smoke was found to contribute to 40% of winter haze (DEP, 1996).
Department of Environmental Protection (1996) *The Perth Haze Study 1994-1996: Summary and major findings.* Government of Western Australia; Perth WA.

8) When you start your car after it's been sitting for more than an hour, it pollutes about five times more than when you start it while it's still warm.
U.S. Environmental Protection Agency MOBILE6 model run performed by the Federal Highway Administration on September 24, 2003

9) It is expected that for every one per cent increase in population in Perth, there will be a 1.6% increase in the number of vehicle kilometres travelled.
“Air Pollution and You” - Department of Environmental Protection 1996

In Australia...

10) More than a quarter (29%) of households were aware of green power schemes in 2005, an increase from 19% in 1999 and from 24% in 2002. However, only 23% of these households were willing to support the scheme, a slight decrease from 26% in 2002. Most of these respondents (53%) were willing to pay less than $100 extra per year for green power.
ABS 4602.0 - Environmental Issues: People's Views and Practices, Mar 2005

11) There has been a significant increase in the number of households with air conditioners from 33% of dwellings in 1994 to 60% in 2005. Reverse cycle/heat pump has been the most popular system of cooling since 1994.

ABS - 4602.0 - Environmental Issues: People's Views and Practices, Mar 2005

12) Although diesel vehicles comprise less than 10% of the total Australian fleet, they contribute 40% of NOx emissions and 60-80% of particulate emissions.
Department of Environment and Heritage, Diesel NEPM Statement 2005

13) Motor vehicle exhaust kills almost twice as many people as road accidents.
The Australian study estimated 1,200 people living in capital cities suffered motor vehicle-related premature deaths a year, compared with about 650 capital city road deaths.
Media release 22 September 2003 Office of Doctor Sharman Stone.

14) During winter, wood heaters can produce up to three times more particulate pollution than cars. City of Sydney.
http://www.cityofsydney.nsw.gov.au/Environment/GreenhouseAndAirQuality/GreenhouseAndPollution.asp

15) It takes at least a year to season firewood properly. Well-seasoned or dry firewood can give upto 40% more heat and reduces the amount of wood smoke emitted when burnt. DEH "Hot Tips"
Todd, J (2004) Wood smoke Handbook: Woodheaters, Firewood and Operator Practice. Environment Australia. Commonwealth of Australia: Canberra, ACT.

16) Concentrations of carbon dioxide in the earth's atmosphere have sat between 275 and 285 parts per million for most of the last 1000 years. In the last 200 years however the concentration has risen to almost 370 parts per billion!
Australian Government Bureau of Meteorology www.bom.gov.au

Around the world....

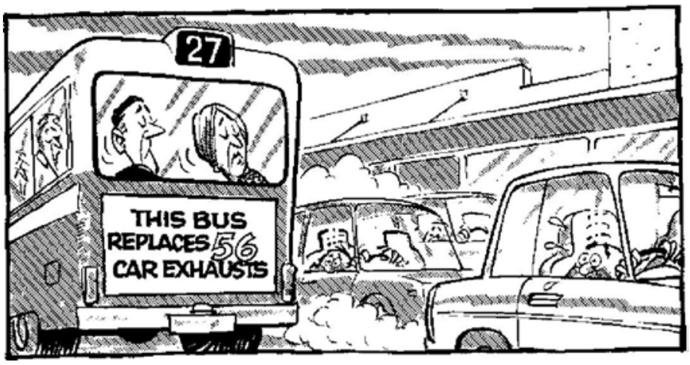
17) Each of us takes 20,000 breaths a day.
Airwatch – Idling Reduction Fact Sheet www.airwatchnorthwest.org/wa

18) One hour of using a petrol-powered 3.5 horsepower lawnmower produces the same amount of air pollution as a car driven for 550 kilometres.
Ontario Conserves www.ontarioconserves.gov.on.ca/english/air_facts.asp

19) One poorly tuned vehicle can emit as much pollution as 20 properly tuned cars.
Ontario Conserves www.ontarioconserves.gov.on.ca/english/air_facts.asp

20) Air pollution is responsible for almost one third of toxic contaminants and nutrients that enter coastal areas and oceans.
ABC - Oceans Alive www.abc.net.au/oceans/facts/default.htm

csc/airwatch/photos/cartoons : nox cartoon ; smoke 1 ; A43 bus27 ; pot belly



Extra resources!

Websites

a) Air quality

Department of Environment WA www.environment.wa.gov.au/airquality
Daily air quality data from monitoring stations around South West WA. Check the levels of ozone, carbon dioxide and particulate pollution nearest to you.

Australian Greenhouse Office www.greenhouse.gov.au
Teacher resources on global warming, energy, travel, fact sheets, 'Cities for Climate protection' and information about Government initiatives.

EPA Victoria www.epa.vic.gov.au
Greenhouse info; air quality monitoring, traffic emissions, pollutant information, health.

US Environmental Protection Agency http://www.epa.gov/epahome/educational.htm
Air quality information for teachers/students and the public. Teacher resources, student activities, environmental kids club, pollution control, effects, types, indoor pollution, fact-sheets.

National Pollutant Inventory – Australian government www.npi.gov.au
Check this site to investigate what's in your local air simply by entering your postcode. The site lists the main pollutants found in your area and background information.

NSW EPA www.environment.nsw.gov.au/air/airwatch/index.htm
On-line resources covering a range of activities relating to air, there is also a course written for the NSW Geography Stage 5 curriculum.

Department for Planning and Infrastructure www.dpi.wa.gov.au/greentransport
Government programs and initiatives which encourage people to use travel options that have a minimal impact on the environment. Find out how to be involved in cycling, walking, and Travelsmart initiatives in Perth.

RAC WA www.racwa.com.au
Car buying tips, maintenance, ownership costs, diesel vehicles.

Australian Bureau of Statistics www.abs.gov.au
Environmental Issues; People's views and practices March 2005
Australian Bureau of Statistics report on heating, cooling, white goods, and green power and people's knowledge and willingness to adopt energy saving practices.

Australian Lung Foundation http://www.lungnet.org.au/education/learn-health.html
How the lungs work, causes and treatments of asthma, bronchitis, sources of indoor and outdoor air pollution.

b) Resources/activities:

Millenium Kids http://www.millenniumkids.com.au
Millenium Kids is a youth organisation run by kids, for kids. It aims to inspire, educate and empower kids to address local environmental issues, implement solutions, and develop leadership skills.

The Green Vehicle Guide www.greenvehicleguide.gov.au
helps you by rating new Australian vehicles based on greenhouse and air pollution emissions

Activities site - www.howstuffworks.com/ozone-pollution
A very interesting site with information on how all sorts of gadgets and phenomena work, including photochemical smog. There is also an activity for students to make their own ozone detectors.

Simulation activity www.kids-for-the-environment.com.au/play/dust/pop_dust1.html
'Eat my dust not my fumes' is a simulation game where players have to buy the greenest car they can.

Urban Tripper – travel choices www.urbantripper.org.au
An interactive game where players take on a colourful character as they travel around a city – highlighting the consequences of their travel choices. (The CD is available free from AirWatch)

Facing the future www.facingthefuture.org
a non-profit organisation providing teachers, students and the public with sustainability and global issues education materials and action opportunities to shape our future.

Australian Bureau of Meteorology http://www.bom.gov.au/lam/Students_Teachers
Curriculum materials for studying weather including lesson plans and activities.

c) Other useful sites
CSIRO Australia www.csiro.au/csiro
Smogbusters www.smogbusters.gov.au
GoSmarter NZ www.gosmarter.org.nz.journeys
David Suzuki Foundation http://www.davidsuzuki.org/WOL/Challenge/
Dept of Environment and Heritage, New Hampshire USA
http://www.des.state.nh.us/ard_programs.htm
Way to school kit http://www.waytoschoolkit.infoxchange.net.au./teachers/amt.html
Air Pollution what's the solution? http://www.k12science.org/curriculum/airproj/index.html
Easybreathers http://www.easybreathers.org/teacher/index.html
Pedestrian Council Australia www.walk.com.au/pedestriancouncil/page.asp

All website references are current at time of publishing.

Extra activities

AirWatch Primary manual "Who cares about our air?"

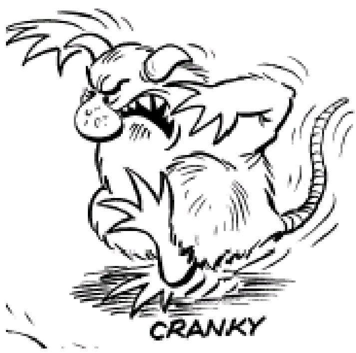
The following activities are taken from the AirWatch primary manual "Who cares about our air?". If you do not have a copy of the manual, please contact AirWatch via www.airwatch.gov.au or call 6364 6463/6500 to obtain one.

3.3 Types of Pollutants Teacher notes

Notes
Students can fill in the missing information during the play or the table can be used as a follow up activity.

Activity 3.3
This play focuses the students' attention on the causes and hazards of air pollution. Students should be able to list and describe the six major air pollutants.

Background
There are hundreds of pollutants that float around in the air that we breathe. Australia has established national air quality standards for six of these pollutants: ozone, carbon monoxide, nitrogen dioxide, particulate matter, sulfur dioxide and lead. These air quality standards are designed to protect the health and welfare of people, plants, and animals, and to protect our water, buildings, monuments, and other resources.



Reference:
The *Air Pollution Gremlins* were created by the Texas Natural Resource Conservation Commission.

Pollutant	Where it comes from	Effect
Smelly sulphur dioxide		
Nasty nitrogen dioxide		
Odious ozone		
Pesky particulate		
Cranky carbon monoxide		
Lumpy lead		

Curriculum links:
- English - Students acquire information through speaking and listening.

Activity 3.3 Student notes

What types of substances cause pollution in our air? This play will help you find out.

Characters:
Christina
Steven
The Gremlins:
Smelly Sulfur Dioxide
Nasty Nitrogen Oxide
Odious Ozone
Pesky Particulate
Cranky Carbon Monoxide
Lumpy Lead
(The Gremlins may be cast singularly or as a group of factors)

Setting:
Christina and Steven are sitting in a lounge room with the television, radio, fan, and three or four lights on. They are watching a television show.

Dialogue:

Christina: This is my favourite show!
Steven: Yeah, I just love the Power Rangers. The song that's playing on the radio right now is pretty cool too. It goes along with the action on the TV.
Christina: (She gets up and looks outside the window) Hey, Steven look at that! (points to the sky).
Steven: Wow! I wonder what it is? Let's go outside and get a better look. Steven and Christina go outside. A large cloud comes closer to them. Underneath or behind the cloud are the Air Pollution Gremlins. The cloud stops right in front of Steven and Christina. Immediately, the Gremlins start jumping around and making faces at the audience and Christina and Steven.
Steven: Who are you?
Smelly Sulfur Dioxide: We are the Air Pollution Gremlins. We've come to take over your town.

Christina: Why would you want to do that? Only nice people live here.
Pesky Particulate: You may be nice people, but nobody seems to care about the air in this town.
So, it looks like a good place to live (sneer).
Steven: I notice each of you has a different name. Why is that? Aren't you guys all the same?

Cranky Carbon Monoxide: We have different names because we come from different sources and cause different problems.
Steven & Christina: Oh No!!
Cranky Carbon Monoxide: I'm Cranky Carbon Monoxide. I mostly come from car exhausts. I
like to make people dizzy and give them headaches (twists hands menacingly).
Smelly Sulfur Dioxide: I'm Smelly Sulfur Dioxide. I come from smokestacks of power plants and industries. I can hurt your eyes, noses and lungs. I can even eat away iron and steel. I like to make the air look hazy (lunges at audience).

Nasty Nitrogen Dioxide: I'm Nasty Nitrogen Dioxide. I have a yellow-brown colour and I come from cars, electric power plants, and other large industries. I can make the air brown and hazy. I like to hurt lungs, plants, and metals (makes an evil laugh)
Lumpy Lead: I'm Lumpy Lead. I can contaminate the air, food, and water. Also, I am found in some old paints. I'm very harmful to children and fish (does a little dance).
Odious Ozone: I'm Odious Ozone. I'm invisible by myself, but when I get together with my friends, I can help form smog. I can make it hard to breathe (lunges at audience).
things dirty and I can carry harmful chemicals into your lungs as well (makes a very loud and evil laugh).

Christina: All of you sound so terrible! We don't want you to live here.
Odious Ozone: You make it easy for us by wasting electricity and asking your parents to drive you everywhere you want to go!
Lumpy Lead: And by using your wood heaters incorrectly all winter.
Steven: You mean that just because we waste electricity, use wood heaters and ride around a lot in the car, you guys are here to stay?

Nasty Nitrogen Dioxide: Bingo! Thank you for the invitation to live in your town!
Christina: Well from now on, you're not invited to our town. I'm not wasting electricity anymore and I'm going to walk or ride my bike if I want to go somewhere nearby.
Steven: Yeah! (firmly), and I'm going to find out how to use our wood heater properly! We're starting right now!

What wood? Teacher notes

Summary

These activities show students that they can use simple methods to ensure that that they are not producing lots of smoke particles when operating a woodheater or fire.

Background

Freshly cut wood from a living tree will contain about 50% moisture, i.e. about half the weight of the green wood is water. If it is left to dry, it will gradually lose its moisture until it reaches about 12-15%. At this point it reaches equilibrium with the air and does not lose any more moisture.

If wood is oven dried so that its moisture content is less than air, and then put back into the air, it again reach 12-15% moisture content.

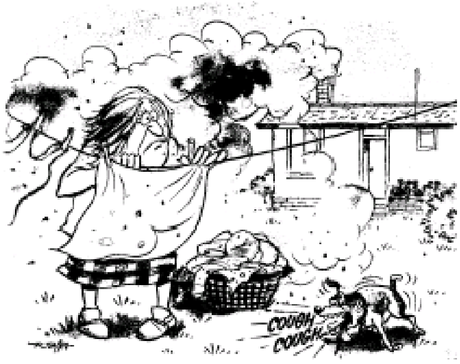
Activity 5.4 (a)

Dry wood produces less smoke. Wood should contain less than 20% moisture if it is to be burnt. This activity shows that dry wood floats higher in a bucket of water than wet wood. If it floats with one sixth of its length out of the water it has less than 20% moisture. This is an easy way to predict whether wood is dry enough to burn.

Activity 5.4 (b)

Drying your wood and storing it correctly is important preparation for the correct use of your wood heater. Using sponge to represent wood, students will prepare it differently to observe the best conditions for drying their wood before burning. Things to do to keep your wood dry:

• cut it into small logs
• Stack it so air can circulate
• Stack it under cover



Activity 5.4 (c)

Using the chimney checker is a simple way to test a fire when it is going.

Discussion questions

1. Why should you use dry wood in your fire or wood heater? (To reduce the amount of particles put in the air)
2. In what way should you stack your wood to ensure it dries most quickly? (With plenty of air spaces between logs and undercover)
3. Who uses wood heaters at home?

Curriculum links:

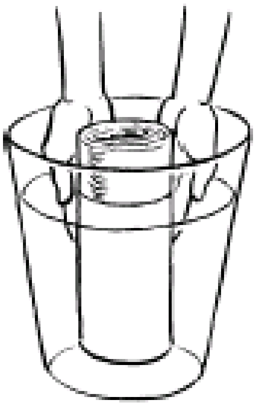
- Science - Students work scientifically in predicting and conducting investigations and processing data in physical and chemical science

What wood? Student Activity

These activities will show you some simple ways you can ensure that you are not producing lots of smoke particles when operating a wood heater or fire.

Activity 5.4 (a)
Materials
Dry wood
Wet wood
Bucket 3/4 filled with water
Marker pen
Get two pieces of similar size wood, one which has been freshly cut and one which is old and dry. With the pen, mark into sixths. Put each into the bucket of water and hold upright. See how much of the log sticks out of the water.

Draw your results
Which wood floated lower in the water?
Why would that happen?
The more moisture in the wood the heavier it is.
Which log was the wetter one?
Which of the two logs should you use to burn? Why?



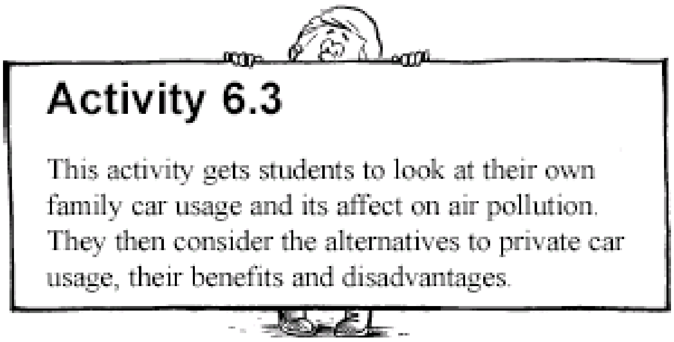
Activity 5.4 (b)
Materials
Sponges (3)
Scissors
Bowl of water
This activity will show you the best way to treat your wood to get it ready for burning.
Sponge 1 - wet in the bowl of water and squeeze. Roll it in a ball and use an elastic band to keep in this shape.
Sponge 2 - cut the sponge into long strips and wet in the bowl and then squeeze. Tie loosely together with another elastic band.
Sponge 3 - Treat as Sponge 2 but lay strips out beside one another. Leave all the sponges in a safe place for 15 minutes. Then check for "wetness". Check again in another 10 minutes.

Describe your results.
Can you use this experiment to guess what you can do to make you wood dry out more quickly? Can you think of any other practical things to keep your wood dry?

Haze and Smog Alerts
In Australian capital cities, haze and smog alerts are issued throughout the year. These are given over the radio, television and in the newspapers.
Find out whether any air pollution warnings are given in your state and what you should do when you hear one issued.

Family cars

Teacher notes



Background

Cars are responsible for emissions of carbon dioxide, nitrogen oxides, hydrocarbons and lead. Ones that are not running properly give off more of these pollutants and also use up more petrol.

So, how do we use our cars? Is there any way in which we can change our use of cars that might reduce the amount of pollutants being pumped into the air?

Discussion questions

1. Why do you think most people choose to own a car rather than use public transport? (Convenience, safety, saves time)
2. What could be done to encourage people to use their cars less? (Make alternative transport more attractive, better public transport, better cycle / walk paths, increased parking costs, etc.)

Notes

Contact the RAC for average running costs for a range of different cars or use the following website to calculate the cost per year to run a vehicle:
www.nrma.com.au/motoring/buyingacar/opcosts or 203.89.198.226/racvm/whichcar/expertsays

Activity 6.3

This activity gets students to look at their own family car usage and its affect on air pollution. They then consider the alternatives to private car usage, their benefits and disadvantages.

Curriculum links:

- Society and Environment:
  - Students have knowledge, skills and values regarding their local geography and the places & spaces that surround them.

- Mathematics:
  - Students integrate number and measurement with chance and data.

Activity 6.3 Student activity

Form a group of four students, discuss and fill in the following table.

Student	Number of people in family	Number who are drivers	Number of cars	Age of vehicle (yrs)	* Number who used car for work	Average running costs per week
Average*						

*** Cars used as part of your work, not just getting to work.**

How does the number of cars relate to the number of drivers in the family?
Can you suggest ways your family could cope with one less car?
What advantages would there be to your city or town if families got rid of one car? Would there be advantages to the families?

Think about it
One alternative to using a car is using public transport. With your group discuss some of the advantages and disadvantages of using public transport.

Compile a table of advantages/disadvantages

What other alternatives are there to using a car?

How to complement the weather watch program There's so much more you can do with it.

Compiled by Simone Harris : Alinjarra Primary School

We have been fortunate to be involved with the Airwatch program since its inception. For reporting purposes you do need a dedicated weather station, but remember you are only reporting four times a year. The package is such a valuable resource to have in a school and it does become a waste to only use the weather station for reporting purposes.

The weather station can become a valuable tool to complement your teaching within the classroom. Besides the classroom, the staff in general has become familiar with the weather station particularly the Admin team. They have used it to determine how the weather will be for sports carnivals, sports sessions, recess and lunch and a variety of up coming activities that involves the school community being outdoors.

The following activities I have outlined are activities I have carried out with children in Year four and five.

Reading graphs

- Once the children become familiar with the graph, there is a large amount of information that can be gleaned.
- How to construct a graph. As you move from one day to the next with the weather station, you will notice the scale changes. Why does the computer automatically change the scale during different weather patterns? Why isn't the same scale used? Discuss scales.
- The everyday use of a graph and interpretation of a graph such as rain readings when there is no rain. Why is the internal temperature different to the external one? Give reasons why.
- Where are graphs used in everyday life, i.e hospitals etc. Have the children look at the real life value of graphs and where they are used in their lives.

Weather patterns and directions

- Listen to Jeff's broadcasts especially when he outlines what rainfall we should have for the month or year. Using rulers, construct a graph showing the average rainfall and construct a 1.5 metre strip and plot next to it the actual monthly rainfall that you receive at your location.
- Comparison of weather readings – the temperatures/ rainfall this year to last year / month. Why the changes or no change.
- Look at the oceans and their temperatures and how they affect our weather patterns. What is El Nino? The weather bureau site is a great resource for looking at this. You can also incorporate the Leeuwin current that runs down our coastline.
- Cyclone Tracking. How is the current cyclone affecting your local weather. Also check the website www.bom.gov.au to see the cyclone moving.
- Weather Bureau radar images showing rain. How much rain actually falls at your location. Compare the two computers.
- Wind direction – maths looking at the directions. – North, south, east west.

• Wind direction – how does this change seasonally and why. What does an easterly wind or a southerly mean. Where do they come from?
• The wind directions and their temperature difference. What is a easterly wind compared to a westerly and when do they occur.
• Weather patterns in W.A. How are they different considering you have monsoonal weather in the north and at times snow in the south. If all the weather comes from one direction, then how does location make a difference.
• Wind directions – The roaring forties and how many explorers came to land in WA as a result of becoming caught in these winds. Would early exploration of our coast be different if we didn't have these winds?

<u>Other suggested ideas</u>

• The Water Cycle is great to bring in and look at how we receive our rainfall.
• Incorporate into the travel smart program. How does air quality affect our life? Does car travel affect this and how so? Here you can include your visual air quality. Cooler days, more cars?
• Experiment. Why are your reading different marginally to the ones on TV. Error in the thermometer. Check with a simple experiment. Does your location make a difference?
• Keep your weather readings as an ongoing local weather record. These can be used for planning strategies within your school such as sports carnivals. We also look at the weather station to see if it is too hot to take classes out for sport. The weather station is also used in conjunction with the Weather Bureau site looking at the Perth radar. We can see how far the rain is and what weather conditions are expected. Very helpful when planning wet weather recess and lunch. This takes the guess work out of what can be a frustrating time of the year for everyone.
• Unsure about taking the kids out in really hot weather, then confirm it with the weather station. Again, the weather bureau site has a very informative section on recommendations on when children should be brought in from hot or humid weather.
• Language – weather words such as condensation, evaporation, precipitation etc.
• Debate Looking at wood fires and bush fires. How does that affect our air quality. Do a survey to look at the type of home heating and it's environmental impact.
• Once a month, have the children photograph the visual air quality in your school. By creating a diary over the year, the children will be able to visually see how the weather conditions change as does the air quality. You may also notice the light quality change as the year progresses.

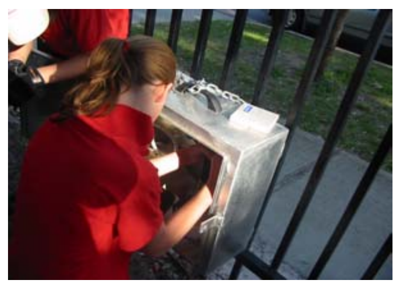
The Airwatch website is another valuable tool for the children. There is a huge amount of information and tests for the kids to try. The website can be very valuable resource for the classroom teacher.

Simone Harris 2004

Snaq Project

On the 23rd of August a man called Karl Hanson came to our school to start up our Air watch activity called the Snaq Project. Every day we would put our air pollution monitoring system outside. It would see how many particles were in the air by using a sort of vacuum to pull in the air and prevent the particles from coming through the system, showing what was in the air. Every one in my class had to learn to use take care of this special system.

We started using it on Monday, and our results were that there was quite a bit of rain, and hardly and haze in the air. Because there was rain, the rain probably washed most of the dust and particles out of the air. The wind was rated 3, which means there was a fresh breeze.



On Tuesday there was a fire on Welshpool road, so there were a lot of particles in the air also, there was hardly any wind so the particles that came from the fire (all the dust, smog and haze) stayed on Wednesday, Thursday and Friday. It stayed for three days because there was now wind in the air, so it stayed there. And because there was no rain, so the particles weren't washed away, that's why it took so long to get the particles out of the air.

The next week, on Monday there was very strong winds, and quite a lot of rain, but the final particulate weight was 3.92, so it was on average on Monday. On Tuesday and Wednesday the particulate weights were not surprisingly 1.34 and 1.62, because of how much rain there was (95.8 and 119.4.)The rain must have washed away all the particles. On Thursday, there was a final particulate weight of zero, which was strange because there was barely any rain (6.35), and no wind (rated a 2 which is hardly any breeze at all), so it was surprising the particulate weight was 0.

On Friday there was quite a lot of particulate in the air (6.75).So we were startled that the weight was almost more than double the average particulate weight for our school. Around Gibbs St we have quite clean air so we are really lucky.

By Allison Ray.

AirWatch Term 2 Project

Community Survey

The aim of this project is for students to design, conduct, analyse and interpret a survey of their community on a topic related to air pollution.

The project is very much an open-ended task. The survey could cover what people believe, what they know, or how that act. What your focus question is, and how sophisticated your survey is, depends the level of your students and their interest in the task.

Examples of focus questions might be:

- how well informed are people about air and pollution in Perth?
- how much do people value clean air?
- are peoples actions in daily life consistent with their beliefs about the environment?
- what do people understand about indoor air quality?
- what are the most popular types of home heating, what do people know about their costs (economic and environmental)?
- how do people use their wood heaters?
- how many / what type of cars do families have and how do they use them?
- why do people love using their cars?
- what do people think about, and how do they use public transport?
- how do people travel to school, why don't more people walk, ride, car pool?
- which environmental issues are most important for our community? How important are they compared other issues (health, education, crime etc)?
- what kind of city environment do people want to live in, in 20 years time?
- how can we make public transport more attractive to people?
- how 'friendly' do people think their suburb is for walking / cycling?

Once the focus of the survey has been decided on students will need to devise 10 - 20 questions to get information on the topic, this may require some background research. Then they will need to decide how to 'score' the responses or present the data.

When interpreting the results the students should consider 'what do these results mean for our future environment?' We will run a competition where any reports written on the survey results will be displayed on the AirWatch web site and will go in the running for a class and individual (or group) prize.

We have given you some examples of surveys from the AirWatch manual that students can use as an example. There are also some pages from a U.S. text for high school students with more information about how to design and conduct surveys, we hope this will help you guide your students' efforts.

If you have any questions call Richard Olive on 9278 0653. See www.airwatch.gov.au for more information on air quality.

SNAQ PROJECT

On the 23rd of August Carl Hanson from Air Watch came to are school to tell us about particulates. He left us an Air Particulate Monitor to monitor for the next two weeks. The particulate monitor consisted of an air pump that sucked in air; a hose with a compartment, in the compartment was a fine threaded piece of paper that collected particulates and a battery that ran the whole thing. We got given four pieces of paper to record the particulates, the wind the temperature and the wind. We first used the particulate monitor on Monday the 29th of August.

Week 1

On Monday and Tuesday there were not much particulate in the air. Though on Monday there was 42mls of rain and Tuesday 14.4mls. On Wednesday there was a fire on Welshpool road. We could see a major change. There were particulates on the filter sheets. We recorded a 2.5 on the grey scale. Thursday surprised me the most. The day after the fire had more particulates then the day of the fire. The grey scale was 3. On Friday the fire calmed down. The grey scale was 2.5.

Over the last 3days there was only 2.4ml of rain.

Week 2

On Monday the following week it seemed to still have the results of the fire. The grey scale was 2. Though there was a lot of rain at 44.4mls. It also was the windiest day out of them 2 week period. There was not much particulate on Tuesday and Wednesday but a lot of rain. On Tuesday there was a whopping 95.8mls of rain and an even bigger amount on Wednesday 119.4mls. That was 266.8mls of rain over 3days. The best day was Thursday with a grey scale of 0 because of the 266.8mls from the first 3days. On Friday we had to run the particulate monitor shorter because we had to get the information into Air Watch.

By Jackson Very good Jackson, you've worked extremely hard on this project, thank you for your efforts on the computer and you enthusiasm for these tasks. Mrs Brenchley

Snap Project

On Tuesday the 23rd of August Karl Hansom came to tell Area 4 about what he does. He works at Air watch where he records weather changes. He gave a small weather box so we can record the weather as well a lot of other schools are doing it as well.

Week 1

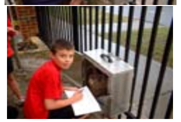
On Monday or first day it rained a lot and there was also a fresh breeze blowing. On Tuesday there was a fire on Welshpool rd, there was no rain and very little wind. On Wednesday the haze from the fire remained so the particulate levels were high. Thursday was almost identical to Wednesday the haze still remained. On Friday it rained a lot so the particulate level was down.

Week 2

On the 2nd Monday it rained like crazy. Tuesday was better than Monday but it was still dark. Wednesday was rainy and cloudy. On Thursday it started to clear up. Friday was a sunshiny day, we could see clearly now the rain had gone.

We found out our air was really quite clean except when we have a fire like in the first week. Maybe not many people in our area have wood heaters or maybe it just rained a lot so that's why our air was so clean.

Matthew Holtham

Date	Volume of Air (m3)	Mass of carbon (ug)	Calculated weight	Multiplying factor	Final weight	High Temp	Low temp	Rain (mm)	Wind	wind speed	Notes	images	
29-Aug	6.676	3	0.45	3	1.35	17.7	5.6	42	S/SW	30	A lot of rain helps keeps air clean		
30-Aug	6.679	3	0.45	3	1.35	14.7	8	14.4	S/SE/ENE	25	The battery is heavy		
31-Aug	6.818	10	1.47	3	4.4	15.7	6.2	0	E/ESE/ENE	12	Fire in Welshpool Rd		
01-Sep	6.491	15	2.31	3	6.93	17.9	3.2	1.6	ENE/NE/N	9	Still showing effects of fire		
02-Sep	10.026	10	1	3	3	19	7.1	0.8	WSW/W	16	Writing down results		
05-Sep	6.129	8	1.31	3	3.92	19.9	10	44.4	NNE/NNW	62	strong winds		
06-Sep	6.715	3	0.45	3	1.34	17.5	6.6	95.8	W/WNW	26	Putting the filter paper in		
07-Sep	5.556	3	0.54	3	1.62	18.7	7.4	119.4	WSW/SW	23	Getting info from computer		
08-Sep	6.758	0	0	3	0	16.7	5.7	6.3	SW/WSW	22			
09-Sep	1.334	3	2.25	3	6.75	13.6	4.3	6.5	SSW/SW/W	24			



Day 1. 29/08/05

Day 2. 30/08/05

Day 3. 31/08/05.


Day 4 1/09/05

Day 5. 02/09/05



Day 6 05/09/05

Day 7 06/09/05

Day 8 07/09/05


Day 9 08/09/05

Day 10 09/09/05

AIR POLLUTION SURVEY 2005

CHALLIS PRIMARY SCHOOL

S1 YEAR 7

This is our school

We
spent the first five weeks discussing in groups the types of questions we could ask everyone.

Discussion Groups

Discussion Groups

What did we do next?

- We sorted the questions out into sections before we typed it up.
- Then we sent the questions home to every family of the school with a letter of explanation.

Letter for Survey

- 23rd May, 2005
- Dear Parents and caregivers,
- This term, the Year 7s in S1 are taking part in a State wide project on Air Pollution in the Armadale area, for the Department of the Environment.

- We would like all the families of Challis Primary School and Challis ECEC to help us with the project.
-
- The students have written a survey, which we would like families to answer to the best of their knowledge. To ensure confidentiality no names or addresses are required.
- Please help us by answering the questions and send the survey back to school by Monday 30th May. (next week).
-
- This will ensure that the students have enough time to analyse the data and present the information in a suitable form. The information will also be sent home in a later newsletter.
-
- Thank you for your help with this project.
-
- Mrs Jefferson and all the S1 year 7 students.

The Survey

- We asked people to answer 9 questions and finished with a set of 20 statements for people to:
- Agree
- Be Neutral
- Disagree.

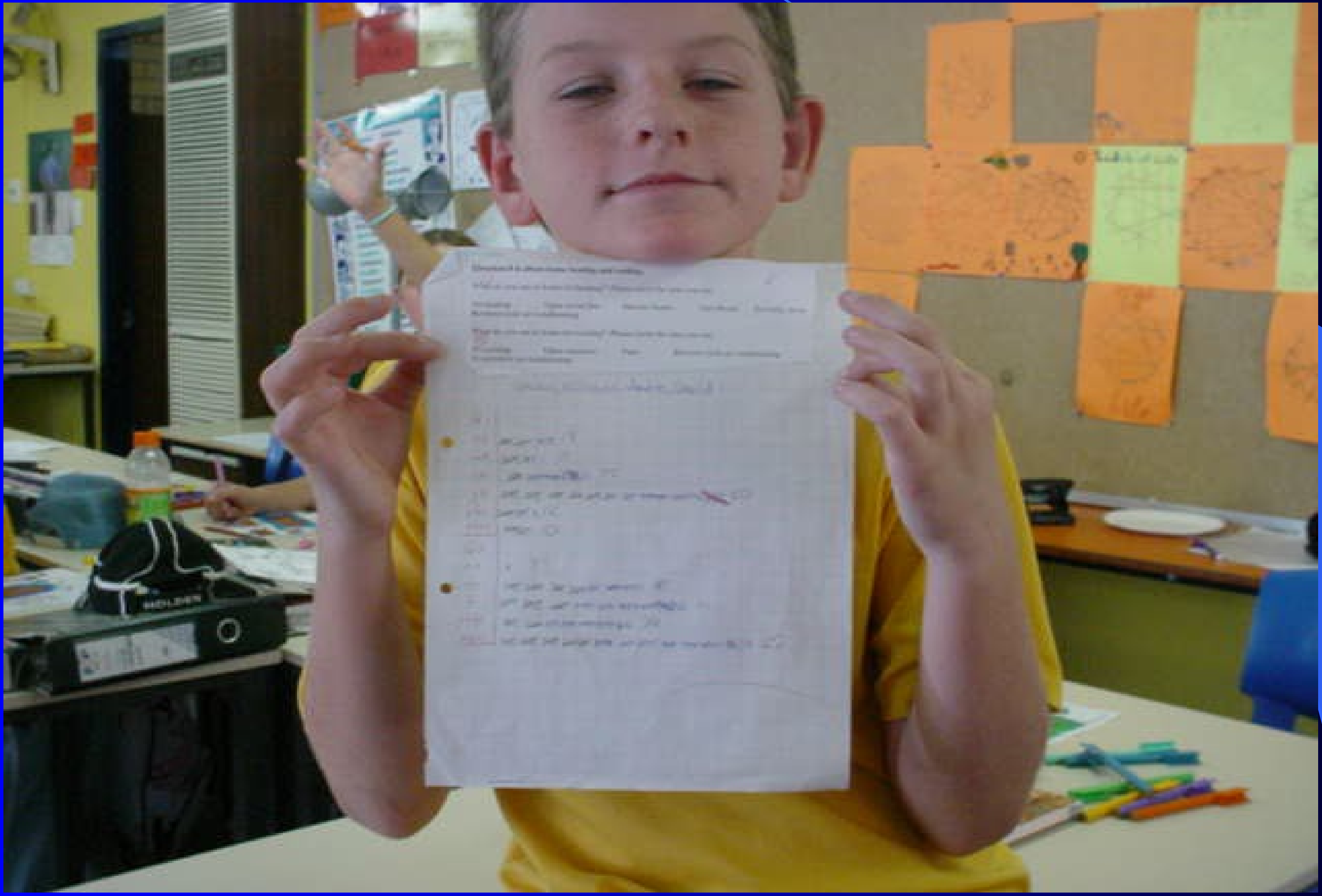
- Not every question was answered on each survey.

How many did we get back?
144 replies

Tallying

Tallying

Tallying completed



Question 1 is about people.

- How many people live in your house?

  ____

-
- How many are adults? (over 17)

  ____

-
- How many are children?(17 and under)

  ____

-

Answers to question 1

- Total number of people
- 493
- Adults over 17 years of age
- 194
- Children under 17 years of age
- 299

Question 2 is about people and illnesses.

- Does anyone suffer from any of these illnesses? Please circle .
-
- Asthma Emphysema Bronchitis Pneumonia Influenza Colds
-

Answers to question 2

Asthma	75
Emphysema	0
Bronchitis	13
Pneumonia	2
Influenza	24
Colds	82

These people definitely need clean air!

Question 3 is about vehicles.

- How many cars does your family have?______
- How many 4w drives? ______
- How many trucks? ______
- How many semi-trailers? ______
- How many are buses? ______
-

Answers to question 3

- We found that our families have:
- Cars 217
- 4w drives 23
- Trucks 4
- Semi-trailers 1
- Buses 1

All of our families have a car.

Question 4 is about the type of vehicles.

- **Please list the make, model and year of your vehicles.**
-
- **1. ______________________________**
- **2. ______________________________**
- **3. ______________________________**
- **4. ______________________________**
- **5. ______________________________**
- **6. ______________________________**

Answers to question 4

- We divided the cars into years:
- 2001-2005 35
- 1996-2000 49
- 1991-1995 45
- 1964-1990 75
- We decided that our families have lots of old cars and therefore these cars possibly help to pollute the atmosphere.

Question 5 is about using the vehicle.

- When are these vehicles used? Please circle one.
- Cars
- every day   once or twice a week   once a month   never
- 4W Drives
- every day   once or twice a week   once a month   never
- Trucks
- every day   once or twice a week   once a month   never
- Semi-trailer
- every day   once or twice a week   once a month   never
- Bus
- every day   once or twice a week   once a month   never

Answers to question 5.

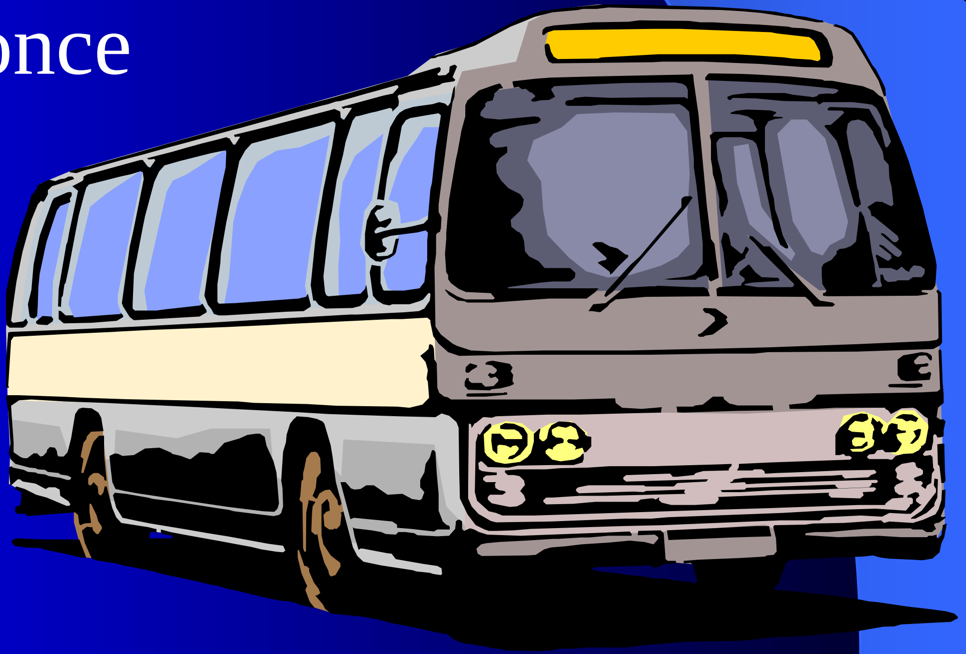
- **Car:**
- **Every day** **123**
- **Once or twice a week** **8**
- **Once a month** **1**
- **Never** **2**

- **4W Drive**:
- Every day 19
- Once or twice a week 0
- Once a month 2
- Never 3

- Truck:
- Every day 6
- Once or twice a week 0
- Once a month 0
- Never 3

- There were no semi-trailers used because it must still be in the garage or not working.

- The Bus was used once
- every day.



Question 6 is about mileage of the vehicles.

- How far do your vehicles travel each week? Please circle one.
- Car
  - 200 km 200km-400km 400km-600km more than 600km
- 4W Drives
  - 200 km 200km-400km 400km-600km more than 600km
- Trucks
  - 200 km 200km-400km 400km-600km more than 600km
- Semi-trailer
  - 200 km 200km-400km 400km-600km more than 600km
- Bus
  - 200 km 200km-400km 400km-600km more than 600km

Answers to question 6

Car	
< 200	46
200-400	49
400-600	19
> 600	6

- Although there are 217 cars not all are used each week.

- 4W Drive
- < 200 6
- 200-400 8
- 400-600 4
- > 600 0

- Not many of these are driven each week.

- Trucks
- < 200 0
- 200-400 2
- 400-600 2
- > 600 2
- Even though we found that there was one semi-trailer, we think it must be kept in a garage because it did not record any mileage.
- Bus
- < 200 1

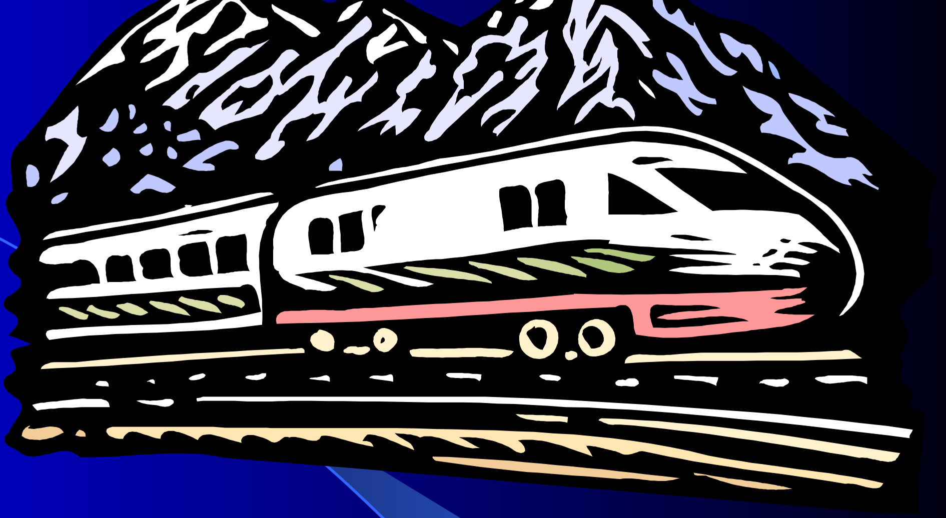
Question 7 is about public transport.

- Does anyone travel by public transport? Please circle one.
- Bus
- every day   once or twice a week   once a month   never
- Train
- every day   once or twice a week   once a month   never
- If some people use public transport please circle how many.
- 1person   2people   3people   4 people   more than 4

Answers to question 7

Bus:

- Every day 8
- Once or twice a week 12
- Once a month 11
- Never 73
- Not many people catch a bus.



- Train
- Every day 11
- Once or twice a week 15
- Once a month 24
- Never 65
- Not many people catch a train.

People who use public transport

1 person	26
2 people	19
3 people	13
4 people	3
More than 4	5

- Very few people in our area use public transport.

Question 8 is about walking and cycling.

- Does anyone walk during the week?
- To school
- every day once or twice a week once a month never
- To work
- every day once or twice a week once a month never
- To sport
- every day once or twice a week once a month never
- To shops
- every day once or twice a week once a month never

- Does anyone cycle during the week?
- To school
- every day   once or twice a week   once a month   never
- To work
- every day   once or twice a week   once a month   never
- To sport
- every day   once or twice a week   once a month   never
- To shops   every day   once or twice a week   once a month   never

If some people walk or cycle please circle how many.

- 1person   2people   3people   4 people   more than 4

Answers to question 8

- **Walking**
- To school:
- Every day 52
- Once or twice a week 26
- Once a month 17
- Never 46

- Walking
- To work:
- Every day 2
- Once or twice a week 8
- Once a month 3
- Never 121

Walking	
To sport:	
Every day	1
Once or twice a week	15
Once a month	7
Never	151

- Walking
- To shops:
- Every day 11
- Once or twice a week 31
- Once or twice a month 20
- Never 76

People who walk or cycle in each family.

1 person	17
2 people	25
3 people	33
4 people	21
>4 people	19

- Cycle
- To school:
- Every day 10
- Once or twice a week 13
- Once a month 9
- Never 99

Cycle	
To work:	
Every day	4
Once or twice a week	5
Once a month	2
Never	123

- Cycle
- To sport:
- Every day 0
- Once or twice a week 3
- Once a month 3
- Never 125

- Cycle
- To shops:
- Every day 4
- Once or twice a week 8
- Once a month 13
- Never 101

Results of Question 8

- Our results show that not many people from our families walk or cycle any where.
- We think that this is not really healthy and in some way must lead to more pollution in our suburb.

Question 9 is about home heating and cooling.

- What do you use at home for heating? Please circle the ones you use.
- No heating Open wood fire Electric heater Gas Heater Pot belly stove Reverse cycle air conditioning
-
- What do you use at home for cooling? Please circle the ones you use.
-
- No cooling Open windows Fans
- Reverse cycle air conditioning Evaporative air conditioning

Answers to question 9

Heating	
No heating	15
Open wood fire	11
Electric heater	72
Gas heater	60
Pot belly stove	12
Reverse cycle air conditioning	10

Cooling	
No cooling	**1**
Open windows	**38**
Fans	**43**
Reverse cycle air conditioning	**34**
Evaporative air conditioning	**62**

Results of question 9

- It seems that most people use either electricity or gas for heating so pollution is reduced.
- Cooling is more varied over all the types that we asked about.

Question 10

- The next section is a number of statements. We would like you to agree, disagree or be neutral (no opinion).

- Please circle A, N or D for each statement.

Statements 1-10

	Statement	A	N	D
1.	Air quality is important.	134	2	0
2.	Air quality should be monitored and reported better.	125	15	1
3.	All cars should be tested for emissions regularly.	88	31	15
4.	People should be made to take public transport to work or school.	15	27	71
5.	Suburbs should be made safer for people to walk.	95	17	8
6.	More parks with trees should be developed in all suburbs.	118	23	0
7.	There should be more cycle ways for everyone.	108	15	1
8.	People should be able to monitor air pollution in their homes.	62	66	8
9.	I do not need to worry about clean air.	5	28	90
10.	Petrol tax should be used to help monitor air quality.	65	55	20

Statements 11-20

11.	There should be more electric buses for public transport.	95	27	13
12.	Vehicles with poor emissions should be removed from our roads.	84	16	24
13.	Our suburb is a great place to live because of the clean air.	111	15	13
14.	Our suburb is a great place to live because of the friendly community.	79	53	7
15.	People with lung problems should be helped more.	79	48	5
16.	I would use public transport if it was better and there were more buses.	44	51	39
17.	Air pollution is not our problem.	3	12	126
18.	The government should ensure that the air is clean.	86	32	16
19.	People should not use wet wood in their fires.	119	20	2
20.	Air quality can be improved if we are all careful.	135	6	1

Results of statements 1-20

- Our survey shows that a huge majority of our families think that air that is fresh and clean is what we really want in our community.
- They think that everyone should be conscientious and think about what is used in the home, or how they use their cars, so that everyone has a wonderful life.

Pollution Check

- We also set our air pollution monitor going.

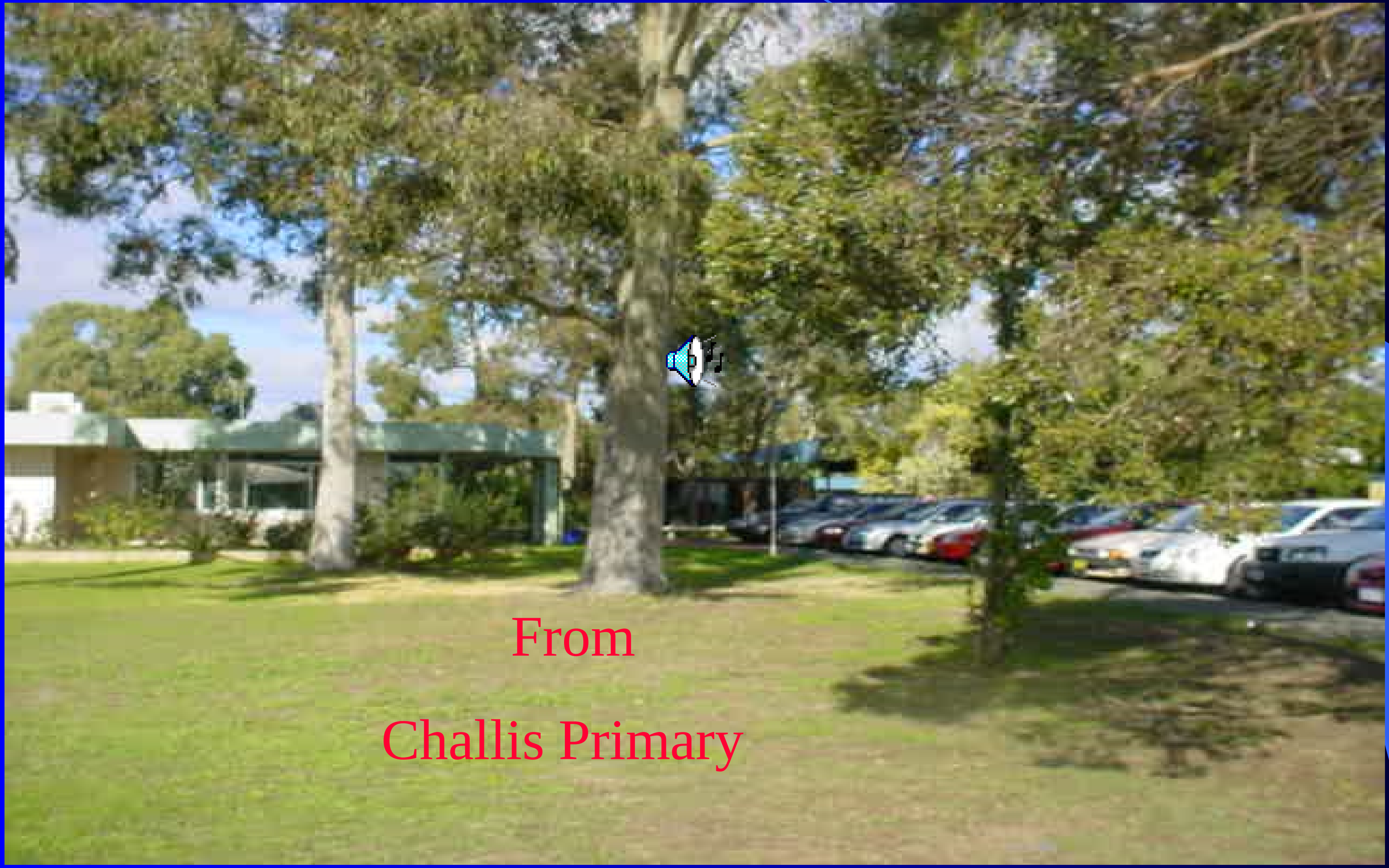
Pollution Check

- We discovered that the filter paper only collected a small amount of pollution over the day.

Armadale

- We really love our area. It is really a great place to live. There isn't really very much pollution and there are plenty of trees and always a healthy breeze that keeps our air clean.
- However people do need to make sure that their cars are cleaner so that everyone, especially children, stay healthy as they grow up.

The End



File references for this folder (examples of student work)

1. Ideas for using AirWatch - Simone Harris Alinjarra Primary school teacher

2. AirWatch school project ideas 2006 – summary of typical air quality activities for students and teachers

3. Woodbridge primary – air pollution survey and class recommendations

4. Schools AirWatch - powerpoint presentation summarising “What our school did in AirWatch”

5. SNAQ on Haze – Jessica Ball Year 9 Duncraig SHS results and analysis

6. Gibb Street primary school - AirWatch particulate data collected over a two-week monitoring period.

7. Gibb Street primary, haze monitoring reports;
   a) jackson, b) Matthew, and c) Alison

8. Particulates – images of 10 monitoring samples from Gibb St Primary

9. Community survey – project description (for reference).

10. John Wollaston Anglican Community School - Nitrogen dioxide monitoring project
    a) report by Rebecca, Stephanie, and Rhys
    b) report by Bec, Tash, and Tim

11. Challis Primary school – community air quality survey – a terms work looking at car usage, public transport, home heating and other air quality issues.

Watchin our Air

Air Watch Report

By Rebecca Collier,
Stephanie Horne and Rhys Voysey

From John Wollaston Anglican Community School

Watchin our Air

Background:

At John Wollaston Anglican Community School we had been invited to take part in a program run by the Department of Environmental Studies in Western Australia called Air Watch. In the experiment we had to monitor the air quality near our school (John Wollaston ACS) on Lake Road. The equipment was set up each day for 3 hours each day over 2 weeks. We then conducted the scientific experiments in class to determine the amount of Nitrogen Dioxide (NO_2) in the air and how safe it is to breathe.

Nitrogen dioxide is an orange brown gas with a pungent odor. NO_2 is made up of oxides of nitrogen that include nitric oxide and nitrogen dioxide. Nitric oxide is a colorless odor less gas. It is released in large quantities into our atmosphere from emissions from the combustion process in industrial boilers and motor vehicles. In the atmosphere it gradually changes due to the ozone in the air to become the more harmful nitrogen dioxide.

It is important to monitor NO_2 because NO_2 can cause health problems for those who have to live with it. The health effects can affect respiratory problems in people and severely affect asthmatics. The NO_2 can impair respiratory defense mechanisms, increase infection rates and reduce the ability to breathe. These can affect young children, the elderly and those with respiratory illnesses more than others

Aim:

The aim of this investigation was to determine the amount of NO_2 in our local area to find out if it is endangering our lives

Equipment:

Monitoring station-
Particle filter
NO_2 filter
Flow meter
Pump
Battery

Filter papers

Zip lock bags
Tweezers
Plastic vials
Reagent solution
HPLC water
Pipettes 2ml and 5ml
Safety glasses
Pink photographic scale

Method:

1. Collect the NO_2 on the filter papers by each day setting up the equipment with filter paper in, turn on pump and place the hose out side of the box. Return 3 hours later and remove the filter, turn off pump, place hose back inside the box, remove filter and place in the fridge.

2. Extract the NO_2 from the filter paper using HPLC water and regent to form a pink color. Compare pink color to that on the pink photographic scale on chart to determine the amount of NO_2 in the air.

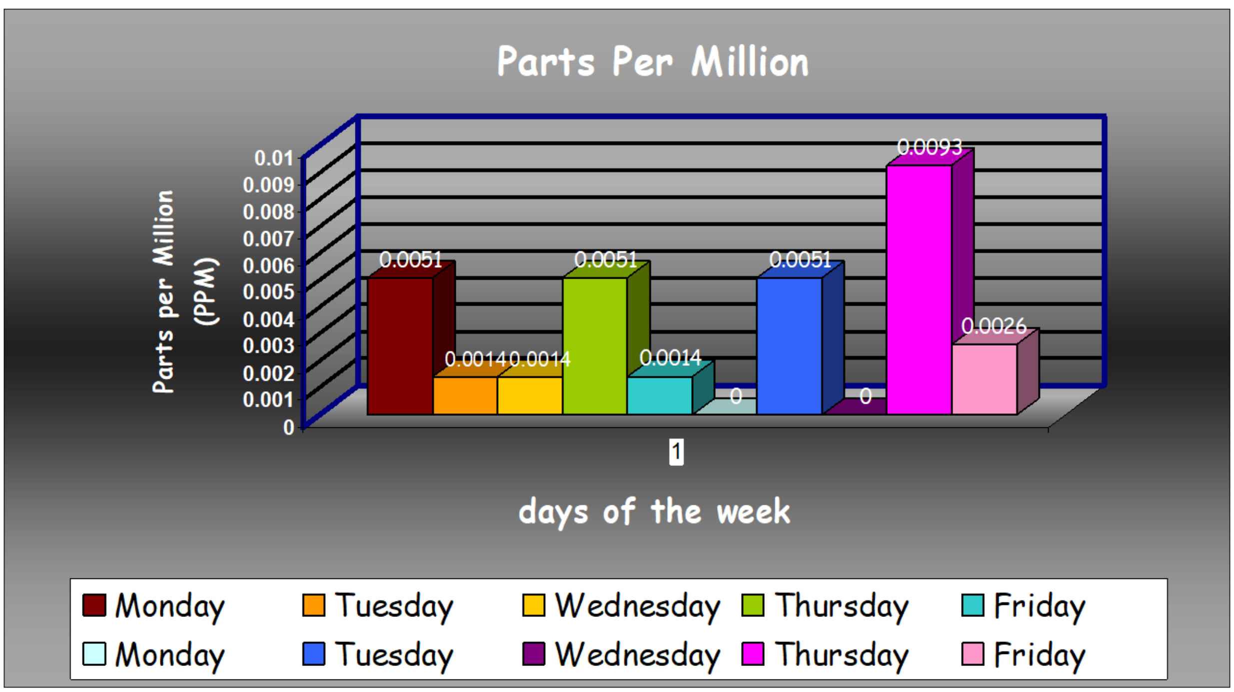
Results:

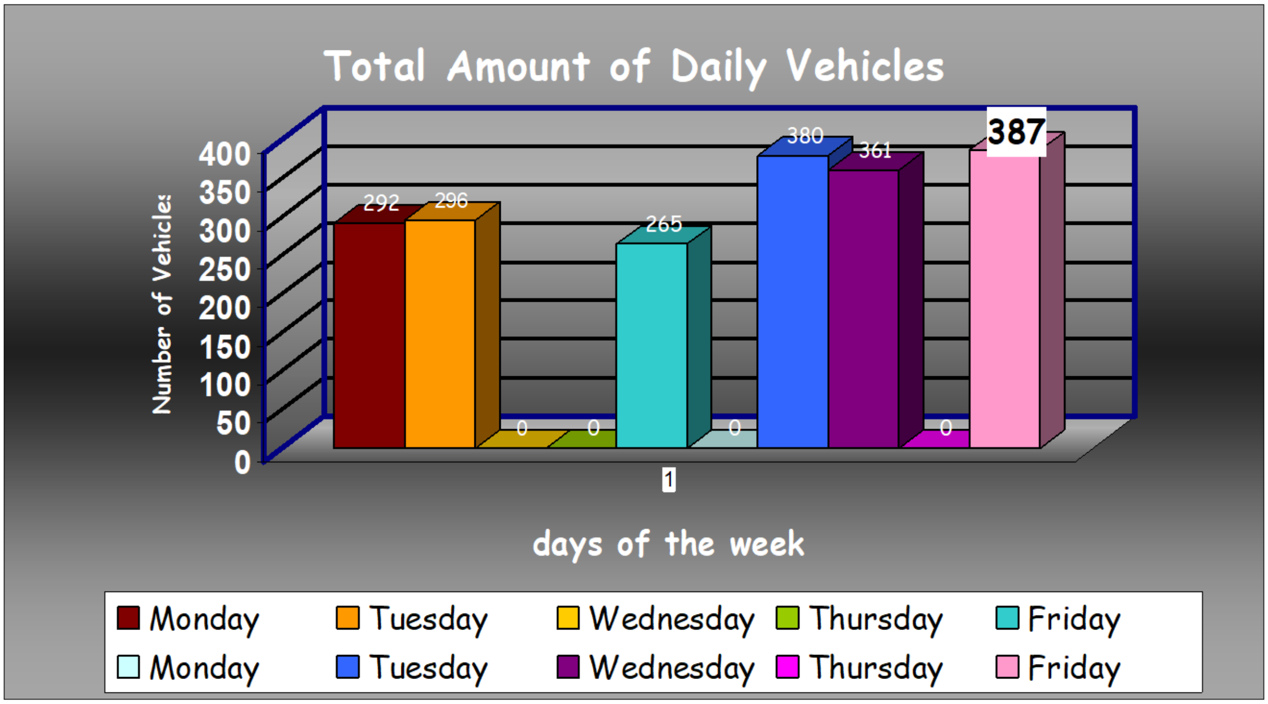
Table of Air Watch Results

Days	Level	Parts per Million (PPM)	Micrograms	temperature
Monday	7	0.0051 PPM	37	25
Tuesday	5	0.0014 PPM	10	32
Wednesday	5	0.0014 PPM	10	30
Thursday	7	0.0051 PPM	37	31
Friday	5	0.0014 PPM	10	32
Monday	----------------	----------------	----------------	----------------
Tuesday	7	0.0051 PPM	37	29
Wednesday	9	----------------	-----------------	27
Thursday	8	0.0093 PPM	67	25
Friday	6	0.0026 PPM	19	32
Average	6.5	0.0039 PPM	28.4	26.3

Table of Car Data

Date	Motorbikes	Car-1 person	Car-2 persons	Car-more than 2 persons	4WD	Buses	Trucks	Semi-trailers
Mon 28-2	5	145	47	7	61	4	17	6
Tues 1-3	2	162	62	7	33	1	12	17
Wed 2-3	------------	----------	---------	-----------	--------	------	--------	------------
Thus3-3	------------	----------	---------	-----------	--------	------	--------	------------
Fri 4-3	4	115	45	19	22	3	16	40counted with utes
Mon 7-3	------------	----------	---------	-----------	--------	------	--------	------------
Tues 8-3	8	203	57	9	40	0	35	28
Wed 9-3	0	202	58	17	34	12	31	7
Thurs 10-3	------------	----------	---------	-----------	--------	------	--------	------------
Fri 11-3	3	203	79	25	52	2	18	5
Average	3.6 = 4	171.6=172	58	14	40.3=41	3.6=4	21.5=22	12.8= 13





As you can see On 9 days that we tested we achieved a level of 9 on Wednesday week 2, which is the highest. The level 9 did not rate on the graph so we could not determine the PPM. We did not conduct tests on the second Monday due to a public holiday. So this leaves some gaps in our results. Car data was recorded on only 6 days due to different disruptions during the week

Analysis:

An analysis of our results goes as follows:

WEEK 1

Monday 28-2-05: we achieved a level 7, which was above our 2-week average. The micro gram level of NO_2 was 37 and 0.0051 was the PPM which is under the national environmental protection measures acceptable level of NO_2 of 0.12 ppm. On Monday the temperature was 25 degrees Celsius and there was S/SW winds and was partly cloudy. On Monday a total of 292 vehicles were recorded today the highest amount of 4WD were recorded today as well.

Tuesday 1-3-05: We achieved level 5, which was below the average. The microgram level of NO_2 was 10 and the PPM was 0.0014, which is under 0.12. On the Monday the temperature was fine and 32 degrees Celsius, which is quite high. There were moderate fresh E/SE winds. Today during the car recording time we recorded a total of 296 vehicles, which was lower than the daily average of 331 vehicles.

Wednesday 2-3-05: On Wednesday we had the same level, micro grams and PPM as Tuesday. The weather was similar with 30 degrees Celsius but cloudy with a thundershower or two with gusty fresh E/SE winds. No car data was recorded today due to a swimming carnival

Thursday 3-3-05: Thursday had a level of 7 and 37 micrograms and 0.0051 PPM. It was mostly fine with 31 degrees Celsius with cloud increasing late showers moderate easterlies and an afternoon sea breeze. No car data was recorded today due to the class not having science on a Thursday.

Friday 4-3-05:There again were similar conditions that were on Tuesday and Wednesday with level 7, 0.0051 PPM and 37 micrograms. The temperature was fine 32 degrees Celsius decreasing cloud ness E/SE winds and an afternoon sea breeze. Car data was recorded today and we had the lowest amount of cars with one person we had 115, lowest car 2 persons 45 and we had the total lowest amount of vehicles with 265.

WEEK 2

Monday 7-3-05: no tests were taken today due to public Labor Day holiday.

Tuesday 8-3-05: Level 7 and 37 micro grams and 0.0051 PPM were achieved today. These were the same results that we recorded from week one on Monday and Thursday. The temperature was similar as well with 29 degrees Celsius and possible showers S/SW winds. Today a total of 380 vehicles were recorded. Today we had the highest amount of motorbikes 8, equal amount of cars one person with 203, trucks with 35 and a total of 28 semi-trailers.

Wednesday 9-3-05: Wednesday was the only day we achieved a level 9. Nine is not on the pink photographic scale so we could not determine the micrograms which would be higher than 70 which means we could not determine the parts per million. The temperature was 27 degrees Celsius it was humid, cloudy there was light winds and an early shower. Today a total of 361 vehicles were recorded during the recording time and we had the lowest number of semi trailers during the 2-week period.

Thursday 10-3-05: Today was our group's day for air monitoring. We had a level 8 from the pink photographic scale and the highest microgram rating of NO_2 with 67 and the highest PPM with 0.0093. The temperature was 25 degrees Celsius with few showers light w/nw winds and a change to S/W early in the afternoon. No car data was recorded today due to the class not having science on a Thursday.

Friday 11-3-05: Today was the only day we achieved a level 6 with 19 micrograms of NO_2 and 0.0026 PPM. It was fine and 32 degrees Celsius with winds shifting light to moderate S/W. on Friday the final day of our car data recording we had a total of 387 vehicles which was our highest over the two week period. Today we highest the equal highest amount of cars 1 person.

Analysis Overview: From our data we observed two main patterns they are the days that we achieved a level 7 and higher the temperature generally was in the mid to high 20's. The days we achieved level 5 and 6 the temperature was in the low 30's. So we can say that when the temperature is high the level is low. When the temperature is low the level is high. The days that we had rain or expected rain the level was very high. Although the car data does not fit a similar pattern. The day we had the most amount of vehicles we only observed a level 6 and the day that we had the highest level we recorded the 3rd highest amount of vehicles.

Discussion:

During the 2-week period we did not exceed the 0.12-PPM level our average level was 0.0039. This is under the national environmental protection measures, which means it is good and safe for us to breathe and is not excessively damaging our environment.

Nitrogen dioxide: Nitrogen dioxide usually enters the air as a result of high temperature fuel burning from cars and industry, heaters and gas stoves, which can cause smog. Smog from the NO_2 is causing major problems in cites around the world. The NO_2 and oxygen (O_2) in the atmosphere in the presence of sunlight combines and forms ozone (O_3), which is a major part of smog.

Health effects: The health effects can affect respiratory problems in people and severely affect asthmatics. The NO_2 can impair respiratory defense mechanisms, increase infection rates and reduce the ability to breathe. These can affect young children, the elderly and those with respiratory illnesses more than others.

With our levels being low, after our testing it means we can be breath clean safe air. The lower level of NO_2 means a lower the level of sick people. It would be impossible to say that there was no NO_2 and every one will remain healthy forever and ever but it won't. Everyone gets affected because it's in the air we breathe so we get affected by each breath.

How we contribute: We all contribute an awful lot to the growing problem. Each time you turn on your car, truck, motorbike or any other vehicle you contribute even more. We do it daily its part of our routines each time we turn the key. It slips our mind we don't think about the effects on the environment and people. It happens in our homes, schools, local areas, cities and counties and around the world.

How we can change: We can prevent polluting our air by doing different things by changing our daily routines. Catching public transport. As simple as sounds it may be difficult. Not everybody can do this though.

You may not have public transport near were you live. You can contribute by catching the train to work, the bus to school, riding your bike to the movies, walking to the shops and Car-pooling. By using other options than cars.

Or you can compromise. Instead of driving all the way work you can drive to the train station then catch the train. Ride your bike to the bus stop. These things can help the environment and keep the air cleaner and you save on petrol too. You can start off using other options than your car a couple of times a month. It might not be major but it will help. Corporate your trips together like doing the shopping after you pick the kids up after school.

With your car if you keep it well maintained it will produce less harmful emissions, don't add non-standard parts to the car and keep tires inflated to reduce resistance. When it comes to buying a new car consider buying one that runs liquid petroleum gas (LPG) it produces less emissions and also saves you money or a smaller more efficient car, which will produce less harmful emissions.

Traffic data: With our traffic recording days we recorded on 6 of the 10 days. This was because of the public holiday, the swimming carnival and the fact that we only have science 4 times a week. Our science lessons were the times we got to record. Each science lesson is 55 minutes long so by the time we arrived at class, made our way outside and set up we did not end up with much time to monitor. So during the two weeks that we were supposed to monitor we would of only managed approximately 2 ½ to 3 hours out of what could of nearly been 6 hours so we lost a large amount of valuable data and data recording time.

In the time frame that we had to monitor the cars were in 2 different time slots between 9:35 to 10:25 and 1:15 to 2:10. When we monitored the NO_2 it was in the morning and only 2 of our data recording times were conducted while we were monitoring the NO_2. So only 2 of our pieces of our car data relates to the NO_2 data.

On contributing factor to the amounts of trucks and semi trailers could be the fact that there is a large amount's of road works being done in our local area with the extension of the Tonkin high way, which is not far from lake road. Also on lake road there is a new water park being built with large amounts of construction traffic coming from there.

Weather: The temperature and weather conditions information could be wrong; they were taken from the paper, which is printed in morning before the weather actually happens. Those results are general for the metropolitan area not at John Wollaston in Kelmscott so what we took from the paper may not of exactly happened. The weather changes through out the day. There could have been s/sw winds forecasted for early morning but those winds might not of come through until the afternoon.

Mistakes: Many things could have caused mistakes in our results. Each day we had a different group of people setting up. Although we monitored for three hours each day in the morning the times that we did could vary. Each group would have not set up exactly at the same time or removed the filter at the same time. It might only be 5 or 10 minutes but that's an extra 5 or 10 minutes monitoring.

Another minor thing would be how far the hose was placed outside the box if the hose was placed closer to the road it would be able to process in more NO_2 into the filter because it would be closer to the source.

When we were conducting the in class experiments many things could have gone wrong here. The amount of HPLC that went into each zip lock bag then the amount regent later as well. The filter paper may not of been completely soaked. Each group then compared there pink liquid in their vial to the graph on the chart. Each groups interpretation of what color they had would be different and then how that rated on the graph as well. They could have said a level 7 when they had a level 6 this could change things in the results on all levels. What the micrograms would be then the PPM and our overall results would be changed.

The traffic data had many holes that were caused mistakes. Firstly all traffic monitoring had to be done in school grounds. This would be alright if the closet point to the road was not the boundary fence which is the top of a small hill which runs all the way down the fence line. The fence is right at the top of the hill and there is no real place to stand or sit for the monitoring time under the direct sunlight. This became a problem when groups choose their own monitoring place, some right next to the fence and others about 30 meters from the fence line. This may of caused human error with the students not being able to determine the amount of people in each vehicle. As mentioned before about the length of monitoring time some groups may have been able to monitor for longer. An extra 5 minutes might be an extra 10 cars. Also some groups may have been monitoring both sides of the road or only one side. So this could be why some groups had higher results.

The speed limit on the part of lake road that we monitor is 70 km per hour but not every body is a law-abiding citizen so vehicles that were exceeding that 70km speed limit would have been hard to determine how many people in each car.

We can certainly say that human error has been part of our results on Friday the 4/3/05 the group that was monitoring on that day included utes with there semi trailers results which then effected our overall semi-trailer average for the 6 day monitoring period.

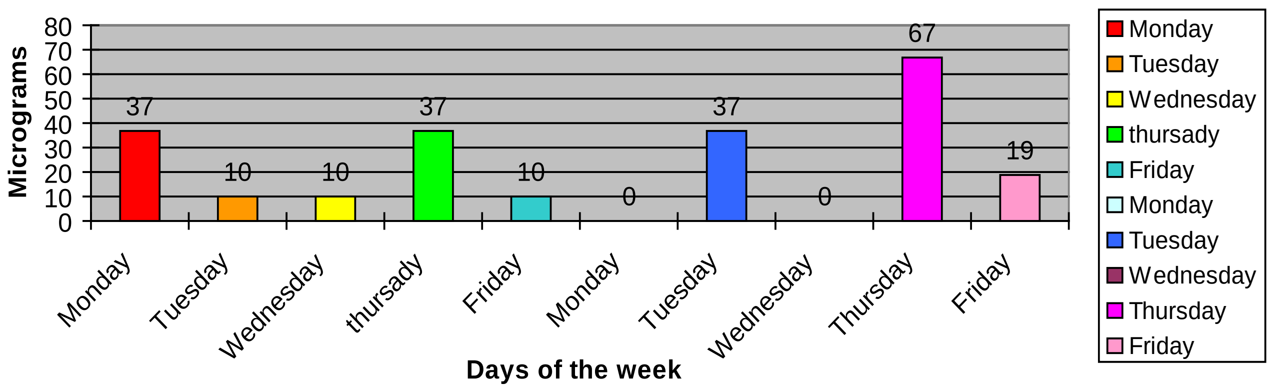
In the future: From our results we got a pretty generalized answer. The answer could however been made clearer if we continued our testing over another 2 week period due to the fact that the weather is unpredictable and was not all that reliable although our results were.

If we were to continue our data collecting it would be interesting to see what the results would be is the monitoring would be like during peak traffic hours the numbers would certainly increase and the difference between peak and non-peak times would be very interesting also we only managed to record on 6 of the 10 days that we ran the program, if we had data from 10 days instead of 6 our results would be clearer.

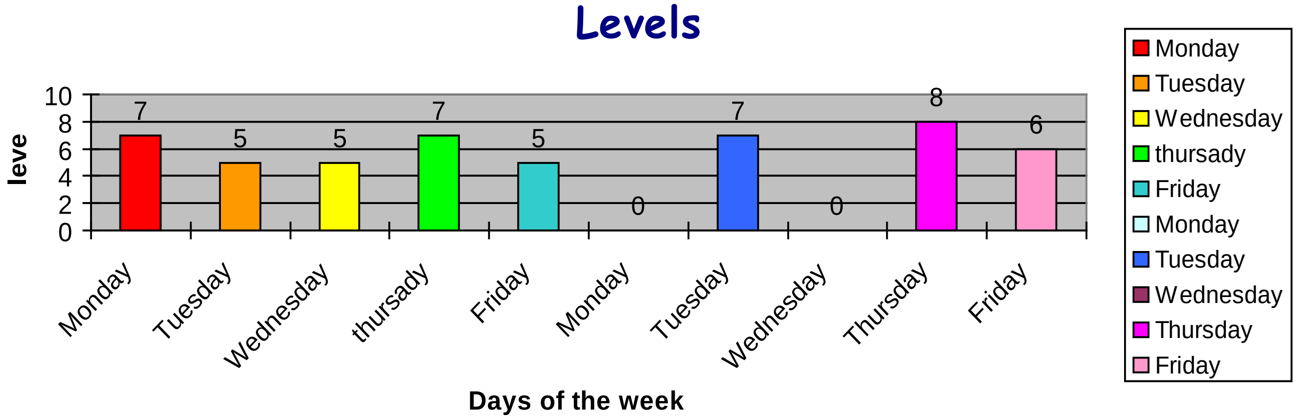
Conclusion: The vehicles in our area are not polluting large amounts NO_2. So during the 2-week period we did not exceed the 0.12-PPM level and we determined the average level, which was 0.0039. This is under the national environmental protection measures, which means it is good, safe clean air and we found that it is not endangering our lives.

Appendix: these graphs refer to the information written in the analysis

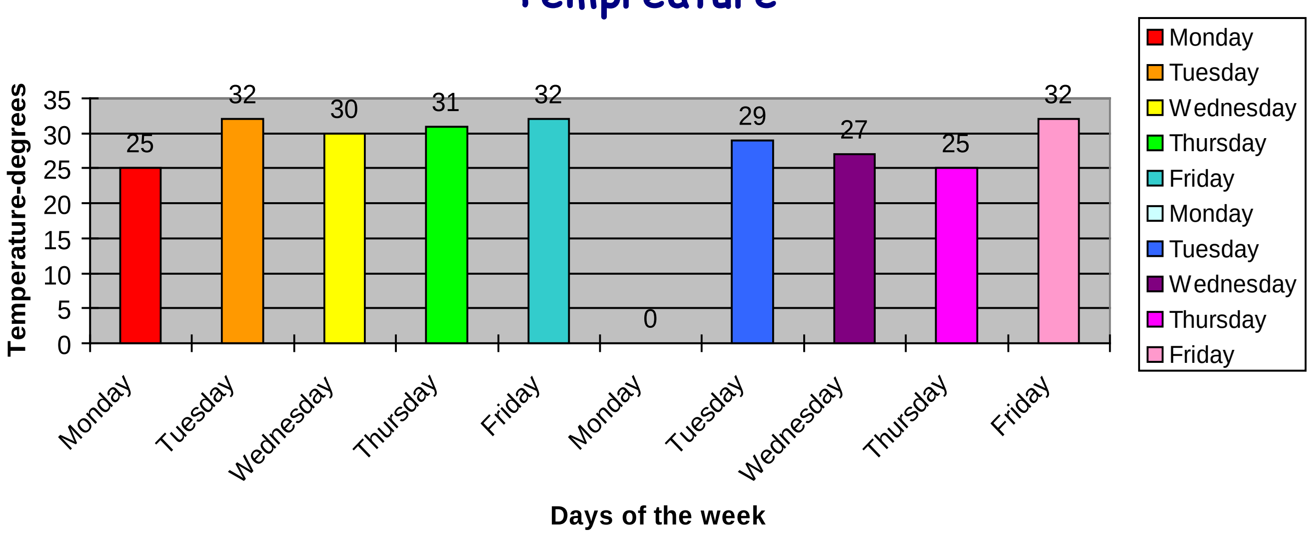
Micrograms



Levels



Tempreature



AIRWATCH REPORT

By Rebecca J, Natasha W and Tim C

BACKGROUND-

We are finding out the Nitrogen Dioxide (NO_2) levels in the Perth metropolitan area because if the NO_2 levels are too high we can lower them by alerting the public and get everyone involved.

NO_2 is a reddish-brown gas that has a pungent and very irritating odour. NO_2 plays a major role in producing ground-level ozone and is a major part of smog. High Level of no in our air can cause many health issues especially to asthmatics and people suffering from bronchitis. NO_2 causes irritation to our lungs. Crops and Trees are also affected by NO_2.

The main source that produces the gas is vehicles and wood fires. Factor's that may affect high no readings include wind, temperature, air pressure, and rain.

The information found and calculated in our NO_2 study will be passed relayed to the Department of Planning and Infrastructure who will then act on our results if they need to.

AIM-

Our aim is to find out the levels of NO_2 on Lake Rd from traffic and to monitor the traffic flow on Lake Road.

METHOD-

Setting up the NO_2 Filter

1. Unscrew blue lid and place filter paper in the filter with smooth side down.
2. Connect pump to battery
3. After 3 hours return, take filter paper out with tweezers and place in bag with specific day on it.
4. Unplug battery and lock box.
5. Put bag in fridge where other filters are stored.

Also during Science Class we monitor the Traffic Flow for a 1 hour period and complete a car survey.

AFTER ALL TESTS ARE CONDUCTED AND COMPLETE

Measuring the NO_2 left on filter

6. Put 5 mls of hplc water into filter bag and lock and soak the filter paper.
7. Extract 2mls of HPLC water using a pipette and place in a vial.
8. Put 2mls of reagent into vial.
9. Compare colour to colour result sheet and take reading from graph.
10. Record Results

RESULTS-

Refer to Last Pages.

ANALYSIS-

The Results were quite varied but the average rating was 5.9. The highest result happened on Wednesday 9.3 with the reading rating of 9 and the lowest reading occurred 3 times- Tuesday 1.3, Wednesday 2.3 and Friday 4.3 with a reading rating of 5.

The weather seemed to have a bit of an effect on the rates of NO_2 in the air. When it was cloudy or raining the no was trapped and couldn't escape which would have made the ground level NO_2 levels higher. The high temperatures didn't seem to have a big effect of the readings.

DISCUSSION-

Our results mean for the community that they can take action towards lowering the NO_2 levels if they feel that it needs it as the levels are currently under the acceptable level. Our group feels that our results weren't higher enough to take drastic action.

A further experiment we could try is to monitor the no levels on Tonkin Hwy because lots of trucks are on Tonkin Hwy and it's a very busy road, so the NO_2 levels would be much higher. Tonkin Hwy has many houses and a school next or near the road so the high levels of NO_2 could harm people living near by. It would be interesting to investigate the NO_2 levels on Lake Rd as a year long monitoring program so we could see the NO_2 rating in all the seasons and different weather conditions.

Our experiment was a bit limited because a) we didn't monitor the cars at the same time as we took the no readings and b) we monitored during the start of the afternoon of the day- not in peak hour traffic, a night or on a weekend because they weren't within our school hours.

CONCLUSION-

In concluding we haven't found any alarming results about the NO_2 levels in our school area.
In the past two weeks we have learnt that NO_2 is a very dangerous gas and is the main contributor to pollution and haze.
It will be interesting to see what the Department of Environmental Studies and the Department of Planning and Infrastructure will do with our information and results.

ACKNOWLEDGMENTS-

We would like to thank Karl Hanson for coming out to our school and showing and teaching us about air pollution and how we were going to monitor our school's NO_2 Levels.
We would also like to thank Mr. Winter for helping us with monitoring the NO_2 levels and editing our reports.

Department of Environment
Government of Western Australia

AirWatch School Projects 2006

Term 1

NOx Hot Spots – Secondary

Students monitor NO2 on a busy road near the school over a two week period using AirWatch loan equipment. Results are shared between participating schools. Air quality in Perth our lifestyle choices and how we use cars and transport is also investigated, as well as our attitudes to our 'wheels'. This is ideally suited to a cross-curricular project across Science, Society and Environment, English and Mathematics.

Focus group – Primary

"Where to from Air?"

AirWatch wants to set up a focus group of experienced teachers to explore possibilities for new project ideas, resources, and activities with AirWatch. Please contact Karl if you wish to be involved in the focus group.
Week 6 Term 1 Venue: TBA

Term 2

NOx at School – Secondary

A project where a class loans two AirWatch kits to monitor local air quality. Students can use the two kits to investigate a question such as is the NO2 levels at out 'drop-off' point higher than 'normal levels'? Students also investigate the health and environmental impacts of major pollutants in their local areas.

What "Air" your Values – Primary

Students investigate their own values and attitudes to a local or global air quality issue and draw comparisons.
How do our beliefs and attitudes shape the way we behave, and what effect does this have on air quality? Can be applied to health and PE as well as Society and Environment.

Arty AirWatch – Primary

Students create posters with messages about air quality to persuade others to change their behaviour in the cause of clean air. The best posters will be collected into an AirWatch Calendar for 2006.

Snug, warm and safe? Heaters and the air in your house. – Secondary

With winter drawing in we are beginning to crank up those heaters, and un-flued gas heaters are now the most popular space heater in Perth. But, what effect are they having on our indoor air quality. Classes can loan the AirWatch equipment to monitor NO2 levels in selected students homes. Students also investigate other important indoor air issues and their health impacts.

Term 3

SNAQ on HAZE – Primary and Secondary

SNAQ stands for Schools Network for Air Quality and is a project where several schools borrow AirWatch equipment to monitor haze (smoke) levels in their areas. Results are shared between schools to compare haze levels across Perth. Students conduct a monitoring program and then investigate health issues; why haze occurs; and greener heating options.

Investigation : Eagle eyes – clear skies!

Perth's skies may look clean and healthy all of the time, but is this true? We are asking students to investigate causes of air pollution, and to develop an action plan to combat the problem in their area.

Term 4

Great Green Inventions! – Primary

Make a model of either a great green transport machine, or a great gadget to measure wind direction and / or speed.
Devise a model of transport that can help reduce greenhouse gas emissions in Australia.
T&E, S&E, Health applications.

Air Inspiration – Secondary

Students are invited to make a sculpture that increases our awareness of the importance of air, wind or weather for our lives.

Alternatively students could write a story or poem highlighting the future consequences of poor air quality.

Schools Air Watch W.A.

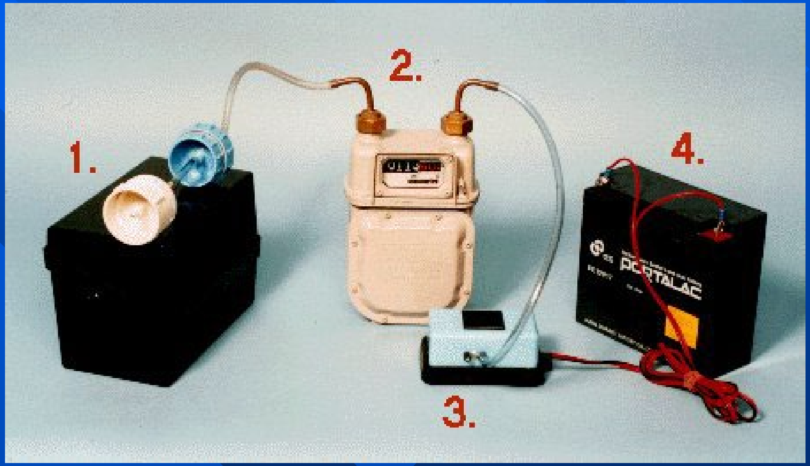
What our school did in air-watch W.A.

Why we need Air Watch

- Air Watch is a system that allows us to monitor the levels of air pollution in the air such as smog and smoke.
- By monitoring the air we can make links between asthma attacks and air pollution.

How it Works

- The Air Watch Machine is basically a fish pump with an air filter and battery. The air filter sucks air in, and the filter paper in the filter becomes slightly dirty.
- When the filter paper is removed, it is put up against a indicator card with many different measurements of dirtiness, and the filter paper has a measurement of one of that on the indicator card.
- That measurement is recorded and a new filter paper is inserted for the next 24 hours.



Air Pollution

- Air pollution is a major problem facing many of today's large cities.

Hazed city

What Could Happen

- If air pollution goes on without treatment it will severely effect the people who live in the polluted areas and the natural ecosystems around the area.
- If trees continue dying because of air pollution the problem will only get worse quicker.

Possible Preventatives

- Use public transport more often.
- Manufacture electric automobiles.
- Plant more trees to try to filter the air.
- Put better filters on most of the machines that cause the pollution.

What is air pollution?

- Air pollution is aggravated because of four developments: increasing traffic, growing cities, rapid economic development, and industrialization.
- Dirty particles in the air aggravate the raspatory system eg. Asthma.

Quit

SNAQ on HAZE

Schools Network for Air Quality

By Jessica Ball

Year 9 ATP Duncraig SHS

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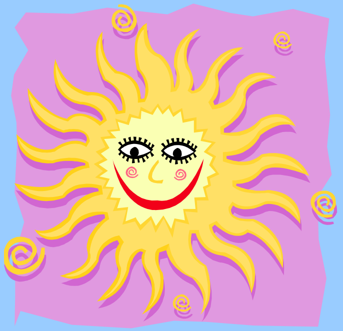
Instructions

This presentation is easy to use. All you have to do is click on the purple buttons, underlined words or click on pictures with a “click me” caption underneath. Have a practice with the ones below.

or



or

Click me

(Click me for enlargement)

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Ready To Start

Well done! Now you've got the hang of it click below to either go to the contents page, re-read the instructions or go straight to the start. There is also a quit button at the top-right corner in if you wish to end the presentation. We hope you learn a lot about the air and haze!

Start

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Page 6 – We Need Air To Survive

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Page 15 – Monitoring Particulates

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Page 20 – How Can We Reduce Haze?

Page 22 – References

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What's In Our Air?

Air is all around us and it essential for our survival. It's something that's always been there and consequently little thought is often given to it. However, it's important as a community that we understand what is in our air, so that we are aware of:

- Why we need air to stay alive
- The quality of our air
- What improvements in our lifestyles could result in cleaner air

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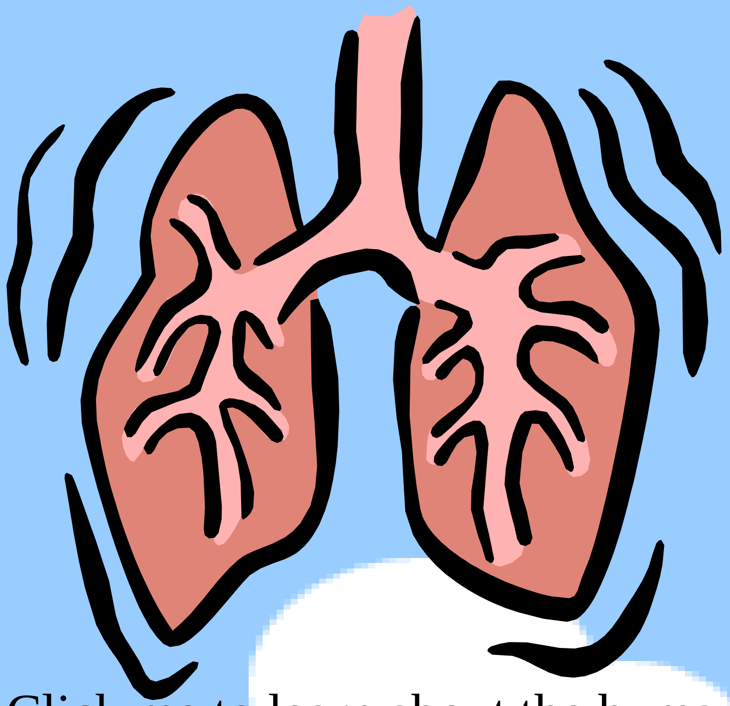
We Need Air To Stay Alive

Humans need to breathe oxygen into their lungs to live and the air is where we get it from. The air contains 78% nitrogen, 21% oxygen as well as smaller amounts of argon, carbon dioxide, hydrogen, neon, helium, and other gases. Other organisms such as animals and plants also require oxygen to stay alive.



Click me to learn about the human respiratory system

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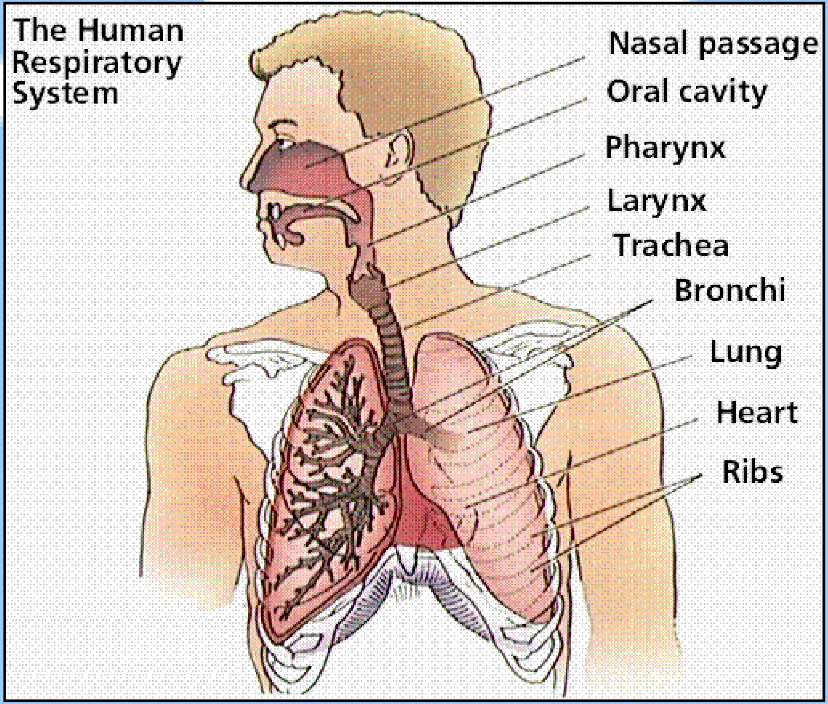
The Human Respiratory System



When we breathe, the air enters through our noses, there the air is filtered, heated and moistened. From there the air leaves the nasal cavity and enters the pharynx (throat) which branches off to the oesophagus and the airways.The larynx opens into the trachea, which then leads into two smaller bronchi, each entering a lung. These bronchi then branch into even smaller, thinner airways called bronchioles, which end up leading to tiny air sacs called alveoli. The Alveoli are surrounded by tiny capillaries filled with blood, this is where the air (oxygen) is exchanged with carbon dioxide. That is how we receive the air we need to live.

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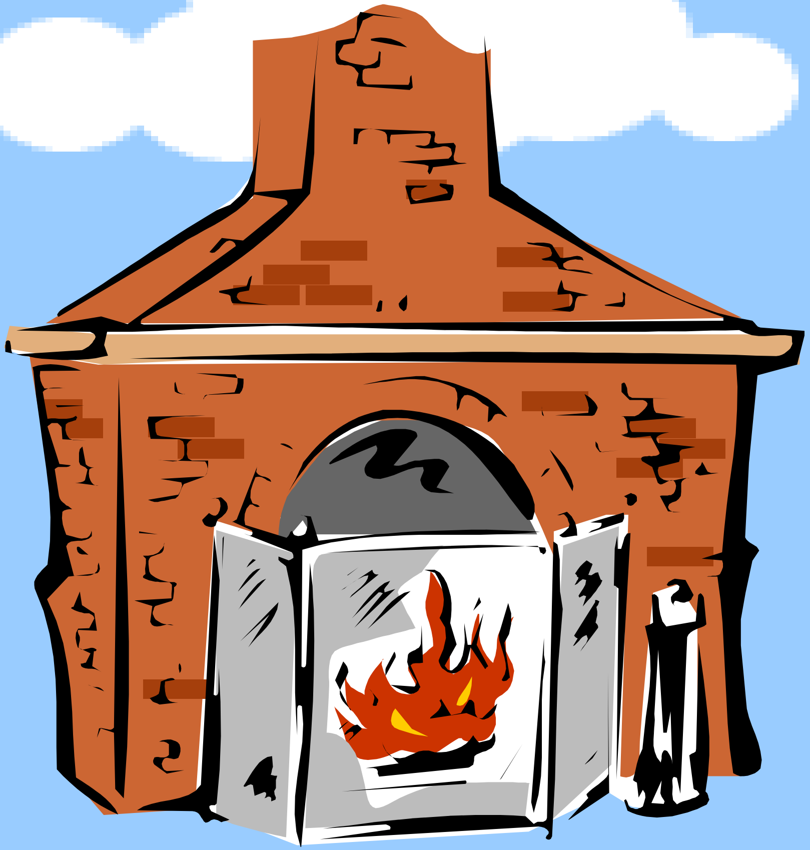
Haze



Haze is a form of air pollution that is caused by lots of tiny particles of wood smoke and exhaust fumes from vehicles, known as particulates. These particulates make the sky turn brown and this usually occurs on cold, calm winter mornings.

During winter the usage of domestic wood heaters dramatically increases which largely contributes to an increase in wood smoke particles and exhaust fumes from cars constantly add to the haze all year round.

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Haze

The **Petronas Twin Towers** and the **KL Tower** in Malaysia

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Haze

A temperature inversion on a cool, calm night makes haze worse. This is because the ground and air near the ground cools down and won't mix with the warm air above, so the wood smoke particulates become caught close to where it is easy for people to breathe them in.

We have fine hairs in our noses and windpipes which trap the larger particulates and they are removed by sneezing and coughing.

Haze

Quit

However, smaller particulates don't always get stopped and they can end up deep in our lungs which can cause dangerous health problems such as:

- Bronchitis
- Emphysema
- Asthma

There is also some evidence that they can cause premature deaths. The elderly and people with respiratory problems are those most at risk.

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Definitions

Bronchitis - Any irritant reaching the bronchi and bronchioles will stimulate an increased secretion of mucus. In chronic bronchitis the air passages become clogged with mucus, and this leads to a persistent cough.

Emphysema - In this disorder, the delicate walls of the alveoli break down, reducing the gas exchange area of the lungs. The condition develops slowly and is seldom a direct cause of death. However, the gradual loss of gas exchange area forces the heart to pump ever-larger volumes of blood to the lungs in order to satisfy the body's needs. The added strain can lead to heart failure.

Asthma - In asthma, periodic constriction of the bronchi and bronchioles makes it more difficult to breathe in and, especially, out.

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Monitoring Particulates

The particulates in haze can be monitored using the monitoring kit pictured right.

Our class monitored particulates from Monday to Friday for a two-week period. We started monitoring at 8:45am (as close to 9am as we could) and then let the equipment run for a 24 hours.

Air Monitoring Kit (click for part details)

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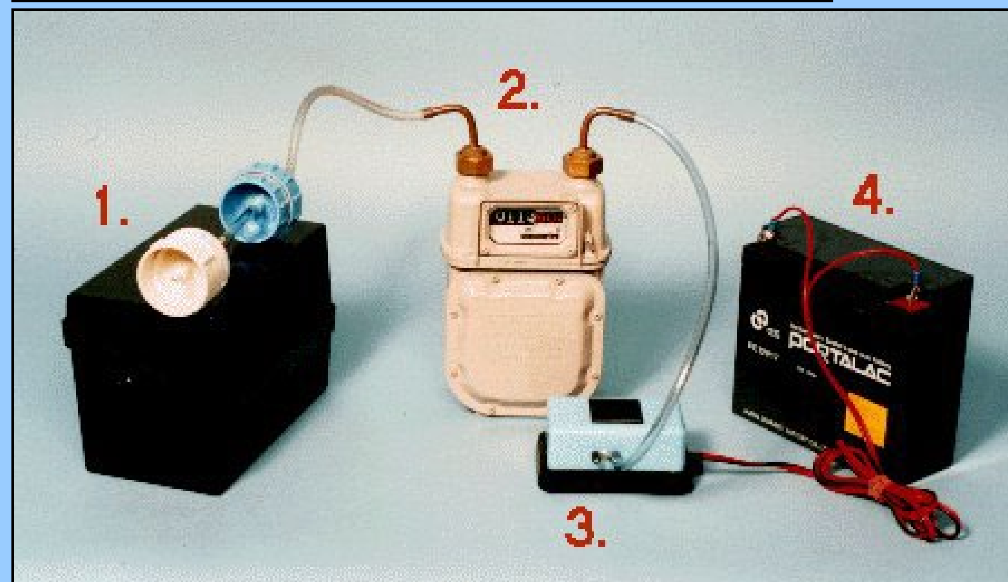
1- A plain filter holder followed by a treated filter holder

2 - A small gas flow meter

3- A 12 volt fish tank pump

4 - Deep-discharge battery.



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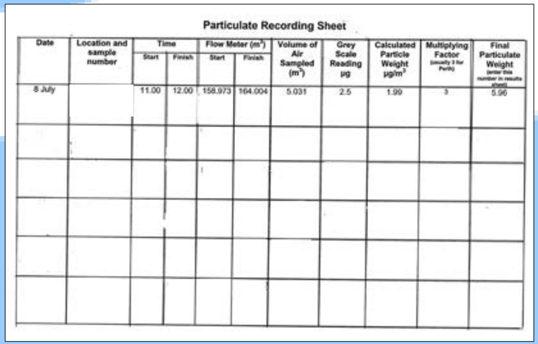
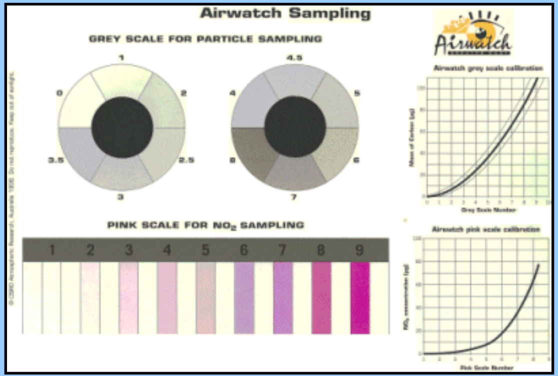
Monitoring Particulates



Particulate Recording Sheet

Date	Location and sample number	Time		Flow Meter (m^3)		Volume of Air Sampled (m^3)	Grey Scale Reading µg	Calculated Particle Weight µg/m^3	Multiplying Factor (usually 3 for Perth)	Final Particulate Weight (enter this number in results sheet)
		Start	Finish	Start	Finish					
8 July		11.00	12.00	158.973	164.004	5.031	2.5	1.99	3	5.96

Click me to enlarge



Click me to enlarge

The monitoring kit draws surrounding air through a piece of fiberglass filter paper using the fish pump. This allows any particles to get caught on the paper. After 24 hours the results were collected and recorded on a particulate recording sheet pictured top-left.

To work out the grey scale reading we compared our filter paper's colour to that in the grey scale pictured bottom-left.

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Particulate Recording Sheet

Date	Location and sample number	Time		Flow Meter (m^3)		Volume of Air Sampled (m^3)	Grey Scale Reading µg	Calculated Particle Weight µg/m^3	Multiplying Factor (usually 3 for Perth)	Final Particulate Weight (enter this number in results sheet)
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8 July	For Example	11.00	12.00	158.973	164.004	5.031	2.5	1.99	3	5.96

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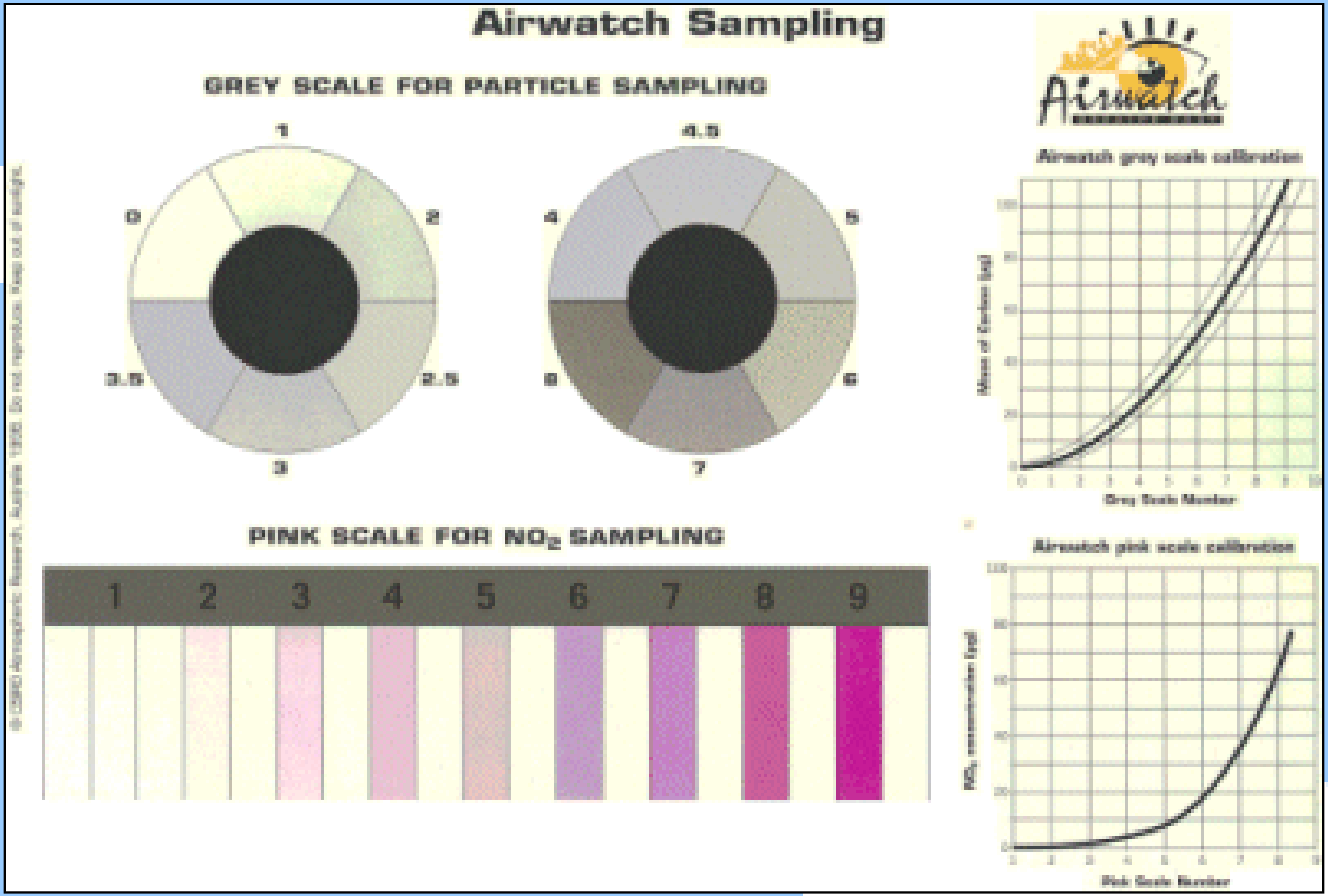

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Results

Our class's results for "Final Particulate Weight" in micrograms per metre cubed are as follows:

- Day 1 (23/8/04) – 0.842
- Day 2 (24/8/04) – 1.142
- Day 3 (25/8/04) – 1.026
- Day 4 (26/8/04) – No Recording
- Day 5 (27/8/04) – No Recording
- Day 6 (30/8/04) – 0.987
- Day 7 (31/8/04) – No …Recording
- Day 8 (01/9/04) – 8.751
- Day 9 (02/9/04) – No …Recording
- Day 10 (03/9/04) – 0.582

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Results

The National Air Quality Standard for Perth is 50 micrograms per metre cubed at an absolute maximum. The air quality around Duncraig is definitely less than that, so this lets us know that our local air quality is really good.

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How Can We Reduce Haze?

Haze is a growing problem, but it can be reduced. Below are ways that you can help:

•Don’t openly burn waste

•Maintain your vehicle well

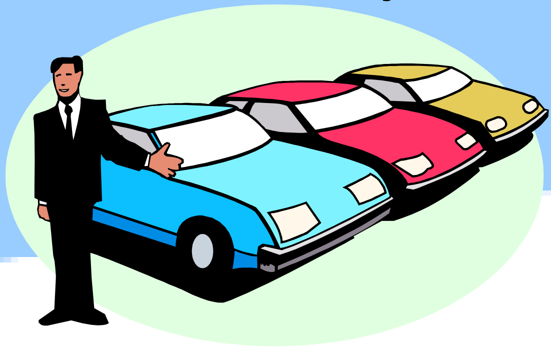
•Use environmentally friendly fuels

•Keep woodstoves and fireplaces clean

•Use public transport whenever you can

•Minimize the use of your air-conditioner

•Drive less, especially in peak hour traffic and hot days



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- http://www.airwatch.gov.au/default.pasp
- http://perso.club-internet.fr/flejou/pics/oz/perth.jpg
- http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/P/Pulmonary.html
- http://www.wunderground.com/history/station/94610/2004/9/1/DailyHistory.html
- www.google.com
- http://www.epa.gov/air/actions/at_home.html
- http://aqmpweb.environ.wa.gov.au/air_quality/Policy_Legislation_and_Regulations/NEPMs/AAQ_NEPM

Room 12 Woodbridge Primary School **Air Watch Survey on Air Pollution**

Student Group	Recommendations
Troy, Jasmine, Andrew	1. Living near a factory is bad for people with asthma. The Government should give people who live near factories cheaper treatment for asthma. 2. To encourage people to not drive cars the Government should make bikes, scooters and skates cheaper. 3. We should stop building cars because the air is getting more polluted and the cars are getting old and breaking down and causing pollution.
Alex, Ben and James	1. The transport that our survey found lets off the most gas is the plane. We could reduce air pollution by creating solar powered cars, planes and trains. At night we could use batteries to run the vehicles. If you think it is too expensive you could bring out a lot of them and eventually they would get cheaper.
Bianca, Rebecca and Amber	1. We could try and encourage petrol stations to reduce the cost of unleaded petrol. We should try ad get everyone to use smaller petrol stations because they usually sell cheaper petrol we should use Western Australian or Australian owned petrol stations. 2. We could reduce the price of electric heaters. Air Watch could put posters around the community to let people know that pollution is getting worse. We could put reminders around the community to say that we should be more careful about what they do.
Rhys and Jeffrey	1. We should try and make bus fares cheaper because we found too many people are using cars and not public transport. If people use buses there will be a lot less air pollution because there will be a lot less cars on the road and a lot less fumes. To make bus fares cheaper and bikes and scooters Air watch could speak and write to the Government to make less the costs and prices.

Student Group	Recommendations
Rhys and Jeffrey	2. Bikes and scooters should be a lot cheaper so more people will buy them and use them more. The reason why they should buy bikes is because they will ride and not drive and not cause air pollution.
Brooke and Elyshia	1. We found that people thought that unleaded petrol is better for the environment than leaded petrol. People could be encouraged to use public transport and also bikes. They may not be aware of how petrol increases air pollution. We would recommend more advertising. 2. Our survey showed that 14 families owned 5-6 cars and this would probably increase air pollution. We think that families should encourage using fewer cars when they can. This could be done on bus billboards, television advertisements and in community newspapers. 3. We found that not very many people are using public transport each year. We think that it should be cheaper. Cars should be banned at night so that you only have public transport at night. There would probably be fewer accidents from drunk or tired drivers and it would be good for the environment. 4. Factories should only operate at night so that people aren't affected during the day.
Brandon, Brodie, Steven	1. We could make bikes and scooters cheaper. 2. We could increase the price of petrol. 3. We should build more train stations so more people would use public transport.
Kaity, Emily and Kaitlyn	1. Cars should be very expensive so that people can't afford to buy them to use aned have to use public transport. 2. Factories should be built away from where people live. To encourage people to use public transport there could be "Public Tranpsort Only" days.

Student Group	Recommendations
Hayley, Taylor, Melinda	1. People should be more aware that cars are polluting the air by doing more advertising. 2. We should put more signs and posters around to warn people about air pollution. The posters should be bright so people will stop and look. 3. the Government should force petrol stations to make unleaded gas cheaper than leaded gas.

Air pollution & You

MAIN ROADS
Western Australia

Department of
Environmental Protection

A booklet about air pollution in Perth

Air pollution & You

Department of
Environmental Protection

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Figure 1. Source of air pollution.

What is air pollution?

Air pollution occurs when the air contains gases, dust, fumes or odour in amounts that could be harmful to the health or comfort of humans and animals or could cause damage to plants or materials. The substances that cause air pollution are called pollutants.

Before the industrial revolution, nature's own air-conditioning managed to keep the air fairly clean. Wind mixed the gases and spread them out, rain washed the dust and other easily dissolved substances to the ground, and plants absorbed carbon dioxide and replaced it with oxygen. In the post-industrial revolution years, considerably more pollution has been added to the air by industrial, commercial and domestic sources. As these sources are usually found in or near Australian cities, the gases that are produced are usually concentrated in the air around them. It is when these concentrated gases exceed safe limits that we have a pollution problem. Nature can no longer manage air pollution without our help.

Pollutants which are pumped into our atmosphere and are polluting in their own right are called primary pollutants. Some examples are carbon monoxide from car exhausts and sulphur dioxide from the combustion of coal.

Further pollution can arise if primary pollutants in the atmosphere undergo chemical reactions. These are called derived or secondary pollutants. An excellent example is photochemical smog.

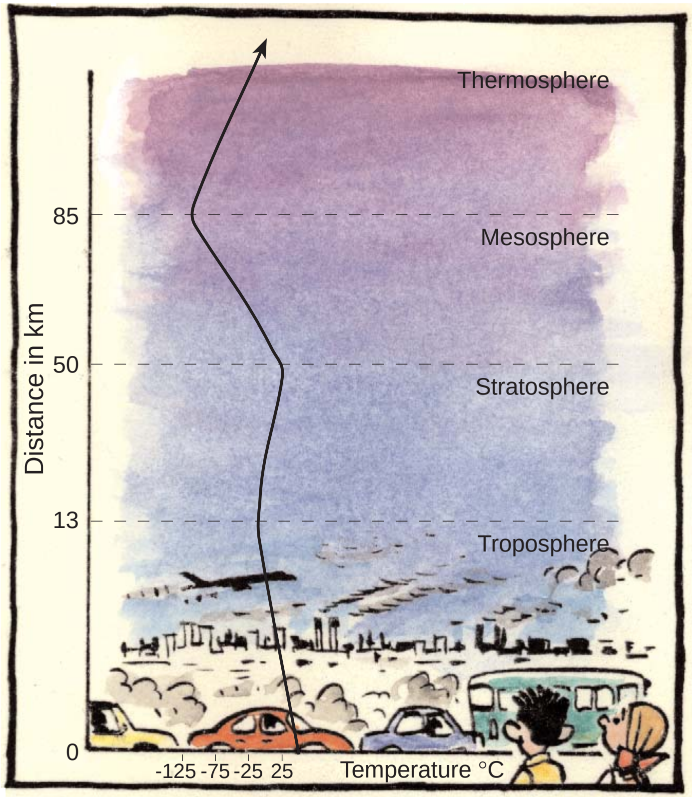


Figure 2. The layers of the atmosphere. (The distance axis is not to scale).

What is the atmosphere?

The gases surrounding the earth make up the atmosphere. It is many hundreds of kilometres thick and is composed of four layers, these resulting from the properties of the air within. Details of the names, thickness and temperature of each layer may be seen in Figure 2.

It is the troposphere, the lowest level of the atmosphere, which is the most important when we consider regional and local air pollution problems.

Ozone depletion and the enhanced greenhouse effect are global air pollution problems that affect the atmosphere. The greenhouse effect is a result of an overall heat gain by the atmosphere as a whole. Ozone depletion occurs in the second level of the atmosphere, the stratosphere.

What is the air?

The air is the substance around us which we breath in and out of our lungs. At the earth's surface, air consists of 78% nitrogen (N_2), 21% oxygen (0_2), less than 1% of argon (Ar), a very small amount (0.03%) of carbon dioxide (CO_2), and traces of other gases such as methane (CH_4) and oxides of nitrogen (NO_X). Water vapour is present in air in varying amounts. (In Perth this can vary from 0.3% on cold days to 1.0% on hot days.) The air also contains tiny particles such as dust, sea salt, volcanic ash and soot which are small enough to float in the air for a long time.

Ozone depletion

The ozone layer refers to an area within the stratosphere where the ozone gas absorbs potentially cell-damaging ultra violet light. The helpful ozone layer can be depleted when certain man-made pollutants make their way from the earth's surface to the stratosphere. The most serious ozone depleting substances are the halons and chlorofluorocarbons.

While ozone depletion is a worldwide phenomenon, it is particularly relevant for Australians. The rate of ozone depletion has been most rapid over the Antarctic and the southern regions of the world.

Greenhouse effect

Strictly speaking, the greenhouse effect is a natural phenomenon. Certain gases (we refer to them as greenhouse gases) absorb radiation that would otherwise escape from the atmosphere into space. This leads to a warming of the atmosphere. Without warmth, life can not be sustained on earth. The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs).

Humans have altered the natural greenhouse effect. By increasing the concentration of the heat absorbing gases in the atmosphere we cause the temperature of the earth to rise a little bit. As the temperature increases more water is converted to the gaseous form. The water vapour may absorb even more of the solar radiation and this further contributes to the heating of the earth. As people continue to emit more greenhouse gases into the atmosphere, the temperature on the earth will continue to rise.

It is anticipated that the earth's temperature may increase between 1°C and 3.5°C over the next 100 years.

It is believed that Australians contribute between one and two per cent of the world's emissions of greenhouse gases into the atmosphere. These contributions are continuing to increase. Carbon dioxide is our largest emission (75%), followed by methane (23%). The nitrous oxides, volatile organic compounds (including chlorofluorocarbons) and photochemically derived ozone make up the remainder of the man-made greenhouse gases. Some of the gases which make up a tiny component of the greenhouse gas emissions are considerably more powerful at warming the atmosphere. For example, a single molecule of a common chlorofluorocarbon has the same warming effect as 10,000 carbon dioxide molecules.

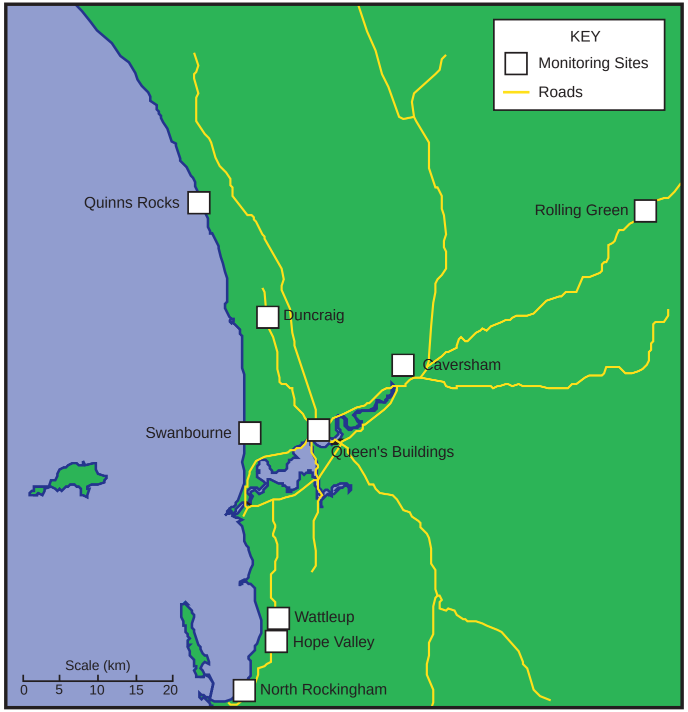


Figure 3. The sites of the Perth Air Quality Monitoring Stations.

Figure 4. A typical Air Quality Monitoring Station.

How and where is air pollution measured in Perth?

There are currently nine government funded air quality monitoring stations in use to collect data on air quality. The sites are as shown on Figure 3 and a typical monitoring station is shown in Figure 4. Data is collected on a variety of pollutants including ozone, nitrogen dioxide, nitric oxide, carbon monoxide, sulphur dioxide, air borne particles and lead.

Vehicles are a major source of our air pollution

Fossil fuel combustion, particularly by motor vehicles, has been identified as the largest single contributor to air pollution.

When considering Perth's air, it is the vehicles which are used for transport that are responsible for almost all of the lead and carbon monoxide pollution and around half of the hydrocarbons and oxides of nitrogen.

The impact of petrol vehicles

The pollution put out by petrol vehicles comes from two sources. The first group are the exhaust emissions and these include carbon monoxide, oxides of nitrogen, hydrocarbons and particulates.

The second type of pollution from cars are called evaporative emissions. Evaporative emissions are vapours of fuel which are released into the atmosphere, without being burnt.

Fuel vapour can be seen coming out of the car's petrol tank when you fill up at the service station. Fuel vapour emissions can be reduced if we avoid spilling petrol and overfilling our cars. Properly fitting fuel caps stop further leakage of fuel vapours. It may also be possible to reduce fuel vapour emissions if fuel formulations with a lower volatility level were made available to the general public.

In 1975, all new cars sold in Australia were required to be fitted with basic anti-pollution equipment. These cars were designed to run on leaded petrol. Since January 1986 all new cars have been built with catalytic converters and have been designed to run on unleaded petrol.

If a car is well tuned and maintained it is likely to emit between 9-25% less pollution into the atmosphere than a similar poorly maintained vehicle. In addition a well maintained car is between 1.5% and 5.0% more fuel efficient.

Cars which have been altered, and no longer conform to the original specifications, tend to put out considerably more pollution into the air. Such modifications include non-standard cylinder heads, pistons, valves, camshafts, fuel systems or exhausts.

How do catalytic converters work?

As illustrated in Figure 5, catalytic converters contain the rare metals platinum, palladium and rhodium. These substances promote the conversion of hydrocarbons, carbon monoxide and oxides of nitrogen in the vehicles exhaust to water, carbon dioxide and nitrogen.

It is not unusual for a catalytic converter to have a life greater than 150,000km. This can be shortened if:

- sulphur, lead or other heavy metals are in the fuel,
- there is phosphorus in the lubricating oil,
- the engine is misfiring,
- mechanical damage occurs.

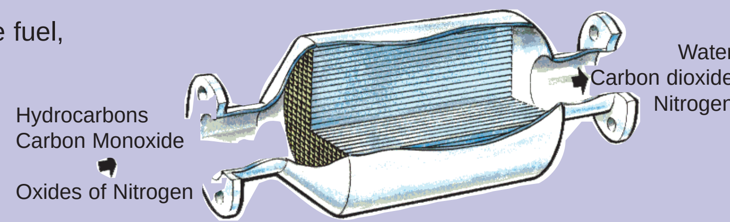


Figure 5. Diagram of a catalytic converter.

Figure 6. Smoke from vehicle exhausts is a source of fine particle matter.

The impact of diesel vehicles

Eighty-eight per cent of the heavy duty vehicles and five per cent of the light vehicles on our roads use diesel. While a diesel vehicle will emit less hydrocarbons and carbon monoxide than a similar sized petrol vehicle, it will give off more oxides of nitrogen and fine particles. Most of the particles are tiny (less than 0.01mm in size) and these can cause or exacerbate respiratory disorders. In addition, they contribute to haze and as a result the particles can soil our environment.

Data is taken from Air Quality gets a Black Mark, Australian Environment Review, Vol 11, No 4, May 1996.

Figure 7. The total vehicle emissions of carbon monoxide and oxides of nitrogen going into Perth's air each day.

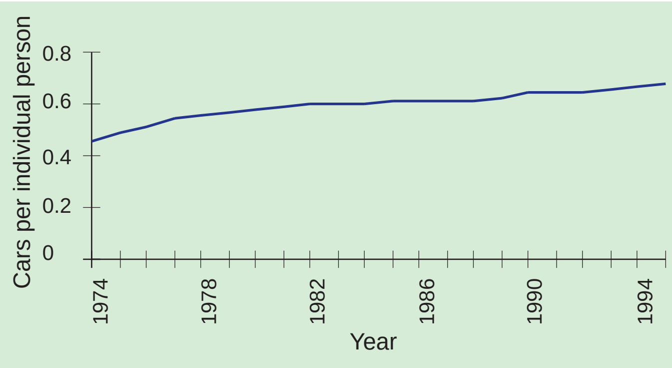


Figure 8. Cars owned per West Australian 1974-1995.

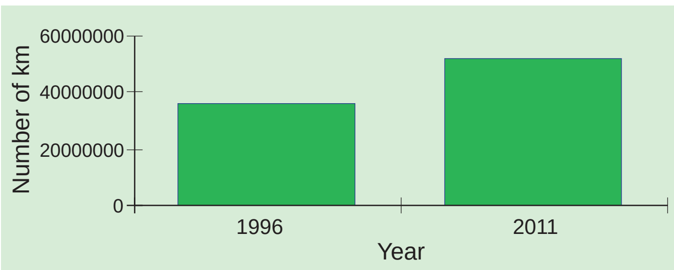


Figure 9. Current (1996) and predicted (2011) number of kilometres travelled in Western Australia per day.

The future impact of vehicles

Figure 8 indicates that over the past 21 years the number of cars licensed per individual West Australian has increased.

Should this trend continue and the population of Perth remain the same, the number of cars on the road will continue to increase.

But, our population is expected to increase. As the population grows, even if the level of car ownership remains the same as it is now, there will be even more cars on the road.

On top of this, the length of our vehicle trips is expected to increase as the size of Perth grows.

It is expected that for every one per cent increase in population there will be a 1.6% increase in the number of vehicle kilometres travelled.

Work completed by the Department of Transport indicates that over the next 15 years there will be a 45 per cent increase in the total number of kilometres travelled every day in Western Australia. This is represented in Figure 9.

Even if the pollution output from our individual cars were to be reduced, an increase in the total distances travelled will lead to an overall increase in the total pollution output from motor vehicles.

Data is taken from Air Quality gets a Black Mark, Australian Environment Review, Vol 11, No 4, May 1996.

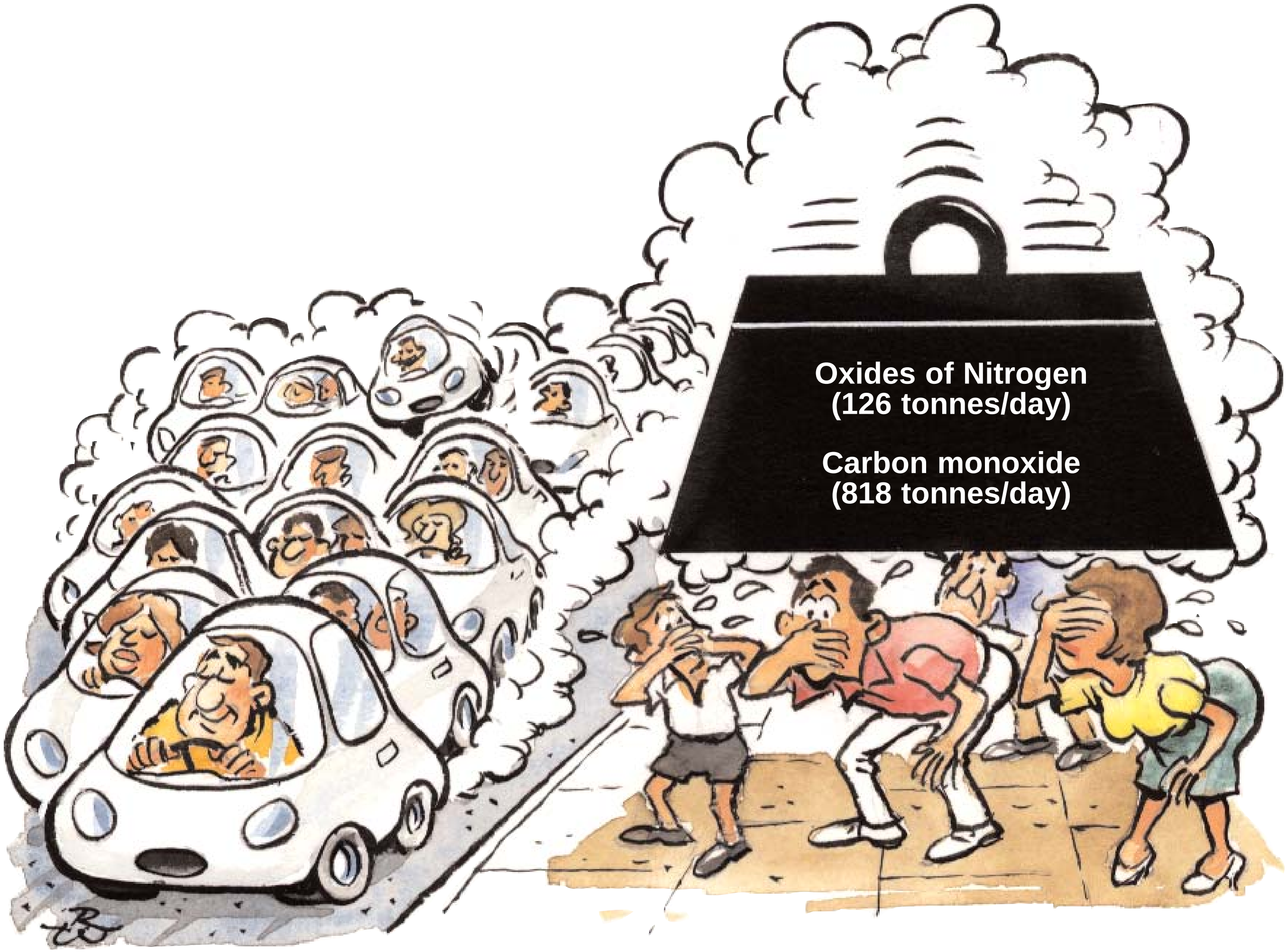


Figure 10. Predicted daily vehicle emissions of carbon monoxide and oxides of nitrogen for Perth in 2011 assuming there is no new anti-pollution technology used in the production of new cars.

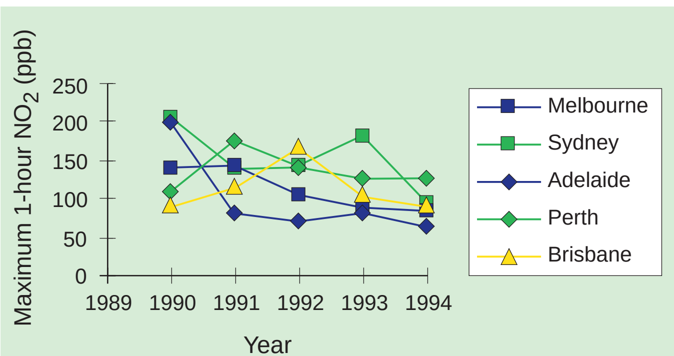


Figure 11. Comparison of the annual maximum 1-hour nitrogen dioxide concentrations for selected Australian cities for the period of 1990 -1994.

Do we have an air pollution problem in Perth?

Perth is on the threshold of an air quality problem.

The pollution problems of Perth and other Australian cities tend to come in episodes. These episodes are influenced by seasonal and meteorological factors.

While Perth has a relatively small population in comparison with some other Australian capital cities our air pollution is significant.

This is demonstrated in figures 11 and 12. Both figures are taken from Publication 468 of the Victorian Environmental Protection Authority.

Figure 13 shows the trends for Perth's air pollution over the past seven years.

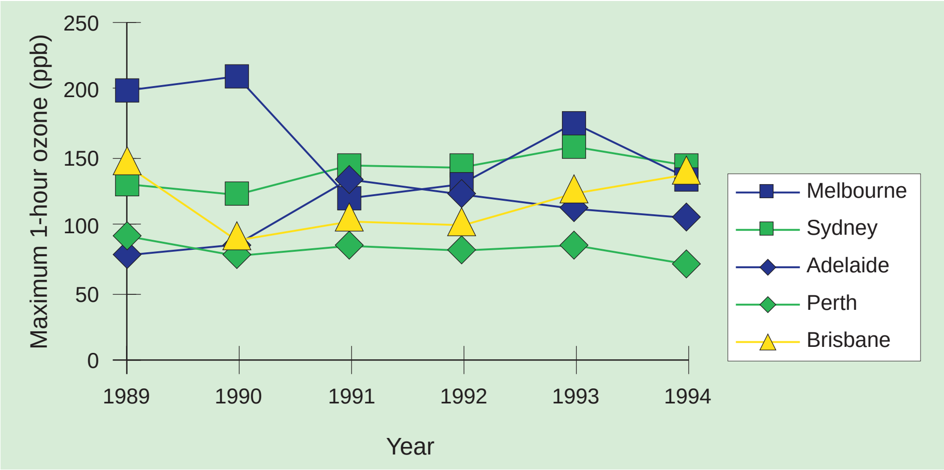


Figure 12. Comparison of the annual maximum 1-hour ozone concentrations for selected Australian cities for the period of 1989 -1994.

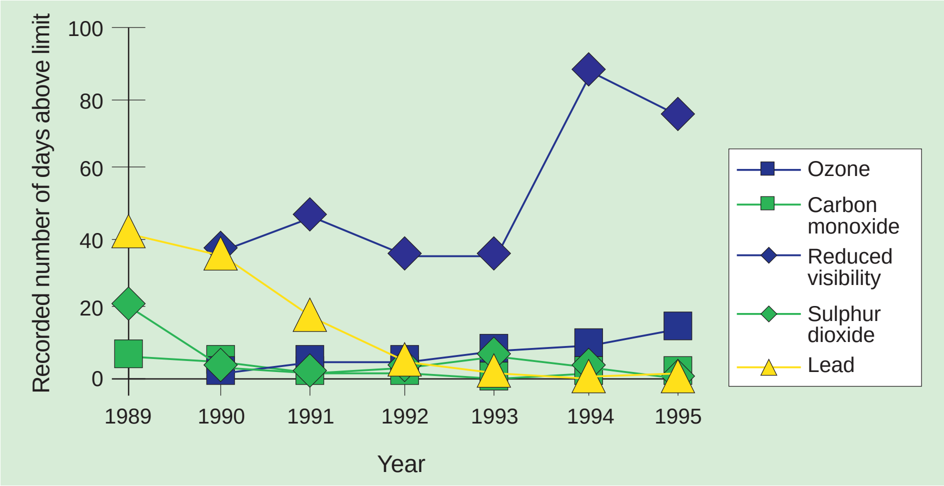


Figure 13. Recorded number of exceedences per year above recommended pollutant limit in Perth.

What are the major air pollution problems for Perth?

1. Photochemical smog

Photochemical smog is considered to be one of the most significant pollution problems facing many cities of the world and Perth is no exception. Cities which are particularly at risk have periods of time when there is an abundance of sunlight, moderate winds and high temperatures. In Perth, photochemical smog tends to occur in late spring, during summer and early in autumn.

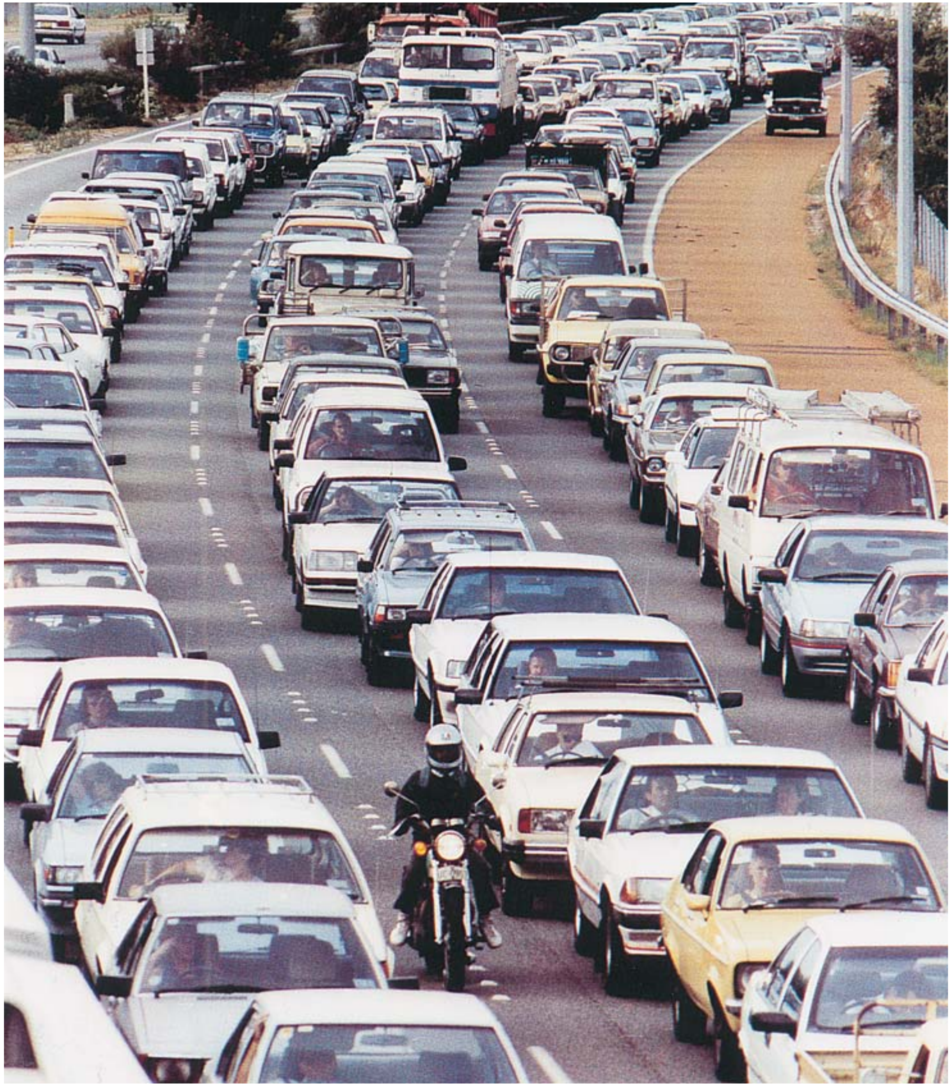
Photochemical smog, which may be invisible to the naked eye, is characterised by high concentrations of ground level ozone. Ozone is formed when oxides of nitrogen and reactive organic compounds, react together for a few hours under the influence of sunlight and high temperatures.

Figure 14 shows that motor vehicles are the major contributor to Perth's photochemical smog. Industry and area sources also make significant contributions.

Perth typically has 9 to 17 days per year when ozone levels exceed the World Health Organisation goal of 80 parts per billion (ppb). This is indicated by Figure 15.

High ozone levels have been measured from Rockingham in the south to Two Rocks in the north, Rottnest to the west and Rolling Green to the east.

Area sources refer to widespread, low-level sources of pollution. For example, there are a large number of homes in Perth. Individually, each home contributes only a little pollution, but in total all homes make a significant contribution. Other examples of area sources include fires, light industry, service stations, road works, gardens and horticultural properties.



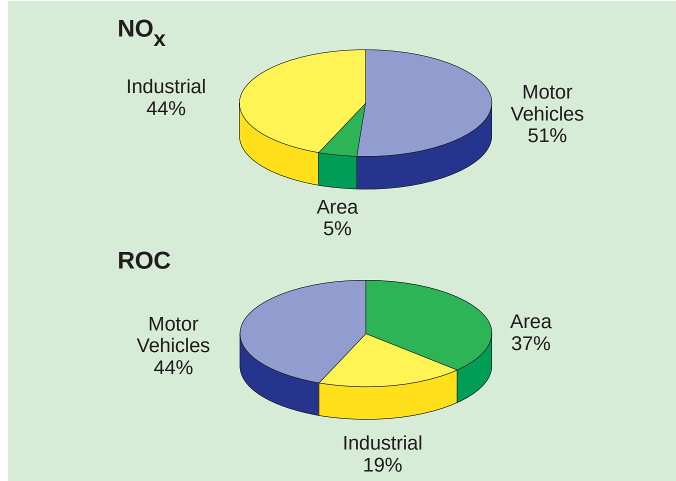


Figure 14. Contributions of vehicles, industry and area sources to oxides of nitrogen and reactive organic compounds. (Photochemical smog is produced when oxides of nitrogen and reactive organic compounds react in the presence of sunlight at high temperatures).

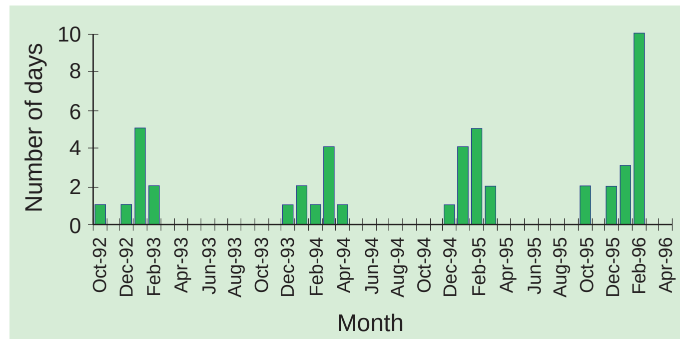


Figure 15.The number of days per month where peak ozone concentrations exceeded 80 parts per billion somewhere in the Perth region.

When at low concentrations ozone is colourless and odourless, but at higher concentrations it has a pungent odour and is bluish in colour.

Ozone impacts upon the healthy and the fit as well as the more susceptible members of the population. These include the very young, elderly and those with respiratory or cardiovascular problems.

Studies have found that our lung function may be reduced if we exercise while ozone levels are elevated.

When ozone levels are increased to around 100 parts per billion there is an increased incidence of eye, nose and throat irritations. Ozone causes damage to all parts of our respiratory tracts, particularly the cells which are involved in gas exchange. This may lead to people experiencing the symptoms of chest tightness and wheezing.

At levels of 120 parts per billion, ozone can cause changes in our airways which will increase our sensitivity to allergens such as pollen.

There is further evidence that elevated ozone levels can trigger asthma attacks and increase our susceptibility to infection.

When at elevated concentrations, ozone can damage the leaves of plants and reduce their ability to photosynthesise. This will lead to reduced growth rates and yields. At current levels the impact of ozone on plant life within Western Australia is not well understood, however, it has been estimated that photochemically produced ozone has lead to a five to 10 per cent decline in crop yields in the United States of America. It is also possible that plants become more susceptible to disease and less tolerant to cold temperatures. Genetic information within the seeds may also be altered.

Ozone also damages susceptible materials such as rubber, plastics, concrete, stone, cloth, dyes and paint work.

I thought ozone was good!

While ozone close to the ground is a real problem, the ozone found in the stratosphere is helpful. It absorbs potentially damaging ultra violet radiation.

Figure 16. While this photo shows a clear sky, this was a day with a high level of air pollution. The ozone reading was in excess of 80 parts per billion.

What can we do about smog?

Should emissions and the consequent photochemical smog concentrations increase by small amounts in the Perth region, it is expected that the number of days when ozone levels are above acceptable standards will increase considerably.

We are in the fortunate position of being able to reduce our photochemical smog emissions before the problem gets out of hand.

There are many things which we can do to reduce the amount and frequency of photochemical smog events in Perth. We must reduce our contributions of oxides of nitrogen and reactive organic compounds to the atmosphere. Suggested actions are outlined in the final section of this booklet, "What can I do to reduce air pollution".

Other cities have had considerable success at reducing their level of photochemical smog. An excellent example is San Francisco which in 1969 had 65 days over 120 parts per billion. Through regulatory and community action this was reduced to one day by 1994.

What causes a smog event for Perth?

Perth's worst photochemical smog days, are between late spring and early autumn, when there is a weak low pressure trough situated very close to the coast. Under these conditions, pollution created by the morning peak hour traffic is blown out to sea by north easterly winds. Here the pollution sits and if the temperature is warm enough, the smog reactions proceed rapidly. The smog is then returned over the metropolitan area with the sea breeze. The process is illustrated in Figure 17.

Photochemical smog may also be experienced if bushfire smoke is blown across the metropolitan region.

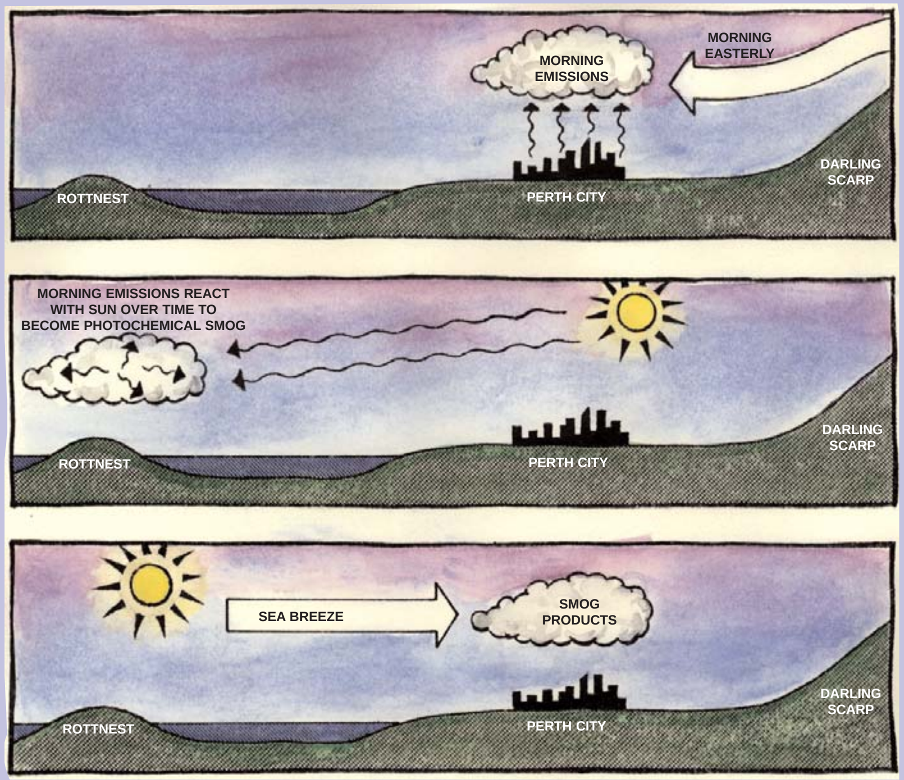


Figure 17. Formation of photochemical smog over Perth.

2. Haze

Haze is the name given to the collections of tiny particles from wood smoke and vehicle exhausts which make our skies look brown. Haze is most likely to be observed on cold, calm winter mornings.

The haze particles are so tiny that between 15,000 and 50,000 particles can be lined up side by side along a line one centimetre long.

Fine particle matter is sampled at the city centre and four metropolitan sites. Some areas have been found to have similar levels to those recorded in Sydney and Melbourne.

As shown by the Duncraig data, Figure 18, haze levels tend to be highest in winter and lowest in summer. The largest source of haze forming particles in winter is smoke from domestic wood heaters.

* Number of hours that Bsp is greater than 1.75 x10^{-4} m^{-1}. Bsp is a measure of the backscattering of light due to particles in the air. Refer to Table 1.

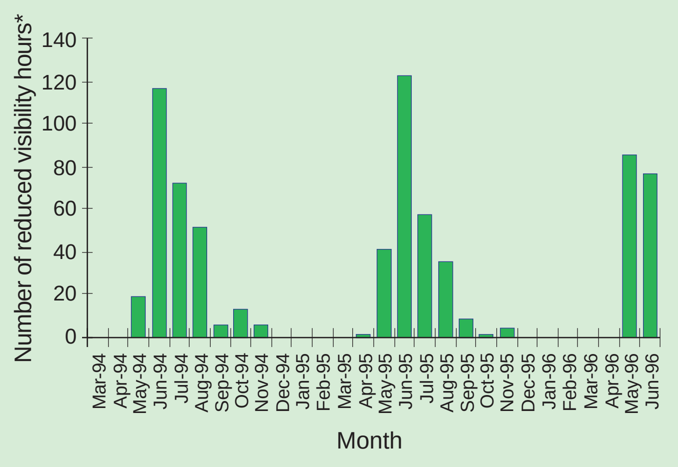


Figure 18. Reduction to visibility at the Duncraig Air Quality Monitoring Station, January 1994 - July 1996.

Table 1. Visibility scale.

Classification	Distance	Bsp scale (x10^{-4} m^{-1})
Clean	≥26 km	1.75 and below
Light	26 km to 20 km	1.76 to 2.35
Significant	19 km to 10 km	2.36 to 4.65
Heavy	≤10 km	4.66 and above

The burning of green wastes, forests, and paddocks contribute to haze formation at other times of the year, particularly autumn and spring.

Particles emitted from exhausts, particularly of diesel engines, also make significant contributions to haze.

Pollutants present in the atmosphere can react together and produce additional fine particle matter.

The smallest source of fine particle matter is naturally occurring dust and sea salts.

Figure 19. The largest source of fine particle matter during the winter months is smoke from domestic wood heaters.

Haze is worst on days of temperature inversions. How do temperature inversions form?

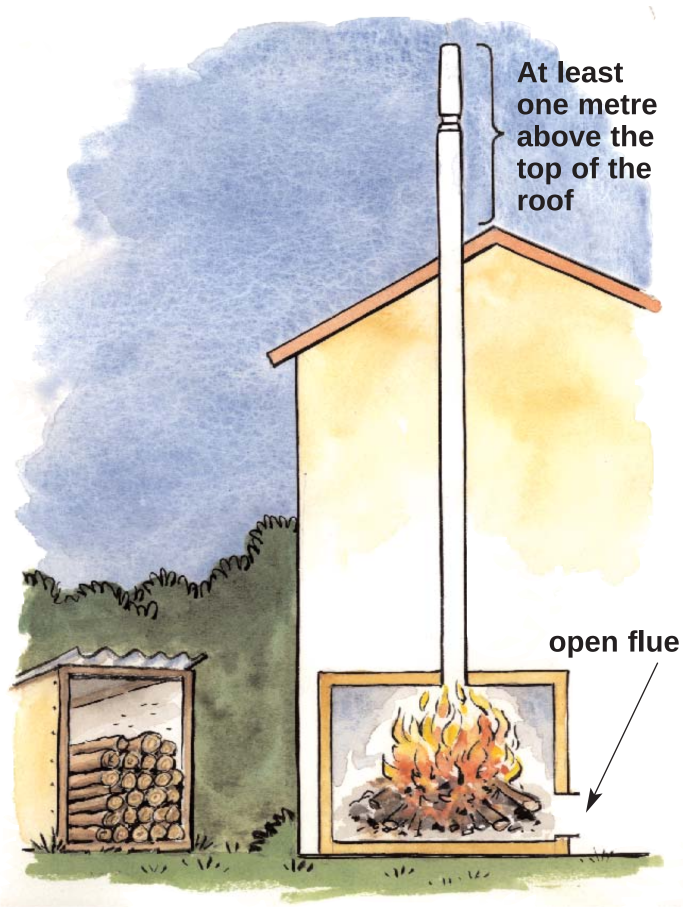
On cool, clear, calm nights the ground and the air next to the ground cool down. As the air cools, it becomes heavier and, as a result, the air does not mix with the warmer lighter air above.

How is this relevant to Haze?

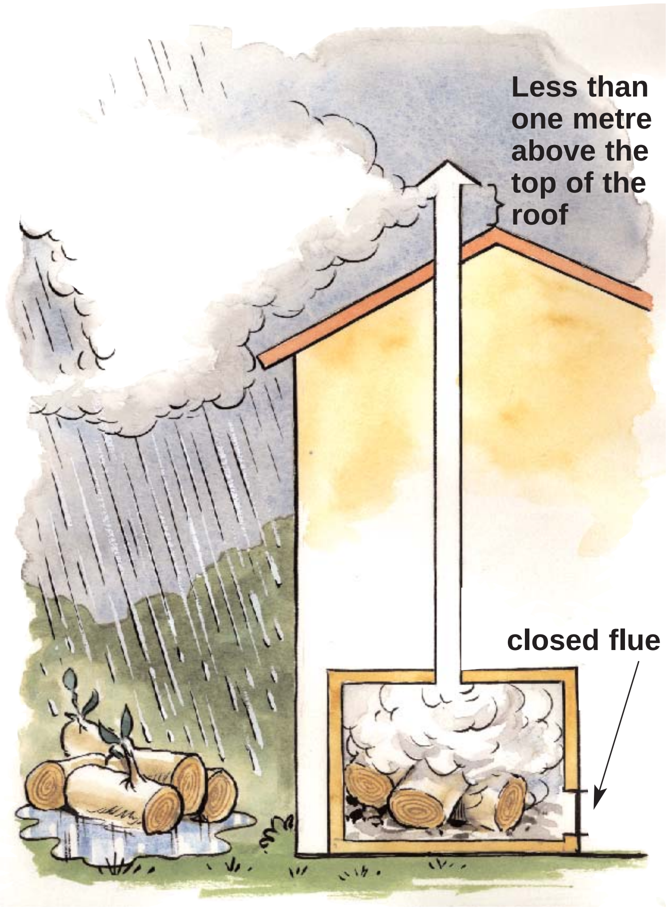
Haze is particularly evident on days of temperature inversions. The fine particle matter gets trapped in the layer of cold air close to the ground. With little vertical dilution due to the inversion, and little horizontal dilution because of light winds, continued production of particles (fires burning, exhaust emissions) causes accumulation in the air. The particles scatter the sunlight, making the sky in the direction of the sun appear bright, while away from the sun the sky looks brown.

Figure 20. Haze can be seen as a brown stain in the sky.

How to use a pot belly fire



How not to use a pot belly fire



Any material floating about in the air can be breathed in to our bodies. The larger particles are trapped by the fine hairs inside our noses and windpipes. These are passed from our bodies when we blow our nose or cough. Because of their smaller size, fine particle matter is inhaled deep into our lungs. While some of the particles are exhaled, a fraction are retained and these can have serious impacts on our health.

The people most at risk are the very young, the elderly, or people with lung or heart diseases. Fine particles are known to exacerbate problems experienced by bronchitis, emphysema and asthma sufferers. There is also evidence that fine particle matter can lead to premature deaths. The main group at risk are elderly people who suffer from chronic respiratory problems. We should also be aware that fine particle matter may also contain harmful chemicals which can damage our lungs, or even worse, cause cancer.

When airborne particles finally settle they add a film of “dirt” to the natural and physical environment.

What can we do to reduce the Haze problem?

1. Use our wood burning heaters and stoves so they produce as little smoke as possible. It is important to burn a hot fire with bright glowing coals. As a guide use small pieces of untreated and well dried wood. Control the heat output by regulating the amount of wood put in the fire rather than closing the flue. For more details, read the Department of Environmental Protection’s pamphlet “Wood Heaters in the Home” or the Australian Solid Fuel and Wood Heating Association’s pamphlet, “Getting the most from your wood heater...it’s easier than you think”.

2. Even if open burning is legal within your shire, avoid the temptation to add more smoke to the air. Compost your garden clippings and recycle them back into your garden as mulch. Alternatively take your garden waste to the nearest rubbish tip or waste transfer station.

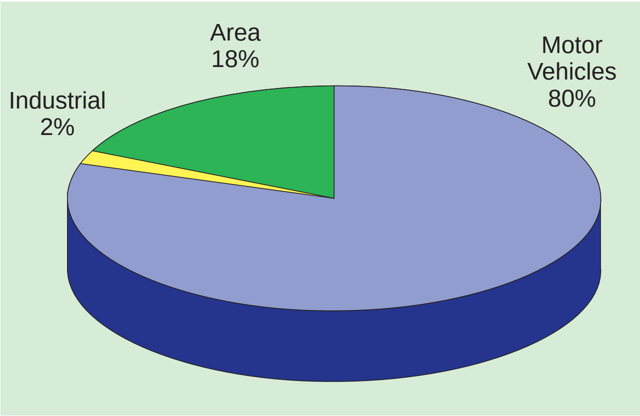


Figure 21. Sources of carbon monoxide in Perth.

3. Carbon monoxide

Carbon monoxide, a colourless, odourless, highly toxic gas, is one of the most common and widely distributed air pollutants. It arises from the incomplete burning of materials, industrial processes and biological decay.

Figure 21 shows the various contributions to carbon monoxide pollution.

The group referred to as "area sources" is diverse. It includes our homes and gardens, schools and office blocks, shops and service stations. Of particular interest to us is our own homes. Information about carbon monoxide sources in our homes is in the appendix.

One of the most significant individual sources of carbon monoxide is cigarette smoke. Scientific research indicates that smokers, and passive smokers, are exposed to up to four times more carbon monoxide than people in a smoke-free environment.

People who are exercising are more prone to carbon monoxide poisoning than people at rest.

Low level of carbon monoxide pollution can lead to a reduction in our ability to carry out exercise. As the concentration of carbon monoxide within our blood increases, our ability to receive information about our environment decreases. We become less able to concentrate and experience headaches.

Short term exposure to very high carbon monoxide levels can prove fatal. Carbon monoxide enters the bloodstream and considerably reduces our body's capacity to get oxygen to the cells. As our heart compensates and sends more blood to each cell, it is put under considerable strain. If vital organs such as the brain are starved of oxygen, some of the cells will die and brain damage can occur.

The health threat of carbon monoxide poisoning is greatest for people who suffer from cardiovascular disease. In some of the world's large cities it has been found that there is a correlation between carbon monoxide levels in the air and the admissions of elderly people to hospital with congestive heart failure.

Since 1990, carbon monoxide levels in Perth have been closely monitored in the central business district because of the high concentrations of motor vehicles found there. The results from the Perth CBD station are shown in Figure 22.

The carbon monoxide level within the air we breathe is currently believed to be within safe limits.

With our population increasing and the expected increase in the number of kilometres travelled per person in vehicles, it has been predicted, despite improved emission controls, carbon monoxide levels will rise in the future.

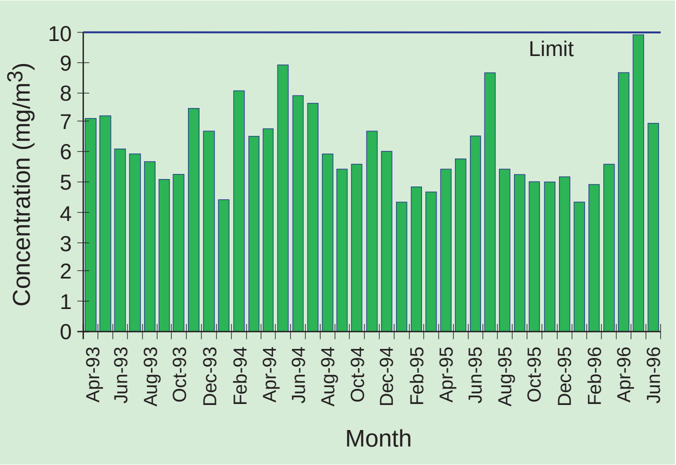


Figure 22. Maximum monthly 8-hour concentration of carbon monoxide, Queens Building, Perth, April 1993 - June 1996.

4. Oxides of Nitrogen

The most common oxides of nitrogen in the atmosphere are nitric oxide and nitrogen dioxide. Nitric oxide is a colourless, odourless gas while nitrogen dioxide is an orange-brown gas with a stinging smell.

The largest man-made source of the oxides of nitrogen is the combustion of fossil fuels. As shown in Figure 4, it is our motor vehicles which are responsible for 51 per cent of the emissions. Industry contributes approximately 44 per cent of the oxides of nitrogen emissions to Perth's air. Examples of such industries include power generation and the production of nitric acid. The remaining contributions of nitrogen oxides come from area sources, including our homes and workplaces. The use of gas appliances for heating and cooking and the smoking of cigarettes both lead to an increase in the oxides of nitrogen within indoor environments.

As previously described, oxides of nitrogen are one of the two groups of pollutants responsible for the formation of photochemical smog.

In addition, oxides of nitrogen can have significant impacts on health. While nitric oxide is a relatively safe gas, it is converted to nitrogen dioxide in the atmosphere.

At levels above 300 parts per billion, nitrogen dioxide can affect our respiratory systems and increase our susceptibility to infection. This is a real problem for new babies, older people, or for those people with problems such as bronchitis and asthma. There is evidence that nitrogen dioxide can trigger asthma attacks in known sufferers. If we are exposed to high levels of nitrogen dioxide for long periods of time, it is possible that cells on the interior surfaces of our lungs may be irreversibly changed. With this, our lung function is reduced.

Nitrogen dioxide is also known to prematurely age materials such as paint, metals, rubber, fabric, leather, paper and building materials. In addition the oxides of nitrogen can react with water and form weak solutions of nitric acid and this can contribute to a phenomenon known as wet acid deposition.

Nitrogen dioxide levels in Perth rarely exceed the West Australian standard of 150 parts per billion on average in any one hour.

What is the difference between acid deposition and acid rain?

Our air contains gases and fine particle matter. Some of these substances can form acidic compounds. If the compounds settle on the earth's surface in a dry form, dry acid deposition has taken place. However, if the compounds are washed to the ground with precipitation, the phenomenon is known as acid rain or wet acid deposition.

Pollutants emitted from high factory chimneys can be dispersed over large distances by wind. Some of these pollutants, including oxides of nitrogen and sulphur dioxide react to form acids. These acids may be deposited in either the wet or dry form.

Acid deposition is a phenomenon that can be very destructive to the environment. Air pollution from one country may lead to acid deposition in another country. This is evidenced in Scandinavia, a country with very little industry and severe acid deposition problems.

Is acid deposition a problem anywhere in Western Australia?

At the moment, because of our relatively low industrial base, acid rain is not a problem.

5. Air toxics

One hundred and eighty nine air toxic substances have been identified by the United States Environmental Protection Agency. The list of air toxics includes benzene, 1,3 butadiene and the polycyclic aromatic hydrocarbons.

Benzene, 1,3 butadiene and polycyclic aromatic hydrocarbons are emitted from internal combustion engines including motor vehicles. Diesel vehicles are known to emit particularly high concentrations of polycyclic aromatic hydrocarbons. It is therefore not surprising to learn that the levels of air toxics will be higher near busy roads.

While cars are the major source of air toxics for people with limited exposure to cigarette smoke, this is not always the case for smokers and their associated sidestream smokers.

Benzene is readily released into the atmosphere in fuel vapour. This occurs if our vehicle has a leaky fuel cap and as we fill up at the petrol station. Smoke produced by incomplete combustion of wood and fossil fuels is another source of air toxic substances.

Table 2 shows the estimated daily intake of airborne benzene for people of England. While the figures can not be directly transferred to Western Australia, we can use this data to build an understanding of our own level of exposure.

Table 2. Estimated Daily Intake Of Airborne Benzene.

Source		Level of exposure in micrograms
Air we breathe	rural	15
	urban	400
Cigarette smoke	10/day	300
	20/day	600

Both benzene and 1,3 butadiene are gaseous substances which are a part of the air we breathe. Once they travel into the lungs, they can pass into the bloodstream and travel to the cells of the body. Benzene accumulates in fat rich areas of our bodies.

At excessively high levels benzene may act like an anaesthetic leading to reduced levels of consciousness. Deaths have occurred when people have been exposed to extreme levels of benzene when trapped within confined spaces. Our exposure is however at much lower levels.

Researchers do have concerns about long term low level exposure to benzene. It has been recognised that this can lead to a slight increase in the incidence of leukaemia.

Short term, high level exposures to 1,3 butadiene can lead to an increased incidence of eye, nose and throat irritation.

Of more relevance to us, although this has not been proven, long term low level exposures have been associated with increased cancers of the lymphatic and blood forming tissues. Such cancers include lymphomas and leukaemia.

The polycyclic aromatic hydrocarbons readily attach to very tiny particles, which are easily breathed in and can settle deep within our lungs. Certain polycyclic aromatic hydrocarbons have also been linked to cancer. There is also evidence that this group of substances can also lead to irreversible changes in genetic material.

It is only the post 1986 petrol vehicles which are fitted with functional catalytic converters that are effective at reducing the emission of air toxics into the atmosphere.

The growth of Perth

It is no doubt a direct result of our long hot summers that the people of Perth have a love affair with the ocean. Not only is the beach a nice place to swim; it is the suburbs closest to the coast that are the first to gain the cooling influence of the sea breeze.

People also enjoy living close to recreational areas such as the Swan and Canning rivers and near the open spaces of the various parklands, wetlands and the hills.

There is a tendency for the people of Perth to live in single residential homes surrounded by private gardens. This leads to large areas being used for housing.

Transport is another factor people consider when choosing where they live.

These factors have all contributed to Perth becoming a sprawling city. The satellite image shows the growth of Perth to date, which tends to be in corridors in a north-south direction. The beach provides the western boundary and the Darling Scarp forms the eastern boundary.

This pattern of development is expected to lead to people travelling greater and greater distances so they may satisfy their work and social requirements.

Figure 23. Satellite photo of Perth.

6. Odour

As can be seen in Figure 24 the majority of air pollution complaints to the Department of Environmental Protection are odour related. Odour causes a great deal of concern for many people. Generally, odours are annoying. In rare cases, the compound causing the odour may be poisonous and lead to illness in people.

Most odour complaints are related to industries which deal with animals or animal by-products. Examples include poultry farms, piggeries, cattle feedlots and tanneries.

While many people choose to move away from the odour source, it is possible to control odour emissions at their source. This may be done by pumping the odour high into the air through an elevated chimney, passing the odour through a chemical or biological removal medium or by incinerating the odour-producing material at high temperatures.

Currently the Department of Environmental Protection, is preparing guidelines for buffer zones between odour production sites and new residential areas. To reduce odour complaints in the future it is important that there is adherence to these guidelines when building urban and industrial developments.

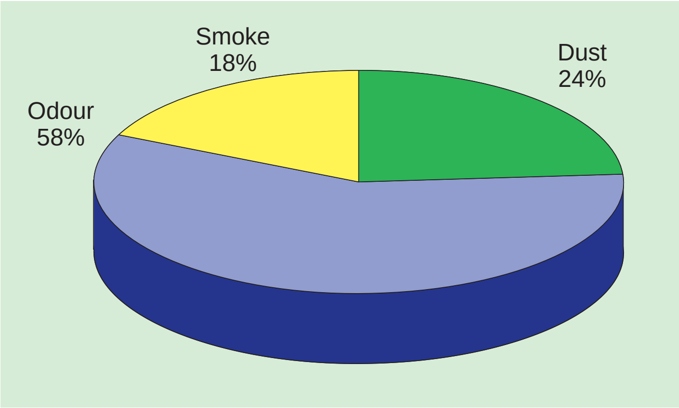


Figure 24. Air Pollution complaints for Perth and Kwinana, July 1 1995 - June 30 1996.

So what is the good news......

1. Sulphur dioxide

Sulphur dioxide is a colourless gas which is soluble in water. The presence of sulphur dioxide is usually indicated by a strong acrid odour.

While a lot of sulphur dioxide is put into the atmosphere by volcanoes, it is the man-made sources which have been a real concern. These emit significant quantities of the gas, they are close to us, and the sources can control their output.

The burning of petroleum, coke, oil and coal release sulphur dioxide into the atmosphere. Sulphur dioxide is a common emission from industry, the sources including coal and oil fired power stations, oil refineries, chemical manufacturing and the smelting of sulphur-containing ores. For Perth, 90 per cent of sulphur dioxide is derived from industrial activity. The majority is produced in the Kwinana industrial area. Motor vehicles (in particular diesels) and the burning of wood also contribute to sulphur dioxide emissions.

What is City Diesel?

In the United Kingdom a new type of fuel called City Diesel is being developed. While City Diesel is more expensive than regular diesel it is a cleaner fuel with a considerably lower sulphur content. Vehicles using this fuel will have reduced sulphur dioxide emissions.

Sulphur dioxide has the potential to affect our health. Exposure to high concentrations causes painful irritation to the eyes, nose, mouth and throat and can lead to coughing, and feelings of chest tightness. Sulphur dioxide can also cause severe damage to the interior surfaces of our lungs, resulting in serious difficulty with breathing.

Sulphur dioxide pollution, as found in many industrialised cities, is most likely to affect people who are exercising or those who have a respiratory condition. Short term low level exposure can lead to a narrowing of the airways in susceptible people, and in the case of an asthmatic, may induce an asthma attack.

It has also been suggested that exposure to sulphur dioxide may lead to people becoming more sensitive to allergy-causing substances such as pollen and dust mites.

The corrosive abilities of sulphur dioxide can damage plants and animals, as well as lead to the general breakdown of non-living things such as brickwork, limestone buildings and metals.

Considerable effort has been made by both industry and the Department of Environmental Protection to reduce the amount of sulphur dioxide in our air. In the mid 1980s many of Kwinana's industries switched to the cleaner energy source of natural gas. In 1992, the Department of Environmental Protection published the Kwinana Environmental Protection Policy which addressed sulphur dioxide emissions. This set air quality standards and led to the setting of emission limits for each industry.

The amount of sulphur dioxide in our air has decreased considerably over recent years. Wattleup, an area very close to the Kwinana industrial area, has experienced a considerable improvement in air quality.

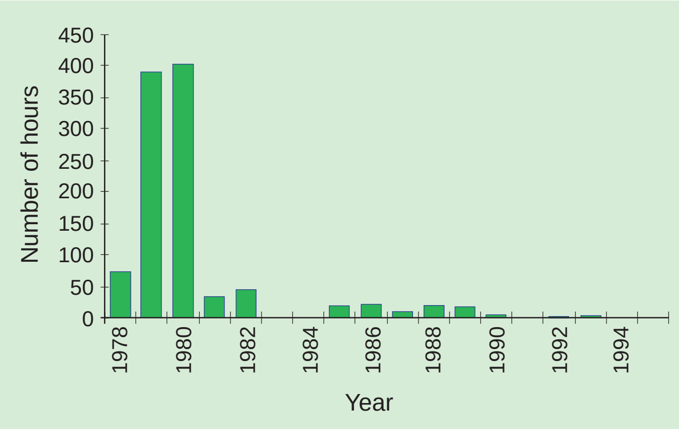


Figure 25. The number of hours each year that the 1-hour average sulphur dioxide concentration exceeded 350 μg/m^3 at Wattleup. (No data was recorded in 1983 and 1984).

2. Lead

Cars which run on leaded petrol are responsible for the majority of lead found in Perth's air.

Adding lead to petrol was once considered a cost effective method of increasing the efficiency of engines. In more recent years petroleum companies have modified petrol formulations to allow for a reduction in the lead content. All new cars built and imported into Australia since 1986 have been designed to run on unleaded petrol. In December 1993 an amendment was introduced under the Environmental Protection Act to reduce lead in super grade petrol sold in Western Australia to 0.4 grams per litre in 1994, 0.3 grams per litre in 1995 and 0.2 grams per litre from 1 January 1996. As a result there have been significant reductions in lead levels in the atmosphere of Perth. This is illustrated in Figure 26. Further falls are expected as the use of leaded petrol decreases.

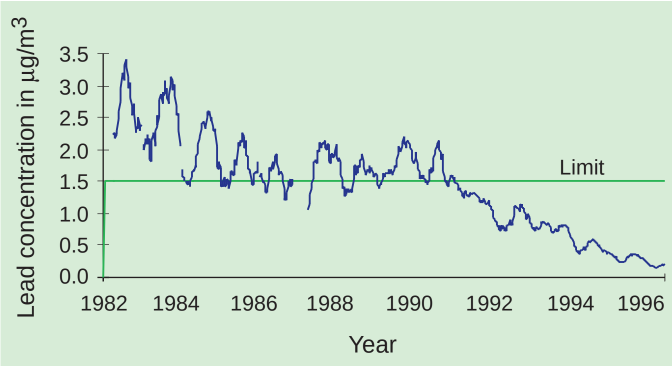


Figure 26. Atmospheric lead levels (90 day average), Queens Building, Perth.

Lead is a toxic chemical which can enter the bloodstream of humans via substances consumed or inhaled. Exposure to excessive amounts of lead can cause health problems. Problems include affecting the ability of the body to make blood components and impairing the intellectual development of people, particularly if exposed to high doses before birth and as young children. There is also some evidence that increased lead levels lead to increased blood pressure.

The effects of high lead levels on plants and animals has not been researched extensively and therefore is not well understood.

Lead in Paints

In past years, many household paints contained lead. Fortunately, this is no longer the case.

The flaking and chalking of old house paints which contain lead continues to be a health risk. People are most likely to be exposed to lead during renovations. Those most at risk of lead poisoning are children who are not yet born and those who are under the age of five.

It is possible for you to minimise the potential of exposure to lead in your home. Details are provided in the series of "Lead Alert" brochures available from the Health Department of Western Australia. (Phone: 09 3884997).

Is there an indoor air pollution problem?

Indoor air quality is important. A good indoor climate reduces illness. It also helps us to feel more comfortable so we are able to work more efficiently.

It may come as a surprise to learn that the quality of air indoors is often poorer than that outdoors. It is therefore important that we understand the impact of indoor air quality on our health. It is particularly important to consider the impact of indoor air pollution when we learn that the majority of people spend between 85 and 95 per cent of their time indoors and that elderly, sick and very young people spend nearly all of their time indoors.

The use of synthetic building materials, household products, gas for cooking and a variety of fuels for heating can lead to pollutants being at excessively high levels indoors. Carpets have also been identified as being a major source of indoor air pollution. This problem is exacerbated by building design and room partitioning which does not allow a good flow of fresh air.

Smoking of cigarettes in indoor and enclosed areas is a considerable health risk for all people using the area. As a result, smoking has been banned in all government offices in Western Australia.

There are a number of substances which have been recognised as indoor pollutants. The sources, health effects and a variety of methods for reducing the concentration of indoor pollutants are shown in the Appendix.

To maintain good air quality within indoor spaces we must minimise the number of pollution sources and encourage the movement of plenty of fresh air into our homes.

I live alongside a major road and I am concerned about the air quality. Are my concerns valid?

While it is known that air quality declines adjacent to busy roads, insufficient work has been done to determine the health impacts of the levels of pollution which are experienced. This is the focus of a future study soon to be undertaken by Main Roads WA.

If you wish to do something to reduce your exposure, you may find these suggestions helpful:

1. Open the windows and air your home when the pollution levels are at their lowest, eg. night time.
2. If you have an air conditioner make sure its air intake is from the side of the house least exposed to air pollution.
3. Have the rooms in which you spend the most hours of your day (bedrooms, living rooms) away from the busy road.
4. Plant vegetation between your home and the source of pollution. Some pollution may be absorbed by plants.

How to reduce the level of volatile organic compounds in new furniture and floor coverings.

Many new household products contain lots of volatile organic compounds (VOCs). When unwrapped, the VOCs vaporise and move into the air. It is these vapours which give new products that brand new smell. Unfortunately, the vapours can also affect our health.

Its easy to reduce the level of VOCs in your new purchase. The first thing you need to do is unwrap the item and put it in an enclosed area which will not be needed for the next few days. A spare bedroom or an enclosed garage is good. More VOCs will dissipate at higher temperatures, so its best if you can put a heater on high in the room with the new item. Leave the heater on for at least one day, then return to the room briefly, turning off the heater and opening up the room to the outside air. Leave the room open for as long as you can to reduce the level of the VOCs in the air. Once you have done this you can enjoy your purchase and feel satisfied that you are breathing healthier air.

What are the economic costs of air pollution?

Air pollution has a real health cost. Various attempts have been made to convert this to a dollar value. A number of broad assumptions have been made in an effort to quantify the costs.

In 1994, a study was completed by the Brisbane City Council to find the health cost of air pollution. The study was considered to be particularly relevant for the people of Perth as Brisbane has a similarly sized population and levels of air pollution.

Given that those carrying out the study estimated a human life to be worth $5 million, the cost of fine particle matter pollution was calculated as being between $230 million and $415 million per year. This translates to between 46 and 83 premature deaths per year. In addition, the authors costed illness caused by fine particle matter and ozone at between $23 million and $45 million per year.

Another study, the Victorian Transport Externalities Study, attempted to estimate the cost of air toxics and ozone on the health of Melbourne's population. The population of Melbourne is two and a half times larger than Perth.

As a result of Melbourne having more traffic, more air toxics are emitted into the atmosphere. During 1990, the estimated cost of cancer caused by air toxics to the Melbourne population was calculated as between $26 and $45.2 million.

Melbourne tends to have more days than Perth when ozone levels exceed the one hourly World Health Organisation's goal of 80 parts per billion. In a 12 month period spanning 1992 and 1993, Melbourne had 13 days exceeding 80 parts per billion of ozone in one hour. The cost associated with premature deaths, asthma attacks and the reduced activity of people, as a result of ozone-related illness, was given an average estimate of $2.5 million dollars.

The two studies considered three aspects of air pollution. No consideration was given to the health costs of carbon monoxide, nitrogen dioxide, sulphur dioxide or lead by the studies.

Even though we are mindful that there were a number of assumptions made by the researchers, it is evident that there are significant health costs associated with air pollution.

To get the total picture of the cost of air pollution we must look beyond human health and consider environmental costs. What is the cost of damage to plants, animals and ecosystems as a whole? What value is placed on the premature deterioration of monuments and buildings or other pollution sensitive materials such as rubber, plastics, cloth and paint work?

At this stage, specific estimates for these costs have not been calculated. It is important however, that we keep in mind that these are important components as we consider the overall cost of air pollution and pollution reduction.

What can we do to reduce our air pollution?

To improve the quality of the air we breathe we must think about our individual contribution to pollution. Each of us add to the air pollution in some way or another.

If we all make an effort and reduce our contribution to air pollution, this will make a big difference to the air we breathe.

In the following pages some suggestions are made as to how we can reduce air pollution from private vehicles, our homes and gardens, through recreation and by working together as a community.

Pollution from private vehicles

Think about the types of trips for which you use your car.

Don't drive if you don't have to

You may find that you do some very short trips where you don't have to carry much luggage. Perhaps you can have fun and breathe some fresher air at the same time. Walking is great for our physical well being, and we often find that other family members, including the dog, also enjoy the trip. Our push bikes allow us to travel a little bit further in the same amount of time. If we have a basket, some panniers or a backpack, we can even carry cargo at the same time as we work on our fitness.

Often there are others who live near us who travel in the same direction at about the same time of the day. If you don't know someone who you could share travelling with, but you are keen to give car pooling a go, try putting a notice on the board at the local shopping centre or your place of work or study.

You have no doubt experienced the frustration of seeing a bus or train sail past, while you are sitting in a car which has come to a grinding halt in a traffic jam. Public transport allows us to get into the city centre quickly, find some time to read, and gives us the opportunity to get a little exercise at each end of our trip. If you have not used public transport for a while you may find it all a bit daunting. The biggest step for most people is getting hold of the appropriate timetable. If you are wanting to travel within Perth, this can be easily solved by ringing the friendly Transperth staff on 132213. They will give you timetable information over the phone, or should you prefer, they will send the correct timetables to you.

With our improved telecommunications systems, more and more people are finding it possible and convenient to change their work practices and do more of their work from home.

Every kilometre you don't drive will make the air a little bit healthier for you and your family to breathe.

Sometimes there is no choice. We just have to drive

At times, we do not have a lot of alternatives to driving, but with a little forward planning we can do a number of car-based tasks in one day. In addition to reducing the distance we drive and our contribution to air pollution, we will also save time.

On those days you drive try to avoid excessive acceleration and breaking. Smooth driving leads to less air pollution.

By avoiding traffic jams we reduce our time wastage and the amount of pollution our cars put into the atmosphere. For many people this can be easily altered by changing the times and the routes on which they travel.

What can we vehicle owners do to make our cars pollute less?

Consider buying a small, fuel efficient, four cylinder car next time you change. They produce considerably fewer emissions. Refer to Appendix B for a guide to vehicle running costs. The most important thing we can do is keep our car well maintained. It is important that we include the emission control gear and the fuel cap in the maintenance program. Well maintained emission control gear leads to a lot less toxic substances passing out the exhaust pipe into the atmosphere. A well maintained car produces, on average, 25% less carbon monoxide and 16% less nitrogen oxides than a poorly maintained car.

Well fitted fuel caps keep the vapour in our petrol tanks rather than letting them waft away into the air where they can be breathed in and contribute to photochemical smog.

Perhaps you are thinking about making your vehicle a little more cost effective. By converting to liquid petroleum gas (LPG) you will also reduce your contribution to air pollution.

By removing any extra wind resisting items from your car, such as the roof rack, and by reducing the load that is carried to the essentials, you will save on fuel and at the same time improve the air quality.

Keeping your tyres inflated to the specified pressure also helps to reduce resistance.

Recent research has demonstrated that cars altered beyond manufacturer's specifications do not run as well and are considerably worse polluters. If you avoid the temptation to "hot" your car up, you will help to keep our air clean.

Many pre-1986 cars have been identified as being able to run on unleaded petrol. If this is the case for your car, you can help to further reduce the lead in Perth's air. Information on your cars suitability is available in the RAC brochure "Pre-1986 cars suited to Unleaded Petrol"

What sorts of things can I do at home?

Indoor pollution

As detailed in the Appendix, there are many sources of indoor air pollution. With some small changes to the types of appliances we use and by thinking carefully about the products we purchase, we can improve the quality of air within our homes.

Many people hate using oil-based paints as they find cleaning the brushes hard work. By painting with a water-based paint you will not only find that it is possible to clean up fast, you will also contribute less pollution to the atmosphere.

Throwing open of the doors and windows within the home is one of the best ways to reduce the level of indoor pollutants. If we put floor rugs and bedding out in the sunshine to air them on a regular basis we also reduce the number of dust mites, fungi and bacteria.

Garden pollution

Two-stroke motors are not only noisy, they put a lot of pollution into the atmosphere. If you need to buy or hire a machine for your garden, remember, electric motors are a lot cleaner.

A little maintenance work in the back shed may also help reduce the amount of pollution drifting into the atmosphere.

Containers used for the storage of volatile substances, including paints, thinners, petrol, pesticides and cleaning agents, need firmly fitting lids.

Burning contributes to the amount of fine particle matter and photochemical smog. Composting garden materials or taking them to the tip or waste transfer station is a much cleaner alternative. Gas BBQs, as well as being less polluting, are more convenient than wood-fired BBQs.

Recreational pollution

Some forms of recreation, including rowing, bushwalking and rock climbing, make little or no contribution to air pollution. Other pursuits however, affect the quality of our air. Trail bikes, jet skis and power boats all put toxic emissions into the atmosphere.

It is possible for us to continue to enjoy all forms of recreation and at the same help improve our air quality. For example, improved technology is currently being used to build outboard motors which will produce less emissions. The technology comes in the form of four-stroke and modified two-stroke engines.

A community approach

Many work places are now helping to make it easier for their staff to be environmentally friendly. The provision of bike lockers and shower facilities means that staff can gain some exercise and be ready for their day at work. Some businesses provide child-care facilities, this means that busy mums and dads can reduce the distances they drive, or even better, enjoy some time with their children as they travel together on public transport.

Some people are provided with a car by their work place. Incentive schemes are being used to encourage people to limit their use of the vehicles. An example includes equivalent mileage payments for work-related travel completed by bike.

A method for improving air quality is vehicle emission checks. In both the United States and British Colombia the issuing of the vehicles annual licence is dependent on a car conforming to predetermined emission levels. At the current time, this practice has not been instituted in Australia. If such a testing program were to be introduced, considerable community support would be needed.

In some large cities, including Sydney, potential photochemical smog days are forecast and announced to the public. Members of the public can then make appropriate decisions about the activities they have planned for the day. At the current time, no such service is available in Western Australia.

Perhaps we can practise our daily air pollution forecasting abilities! On days of high pollution risk we could make an all out effort to reduce our personal contributions. We could walk, bike or catch public transport. Our lawn mower could get a well earnt rest and we could have a salad for lunch rather than a BBQ.

Now is the time to act

If we make comparisons between Perth and other cities of the world we may conclude that Perth's air pollution is not that bad. While this is good, we must not relax. At this point in time we have the opportunity to prevent Perth becoming seriously polluted.

Our population is growing and our use of private vehicles is showing an increasing trend. If no change is made more toxic emissions will be pumped into the air. Some of these will cause immediate affects for us and our environment, while others will show their effects at later stages.

Scientists have identified that only a small increase in emissions of reactive organic compounds and oxides of nitrogen will lead to a considerable increase in the number of days when ozone levels exceed what are currently considered to be acceptable limits.

Air pollution has its costs. It affects the health and quality of life of people, animals and plants. Buildings, monuments and artworks are damaged by a variety of pollutants.

By reducing our air pollution emissions, we are contributing to a cleaner and healthier environment.

Appendix A

Indoor Pollutants, their health impacts, sources and what can be done to minimise their concentration

Toxic Substance	Health Impacts	Sources	What can you do
Carbon Monoxide	Lethargy and headaches at low concentrations. Lack of ability to concentrate. Suffocating gas which impairs the functioning of the nervous system.	The running of motor vehicles adjacent to indoor spaces. This is a real problem with indoor parking and carports directly adjacent to indoor spaces. Unflued combustion heaters. Gas appliances (eg. cooktops). Tobacco smoke.	Close doors and windows along side garages and carports at times when cars are running to prevent fumes entering indoor areas. Keep garages and carports well ventilated. If a vehicle is left to idle, ensure its fumes are not blowing into the house. When choosing a new heater consider the installation of a flue. Use an externally vented exhaust fan. Request smokers smoke out doors.
Oxides of Nitrogens	Reduces our lungs ability to function. May induce asthma attacks in known sufferers. Weakens our bodies defence system against infections. Irritates eyes, nose and skin when levels are high. May cause irreversible damage to cells on the interior surfaces of the lungs.	Gas appliances and leaking gas pipes. Kerosene heaters and wood fires. Tobacco smoke.	Maintain gas appliances and their flues. Use externally vented exhaust fans. Open windows and doors of the house on a daily basis to allow indoor pollutants to escape. This is particularly important in winter. Request smokers smoke out doors.

Toxic Substance	Health Impacts	Sources	What can you do
Volatile Organic Compounds (VOCs) eg. Formaldehyde	May cause sleepiness, lack of ability to concentrate, irritability, inflammation of eyes and respiratory problems. Some are known to weaken our bodies defence system so we are more vulnerable to infections. Some cause cancer and lead to irreversible changes to the genetic materials of our cells.	A wide variety of sources. Includes carpets, particle board and plywood, paper products, pesticides, disinfectants, air fresheners, cleaning agents, foam insulation, glues, paints and solvents, tobacco smoke.	Reduce use of VOC containing substances. Maintain a high degree of air flow between indoor and outdoor environments. Healthy indoor plants are known to be efficient at taking up and therefore reducing the level of a variety of air pollutants within indoor spaces. Request smokers smoke out doors.
Particles	Reduce the functional ability of our lungs. Exacerbation of respiratory problems such as asthma. Some particles cause cancer and lead to irreversible changes of genetic material within our cells.	Cooking (particularly if food is burnt). Open fires and combustion stoves. Smoking.	Use an externally vented exhaust fan. Wet dusting and thorough vacuuming will reduce the level of settled particles. Open windows and doors to allow indoor pollutants to escape. Request smokers smoke out doors.
Biological Materials	Symptoms vary. These range from those experienced when suffering from various allergies, common colds and the flu.	Fungi and their spores. Bacteria and viruses. Pollen and other plant materials. Invertebrates (mites, spiders and insects). Pet hair and dandruff.	Regular opening and airing of the space. Thorough regular vacuum cleaning. This is particularly beneficial if the vacuum has an effective air filter to trap very tiny particles. Routine airing of floor mats and bedding. Cleaning and disinfection of air conditioning units.

Toxic Substance	Health Impacts	Sources	What can you do
Asbestos	Asbestosis, lung cancer, mesothelioma.	Disturbance and weathering leads to the release of dangerous asbestos fibres from asbestos containing materials.	For information on the safe treatment and handling of asbestos containing products read the Environmental Health Guide “How Safe is Asbestos Cement”. The pamphlet is available from the Health Department of Western Australia. (Ph 388 4997)
Ozone	Irritation to eyes and nose. Increased incidence of headaches, nausea, respiratory and cardiovascular disease. May trigger asthma attacks, increase susceptibility to infection and contribute to premature death.	Photocopiers, laser printers, air purifiers, negative ion generators.	Keep well maintained. Use of ozone trapping devices on photocopiers and printers. Maintain a high degree of air flow within the indoor environment.
Radioactive by-products of Radon decomposition	Radon gas emits alpha particles, a damaging and low penetrating form of radiation. Alpha particles can give rise to mutations and cancer. The effects are generally confined to the lungs.	Buildings with a low degree of airflow which are built on soils with a high uranium content. Work done by the Health Department of Western Australia indicates the risk of a Western Australian’s exposure to radon gas within their home environment is minimal.	If you wish to test the radon level of your home a service is offered at minimal cost by the Australian Radiation Laboratories. (Ph: 1 800 678 112) Should your home be found to have high radon levels it is advised you seal cracks in the sub-surface area of the home and increase the degree of air flow between internal and external environments.

Appendix B

The Royal Automobile Club of W.A. (Inc)

Private running costs, new - 5 years @ 15,000 km per year (All costs in cents per km unless otherwise stated)									
	Hyundai Excel 1.5 GLX Auto	Toyota Corolla Conquest 1.8 Auto	Toyota Camry CSI 2.2 Auto	Mitsubishi Magna 2.6 Executive Auto Sedan	Holden Commodore Executive 3.8 Auto Sedan	Ford Fairlane V8 Sedan	Mitsubishi Starwagon GLX Manual	Mitsubishi Pajero V6 GLX Manual	Toyota Landcruiser GLX Diesel Manual
Standing cost									
Depreciation	14.01	16.11	18.04	18.49	18.91	33.14	28.44	29.77	36.18
Interest	8.18	9.40	10.22	10.47	10.75	18.84	16.16	16.92	20.56
Registration	2.05	2.08	2.14	2.18	2.34	2.55	2.20	2.41	2.45
Insurance	2.60	3.02	2.85	2.89	2.92	4.39	3.98	4.09	4.67
RAC Membership	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Running costs									
Fuel	6.62	7.40	8.70	10.00	10.00	12.62	10.00	11.63	9.53
Tyres	1.11	1.16	1.06	1.06	1.67	1.99	1.41	2.27	2.78
Service/Repairs	4.78	5.20	6.51	5.03	4.25	4.80	7.47	5.51	7.18
Total cost									
Average cents per km	39.61	44.63	49.78	50.38	51.10	78.59	69.32	72.86	83.61
Average dollars per week	114.26	128.74	143.60	145.33	147.41	226.70	201.70	210.18	241.19

Calculations are based on private running cost at an annual distance of 15,000 km per year. For 'Vehicles 6 years and older' we have assumed the vehicles are fully owned so no loan repayments have been included. Depreciation is also significantly lower than for the first 5 years.

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AirWatch P.D. include:

- ideas, activities, and FREE curriculum materials;
- how to use the AirWatch equipment and website;
- talks from teachers who have used the resources;
- air pollution information; and
- links with the Curriculum Framework.

Primary 'school visits'

An AirWatch coordinator can visit your school to present talks and activities on air pollution. The school visit can complement existing studies or act as a starter to get busy on air quality studies! **Available for years 4-7 only. You must book a free P.D. to receive a 'school visit'.**

Free loan of simple, effective pollution monitoring kits!

- Schools in the AirWatch program use simple hands on monitoring equipment to get a picture of air quality issues in their area. Using the AirWatch monitoring kit students test the air for some common pollutants:

Particulate levels, Nitrogen dioxide (NO2), Pollen levels

- Students use the manuals to undertake community surveys on air quality issues such as car and wood heater usage, travel patterns and vehicle counts.

  Results are entered onto the AirWatch homepage www.airwatch.gov.au

Air pollution and weather

To obtain an understanding about why air quality can vary from day to day, students measure meteorological conditions using a sophisticated weather station. They then use this information to investigate the relationship with current air quality.

Visual Air Quality

Students measure Visual Air Quality (VAQ) to determine daily visibility. As objects are viewed from distance, how clearly they are seen will depend on the quality of the air in between. This is a simple exercise to demonstrate air pollution in the air, and does not require equipment.

WeatherWatch

Schools collect and submit weather and pollution information, which is shown on the 7 Nightly News and Weather report. This program is sponsored by HBF/Ask Ted and Channel 7. Schools are encouraged to commit to one other aspect of AirWatch while participating in WeatherWatch.

The Homepage

www.airwatch.gov.au

The AirWatch homepage offers students:

- news and events, what's on!
- teaching manuals and resources to download;
- air pollution educational information;
- display of student projects;
- on line surveys and activities; and
- links to other air quality sites.

For more information

Contact the AirWatch coordinator to help implement AirWatch in your school!

Department of Environment
Level 2, Hyatt Centre, 3 Plain St,
East Perth WA 6004
Ph: (08) 9278 0649 Fax: (08) 9278 0639
E-mail: richard.olive@environ.wa.gov.au
karl.hansom@environ.wa.gov.au

Printed on recycled paper

Government of Western Australia
Department of Environment

Western Australia

AirWatch
BREATHE EASY™

www.airwatch.gov.au

An environmental education program for schools

About AirWatch

AirWatch is an exciting program for primary and secondary schools where students gain an understanding of air pollution issues in their local area. Through collaborative and inquiry-based learning, students find out about air pollution; its causes, effects and solutions.

AirWatch aims to:

- educate the school community about the causes and effects of air pollution;
- give teachers, children and parents an opportunity to act on this problem;
- provide fun, hands-on activities that meet outcomes across the curriculum; and
- contribute to a healthier environment and help keep the air clean for all.

What can AirWatch do for you?

- free teacher P.D. and ongoing support;
- primary and secondary curriculum materials;
- information on air quality and related issues;
- purchase or loan of air monitoring equipment;
- the opportunity to purchase a fully automated weather station; and
- interactive website to view projects and submit results.

The Primary manual

"Who cares about our air?" is an activities based workbook which addresses air pollution, weather, and related issues with primary school students.

By using this workbook students should be able to:

- understand causes and effects of air pollution;
- describe how weather affects air quality;
- relate air quality to their own activities;
- understand cause and effects of haze and smog;
- discuss how air pollution can be controlled; and
- examine alternatives for action.

The Secondary manual

The AirWatch manual contains activities which explore all aspects of air pollution, using indoor and outdoor experiments, community surveys and internet access.

Topics covered in the manual include:

- pollutants and their sources;
- effects of weather on pollution;
- haze formation and wood heaters;
- photochemical smog and its effects;
- cars and pollution;
- understanding pollens; and
- how individuals can improve air quality.

Case studies of teachers who have used AirWatch:

Teacher Sue Hall from North Woodvale Primary School investigates Air Pollution:

"Balloons were filled with helium gas. The students then attached details of release place and time, together with a request for finders to contact the school."

"The balloons were released, and directions of flight noted. Students were then able to discuss how this discovery was applicable to the spread of pollutants we had been measuring with our monitoring equipment."

Curriculum Links: Science-Working Scientifically and Maths-Space Strand.

AirWatch at Mount Helena Primary

Jim Cassin, Year 7 teacher Mount Helena Primary:

"We have used the AirWatch information in various ways. Graphing has become more realistic and serves a purpose. We can compare Perth's official weather statistics with those that we collect and suggest reasons why there is a difference."

"Visual Air Quality has been discussed. When is it better? What factors affect VAQ? How does Mt Helena compare to other areas?"

Outcomes that have been addressed include Mathematics (Measurement Space, Chance and data), S&E (Natural Systems), (Time Continuity and Change) and (Culture) and English (Reading).

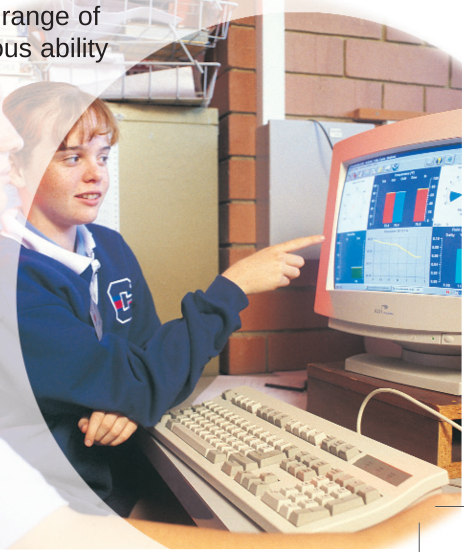
Ian Carroll of Carine SHS piloted the AirWatch program in 1996:

"Airwatch can be used as a unit by itself with easy modification to Lower School Science, but could be incorporated into Social Studies and PEAC schemes. We decided to focus our group projects on two areas: Visual Air Quality and nitrogen dioxide particulate studies. It is topical, the experiments work and it has a wide range of activities suited to various ability groups."

AirWatch P.D.

AirWatch teacher P.D. is held in Perth and regional centers each school term.

Should you prefer, a coordinator can talk to staff at your school.



Getting to school

Escorting primary school children to school by bicycle or on foot ensures they reach their destination safely and provides opportunities to teach them good road sense. You can enjoy the exercise, get to know other parents, develop an appreciation of your neighbourhood and introduce the exercise habit early in your child's life.

The Walking School Bus is a popular way of encouraging young children to walk to school together. It encourages physical activity as well as decreasing the number of cars around schools. Two or more trained parent volunteers or other responsible adults escort each Walking School Bus group to and from school. Walking School Buses operate as frequently as the volunteers are able to commit their time.

If you are interested in sending your children to school with a Walking School Bus, contact the Parent Association at the school.

The Walking School Bus is a popular way of encouraging young children to walk to school together.

Help your secondary student plan their public transport trips to and from school and other destinations by visiting Transperth's Journey Planner at www.transperth.wa.gov.au. The Journey Planner co-ordinates information on bus and train times and connections, or call the Transperth InfoLine on 13 62 13.

TRAVEL SMART

It's how you get there that counts

TravelSmart helps people choose walking, cycling or public transport for a few trips each week.

For more TravelSmart ideas, see the website at **www.dpi.wa.gov.au/travelsmart**

To speak to a TravelSmart Officer, contact:

Department for Planning and Infrastructure
441 Murray Street, Perth
Phone: (08) 9216 8000 or (08) 9216 8313
Facsimile: (08) 9216 8497

Copies of this document are available in alternative formats on application to the Department.

TS 030-08-2005

Department for Planning and Infrastructure
Government of Western Australia

Better ways to get to school

Less Traffic Better Communities

TRAVEL SMART

It's how you get there that counts

"There are probably more benefits than you realise when you encourage your children to walk, cycle or catch public transport to school."

Healthy living, social confidence and financial responsibility are valuable skills parents can encourage their children to develop.

One way to help children with this is to encourage them to get to school independently by walking, cycling or using public transport.

In 1986, more than 60 per cent of children walked, cycled or used public transport to travel to school.

Twenty years later, children are still travelling the same distances to school but less than half walk, cycle or use public transport. In fact, almost half of all primary school students in Perth are driven distances of less than 2km to school.

This growing dependency on cars is teaching children to become less physically active and inhibiting valuable social opportunities.

Young Australians are spending more time watching television, playing video games or using the computer.

For many childen, the trip to school is one of the few opportunities they have to exercise.

Mobile children are healthy children

Children who walk, cycle or use public transport to travel to school develop good exercise and health habits for life.

Active children are more likely to:

Maintain a healthy weight

In Western Australia, the prevalence of overweight and obesity in 7 to 15 year olds has doubled in males and tripled in females between 1985 and 2003. Walking, cycling and using public transport are a good start to ensuring your children get regular exercise to maintain a healthy weight.

Avoid developing diabetes

About 14 in every 100,000 children under 15 years of age develop insulin dependent diabetes each year. Moderate exercise manages body weight and prevents obesity, a key factor in the development of diabetes.

Avoid developing a heart disorder later in life

Through exercise, children and young adults reduce risk factors such as high blood pressure and cholesterol levels which can lead to heart disease later. Walking, cycling and other moderate levels of exercise have been shown to improve children's cholesterol levels and have a positive impact on blood pressure.

"A little independence goes a long way to building your child's social confidence and self-esteem."

Building self confidence

When children walk, cycle or use public transport to get to school, they are learning to make responsible decisions such as applying good road sense and managing money.

Walking, cycling or using public transport to get to school as part of a group can also be an important social experience for children. It provides them with an opportunity to expand friendships and develop an awareness of their neighbours and the local community.

Encouraging children to cycle to school or walk to the bus stop is an easy way to incorporate physical activity into their day.

Getting children back onto their bikes, into their walking shoes and on the road to good health and social opportunities begins by considering TravelSmart options.

How do I get my children started?

- Try walking or cycling to school with your children once or twice a week instead of driving all the time.
- Organise several children in the neighbourhood to walk to school together in a group.
- Talk to your school's Parent Association to find out more about TravelSmart to School.

- Contact neighbours with young children to see if they are interested in forming a walk to school group.

Programs to help

The RoadWise Safe Routes to School program locates and maps out the safest and easiest street route for children to follow on the way to and from school. The program encourages more children to walk or cycle to school.

Contact RoadWise on 9213 2054.

The TravelSmart to School program runs in selected schools over a ten-week period each year and encourages primary and secondary students to consider the environmental and health impacts of their travel choices.

Department of Environment

Wood Smoke Workshops 2005

Perth Air Quality and Haze

Constance Dewan

Why are we here?

Perth AQMP

- Initiative 9: Haze Reduction
- LGAs Important player in Haze Reduction
- Health Act Amendments progressed
- DoE to share ideas on future plans & get feedback

Department of Environment

What is Haze? Cause?

- Elevated particle levels in the air
- Appears as brown stain on horizon
- Occurs in winter (and Spring)
- Different from Smog

Haze in Perth

Department of Environment

Particle Sources in winter

Perth Haze Study

Smoke	-	40%
Motor vehicles	-	22%
Natural Sources	-	14%
Other Sources	-	24%

Department of Environment

Why is Haze an Issue?

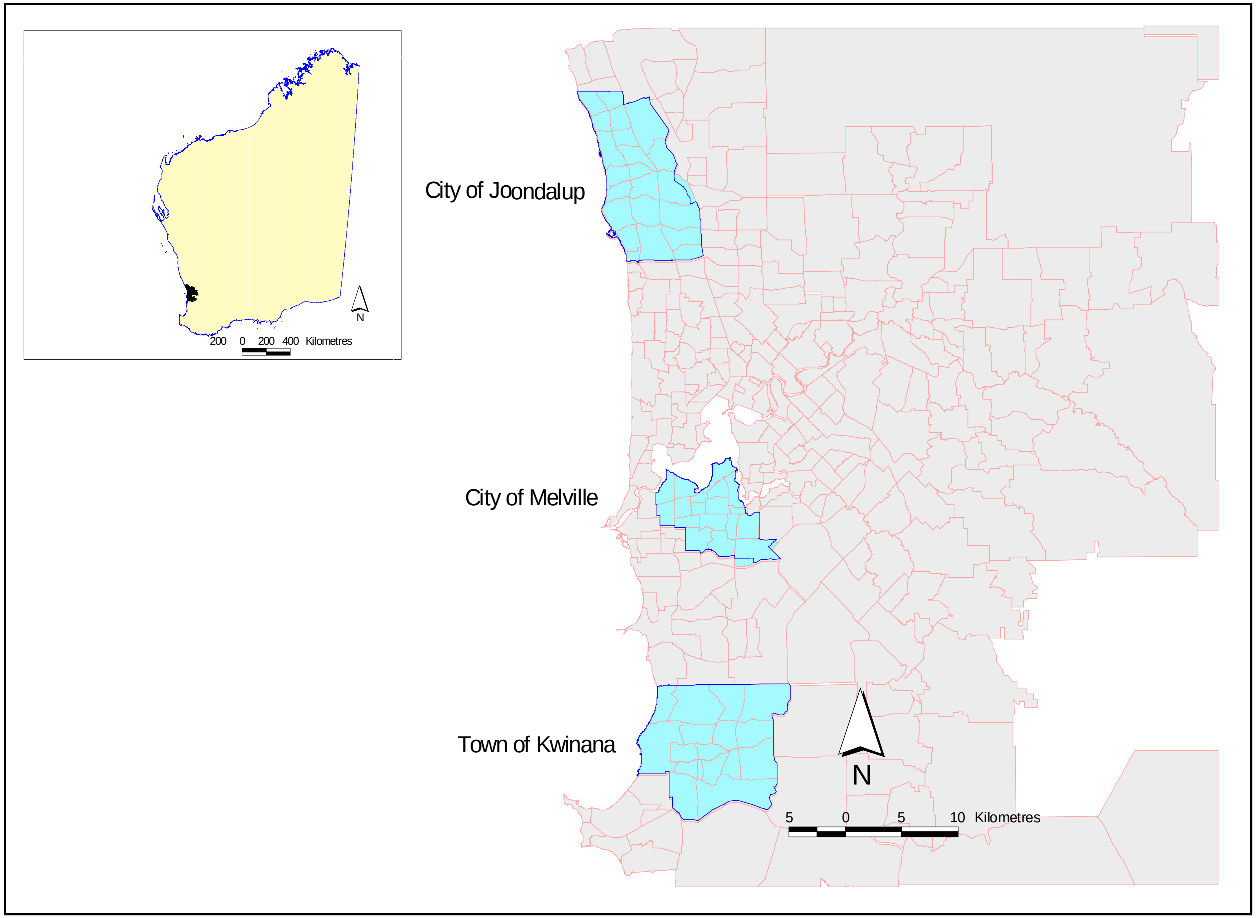
- Significant Health Impacts
- Vulnerable Groups: Aged, children, asthmatics
- Annual Cost on Health System of WA - $18.1m

Haze Reduction Activities

- Community Education
- Haze Alerts
- LG Wood Smoke Workshops
- Environmental Protection (Domestic Solid Fuel Burning and Firewood Supply) Regulations 1998.
- Health Act Amendments
- Schools Network on Air Quality (SNAQ) on Haze
- Home Heating Survey
- Pilot Wood Heater Replacement Program

Department of Environment

Participating LGAs



Home Heating Survey Objectives

To obtain information on:

- The type, number, location, frequency of use, and operation method of heaters in target areas;

- Awareness of the impacts of wood heater use; and

- The motivators for change from wood heating to cleaner heating options.

Department of Environment

Home Heating Survey Outcomes

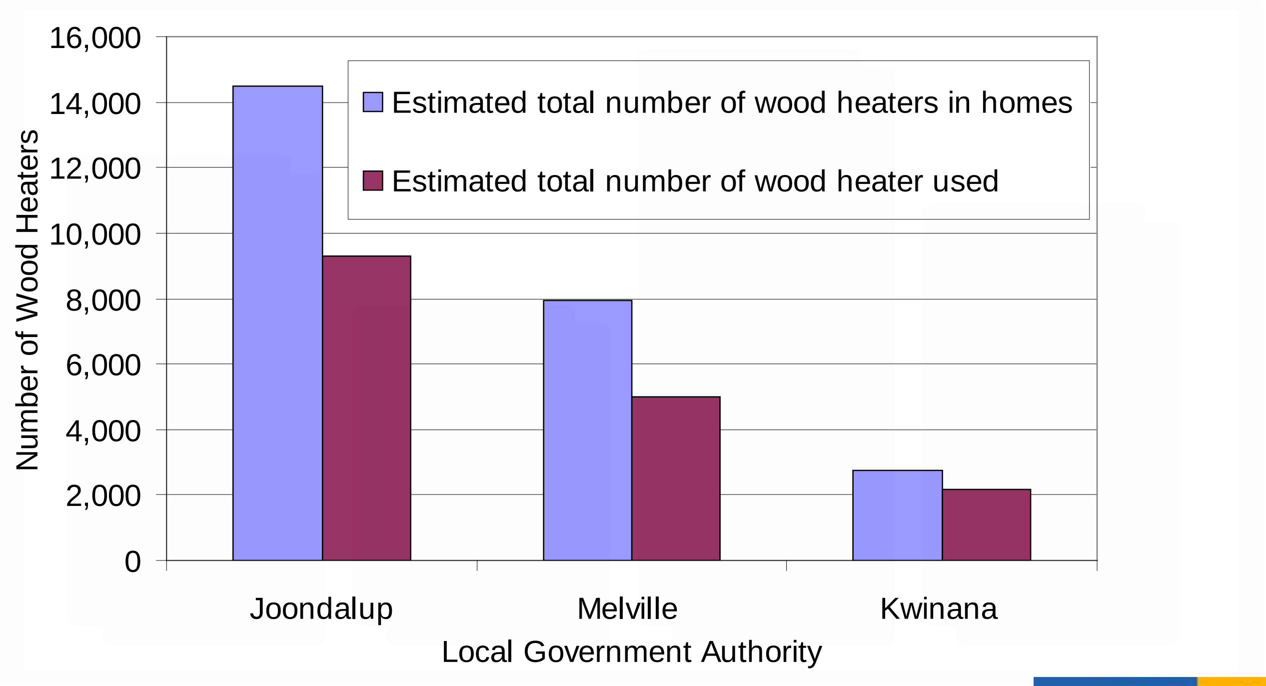
- **1994 = peak wood heater usage was 140,000.**
- **2004 = 134,000 wood heaters in Perth homes.**

  = 88,000 wood heaters are currently used as a main form of heating Perth wide.
- **Average age of all wood heater sampled was 15.5 years.**

Department of Environment

Home Heating Survey Outcomes

Estimated wood heater numbers for the City of Joondalup, City of Melville and the Town of Kwinana.



Home Heating Survey Outcomes

- $700 rebate would motivate most people to changeover from wood heating to cleaner heating.
- The community recognised wood smoke as an air pollutant that contributes to winter haze and that there are associated health impacts.
- Air pollution was not considered to be a major environmental issue in the Perth metropolitan region. (Most people rated Perth's air quality as good or very good).
- Possible reasons : domestic wood smoke is usually not a problem in Perth during the day and cannot be seen at night.

Pilot Wood Heater Replacement Program

Program Outline

- 2 June to 31 December
- $600 to replace wood heater with flued gas heating
- LGA administration of program
- Wood Heater Surrendered for Disposal

Wood Heater Recycling

Department of Environment

Pilot Wood Heater Replacement Program

Outcomes

- Significant interest across Perth & Regional Centres
- High cost of Flued gas heating affected uptake (218 of 300)

LGA	WH Numbers	Uptake	%Uptake
Joondalup	*5,692*	*116*	*1.20*
Melville	*2,439*	*75*	*2.40*
Kwinana	*1,852*	*27*	*1.55*

Department of Environment

Future Haze Management

Home Heating Policy Options Paper

- All heating types
- Recommendations for Future Policy/Program development
- Push towards cleaner heating
- For Minister’s consideration & Public comment June 2005 (planned)

The End

Natural Heritage Trust

Helping Communities Helping Australia

A Commonwealth Government Initiative

HOT TIPS

for cleaner wood heating

This brochure is a guide on how to use your wood heater to maximise the heat obtained from your wood and reduce woodsmoke pollution.

The facts are clear

Many Australian households use woodheaters and open fireplaces for home heating. As a consequence, in some of our towns and cities, levels of winter air pollution are unacceptably high.

This pollution is made up of very small particles that can be taken directly into the lungs and contains a number of toxic and cancer causing agents.

Many people don’t realize that smoke from their woodheaters and fireplaces can present a real hazard to their neighbours, causing physical discomfort for those with respiratory problems, especially older people and young children.

Australia's woodsmoke problem

Woodheaters and open fireplaces are often the major contributors to outdoor air pollution levels in cities and towns during winter. They are used extensively throughout Australia and their use varies quite dramatically from suburb to suburb and town to town. In some areas, over 60% of households use wood as their main fuel for home heating. Wood can be an efficient and economical way to heat your home. However, its use can lead to poor air quality.

One obvious feature of this poor air quality is the brown haze often seen over residential neighborhoods on clear, cold nights. Sometimes whole cities, such as Launceston or Armidale are affected. This haze is a result of temperature inversions, often combining with limited air movement leading to woodsmoke being trapped at ground level.

Managing a woodheater takes time, effort and planning. All woodheaters, when operated well, should produce heat without smoke. You can help to improve air quality in your local area and ensure your community breathes easier by operating your woodheater better.

This brochure offers advice about how to operate your woodheater to ensure you do not create an unhealthy environment for your neighbours and other community members.

The secret of successful burning:

When wood is completely burned, you are left with carbon dioxide and water vapour, which escape into the air, and an ash residue.

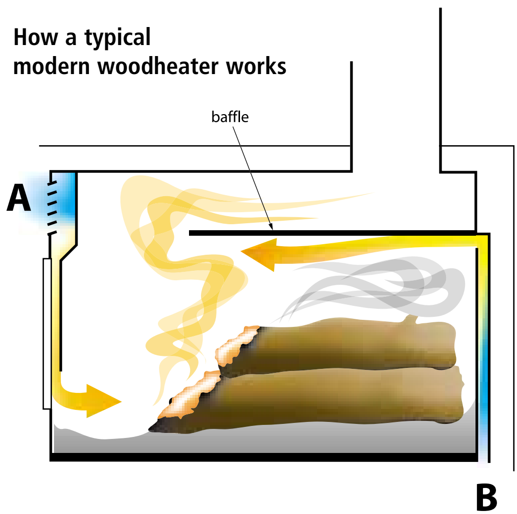
Complete combustion is important to the performance of your woodheater and to reduce woodsmoke. The following conditions are needed for your woodheater to achieve complete combustion:

- **dry, seasoned firewood;**
- **a fire that is hot enough;**
- **sufficient air flow to provide enough oxygen for combustion;**
- **sufficient mixing of air and the hot gases given off by the fire; and**
- **enough time for burning to be complete.**

If there is a lack of any or all of the above, incomplete burning will occur. You can tell if you have enough heat, air and mixing if the coals are glowing brightly and there are bright swirling flames. Dark, smoldering fuel and a lot of smoke in the firebox indicate incomplete burning.

Incomplete combustion will lead to the generation of toxic pollutants, such as particles and carbon monoxide, and also means you are wasting both wood and money.

How a typical modern woodheater works



Primary air [A] is drawn in through a sliding or hinged air control mechanism, usually above the door. The air is pre-heated before being directed down the inside of the door, helping to keep the glass clean. It then enters the base of the fire. This primary air supply determines how quickly the firewood burns.
Secondary air [B] is heated to a high temperature before entering the firebox just below the baffle. This air does not influence how fast the fire burns, but is critical in ensuring a strong flame and a clean burn, even when the heater is burning slowly.

Start out right:

When lighting a cold woodheater always use sufficient dry kindling to establish a good fire quickly. Place kindling and small wood in the fire-box so that there is at least 2cm between each piece. This allows air to circulate freely and leads to faster combustion and cleaner burning.

As well as putting plenty of paper underneath, put two or three loosely crumpled sheets of newspaper on top of the wood when first lighting the heater. The paper will burn rapid-ly, heating the flue and creating a draught quickly.

It is also important to get the wood-heater hot as quickly as possible. To do this the air controls should be left fully open for at least 20 minutes to create the right conditions for the wood to burn completely and cleanly right from the start. A hotter fire means there will be less smoke.

Always leave a bed of ash in the fire-box on which to light the next fire, as this will assist burning.

Keep it burning brightly:

Wait for the fire to be fully established before adding extra fuel. Larger pieces of wood should only be added after a bed of coals has been established. If a woodheater is operating well 20 min-utes after lighting or loading, there should be no visible smoke.

Open the air controls fully every time you add more firewood. Failure to do this can generate a lot of smoke. If there is a vigorous flame established when you add more firewood, then most of the smoke will be burnt before it reaches the flue preventing it from polluting the atmosphere. Burning this smoke means you are producing more heat, as well as reducing pollution.

After 20 minutes, when all the wood is burning fiercely, you may then turn down the controls to give a comfort-able fire. If it begins to smoke you may need to open it up a little until it stops.

- **Use plenty of paper and small kindling**
- **Paper will produce a hotter fire more quickly than fire lighters**
- **Only use larger wood when a bed of coals has been established.**

Managing your fire

Air flow is important for good combustion. Modern woodheaters are designed to warm the air before it enters the firebox. This stops the firebox from cooling and helps to burn the wood completely.

Most modern woodheaters draw their main air supply for combustion down the inside of the glass on the door. This constant supply of clean air helps the wood to burn efficiently and at a higher temperature. If a large log is loaded parallel to the door of the heater it will stop this air supply getting into the base of the fire, where it is needed for good combustion.

Packing your firebox too tightly will also cause it to smolder. This causes the worst woodsmoke pollution and is what your neighbours are most likely to complain about.

Another common mistake is to put a single large log on a fire to keep the fire going longer. This causes a lot of smoke because there is not enough surface area for good combustion.

If your woodheater is old, it may not have an effective air supply or it may have other design faults that mean that you may not be able to stop it from smoking. In this case, you may have to consider replacing it.

- **Do not block the incoming air supply with pieces of wood**
- **Do not pack the firebox too tightly**
- **Do not use wood too big to burn properly**
- **Do not use a single large log on the fire**
- **Replace your woodheater if it won't stop smoking**

Keep a flame burning at all times

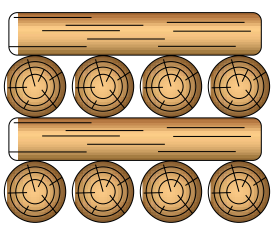
This sequence shows a well maintained fire. New pieces of seasoned wood are added only when a good bed of coals are established. This makes the fire burn efficiently producing less smoke and saving you money.

Use the right fuel for your woodheater

When purchasing your wood you should buy wood that is fully seasoned. You can test whether the wood is fully seasoned by striking two pieces together. Dry wood gives a sharp 'crack' while unseasoned wood sounds more like a dull 'thud'.

If you collect your own wood, or prefer to buy unseasoned wood, plan to get it a year ahead. It takes green wood at least one year to dry out sufficiently to ensure it will be fully seasoned. Some wood may take longer.

To season wood, split and open stack it in a criss-cross fashion to allow for maximum air circulation. A roof to prevent the rain from wetting the wood will speed drying, but ventilation is more important than cover. Do not totally cover the woodpile with plastic or a tarpaulin as this creates a high humidity environment, drawing moisture out of the soil.



It takes at least a year to season firewood properly. Well-seasoned firewood can give up to 40% more heat. Burning green wood may block your flue, causing fires. Check you flue and clean it regularly.

If the wood gets wet, keep it inside or on the porch for a day or two before using it. If it is already fully seasoned it will dry out quickly ready for use.

Freshly cut wood from living trees has a moisture content of around 50%. If cut to firewood lengths and stacked in the open it takes roughly 12 months for the moisture content to drop to good levels for burning - below 30%. Precise drying rates vary from one wood species to another and are climate dependent. Warm and windy conditions with low humidity are best.

Check your chimney or flue for smoke every now and then

Make it a habit to occasionally go outside and check your chimney or flue for smoke.

If, after 20 minutes of operation, there is continuous visible smoke from your chimney or flue, check that you are following the operating tips in this brochure.

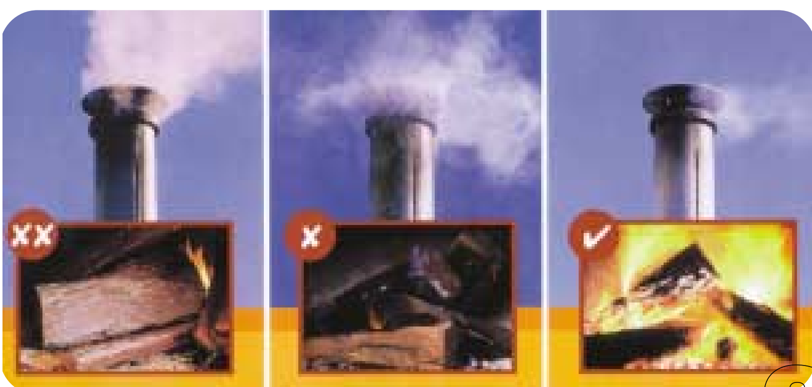
With a little care, even the first few minutes after lighting the heater can be relatively smoke free. Try moving the logs in the heater to improve the air flow or adding a bit more newspaper to increase the draught.

Each model of heater will have certain ways of loading the fuel that give the cleanest burning. You will have to use trial and error to get the best arrangement for your heater.

If the smoke is black it means there is a lot of carbon, or soot, present. Black smoke suggests the fire is too hot, and may damage your heater or flue.

As well as inhibiting proper burning, the moisture and sap in unseasoned wood generates smoke and toxic pollutants. When you use unseasoned wood, a dark sticky substance known as creosote is produced that attaches to the walls of the flue. This will cause the flue to block up and can lead to fire in your flue. Creosote production can be minimised by burning at higher temperatures.

Smoke is wasted fuel so the more a heater smokes the more fuel is wasted.



Overnight Burning

Many people keep their woodheaters burning through the night when it is cold. To do this, they reduce the air flow and maintain a low flame.

If you do this you will need to inspect the flue and chimney regularly for tar and soot build-up. Clean it if necessary, as this will maintain the heater's capacity. A clogged flue decreases performance increasing heating costs and could catch on fire.

If you wish to keep the fire alight overnight, burn it on high for at least twenty minutes before retiring to bed, to ensure a good bed of coals is established and all gases are burnt off.

Don't put large pieces of wood in it that can't burn properly and only reduce the air flow to a level where there is no visible smoke.

Let your fire go out at night

To reduce the level of woodsmoke pollution in badly affected towns and cities it is strongly recommended that you do not burn your wood-heater overnight on reduced air flow.

Even if your woodheater goes out after the family goes to bed, a well insulated house should still be warm in the morning.

It will cost only half as much to let your woodheater go out over night and run an electric heater in the morning for 2 hours, than to keep your woodheater alight for the night causing unnecessary smoke.

Selecting a new woodheater

When selecting a woodheater, the appropriate heat output for your house is important. Operating a woodheater that produces more heat than required will lead to increased heating costs, and create pollution for neighbours when operated on low air flow. It is better to operate a smaller woodheater at its full capacity than a larger one at a lower capacity.

Some design features that promote complete burning in your wood-heater are:

- provision for preheating the incoming primary air to be directed through the active fire or the secondary air above the fire; and
- insulation of the flue as high as possible to minimise condensation fouling and assist both dispersion and air flow to the fire.

Before buying a new woodheater check with your supplier that it meets Australian Standards.

Preferably purchase a cleaner-burning woodheater, one that emits less than 2g of particle pollutants per 1kg of dry wood. For all new wood-heaters a plate is required to be fixed to the heater stating its emission levels.

Check with your local Council before having your woodheater installed, as approval is required under building codes. Make sure the woodheater is properly installed in accordance with manufacturers' instructions.

The installation of second hand woodheaters is not recommended. However if you should do this the heater must be certified to comply with Australian standards.

Don't burn rubbish or treated wood

Remember, your woodheater has been designed to burn firewood.

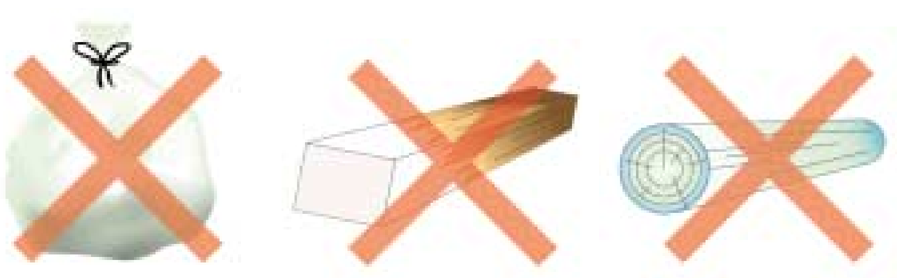
Plastics, such as bags and nappies, are especially bad to burn as they create unpleasant odours and toxic fumes. Burning these items are most likely to lead to complaints from neighours. Burning these also reduces the performance of your woodheater.

Be careful not to use wood treated with copper-chromate-arsenate (the green colour in playground logs) as it releases poisonous fumes when burnt. Wood collected from the seashore is not suitable as it contains corrosive salts.

Ensure your flue is well designed and maintained

Make sure your flue or chimney is high enough to allow the combustion gases to disperse. If you are unsure if your chimney or flue meets minimum height requirements, check with an accredited installer or your local Council.

Do not fit a 'Chinamans cap' or any rain protector which restricts the upward flow of the hot gases. Fit only concentric rain excluders (shown here). If you have a cap on your flue and have tried other measures to reduce woodsmoke with-out success, try removing the cap.



Don't burn garbage, painted or treated timber or particle board as these produce toxic fumes.

Save money and insulate

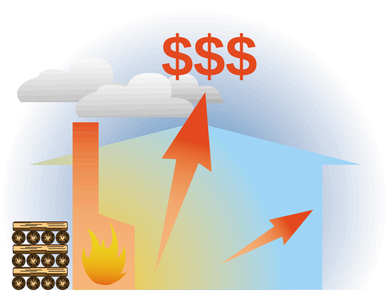
If your ceiling is uninsulated, between 30 and 40% of the heat from your woodheater is going straight through the roof. This means you need to burn more wood which costs more money and results in more air pollution.

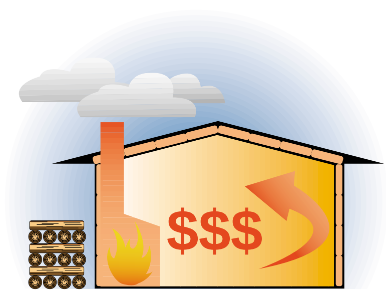
If finance is a problem, do one room at a time beginning with the room with the woodheater in it. You will probably find the room stays warm enough that you can let your heater go out overnight without waking up to a cold house.

If your ceiling is already insulated check the insulation to ensure it is still adequate. Some types of insulation pack down or move over time and loose some of their insulating properties.

Other areas of heat loss are windows and doors. Thick curtains with pelmets and draught proofing around doors will also assist in maintaining heat in the house over night. Close the doors to any rooms you do not wish to heat.

If your house is well insulated it will be around 7°C warmer than an uninsulated house.





Avoid using your woodheater on poor air quality days

In some locations forecasted air pollution levels are reported during winter in the daily press. 50 micrograms of particles per cubic metre* of wood burnt is the accepted Australian Standard for particle pollution. Above 50ug/m^3 the air quality forecast will be "poor".

At this level, particle pollution is likely to cause adverse health effects, especially among the elderly, the very young and sensitive groups such as those with lung disease, heart disease and asthma.

If the weather prediction is for levels of air pollution above 40ug/m^3 you might think about using an alternative source of heat, even if just for a night or two. Even well operated wood-heaters emit some smoke during lighting and refueling. If you need to use your woodheater make sure you let it go out before you go to bed, rather than having it smolder overnight.

You may have some form of alternative heating such as oil, gas, or a fixed electric heater. Consider using these on those especially cold nights and mornings. Think seriously about topping up the gas cylinders or buying a few gallons of oil for the oil heater. These measures will help to reduce woodsmoke when high levels of pollution are forecast.

* ug/m^3

Woodsmoke is an Environmental Nuisance

An environmental nuisance is any emission of a pollutant that may unreasonably interfere with a persons enjoyment of the environment or cause harm to the environment.

Some Councils have provisions for penalties against householders who cause an environmental nuisance by operating excessively smoky woodheaters. There may also be State or Territory regulations that impose penalties against householders who continue to operate woodheaters badly.

In some regions of Australia targeted education programs are being conducted to educate woodheater users in the better operation of their woodheaters. Under these programs specially trained environmental health officers are on hand to assist householders with woodsmoke problems. You may wish to contact your local government Environmental Health Department or State Environment Protection Authority who may be able to assist you with information about programs in your area.

A woodsmoke training program has been developed by Environment Australia and is available for local government authorities wishing to increase their capacity to manage woodsmoke as an environmental nuisance.

Contact Environment Australia on (03) 6274 1641 for further information.

Natural Heritage Trust

Helping Communities Helping Australia

A Commonwealth Government Initiative

Quick Tips to Reduce Woodsmoke

1. Always use properly seasoned dry wood in your woodheater
2. Get a hot fire going quickly with plenty of paper and small kindling
3. Keep air controls set high enough to keep your fire burning brightly
4. Only use larger pieces of wood when the fire is well established
5. Check you chimney or flue at least once every evening for smoke
6. Consider the well-being of your neighbours

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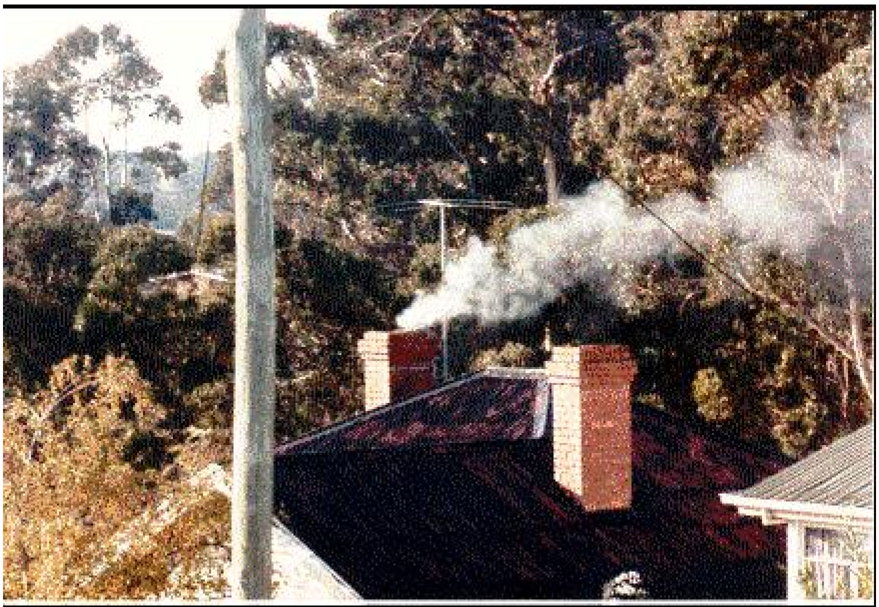
For more information visit our website:
www.ea.gov/woodsmoke

Woodsmoke Handbook: Woodheaters, Firewood and Operator Practice



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2005

Western Australia Edition

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Dr John Todd has been involved with research into the testing and design of woodheaters since 1978 and has published over 120 technical papers and reports on biomass and woodsmoke. He was chairman of the Australian Standards Committee that developed the safety, quality, performance and emission standards for woodheaters and has represented Australia on the International Organization for Standardization technical committee dealing with woodheaters. He works as an environmental consultant and teaches environmental management and environmental technology subjects on contract to the School of Geography and Environmental Studies, University of Tasmania.

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Glossary

This glossary provides some basic definitions of terms commonly used in air pollution and woodheater studies. Scientific dictionaries or specialist textbooks will provide more precise definitions if required.

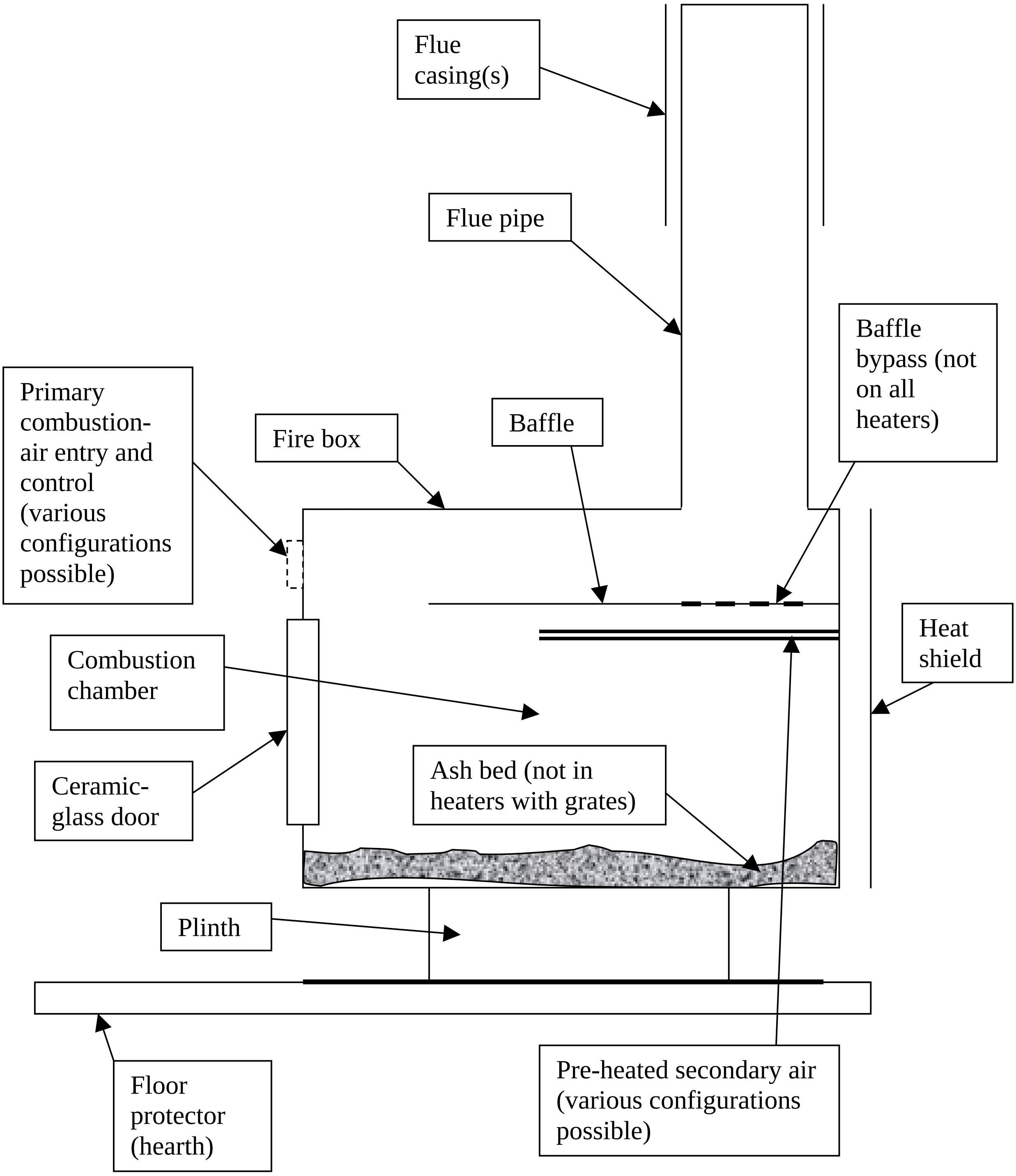
Ambient air	Any outdoor air. When measuring concentrations of pollutants in ambient air, the concentration may be local or representative of a region (the two can be quite different).
Chimney	A masonry or concrete construction for discharging unwanted gas from a building.
Concentration	A measure of the quantity of a pollutant in a stated volume of air, water or solid. When stating or reading concentrations the units must be carefully considered. It is also important, when considering air pollutants, to know what time the measurement is taken over (one hour or 24 hour averages for ambient air are common).
Emission factor	The weight of particles or a specific chemical compound emitted to the atmosphere (expressed in grams, milligrams or micrograms) per oven-dry kilogram of fuel burnt.
Emission rate	The weight of particles or a specific chemical compound emitted to the atmosphere (expressed in grams, milligrams or micrograms) per hour of operation of the appliance.
Epidemiology	A study of diseases and broad health impacts on a community. Large-scale epidemiological studies can identify relatively small risk factors such as the health impact of fine particles in the atmosphere.
Firewood	Wood used as a domestic fuel in stick form (logs, kindling).
Flue	A passage for discharging gases out of an appliance into the ambient air. In common use, the metal flue pipe used with woodheaters is often referred to as 'the flue'.
Fuelwood	A general term used to identify any woody biomass used as a fuel. It includes firewood, pellets and wood used for fuel in industry (e.g. wood chips, sawdust, shavings).
Moisture	The moisture content of firewood is usually expressed as the weight of water as a percentage of the total weight of the firewood piece. The water is measured taking the weight loss when drying the wood at 100 to 105ºC. So, for a 2kg log, if the weight after drying is 1.4kg, the water is 0.6kg and the moisture is expressed as 0.6/2x100= 30%. This is known as the moisture content expressed on a wet-weight basis. Care must be taken when referring to moisture content because the convention in forestry is to express the moisture as a percentage of the oven dry weight, so in the example above the moisture on a dry-weight basis would be 0.6/1.4x100=43%. Many electronic moisture meters are calibrated on the dry-weight scale because foresters use them.
Particles (particulates)	Small particles, either solids or droplets of liquid, suspended in the atmosphere. Particles with diameters less than 10 microns (micro-metres, μm, 10^{-6}metres) are referred to as respirable particles (i.e. they are breathed into our lungs). Particles with diameters less than 2.5μm are referred to as fine particles.

Pellets	Wood pellets are a common domestic heating fuel in North America and Europe. They are small pellets, about the size of bran breakfast cereal, and are used in specially designed pellet burning woodheaters.
Pollutant	A pollutant is a discharge into the environment that does, or could, cause adverse impacts on human or ecological health, damage property or cause loss of amenity. In woodsmoke, pollutants include many solid and gaseous compounds.
Units	The units used for reporting woodsmoke emissions and ambient smoke levels must be carefully noted. Emissions from heaters and fireplaces are usually reported as emission factors (g/kg) or emission rates (g/h). Individual chemical species are usually reported as emission factors (g/kg) or concentration within the emitted particles (mg/kg). Ambient concentrations are usually reported as $\mu g/m^3$ (micrograms per cubic metre).
Woodheater	A woodheater is a controlled-combustion, residential, heating appliance. In North American literature it is referred to as a wood-stove.
Woodsmoke	The products of wood combustion consisting of fine particles and gases. The particles cause the smoke to be visible by scattering light. It is usually white or pale blue in appearance.

Prefixes

E	Exa = 10^{18}		
P	Peta = 10^{15}	f	fermi = 10^{-15}
T	Tera = 10^{12}	p	pico = 10^{-12}
G	Giga = 10^{9}	n	nano = 10^{-9}
M	Mega = 10^{6}	µ	micro = 10^{-6}
k	kilo = 10^{3}	m	milli = 10^{-3}
		c	centi = 10^{-2}
		d	deci = 10^{-1}

Schematic diagram of a typical freestanding woodheater marketed in Australia. The design shown incorporates a solid base, where the fuel load burns on a bed of ash. The ash is periodically removed. Some woodheater models incorporate a grate, allowing ash to drop through into an ash-tray used for ash removal.



Summary

This Handbook is intended to provide background information for local and state government officers involved with the management of woodsmoke from residential heating.

The Handbook summarises available information about the number of households in Australia using firewood for space heating and the total firewood consumed for this purpose each year. This addition includes an Appendix with additional information specific to Perth and Western Australia. The Handbook also provides some information about basic wood combustion principles, and the design of woodheaters.

The health impacts of woodsmoke are discussed. It is pointed out that although there is still some uncertainty, there is a strong likelihood that present concentrations of woodsmoke in typical Australian suburbs in winter are high enough to cause health problems, possibly running to millions of dollars in health costs each year.

The practical issues discussed (i.e. those that provide suggestions about reducing woodsmoke) include:

- observing woodsmoke,
- the levels of woodsmoke that are measured in the suburbs,
- how to operate a woodheater to produce less smoke,
- how to measure moisture content of firewood,
- problem solving when faced with a smoky heater,
- the advantages and disadvantages of alternative types of heating, and
- how state and local government can help reduce woodsmoke emissions.

The focus of the argument throughout this Handbook is that people can operate their woodheaters to produce much less smoke than they now do. So far, we have not hit on the right regulatory and enforcement approaches to achieve this goal. The workshops with local government officers around Australia are providing information that might help reduce woodsmoke. The workshops are also collecting ideas from you, and passing them on to other local government and state government officers. With a little luck and some persistence we should be able to improve winter air quality across the country and improve community health and amenity.

A list of web sites and reports for further reading, and a list of references cited in this Handbook are also provided.

Recent Western Australia Woodsmoke Studies

Two recent reports prepared by the Department of Environment provide valuable information on woodsmoke mitigation programs. The two reports are part of the *Perth Air Quality Management Plan for Haze Reduction*.

"Pilot Wood Heater Replacement Program 2004 – Program Review" (December 2004)

"Pilot Home Heating Survey 2004 Report" (2005)

A third report is in preparation:

"Future Policy Options for Managing Winter Haze in Perth Based on a Review of 'Halt the Haze 2004'"

1 Introduction

This Handbook has been prepared to assist local government officers, and others, in identifying and dealing with localized woodsmoke nuisance and broad-scale woodsmoke pollution. Local government employees, usually environmental health officers (EHOs), are often faced with complaints about woodsmoke nuisance. Occasionally, state pollution control agencies also receive complaints relating to woodsmoke. Additionally, certain regions in Australia have unacceptable air quality in winter because of residential use of firewood and authorities are required to deal with this longer-term problem. The tasks of dealing with complaints and reducing overall smoke levels can be helped through the development of general understanding of firewood properties, wood combustion and heater technology. Controlled combustion heaters (woodheaters) and open fireplaces are the main sources of winter woodsmoke in many urban areas. Wood-fuelled cooking stoves and wood-fuelled water heaters also emit woodsmoke but are considered less of a problem because few are used except in isolated rural households.

In the past four years, some regions around Australia have appointed local government employees specifically to deal with woodsmoke problems. The roles of these officers, together with EHOs dealing with woodsmoke, are:

- to identify households with heaters that emit excessive quantities of smoke, provide advice to these households to help them reduce smoke emissions or, if no improvement is achieved, utilize appropriate state and local government regulations (where available) to force the household to reduce emissions to acceptable levels;
- to participate in community education programs aimed at making all users of woodheaters and open fireplaces more conscious of correct operation and smoke minimisation;
- to check firewood supplies to ensure wet wood is not being sold for immediate use;
- to provide advice on ways to reduce heating needs and the range of heating appliances available; and
- in some cases, to conduct monitoring of ambient particulate concentrations in areas where woodsmoke is thought to be a problem.

With these roles in mind, this Handbook provides information covering:

- the combustion properties of wood;
- an understanding of the design and operation of woodheaters;
- the difference between high-performance and substandard woodheaters;
- the chemistry of woodsmoke and its environmental and health impacts;
- Australian Standards for woodheater installation and emissions;
- scientific measurement of ambient woodsmoke;
- observed concentrations of woodsmoke in urban areas;
- the proper operation of woodheaters and the typical causes of excessive smoke;
- how to identify smoky chimneys;
- how to recognise a woodheater that has been tampered with;
- identification of wet wood and testing wood moisture content;
- the burning properties of different types of wood; and
- the range of alternative, cleaner heating technologies available.

This rather ambitious coverage of firewood, woodheater and woodsmoke issues is dealt with at a level that is intended to avoid purely academic issues and concentrate on practical wood combustion that leads to a better understanding of the appliances, their use and the potential harm woodsmoke can cause.

1.1 Firewood use in Australia

Firewood is a popular and important residential heating fuel throughout Australia. It provides very effective and low cost heating; it employs many people, particularly in rural areas; and if properly managed it is renewable and does not contribute significantly to greenhouse gas emissions. However, poor combustion leads to high emissions of smoke and inappropriate firewood harvesting is contributing to ecological damage in some regions.

As shown in Table 1.1, about one and a half million Australian households, some 4 million people, use firewood for heating. They burn about 4 million tonnes of firewood each year. A rough estimate of pollution from this heating suggests about 40,000 tonnes of fine particulates and 240,000 tonnes of carbon monoxide are emitted into the atmosphere each year.

Table 1.1

Estimates of the number of households using firewood for as their main heat source and secondary heat source and estimates of total firewood use.

Firewood using households 2002						
State	**Main**	**t/year**	**Secondary**	**t/year**	**Total (t)**	
NSW	291900	3	115000	1	990,700	
Vic	228500	4.3	180000	1.5	1,252,550	
Qld	138500	2.9	34000	1	435,650	
SA	106700	3	25000	1	345,100	
WA	166300	2.5	40000	1	455,750	
Tas	85800	4.8	12000	2	435,840	
NT	1200	3	450	1	4,050	
ACT	5300	3.7	4000	1.5	25,610	
Australia	1,024,200		410,450		3,945,250	firewood (t)
					1,434,650	houses (no.)

Sources: Number of households using firewood as main heat source (ABS 2002)
Number of households with secondary firewood use (adapted from Todd *et al*. 1989a)
Firewood use per household (adapted from Todd *et al*. 1989a)

As illustrated in Figure 1.1, the popularity of firewood for heating rose sharply from 1978 when the price of heating oil suddenly doubled. Around 1992 the proportion of households choosing firewood as their main heating fuel peaked. From 1992 to 2002 the proportion of households using firewood as their main heating fuel dropped quite significantly, but because of population increases the total number of houses using firewood declined slowly (dropping by about 1% per year). The past few years has seen a slight increase in the rate of decline of the total number of woodheaters and open fires and a decrease in firewood use. The total number of households using firewood seems to be declining by about 30,000 per year at the moment. The next ABS survey of heating preferences will give a better indication of this trend.

One important aspect of the trends in firewood use shown in Figure 1.1 is the rapid growth in popularity of firewood through the 1980s (almost all this growth is attributed to woodheaters rather than open fireplaces). Woodheaters have a typical working life of 20 to 25 years. This means that many households with woodheaters installed in the 1980s will have to consider either replacing their woodheaters or moving to another form of heating about now. This gives a ‘window of opportunity’ to influence both choice of heating fuel and choice of low-emission woodheaters.

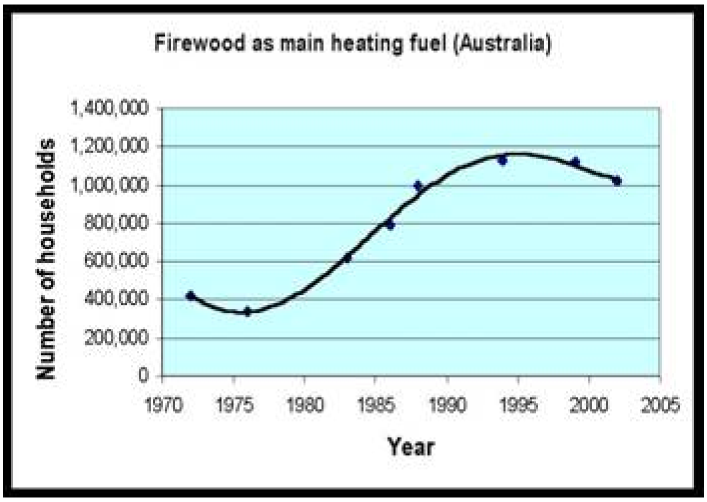


Figure 1.1 Number of households in Australia using firewood as their main heating fuel.

The goal of the woodsmoke management program is to significantly reduce the quantity of particles and gases emitted from woodheaters while maintaining the benefits woodheater use and firewood supply bring to the Australian community. Technically, it would be possible to reduce emissions to just one third of present levels without reducing the number of households using firewood. However, it has proved very difficult to convince many of the householders with woodheaters that they must take personal responsibility for their smoke emissions. Some are ignorant of the problems they are causing, some only think of it now and then, some don’t care, and some seem to think that no-one should be telling them what to do with their heating. The same applies to some, hopefully only a minority, of firewood merchants who sell wet firewood.

2 Wood Combustion

This section provides a brief introduction to combustion processes in wood. It is useful to have some understanding of this because it makes it easier to understand why woodheaters smoke and what can be done to reduce smoke.

The combustion processes taking place when burning wood are quite different to other solid, liquid or gaseous fuels (Figure 2.1). An external heat source is required to start the process of drying and thermal decomposition of wood. At temperatures above about 250°C, exothermic reactions (i.e. giving off heat) commence and the decomposition process can become self-sustaining. This process of thermal decomposition causes chemical changes in the complex organic molecules that constitute lignin, cellulose and hemicellulose. Organic gases are released, leaving a carbon-rich solid residue. Under controlled conditions it is possible to produce a solid residue of relatively pure carbon. The carbon (charcoal) burns as a result of surface reactions (with little gas release) leaving a residue of ash. Ash content is low, typically 0.5% by weight of dry wood (slightly higher for bark). The energy content of wood does not vary much from one species to another; hardwoods typically release 19 MJ/kg (oven dry wood basis) and softwoods 20 MJ/kg, provided combustion is complete.

In domestic combustion of firewood, air pollution occurs because of incomplete combustion of the volatiles released from the wood. Volatile organic compounds (VOCs) are released from wood at temperatures as low as room temperature, but substantial, rapid release only begins when exothermic reactions commence (250°C). The volatiles are a complex mix of combustible gases. The ignition temperature of the gas mix is around 600°C. Many of the unburnt volatiles released from wood will condense to form fine particles when cooled to near-ambient temperatures. This is what we observe as woodsmoke. Relatively low gas velocities in domestic appliances usually mean that little ash is entrained in the flue gas so inorganic compounds in woodsmoke are not an issue.

Incomplete combustion of the volatiles occurs for several reasons. When a batch of wood is added, the heat from the coals and appliance soon causes gases to be released from the wood. When lighting a fire, the burning paper and kindling provide this heat. If the volatiles are not exposed to a high temperature source (flame or glowing charcoal) they will not ignite and simply pass up the flue/chimney causing pollution. If the gas does ignite, it can be quenched if it is cooled by a cold surface (e.g. the metal walls of a cool firebox) or cool combustion air. If the combustible gas is not well mixed with air (oxygen) it will not burn. If combustion air is reduced to slow the combustion rate, there may be insufficient oxygen for complete combustion. In practice, a small proportion of the volatiles escape the combustion zone and condense to form the fine particles in visible smoke. Emissions of particles are greatest in the first half-hour or so after lighting or a new batch of fuel is added.

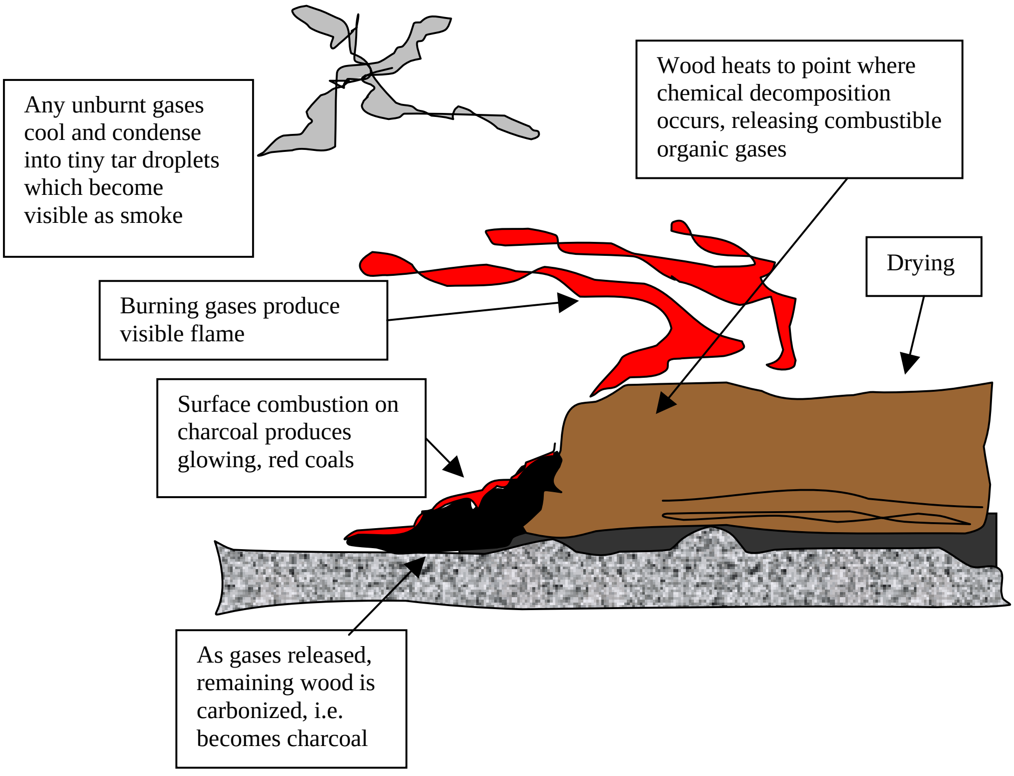


Figure 2.1
Schematic diagram of a burning log showing different stages of combustion.

2.1 Chemistry of woodsmoke

Woodsmoke has a complex chemical composition. It consists of a mix of low molecular weight carbon based gases and many large molecular weight organic compounds in the particles. The main polluting gas emitted by woodheaters and open fireplaces is carbon monoxide (CO). The concentration of CO in the emission from a smouldering woodheater is high enough to kill someone if released into an enclosed space. Other gases emitted include methane (CH_4), ethane, propane and other low molecular weight organic gases. Generally, other 'priority air pollutant gases' such as sulphur dioxide (SO_2) and oxides of nitrogen (NO_x) are only emitted in very small quantities and are not considered a problem from woodheaters.

The particles (or condensed droplets of tars) are made up of a complex mix of organic compounds, with the chemistry changing depending on combustion conditions in the heater. Essentially the combustion chamber of a woodheater is like a chemical manufacturing process where the large molecules of lignin and cellulose making up the wood are converted into other organic chemicals. The organic chemicals include some known to be respiratory irritants and known or suspected carcinogens. One significant group is known as poly-aromatic hydrocarbons or PAH. Increased interest from pollution control authorities in a range of trace chemicals known as *air-toxics* has led to greater attention being paid to woodsmoke. A recent study conducted by CSIRO for Environment Australia has determined emission factors for 65 chemicals in woodsmoke and will assist authorities in developing control strategies for these chemicals. This report is available from the Environment Australia web site (see reference list – Environment Australia 2002).

Table 2.1, based on US measurements, lists just some of the chemicals measured in woodsmoke. While this looks like an impressive list, even frightening, it is important to always consider the level of exposure rather than simply the presence or absence of these chemicals. In some cases they are in extremely small concentrations, in which case they may, or may not, be considered a problem.

3 Design Features of Woodheaters

The important design considerations for woodheaters (as opposed to open fireplaces, which are discussed at the end of this section) are:

- to achieve good control of combustion rate and heat output;
- to maximise efficiency and heat output;
- to minimise smoke;
- to ensure safety;
- aesthetics;
- convenience and
- cost.

Only the first three dot points are discussed in this handbook, but all of the above are considered very carefully when setting up to manufacture a new woodheater model. In some cases trade-offs have to be made to achieve a balance between the various design features. This is a manufacturing decision that is only constrained by the regulations applying to safety and emissions of smoke.

Table 2.1

Emission factors for various compounds for woodheaters selected from US EPA (1996). The numbers are for non-catalytic or conventional woodheaters.

Compound	g/kg
Ethane	0.735
Ethylene	2.245
Acetylene	0.562
Coronene	
Propane	0.179
Propene	0.622
i-Butane	0.014
n-Butane	0.028
Butenes	0.596
Pentenes	0.308
Benzene	0.969
Toluene	0.365
Furan	0.171
Methyl Ethyl Ketone	0.145
2-Methyl Furan	0.328
2,5-Dimethyl Furan	0.081
Furfural	0.243
o-Xylene	0.101
PAH total	<0.250
Acenaphthene	0.005
Acenaphthylene	0.016
Anthracene	0.005
Benzo(a)anthracene	<0.0005
Benzo[*a*]pyrene	0.003
Benzo(e)pyrene	0.001
Benzo[*b*]fluoranthene	0.004
Benzo[*k*]fluoranthene	<0.001
Benzo(g,h,i)fluoranthene	0.014
Benzo[*g*,*h*,*i*]perylene	0.028
Benz[*a*]anthracene	<0.001
Dibenzo[*a*,*h*]anthracene	0.004
Biphenyl	0.011
Chrysene	0.005
7,12-Dimethylbenz(a)anthracene	0.002
Fluoranthene	0.004
Fluorene	0.007
Indeno[1,2,3,*cd*]pyrene	0.010
12-Methylbenz(a)anthracene	0.001
9-Methylchlolanthrene	0.002
3-Methylchlolanthrene	<0.0005
1-Methylphenanthrene	0.015
Naphthalene	0.072
Nitronaphthalene	BDL
Perylene	0.001
Phenanthrene	0.059
Phenanthrol	BDL
Phenol	<0.001
Pyrene	0.004

The reason for including this table in the Handbook is to illustrate that woodsmoke has a very complex chemistry. It also illustrates that scientists are working on the chemistry of woodsmoke with a view to better identifying the potential health risks associated with exposure to smoke.

BDL = below detection limit.

Domestic wood-burning appliances are usually batch-fed (i.e. a load of firewood, usually 5 to 15 kg, is placed into a heater at one time). As the load of fuel burns down, a new batch of one or more logs is added to the bed of hot charcoal. In a batch-fed appliance, the only way to control how fast the fuel burns is to control the amount of combustion air entering the base of the fire. Insufficient combustion air is a potential cause of incomplete combustion and higher smoke emissions.

Another critical design feature in residential woodheaters is the fact that most rely on natural draught up the flue to draw air into the combustion chamber. Natural draught is a function of the height of the flue and the temperature of the flue gas. If too much heat is extracted from the heater itself, the flue gases will be too cool to induce good draught and insufficient air will be drawn into the heater. This means there will always be some heat 'lost' out the flue and so a woodheater can never be 100% efficient. In practice an upper limit of around 80% is the best efficiency possible with a natural draught heater. Very few heater models achieve this because sophisticated heat exchanges are required and these add to the cost.

3.1 Sub-standard design

From an air quality point of view, many of the woodheater models sold into the Australian market between 1978 (the commencement of the boom in woodheater sales) and about 1990 (when the Australian Standard for woodheater emissions became available in draft form) were sub-standard. During this period, marketing emphasis was on achieving high heat outputs and long burn times between refuelling, i.e. overnight-burn. Even though woodsmoke was considered a serious pollutant in the United States, pollution control authorities in Australia generally ignored it.

High heat output is relatively easy to achieve (at least up to about 25kW) simply by allowing more combustion air into the firebox and having sufficient heat exchange area to let the heat out and into the room. Even quite small woodheaters were achieving peak outputs of 20kW. Most woodheater models burnt relatively cleanly at these high combustion rates. However, in some designs the heater would get so hot that the fuel load would be gasified much too quickly, so much so that even with lots of combustion air the heater would smoke profusely, usually a black foul-smelling smoke.

Slow burn was achieved by designing the combustion air control so that it could be shut off completely. This meant that the heater operator, with a little experience, could make the fire burn (more like smoulder) for 12 hours or more on one load of wood. [*In my laboratory, I was able to get burn times of up to 36 hours on one load of wood in a large heater and still have it hot enough to light a new load of wood when added. Under these air-starved conditions the heater will smoke profusely, often for many hours. The worst smoke emissions I was able to achieve in the laboratory were about 100g/kg of particles, or about 100 times worse than the best heaters now available*.]

High smoke emissions also lead to rapid creosote build-up in the flue. As the flue clogs up, the heater burns even slower and smoke gets worse. [*I have heard stories from chimney sweeps of flues that have totally blocked within two weeks of their last cleaning. I have seen sections of flue where only a pencil-sized hole remained in the middle of the creosote-blocked flue.]*

Having pointed out how poor some of these early designs were, it is important to note that most of these heaters can still be operated so that they produce only modest smoke emissions (say 4 or 5 g/kg) if the householder takes particular care.

3.2 High performance woodheaters

From around 1990 Australian woodheater manufacturers began to pay more attention to woodsmoke emissions and to re-design their heater models to be much cleaner burning. The initial step for most manufacturers was to simply put a 'stop' on the combustion air control so that it could not be totally shut off. This immediately improves smoke emissions at the extreme slow-burn end of the heater operation range. It meant that with little change to manufacturing processes, heater models could be modified to pass the Australian Standard for emissions. However, in some cases this meant the heater would no longer burn overnight, and so in these cases it was common for householders, and even retailers and installers, to remove the 'stop', thus totally negating the pollution reduction modification on the heater.

Gradually, as heater models were totally redesigned, a new type of low emission woodheater entered the Australian market. These designs incorporated many features to reduce emissions. The main features are:

- a fixed minimum combustion air supply (one that is not easy to modify);
- a primary air supply to control combustion rate and a secondary air supply that always provides combustion air above the fuel load to burn off the gases released;
- a high level of pre-heating of combustion air (both primary and secondary) so that air quenching does not occur;
- insulation of the combustion chamber, usually with firebrick, to keep flame temperatures as high as possible and to prevent flame quenching on cool surfaces;
- firebox design to achieve maximum turbulence in the flame to mix gases and combustion air; and
- a well designed heat exchange to extract as much heat as possible once combustion is complete.

The requirements to sell only certified heaters, that is woodheaters that comply with the Australian emission standard, came into force gradually from 1992 when the standard was first released. It has taken ten years for most states and territories to adopt the standard, but even now some woodheaters that do not comply with the standard may be legally sold in one state (South Australia). The 1992 edition of the standard (AS4013) set a maximum emission factor of 5.5g/kg for compliance. By the late 1990s, the wood heating industry and some pollution control authorities decided a more stringent limit was desirable and the standard was revised with a maximum allowable emission factor of 4g/kg.

Some heater models achieve emission factors well below this maximum allowable limit. Unfortunately the certification compliance plate attached to all new heaters that are certified as clean burning does not give the actual emission factor. This oversight is being corrected in a revision to AS4013 now in progress. In future, compliance plates will state the actual emission factor, but in the meantime consumers should be encouraged to get details of emission factors for the particular heater models they are considering purchasing from the retailer. Figure 3.1 shows the number of heater models with various emission factors.

3.3 Shortcomings in modern woodheaters

An audit program, funded by Commonwealth and state governments, in 2002/03 selected 12 popular woodheater models from retail outlets and tested them to see if they complied with

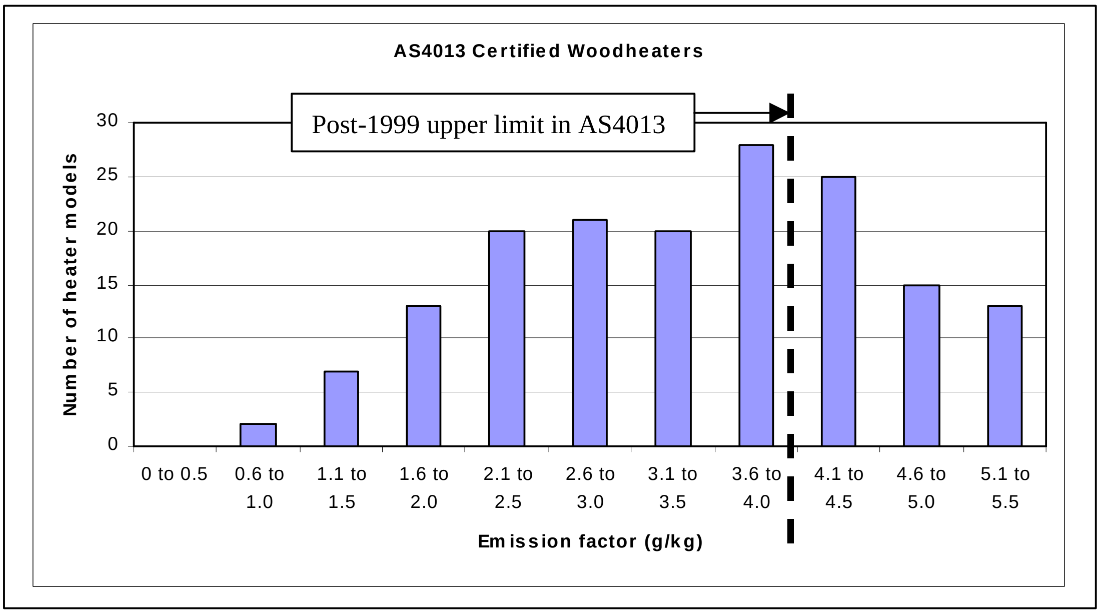


Figure 3.1. Emission factors for certified woodheaters based on information provided by the Energy Information Centre, Adelaide.

their stated emission factors (Bagchi *et al*. 2003). The results were disturbing, with seven failing to meet the required emission standard of 4 grams of smoke per kilogram of wood burnt, including five models that emitted more than double the allowed limit. In addition, 35 woodheater models were closely examined to see if the model being sold was identical to the model tested for emissions. Of the 47 heaters checked for design changes, including the 12 tested, only 45% were the same as when originally tested. The results of this audit program cast doubts over the effectiveness of the emission standards approach as applied between 1992 and the present. Clearly, self-regulation has not worked, and more government intervention is required. At time of writing (April 2005), the woodheater industry and pollution control authorities had still not determined the mechanism for ensuring future compliance with the intent of the emission regulations.

In addition to this failure by some parts of the industry to comply with the emission standard, the standard itself has several shortcomings. For example, the standard tests the slow burn emissions with any heater fans switched off (provided this is stated in the heater operating instructions). Unfortunately, many households leave the fan switched on during slow burning. This can lead to very large increases in emissions because it cools the firebox off too much. This problem could be overcome if the standard required all fans to be fitted with a temperature controlled switch that automatically turned the fan off when the heater became too cool. This, and several other shortcomings in the standard, suggest that a rethinking of the standard is required.

3.4 Pellet-fuelled heaters

In North America and Europe wood-pellet stoves, with automatic fuel-feed, are popular. The continuous addition of fuel allows much closer control of combustion conditions and lower emissions. When low heat output is needed less pellets are fed into the combustion chamber, but ample air is still supplied so the fire is not starved of oxygen. Emission factors of around 1g/kg are typical (i.e. at the low end of the woodheater range). Significantly, pellet heaters are much less subject to operator carelessness and so they achieve good emissions all the time. Some pellet-fuelled woodheaters have been marketed recently in Australia, including one locally manufactured model. Pellets cost around $400 per tonne, so these heaters are still quite expensive to run. If a cheap and readily available supply of pellets becomes available it is likely the pellet heaters will increase their market share.

3.5 Open fireplaces

Open fireplaces rely on radiant heat from the flames and glowing coals to transfer heat. The fireplace draws large quantities of air out of the living room and up the chimney. For an average size room (40m^3), an entire room-full of air can be drawn up the chimney every 5 minutes. This limits the efficiency of an open fire to about 10%, in fact, if a home is centrally heated, use of an open fireplace will usually cause an overall loss of heat (i.e. negative efficiency). The large airflow into the fireplace also cools down the flames, quenching them (see discussion of wood combustion above). This leads to the relatively high emissions of smoke from open fireplaces (typically 12 to 15g/kg emission factor).

There are ‘circulating fireplaces’ available that increase efficiency by circulating air in ducts around the fireplace and blowing the warmed air back into the room. They may also have adjustable dampers in the chimney so that the airflow through the fireplace can be reduced. These improvements may double the efficiency of an open fire. Some of the fireplace insert manufacturers have also designed emission reduction features into their appliances and they are capable of meeting the 4g/kg emission factor even though the Standard (AS4013) does not specifically require them to do so.

4 Environmental and Health Impacts of Woodsmoke

In recent years there has been a lot of attention paid to fine particles in the atmosphere, that is particles less than 2.5 microns (one micron (μm) = one millionth of a metre) in diameter. These very small particles have the unfortunate property of being able to penetrate deep into the lungs, while larger particles in the air are trapped in the nose or throat. Even in 'clean' air we breathe millions of fine particles into and out of our lungs in the 10,000 litres of air that pass through our lungs each day. In polluted air, it seems that the normal cleansing functions of the lungs become overloaded and health problems, linked to the number and chemical composition of the fine particles, become apparent.

In the United States, several studies in recent years have indicated that for each 10μg/m^3 increase in fine particles (PM10, averaged over 24 hours) there is a 1% increase in mortality (e.g. Schwartz 1993, Dockery *et al*.1992). In Europe, a similar, but slightly smaller 0.5% increase has been measured (Vedal 1997). At this stage, the epidemiological studies suggest that the chemical composition of the particles is not a critical factor; it is simply the mass of these fine particles in the air. These findings have far reaching implications for air pollution control. The situation is complex, with considerable variation in findings from one study to the next, and some experts feel that there may be more to the problem than simply the concentration of fine particles (Vedal 1997).

Despite some uncertainty, these are very significant findings for those involved in pollution control. Much stricter controls are being imposed on fine particle concentrations in the air. For example, the Australian national goal for fine particles in ambient air is 50μg/m^3 (EPHC 2003); a significant reduction from the previous 'guideline' of 120μg/m^3 (Streeton 1990).

One of the important aspects of all these studies on the health impacts of fine particles is that there does not seem to be a lower limit that is perfectly 'safe'. In other words - the cleaner the air is, the better our health is. Thus the national goal of 50µg/m^3 is a pragmatic limit, i.e. one that will not cost too much to achieve, rather than a concentration that has no health impact. The National Environmental Protection (Air Quality) Measure (Air NEPM) suggests that fine particles in air contribute to about 2400 premature deaths in Australia each year. It is likely that woodsmoke contributes 5 to 20% (the numbers are still very uncertain) of those particles, so it could be argued that woodsmoke contributes to premature deaths of some 120 to 480 people each year[1]. This is a very worrying outcome of wood heating, especially as it is a pollution source that could be relatively easily reduced.

Another worrying health matter is the chemical composition of woodsmoke. The many chemical in woodsmoke (discussed in section 2.1) include several that are considered carcinogenic or known to cause respiratory problems.

Thus, even though it is difficult to 'prove' that woodsmoke presents a significant health risk at the concentrations typically observed in Australian suburbs, there is good reason to believe that people are adversely affected, especially those that suffer from other respiratory or heart problems.

5 Australian Standards

In response to concern from fire authorities, the insurance industry and academics about safety and air pollution, the Standards Association of Australia (SAA), now Standards Australia, established a committee to prepare a series of Australian standards for residential solid-fuel burning appliances - Committee CS/62. The Committee first met in 1983 and determined its first priority should be to prepare a standard for the safe installation of solid-fuel burning appliances.

5.1 Safety

Between 1978 and 1984, when the number of woodheater installations in Australia were increasing rapidly, building inspectors were recommending that installations should comply with the installation standard for oil burning heaters, AS 1691. The higher flue temperatures, more corrosive combustion products, and higher heat outputs from woodheaters meant that the oil heater installation standards were totally inadequate. A study of house fires in Tasmania from 1980 to 1983 indicated one house fire per year attributed to a woodheater for every 1000 heaters in use (Todd *et al*. 1985). When the draft Standard was released for public comment in 1984, it was rapidly adopted as the safest method of installation even though it had not been formally published.

The Standard AS 2918-1987, 'Domestic solid fuel burning appliances – Installation' (SAA 1987) adopted the usual practice for standards of this type in providing both performance based options and 'deemed to comply' options based on worst case situations (Todd 1987). The Standard applied to woodheaters, slow combustion cooking stoves, solid-fuel water heaters and solid fuel furnaces. It did not apply to masonry open fireplaces. From a practical installation perspective, the Standard meant that all manufacturers of solid-fuel burning residential appliances would have to have their installation requirements checked by a registered laboratory. The test procedure specified in the Standard included verification that

[1] In a recent conference paper I have estimated that the health cost of woodsmoke is $200 to $800 million per year (see Todd 2005 in reference list).

minimum installation clearances for the appliance and flue were adequate and that sufficient protection for the floor under and around the appliance was provided. Two test regimes were required, one for ‘normal’ high fire operation and one for ‘flash-fire’. Testing was to be carried out using air-dry *Pinus radiata* timber. A softwood species was chosen because softwoods were shown to give higher temperatures in the appliance and flue than hardwoods. In the high fire test, fuel is added every 10 minutes at the maximum rate the appliance will burn. The test is continued until all temperatures have stabilised at their maximum values. Temperatures on test enclosure walls, ceiling and floor must not exceed specified limits. The flash fire test requires removal of half the burning fuel load from the appliance while it is at its maximum temperature and filling the firebox with fresh fuel, then leaving the refuelling door ajar, opening ash removal doors or any other adjustment to give maximum heat conditions for the duration of this one burn cycle.

The Standard also set minimum height requirements for the appliance flue. These were aimed at safety issues, not smoke dispersion. The Standard was called up in building regulations around the country, greatly reducing the risk of house fires associated with these appliances.

A second edition of the Standard was published in 1990 (Standards Australia 1990). The second edition included some revision of the ‘deemed to comply’ conditions as a result of experience gained in test laboratories (worst case conditions were made tougher, i.e. greater clearances) together with some other minor changes. A third revision has recently been published (AS/NZS 2918:2001), making this important standard a joint Australia/New Zealand document.

5.2 Appliance

The design and construction standard for residential solid-fuel burning appliances was first published in 1991 as AS3869-1991. It was revised in 1999, creating a joint Australian/New Zealand Standard, AS/NZS 3869:1999 *Domestic solid fuel burning appliances – Design and construction*. The Standard specifies materials (e.g. the type of steel and thickness) for various components of solid-fuel burning appliances based on the maximum temperatures reached during a specified test process. The aim of the Standard is to ensure the durability of the appliance.

This standard has not been called up in any Australian legislation (i.e. it is purely voluntary). No manufacturer has had any appliance model tested to this Standard by NATA registered laboratories. However, the Standard is widely used by manufacturers when designing new models as a guide to materials and components. In practice, the durability of woodheaters appears good, with an average lifetime of 15 to 20 years.

5.3 Performance

The performance test method standard was first published in 1992 as AS4012-1992. It was revised and published as a joint Australian/New Zealand Standard in 1999, AS/NZS4012:1999 *Domestic solid fuel burning appliances – Method for determination of power output and efficiency*. The Standard provides a test method, using a calorimeter room, for accurate measurement of heat output rate (power) and efficiency of residential solid-fuel burning heating appliances. The Standard specifies design parameters, measurement accuracy and calibration procedures for a calorimeter room. It also specifies a ‘real-world’ fuel and operating procedure for the appliance.

The Standard was developed in response to industry and consumer group requests for a standard method of measuring and reporting appliance performance. The Standard measures and requires reporting of the total efficiency, which is the product of the combustion and heat transfer efficiencies. Also, the Standard requires labelling of the appliance with the average efficiency measured at high, medium and slow burn rates and the average heat output rate for the high burn rate cycle. This Standard is indirectly called up in State legislation because it is an integral part of the emission standard.

5.4 Emissions

The emissions test method standard was first published in 1992 as AS4013-1992. It was revised and published as a joint Australian/New Zealand Standard in 1999, AS/NZS4013:1999 *Domestic solid fuel burning appliances – Method for determination of flue gas emission*. The Standard provides a test method, using a dilution tunnel, for accurate measurement of particulates emitted by residential solid-fuel burning heating appliances. The Standard specifies design parameters, measurement accuracy and calibration procedures for a dilution tunnel that must be operated in conjunction with a calorimeter room. Emission testing can be carried out simultaneously with performance testing.

The Standard applies to solid-fuel burning space-heating appliances (including those fitted with water heating devices). It does not apply to masonry fireplaces, cooking stoves, central heating appliances or water-heating-only appliances. Nor does it apply to heating appliances that have heat output rates greater than 25kW or appliances where the carbon dioxide concentration in the flue at high burn rates is less than 5% by volume. These last two exceptions relate to the difficulty in carrying out tests in the laboratory, rather than any suggestion that emissions from these appliances are less significant.

The Standard includes an upper limit for acceptable particulate emissions of 4 grams of particles per kilogram (oven-dry weight) of fuel burnt. This emission factor was reduced from 5.5g/kg (in the 1992 Standard) to 4g/kg at the request of pollution control authorities. The decision to set the maximum allowable emission as an emission factor, rather than emission rate (g/h), was made so that the emissions during slow burning carried more weight in the overall average emission factor.

The emission Standard has been called up in legislation in most Australian states and territories (see Section 2.3.2). The legislation varies from state to state, but generally it applies at point of sale (i.e. it is not retrospective). The audit program referred to in section 3.2 (above) highlights the need for greater government intervention to ensure all models sold actually comply with the standard.

In developing the test method adopted in the Standard a series of inter-laboratory tests were conducted (Todd *et al*. 1989b). Testing at the Home heating Laboratory, University of Tasmania and Amdel in South Australia demonstrated that good agreement was possible between the laboratories (within ±4%) provided wood parameters were carefully controlled.

The Standards Committee is considering a further revision of this Standard. It will make labelling of the emission factor on a permanent plate on the heater compulsory (at present the label is only required to state that the appliance meets the emission limit). The new labels will assist consumers in selecting heaters that have emission factors well below the maximum allowable value.

5.5 Test Fuels

The test fuels standard, AS/NZS4014:1999 *Domestic solid fuel burning appliances – Test Fuels*, has five parts each dealing with a test fuel used in the performance and emission test standards. The standard sets the acceptable range for physical parameters of each fuel type for use in the appliance testing. Parameters such as density, moisture content, calorific value, and piece size are specified. The five parts of the standard cover: hardwood, softwood, lignite briquettes, sub-bituminous coal, and semi-anthracite coal briquettes. Virtually all the testing done in Australia is done with the hardwood test fuel.

6 Measuring Woodsmoke

Measurement of woodsmoke as it is emitted from a flue or chimney has been discussed in section 5(d) above. As you would expect, measurement of woodsmoke in urban areas requires quire different approaches. Woodsmoke is only one of many sources of fine particles and polluting gases in the urban atmosphere, other major sources include motor vehicles, industries, bushfires, and natural sources (pollens, spores, sea salt etc.).

There are several quite different methods used for measuring fine particles in the urban atmosphere. Each of these is discussed briefly below.

(a) High-Volume Sampler. The 'reference method', that is the method that is assumed to give the correct measurement is the High-Volume sampler. This equipment draws a large volume of air (40m^3/min) through a pre-weighed paper or fibreglass filter continuously for 24 hours. The filter is then dried and re-weighed. The volume of air passing through the filter is known (the sampler monitors the flow rate and maintains a constant flow as the filter collects more particles). The concentration of particles in the air is simply the total weight of particles captured divided by the air passing through the filter. Since most interest is on respirable size particles or fine particles, the high-volume sampler is usually fitted with a device that separates larger suspended particles out of the air stream before it reaches the filter. In this way only PM10 or PM2.5 particles are captured on the filter.

Some of the limitations of this method include the relatively high labour input required. Filters must be prepared, installed, collected and weighed manually on a regular basis. The method only gives a single average value for 24 hours. This limits interpretation of possible sources (e.g. do most particles occur during peak traffic times?) The method does not give 'real-time' measurement; at best, results are available several days after monitoring.

An advantage of the filter method is that the particles collected can be analysed to determine their chemical structure, thus identifying harmful compounds as well as obtaining a better idea of the source of the particles.

(b) Low-Volume Sampling. Low volume sampling, where relatively small quantities of air are drawn through a filter offer a lower cost option of particle sampling. But the very small change in weight of the filter means accuracy is poor unless very high smoke concentrations are present.

(c) TEOM. A popular monitoring device around Australia at present is the TEOM (Tapered Element Oscillating Microbalance). This equipment draws an air sample through a filter attached to an oscillating tube. The natural frequency of vibration is extremely sensitive to the weight of particles on the filter. This means that by measuring the vibration frequency continually it is possible to measure the particle concentration in the air stream on a continuous basis with reasonable accuracy.

Some disadvantages of this method are that the incoming air must be warmed to prevent moisture problems in the instrument. Up to 30% of the woodsmoke particles are volatised (i.e. turned back into gas).

Advantages include real-time monitoring and details of how particle concentrations vary from hour to hour.

(d) Nephelometer. A nephelometer is an instrument for measuring the scattering of light by particles in the air (or in water). The size and number of particles determines how much light is scattered. By drawing an air stream through the instrument, or by using a long-path instrument that measures the scattering in situ, it is possible to continuously measure and record the scattering (reported as *scattering coefficient*). The measurements can be converted to concentration of particles in the atmosphere through calibration, provided the size distribution of particles is relatively constant. In practice, it usually requires a different calibration factor for each season because of different sources of particles (e.g. woodsmoke in winter).

(e) Particle Counter. The particle counter is a variant of the nephelometer. The instrument draws an air sample through the sensing chamber where a laser beam is scattered by particles as they pass through. By measuring the scattered laser light the number of particles can be electronically counted. If the size distribution of the particles is known, the particle count can be converted into the particle mass concentration ($\mu g/m^3$) in the air, giving an instantaneous reading.

The particle counter has similar advantages and disadvantages to the nephelometer. The advantages are the real-time measurement of particles, the low labour requirements and, in the case of the particle counter, lower costs than high volume or TEOM samplers. The disadvantages include the need to calibrate the instrument against the type of smoke or dust to be measured, and the interference caused by fog or mist (i.e. it does not distinguish between water droplets and dust particles).

7 Smoke Concentrations in Urban Areas

The National Environmental Protection Measure for Air quality (Air-NEPM) states that the national goal is to have typical urban respirable particles (PM10) less than $50\mu g/m^3$ (24 hour average), and that this goal should not be exceeded more than 5 times per year. This goal is a compromise between possible health impacts and the cost of achieving this level of particle pollution. The Air-NEPM indicates that the goal should be achieved by 2008 across Australia.

There are many regions in which the $50\mu g/m^3$ target is exceeded. In smaller cities and towns, residential sources, especially woodheaters and open fireplaces, are thought to be the main source of particles in winter months. In summer, bush fires and hazard reduction burning can be significant. Table 7.1 provides estimates of the main sources of particles in various regions in Australia. This shows ‘area based sources’, which include woodheaters and open fireplaces as well as bushfires, small industry and other distributed sources, are particularly significant outside major industrial areas.

Two important variations to this NEPM are under consideration. One is to include a requirement to monitor PM2.5. These smaller particles are considered to have stronger links to respiratory problems. At this stage it is not proposed to set a national goal that has to be met, rather a national information base will be built up over a few years. The reporting value (i.e. number of exceedences) will be 25μg/m^3 for 24 hours and 8μg/m^3 as an annual average. These limits will place additional constraints on woodsmoke emissions (woodsmoke is all PM2.5). The second change/addition is to establish a NEPM for air toxics. A selection of compounds known to be toxic to humans will have to be measured in population centres. Most of the toxic compounds being considered are emitted to some degree in woodsmoke. So this will place further constraints on woodsmoke emissions. Details of these changes can be found on the NEPC web site (http://www.ephc.gov.au/nepms/).

Table 7.1

Emissions of particles from different sources in various airsheds (source NEPC 1998).

Airshed	Mobile Sources	Industrial sources	Area based sources (including wood heating)
Sydney	30%	34%	36%
MAQS Region	16%	67%	16%
Port Philip region	16%	10%	74%
SE Queensland	18%	65%	17%
Perth-Kwinana	8%	68%	24%
Port Pirie	2%	94%	4%
Launceston	1%	2%	97% *

* my own estimates for Launceston suggest area based sources are about 75-80%

Launceston

More detail is provided here about Launceston because it is a city known to have a high proportion of woodheaters and high particulate levels in winter. It is also a city that I am familiar with in terms of the woodsmoke problem and the mitigation efforts. It illustrates the problem of woodsmoke well and how effective action can significantly reduce smoke levels.

Woodheater use in Launceston increased quickly through the 1980s because of the marketing of efficient woodheaters capable of burning unattended overnight and very cheap firewood. Even in 2003, delivered loads of air-dry firewood sold for about $65-75/t. This provides very cheap heating. In addition, many residents were able to collect their own firewood at little cash cost, simply their own time and effort. Smoke levels rose through the 1980s, but it was not until 1991 when thick smoke often blanketed the Tamar Valley that measurements of particle concentrations were made. The high levels observed, up to 250μg/m^3 in 1991, prompted a larger monitoring program (routine monitoring started in 1992, and since 1997 daily measurements have been made throughout the year, see Figure 2). By 1991, around 70% of homes were using woodheaters. Various efforts at public education aimed at encouraging correct use of woodheaters were commenced at that time, although little benefit was observed. By 1998, when there was widespread acceptance of the potential health impact of fine particles, public concern about woodsmoke in Launceston became more vocal.

Gradual reductions in smoke levels occurred, but it was not until 2001 that pollution control authorities achieved significant gains (Table 7.2 and Figure 7.1). It appears that a combination of active marketing of alternative heating by the electricity authority, coupled with a special low-cost heating tariff, and targeted education (smoke-patrols) by local government authorities has led to an extremely effective smoke mitigation program.

To support this approach, new air pollution legislation is about to be introduced in Tasmania. The Environmental Protection Policy (Air Quality) is due to be introduced into state parliament early in 2003. It has been through all review processes and so seems likely to be passed. It deals with air pollution control in general, but includes a novel approach to woodsmoke. The legislation defines nuisance smoke as visible smoke impinging on a neighboring house or land for a period of two minutes continuously or 3 minutes in a 5 minute period. In practice, if nuisance smoke is observed, the offending household receives advice in the mailbox, if excessive smoke is observed a second time the house is visited by local government officer(s) and warned in writing of possible fines if the smoke continues. If excessive smoke continues to be emitted, the legislation provides for a fine of up to $1000

Table 7.2
Summary of PM10 measurements in Launceston over the past 6 years
(DPIWE 2002 and updated 2004).

Year	Number of days > 50μg/m^3	Highest reading μg/m^3	Annual mean μg/m^3
1997	51	124	34
1998	47	125	34
1999	43	94	31
2000	39	111	30
2001	28	81	22
2002	14	76	19
2003	24		na

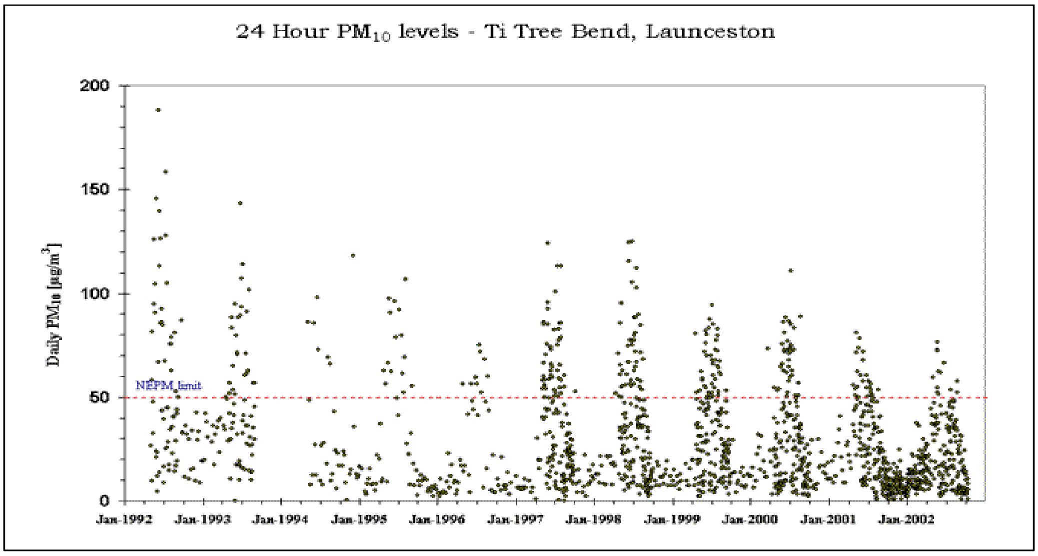


Figure 7.1
Measure PM10 concentrations (24 hour average, μg/m^3) in Launceston, Tasmania.
(Source: DPIWE 2002)

The local electricity utility decided they wanted to capture a larger share of the residential heating market and introduced a special heating tariff (*HydroHeat*) and strongly promoted the use of heat pumps. The low cost tariff and efficient heat pump gave running costs very similar to woodheaters. In the past two or three years there has been a very significant swing away from woodheaters to various types of electric heating. There are now about 40-45% of houses using firewood as their main heating fuel. Air quality has shown a significant improvement (see Table 7.2 and Figure 7.1). It seems likely that the combined effect of more electric heating, better woodheaters replacing old, smoky models and better heater operation through response to education campaigns have led to the reduced smoke levels in Launceston in winter. This is promising, but there is still a long way to go (a further 20 to 25% reduction) before the NEPM goal is achieved. On-going promotion of electric heating, the introduction of natural gas (due by 2005), community education and smoke patrols to target the most smoky heaters are expected to keep the air quality improving.

Armidale

Armidale is another smaller city known to experience serious woodsmoke problems. In Armidale, smoke monitoring has been carried out using a nephelometer. This shows that up to 50% of winter days register as high, very high or extreme based on the maximum one-hour average scattering coefficient. These values are difficult to compare directly to 24 hour average particle concentrations, but the evidence suggests many winter days, possibly over half, exceed the national goal of 50$\mu g/m^3$ (24 hour average).

Larger cities such as Melbourne or Sydney have lower PM10 concentrations than Launceston or Armidale. In Melbourne, for example, 24-hour PM10 concentrations range from 15 to 30$\mu g/m^3$ with very few peaks reaching 50$\mu g/m^3$. A study of health impacts (mortality) of air pollutants in Melbourne (Vic EPA 2000) suggested a link between respirable particles and mortality. The association was not statistically significant when effects of other pollutants (CO, NO_2, O_3) were included in the analysis. The study concluded that a 10$\mu g/m^3$ increase in PM10 most likely resulted in a 1.4% increase in mortality, and that the effect was strongest in summer.

Epidemiological analysis in Sydney suggested a 1% increase in mortality for a 10$\mu g/m^3$ increase in PM10 (Morgan *et al*. 1998) and for Brisbane a 1.2 to 1.3% increase in mortality for a 10$\mu g/m^3$ increase in PM10 (Simpson *et al*. 1997).

In Perth WA, PM10 over the past decade, particulate matter has generally been below the 50$\mu g/m^3$ NEPM goal. The highest 24-hour concentration was about 76$\mu g/m^3$ at one site in 1996, but average values are around 25$\mu g/m^3$. Residential sources, which include woodheaters, were estimated to contribute about 40% of urban PM10.

There is little doubt that woodheaters and open fireplaces are significant contributors to the observed PM10 levels in many cities and towns in the winter. This is confirmed by emission inventories – theoretical analyses of all likely sources of particles into a given air shed; and chemical analysis of the particles themselves – which show a significant proportion of ‘new carbon’, that is carbon from biomass not fossil fuels.

It should be noted that the concentrations of PM10 measured in Australian cities, even those with the highest readings such as Launceston, are still well below some of the more polluted cities around the world. Extremely high levels of exposure are endured by millions of women and children who cook over open fires, often inside a building. Average exposures, i.e. every day, can exceed 1000μg/m^3. Based on the trace chemical benzo-a-pyrene, a carcinogen, this is equivalent to smoking 20 packets of cigarettes per day. Chronic health problems are observed.

8 Effect of Operation on Woodsmoke Emissions

Having built up a case that pollutants in urban air, at concentrations sometimes observed in Australia, are a risk to health; and woodsmoke from residential heating is a significant source of some air pollutants in winter months, the next questions is what can be done about it?

- Improved technology (i.e. low emission woodheaters) has been discussed in relation to Australian Standards. There has been a big improvement in appliance design and further improvement is certainly possible. However, woodheaters have a long service life (15 to 20 years), so changeover to new appliances is slow.
- It is well established that poor operation of woodheaters contributes to excessive smoke, so if user behaviour could be modified it would be possible to rapidly reduce smoke emissions. This section of the handbook deals with operator practice.
- It is likely (but not well proven in scientific tests) that wet firewood also contributes to higher smoke emissions, so encouraging use of dry firewood only will probably also lead to reduced smoke emissions. This is discussed in more detail below.
- Finally, if less households burn wood there will be a reduction in woodsmoke. Alternative heating choices are also discussed below. If home owners are forced to use other heating systems there is potential for social and health impacts in lower income families and rural households.

Here are a few suggestions for getting the best performance out of a woodheater (Todd 2001). A brief explanation of why each suggestion helps reduce smoke is also provided. Every heater model is a little different, which is why householders need to check their own smoke levels to work out the best way to obtain a clean burn.

(a) Always run the heater on high burn rate (air controls fully open) for 15 to 20 minutes after re-loading. This is particularly important before turning the heater down for overnight burning.
Why? – Wood is a complex fuel. It goes through three main phases when it burns. The first phase is drying, when any moisture left in the wood is evaporated. This absorbs energy. At the same time, the increasing temperature causes the wood to undergo chemical change and gas is released from the wood. This is the time when the highest concentrations of smoke are produced. If there is a vigorous flame in the woodheater then this stage of combustion is shortened and most of the smoke is burnt up before it gets to the flue. The second phase of combustion is the main flame burning stage. Burning kindling, or other burning wood, ignites the gases coming off the new wood. The gases burn to give the bright flame we see when wood is burning. The fastest release of gas occurs during the first 20 minutes or so after refuelling a hot heater. This is when it is essential to have plenty of air to mix with the gas to make sure it burns. This is why it is so important to keep the air control fully open for the first 15 - 20 minutes. Once the wood is well alight, with some burning embers on the wood surface, the chances of the flame disappearing are slight, even when the air is reduced. The main flame combustion phase, which lasts for one to two hours or so in a typical heater, releases about half the energy in the wood. The third phase of wood burning is the charcoal stage. Once most of the gas has been released from the wood,

a residue of almost pure carbon remains. This burns with very little release of smoke. This is when the air supply can be reduced without producing smoke particles.

(b) Do not over-fill the heater. There must be enough space for the air to move down the glass and into the base of the fire. This means at least 5 to 10cm between the front of the logs and the door. There must also be space over the top of the fuel load to allow flame to develop and burn off the gases released from the wood.
Why? – Even in a hot woodheater, the gas given off by the wood will not burn if it does not get mixed with air (the gas must have oxygen to burn). This requires a bit of space for the gas and air to mix together in a turbulent flame. If the gas and air do not mix together until they reach the flue, they are too cool to ignite and all the gas escapes unburnt, condenses into droplets of tar and causes lots of smoke.

(c) If the fuel load has burnt down very low so that there are only a few glowing coals left, it is important to add a bit of newspaper and some smaller pieces of wood when refuelling so that there is a vigorous fire established quickly.
Why? – When the fresh wood is added to the hot bed of coals there is enough heat to start driving off the gas from the wood, but the temperature is not high enough to actually ignite the gas. As soon as there is some flame present, the gas will ignite.

(d) When lighting a cold heater, always use sufficient dry kindling to establish a good fire quickly.
Why? – When flames get close to cold surfaces (such as the cool metal surface of a heater that has just been lit), the flame is cooled down because heat is transferred to the cold metal. If the flame cools too much it will simply go out. If you look closely at the bottom of a pot of cold water held over a wood fire you will see a thin layer (two or three millimetres thick) where there is no flame because the cool bottom of the pot has put the flame out. This is why it is important to get the heater warmed up as quickly as possible, using good kindling and plenty of paper.

(e) It is also a good idea to put two or three loosely crumpled sheets of newspaper on top of the fuel load when first lighting the heater because this burns rapidly, heats the flue and gets the draught going. Of course you also need newspaper or firelighters under the kindling.
Why? – Woodheaters rely on 'natural' draught to draw air from the living room into the firebox (i.e. they do not have fan-forced combustion air as larger industrial wood combustion systems do). This natural draught depends on the temperature difference between the gas in the flue and the outside air. By warming the flue quickly with the burning newspaper, more air is drawn into the heater, stimulating the fire.

(f) Use smaller logs to get the fire established and for high heat output, use larger logs for slower burning.
Why? – Using smaller logs allows the flame and hot gas to circulate through the wood load in the heater. This causes more rapid release of gas and so more flame and a hotter fire. Larger logs have less surface area for a given weight of wood. This means they release the gas from the wood slower and so the fire will burn slower.

(g) Use dry firewood. Wet wood means less efficiency and much more smoke. Store your firewood in a well-ventilated shed or other covered area.
Why? – Freshly cut, live trees have about 50% of the weight of their wood as water. This means if you try to burn green wood and you add a 10kg load to your heater, 5

kg (or 5 litres) is simply water. Think about putting 5 litres of water on your stove and heating the pot until it has boiled dry. This is how much energy you are wasting. Also, the heat required to boil off all the water means the fire is cooler and so less of the wood-gas ignites and smoke increases.

(h) Place logs in the firebox so that there is at least 2cm between each log. This allows air to get into the hot area of the fire and leads to better combustion.
Why? – The most efficient and complete combustion occurs when the wood-gas and air have had plenty of chance to mix and burn. By allowing air in between the logs, this mixing of air and gas is greatly improved. So the fire burns cleaner.

(i) Do not place logs in the firebox so that they block the incoming air supply.
Why – Most modern woodheaters draw their main combustion air supply down the inside of the glass on the door. This constant supply of clean air helps prevent creosote staining the glass. However, if a large log is loaded parallel to the door of the heater it will stop this air supply getting into the base of the fire, where it is needed for good combustion. Some heaters have the longest dimension of the firebox parallel to the door. If this is the case, you should always use logs that are short enough to fit comfortably perpendicular to the door.

(j) Never run the fan on a woodheater (if fitted) when the heater is set for slow burn.
Why – The fan circulates room-air around the firebox to improve transfer of heat into the house. In doing so it cools the firebox. When a woodheater is operating at slow burn rates it is essential to maintain sufficient heat in the firebox and flue to draw in adequate combustion air. If the firebox becomes too cold, combustion air drops below the volume needed to ensure clean burning and the heater may smoke copiously for hours.

(k) Check the heater flue for smoke every now and then. If it is producing lots of visible smoke for more than 15 to 20 minutes after lighting or refuelling then the heater user needs to adjust the fuel to get a better fire. With a little care even the first few minutes after lighting the heater can be relatively smoke free. Try moving the logs in the heater or adding a bit more newspaper. Each model of heater will have certain ways of loading the fuel that give the cleanest burning. Homeowners will have to use trial and error to get the best arrangement for the heater.
Why? – Unburnt wood-gas condenses into tiny droplets of tar when it cools down to 40 or 50°C. These tiny droplets scatter visible light in the same way steam does when it condenses into tiny water droplets. The scattered light from the woodsmoke is a bit like seeing a cloud. The thicker the appearance of the smoke the more particles are present, so it is quite a good indicator of the amount of smoke coming out of the heater. It usually has a white, or sometimes faint blue, appearance. If the smoke is black it means there is a lot of carbon, or soot, present. Black smoke suggests the fire is too hot, and may damage the heater or flue.

(l) Keep your heater and flue in good working order. The flue should be checked each year and cleaned of creosote if necessary.
Why? – If the flue is partially blocked it slows the flow of air through the heater. This makes it harder to light and smoky. It also means the heater will take longer to get up to proper working temperature and so produce more smoke. In extreme cases it may cause the heater to smoke back into the lounge room, something that should

never happen. If the creosote in the flue catches fire it can get so hot that it damages the stainless steel flue and a replacement flue will be required.

(m) If smoke from your heater is blowing into a neighbour's home this can be very annoying for the neighbour. It can also be a health hazard. If it is a regular problem it may be possible to solve it by increasing the height of your flue. But make sure your heater is correctly installed because a taller flue usually means the heater will run a bit hotter.
Why? – When the wind blows it creates complex air flows around a house. Some of the air is drawn down almost to ground level as it passes beyond a house. If this layer of air includes the smoke from your heater it can cause serious air quality problems in neighbouring properties. By increasing the height of the flue it is often possible to discharge the smoke into higher layers of air that simply pass well over neighbouring properties.

9 Identifying Smoky Chimneys and Flues

Woodsmoke, which is made up of ultra-fine particles, scatters light very well. This makes it very visible under most lighting conditions, although the direction and intensity of the light does influence how thick the smoke appears. But the fact that woodsmoke is so visible means that a simple visual observation can give a good estimate of the smoke emission rate. Careful observation, that is several repeat observations noting light conditions, wind and smoke persistence, are a reliable means of checking how well a person is operating their woodheater or open fireplace.

In a recent woodheater study in Hobart, we made smoke observations by walking through various neighborhoods during the day and evening. Houses with operating woodheaters or fireplaces were observed for a period of two or three minutes and a judgement made on the severity of the smoke. A scale of 1 to 5 was used (see Figure 9.1). Three people made observations of smoke through this project. To try to get some uniformity in an otherwise very subjective process, all three observers spent some time simultaneously observing smoke and agreeing on the relative opacity (i.e. the scale number).

The address of the house, time of day, observer and level of smoke were recorded and then transferred to a master list that recorded all observations and addresses. Each house was monitored at least three times on different days. Observations were made on different days of the week, including weekends, and different times of day (but only during daylight hours). The smoke was easiest to observe when sun angles were low and when looking towards the sun. Allowance in allocating a scale number to the observed-smoke had to be made for these variations in visibility of the smoke. This ‘correction’ was very subjective and limited the accuracy of the observations.

The important aspects of the above study as far as ‘smoke patrols’ (see Box 9.1) are concerned are:

- just one observation of a smoky flue or chimney does not give a ‘fair’ assessment of whether a person is operating their heater well, because all heaters will smoke for a few minutes after lighting or refueling;

Figure 9.1
Smoke scale suggested for recording observed smoke from households. 5 is very thick smoke which remains visible beyond the boundary of the property. 1 is just a heat haze (i.e. confirms heater is operating). The three photographs (smoke-scale 4, 3 and 2) are based on the *Breathe the Benefits* refrigerator stickers.

Thicker than 4 **Almost clear**

5 4 3 2 1

SMOKE SCALE

Box 9.1
Terminology. Some sections of the community find the terms ‘smoke patrol’ or ‘smoke police’ offensive. It suggests local government is sneaking around watching people go about their daily business. Other terminology such as ‘smoke survey’, ‘woodheater education program’ or ‘targeted woodsmoke education’ may be more acceptable.

- it is important to build up a good database of houses that seem to produce too much smoke (a simple form for recording observations and a computer record back at the office is one possible way of doing this);
- if several people are going to contribute to the database, then some common training to agree on a scale of ‘smokiness’ is essential; and
- light and wind conditions need to be recorded.

Using the scale in Figure 9.1 as a guide, the following comments indicate how severe the smoke problem is.
- Thick smoke extending beyond the property boundary (smoke scale 5) should never occur with a reasonably well operated heater, even during start-up or with a non-certified heater. It suggests very bad operation and/or wet wood.
- Thick smoke (smoke scale 4) which disperses before reaching the boundary (i.e. visible for 5 to 15 metres) should never occur even for a non-certified heater.
- Moderate smoke (smoke scale 3, visible for 2 to 5 metres) is likely to occur when lighting a non-certified heaters for about 10 to 15 minutes and for 5 minutes after refueling. An open fireplace may produce moderate smoke for extended periods.

- Faint smoke (smoke scale 2) is likely to occur when lighting a certified heater and for extended periods with non-certified heaters, even when they are operated carefully. Certified heaters should operate without any visible smoke most of the time.
- No visible smoke, just a heat haze, indicates good operation of a woodheater. All certified heaters should operate without visible smoke except following lighting or refueling. Even non-certified heaters can operate without visible smoke for much of the time if the operator takes particular care.

A study of 60 households using firewood for heating was carried out in NSW in the winter of 2003 (Todd 2003). Each household was visited by a consultant, they were asked to operate their heaters the way they normally would. If the heater produced more smoke than the consultant though appropriate, the consultant would show the householder how to reduce smoke through correct operation. Firewood moisture content was also checked. The results demonstrated that every certified heater, correctly operated, would produce only a wisp of smoke or only a heat haze, within 10 minutes of lighting or refuelling. The most common problems observed when lighting the heaters were insufficient kindling, too much firewood loaded into the heater and use of very wet wood. The most common problems leading to excessive smoke after lighting were: turning the air control to low too soon; trying to burn a single large log; adding logs without opening the air control; and blocking the air supply with an incorrectly placed log. About 10% of the households appeared to have partially blocked flues (i.e. required flue cleaning).

10 Tampering with Certified Heaters

As mentioned in Section 3.2 above, some woodheater models achieved cleaner burning by putting a physical stop on the air control to ensure sufficient combustion air at all times. Removing this stop allows longer burn times, but greatly increases smoke during slow burning. If the air control is visible on the heater it is relatively easy to see if this has been tampered with. For example, if the air slide can be positioned to totally shut off the main combustion air it is likely the slide has been tampered with (but this is not always the case). Unfortunately, in many heater models, the air control device is not visible without partially dismantling the appliance.

Other modifications to check for are dampers placed in the flue. These can increase emissions by reducing draught.

The only reliable way of determining if a woodheater has been modified is to get precise details of the combustion air system for a particular model of heater from the manufacturer, and compare them to the heater in question.

11 Wood Moisture Content

It is widely accepted that wet firewood leads to smoky fires although there is surprisingly little scientific evidence to back up this common observation or to quantify the effect. The reason wet firewood leads to increased smoke is that the heat required to evaporate the water before the wood will burn lowers the temperature of the fire causing less complete combustion. If the wood is so wet that good combustion fails to take place at all, the fire will smolder and produce large quantities of smoke.

Experience suggests that most woodheaters will burn wood with up to 20% moisture without noticeable increases in smoke (good air-dry wood has about 15% moisture). From 20 to 25% moisture, smoke starts to increase, and by about 35 to 40% moisture large quantities of smoke will be produced even if the heater is otherwise operated carefully.

Freshly cut wood from living trees has a moisture content of around 50%. If cut to firewood lengths and stacked in the open it takes roughly 12 months for the moisture content to drop to acceptable levels (i.e. below 20%). Precise drying rates vary from one wood species to another and are climate dependant (warm and windy with low humidity is best). A roof to prevent rain-wetting will speed drying, but ventilation is more important than cover. Do not cover the woodpile with plastic or a tarp as this created a high humidity region drawing moisture out of the soil.

11.1 Measuring moisture content

The standard method for measuring moisture content of wood is to weigh the wood samples carefully then place them in a ventilated oven set to about 60ºC; reweigh at regular intervals until no further weight loss occurs. The difference in weight is due to the loss of water. The moisture content is then calculated as

$$\text{Moisture (\% wet-weight basis)} = \frac{\text{(Initial weight – final weight)}}{\text{Initial weight}} \times 100$$

It is possible for a householder to measure the moisture content using the following approach:

> If a householder suspects a firewood delivery is too wet they can check the moisture without any specialised equipment. Firstly three or four logs from various parts of the pile should be selected. These should be split and then some small kindling size pieces taken from each log making sure to select some from the inner part of the log and some from the outside. Then two or three pieces, about the size of a 50 cent piece, should be cut from each piece of kindling. A small pile of exactly 100 grams should be weighed as accurately as the scales allow. This should be done within a few minutes of splitting the wood because the small pieces start to dry out quickly. The wood pieces should be placed on aluminium foil or a tray in an oven on low (about 100ºC) for about an hour and then reweighed. This should be repeated, with the wood reweighed after another half hour to see if it has fully dried out. If the weight is still falling repeat the drying/weighing process. Once dry, if the final weight is above 80g the wood was nice and dry. With a final weight of 65 to 80g the wood is a bit too wet and should be left to dry for another couple of months. If the final weight is 50 to 65g the wood was far too wet and should be left for the next heating season. Householders who have unwittingly purchased very wet wood should contact consumer affairs and they may be able to get a refund.

11.2 Moisture meters

Electric moisture meters are available that allow on-the-spot moisture checks of firewood. The meters have two small metal spikes that must be stuck into the wood and then a meter gives a reading of the wood moisture. The meters are not as accurate as the drying method but they are excellent for making a rough check of wood moisture. The less sophisticated models are available for less than $150.

When using electric meters it is important to measure across the grain and push the spikes in the correct depth. Several readings, from randomly selected pieces of wood should be made.

The electronic moisture meter should be used as a guide. If it is likely that a measurement could be challenged (e.g. if there is to be a prosecution), then wood samples should be collected, placed in sealed plastic bags and delivered to a laboratory for oven drying.

11.3 Moisture conversions

Unfortunately, there are two different conventions for reporting on the moisture content of firewood (this applies to wood generally). The weight of 'free water' (free water is the water that is driven off the wood when it is heated to 100ºC) can be expressed as a percentage of the initial weight of the wood (i.e. before drying it) or the final dry weight of the wood. Most people working with fuels use the initial weight approach, which is known as the wet weight basis for expressing moisture (%ww). Most foresters use the final weight approach, which is known as the dry weight basis for expressing moisture (%dw).

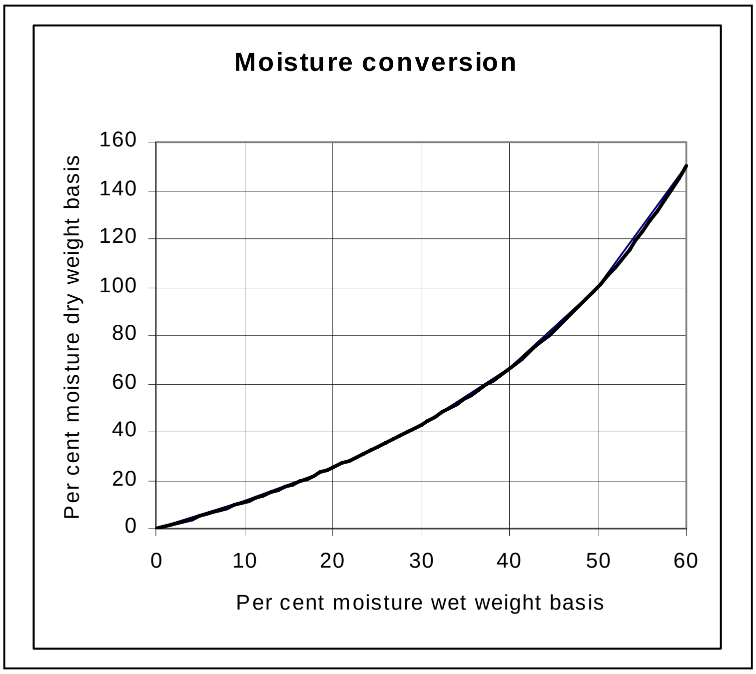
Conversion is possible using the formulae:

$$\%dw = \frac{100 \times \%ww}{(100 - \%ww)} \qquad \%ww = \frac{100 \times \%dw}{(100 + \%dw)}$$

Or, the chart in Figure 11.1 could be used.

Figure 11.1

Conversion chart for converting from wet weight to dry weight moisture.



12 Wood Species and Emissions

Different wood species can have quite different combustion properties. This can influence how much smoke is produced. The physical factors having most influence on combustion are the density and the lignin content (excluding moisture as discussed above). The actual energy per kilogram in various wood species does not vary much. Hardwoods generally have 19±1 MJ/kg and softwoods 20±1 MJ/kg.

The higher density of hardwoods leads to greater difficulty in lighting the wood, slightly slower burn rates and better coals. This can lead to higher smoke emissions during lighting unless sufficient kindling is used and after refueling unless a good hot fire is quickly established, but hardwoods give lower emissions during the slow charcoal burning stage. Softwood are usually easier to light, they burn faster but produce less coals. This means softwoods can have lower emissions when lighting or refueling because a vigorous, hot fire is established quickly, but in order to slow the burn rate down the fuel has to be starved of air, so emissions increase when trying to burn softwood slowly. These generalizations do not apply to every model of heater on the market. Some heaters are designed to burn softwoods well, even at slow burn rates. Similarly, some heater models provide easy lighting of hardwoods.

The important thing about different wood species is for the householder to operate their heater to minimise smoke from the particular wood species they have chosen to use.

13 Alternative Types of Heating

Households have a number of options for space heating. The preferred type of heater will depend on running cost, capital cost of the heater, availability of fuel (this applies particularly to reticulated natural gas), convenience, heating load, and aesthetics. Costs (running and capital) are important, but by no means the only factor influencing the choice of heating. Surveys have shown that most households with woodheaters are very satisfied with their appliances. But people’s heating preferences change as their lifestyle and income change. The advantage of low running cost (which often applies to woodheaters) may be more than off-set by convenience, automatic controls or instant heat output.

13.1 Woodheaters

Woodheaters are popular in rural areas because they offer very low running costs and have high heat outputs, so several rooms, or even the whole house, can be warmed with a single woodheater.

If alternative heating systems are to be encouraged it is important to know the performance of a typical wood heater.

- maximum heat output around 15 to 20kW (this is very high heat output compared to other residential heaters);
- minimum heat output around 3 to 5kW (this is also quite high, which means sometimes too much heat might be produced and windows will have to be opened);
- when burning quickly the heater will consume 6 to 8kg/h of firewood, when burning slowly 1 to 2kg/h;
- if good kindling and dry firewood is used, heat outputs of 10kW can be achieved within about half an hour from lighting; and
- to burn overnight 10 to 15kg of wood is required.

Some of the costs associated with woodheaters are summarised below.

Woodheater Capital cost (installed) around $2000, appliance life about 15 years,
Simple capital amortisation $133/year
Efficiency 50 to 70%, say 60%
Fuel energy 16GJ/t for air dry firewood
Running costs

Collect your own	very low
$75/tonne (typical rural price)	$7.80 per GJ of delivered heat
$125/tonne (typical rural town)	$13.00 per GJ of delivered heat
$190/tonne (typical big city)	$20.00 per GJ of delivered heat

Each of the common alternative heating fuels is now discussed in relation to the above aspects of wood heating.

13.2 Gas heaters

In regions serviced by reticulated natural gas, gas-fired heaters are very popular. In Melbourne, where natural gas is very cheap, gas heaters offer running costs similar to woodheaters. For example, with gas at $12/GJ, the delivered cost of heat into the home is about $16/GJ, which is roughly the same as running a woodheater with wood costing $150/t. The added convenience and fast response of gas heating is an advantage.

Elsewhere in Australia, natural gas costs more than in Melbourne, $18/GJ would be a more typical cost. This pushes the running cost of gas heaters up to about $24/GJ (delivered heat). If firewood is available at $125/t (as it is in many rural areas, often less) then gas heating costs almost twice as much as wood heating. In such situations, householders might be reluctant to switch from wood to gas unless heating costs were a small part of overall expenses, which is where insulation and solar heating could play a role (see below).

If natural gas is not available, liquid petroleum gas (LPG) may be an alternative. LPG prices vary from area to area, but taking a mid-range cost of $1.50/kg, the cost of delivered heat is $40/GJ, or about three times the cost of running a woodheater with wood at $125/t.

13.3 Electric heater

Electric heating is popular because of its convenience and the low cost of many portable electric heaters, including fan heaters, radiators and oil filled radiators. However, if electricity costs 10c/kWh the cost of delivered heat is about $28/GJ, about double the running cost of a woodheater where wood costs $125/t.

Electric heat pumps (also referred to as reverse-cycle air conditioners) offer lower running costs because of their high efficiency (around 250%), but they are relatively expensive to purchase, especially for larger models. With electricity at 10c/kWh, the heat pump will deliver heat at about $11/GJ, which is equivalent to firewood at about $105/t.

13.4 Other heating fuels

Oil heating was very popular through the 1970s and caused a minor revolution in comfort levels in Australian homes. Its running costs are similar to LPG, but it appears that no new oil heater appliances are on the Australian market.

Kerosene was a common heating fuel in the 1950s, but the odour from these heaters has decreased popularity to the point where they are rarely seen these days. Running costs are similar to LPG and heating oil.

13.5 Insulation and solar heating

Insulation of ceilings, floors, walls, windows and doors has generally been neglected in Australian housing. The relatively poor thermal performance of most Australian homes is the main reason many householders are having to spend $1000 or more on heating each year. Households with high heating and cooling costs can recover the investment in new or additional insulation within 5 to 10 years.

Insulation is best installed as a house is being built, but retrofitting is possible. In houses with accessible attic space, adding insulation to ceilings is straightforward. Adding insulation under raised wooden floors is also relatively straightforward. Replacing single glazed windows with double-glazed is straightforward, but costly.

13.6 Overview

The implications for a householder switching from firewood to another form of heating are summarised in Table 5.

Table 5

These comments are a rough guide only. Energy prices vary significantly around the country and, depending on the quantity required, different tariffs/costs apply. The installed cost also varies significantly for all types of heater.

Heater	**Running costs**	**Capital cost**	**Comment**
Woodheater	Low	Medium	Replacement of old woodheater with new will cost around $2000 (the flue should always be replaced too). Aesthetics may be important.
Natural gas	Low/ medium	Medium	Gas offers high heat output and convenience. Rapid start-up. Artificial log fire available.
LPG	High	Medium	LPG offers medium/high heat output, convenience, rapid start up. Artificial log fires available. High running costs.
Electricity	Medium/ high	Low	Running cost depends on available tariffs. Small portable heaters offer flexibility. Only low to medium heat output available unless multiple heaters installed. Convenient, fast response (except storage heaters or heated slabs).
Electricity (heat pump, reverse cycle air conditioner)	Low	High	High efficiency leads to low running costs. Reverse cycle air conditioners can supply heating and cooling. Convenient, quick response.
Insulation	Nil	Low/ medium	Reduces heating and cooling requirements. Opens up opportunities for various types of heating that might be too expensive otherwise. Shortens ‘heating season’.
Solar	Nil	High	Passive solar heating best included at building design stage but can be retrofitted. Careful design, including heat storage is essential.

14 Reducing woodsmoke emissions through legislation and education

In Australia, the regulation of woodsmoke is addressed through various means. Ambient air standards for smoke particles and carbon monoxide are in place through the National Environmental Protection Measure (NEPM) and controls over some of the toxic chemicals emitted by woodheaters (and other sources) are proposed. The existing and proposed NEPMs are available at the Environmental Protection and Heritage Council (EPHC 2003) web site (See reference list). These national goals must be enforced through legislation in each state and territory. So the states and territories each have their own requirements for the control of woodsmoke, e.g. see discussion about Launceston's smoke controls in Section 7 above.

The options for reducing woodsmoke include:
- Designing cleaner-burning heaters and gradually replacing the existing stock of heaters;
- Public education campaigns that inform people how to operate woodheaters so that they produce less smoke;
- Fining, or punishing in some appropriate way, householders that refuse to take sufficient care when operating their woodheater and so produce excessive smoke;
- Taxing woodheater use (possible through rates or levies) to discourage woodheater use, or grants to encourage other types of heating; and
- Introducing bans on new installations of woodheaters in specified areas (or possibly phasing out woodheater use over a set time period).

Each of these options is discussed below.

14.1 Design of cleaner-burning woodheaters

The introduction of the Australian Standard (AS4013) in 1992 was intended to force manufacturers to build cleaner heaters. It has had some success, but the effectiveness of the approach has been seriously diminished because:
- Not all states made compliance with the standard compulsory. This means that non-compliant heaters can be legally sold anywhere in Australia because of free-trading arrangements between the states.
- Lack of auditing (i.e. checking to see if the heaters sold with claims that they met the standard really did meet the standard) meant that manufacturers who bent the rules obtained a financial advantage over those that strictly complied with the rules (because those complying had to pay for retesting every time they changed their heater design). When an audit was finally carried out in 2003, widespread non-compliance was identified.
- The standard itself has shortcomings because it does not adequately cover poor operating practice that occurs in people's homes.

Unfortunately, it is almost impossible to check whether or not a heater complies with the standard when it is installed in someone's home. Thus, at local government level, EHOs can do little about this problem.

What is urgently needed is
(a) Uniform national requirements for all new woodheaters to meet the standard.
(b) An effective national auditing program, with appropriate penalties for non-compliance that forces all manufacturers (and importers) to comply with the standard.
(c) Revisions to the Australian standard that cover some of the poor operating practices.

14.2 Public education campaigns

Public education campaigns urging people to use their woodheaters correctly have been run for at least the past 15 years. They have had some success, but incorrect woodheater use is still widespread. The lack of effectiveness is probably because:

- The information in the education campaigns has been inadequate, in a few cases the information has been wrong, and in many cases important operating practices have been ignored.
- There has been too much emphasis on getting dry wood. This has led people to believe that if they use dry wood their smoke problems are solved. This is far from the truth.
- Some people are apathetic and do not bother doing the correct thing, even when they are informed.
- Broad scale public education campaigns are inefficient because the message is delivered to many people who do not have woodheaters (80% of the population).
- Targeted education, where information kits are given to households seen to be emitting excessive smoke have been the most effective form of education. A high proportion of households provided with kits and a letter indicating they seem to be emitting too much smoke operate their heaters much better from then on. But, targeted education programs are labour intensive and seen by some as being too invasive of private activity in the home.

If, somehow, public education campaigns could be made more effective then woodsmoke emissions could be reduced by as much as half very quickly. Targeted education seems to be the best approach. In several areas community groups and volunteers have helped with targeted education programs, which have kept costs down.

14.3 Enforcement and penalties for excessive smoke

Until recently, laws and regulations have not been suited to prosecuting households that consistently emit excessive smoke. This is slowly changing. Changes to local government nuisance provisions and health acts are making the possibility of successful prosecution more feasible.

If excessive smoke is emitted from a house, and the problem persists despite warnings and information about how to operate a heater correctly, then a prosecution might be warranted. It will be necessary to collect evidence that could be used in a court. So far, no-one in Australia has been prosecuted[2] so the nature of evidence required and the likely response of magistrates is not known. On the basis of other successful prosecutions for breaches of environmental laws it is likely that the following matters will be important:

- Evidence of excessive smoke will have to be gathered.
- The collection of evidence will have to be done carefully and systematically.
- The most likely indicator of excessive smoke will be the visible smoke plume. This is a good indicator because there is no doubt where the smoke plume comes from (it is possible to see which chimney/flue it comes from).
- If the observer (e.g. the EHO) has experience observing smoke then his/her evidence will carry more weight. Experience can easily be gained by carrying out smoke surveys and keeping a record of how much smoke each house emits based on a smoke

[2] As far as the author is aware, no-one has been taken to court due to excessive woodsmoke emissions. Several jurisdictions are talking of possible prosecutions in 2005.

scale such as the one discussed in Section 6 above. After a few surveys, an observer becomes well aware of how much smoke most heaters emit and so the very bad smokers stand out.

- Most woodheaters will produce some visible smoke when they are first lit or when they are refueled, even if they are operated carefully. This smoke may last for 10 to 15 minutes. But even during lighting or refueling the visible smoke plume should never extend more than 10 metres or so. Just to give the householder benefit of the doubt, two observations about 15 minutes apart will remove the problem of lighting or refueling.
- A visible smoke plume has high particle concentrations and strong odours. So, if a visible smoke plume is seen swirling around a neighbour's home it will almost certainly be causing some inconvenience to the neighbour. It will probably also be a slight health risk to the neighbour, but this would be hard to prove on a case by case basis.

14.4 Taxes, levies and subsidies

Financial disincentives to use firewood and woodheaters have not been applied in Australia. In part this is because there are no records of which houses have woodheaters and which do not. This makes levies in local rates almost impossible. The firewood industry includes many small operators, so taxes on firewood supply would be extremely difficult to administer. These problems make it unlikely that financial mechanisms will be used to make firewood use less attractive.

However, subsidies in the form of grants to get rid of woodheaters and replace them with other form of heating have been successfully used in several states (including NSW, WA and Tasmania). These incentives have the effect of bringing forward decisions about installing alternative heating systems (i.e. people considering getting rid of their woodheater anyway will act to gain the subsidy). However, the cost of changing from one heating system to another is usually several thousand dollars, so a grant of, say, $500 is unlikely to influence someone who is happy with their woodheater to change.

14.5 Bans

Woodheater numbers could be gradually reduced by preventing the installation of new heaters. As old woodheaters wore out, they would have to be replaced by other forms of heating. This seems a relatively simple option, however it might prove difficult to enforce, especially where a new heater was replacing an older one, rather than a totally new installation. It might also encourage households to keep old heaters rather than upgrade to potentially cleaner models. It also introduces restrictions in choice of heating which some people might find objectionable. It could be applied quite selectively (e.g. in areas where smoke tended to accumulate) and it need not involve state or local government in high costs.

More interventionist approaches could involve gradual phasing out of all woodheaters and open fireplaces in selected areas. The community could be warned that in, say, 10 years, no open fireplaces or woodheaters would be allowed to operate.

[My own view is that bans should only be seen as a last resort. They restrict heating choice and force some households into more expensive heating options. From a technical perspective, the woodsmoke problem can be greatly reduced, perhaps to the point where it becomes negligible compared to other air pollution sources, through better appliances and better enforcement of nuisance and related laws.]

15 Problem Solving

This section examines a few problems that might occur when trying to assist homeowners reduce the smoke from their heater.

If the woodheater is operating, have a close look at fire. Most heaters have a transparent ceramic-glass panel in the door, although sometimes it is too sooted-up to see through. If it is sooted-up, this is an indication that the heater has been producing lots of smoke.

If any wood (as opposed to charcoal lumps) is present in the firebox then there should always be visible flame. If there isn't then

1. Open the air supply fully, if flames don't appear add a piece of crumpled paper and light. If flames are not maintained after the newspaper has burnt then; the flue may be almost blocked with creosote, the space above the baffle may be almost blocked with ash, or the wood may be very wet. Less likely is a fault in the air inlet (although I have investigated one problem heater where the marking on the air control was wrong and the owner was turning the air off when they thought it was on full).
2. If there are some flames, but the fire is 'sluggish' then open the air control to full and see if the flame increases. Also check to see if the smoke emissions have decreased. If there is no improvement, try adjusting the geometry of the logs in the fire. If a log is placed parallel to the door this may be preventing the combustion air that flows down the inside of the glass on most heaters reaching the base of the fire. If there is just one large log in the heater this is likely to burn very poorly. If logs are packed in too tightly, air cannot penetrate the wood load. There should be about 2 to 3cm between logs. The problems mentioned in 1 above are the most likely causes.
3. Check the moisture content of several samples of firewood. The moisture should be below 20% (wet weight basis) or below 25% (dry weight basis). If it is well over these values, the wood should not be burnt. If it is just over, it may be possible to achieve a clean burn if the wood is split into smaller logs and the fire is not run on slow burn at all.

Flue cleaning
If it appears a flue could be blocked with creosote the best option is to have a professional chimney sweep in to check the flue. The sweep will have the necessary equipment and experience to get on the roof, sweep the flue and check for any obvious safety problems (e.g. corroded heat shields, blocked ventilation of flue casings, etc.). Some poorly installed flues can actually pull themselves apart through regular thermal expansion and cooling. Thus, loss of good draught may be a warning sign of some potentially more serious problem. Using a professional sweep is important, because a helpful amateur, who has not been trained in woodheater installations, may well miss something important. The Australian Home Heating Association (contact details in reference list below) will be able to advise of sweeps in local regions.

Woodheater cleaning
A common problem in most woodheaters is a gradual build-up of ash on top of the baffle. This ash will not burn-off with a hot fire so it tends to slowly accumulate, possibly over a period of years. At some stage it will start to affect the performance of the heater, reducing draught, making the heater harder to light and increasing smoke. Depending on the design of the heater, it can be difficult to see if ash is accumulating. Sometimes it is possible to reach in above the baffle to check (obviously the heater must be cooled right down), otherwise a

bent metal coat hanger might be used to scrape the ash out. It is possible to use a vacuum cleaner, but it is absolutely essential that the heater is cold, because any small pieces of warm charcoal can quickly become red hot with a flow of air over them causing the vacuum cleaner to catch fire.

Clean glass

Clean glass on a woodheater is more than just an aesthetic benefit, it allows the operator to easily check that the fire is burning well and allows a new batch of wood to be added before the fire has nearly burnt out.

16 Summing Up

Woodsmoke from residential heating can be a nuisance if it interferes with the amenity of nearby properties, and the smoke from many households can cause unacceptable air quality over whole urban areas. The physical and chemical properties of woodsmoke mean that it is almost certainly a hazard to human health if exposure levels exceed accepted standards. From time to time, millions of Australians are exposed to air pollution conditions that exceed accepted standards and there is strong evidence that woodsmoke is a significant component of air pollution in winter.

This establishes a strong case for taking action to reduce woodsmoke. It appears, from the preliminary outcomes of programs commenced in 2001, that targeted education is one of the most effective means of reducing woodsmoke. It is proving to be a strong incentive for households to accept greater responsibility for operating their wood heating appliances so that smoke is minimized. Targeted education can only be carried out at a local level. This requires a commitment and appropriate skills. The information in the Handbook should provide a good foundation for the understanding of woodheater operation and the hazards of woodsmoke.

In theory, woodsmoke can be reduced to levels that would make it relatively insignificant compared to other air pollution sources, without eliminating firewood from the urban energy supply system. In practice, this will require a change in community attitude/behavior that is going to be difficult to achieve. However, encouraging results from Launceston, Tasmania, suggest that the community can change if given the right prompting.

Here is an opportunity to contribute large improvements to urban air quality at relatively low cost (but still at a cost) and in a relatively short time period. Let’s hope the opportunity is grasped.

17 Further Reading and References

Further Reading

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This report discusses all the localised (suburban) sources of air pollutants, including smoke from woodheaters and open fireplaces.

Web Pages about woodheaters and woodsmoke

Australian Home Heating Association web page
http://www.homeheat.com.au

Armidale Air Quality Group web page
http://members.ozemail.com.au/~airqual/index.html

The Australian Home Heating Association
The AHHA has members in every state and territory. The Head Office, in Adelaide, can provide details of local members who might be able to assist with problem situations (where householders seem unable to achieve clean burning conditions).
Phone 08 8231 4633 Fax 08 8231 5633 e-mail demi@homeheat.com.au

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Western Australia Supplement

S1 Residential Heating Preferences

Household heating preferences in Western Australia vary significantly from region to region depending on climate and availability of reticulated gas or electricity. They also vary over time depending on relative costs of fuel and appliances, availability of energy sources, environmental concerns and changing fashions. Figure S1 shows the changes in the main form of heating used in WA from 1972 to 2002. The graph demonstrates that quite large changes in heating preferences can occur over time frames of about a decade.

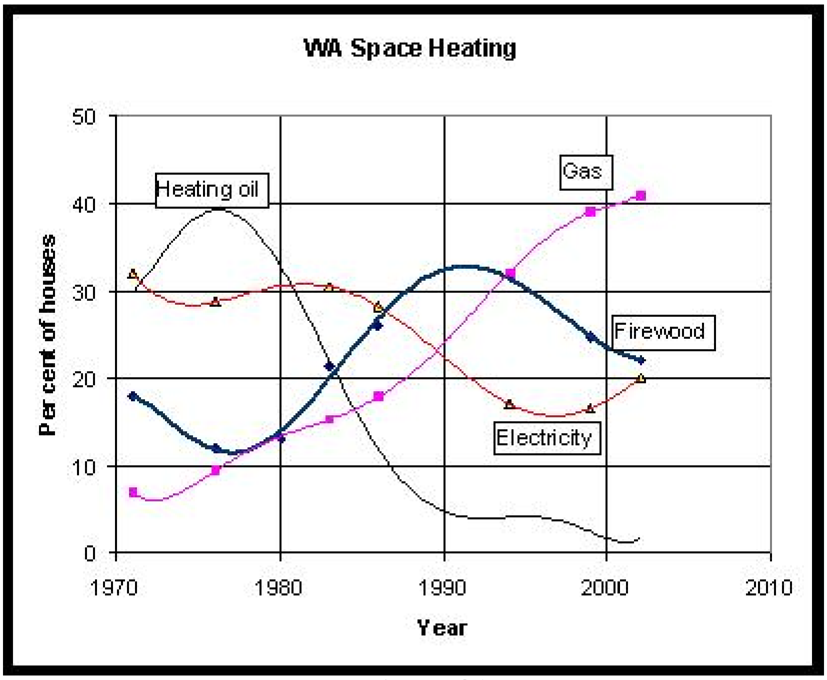

Figure S1
Proportion (%) of households using various energy sources as the main form of heating in the house (numbers are from Australian Bureau of Statistics surveys and Census information)

Some of the significant features are the rapid decline in the use of heating oil (used in oil heaters) from 1978 when Australia moved to world parity pricing for petroleum products resulting in a doubling of heating oil price. This triggered a rise in the popularity of woodheaters, which grew from about 12% of households in 1978 to about 33% in 1992. The decline in the proportion of woodheaters through the 1990s was probably caused by a number of factors including:

- expansion of the reticulated natural gas network through urban areas;
- concerns about woodsmoke; and
- changing fashions.

Natural gas is now the dominant type of residential heating fuel in WA. It is also interesting to note an apparent change in the popularity of electric heating, which might be linked to improved technology for reverse cycle air conditioners.

The proportion of households using the various heating fuels is only one part of the picture because the total number of households has been increasing rapidly over the last three decades. Figure S.2 shows the actual number of households using the three most popular energy sources for their main space heating.

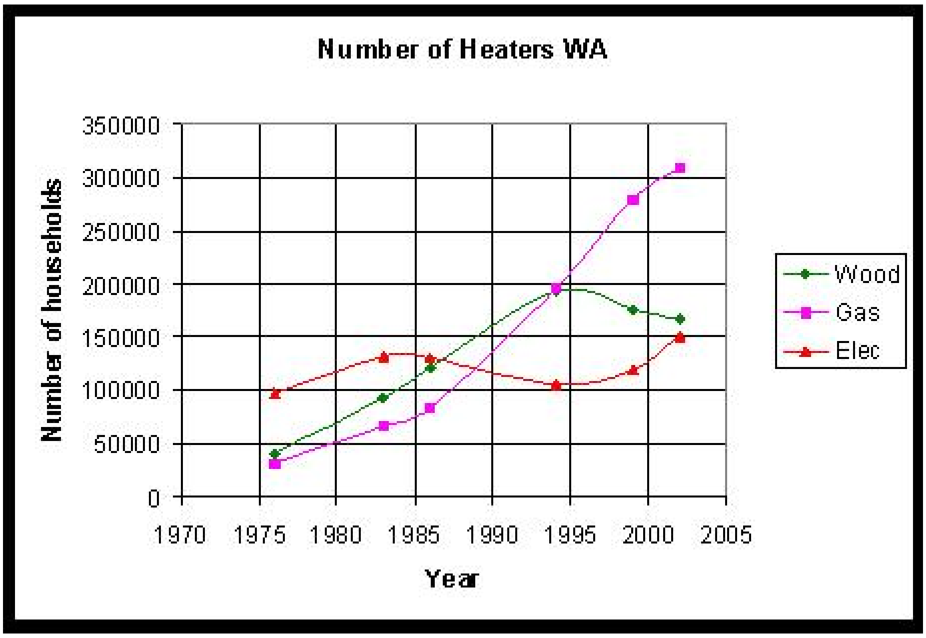

Figure S.2
Number of households in WA using gas, electricity and wood between 1976 and 2002 (numbers are from Australian Bureau of Statistics surveys and Census information)

The significance of the graphs in Figures S.1 and S.2 for woodsmoke are that they show a decline in the proportion of houses using woodheaters as their main heating from about 33% to 22% over the past decade (a one-third drop), while in total numbers the drop is from about 190,000 to about 165,000 over the decade (only a 13% drop).

The current trend is a swing of about 3000 households per year away from woodheating. It is very difficult to say whether this trend will continue. The relative cost of energy will be a factor, as will development of new heating appliances. Extended interruptions to reticulated gas or electricity supply could increase woodheater popularity. Publicity about the adverse health impacts of woodsmoke could decrease woodheater popularity.

Another important factor when considering woodsmoke problems is the urban/rural mix of firewood use. In many remote areas of WA firewood is the only practical fuel for heating (including water heating and cooking). These households will probably continue their use of firewood, and the air quality consequences are unlikely to be a problem. Obviously, it is the use of firewood in urban areas that is most relevant to the woodsmoke issue.

A rough estimate, based on an extension of 1986 survey work by the Australian Bureau of Statistics) suggests that in 2002 roughly 110,000 households in greater Perth used firewood as their main heating fuel, with about 50,000 outside Perth. In addition, around 30,000 households in Perth use firewood occasionally (secondary heating). Table S.1 shows the estimated particle emissions in woodsmoke for Perth. This suggests around 3000 tonnes of respirable particles are emitted into the Perth airshed each winter.

Table S.1 Estimated firewood use and particulate (PM10) emissions in Perth in 2002. The numbers shown in the table are all approximate, based on the author's own estimates of firewood use and emission factors.

Perth	Number of households	Firewood per h'hold per year	Total firewood per year	Approx. emiss. fact.	PM10 emitted/year
	number	tonnes/year	tonnes	g/kg	tonnes
Main Heating	110000	2.4	264000	10.2	2693
Secondary Heating	50000	0.75	37500	10.2	383
Total	160,000		301,500		3076

The emission factor shown in Table S.1 is derived from the information shown in Table S.2. Table S.2 shows an estimate of the proportion of wood-burning households who use their heater well, carelessly and badly. These percentages are based on a survey conducted by the author in NSW in the 2003 winter. The proportions shown for three years in the future are purely speculative. They represent what might be possible if an effective targeted education campaign was carried out. This suggests the very bad heater operators might all be convinced to operate their heaters with greater care (risks of fines would assist this conversion). Also, two-thirds of careless heater operators might be convinced to become good heater operators.

Table S.2 Estimates of average emission factors using a mix of good, careless and bad heater operation. These numbers are all very approximate.

	Now	**In three years**
	Emission factor (g/kg)/per cent households in this group	Emission factor (g/kg)/per cent households in this group
Good heater operation	3g/kg / 40%	3g/kg / 80%
Careless heater operation	10g/kg / 45%	10g/kg / 20%
Bad heater operation	30g/kg / 15%	30g/kg / 0%
Average emission factor	*10.2g/kg*	*4.4g/kg*

Using this relatively optimistic scenario of the impact of a woodsmoke reduction program on average emission factors, together with an assumption that the number of households switching from woodheaters to gas or electricity increased from 3000 per year to 6000 per year, with a proportional decrease in secondary woodheater use, the total PM10 emissions from woodsmoke in the Perth airshed would reduce from 3000 tonnes/winter to about 1000 tonnes/winter. While this is optimistic, it is not unrealistic, and would represent a significant improvement in air quality, health and general well-being. It is an exciting goal.

PROGRESS REPORT TO
JUNE 2004

GOVERNMENT OF WESTERN AUSTRALIA

Implementing the Perth Air Quality Management Plan

Implementing the Perth Air Quality Management Plan

Progress Report to June 2004

Printed in
June 2005

Air Quality Coordinating Committee

Chair	Fred Tromp (Department of Environment)
Members	Robert Griffiths (Department for Planning and Infrastructure)
	Antony Mee (Department of Housing and Works)
	Rick Sneeuwjagt (Department of Conservation and Land Management)
	Jim Dodds (Department of Health)
	Tanya Carpenter (Sustainable Energy Development Office)
	Dale Newsome (WA Local Government Association)
	Mary Askey (Chamber of Commerce and Industry of WA)
	Chad Bishop (Kwinana Industries Council)
	Prof. Philip Jennings (Conservation Council of WA)
	Dr Sue Graham-Taylor (Pollution Action Network)
	Mike Upton (Royal Automobile Club of WA)

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Foreword

On behalf of the Air Quality Coordinating Committee (AQCC), I am pleased to present the third annual progress report on implementation of the *Perth Air Quality Management Plan* (AQMP), the *Progress Report to June 2004*.

The Committee acknowledges the increase in funding from the State Government. This has allowed a greater emphasis on the priority area of reducing the contribution of domestic wood heaters to haze formation.

The Committee acknowledges the contribution of several outgoing members including Margaret Stephens (Department of Health), Nicole Workum (Sustainable Energy Development Office), Rachel Siewert (Conservation Council of WA) and Nathan Malin (WA Local Government Association).

New members to the Committee include Jim Dodds (Department of Health), Tanya Carpenter (Sustainable Energy Development Office), Philip Jennings (Conservation Council of WA) and Dale Newsome (WA Local Government Association). We welcome them and look forward to their contribution.

I also thank the multi-stakeholder AQCC for overseeing the implementation of the Plan and ensuring that progress continues in a consultative, effective and efficient way. I would also like to thank the community, industry and local government groups who have contributed to implementing the Perth AQMP in conjunction with the lead government agencies, and look forward to ongoing support as this important initiative is progressed.

Fred Tromp

CHAIR, AIR QUALITY COORDINATING COMMITTEE

Executive Summary

Hope for the Future: The Western Australian State Sustainability Strategy has identified preserving air quality as essential to a healthy population and healthy environment. The Perth AQMP is a key program for fulfilling these aims.

Review of public concerns on environmental issues continues to indicate that the community rates air quality as one of its main environmental concerns. The State Government continues to provide leadership on this important subject through continued support of the ongoing implementation of this 30-year Plan.

There has been significant progress over the past 12 months with implementing key aspects of the Plan including:

- Changing commuter behaviour to reduce the reliance on private vehicle use;
- Increasing public awareness on the health impacts of unflued gas heaters;
- Reducing emissions from domestic sources including wood heaters;
- Introducing energy efficiency requirements into the Building Code of Australia; and
- Managing smoke from planned burning activities.

Progress has been made in reducing vehicle emissions, managing industrial emissions and enhancing community education on the impacts of air quality as well as ongoing monitoring of air quality. Progress has also been made on the reduction of industrial emissions with the completion of modelling work to allow a targeted reduction in smog precursor emissions.

An important output of the Perth AQMP over the past 12 months has been the winter haze campaign *Halt the Haze 2004*. This includes the pilot *Wood Heater Replacement Program*, the pilot *Home Heating Survey* and supporting *AirWatch Schools Network for Air Quality (SNAQ) on Haze* air monitoring.

In the year ahead several keys programs are scheduled including:

- A pilot *Petrol Vehicle Emissions Testing* program aimed at developing a future policy for reducing emissions from petrol vehicles through testing and maintenance;
- Completion of a peer reviewed Technical Report on air quality modelling which will assist in further targeted reduction in smog precursor emissions;
- Establishment of the Air Monitoring Steering Group to guide and provide community participation in a number of monitoring programs; and
- A continued winter haze campaign incorporating an expanded *Wood Heater Replacement Program*, additional local government training to assist in domestic smoke nuisance resolution, review of legislation for the sale of wood heaters and firewood and expanded public education on the correct operation of wood heaters.

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1.0 Introduction

The Perth AQMP was launched in December 2000 and details 126 actions to ensure that clean air is achieved and maintained throughout the Perth metropolitan region over the next 30 years. The actions within the Perth AQMP seek to achieve this by reducing the emission of those air pollutants that are causing occasional episodes of unacceptable air quality now, and by preventing the development of future air quality problems. The aim of the AQMP is to steadily improve Perth's air quality so that we have cleaner air to a level that is acceptable to the community.

A whole of government initiative, the Perth AQMP was developed via a consultative process that included key government agencies with lead roles in implementation and a range of stakeholders. The AQCC was established by the Government of Western Australia to oversee the development of the Perth AQMP, to monitor implementation of the Plan and to review progress towards achieving the aims of the Plan.

While membership of the AQCC has changed during the development and implementation of the AQMP, the government, industry and community groups represented have remained essentially unchanged. Membership of the AQCC for the reporting period up until June 2004 is listed in Appendix 2.

A Strategy for implementing the Perth AQMP was developed by involved stakeholders and endorsed by the AQCC. The *Implementation Strategy*, released in June 2002, was developed to provide a framework for how the actions within the Perth AQMP would be carried out by State government agencies and other involved organisations.

There is a requirement for the AQCC to report annually to the Government via the Minister for the Environment on implementation of the Perth AQMP, as established in the AQCC's Terms of Reference:

The Committee will, after commencement of implementation of the AQMP, report annually to the Government through the Minister for the Environment on the degree of implementation of the AQMP and progress in achieving the performance targets set in the AQMP.

This Progress Report forms the basis of the AQCC's advice to the Minister for the Environment in accordance with the above requirement.

The previous *Progress Reports to June 2002 and June 2003* were released in April 2003 and March 2004 respectively, and are available from the Department of Environment (DoE) web page at www.environment.wa.gov.au.

Documents published as part of the development of the Perth Air Quality Management Plan; the Perth Photochemical Smog Study, Perth Haze Study, Parliamentary Select Committee's Report and the Government's Response to the Select Committee's report.

The format of this year's Progress Report has changed slightly from last year to reflect comments received. The *Progress Report to June 2004* includes:

- A table providing the status of each program as either not commenced or commenced;
- A summary providing progress on actions to the end of June 2004 and comments from each lead agency outlining major achievements or changes; and
- A table showing the staff time and operational budget for each program.

A summary table similar to the one in the Implementation Strategy to provide an easy-to-read progress report on each of the programs in the AQMP at Appendix 1.

A copy of all reporting templates from lead agencies is available as a separate document (*Progress Report to June 2004 – Completed Reporting Templates*).

2.0 Reporting Process

The DoE's Project Team undertakes the review of progress made and develops the annual Progress Report. The Project Team is also responsible for the organisation and running of AQCC meetings.

Based on discussions with the AQCC, the DoE Project Team has developed a reporting format. The AQCC suggested that reporting of the implementation of the initiatives should allow tracking against the original AQMP actions and should also reflect the whole of government approach.

The *Implementation Strategy* restructured the 126 original AQMP actions into 12 Initiatives covering a total of 43 programs. In order to accurately report the progress of actions, programs being undertaken by more than one agency have been split into sub-programs. There are a total of 89 sub-programs within the Perth AQMP.

A reporting template for each program was produced, containing the information provided in the *Implementation Strategy* and previous years reporting, with space for additional comments. The reporting templates were distributed to the AQCC member from each of the lead agencies for all AQMP programs having already commenced or commencing prior to June 2004. Using the reporting template allowed the consistent reporting of progress of AQMP programs. This was especially useful for programs operating across more than one agency.

Reporting templates were also produced and distributed to the non-government organisations represented if identified as supporting agencies to programs.

All completed reporting forms were then collated and used as the basis for the *Progress Report to June 2004*.

Documents published as part of the consultation of the Perth Air Quality Management Plan; Consultation Draft and the State of Knowledge.

3.0 Progress to June 2004

This section of the report highlights the major achievements of the Perth AQMP up until 30 June 2004. Key actions identified by the AQCC during finalisation of the Perth AQMP as being likely to have the largest impact on air quality in the short term were:

- Changing commuter behaviour to reduce the reliance on private vehicle use;
- Reducing vehicle emissions; and
- Managing industrial emissions.

While these actions will provide significant improvements in Perth's air quality, information on how to reduce all sources of air pollutants need to be provided to the community if generally acceptable air quality is to be achieved. Accordingly, it is essential that the key sectors of land use and transport planning, vehicle, domestic, burning and industrial emissions be addressed. It is also essential to continue with direct emissions reduction, research, prevention, minimisation and education/ partnership programs.

The *Implementation Strategy* for the Perth AQMP includes 43 programs in 12 initiatives. Of these, 39 programs have commenced and will continue in 2004-05. During the reporting period from 1 July 2003 to 30 June 2004, one additional program commenced implementation. Of the four programs yet to commence, one is scheduled to commence in the second half of 2004. The remaining three are contingent on the completion of other programs.

Table 3.1 shows the status of each program as either not commenced or commenced as at June 2004. This table also indicates where implementing programs have been delayed from the date within the *Implementation Strategy* and programs where limited progress has occurred during the period to June 2004.

Section 4 includes a more detailed table showing progress to June 2004 with timelines, reasons for delays to programs and highlights major achievements under each initiative.

Appendix 1 provides a summary report similar to the one in the *Implementation Strategy*, and has been produced to provide an easy-to-read progress report on each of the programs in the AQMP.

Table 3.1: Program Overview

	Not Commenced / Commenced[1]	Program Delayed[2]	No Progress in 2003-2004[3]
Initiative 1: Community Education			
Program 1: Review existing education and behaviour change programs and establish a strategy and framework for developing and implementing supporting programs in future	✓	🕒	
Program 2: Improve everyone's access to air quality information and programs via the Internet	✓		
Program 3: Influence the community's travel behaviour through implementing *TravelSmart*, teleworking and other travel alternatives	✓		
Initiative 2: Vehicle Emissions Reduction			
Program 1: Develop policy and regulations for automotive fuel quality in WA, promote national fuel quality regulation in line with international standards and co-ordinate fuel quality standards with improved vehicle emission standards	✓		
Program 2: Evaluate LPG and CNG as fuel sources for the passenger and freight sectors	✓	🕒	🕒
Program 3: Evaluate various emissions testing options for introduction to Perth and implement the committed outcomes to reduce in-service emissions from motor vehicles	✓	🕒	
Program 4: On-road enforcement of controls on excessive vehicle emissions	✓	🕒	
Program 5: Evaluate and introduce appropriate measures to remove older vehicles from the Perth fleet	✓		🕒
Program 6: Emissions testing training and equipment and technology review	×		
Program 7: Investigate the cost effectiveness of Stage II vapour recovery and promote at national level if cost effective	✓		
Program 8: Investigate the use of electric, alternative fuel vehicles and ultra-light vehicles	✓		
Initiative 3: Reduction of Industrial Emissions of NO_x and ROCs			
Program 1: Assess contribution of industrial NO_x and ROC emissions to smog formation in the Perth airshed	✓	🕒	
Program 2: Assess cost effective NO_x emission reduction options, and implement agreed options to reduce emissions from significant industrial sources	×	🕒	
Program 3: Identify and assist the major emitters of ROCs to reduce industrial contributions, and encourage continuous improvement in ROC reduction measures already introduced	×	🕒	
Initiative 4: Health Research			
Program 1: Investigating the public health impacts of air pollution	✓		
Program 2: Investigating sources of air pollutants and their impact on residents by determining the potential health impacts of variations in Perth's daily air quality	✓	🕒	
Program 3: Development of an Air Pollution and Health Network	✓		
Initiative 5: Modelling Improvements			
Program 1: Update and consolidate air emissions databases	✓		
Program 2: Validate / improve emissions estimates for key emission sources	✓		
Program 3: Improve modelling capability and accuracy	✓		
Initiative 6: Air Quality Monitoring			
Program 1: Establish an Air Monitoring Steering Group to review air quality monitoring issues in the Perth metropolitan region	×	🕒	
Program 2 Review air quality monitoring practices and procedures in the Perth metropolitan region	✓		
Program 3: Develop future monitoring programs	✓		
Program 4: Support community information and education programs on air quality monitoring	✓		

[1] Programs with a tick (✓) have commenced and those with a cross (×) have not commenced. Shaded programs have been completed.
[2] Indicates that a program has been delayed from the commencement date in the Implementation Strategy (June 2002). Further details are provided in Section 4 of the report.
[3] Indicates that although a program has commenced, there has been little or no progress in the period 1 July 2003 to 30 June 2004.

	Not Commenced / Commenced[1]	Program Delayed[2]	No Progress in 2003-2004[3]
Initiative 7: Indoor Air Quality			
Program 1: Development of an Indoor Air Quality Network	✓	◷	
Program 2: Investigate indoor air quality and the contribution of indoor air exposure to personal exposure	✓		◷
Program 3: Increase community indoor air quality awareness	✓	◷	
Initiative 8: Land Use and Transport Planning			
Program 1: Include regional and local air quality considerations in the strategic planning and implementation of *Network City: Community Planning Strategy for Perth and Peel*	✓		
Program 2: Include regional and local air quality considerations in the planning and implementation of development proposals	✓		
Program 3: Monitor and review the effectiveness of land use and transport planning decisions in influencing Perth's air quality	✓		
Program 4: Assist local government in influencing the community's travel behaviour to bring about positive change	✓		
Initiative 9: Haze Reduction			
Program 1: Increase community awareness of the impacts of domestic wood heaters on air quality	✓		
Program 2: Increase awareness among wood suppliers and wood heater installers of the impacts of wood heaters on air quality	✓		
Program 3: Domestic smoke nuisance resolution	✓		
Program 4: Manage green waste disposal and recycling to reduce local haze creation	✓		◷
Initiative 10: Energy Efficient Buildings			
Program 1: Adoption of energy efficiency principles through building codes	✓		
Program 2: Encourage energy efficient building design and planning	✓		
Initiative 11: Cleaner Production			
Program 1: Encourage cleaner production	✓	◷	◷
Program 2: Ensure proper airshed planning for future industrial development and power generation in the Perth metropolitan region	✓		
Initiative 12: Smoke Management			
Program 1: Establish a Smoke Management Awareness Group to facilitate community education and information about smoke impacts from planned burns	✓		
Program 2: Smoke Management Liaison Group	✓		◷
Program 3: Smoke management policy and regulation	✓		
Program 4: Smoke management research	✓	◷	

[1] Programs with a tick (✓) have commenced and those with a cross (×) have not commenced. Shaded programs have been completed.
[2] Indicates that a program has been delayed from the commencement date in the Implementation Strategy (June 2002). Further details are provided in Section 4 of the report.
[3] Indicates that although a program has commenced, there has been little or no progress in the period 1 July 2003 to 30 June 2004.

4.0 Achievements to June 2004

4.1 INITIATIVE 1: COMMUNITY EDUCATION

The objective is to inform the community about air quality issues aiming at behaviour change that will bring about a reduction in emissions of air pollutants. The following three programs have been identified to achieve these aims:

1 Review existing education and behaviour change programs and establish a strategy and, framework for developing and implementing supporting programs in the future;

2 Improve access to air quality information and programs via the internet; and

3 Influence the community's travel behaviour through implementing *TravelSmart*, teleworking and other travel behaviour change programs.

Table 4.1 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. The key points this table shows are:

- There has been substantial progress with the majority of programs that were scheduled to commence. Particularly the priority programs of influencing the community's travel behaviour through programs such as *TravelSmart*.
- The review of existing education and behaviour change programs was rescheduled to January 2003 due to delays in staff recruitment to undertake the review and develop the *Community Education Strategy*.
- The current funding arrangement for the Sustainable Transport Officer (STO) position undertaking activities under Program 3a will end on 31 January 2005. Activities under this program will only continue if funding for the STO position is maintained.
- A program to scope opportunities to reinstate the *Cycle 100* program has been scheduled for 2004-05.

Details of progress on key issues up until June 2004

1 The Community Education working group (see Appendix 2 for membership) has been formed and meetings held to develop the draft *Community Education Strategy*. The release of the *Community Education Strategy* has been delayed whilst the draft *Communications Framework* is developed. The draft *Communications Framework* was submitted to the AQCC for comment in May 2004. It is expected to be finalised in late 2004.

The review of existing education and behaviour change programs commenced in 2004 in parallel to the development of the *Communications Framework*. Gap analysis has commenced at a tertiary and community level with meetings conducted. A review of existing programs is to be undertaken commencing with an evaluation of *AirWatch* primary and secondary school programs. A Memorandum of Understanding (MoU) with *AirWatch* is being developed to facilitate delivery of AQMP outcomes within schools.

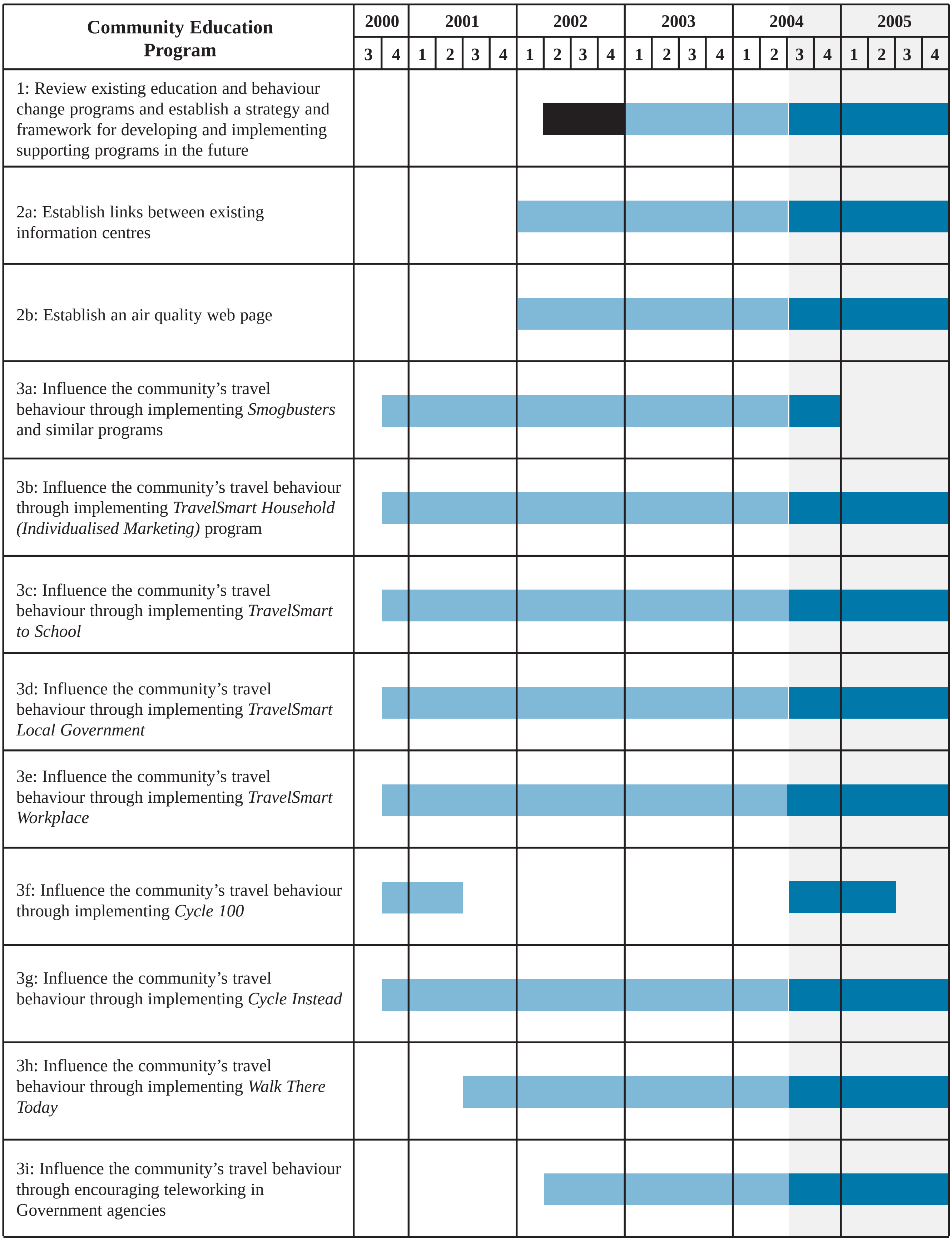
An Honours project to develop a module for secondary, tertiary and community based passive sampling will be conducted in 2005.

Many non-Government organisations have expressed interest at further participation in the delivery of this program:

- Conservation Council of WA (CCWA) is keen to take a major role in this area dependent upon accessing funding support for staff to carry out this work. There is enormous potential for CCWA to assist by providing information and training to the public. CCWA also provides information and advice to the public on air quality issues through its office.
- Royal Automobile Club of WA (RAC WA) will provide input and assist with the production of articles for their member's magazine '*Road Patrol*'.
- Pollution Action Network (PAN) will continue to contribute directly to the AQMP via the State of Environment process and State Sustainability Strategy. PAN continues to provide information on air quality issues to the community and intends to organise a community forum on air quality later in 2004.

Students participating in the DoE's award winning AirWatch program.

Table 4.1: Progress to June 2004 – Community Education



Key: Program Delayed/ Limited Progress · Program Commenced · Future Activity

In *Hope for the Future: The Western Australian State Sustainability Strategy* the section on air quality ensures that the Perth AQMP, *Community Education Strategy* and *Communications Framework* objectives are reflected.

The *Community Education Strategy* is a component of the draft *Environmental Education Strategy* and was developed to ensure that the messages about air quality are communicated to the public in a consistent manner.

2 An air quality web site was developed and has been on-line since the launch of the *Implementation Strategy* in June 2002. The web site has received a steady number of 'hits' since its launch in June 2002, with the air quality web site serving an average of between 300 and 600 pages on any given day. The web site has run smoothly and reliably with reported faults corrected in a timely manner.

DoE is currently developing a new agency website which will be launched in July 2004 (www.environment.wa.gov.au). The content from the air quality web site will be incorporated into the new web site.

The major features of the web site include:

- Access to daily air quality data from monitoring sites (the most heavily used feature of the web site);
- Access to information about air pollutants, Perth's air quality, studies and programs;
- Access to air quality publications; and
- Links to related sites.

The web site provides for feedback from users, which will assist in ongoing maintenance and development of the site. The *Community Education Strategy* will also provide feedback on new materials and links, including greater use and cross promotion of the *AirWatch* web site which is funded through the AQMP, are planned.

Identifying and evaluating web sites with an air quality component has facilitated the establishment of links between existing information centres. In addition, information has been provided for inclusion on Asthma WA and Western Power Corporation web sites. CCWA has indicated they would also be willing to provide a link to the air quality site from their homepage. All links will be updated following the establishment of the new DoE agency web site.

A new display for air quality management and the AQMP was developed and used for *World Environment Day* in June 2003. This display will be evaluated for ongoing involvement in *World Environment Day* displays and utilised at other public forums and events held throughout the year. The *World Environment Day* display was not repeated in June 2004, as activities focussed on the launch of the pilot *Wood Heater Replacement Program*.

3 Influencing the community's travel behaviour has been identified by the AQCC as one of the key programs for the Perth AQMP. There have been a number of developments in this program since commencing implementation of the Perth AQMP.

- *Smogbusters* was a Commonwealth program established under the Natural Heritage Trust (NHT) and operated locally by CCWA. Working with local communities, schools, non government organisations, local governments, State government agencies and business; Smogbusters promoted the use of walking, cycling and public transport as a means of improving the air quality of Perth. Actions to achieve this involved holding public forums and speaking tours, providing media statements and community information on urban transport issues to foster local community action. CCWA also worked to promote and develop Green Transport Plans (GTPs) for several organisations under the *TravelSmart Workplace* program.

  Unfortunately, the program ceased in April 2002 due to the withdrawal of NHT funding. The Federal Government provided funding for a school debating project and *Smogbusters* speaking tour in March-April 2003, however there is no ongoing activity.

  CCWA now has a STO position responsible for advocacy of sustainable transport such as cycling, walking and public transport. Several workshops, conferences and seminars have been held successfully on these issues.

  The present funding arrangement for the STO position will end on 31 January 2005. Funding is being sought to continue the STO position beyond that date. This work will continue provided funding is obtained for the STO.

- The South Perth large scale demonstration project, Stage 1 of the *TravelSmart Household (Individualised Marketing)* program, was evaluated by a third survey after completion of the trial. The results indicated travel behaviour change has been sustained. *TravelSmart* (Stage 2) has been delivered to the Town of Cambridge, City of Subiaco, suburb of Marangaroo in the City of Wanneroo and parts of the City of Melville, City of Fremantle, Town of Vincent, City of Armadale and City of Belmont. Projects are planned for the City of Gosnells in early 2005 to complete Stage 2.

Five projects fully evaluated to date indicate the achievement of a 10% reduction in car-as-driver trips and a 13% reduction in car kilometres travelled.

- The *TravelSmart to School* program has developed a partnership with Millennium Kids to assist with the engagement of primary and secondary schools in the program. The applicability of the program for secondary schools was reviewed with the funding for the secondary schools program being reallocated to further expand the Primary School Program in 2003 and 2004. A reduction in car trips to school of up to 23% has been achieved in 119 classes (3472 students) in 25 metropolitan and 17 regional primary schools participating in the *TravelSmart to School Week*.

  A *Walking School Bus Program* has been established in 16 primary schools, consisting of 24 routes (cumulative) to promote and support increased walking to primary schools.

- The *TravelSmart Local Government* program provided funding, training and support for eight local governments to employ *TravelSmart* Officers during 2001-02 to work on travel behaviour programs. This program has been extended to the end of the 2004-05 financial year with funding support from the Australian Greenhouse Office. Additional funding will be required to continue and expand the program beyond June 2005.

  All participating local governments (Cities of South Perth, Melville, Subiaco, Nedlands, Fremantle and Towns of Victoria Park, Cottesloe and Claremont) have produced Local Action Plans, with plans reviewed and actions updated as required. Program focus may expand to include broader sustainability issues.

- The *TravelSmart Workplace* program has resulted in GTPs being developed and implemented for a number of workplaces including:

  - Prior to 2002: Woodside, Water Corporation, Department of Health, City of Perth, Ove Arup and Partners, Clough Engineering, HomesWest, MarketForce, Hartley Poynton, Institute for Child Health Research;

  - 2002: Four metropolitan DPI offices, Schlumberger Oil Fields Australia and Pharmacia Pty Ltd;

  - 2003: Department of Environment and City of South Perth (Depot and Civic Centre); and

  - 2004: Fremantle Hospital, Hollywood Private Hospital, Department of Industry and Resources, Department of Agriculture and Technip-Coflexip Oceania, representing a total of approximately 4,000 employees. All organisations involved in the 2004 program have developed their GTPs and are due to launch these in October 2004.

  Follow-up surveys from workplaces have indicated that travel behaviour changes away from single occupant vehicles are being sustained over time and the GTPs are being updated where necessary.

  For workplaces participating in 2003, DoE recorded a reduction in overall kilometres travelled by car and the City of South Perth recorded mixed results across its two sites, with no net change. The Civic Centre recorded a reduction of 20% in overall kilometres travelled.

  Schlumberger Oil Fields Australia conducted another survey in 2004 to determine if there was sustained change following the development of their GTP in 2001. They recorded a reduction of 14% from the baseline survey of travel behaviour, better than the initial target of 10%.

  12 articles appeared in local printed media covering the activities of participating organisations.

  In 2005 over 6,000 employees will be recruited to participate in the program. Six workplaces including QE2 Medical Centre, City of Joondalup, Transfield, Department of Premier and Cabinet, Disability Services Commission and Sinclair Knight Mertz will participate.

- The *Cycle 100* program did not continue into 2003-04. A program is scheduled in 2004-05 to scope opportunities to reinstate the program for 2005-06.

- The *Cycle Instead* program has continued to promote cycling as a viable transport choice by running an electronic and print media campaign to position cycling as the solution to a series of health, environmental and road congestion problems. The campaign provides a series of role models for cyclists and promotes cycling for short trips, supported with community bike rides and events. The *Cycle Instead* radio and media campaign was cancelled in 2003-04 because of lack of funds to sustain such an expensive program. *Cycle Instead Bikeweek* was held in March 2004 as part of the ongoing promotion of cycling. A number of events, including the well attended *Bike to Work Breakfast* were held during *Bikeweek*.

The program is having the positive effect of maintaining cycling activities among adults in the face of a drop-off in children cycling.

- The *Walk There Today* program has been developed and implementation has commenced. The '*Walk There Today to Find Thirty*' message icon was developed and launched each October as a collaborative project with the '*Find Thirty*' program.

  Activities during *Walk Week*, held from 3 to 9 November 2003, included Community Walks, Walk to School Day and Walk There to Find Thirty for Corporate Workers. During *Walk Week* 25,000 school children walked to school, 2,300 adults participated in community walks, 16,000 copies of walking guidebooks were distributed and 300 corporate workers participated in lunchtime walks. During *Walk Week* 85% of the people in metropolitan area were exposed to the promotional message of '*Walk There Today to Find Thirty*'.

- The program to support teleworking in government agencies commenced, with preliminary research and information gathering being completed.

  Following the review of the telework pilot results the project has not progressed due to insufficient resources. The program is not expected to progress any further due to a continued lack of resources.

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.2.

4.2 INITIATIVE 2: VEHICLE EMISSIONS REDUCTION

Motor vehicles are the largest single source of air pollution in the Perth airshed and contribute significantly to the development of smog. Reduction of vehicle emissions can be achieved by implementing a range of programs including:

1 Developing policy and regulations for automotive fuel quality in WA, promoting national fuel quality regulation in line with international standards and coordinating fuel quality standards with improved vehicle emission standards;

2 Evaluating liquefied petroleum gas (LPG) and compressed natural gas (CNG) as fuel sources for the passenger and freight sectors;

3 Evaluating various emissions testing options for introduction to Perth and implementing the committed outcomes to reduce in-service emissions from motor vehicles;

4 On-road enforcement of controls on excessive vehicle emissions;

5 Evaluating appropriate measures to remove older vehicles from the Perth fleet;

6 Emissions testing training, equipment and technology review;

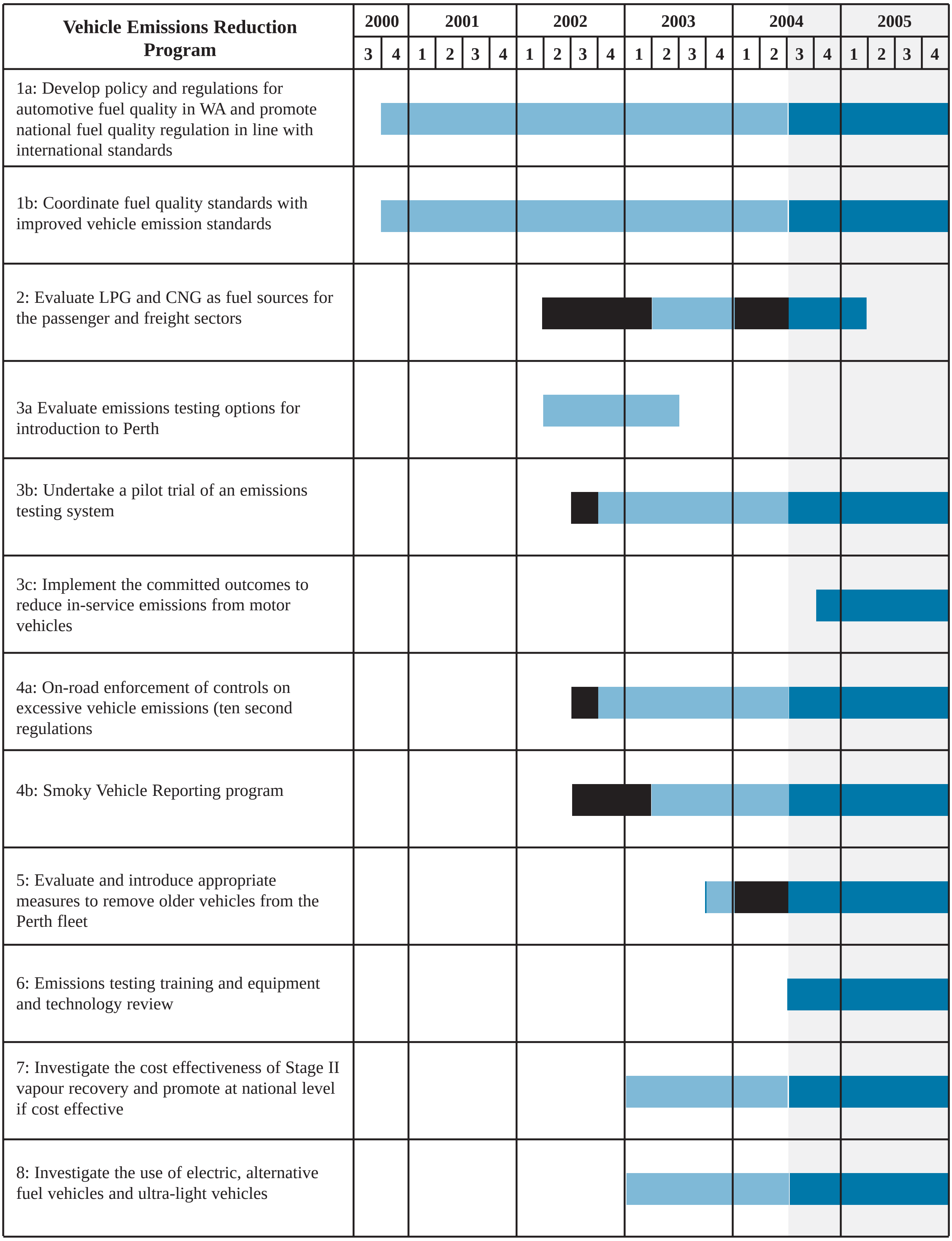
7 Investigating the cost effectiveness of Stage II vapour recovery and promoting at national level if cost effective; and

8 Investigating the use of electric, alternative fuel vehicles and ultra-light vehicles.

Table 4.2: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 1: Community Education		
Program 1: Review existing education and behaviour change programs and establish a strategy and framework for developing and implementing supporting programs in future	0.6 FTE	
Program 2: Improve everyone's access to air quality information and programs via the Internet	0.1 FTE	
Program 3: Influence the community's travel behaviour through implementing *TravelSmart*, teleworking and other travel alternatives	10.9 FTE	$1,328,000

Table 4.3: Progress to June 2004 – Vehicle Emissions Reduction



Key: Program Delayed/ Limited Progress   Program Commenced   Future Activity

Table 4.3 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. This table shows:

- There has been substantial progress with most programs having commenced including the priority programs of maintaining clean fuel regulations and introducing an emissions testing program.
- The review of LPG and CNG as fuel sources for passenger and freight sectors has not progressed as the research project was not taken up in January 2004. This will be re-offered for commencement in January 2005.

Details of progress on key issues up until June 2004

1 The original AQMP actions predate a number of significant national developments including the Commonwealth's *Fuel Quality Standards Act 2000* and associated *Fuel Quality Standards Regulations 2001*. These developments have meant that a different approach to the implementation of this program was required. For example, the coordination of future *Euro* vehicle emission standards as Australian Design Rules (ADRs) and fuel quality requirements is part of the Commonwealth's *Fuel Quality Standards Act 2000*. Therefore, the target of continuous improvements in fuel quality will be met by the adoption of the national standards.

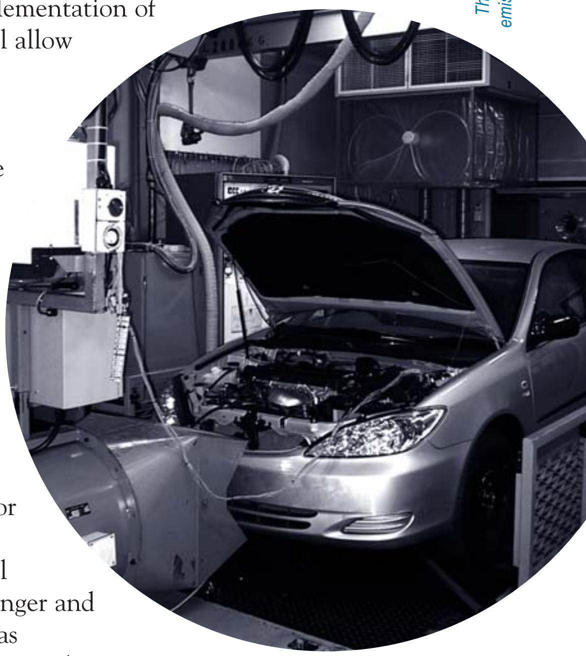
The *Environmental Protection (Diesel and Petrol) Regulations 1999* were introduced in January 2000 to reduce vehicle emissions by improving fuel quality in WA. The Commonwealth introduced less stringent national fuel standards in January 2002. Following the introduction of the less stringent Commonwealth standards, WA fuel standards have been a highly contentious issue and there has been continued pressure to revert to the Commonwealth standards due to perceived pricing and competition impacts of the State regulations. However, the WA fuel standards have been maintained with Commonwealth monitoring indicating no recorded breaches to date.

A national study for exposure to benzene, toluene, ethyl benzene and xylene in Sydney, Melbourne, Adelaide and Perth, released in May 2003, found that participants in Perth had significantly lower exposure to benzene than participants in the other cities. The Perth participant's lower exposure to carcinogenic benzene may be linked to WA's more stringent fuel quality regulations. The WA regulations limit benzene to a maximum of 1% by volume.

Future fuel policy in WA is aimed at maintaining standards and alignment with future Commonwealth fuel standards in 2006. Up until 1 January 2006, when the Commonwealth and WA regulations fully align, the Commonwealth standards become increasingly more stringent reducing the likely price difference between WA and the rest of Australia.

WA provides input into proposed future Commonwealth standards as required. WA also participates in the Fuel Standards Consultative Committee (FSCC) and the review of future fuel and emissions standards through the Land Transport Environment Committee (LTEC) (previously known as the Motor Vehicle Environment Committee). Participation in these forums ensures future national fuel and emissions standards are inline with *Euro* emissions standards established through ADR development.

It is considered that the approaches adopted for implementation of this program will allow continuous improvement. However, if relaxation of the WA fuel standards was to occur, there is some risk that continuous improvement in fuel quality will not oocur.



The testing of the exhaust emissions from a family car.

2 Initial scoping for a review of LPG and CNG as fuel sources for passenger and freight sectors has commenced. The evaluation was to be completed as a funded university research project commencing January 2004. However this research project was not taken up in 2004 and will be re-offered in early 2005.

Following completion of the student project a report with recommendations will be presented to the AQCC.

It should be noted that this is an area of constant change, with rapid development of improved emissions control technology for vehicles operating on alternative fuels and petroleum based fuels. In addition, there is no clear consensus on the preferred method for conducting life cycle analysis for fuel production. These issues make the assessment of different fuels problematic.

3 The evaluation of emissions testing options for introduction to Perth was initially planned as a desktop review. The Program phases were reviewed in September 2002 due to the availability of Commonwealth funding under the National Environment Protection (Diesel Vehicle Emissions) Measure (Diesel NEPM). Evaluation has now been included as a 'real world' assessment as part of the vehicle emissions testing program. Scenario and air quality impact modelling will be considered, once the emissions testing pilot programs have been completed.

Commonwealth funding under *Measures for a Better Environment* for emissions testing capabilities was made available for contracting emissions testing services to undertake a pilot program as part of Diesel NEPM implementation. The funds were available for the capital costs of vehicle testing stations, human resources, training and promotion, with ongoing operational costs being the responsibility of the State.

A proposal for a pilot *Diesel Vehicle Emissions Testing* program was prepared and submitted to the Commonwealth in late 2002 in an attempt to secure funding available for implementing the Diesel NEPM in WA. In early 2003, the Commonwealth indicated the amount of funding available had been significantly reduced with WA likely to receive less than required to undertake the proposed pilot program. Negotiation between the Commonwealth and State has resulted in a revised pilot *Diesel Vehicle Emissions Testing* program being submitted based on available Commonwealth funding.

It is expected the Commonwealth Environment Minister will review the proposal and make a funding decision by July 2004. If the proposal is successful, the contract details will be finalised and initial stages of the pilot *Diesel Vehicle Emissions Testing* program will commence in late 2004 with input from the Vehicle Emissions Reduction working group.

The revised program consists of four main components: vehicle testing and repair, communications and education strategy, in-service and apprenticeship training and program evaluation. It is proposed that these components will be implemented over a three year period in conjunction with a range of stakeholders.

A State funded pilot *Petrol Vehicle Emissions Testing* program commenced in 2003-04. This program is aimed at developing a future policy for reducing emissions from petrol vehicles through testing and maintenance, including the replacement of three way catalytic converters. Mid-aged petrol passenger vehicles have been identified as the test fleet for this program. The reason they primarily rely on 'active' systems (catalytic converters, on-board computers and sensors) to significantly reduce their emissions. These systems become less efficient as total vehicle kilometres travelled increases.

To determine the significance of properly operating 'active' systems, it is proposed a sample of vehicles will have their exhaust emissions tested. Subsequent to this testing, the worst emitting vehicles will have either a new catalytic converter fitted and/or a service undertaken. These vehicles will then be re-tested to measure the emissions improvements.

Petrol vehicle evaporative emissions are also critically important in Perth in terms of ozone formation. For this reason, evaporative testing is considered to be an important component of the program. It is proposed a number of the sample vehicles are tested for evaporative emissions. After this initial test, the fuel caps would be replaced and the vehicle retested. This exercise will provide valuable cost benefit data regarding the replacement of fuel caps to reduce evaporative emissions, and allow comparison with catalytic converter replacement to reduce tailpipe emissions. This work is also of national importance because there is little data available on evaporative emissions from the Australian fleet, and these emissions can be more important than exhaust emissions under the summer time conditions typically experienced in Perth.

Project scoping documents were developed and released for public tender to identify a suitable service provider. Limited expression of interest was shown through the tender process and the submitted tender was significantly higher than budgeted for. Negotiations with the preferred tender are continuing in order to progress the program within budget.

A cost benefit analysis will be conducted after both the petrol and diesel pilot emissions testing programs are completed. Detailed timing and resourcing for the introduction of vehicle emissions testing will be developed once the recommendations of the cost benefit analysis have been finalised.

It should be noted that without external funding of some kind (including cost recovery options), widespread vehicle emissions testing is unlikely to be introduced in WA. It is considered that the proposed testing program will provide a good understanding of the costs of testing, the emission reduction benefits and the likely costs/requirements of a vehicle maintenance regime.

4 In November 2002, the introduction of the *Road Traffic (Vehicle Standards) Rules 2002* placed limits on the visible exhaust emissions from vehicles.

Known as the '10 second rule', it makes it illegal for a vehicle to produce continuous visible smoke for more than 10 seconds. Legislative amendments were subsequently introduced to minimise complications with the enforcement of the '10 second rule'.

A brochure entitled 'Clear the Air' was released to promote the requirements of the new 10 second regulations. Training resources and documentation have also been produced. However, agreements need to be finalised for the enforcement of the '10 second rule' and funding obtained before further public education campaigns are launched and officer training is instigated.

There is a need to refine the *Smoky Vehicle Reporting* program as a primary enforcement tool. A review of the *Smoky Vehicle Reporting* program for effectiveness and incorporation with the '10 second rule' was scheduled for completion by June 2004. Initial review indicated that the program needed improvement at an operational level in order to facilitate the review proceeding. This involves improving the administrative operation of the program planned for July 2004. The review is scheduled to commence in November 2004.

Owners of vehicles who receive multiple reports to the *Smoky Vehicle Reporting* program are notified and advised that failure to rectify their vehicle may lead to further enforcement under the 10 second regulations. Negotiations are continuing to develop a process for active enforcement for vehicles reported more than five times. Preliminary discussions have occurred, with a final enforcement procedure to be developed in 2005.

5 The evaluation of appropriate measures to remove older vehicles from the Perth vehicle fleet will be undertaken as a funded research project. Initial scoping of the research project has been completed and will be offered for commencement in early 2005.

6 The emissions testing training, equipment and technology review will commence if an emissions testing regime for Perth is introduced. Initial scoping of course content and structure will occur as part of the pilot *Diesel Vehicle Emissions Testing* program.

7 International experience has shown that if Stage I vapour recovery is in place and the volatility of petrol has been reduced (as is the case in Perth), the cost effective emissions reduction benefit of Stage II vapour recovery is limited. LTEC has indicated there is currently no plans to introduce Stage II vapour recovery at a national level. An ongoing watching brief will be kept and input provided to LTEC where required. NSW Department of Environment and Conservation (DEC) is conducting a trial of Stage II vapour recovery, and the results of trial will be used to aid in the evaluation of the appropriateness of stage II vapour recovery for Perth.

8 The Transport Energy Strategy Committee undertook investigation of the use of electric, alternative fuel vehicles and ultra light vehicles, and submitted it's report to the Minister for Planning and Infrastructure for consideration. An ongoing watching brief will be kept. Representation on an advisory group to this Committee has ensured the *Transport Energy Strategy* is consistent with and builds upon actions within the Perth AQMP.

The uptake of LPG vehicles has been supported by a Government fleet policy that requires 25% of all eligible 6 cylinder vehicles to be LPG fuelled (either bi fuel or dedicated). The makeup of the State Government fleet is shown in Table 8.1. The total number of vehicles in the State Government fleet is 9635, made up of 6327 passenger vehicles and 3308 commercial vehicles. Of these 692 (11%) are passenger LPG vehicles and 135 (4%) are commercial LPG vehicles.

Table 8.1: Makeup of the State Government fleet
(from Department of Treasury and Finance)

	Passenger					Commercial			
No. of Cylinders	Petrol	Diesel	Bi Fuel LPG	Dedicated LPG	Hybrid Petrol / Electric	Petrol	Diesel	Bi Fuel LPG	Dedicated LPG
4	1943	0	0	0	24	544	1027	0	0
5	0	0	0	0	0	0	4	0	0
6	3658	0	255	437	0	952	636	18	118
8	10	0	0	0	0	9	0	0	0
Total	5611	0	255	437	24	1505	1667	18	118

The increased use of 4 cylinder, hybrid petrol / electric and LPG vehicles has resulted in reductions in both greenhouse and noxious vehicle emissions. The current vehicle fleet policy is under review to include a requirement to purchase 4 cylinder vehicles in preference to 6 cylinder vehicles, resulting in a further reduction in greenhouse emissions from the State Government vehicle fleet. This review is expected to be completed late in 2004. An evaluation of emissions performance information has been provided where requested during this process.

The Commonwealth has a program of investigating the use of biofuels and other alternative fuels, and WA will continue to provide input where required.

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.4.

4.3 Initiative 3: Reduction of Industrial Emissions of NO_x and ROCS

Heavy industry can emit significant quantities of oxides of nitrogen (NO_x) and reactive organic compounds (ROCs) that are precursors to photochemical smog. Provisions within the *Environmental Protection Act 1986* require industry to meet emissions limits as prescribed in licences. An ongoing review of emissions limits prescribed in licences as they are assessed and issued will ensure that emissions limits comply with agreed international and national standards. This may result in further reduction in emissions in some instances. The Government is also engaged in stakeholder consultation process to implement an Environmental Improvement Plan (EIP) model for WA as recommended by the Welker Review of licences. Licensee's that implement EIPs will aim to reduce or minimise emissions through a process of continuous improvement.

Reduction of these emissions can be further achieved through the following programs:

Table 4.4: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 2: Vehicle Emissions Reduction		
Program 1: Develop policy and regulations for automotive fuel quality in WA, promote national fuel quality regulation in line with international standards and co-ordinate fuel quality standards with improved vehicle emission standards	0.3 FTE	
Program 2: Evaluate LPG and CNG as fuel sources for the passenger and freight sectors	0 FTE	
Program 3: Evaluate various emissions testing options for introduction to Perth and implement the committed outcomes to reduce in-service emissions from motor vehicles	0.6 FTE	
Program 4: On-road enforcement of controls on excessive vehicle emissions	0.1 FTE	
Program 5: Evaluate and introduce appropriate measures to remove older vehicles from the Perth fleet	0 FTE	
Program 6: Emissions testing training and equipment and technology review	0 FTE	
Program 7: Investigate the cost effectiveness of Stage II vapour recovery and promote at national level if cost effective	< 0.1 FTE	
Program 8: Investigate the use of electric, alternative fuel vehicles and ultra-light vehicles	1.0 FTE	

1 Assessing contribution of industrial NO_x and ROC emissions to smog formation in the Perth airshed;

2 Assessing cost effective NO_x emissions reduction options, and implementing agreed options to reduce emissions from significant industrial sources; and

3 Identifying and assisting the major emitters of ROCs to reduce industrial contributions, and encourage continuous improvement in ROC reduction measures already introduced.

Table 4.5 shows the progress of implementation to June 2004 and future timing to December 2005 for each program within this initiative. This table shows:

- Delays in undertaking the modelling due to resolution of inventory data taking longer than expected. This has now been resolved and preliminary modelling has been completed.
- Minor delays in the program to assess cost effective NO_x emissions reduction options and implement agreed options to reduce emissions from significant industrial sources, due to the delay in modelling.

Details of progress on key issues up until June 2004

1 The *Perth Photochemical Smog Study* (1996) included modelling of emissions sources such as industrial, domestic and area sources. A more detailed assessment of the contribution of industrial sources of NO_x and ROCs to photochemical smog formation in Perth was considered by the AQCC as a priority.

A review of modelling capabilities has been completed and the model has been configured to enable seasonal runs. In addition, real time emissions data is now available to assist with seasonal modelling. The reliability of inventory data was found to be an issue, as modelled concentrations were significantly higher than measured concentrations. The NO_x inventory data was found to have over-estimated emissions and estimates have since been refined in response. This has resulted in a more representative emissions inventory and improved accuracy in model outputs.

Preliminary modelling has been completed and will help inform decisions on priorities for industrial emissions management. A draft technical report is under going peer review. The final report incorporating results of reviewers will be made available for stakeholder comment.

Table 4.5: Progress to June 2004 – Reduction of Industrial Emissions of ROCs and NO_x

Reduction of Industrial Emissions of ROCs and NO_x Program	2000		2001				2002				2003				2004				2005			
	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1a: Review modelling capability and needs in order to assess contribution of industrial NO_x and ROC emissions on smog formation in the Perth airshed																						
1b: Undertake modelling																						
2: Assess cost effective NO_x emission reduction options, and implement agreed options to reduce emissions from significant industrial sources																						
3: Identify and assist the major emitters of ROCs to reduce industrial contributions, and encourage continuous improvement in ROC reduction measures already introduced																						

Key: Program Delayed/ Limited Progress   Program Commenced   Future Activity

2 Assessment of cost effective emissions reduction options and implementation of agreed options to reduce NO_x emissions from significant industrial sources has not commenced, pending outcomes of Program 1. Program 2 is scheduled to commence following the release of the final technical report on the results of the modelling. At this time, the Industrial Emissions Reduction working group will be convened to progress development of cost effective emissions reduction strategies.

3 Assessment of cost-effective emissions reduction options and implementation of agreed options to reduce ROC emissions from significant industrial sources has not commenced, pending outcomes of Program 1. Program 3 is scheduled to commence following the release of the final technical report on the results of the modelling. At this time, the Industrial Emissions Reduction working group will be convened to progress development of cost effective emissions reduction strategies.

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.6.

Aerial view of the Kwinana Industrial Area.

Table 4.6: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 3: Reduction of Industrial Emissions of NO_x and ROCs		
Program 1: Assess contribution of industrial NO_x and ROC emissions to smog formation in the Perth airshed	0.2 FTE	
Program 2: Assess cost effective NO_x emission reduction options, and implement agreed options to reduce emissions from significant industrial sources	< 0.1 FTE	
Program 3: Identify and assist the major emitters of ROCs to reduce industrial contributions, and encourage continuous improvement in ROC reduction measures already introduced	< 0.1 FTE	

4.4 Initiative 4: Health Research

There are now numerous studies which have demonstrated a significant relationship between air pollutants and population level health outcomes. The new emerging areas of research are the impacts of air pollutants on children and long term health impacts of exposure to air pollutants. Aspects relating to the application of standards for the protection of public health also require further attention. The following programs envelop these issues:

1 Investigating the public health impacts of air pollution;

2 Investigating sources of air pollutants and their impact on residents by determining the potential health impacts of variations in Perth's daily air quality; and

3 Developing an Air Pollution and Health Network (APHN).

Table 4.7 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. This table shows that program 2 was delayed, but has now commenced as it was dependent on the results from the Commonwealth's *BTEX Personal Exposure Monitoring in Four Australian Cities* which was finalised in May 2003.

Details of progress on key issues up until June 2004

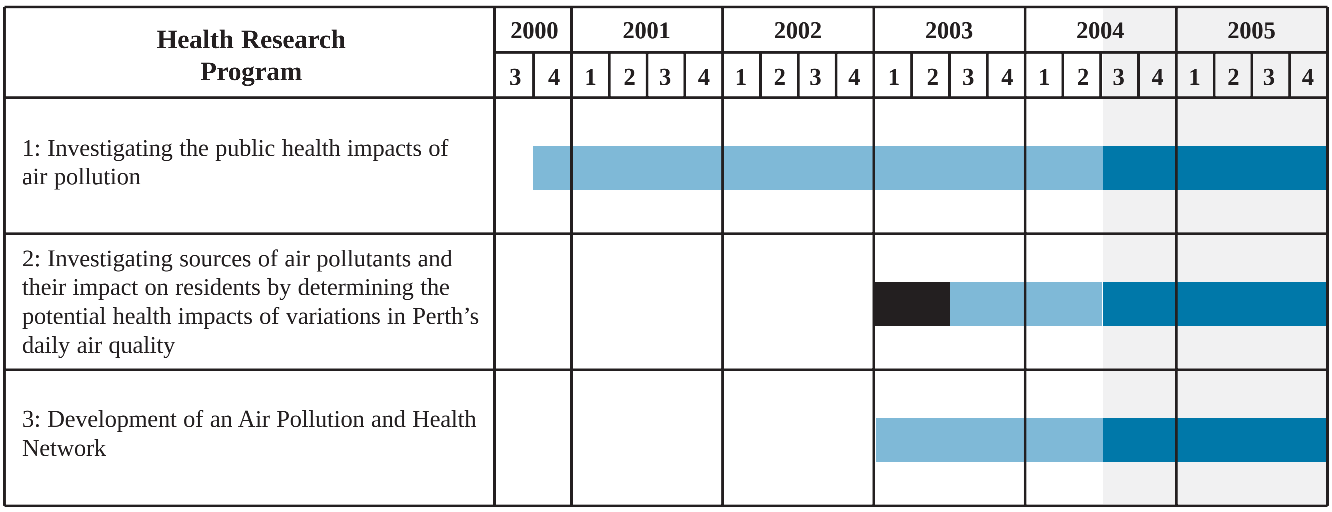
1 Investigation of the relationship between changes in daily air quality, hospitalisation and mortality, has been a long term priority. Initial delays occurred due to re-analyses of data and changes resulting from comments during peer review.

The study used a case-crossover study design, which is an alternative to the traditional time series analysis. It took into consideration the effects of transient risk factors such as changes in air pollutant concentrations on acute events such as mortality and hospitalisation. The study also used a time series analysis protocol previously recommended by the Air Pollution and Health European Approach.

The completed report, *Research on Health and Air Pollution in Perth – Morbidity and Mortality – A Case-Crossover Analysis 1992-1997*, was released in June 2003. Results of the study support those reported in Sydney, Melbourne and Brisbane, as well as numerous international studies and indicate that air quality is impacting on the health of Western Australians. Key findings of the report included:

- An association between changes in daily ozone concentrations and cardiovascular mortality;
- Significant associations for daily changes in ozone and particle concentrations and

Table 4.7: Progress to June 2004 – Health Research



Key: Program Delayed/ Limited Progress | Program Commenced | Future Activity

hospitalisation for asthma, chronic obstructive pulmonary disease (COPD), pneumonia and respiratory disease for all ages;

- Significant associations for changes in daily ozone and particle concentrations and cardiovascular disease, COPD, pneumonia and respiratory disease for people aged over 65 years; and
- Significant associations for changes in daily ozone and particle concentrations and asthma hospitalisation for children aged less than 15 years.

These findings have influenced future priorities for air quality and health research. A discussion paper on future health research priorities in relation to ambient air quality in WA is under development by the Health Research working group and was due for release in February 2004. However, the Health Research and Indoor Air Quality working groups were merged to form the APHN in early 2004. As a result of this merger, the APHN decided that publication of the discussion paper should be delayed so that an indoor air quality component could be added. A series of APHN workshops starting in August 2004 will develop the indoor air quality component of the discussion paper and scope collaborative research projects that will address the priority research areas outlined in the Paper. The discussion paper is planned for release in 2005.

A series of research projects have been identified including:

- Pilot study to determine health impacts of domestic wood smoke will be conducted as a university student project investigating the number of General Practice (GP) visits for respiratory illness in relation to air quality. This study is scheduled to commence in March 2005.
- Project to investigate the contribution of outdoor air to indoor air quality involving the determination of baseline personal exposure to NO_x is almost complete. Data from an earlier study was re-analysed to determine the effect of heating on personal exposure to NO_x. A draft paper has been prepared for submission to a scientific journal. Submission of research paper outlining the results to scientific journal and subsequent publication of paper is expected in early 2005.
- Project to conduct a health risk assessment studies of air contaminants not covered by the Ambient Air Quality National Environment Protection Measure (NEPM) has commenced. This project involves developing ambient air quality guidelines via health risk assessment process for draft list of air pollutants. Once agreed to via community consultation, the five pollutants of priority will trial the risk assessment approach and methodology. The initial stage of development of the ambient air quality guidelines is due to commence in January 2005.
- An AQMP-funded Edith Cowan University (ECU) study has commenced to 'Investigate the use of methoxyphenol and levoglucosan as biomarkers for wood smoke exposure'. Phase 1 of the study involving validation of the wood smoke characterisation technique has commenced, after initial delays in receiving ethics approval. Phase 2 of the study involving the testing of biomarkers on volunteer firefighters has yet to commence. Results from this study will be submitted to scientific journals upon completion of Phase 2.
- An AQMP-funded ECU study has commenced to 'Investigate the relationship between health outcomes in children and measures of air pollution'. Phase 1 of the study involving the linking of children's cohort database with ambient air quality data has been completed. Phase 2 involving the analysis of data from linked database with health endpoints has not commenced. Data availability and potential to link this data to air quality information has been thoroughly investigated. A number of health endpoints have been proposed for Phase 2 of the study. Completion of the final progress report for Phase 1 with recommendations for Phase 2 is expected in early 2005.
- An AQMP-funded University of WA (UWA) / Institute of Child Health Research study to investigate the 'Daily exposure to indoor air pollution and asthma in children' has been delayed due to extensive delays in receiving ethics approval. Recruitment of children for study is scheduled to commence in August 2004, followed by collection of data and its analysis. Initial drafts of research papers outlining the results are expected by late 2005.
- Discussions regarding the type of air quality data available and its potential use for health research in the context of an exposure database being developed under the 'UWA Spatially-Defined Exposure Database' project. Ambient air quality monitoring data for the UWA database will be provided on request.
- Several future projects have been scheduled to commence in January 2007 including to:

- Investigate relationship between Perth's daily air quality and hospital emergency department visits;
- Develop a project trialing routine recording of GP health data in standardised way;
- Investigate relationship between re-admission of patients and air quality;
- Investigate potential of local variations in Perth's daily air quality to have any health impact;
- Develop program to investigate exposure of Perth's residents' to air toxics; and
- Investigate relationship between personal exposure, ambient air quality and defined health outcomes.

Contribute funding and resources for the expansion of the Cooperative Research Centre (CRC) for Asthma in an application to the Australian Research Council. The results of the CRC application will be known by late 2004. If the application for the new CRC for Asthma is successful, various projects will be scoped that address the priority areas of health and air quality in WA.

In addition, there are a number of health research programs at the Commonwealth level that WA participates in:

- The Environment Protection and Heritage Council (EPHC) Cooperative Health Research working group. This working group prepared a paper of priority research areas for health and air quality after consultation with health experts. This paper was submitted to EPHC for the Ministerial Council's endorsement. The working group scoped various projects and investigated funding opportunities for such research. The working group will seek funding for studies investigating the impacts of air quality on children and the elderly as well as a study looking at particles to determine what sources they come from.
- The ARC SPIRT multi-city health and air pollution study entitled 'Comparative Study between Major Cities in Australia of the Association between Air Pollution Exposure and Human Health' which examined the short-term health effects of air pollution in four Australian cities, and preparation and acceptance of papers for the International Society for Environmental Epidemiology conference held in September 2003.
- Participation in production of scientific publications of ARC SPIRT multi-city morbidity and mortality study. Several research papers outlining the results for all of the cities were prepared and submitted by the researchers to scientific journals.
- Participation in EPHC Air Pollution and Health Project (a national multi-city morbidity and mortality study). The study has now been completed, with progress reports provided to EPHC in December 2003 and June 2004. The final progress report is scheduled for March 2005. Results of study will be presented at conferences by the researchers and submitted to scientific journals.
- The EPHC Jurisdictonal Reference Network for the NEPM Ozone and Sulfur Dioxide Review by providing data for the reports and continued participation in workshops and teleconferences on the upcoming review of the Ambient Air Quality NEPM for Ozone and Sulfur Dioxide standards.
- The EPHC Air Quality Standard Setting working group has been established to develop a risk assessment framework for the development of national air quality standards. The working group will have developed a detailed work program and begun the initial phase of assessing current risk assessment methods for air quality standard setting that are used internationally.

2 The investigation of the sources of air pollutants and their impact on residents by determining the potential health impacts of variations in Perth's daily air quality has commenced. The report for BTEX PEM study, *BTEX Personal Exposure Monitoring in Four Australian Cities*, was released May 2003 and the results of this study are being reviewed. Results from SPIRT project have not been publicly released and review will commence upon official release. Upon completion of this review, studies will be scoped to study local variations in relation to these pollutants.

3 The APHN comprises members of both the Health Research and Indoor Air working groups and is chaired by the Department of Health (DoH). The Terms of Reference were drafted and endorsed at the inaugural meeting of the APHN held in June 2004.

The APHN will be given the task of ensuring that the information base in health research issues as a result of ambient air quality and indoor air quality is maintained via a review process. This includes identifying priorities, recommending and supporting research programs and identifying appropriate funding sources. The proposed composition of these networks would enable current information on funding organisations and grant processes to be available.

Table 4.8: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 4: Health Research		
Program 1: Investigating the public health impacts of air pollution	0.4 FTE	$80,000
Program 2: Investigating sources of air pollutants and their impact on residents by determining the potential health impacts of variations in Perth's daily air quality	1.7 FTE	
Program 3: Development of an Air Pollution and Health Network	0.4 FTE	

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.8.

4.5 Initiative 5: Modelling Improvements

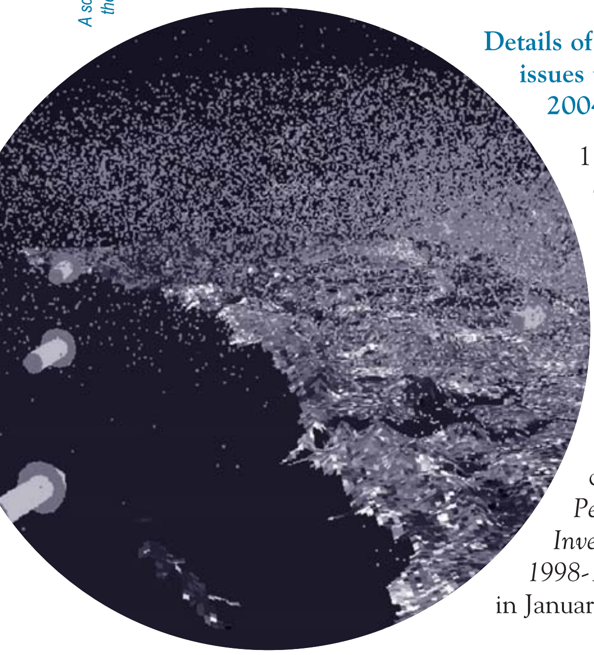
Modelling can provide information on the likely effects of various emission control strategies and is an important tool used in the management of Perth's air quality. Modelling of air quality in Perth focuses on two significant air quality problems: photochemical smog (in summer) and particulate haze (in winter). The following programs have been established as part of the AQMP:

1 Updating and consolidating air emissions databases;

2 Validating/improving emissions estimates for key emission sources; and

3 Improving modelling capability and accuracy.

Table 4.9 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. This table shows all programs within this initiative have commenced on schedule.



A screen shot from Smog Show, the DoE's Photochemical Smog Display software, showing the movement of a photochemical smog plume over Perth.

Details of progress on key issues up until June 2004

1 Up-to-date emissions inventories, databases and estimates are an essential input for air quality models. The latest update of air emissions databases, the *Perth Airshed Inventory Update 1998-1999*, was released in January 2002.

The Perth Airshed Inventory Update and the National Pollutant Inventory (NPI) will be updated on a five yearly basis to align with the national timeframe. The inventory year 1 July 2004 to 30 June 2005 will be the focus of the project. Projects scope will be completed by end of November 2004. As the timetable for completion of the Perth Airshed Inventory Update has been revised, the linked database program has been rescheduled to commence post-2006.

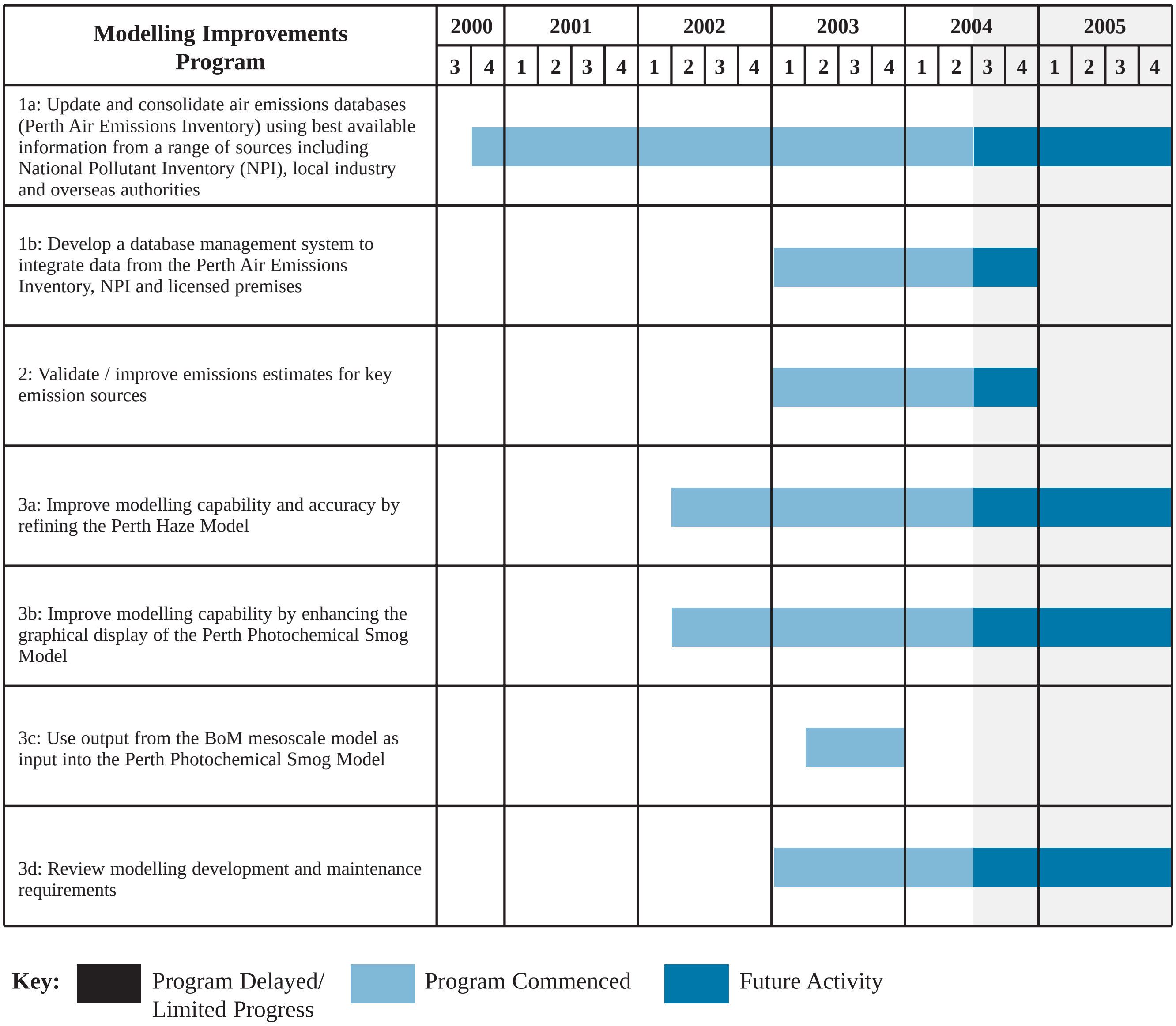
2 The validation / improvement of emissions estimates for key emission sources has been rescheduled to commence in January 2007. (Since the timetable for completion of the Perth Airshed Inventory Update has been revised)

3 Improvement of modelling capability has commenced with the development of a Haze Model. The Haze Model is used to assess particle impacts by providing estimates of particle concentrations in the Perth airshed. A peer reviewed paper discussing model development was prepared and presented at the Clean Air Society of Australia and New Zealand 2002 Conference. The final report resulting from this work will be peer reviewed in October 2004 and published as a Technical Series in early 2005. A 'Haze Movie' (fly-through of a Perth haze event) educational tool is under development.

Visualisation software for the Perth Photochemical Smog Model, which provides a simulation of typical photochemical smog episodes in Perth, has been made available via the air quality web site. This allows improved access to the simulation enabling feedback for future development. Further refinement of the graphical user interface of the model will be assessed from this user feedback.

The project to investigate the use of output from the Bureau of Meteorology mesoscale model as input to the Perth Photochemical Smog Model has commenced. The assessment of the results of recent studies using the Limited Area Prediction Scheme (LAPS), the Ambient Air Quality Forcasting System (AAQFS) and The Air Pollution Model (TAPM) has shown none of these to be applicable.

Table 4.9: Progress to June 2004 – Modelling Improvements



The review of meteorological data for a wider range of smog events has lead to the modelling of a full season for the first time. A draft report has been completed and will undergo peer review in September 2004. It will be published as a Technical Series in early 2005.

A review of in-house modelling development and maintenance requirements has commenced, including an assessment of the suitability of use of alternative models, including advanced Gaussian 'puff' models. The Gaussian puff model is an enhancement of the traditional Gaussian plume type. The traditional Gaussian plume models presume that emissions from a source travel directly downwind, dispersing in the horizontal and vertical directions, with concentration profiles following a Gaussian form. The Gaussian puff model represents the emissions as a sequence of puffs released from the source, each puff dispersing in directions both across and along the current wind direction, as well as vertically. Such a model can handle much more complicated meteorological conditions, including the effects of topography and near-coastal variations of stability and mixing depth resulting in a more accurate model output.

Further progress on this Program has been delayed due to insufficient resources. The completion of the assessment of various modelling methods for suitability in regards to use in WA and recommendations regarding the most suitable methods will occur in 2004-05. Investigations of the hardware requirements for modified or new software for these modelling methods and assessment of funding implications will then commence.

Table 4.10: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 5: Modelling Improvements		
Program 1: Update and consolidate air emissions databases	< 0.1 FTE	
Program 2: Validate / improve emissions estimates for key emission sources	< 0.1 FTE	
Program 3: Improve modelling capability and accuracy	< 0.1 FTE	

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.10.

4.6 Initiative 6: Air Quality Monitoring

Monitoring of ambient air quality is undertaken for a number of reasons: to aid in identifying areas which may have higher than desirable levels of some pollutants and to better understand how some pollutants impact on the environment and human health. This information can be used in design of management programs.

Air monitoring programs were conducted during 2003 at Wagerup, Brookdale and Bellevue. Monitoring during 2004 has continued at Wagerup in response to community concerns. Campaign monitoring has also been under taken at Kalgoorlie.

The Air Monitoring Steering Group (AMSG) will be formed in order to identify and oversee future monitoring programs in response to new information, increased knowledge and community concerns.

The *Kwinana Gap Emissions Study Stage 1: Significant Emissions in the Kwinana Industrial Airshed* involved a review of air emissions associated with industrial activities in the Kwinana Industrial Area. The aim being to assess the appropriateness and effectiveness of current facility specific monitoring programs. The completed study was released in 2004 and is available from the DoE web site.

The following programs assist in achieving the aims of the Perth AQMP:

1 Establishing an AMSG to review air quality monitoring issues in the Perth metropolitan region;

2 Reviewing air quality monitoring practices and procedures in the Perth metropolitan region;

3 Developing future monitoring programs; and

4 Supporting community information and education programs on air quality monitoring.

Table 4.11 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. The establishment of an AMSG to review air quality monitoring issues in the Perth metropolitan region has been delayed. The AMSG will be based on the membership of the Air Quality Monitoring working group, and is scheduled to first meet in December 2004. All other programs have commenced on schedule.

Details of progress on key issues up until June 2004

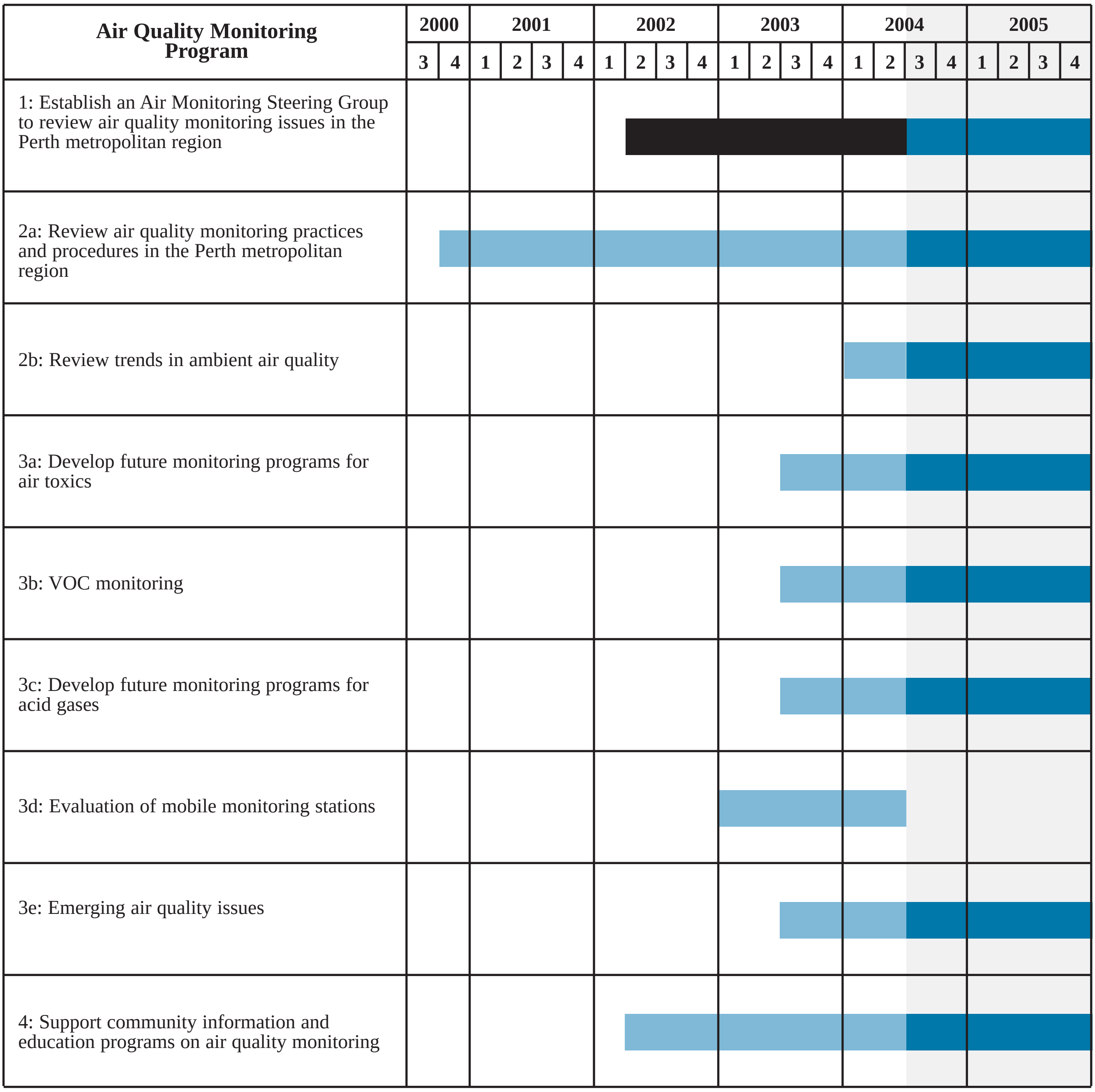
1 The AMSG will be established to maintain communication between relevant government agencies, research bodies, industry and the APHN on air quality monitoring needs in the Perth metropolitan region and to oversee the implementation of programs within this initiative. Terms of Reference are being drafted accordingly. The AMSG is now scheduled to meet in early 2005 and a work program will be developed. CCWA has indicated they are willing to participate through membership of the AMSG.

2 Air quality trends identified through monitoring will also monitor the long-term effectiveness of the Perth AQMP. Trend analysis was undertaken in 2000 using data for the data period 1992-1999 and again in 2003 for the data period 1992-2002. The results of this study were presented at the Clean Air Society of Australia and New Zealand Conference in November 2003.

Key findings for the study period of 1992 to 2002 were:

- Ambient carbon monoxide concentrations have decreased in the Perth airshed;
- Ambient NO_x concentrations have shown little improvement;
- Ambient ozone concentrations have increased slightly, with an increase in the number of days above the background level of ozone;
- Ambient concentrations of particulate matter with size less than 10 micrometres (PM_{10}) have shown little improvement, with regular exceedences of standards;

Table 4.11: Progress to June 2004 – Air Quality Monitoring



Key: Program Delayed/ Limited Progress Program Commenced Future Activity

- Ambient concentrations of particulate matter with size less than 2.5 micrometres ($PM_{2.5}$) have fluctuated; and
- Additional data is needed for analysis to confirm the trends observed.

This latest analysis used 10 years of data and allowed improved detection of significant trends in Perth's air quality. The final draft of report was completed January 2004. The report was subsequently peer reviewed and the final report is to be released in late 2004. The findings of this trends review will be used to refine / direct future program development. The trends analysis will be undertaken and reported for each additional four years of data. The next report target date is June 2008.

Air quality data was also provided for the *National Ambient Air Quality Status and Trends Report, 1991-2001* released in April 2004.

The review of air quality monitoring procedures involves meeting the requirements for National Association of Testing Authorities (NATA) accreditation of the monitoring network. Equipment, such as multi-gas calibrators and zero air generators, has been purchased and is undergoing testing prior to installation. Installation to change to fully automated calibration system for the entire monitoring network has commenced.

An evaluation of data logging systems with a view to purchase in 2004-05 has commenced and the monitoring network has been enhanced with the replacement and upgrade of all HiVol monitors. The amendment of the Quality Assurance program for HiVol monitors and new automated calibration system to comply with NATA Accreditation has commenced.

In addition to NATA accreditation there are monitoring requirements under the Ambient Air Quality NEPM. The *National Environment Protection Measure for Ambient Air Quality - Monitoring Plan for Western Australia* (DEP, 2001) has been produced to describe monitoring which will be undertaken in the State of Western Australia to determine compliance with the Standards and Goal of the Ambient Air Quality NEPM. The Plan identifies five regions within which monitoring is (or may be) required, namely:

- Perth (including Kwinana and Rockingham);
- Mandurah;
- Bunbury;
- Geraldton; and
- Kalgoorlie.

The plan presents details of the monitoring program identifying for each of the regions in turn:

- Those pollutants for which monitoring is clearly necessary;
- Those pollutants which are unlikely to be significant but which warrant a short 'campaign' of measurements for certainty; and
- Those pollutants which can be demonstrated by means other than monitoring to be clearly complying with their NEPM standard and therefore do not warrant the expense of monitoring.

Further details are available by referring to the *National Environment Protection Measure for Ambient Air Quality - Monitoring Plan for Western Australia*. In response to requirements under the NEPM, the $PM_{2.5}$ monitor installed at Caversham was converted to monitor PM_{10} from January 2004.

3 Ambient air toxics are an emerging concern with the Air Toxics NEPM being finalised in early 2004, although its introduction is awaiting legislative requirements. The Air Toxics NEPM sets monitoring investigation levels for five air toxics; benzene, toluene, xylene, formaldehyde and benzo-a-pyrene. Air toxics monitoring will be conducted under the guidelines for implementation of the Air Toxics NEPM in WA. Project scoping has commenced for street side personal exposure monitoring of air toxics along entertainment districts (including Fremantle, Northbridge and Leederville), with the project to commence in late 2004.

In addition, a project to monitor for volatile organic compounds (VOCs) at selected locations is under development, with specifications currently being reviewed by external agencies. Commercial / industrial partners are being sought for funding VOC monitoring and the final scope of project will depend on the funding available. Scoping for field trials has been completed, with the draft report from the field trials to be provided to the newly formed AMSG for their comment and suggestions regarding future work.

A six-month review of the environmental impacts of brickworks in the Swan Valley and an assessment of the adequacy of current regulatory arrangements was completed in October 2003. Significant strengthening of emission limits, monitoring and air quality control measures outlined in the report will be implemented to improve air quality in the Swan Valley.

The *Brickworks Licensing Policy* was released in October 2003. This policy outlines a *Brickworks Review Implementation* program aimed at reducing emissions from brickwork facilities. The status of this implementation program is as follows:

- Brickworks in the Swan Valley have been required to reduce emissions and improve monitoring. Companies concerned have been looking at technologies and considering options.
- Midland Brick has decided on a system for its new kiln that should achieve 90% reduction in acid gas emissions. The new kiln will be tested to determine if such a reduction in emissions is truly achieved before incorporating the technology into the remainder of their kilns.
- Midland Brick is also investigating the use of monitoring equipment capable of continuous stack and ambient monitoring.

Table 4.12: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 6: Air Quality Monitoring		
Program 1: Establish a Air Monitoring Steering Group to review air quality monitoring issues in the Perth metropolitan region	0 FTE	
Program 2 Review air quality monitoring practices and procedures in the Perth metropolitan region	0.1 FTE	
Program 3: Develop future monitoring programs	< 0.1 FTE	
Program 4: Support community information and education programs on air quality monitoring	0 FTE	$12,000

- Austral Brick is still considering the technological options available.

A scoping document for the development of a comprehensive mobile monitoring station was completed and infrastructure requirements costed. Due to cost, the mobile monitoring station was not deemed a viable option.

Mobile monitoring capacity is to be integrated with emergency response functions. A portable instrument (Gas Chromatography Mass Spectrometer (GCMS)) for measurement of VOCs has been purchased. Field trials using the portable instrument are to be conducted collaboratively with the Chemistry Centre WA. In addition, results of field trials of a Photo Ionisation Detector (PID) are being incorporated into a report on the potential use of the PID in areas with air quality issues.

The ASMG and the AQCC will consider emerging air quality issues. WA is represented on the national EPHC Air Quality working group, dealing with air quality priorities on a national scale. Outputs from field investigations and community consultation will also guide priorities in emerging air quality issues.

4 There are several projects aimed at supporting community information and education programs on air quality monitoring, including:

- The air quality web site provides monitoring data 'live', with the Haze Movie and Smog Movie simulations also available for viewing. Further update of graphics for Haze Movie and Smog Movie will occur based on feedback received. There is also a project to explore additional learning aids which may supplement those already available on the web site.
- The scoping and implementation of pilot *SNAQ (Students Network for Air Quality) on Haze* program in conjunction with *AirWatch* during winter 2004 will be reviewed and expanded to additional schools in Winter 2005.
- Initial scoping has been scheduled for a project to develop an *AirWatch Community* program in line with the schools program. This will involve a pilot trial of various projects under the auspices of *AirWatch Community*.
- Continued support and encouragement of the development of local air quality management plans through regional strategies and local government.

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.12.

4.7 Initiative 7: Indoor Air Quality

The potential impact of indoor air quality on human health is an important issue which requires ongoing research and community awareness. In recent years there has been increasing concern about indoor air quality and personal exposure. The following programs address some of these concerns:

1 Developing an Indoor Air Quality Network;

2 Investigating indoor air quality and the contribution of indoor air exposure to personal exposure; and

3 Increasing community indoor air quality awareness.

Table 4.13 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. This table shows:

- A preliminary review of studies to evaluate the presence and concentration of indoor air pollutants and personal exposure measurements for the Perth metropolitan population has commenced.
- A preliminary review of indoor air quality resources and community education programs that have been conducted in Australia and overseas has commenced.

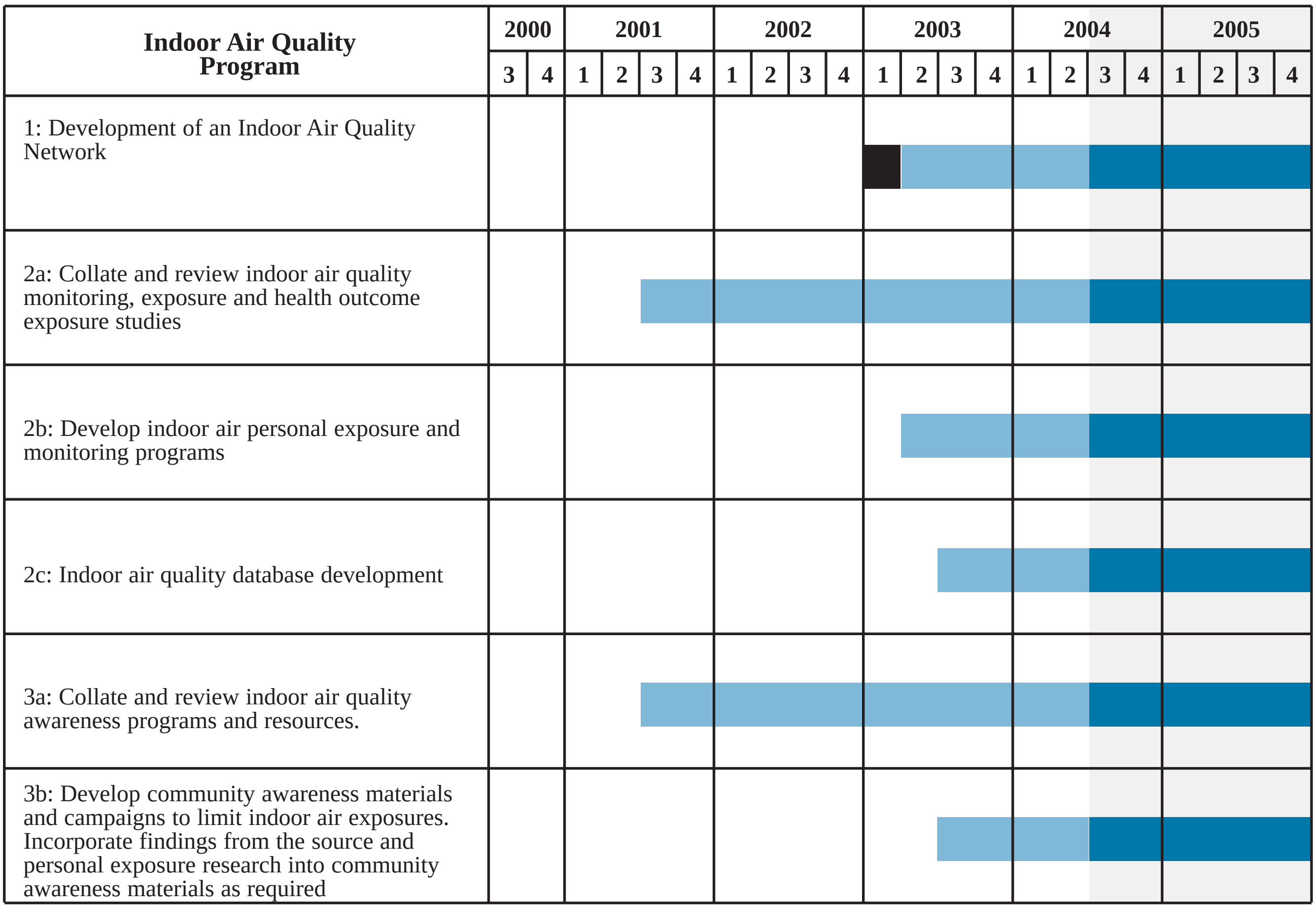
Details of progress on key issues up until June 2004

1 The Indoor Air Quality Network (IAQN) to be formed under Program 1 was integrated into the APHN (see Initiative 4).

A series of APHN workshops starting in August 2004 will develop the indoor air quality component of the discussion paper (Initiative 4) and scope collaborative research projects that address the priority research areas. Appropriate areas of study will be determined by the APHN.

2 The collation and review of indoor air quality monitoring, exposure and health outcome exposure studies (Program 2a) has commenced. The APHN will hold several workshops to utilise the collective strength of indoor air quality specialists to direct health research priorities at the State level.

Table 4.13: Progress to June 2004 – Indoor Air Quality



Key: Program Delayed/ Limited Progress; Program Commenced; Future Activity

The development of indoor air quality monitoring, exposure and health outcome exposure studies (Program 2b) has commenced. The APHN has identified domestic unflued gas heaters as a high priority current key issue.

The development of an indoor air quality database (Program 2c) has not commenced and appropriate areas of study will be determined by the APHN.

3 The collation and review of indoor air quality awareness program and resources (Program 3a) has seen existing brochures updated where needed. Involvement with the Asthma Foundation is ongoing, with brochures on effects of indoor air quality and asthma being published and are accessible to the public.

The development of community awareness materials and campaigns to limit indoor air exposures (Program 3b) has largely been focused on domestic unflued gas heaters. A leaflet on unflued gas heaters has been published which is accessible to the public through the Environmental Health Directorate and the DoH web site. The Minister for Health released media and press statements on the implications from operation of domestic unflued gas heaters.

Delegates from the national enHealth Council (including WA representatives) were involved in deliberations with the gas industry at the national level. A leaflet on unflued gas heaters will be published by the national enHealth Council.

A brochure on managing the risks from operation of unflued gas heaters will be produced under the Environmental Health Guide Series.

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.14.

Table 4.14: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 7: Indoor Air Quality		
Program 1: Development of an Indoor Air Quality Network	< 0.1 FTE	
Program 2: Investigate indoor air quality and the contribution of indoor air exposure to personal exposure	0.1 FTE	
Program 3: Increase community indoor air quality awareness	< 0.1 FTE	

4.8 Initiative 8: Land Use and Transport Planning

Land use and transport planning decision making directly influences the way in which the community undertakes daily activities. These activities have implications for air quality at local and regional levels. For example, extensions to the existing rail network, including the South West Metropolitan Rail and the Clarkson extension in the northern suburbs, will reduce car usage and consequently result in reduced vehicle emissions.

The following programs seek to ensure that air quality considerations are incorporated into the existing mechanisms for decision making related to land use and transport planning:

1 Including regional and local air quality considerations in the strategic planning and implementation of *Network City: Community Planning Strategy for Perth and Peel*;

2 Including regional and local air quality considerations in the planning and implementation of development proposals;

3 Monitoring and reviewing the effectiveness of land use and transport planning decisions in influencing Perth's air quality; and

4 Assisting local government in influencing the community's travel behaviour to bring about positive change.

Table 4.15 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. This table shows all programs within this initiative have commenced on schedule.

Details of progress on key issues up until June 2004

1 The banner under which most of these actions fall is called *Dialogue with the City*, which was initiated in June 2003. (The term '*Greater Perth*' is no longer used.) The community plan that has evolved from *Dialogue with the City - Network City: Community Planning Strategy for Perth and Peel* - outlines a change in direction for Perth, not only in how the city develops, but also how planning is carried out. The key is to plan through participative decision-making. *Network City* will be open for public comment from September to December 2004. Thereafter, comments will be reviewed changes made to the document if appropriate and the strategy finalised.

Network City addresses air quality issues in a variety of broad strategies, each of which has supporting actions. It is hoped that the following strategies will address Perth's air quality issues:

- 'Strategy 1-1: Foster land use and transport integration to form a network city', the objective of which is to reduce car dependency and increase the use of public and other transport modes.
- 'Strategy 2-2: Using land resources efficiently, make fuller use of existing urban land by supporting additional residential development within existing urban areas, so that 60% of all new dwellings are being constructed in this area as soon as possible.'
- 'Strategy 1-3: Manage urban growth to limit urban sprawl through a development staging strategy and other complimentary techniques.'
- 'Strategy 3-6: Adopt a 'place management' approach to major development projects and planning initiatives that allows for a focus on local issues and local solutions.'
- 'Strategy 3-16: Encourage the local mixing of uses, to reduce the overall need for people to travel between their places of residence, employment and recreation.'
- 'Strategy 3-17: Continue to promote an urban structure that enhances accessibility through legible and interconnected street networks and walkable neighbourhoods.'
- 'Strategy 6-1: Integrate local and longer distance transport needs to support Network City with a view to decreasing car dependency.'
- 'Strategy 6-2: Ensure that transport within activity corridors compliments and links activity centres and supports the corridor concept.'
- 'Strategy 6-6: Enhance accessibility to facilities and services, and to employment and recreational opportunities, through a balanced transport system that provides choice in transport modes, prioritises public transport, walking and cycling wherever possible, and does not inequitably limit accessibility based on location or access to a private car.'

Post public comment period an implementation plan is to be produced, which will give better guidance as to the timing of, and resources required, to implement strategies and actions in *Network City*.

2 The inclusion of air quality considerations in the planning and implementation of development proposals has begun and a data sharing agreement has been signed. Draft Transport Assessment guidelines were prepared in January 2003, with

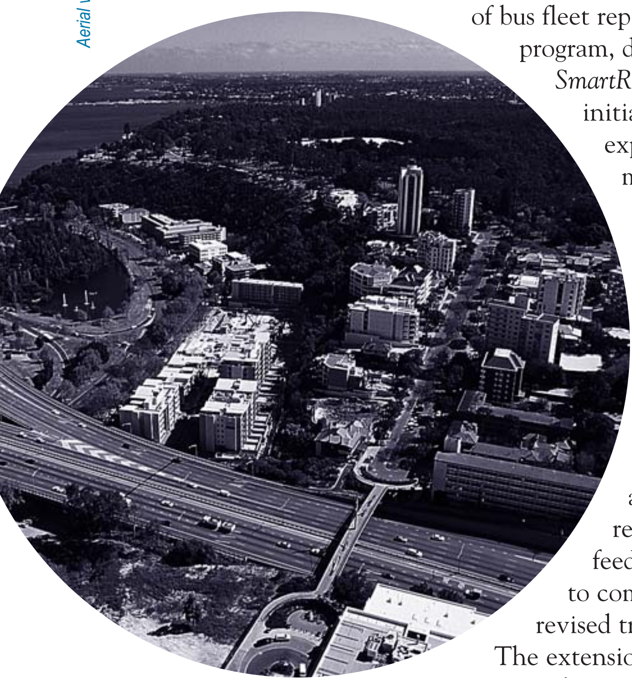
Table 4.15: Progress to June 2004 – Land Use and Transport Planning

Land Use and Transport Planning Program	2000		2001				2002				2003				2004				2005			
	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1a: Include regional and local air quality considerations in the strategic planning and implementation of *Network City: Community Planning Strategy for Perth and Peel*																						
1b: Assess the environmental impact of the various strategies contained within *Network City: Community Planning Strategy for Perth and Peel* and the *Metropolitan Transport Strategy*																						
2: Include regional and local air quality considerations in the planning and implementation of development proposals																						
3a: Monitor and review the effectiveness of land use and transport planning decisions in influencing Perth's air quality																						
3b: Review of DC 1.6 policy																						
3c: Assess the cost effectiveness of money spent on the transport network																						
4a: Assist local government in influencing the community's travel behaviour by developing ITPs																						
4b: Cyclist access																						
4c: Pedestrian access																						
4d: Parking																						
4e: Home-based employment and business																						

Key: Program Delayed/ Limited Progress | Program Commenced | Future Activity

internal stakeholder review completed in September 2003. The draft guidelines will be submitted to the WA Planning Commission (WAPC) for endorsement in November 2004. They will then be distributed to external stakeholders for comment and revised as appropriate. It is then proposed to introduce the guidelines into the development control / planning process on a voluntary trial basis for 12 months, to allow benefits to be evaluated.

3 Many long-term public transport initiatives, capital works and major infrastructure projects are progressing. These include improving passenger information services, increasing Park 'n' Ride capacity, improving bus stop and station facilities (including upgrading of train stations to meet accessibility standards), continuation of bus fleet replacement program, development of *SmartRider* ticketing initiative and expansion of metropolitan train system. The extension of train services to Clarkson will commence in October 2004 with an attendant reorganization of feeder bus services to compliment the revised train network. The extension of the train services to the new Thornlie Station is scheduled to commence in early 2005.



Aerial view of the freeway, looking south.

The Mandurah Bus Station opened in September 2003 with an improved feeder and main line bus network. The review of Bunbury regional town services has been conducted and the recommendations implemented. The bus fleet replacement program slowed while development continued on gas buses, with delivery and commissioning of new gas buses continuing. Work is progressing on the *SmartRider* ticketing initiative and is expected to roll out in April 2005.

Transperth's ongoing service improvement initiatives have resulted in strong patronage. Market share data from the Perth Travel Survey has shown bus patronage has increased again this year for the fourth consecutive year totaling over 18%. The service development plan has been progressed within the Transperth finite budget by improvement to bus services in one area being funded by the withdrawal of services from other areas, where services were under performing. 11 out of the 26 bus service improvement projects earmarked for 2003-04 were delivered.

Transperth's ongoing Bus Services Improvements Plan includes some 65 planned improvements to bus services that have been costed and prioritized to 2007 but they are as yet unfunded. These include the establishment of bus services to newly developing areas as well as the roll out of more of Transperth's successful 900 Series 'High Frequency' services, and general improvements to bus service frequencies. Also included is the proposed feeder bus network to augment the extensions to the suburban train system. The introduction of these bus services is critical to the continued success of an integrated network. Indications are that the recurrent budget will not increase for 2004-05. The exception may be for a possible injection of funds on a one off project basis. Such projects may not form part of our Services Improvement Plan.

The review of *Development Control Policy 1.6 – Planning to Enhance Public Transport Use* integrated with review of *Liveable Neighbourhoods* policy has commenced with a revised interim policy drafted in March 2004 but not released. An evaluation of policies against sustainability principles has also been completed. Consideration of revised *Liveable Neighbourhoods* policy by WAPC and advertising of revised *Liveable Neighbourhoods* policy for public comment is scheduled for 2005.

The assessment of the cost effectiveness of the transport network has not commenced, deferred whilst awaiting outcomes from *Dialogue with the City and Network City: Community Planning Strategy for Perth and Peel*. It is likely the timelines will require revising given the expansion of the Perth rail network.

4 Assistance for local government in influencing the community's travel behaviour by developing integrated transport plans has commenced. *Traveling Together - South West Metropolitan Integrated Transport Plan* which covers seven local government authorities has been developed and released. Implementation is expected to commence in late 2004. Development of the *Eastern Metropolitan Region Integrated Transport Strategy* in partnership with the Eastern Metropolitan Regional Council will also commence in late 2004.

Promotion of cyclist and pedestrian access has begun with a review of the existing network and facilities to investigate short comings of cyclist and pedestrian access. In addition, the strategies contained in *Bike Ahead* and *Perth Walking* have commenced. Policy development to progress provision of cyclist access through and within train station precincts has been completed. Projects have also been developed to provide improved pedestrian infrastructure in local government areas. Monitoring of Perth Bicycle Network (PBN) Routes has shown that usage of the routes has doubled since 1999. A 'Cycling and Walking Behaviour and Attitudes Track' was done, the ninth such survey for cycling, with both surveys again being undertaken in 2004-05.

Terms of reference for the Western Australian Pedestrian Advisory Committee have been broadened to include walking for health, recreation and sustainability. The committee has been renamed the Walking WA Committee.

The *Perth Parking Policy* has been successfully used to reduce the amount of tenant parking provided and to increase the supply of bicycle parking and end of trip facilities throughout the Perth central business district. An initial review has been completed. Further progress is subject to the resolution of program priorities and associated resources. Draft strategy development and the *Stage 1 Review of Public Parking* have commenced. The *Stage 1 Review of the Public Parking* elements will be finalised in 2004-05. Ongoing work on the development of a "policy approach" to parking in the Perth Metropolitan Region is underway and is part of the Land Transport Branch work program.

The extent and characteristics of home-based employment were covered in section 5.6 of Greater Perth Economy and Employment (Discussion Paper 3). This paper concluded that there is only a very small proportion of people actually working at home (as opposed to being highly mobile and vehicle-dependent) within the "home-based employment category". Further review is required relating to whether increases in home business numbers and resultant traffic impacts will be of benefit to air quality.

An investigation of home-based employment is expected to be a component of the implementation plan for *Network City*.

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.16.

Table 4.16: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 8: Land Use and Transport Planning		
Program 1: Include regional and local air quality considerations in the strategic planning and implementation of *Network City: Community Planning Strategy for Perth and Peel*		
Program 2: Include regional and local air quality considerations in the planning and implementation of development proposals	0.1 FTE	
Program 3: Monitor and review the effectiveness of land use and transport planning decisions in influencing Perth's air quality	6.6 FTE	$115,000
Program 4: Assist local government in influencing the community's travel behaviour to bring about positive change	1.2 FTE	$47,000

4.9 Initiative 9: Haze Reduction

Haze is Perth's major winter air quality concern. Domestic wood heaters are the largest single source of particles contributing to haze formation. Four programs have been developed to reduce emissions contributing to haze including:

1 Increasing community awareness of the impacts of domestic wood heaters on air quality;

2 Increasing awareness among wood suppliers and wood heater installers of the impacts of wood heaters on air quality;

3 Resolving domestic smoke nuisance complaints; and

4 Managing green waste disposal and recycling to reduce local haze creation.

Table 4.17 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. This table shows all programs within this initiative have commenced on schedule.

The Haze Reduction working group was established with its current membership (as listed in Appendix 2) in July 2003 to oversee the implementation of programs within the Haze Reduction Initiative. To date 10 meetings of the working group have been held.

Table 4.17: Progress to June 2004 – Haze Reduction

Haze Reduction Program	2000		2001				2002				2003				2004				2005			
	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1a: Increase community awareness of the impacts of domestic wood heaters on air quality																						
1b: Incentive programs and *Halt the Haze* campaign																						
2a: Increase awareness among wood suppliers and wood heater installers of the impacts of wood heaters on air quality																						
2b: Wood heater installation course																						
3a: Domestic smoke nuisance resolution																						
3b: Mediating process for domestic smoke nuisance																						
4a: Backyard burning ban																						
4b: Manage green waste disposal and recycling to reduce local haze creation																						

Key: Program Delayed/ Limited Progress · Program Commenced · Future Activity

Details of progress on key issues up until June 2004

1 Increasing the community's awareness of the impacts of domestic wood heaters is very important in encouraging the correct operation of wood heaters or the use of alternative heating sources. A six page brochure 'Choosing a Heater' was released in November 2002. This brochure provides a guide to consumers on the types of heaters available including some information on air quality. These brochures are available through the Sustainable Energy Development Office (SEDO) Energy Smart Line (1300 658 158), local government authorities and other community and promotional activities. Up to 2,500 brochures are distributed each year.

The wood smoke brochure 'Store Right, Burn Bright, Breath Alright' was revised. 10,000 copies were produced for distribution to local government authorities and the public. Revision and updating of brochures will occur as required. Information packs on alternative heating, energy efficiency and correct wood heater use were distributed as part of the pilot *Home Heating Survey* conducted in City of Joondalup, City of Melville and Town of Kwinana. A total of 3,000 information packs were produced for distribution.

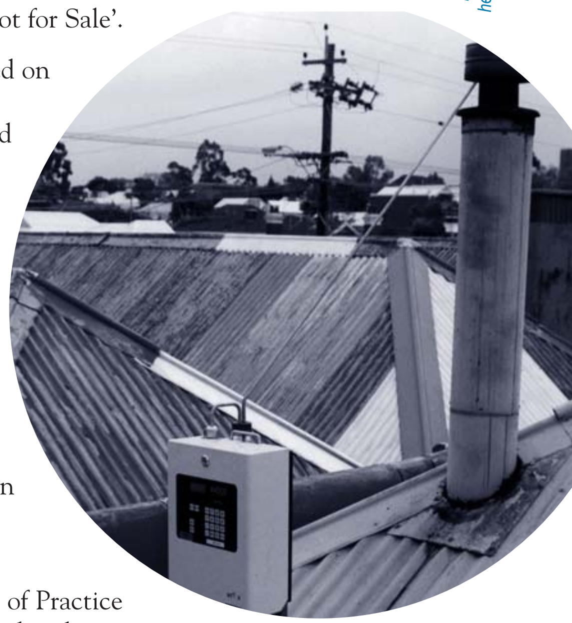
Winter Haze Alerts are issued by the Bureau of Meteorology from 1 June to 30 September each year on days likely to have haze formation. Media outlets are provided with these alerts and may broadcast them as part of the weather report. Messages broadcast include encouraging the community to ensure correct operation of wood heaters, avoid using their wood heater if it is a secondary heating source and avoid backyard burning. The Winter Haze Alert program was improved for the winter of 2003 and 2004 to include follow-up messages and message posting on air quality web site.

An information session was held for media / weather presenters in June 2003 prior to the commencement of issuing alerts, to provide an update on the enhanced program. The session had limited attendance and consequently was not repeated for the winter 2004 alerts season. Information for the Winter Haze Alert program for 2004 was disseminated through the Bureau of Meteorology.

Information on haze, haze alerts and the practices to minimise haze occurrence were distributed to other agencies via the InterSector magazine, provided to local Community newspapers and for the Department of Conservation and Land Management (CALM) information newsletter.

2 The Department of Housing and Works (DHW) has issued a Building Note recommending to all local government authorities that a Building License be required for all solid fuel burning appliances. This will assist in ensuring that the installation is carried out in accordance with *AS/NZ 2918 2001: Domestic Solid Fuel Burning Appliances – Installation* referenced by the Building Code of Australia.

The Environmental Protection (Domestic Solid Fuel Burning Appliances and Firewood Supply) Regulations 1998 set maximum moisture content for firewood for sale. Awareness amongst wood suppliers of the impacts of using unseasoned wood on air quality is increased by providing information during inspection of wood yards. Inspections were not undertaken during winter 2003. Wood yard inspections were conducted in December 2003 with a total of 21 wood yards inspected. This resulted in one breach of the regulations, pertaining to the failure to label green wood as 'Not for Sale'.



Rooftop monitoring of volatile organic compounds (VOCs) in domestic wood heater smoke emissions from residences in Perth's suburbs.

A handbook based on the Australian Standard for wood heater emissions *(AS4013 Domestic Solid Fuel Burning Appliances – Method for Determination of Fuel Gas Emission)* has been developed for the installation of wood heaters.

A wood heater installation Code of Practice has been developed and is in widespread use by installers. In addition, the Australian Home Heating Association (AHHA) and Victorian Sustainable Energy Association are seeking funding for running a training course, developed for wood heater installers. This is proving difficult with TAFE recently advising that they will require a training body to write up and formally approve the course before they can offer it.

3 Another important issue is how complaints involving domestic smoke nuisance are dealt with. The *Health Act 1911* currently excludes smoke from domestic chimneys from being subject to the nuisance provisions under the Act and limits the options available to local government Environmental Health Officers (EHOs) to resolve the complaint. *The Health Act Amendment Bill*

2004 (removing this exclusion) has been prepared and introduced to Parliament. The Bill was at its First Reading in the Legislative Council at 25 June 2004. It is expected the Bill will be passed prior to winter 2005.

The Haze Reduction working group is currently finalising a 'toolkit' for use by EHOs in resolving wood smoke complaints. A training session for EHOs in wood smoke issues and wood heater operation was held in April 2002. An expanded training program for local government EHOs and other local government officers was held in April 2004. The Wood Heater and Firewood Information Kit for Environmental Health Officers has been revised based on comments from local government officers who participated in the Wood Smoke Workshops and is being prepared for distribution prior to winter 2005

Four wood smoke workshops were held, three across the Perth metropolitan region and one in the South West. Dr John Todd, a wood heater expert from Tasmania, delivered the workshops. Future workshops will target other local government officers, such as rangers and security officers, wood heater installers, community groups and the community through train the trainer programs.

Town of Kwinana has commenced development of a Local Law under the *Local Government Act 1995* for the prevention of domestic smoke nuisance impacts. The intention of the working group is to use this Local Law as the basis for a Model Local Law for adoption by other local governments.

Following on from the 'Clean Air Melville' wood heater replacement program conducted in 2001, a pilot *Wood Heater Replacement Program* (WHRP) was launched on 2 June 2004 at Greenwood Senior High School. The pilot is a joint program between the State Government and the City of Joondalup, City of Melville and Town of Kwinana. The pilot Program aims to remove 300 wood heaters (100 in each local government area) by providing a rebate of $600 for the replacement of a wood heater with a flued or ducted gas heating system. The pilot Program will be reviewed, commencing September 2004, with the view to expanding into at least three more local government areas for the winter of 2005.

A pilot *Home Heating Survey* (HHS) also commenced in May 2004 in the same three local government areas. The information from the HHS will be used to guide the further expansion of both the WHRP and HHS.

The *Community Education Strategy* being developed under Initiative 1 will consider the form of future campaigns to reduce impacts on air quality from wood heaters.

A *Wood Heating Policy Options Paper* was initially developed to explore future policy options for reducing the impacts on air quality and health from domestic wood heaters. Due to concerns with the air quality, indoor air quality and health impacts of alternative heating sources, the *Home Heating Policy Options Paper* was revised to include all heating options.

A national wood heater audit was conducted in 2003. The audit was coordinated by the Commonwealth Department of Environment and Heritage and the AHHA, and undertaken in conjunction with a number of States, including WA. New wood heaters (show room floor models) were tested to audit compliance against the emission standard AS 4013, engineering design and labelling requirements. In general there was poor performance with less than 50% compliance. WA had input to the development of the joint industry/environment agency action plan for future audits to ensure that industry compliance is achieved.

The second round of national auditing for compliance to AS 4013 is due to commence on 1 September 2004. In addition, the Australian Standard is subject to periodic review, which WA is providing input to.

4 The voluntary response of local governments to the *Parliamentary Select Committee on Recycling and Waste Management* has resulted in separate green waste collections and less waste being burned, reducing emissions contributing to haze formation. The Town of Kwinana has developed a local law to prevent backyard burning in its urban areas, and other local governments are considering a similar local law where needed.

The Haze Reduction working group will examine this issue, however, it is rated a lower priority than wood heaters. A policy has yet to be developed, although the 'Towards Zero Waste' prepared by the WAste2020 Task Force considers the issue. 'Towards Zero Waste' has been followed by the 'Strategic Direction for Waste Management in WA' which considers green and organic waste as a priority issue. Various local governments are dealing with the issue of green waste disposal by providing green waste collection and/or banning backyard burning, although this is not being done in a consistent manner.

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.18.

Table 4.18: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 9: Haze Reduction		
Program 1: Increase community awareness of the impacts of domestic wood heaters on air quality	5.6 FTE	$210,000[1]
Program 2: Increase awareness among wood suppliers and wood heater installers of the impacts of wood heaters on air quality	0.1 FTE	
Program 3: Domestic smoke nuisance resolution	0.1 FTE	$17,000[1]
Program 4: Manage green waste disposal and recycling to reduce local haze creation	0 FTE	

4.10 Initiative 10: Energy Efficient Buildings

Energy requirements for heating and cooling are reduced with the incorporation of building energy efficiency design principles, resulting in reduced emissions of air pollutants and greenhouse gases. These objectives are achieved by implementing the following programs:

1 Adoption of energy efficiency measures into the Building Code of Australia (BCA); and

2 Encouraging energy efficient building design and planning.

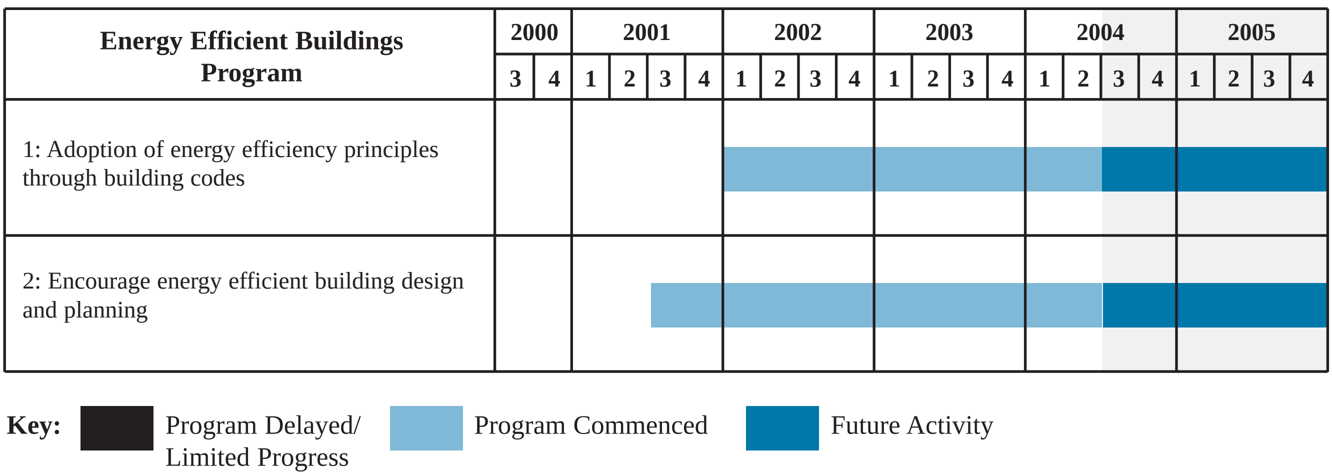
Table 4.19 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. This table shows both programs within this initiative have commenced as scheduled.

Details of progress on key issues up until June 2003

1 Changing the BCA to incorporate energy efficiency measures ensures all new buildings, and alterations to existing buildings, will meet minimum standards for energy efficiency when built.

Overall, the building sector is one of the fastest growing sources of greenhouse gas emissions and therefore needs effective and speedy corrective action. Further environmental benefits of improving energy efficiency of houses include

Table 4.19: Progress to June 2004 – Energy Efficient Buildings



[1] Operational is for the Winter Haze 2004 campaign (to September 2004).

potential reductions in air pollution from the use of solid fuel heaters. Energy efficient homes deliver cost savings to consumers through reduced electricity and gas bills. Inside houses, the quality of the internal environment is improved by reducing occupants' thermal stress.

Since buildings have very long lives compared to other energy consumers such as appliances or cars, and as much larger reductions in greenhouse gas emissions are expected to be necessary over coming decades, it is important that new buildings be compatible with a future of low greenhouse gas emission levels.

Staff from the SEDO promoting the Home Energy Line.

To address these issues, the Australian Building Codes Board (ABCB) agreed in principle to the recommendation by the Energy Efficiency Steering Committee that the revised energy efficiency measures for housing be included in BCA Amendment No 12 commencing 1 January 2003 at a national level. Western Australia adopted technical provisions, via the BCA, on 1 July 2003 at Amendment 13. Measures being developed for multi-residential (classes 2, 3 and 4 buildings) and commercial, public and institutional buildings are being developed with the view to adoption into the BCA on 1 May 2005 and 2006 respectively.

The objective of introducing energy provisions into the BCA is to reduce greenhouse gas emissions by first focussing on housing energy efficiency as a means of achieving this goal. Such mandatory measures are intended to eliminate poor practice within the industry, rather than to drive best practice.

The ABCB Project Team, in conjunction with the State and Territory building control jurisdictions and various committees, working groups and industry experts, developed the energy efficiency provisions for new housing. Several research projects were undertaken to develop the measures. As a result of public and industry comment, the technical details were revised and finalised at the ABCB National Technical Summit held in late September 2002.

Energy efficiency measures will vary from location to location. The measures described in this proposal are based on climate zones. The provisions include a map, which contains eight climate zones, and the measures proposed for each zone vary depending upon the severity of the climate. The zones in turn are based on climatic data, alignment with local government boundaries where practical, and other adjustment where considered appropriate.

The measures will include insulation for walls, ceiling and floor, improved glazing and shading, draught control, making use of air movement for cooling and the reduction of energy waste in services as appropriate for the proposed eight climate zones.

The range of measures being proposed for the BCA Housing Provisions will include new Performance Requirements and Deemed-to-Satisfy Provisions for the following aspects of houses:

- The thermal performance of walls, ceilings, floors, glazing and shading in order to avoid, or reduce, the use of artificial conditioning (heating and cooling);
- Natural ventilation and internal air movement, where appropriate, to avoid or reduce the use of artificial conditioning;
- Sealing houses in some climates to reduce energy loss through leakage;
- Insulation and piping arrangements to reduce heat loss from piping connected to storage hot water units;
- Insulation to reduce heat loss from water piping of central heating systems;
- Insulation to reduce energy loss through the walls of the ductwork associated with heating and air-conditioning systems.

The building fabric and glazing measures together are expected to reduce potential CO_2 emissions by nearly 200,000 tonnes nationwide each year. After 10 years the savings will have accumulated to around 3.7 million tonnes.

2 An education program was conducted during May 2003 on the BCA housing energy provisions to ensure that building practitioners were adequately prepared for these new requirements.

The BCA contains a complete package of performance requirements, approved solutions, and the means of assessing innovative alternative designs including the use of Nationwide House Energy Rating Scheme software, such as FirstRate and NatHers. A brochure was developed providing information on energy efficiency design principles for members of the public. A series of community seminars where the community could bring in their plans for a quick rate assessment were also held.

Training in the use of the FirstRate scheme has commenced with approximately 750 people trained, 150 trained Accredited Assessors and 9% of dwelling applications rated using FirstRate to assess energy performance as of 30 June 2004. This represents a small but growing proportion of total dwelling applications.

Training was conducted on the introduction of Australian Building Greenhouse Rating Scheme (ABGR) with efforts focused on increasing industry awareness. 14 people have received training in 2004 and to date there are 11 accredited people to conduct ratings using ABGR. Five buildings have been rated using ABGR. The DHW is expected to release the latest version of its Office Accommodation Policies in September 2004. This document will set mandatory requirements for ABGR ratings for State Government office leases.

CCWA is involved in energy efficiency through the Cool Communities project funded by the Australian Greenhouse Office. CCWA will continue to advocate energy efficiency. The Commonwealth is terminating the Cool Communities project. CCWA is seeking funding to continue its involvement in this area.

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.20.

Table 4.20: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 10: Energy Efficient Buildings		
Program 1: Adoption of energy efficiency principles through the building code	2.5 FTE	
Program 2: Encourage energy efficient building design and planning	1.5 FTE	

4.11 Initiative 11: Cleaner Production

It is surmised that small to medium enterprises make a significant cumulative contribution to atmospheric emissions in Perth, and it is therefore important to minimise these emissions. The encouragement of cleaner production and waste minimisation will lead to a reduction in these emissions. Implementation of the following programs assist in achieving the above:

1 Encourage cleaner production; and

2 Ensure proper airshed planning for future industrial development and power generation in the Perth metropolitan region.

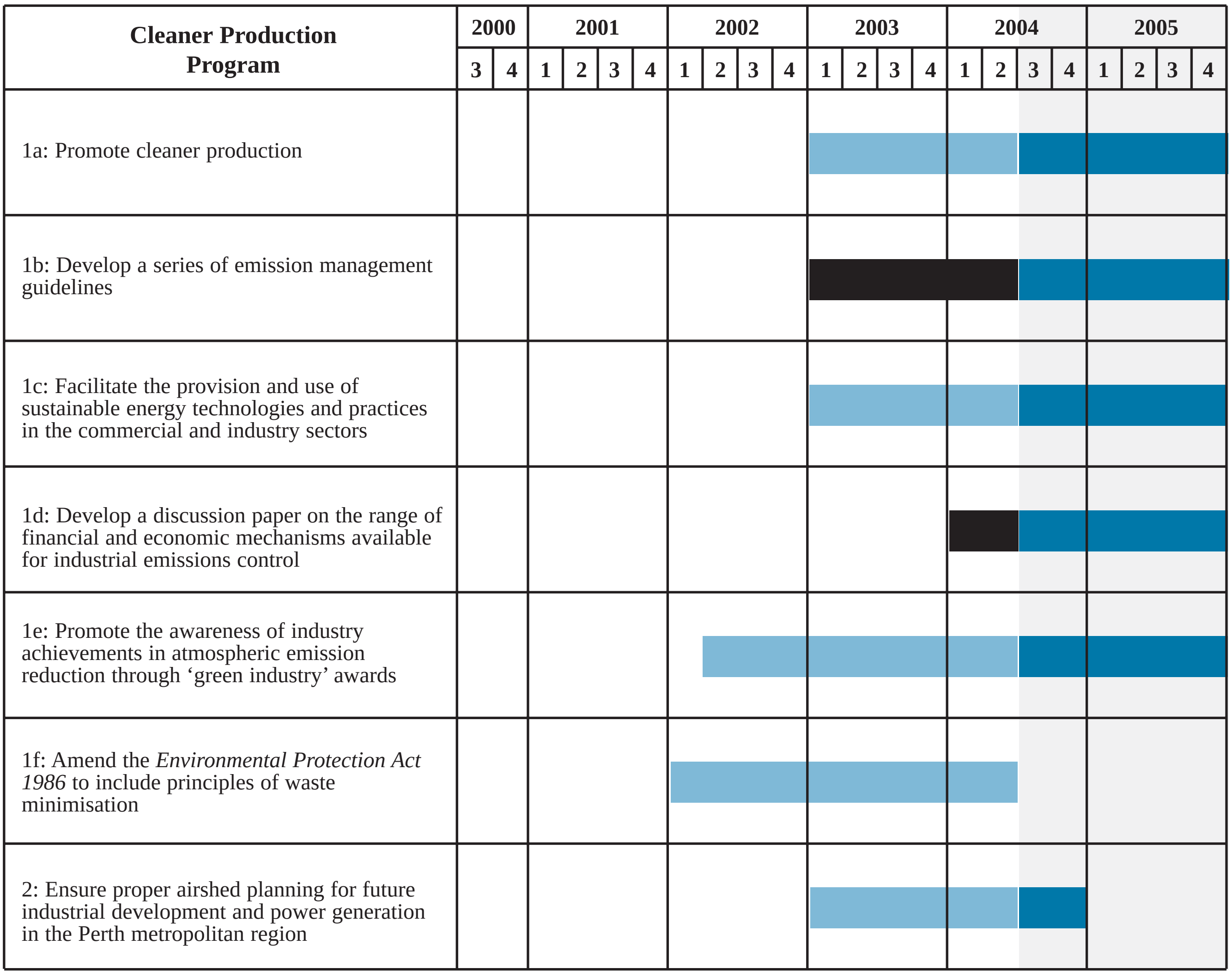
Table 4.21 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. This table shows most of the programs have commenced as scheduled. Development of a series of emission management guidelines has not commenced on schedule due to a diversion of resources into priority areas of vehicle emissions and haze reduction initiatives.

Details of progress on key issues up until June 2003

1 A Cleaner Production Directory for Small to Medium Businesses is under development, and has been reviewed during drafting to include air quality issues.

The principles of waste minimisation that were to be incorporated into the *Environmental Protection Act 1986* are now going to be incorporated into the new waste management legislation (*Resource Recovery and Waste Avoidance Bill*). Drafting instructions for the Bill are being finalised and may be introduced to Parliament early in 2005.

Table 4.21: Progress to June 2004 – Cleaner Production



Key: Program Delayed/ Limited Progress | Program Commenced | Future Activity

Promotion of activities to reduce emissions to the Perth airshed is occurring through the annual *WA Environment Awards*, with the addition of an air quality category. BP Refinery won the 2003 award for 90% reduction in volatile organic compounds emissions.

2 In December 2002 the Energy Smart Directory, an on-line directory of energy efficiency and renewable energy product and service providers, was launched by SEDO to enable easy access to sustainable energy solutions. An additional on-line web toolbox for business is under development to compliment existing tools. Since its launch in December 2002, the Directory has attracted an average of 1,500 visits per month, with 2,000 hits the maximum recorded in one month.

A range of five information brochures on energy efficient technologies for use by industry and commercial building operators were developed in December 2002 by SEDO and distributed commencing January 2003. Two energy efficiency seminars designed for industry were held in August and October. The seminars were held in conjunction with the WA Sustainable Industry Group, concluding a series of six seminars.

A seminar was conducted for government organisations on energy efficiency and office fit out. More than 30 government agency representatives attended. 41 government agencies achieved a reduction in their energy use of which 28 government agencies achieved their first year target of a 5% energy reduction. A business energy survey and energy use research is to be undertaken in 2004-05 to assist in the further development of Energy Smart Business strategies.

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.22.

Table 4.22: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 11: Cleaner Production		
Program 1: Encourage cleaner production	2.0 FTE	
Program 2: Ensure proper airshed planning for future industrial development and power generation in the Perth metropolitan region	0 FTE	

4.12 Initiative 12: Smoke Management

Unless properly considered as part of a burn-decision process, smoke from planned burning activities can impact on local and regional air quality. Several programs have been developed to ensure air quality is considered adequately, including:

1 Establishing a Smoke Management Awareness Group to facilitate community education and information about smoke impacts from planned burns;

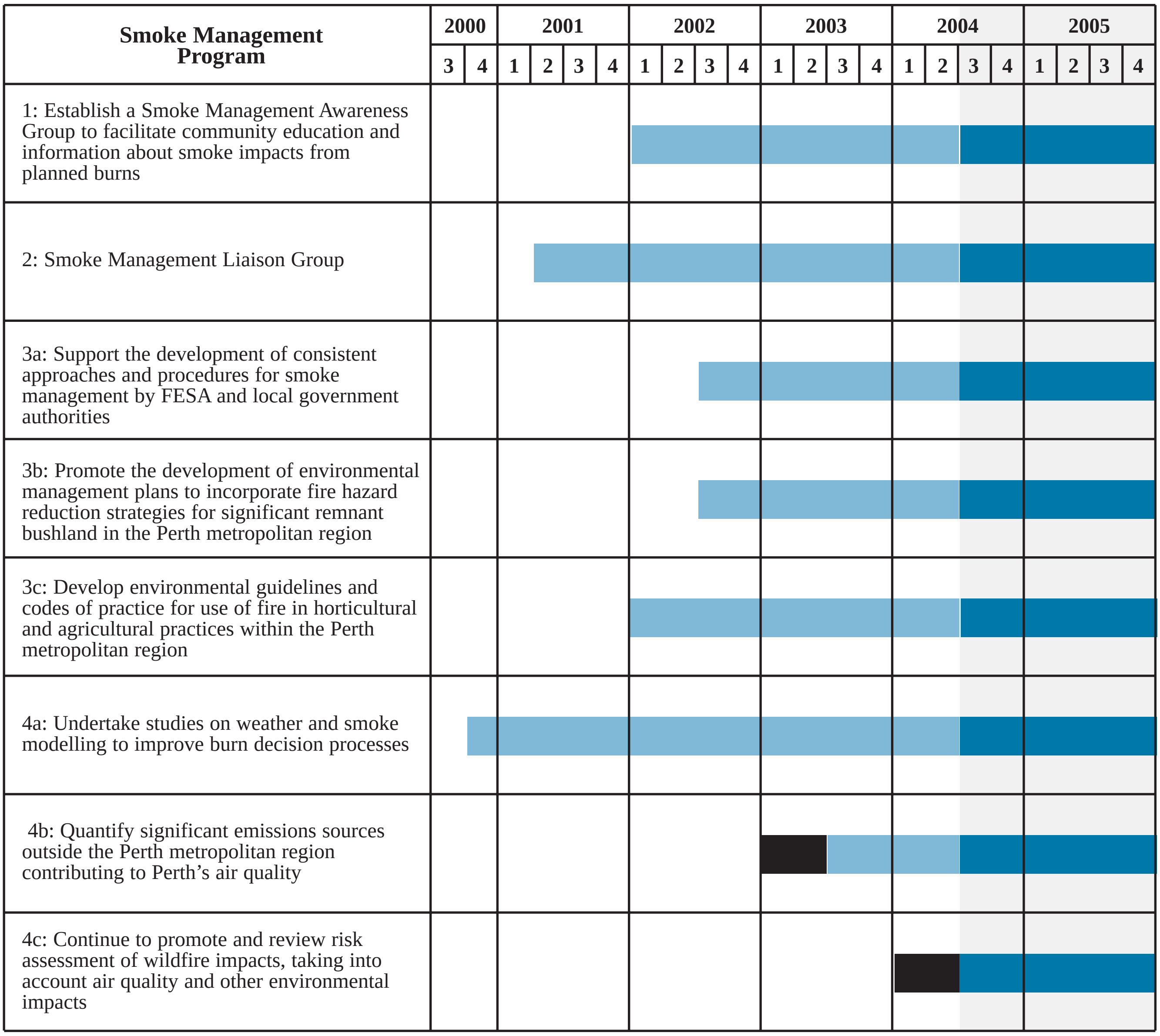
2 Continued operation of the Smoke Management Liaison Group;

3 Development of smoke management policy and regulation; and

4 Continued smoke management research.

Table 4.23 shows the progress of implementation to June 2004 and future activities to December 2005 for each program within this initiative. This table shows the majority of programs have commenced as scheduled.

Table 4.23: Progress to June 2004 – Smoke Management



Key: Program Delayed/ Limited Progress; Program Commenced; Future Activity

Details of progress on key issues up until June 2003

1 Through development of the implementation strategy for this Initiative, the Burning Emissions working group recognised that an additional Smoke Management Awareness Group was also needed. This group would assist in educating authorities and landholders undertaking burning activities to consider air quality impacts. Formation of the Smoke Management Awareness Group has been recognized as a priority and will occur during 2004. Discussions with FESA will occur to progress the development of this group.

A series of leaflets have been produced for all metropolitan local governments to distribute with burning permits each burning season. The leaflets provide basic information to land holders undertaking burning to consider when undertaking burns in order to minimise smoke impacts. These leaflets will be reviewed periodically.

2 The Smoke Management Liaison Group (SMLG) was established in the mid-1990s to improve communications between Government agencies and to reduce the impact of planned burns on air quality while recognising the need to reduce flammable vegetation. SMLG meets several times a year, both pre and post fire season.

The SMLG continues to meet as required, and has proven to be an effective forum for liaison between key agencies and personnel involved in various aspects of smoke prediction, management, monitoring and regulation.

This Initiative includes an action to review the operation of the SMLG protocol to assess its effectiveness. This review commenced in 2003, but was not progressed during 2004 due to reallocation of resources to progress haze reduction and vehicle emissions reduction programs.

3 A smoke management protocol for haze reduction in burning by local government authorities, volunteer brigades and land owners is also under development, including the *Rural / Urban Bush Fire Threat Analysis* which has been finalised for widespread distribution. The *Rural / Urban Bush Fire Threat Analysis* was trialed in the Shire of Gingin and Shire of Mundaring. A statewide bush fire threat analysis tool that will have the capability to be able to be applied across all land tenures is also under development. This tool offers a range of considerations for bush fire risk mitigation, including burning but not restricted solely to burning.

A number of staff have been consulted over the application of the draft smoke management guidelines for prescribed burning. The prescribed burning course has led to 18 participants having been familiarised with the guidelines. A number of volunteer fire fighters have also been referred to the smoke management requirements. The improvement and promotion of smoke management through guidelines and awareness information will continue.

An Environmental Protection Authority (EPA) review of the CALM *Fire Management Policy* has commenced. The EPA Review includes consideration of possible adverse health affects associated with smoke emissions from prescribed burns and wildfires. The EPA discussion paper was released for an eight week public comment period on the 23 June 2004. The EPA is likely to complete their review before the end of 2004 and the outcome will be used to guide future work areas and priorities.

Urban bushland fire response plans are being produced for regionally and locally significant remnant bushland in the Perth metropolitan region. These plans are reviewed annually and updated when appropriate.

The primary concern in Programs 3c relates to agricultural practices, such as the burning of wheat and other crop stubble. As there are no agricultural areas where this is likely to occur in the Perth metropolitan region, the Smoke Management Awareness Group will consider whether this action needs to include agricultural practices outside the metropolitan region.

4 Studies on weather and smoke modelling to improve burn decision processes were undertaken as a national project coordinated by the Australasian Fire Authorities Council (AFAC). The Bureau of Meteorology Research Centre smoke trajectory model has been used to assist in burn decision making. Information on smoke dispersion from a number of burns undertaken in spring 2001 and autumn 2002 was used to assist in model validation. The AFAC study was completed in June 2003, and the final report *Final Report – Smoke Trajectory Predictions for Prescribed Burns, Wildfires, and Hazardous Substances Incidents* is available. The AFAC study has resulted in the development of a prediction tool that assists fire managers in day-to-day decision making on the size, location and scheduling of prescribed burns and associated smoke emissions. The smoke trajectory model has increased the accuracy and reliability of predicting smoke plume movements and likely impacts on residential

areas. The model has been trialed and validated in the Spring 2003 and Autumn 2004 burning seasons.

More research is required in relation to the spread of smoke plumes under a wide range of synoptic and weather conditions. Further studies are planned for the next few years as part of the Bushfire CRC program on weather and smoke modelling, smoke impacts and smoke management.

An exploratory study to quantify significant emissions sources outside the Perth metropolitan region contributing to Perth's air quality was completed using current available data. An internal report was produced, which will guide future work.

Resource Use

The staff and operational resources used for the period 1 July 2003 to 30 June 2004 for programs within this initiative are shown in Table 4.24.

Smoke resulting from a controlled burn.

Table 4.24: Resource use for the period 1 July 2003 to 30 June 2004

	Staff	Operational
Initiative 12: Smoke Management		
Program 1: Establish a Smoke Management Awareness Group to facilitate community education and information about smoke impacts from planned burns	< 0.1 FTE	
Program 2: Smoke Management Liaison Group		
Program 3: Smoke management policy and regulation	< 0.1 FTE	
Program 4: Smoke management research	0.1 FTE	

5.0 Future Years Reporting

The reporting format used for next and subsequent years, like the *Implementation Strategy* itself, is expected to be dynamic. Comments regarding this year's process will be incorporated into the following year's reporting process.

The five year review of Perth AQMP is scheduled to commence in December 2005. This review will utilise the updated air emissions inventory, trends report and scenario modelling to evaluate effectiveness of the Perth AQMP in reducing emissions to the Perth airshed since finalisation of the Implementation Strategy in June 2002.

Publications related to the Perth AQMP including the previous year's progress reports are available from the DoE web site at www.environment.wa.gov.au.

APPENDIX 1: SUMMARY TABLE

This summary table is similar to the one in the *Implementation Strategy*, and has been produced to provide easy-to-read progress on each of the programs in the Perth AQMP.

Programs that have commenced prior to 1 July 2004 (shown in bold print) have been broken into sub-programs for reporting purposes. There are two types of programs, those of finite duration and those of an ongoing nature.

The **Agency Responsible** is the lead agency for the program.

The **Planned Start Date** is taken from the *Implementation Strategy*.

The **Actual Start Date** is provided for all commenced or ongoing programs.

The **Planned Completion Date** is provided (when available) to indicate when a program of finite duration is due for completion. Programs of an ongoing nature are shown by → in the planned completion date column.

Programs that have been completed are **shaded** in the table.

Program Constraints include reasons for delayed implementation and funding constraints.

Lead Agency Comments about the program include major achievements of the program and any proposed changes to phases of programs. A copy of the complete reporting templates from lead agencies is available in a separate document (*Progress Report to June 2004 – Completed Reporting Templates*).

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
INITIATIVE 1: COMMUNITY EDUCATION						
Program 1: Review existing education and behaviour change programs and establish a strategy and framework for developing and implementing supporting programs in the future	DoE	Apr 2002	Jan 2003			Review of existing programs is to be undertaken with the evaluation of *AirWatch* primary and secondary programs conducted as an AQMP funded honours project. Review of existing education and behaviour change programs commenced in 2004 in parallel to the finalisation of the *Community Education Strategy*. Draft *Communications Framework* was submitted to the AQCC for comment in May 2004. Draft MoU with *AirWatch* has been developed to facilitate delivery of AQMP outcomes.
Program 2a: Establish links between existing information centres	DoE	Jan 2002	Jan 2002	→		Air quality relevant web sites have been identified and evaluated as outlets for AQMP information. Links to be updated following the establishment of the new DoE web site.
Program 2b: Establish an air quality web page	DoE	Jan 2002	Jan 2002	→		Air quality web site is serving between 300 and 600 pages on any given day - site has run smoothly and reliably since its launch in 2002. The 'live' air quality data are of key interest. New DoE web site to be launched in July 2004. All information from the existing site will be available on the new site. Maintenance and currency of information will continue based on comments received, new developments and needs as identified through regular review and development of the *Community Education Strategy*. New materials and links to be included, with greater use and cross promotion of *AirWatch* web site which is funded through the AQMP.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 3a: Influence the community's travel behaviour through implementing *Smogbusters* and similar programs	DPI	Prior to Dec 2000	Prior to Dec 2000	→	Present funding arrangement will end on 31 January 2005 Funding is being sought to continue the STO position.	CCWA has a STO who advocates cycling, walking and public transport. Several workshops, conferences and seminars have been held on these issues.
Program 3b: Influence the community's travel behaviour through implementing *TravelSmart Household (Individualised Marketing)* program	DPI	Prior to Dec 2000	Prior to Dec 2000	→		*TravelSmart* (Stage 2) delivered to Town of Cambridge, City of Subiaco, suburb of Marangaroo in the City of Wanneroo, and parts of the City of Fremantle, Town of Vincent, City of Armadale and City of Belmont. Projects planned for the City of Gosnells in early 2005 to complete Stage 2. Average results across five projects fully evaluated to date achieve a 10% reduction in car as driver trips and a 13% reduction in car kilometres.
Program 3c: Influence the community's travel behaviour through implementing *TravelSmart to School*	DPI	Prior to Dec 2000	Prior to Dec 2000	→		Partnership with Millennium Kids established to assist with engagement of primary and secondary schools in the program. Limited interest from secondary schools; hence funding reallocated to expanded Primary School Program. Walking School Bus Program established in 16 schools (24 routes (cumulative)) to support increased walking to primary schools.
Program 3d: Influence the community's travel behaviour through implementing *TravelSmart Local Government*	DPI	Prior to Dec 2000	Prior to Dec 2000	→	Funding from this program extended to end 2004-05 financial year has enabled maintenance of these positions.	*TravelSmart to School* week achieved 23.2% reduction in 119 classes (3472 students) in 25 metro and 17 regional primary schools. During 2001-02 this program enabled 8 local government authorities to employ *TravelSmart* officers. All participating local governments Local Action Plans are updated as required. Program focus may expand to include broader sustainability issues.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 3e: Influence the community's travel behaviour through implementing *TravelSmart Workplace*	DoE	Prior to Dec 2000	Prior to Dec 2000	→		Prior to 2002: GTPs have been produced and implemented for Woodside, Water Corporation, DoH, City of Perth, Ove Arup and Partners, Clough Engineering, HomesWest, MarketForce, Hartley Poynton and the Institute for Child Health Research. 2002: GTPs have been produced and implemented for DPI (4 offices), Schlumberger Oil Fields Australia and Pharmacia Pty Ltd. 2003: GTPs under development for DoE and City of South Perth (Depot and Civic Centre). 2004: GTPs under development for Fremantle Hospital, Hollywood Private Hospital, Department of Industry and Resources, Department of Agriculture and Technip-Coflexip Oceania. 2005: GTPs to be developed for QE2 Medical Centre, City of Joondalup, Transfield, Department of Premier and Cabinet, Disability Services Commission and Sinclair Knight Mertz. DoE recorded a reduction in overall kilometres travelled by car. City of South Perth recorded mixed results across its two sites, with no net change. The Civic Centre recorded a reduction of 20% in overall kilometers travelled. Schlumberger Oil Fields Australia conducted another survey in 2004 to determine if there was sustained change following the development of their GTP in 2001. They recorded a reduction of 14% from the baseline survey of travel behaviour, better than the initial target of 10%.
Program 3f: Influence the community's travel behaviour through implementing *Cycle 100*	DoE	Prior to Dec 2000	Prior to Dec 2000	→	Program not continued into 2003-04 due to lack of funding.	Project has been scheduled for 2004-05 to scope opportunities to reinstate program for 2005-06.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 3g: Influence the community's travel behaviour through implementing *Cycle Instead*	DPI	Prior to Dec 2000	Prior to Dec 2000	→	The *Cycle Instead* radio and media campaign was cancelled in 2003-04 due to lack of funds to sustain such an expensive program.	Bikeweek was held in March 2004 to promote cycling. Radio advertising was utilised to support *Cycle Instead Bikeweek 2004* during which a number of community bike rides and events received funding support, in an effort to influence the community's travel behaviour. No significant change in travel behaviour has been noted. However the program is having the positive effect of maintaining cycling activities among adults in the face of a drop-off in children cycling.
Program 3h: Influence the community's travel behaviour through implementing *Walk There Today*	DPI	Jul 2001	Jul 2001	→		Implementation plan has been developed and walking program implementation has commenced. Message icon is now '*Walk There Today to Find Thirty*' in collaboration with health message of '*Find Thirty*'. During *Walk Week* from 3 to 9 November 2003, 25,000 walked to school, 2,300 participated in community walks, 16,000 copies of walking guide books were distributed and 300 corporate workers participated in lunchtime walks. 85% of the people in metro were exposed to the promotional message of '*Walk There Today to Find Thirty*'.
Program 3i: Influence the community's travel behaviour through encouraging teleworking in Government agencies	DPI	Apr 2002	Apr 2002		Following review of 'telework pilot results' the project has not progressed due to insufficient resources. It is not expected to be progressed due to continued lack of resources.	Preliminary research and information gathering is completed.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
INITIATIVE 2: VEHICLE EMISSIONS REDUCTION						
Program 1a: Develop policy and regulations for automotive fuel quality in WA and promote national fuel quality regulation in line with international standards	DoE	Prior to Dec 2000	Prior to Dec 2000		→	WA Fuel policy is to maintain WA's standards until Commonwealth standards align in January 2006, then adopt future Commonwealth fuel standards. *Environmental Protection (Diesel and Petrol) Regulations 1999* implemented with Commonwealth monitoring indicating no breaches to date. Input into future fuel quality standards through participation in FSCC.
Program 1b: Coordinate fuel quality standards with improved vehicle emission standards	DoE	Prior to Dec 2000	Prior to Dec 2000		→	Participation in LTEC review of future fuel and emission standards ensures consistency.
Program 2: Evaluate LPG and CNG as fuel sources for the passenger and freight sectors	DoE	Apr 2002	Apr 2003		Research project was not taken up in 2004 and will be re-offered as a funded research project for commencement in early 2005.	Initial scoping has commenced with the evaluation to be completed as a funded research project. The evaluation of emissions performance has commenced for input into government's vehicle fleet purchasing. The Transport Energy Strategy Committee is examining the further promotion of LPG, CNG, LNG and smaller capacity vehicles, particularly in the Government fleet.
Program 3a Evaluate emissions testing options for introduction to Perth	DoE	Apr 2002	Apr 2003			Program integrated into Diesel NEPM activities. Previously desktop review, now 'real world' emissions testing trial. Scenario and air quality impact modelling to be considered once emissions testing pilot programs have been completed.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 3b: Undertake a pilot trial of an emissions testing system	DoE	Jul 2002	Oct 2003			Negotiation between WA and Commonwealth resulted in funding being available for a revised testing program. Pilot *Diesel Vehicle Emissions Testing Program* revised and submitted based on available Commonwealth funding. The pilot *Petrol Vehicle Emissions Testing Program* scope was finalised and released for public tender to identify a suitable service provider.
Program 3c: Implement the committed outcomes to reduce in-service emissions from motor vehicles	DoE	Oct 2004			Scheduled to commence following the recommendations of a cost benefit analysis (Program 3b).	
Program 4a: On-road enforcement of controls on excessive vehicle emissions (10 second regulations)	DPI	Jul 2002	Oct 2002			Legislation was enacted in November 2002. Legislative amendments to minimise complications with enforcement in 2003-04. *'Clear the Air'* brochure produced and information for industry has been widely distributed. Training of DPI and Police officers in 2001, with additional training provided as required. Awaiting refinement of the *Smoky Vehicle Reporting* program as a primary enforcement tool.
Program 4b: Smoky vehicle program	DoE	Jul 2002	Apr 2003			Initial scoping of criteria for review commenced. The initial review indicated that the *Smoky Vehicle Reporting* program needed improvement at an operational level in order to allow review to occur. This involved improving the administrative operation of the program, commencing 1 July 2004. The review will commence following this. Multiple reports to the *Smoky Vehicle Reporting* hotline are notified and advised that failure to rectify their vehicle may lead to further enforcement under the 10 second regulations. Negotiations are continuing to develop a process for active enforcement by the Police for vehicles reported more than five times.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 5: Evaluate and introduce appropriate measures to remove older vehicles from the Perth fleet	DoE	Oct 2003	Oct 2003			Initial scoping has commenced, with the evaluation to be completed as a funded university research project commencing in early 2005.
Program 6: Emissions testing training and equipment and technology review	DoE	Jul 2004			Not scheduled to commence until emissions testing program is underway (Program 3b).	Vehicle emissions training and education has been incorporated into the pilot *Diesel Vehicle Emissions Testing* program proposal (Program 3b).
Program 7: Investigate the cost effectiveness of Stage II vapour recovery and promote at national level if cost effective	DoE	Jan 2003	Jan 2003			Regulations are in place for Stage I vapour recovery in WA. No plans for the introduction of Stage II vapour recovery at Commonwealth level. Continued watching brief and input to LTEC where required. NSW DEC is conducting a trial of Stage II vapour recovery, and a watching brief will be kept. Results of trial will be used to aid in the evaluation of the appropriateness of stage II vapour recovery.
Program 8: Investigate the use of electric, alternative fuel vehicles and ultra-light vehicles	DPI	Jan 2003	Jan 2003			This program includes investigation of biofuels. The Commonwealth has a number of programs, WA will continue to provide input into these. Review being undertaken by Transport Energy Strategy Committee. Transport Energy Strategy Committee delivered their report to the Minister for Planning and Infrastructure in March 2004.
INITIATIVE 3: REDUCTION OF INDUSTRIAL EMISSIONS OF NO_X AND ROCS						
Program 1a: Review modelling capability and needs in order to assess contribution of industrial NO_X and ROC emissions on smog formation in the Perth airshed	DoE	Apr 2002	Apr 2002	Jan 2003		Model configured to enable seasonal runs. Reliability of current NO_X inventory data was found to be an issue, and NO_X inventory data updated in response. Program completed January 2003.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 1b: Undertake modelling	DoE	Oct 2002	Jan 2003			Preliminary modelling was completed early 2004. A draft technical report has been prepared and circulated for peer review. The draft report, incorporating comments of peer review, will then be circulated for stakeholder comment.
Program 2: Assess cost effective NO_X emission reduction options, and implement agreed options to reduce emissions from significant industrial sources	DoE	Apr 2003			Discussion with major emitters to identify cost effective options will commence following finalisation of the modelling report (Program 1b).	The Industrial Emissions Reduction working group will be convened to progress this.
Program 3: Identify and assist the major emitters of ROCs to reduce industrial contributions, and encourage continuous improvement in ROC reduction measures already introduced	DoE	Apr 2003			Discussion with major emitters to identify cost effective options will commence following finalisation of the modelling report (Program 1b).	
INITIATIVE 4: HEALTH RESEARCH						
Program 1: Investigating the public health impacts of air pollution	DoE	Prior to Dec 2000	Prior to Dec 2000			Research on *Health and Air Pollution in Perth - Morbidity and Mortality: A Case-Crossover Analysis 1992-1997* report released June 2003. Continued participation in a number of Commonwealth health research programs. APHN decided that publication of the Discussion Paper should be delayed so that an indoor air quality component could be added. A number of AQMP-funded studies have commenced.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 2: Investigating sources of air pollutants and their impact on residents by determining the potential health impacts of variations in Perth's daily air quality	DoE	Jan 2003	Jul 2003			Report for BTEX PEM study released May 2003 and the results of this study are being reviewed. Results from SPIRT project have not been publicly released. Commencement of review of SPIRT results upon official release of results. Upon completion of this review, studies will be scoped to study local variations in relation to these pollutants.
Program 3: Development of an Air Pollution and Health Network	DoE	Jan 2003	Jan 2003			The Health Research and Indoor Air Quality working groups merged to create the APHN. The Discussion Paper on research priorities for ambient air will incorporate an indoor air quality component. A series of APHN workshops will be held to develop the indoor air component of the Discussion Paper. Collaborative research projects between APHN members will also be scoped at these workshops.
INITIATIVE 5: MODELLING IMPROVEMENTS						
Program 1a: Update and consolidate air emissions databases (Perth Air Emisions Inventory) using best available information from a range of sources including National Pollutant Inventory (NPI), local industry and overseas authorities	DoE	Prior to Dec 2000	Prior to Dec 2000	→		*Perth Airshed Inventory Update 1998-1999* released January 2002. The NPI and the *Perth Airshed Inventory Update* will be updated on a five yearly basis. The inventory year 1 July 2004 to 30 June 2005 will be the focus of the next update.
Program 1b: Develop a database management system to integrate data from the Perth Air Emissions Inventory, NPI and licensed premises	DoE	Jan 2004	Jan 2003			The timetable for completion of the *Perth Airshed Inventory Update* has been revised to commence in January 2007.
Program 2: Validate / improve emissions estimates for key emission sources	DoE	Apr 2004	Jan 2003			The timetable for completion of the *Perth Airshed Inventory Update* has been revised to commence in January 2007.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 3a: Improve modelling capability and accuracy by refining the Perth Haze Model	DoE	Apr 2002	Apr 2002	→		Peer reviewed paper prepared and presented at Clean Air Society of Australia and New Zealand 2002 conference. Draft final report to be sent out for peer review in October 2004 and revised to incorporate key comments of peer reviewers. Final report to be published in Technical Series in early 2005. Model used in the 'Haze Movie' educational tool under development to be peer reviewed prior to finalisation.
Program 3b: Improve modelling capability by enhancing the graphical display of the Perth Photochemical Smog Model	DoE	Apr 2002	Apr 2002	→		A version of the software is now available on the air quality web site. Further improvement in graphical user interface to be assessed from user feedback.
Program 3c: Use output from the BoM mesoscale model as input into the Perth Photochemical Smog Model	DoE	Apr 2003	Apr 2003			Appropriateness investigated, but found not suitable. Final draft report completed for peer review. Publication of report as part of Technical Series following peer review in early 2005.
Program 3d: Review modelling development and maintenance requirements	DoE	Jan 2003	Jan 2003			The assessment of various modelling methods for suitability in regards to use in WA has commenced and recommendations regarding most suitable methods will be made.
INITIATIVE 6: AIR QUALITY MONITORING						
Program 1: Establish an Air Monitoring Steering Group to review air quality monitoring issues in the Perth metropolitan region	DoE	Apr 2002				Due to the increasing number of programs under the AQMP Initiatives that involve an air monitoring component, the AMSG will be formed with the view of expanding its membership. The AMSG is scheduled to meet in December 2004 and a work program for the working group will be developed.
Program 2a: Review air quality monitoring practices and procedures in the Perth metropolitan region	DoE	Prior to Dec 2000	Prior to Dec 2000	→		Monitoring Plan for WA released in May 2001 as requirement under the Air NEPM. Purchase and installation of equipment to enable NATA accreditation is continuing.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 2b: Review trends in ambient air quality	**DoE**	**Jan 2004**	**Jan 2004**			**Trends analysis was repeated for the data period 1992-2002. Final draft of report completed January 2004. Report was peer reviewed and final copy at publishers in May 2004.** **Significant trends identified (particles and ozone) are influencing program priorities and direction.** **Trends analysis and report to be completed for every additional four years of data, with next report target is June 2008.**
Program 3a: Develop future monitoring programs for air toxics	**DoE**	**As required**	**Jan 2003**	→		**Ambient air toxics monitoring will be conducted as required under the guidelines for implementation of the Air Toxics NEPM in WA.** **Project scoping for street side monitoring in entertainment districts has been completed.** **Draft report from field trials to be provided to newly formed AMSG for their comment and suggestions regarding future work.**
Program 3b: VOC monitoring	**DoE**	**As required**	**Jan 2003**	→		**A project to monitor for VOCs at selected locations is under development, with specifications currently being reviewed by external agencies.** **Commercial / industrial partners will be sought for funding VOC monitoring. Scope of project is dependent on final available funding.** **Awaiting recommendations of review of BTEX and SPIRT study. Recommendations of review to be provided to AMSG subject to its completion.**
Program 3c: Develop future monitoring programs for acid gases	**DoE**	**As required**	**Jul 2003**	→		**The *Brickworks Licensing Policy*, released in October 2003, outlines a *Brickworks Review Implementation* program aimed at reducing emissions from brickwork facilities.**

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 3d: Evaluation of mobile monitoring stations	DoE	Jan 2003	Jan 2003	→		Scoping document of mobile monitoring options completed. Due to cost, the mobile monitoring station was not deemed a viable option. Portable instrument (GCMS) for measurement of VOCs has been purchased. Field trials using the portable GCMS are to be conducted collaboratively with the Chemistry Centre WA. Results of field trials of the PID are being incorporated into a report on the potential use of the PID in areas with air quality issues.
Program 3e: Emerging air quality issues	DoE	As required	Jul	→		Will be considered by the AMSG and the AQCC. WA engaged with national EPHC Air Quality working group.
Program 4: Support community information and education programs on air quality monitoring	DoE	Apr 2002	Apr 2002			Ambient air quality information and real-time monitoring data available on the air quality web page. Haze Movie and Smog Movie are available on web site. Scoping and implementation of pilot *SNAQ (Students Network for Air Quality) on Haze* program. Review of *SNAQ on Haze* and expansion of *SNAQ on Haze* to additional schools in Winter 2005. Initial scoping of an *AirWatch Community* program in line with the schools program.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
INITIATIVE 7: INDOOR AIR QUALITY						
Program 1: Development of an Indoor Air Quality Network	DoE	Jan 2003	Oct 2003			The Health Research and Indoor Air Quality working groups merged to create the APHN. A series of APHN workshops starting in August 2004 will be held to develop the indoor air quality component of the Discussion Paper and to scope collaborative research projects that will address the priority research areas outlined in the position paper. APHN is holding several workshops to utilize the collective strength of indoor air quality specialists to direct health research priorities at the State level. APHN identified domestic unflued gas heaters as a high priority current issue.
2a: Collate and review indoor air quality monitoring, exposure and health outcome exposure studies	DoH	Jul 2001	Jul 2001			A preliminary review of relevant indoor air quality studies completed. A more extensive review has not commenced.
2b: Develop indoor air personal exposure and monitoring programs	DoH	Apr 2003	Apr 2003			Project to commence in the second half of 2004 undertaking an analysis of nitrogen dioxide exposure.
2c: Indoor air quality database development	DoH	To be determined				
3a: Collate and review indoor air quality awareness programs and resources	DoH	Jul 2001	Jul 2001			A review of existing community education leaflets is completed. Leaflets are being reviewed and updated where required.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
3b: Develop community awareness materials and campaigns to limit indoor air exposures. Incorporate findings from the source and personal exposure research into community awareness materials as required	**DoH**	**As required**	**Jul 2003**			**Community awareness on indoor air quality issues has largely been focused on domestic unflued gas heaters.** **Leaflet on unflued gas heaters has been published and is accessible to the public through the Environmental Health Directorate and from the DoH web site.** **The Minister for Health released media and press statements on the implications from operation of domestic unflued gas heaters.**
3c: Develop a protocol for a Perth indoor air quality community awareness program, trial and implement this program	**DoH**	**To be determined**				
INITIATIVE 8: LAND USE AND TRANSPORT PLANNING						
Program 1a: Include regional and local air quality considerations in the strategic planning and implementation of *Network City: Community Planning Strategy for Perth and Peel*	**DPI**	**Prior to Dec *2000***	**Prior to Dec *2000***			**The banner under which this program falls is called *Dialogue with the City*, which was initiated in June 2003. (The term 'Greater Perth' is no longer used.)** **The community plan that has evolved from Dialogue with the *City - Network City: Community Planning Strategy for Perth and Peel* - outlines a change in direction for Perth, not only in how the city develops, but also how planning is carried out. The key is to plan through participative decision-making.** ***Network City* addresses air quality issues in a variety of broad strategies, each of which has supporting actions. It is hoped that these strategies will address Perth's air quality issues.** ***Network City* will be open for public comment from September to December 2004. Thereafter comments will be reviewed, changes made to the document if appropriate and the strategy finalised.** **Post public comment period an implementation plan is to be produced, which will give better guidance as to the timing of, and resources required, to implement strategies and actions in *Network City*.**

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 1b: Assess the environmental impact of the various strategies contained within *Network City* and the *Metropolitan Transport Strategy*	DoE	Jul 2002	Jul 2002			Review of *MTS / Future Perth / Greater Perth,* their linkages and objectives and findings of previous reviews undertaken by DEP/EPA has commenced. Modelling of air quality impacts dependent on outcome of *Dialogue with the City.*
Program 2: Include regional and local air quality considerations in the planning and implementation of development proposals	DPI	Sep 2002	Apr 2002	→		Draft Transport Assessment guidelines were prepared in January 2003, with internal stakeholder review completed in September 2003. The draft guidelines will be submitted to the WAPC for endorsement in November 2004. They will then be distributed to external stakeholders for comment and revised as appropriate. It is then proposed to introduce the guidelines into the development control / planning process on a voluntary trial basis for 12 months to allow benefits to be evaluated.
Program 3a: Monitor and review the effectiveness of land use and transport planning decisions in influencing Perth's air quality	DPI	Prior to Dec 2003	Prior to Dec 2003	→		The capital works and major infrastructure projects detailed in the *Better Public Transport: Ten Year Plan for Transperth* are progressing. These include improving passenger information services, increasing Park n Ride capacity, improving bus stop and station facilities including upgrading of train stations to meet accessibility standards, continuation of bus fleet replacement program, development of *SmartRider* ticketing initiative and expansion of metropolitan train system. The extension of train services to Clarkson will commence in October 2004, with an attendant reorganisation of feeder bus services to compliment the revised train network. Extended train services to the new Thornlie Station will commence in early 2005. The service development plan has been progressed within the Transperth finite budget by improvement to bus services in one area being funded by the withdrawing services from other areas, where services were under performing. Indications are that the recurrent budget will not increase for 2004-05. The exception may be for a

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
						possible injection of funds on a one off project basis. Such projects may not form part of our Services Improvement Plan. 11 out of the 26 bus service improvement projects earmarked for 2003-04 were delivered. Bus patronage has increased again this year for the fourth consecutive year totaling over 18%.
Program 3b: Review of DC 1.6 policy	DPI	Jul 2003	Jul 2003	→		Review of *DC 1.6 – Planning to Enhance Public Transport Use*, commenced in August 2003. Revised interim policy drafted in March 2004 but not released. An evaluation of policies against sustainability principles completed.
Program 3c: Assess the cost effectiveness of money spent on the transport network	DoE	Apr 2003	Apr 2003			Initial program scoping may lead to the timelines being revised in view of current government policy and plans for the expansion of the Perth rail network. Awaiting scenario data from DPI as a result of *Dialogue with the City* and *Network City: Community Planning Strategy for Perth and Peel*.
Program 4a: Assist local government in influencing the community's travel behaviour by developing ITPs	DPI	Prior to Dec 2000	Prior to Dec 2000	→		*Travelling Together - South West Metropolitan Integrated Transport Plan* completed (covers 7 local authorities) and implementation has commenced. Commence *Eastern Metropolitan Region Integrated Transport Strategy* in partnership with EMRC.
Program 4b: Cyclist access	DPI	Prior to Dec 2000	Prior to Dec 2000			Implementation of strategies outlined in *Bike Ahead* is continuing. Monitoring of Perth Bicycle Network routes has shown that usage of the routes had doubled since 1999. *'Cycling and Walking Behaviour and Attitudes Track'* undertaken – the ninth such survey for cycling. Both surveys will be undertaken again in 2004-05.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 4c: Pedestrian access	DPI	Jan 2001	Jan 2001			Implementation of strategies outlined in *Perth Walking* is continuing. Projects developed to address better pedestrian infrastructure in local government. Terms of reference for Walking WA Committee have been broadened to include walking for health, recreation and sustainability.
Program 4d: Parking	DPI	Dec 2000	Dec 2000			Policy is being successfully used to reduce the amount of tenant parking provided and to increase the supply of bicycle parking and end of trip facilities. Initial review has been conducted in-house. Draft strategy development commenced. Stage 1 *Review of Public Parking* will be finalized in 2004-05. Ongoing work on the development of a "policy approach" to parking in the Perth metropolitan region is underway.
Program 4e: Home based employment and business	DPI	Apr 2003	Apr 2003			Extent and characteristics of home-based employment was covered in section 5.6 of *Greater Perth Economy and Employment* (Discussion Paper 3). An investigation of home-based employment is expected to be a component of the implementation plan for *Network City*.
INITIATIVE 9: HAZE REDUCTION						
Program 1a: Increase community awareness of the impacts of domestic wood heaters on air quality	SEDO / DoE	Apr 2002	Apr 2002	→		Approximately 2,500 '*Choosing a Heater*' brochures distributed through Energy Smart Line, local government authorities and other community and promotional activities each year. Wood Smoke brochure '*Store Right, Burn Bright, Breath Alright*' revised and 10,000 copies produced. 3,000 information pack on alternative heating, energy efficiency and correct wood heater use in 3 local government authorities where the pilot *Wood Heater Replacement Program* is being trialled.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 1b: Incentive programs and *Halt the Haze* campaign	DoE	Jan 2003	Jan 2003			Winter Haze Alert program enhanced to include posting on air quality web site. Information session held for media / weather presenters in June 2003. Not repeated in 2004. Haze Reduction working group formed and 10 meetings held. Pilot *Wood Heater Replacement Program* developed and launched in June 2004. Initially involves City of Joondalup, City of Melville and Town of Kwinana and offers a $600 rebate. Pilot *Home Heating Survey* commenced in May 2004 in the above local government areas. *Wood Heating Policy Options Paper* revised to include all heating options, now titled *Home Heating Policy Options Paper*.
Program 2a: Increase awareness among wood suppliers and wood heater installers of the impacts of wood heaters on air quality	DoE	Apr 2002	Apr 2002	→		Annual inspections of wood yards are undertaken to ensure compliance with moisture content regulations. 21 Wood yard inspections conducted in December 2003, with one breach for not labeling green wood as 'Not for Sale'.
Program 2b: Wood heater installation course	DoE	Apr 2002	Apr 2002			Course has been written and is awaiting a training body to write up formally and get approved. TAFE has stated that they will require $35,000 to do this. AHHA does not have the funds and is seeking an alternative training body.
Program 3a: Domestic smoke nuisance resolution	DoE	Apr 2002	Apr 2002			Health Act 1911 amendments to remove the exclusion of domestic chimneys from the nuisance provisions have been prepared and introduced to Parliament. At the First Reading in the Legislative Council at 25 June 2004. Haze Reduction working group has develop a 'toolkit' for use by local government in resolving wood smoke complaints.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 3b: Mediating process for domestic smoke nuisance	DoE	Apr 2002	Apr 2002			EHO training in wood smoke issues and wood heater operation was held in April 2002 and April 2004. Revision of *Wood Heater and Firewood Information Kit for Environmental Health Officers* is complete and ready for distribution.
Program 4a: Backyard burning ban	DoE	Apr 2002	Apr 2002	→		Voluntary response of local governments to *Parliamentary Select Committee on Recycling* and Waste Management has resulted in separate green waste collections and less waste being burned. It is therefore not clear whether a regulation to ban backyard burning will be developed and phases for this action should be reviewed. Town of Kwinana has developed a local law to prevent backyard burning, and other local governments are looking at developing a similar local law.
Program 4b: Manage green waste disposal and recycling to reduce local haze creation	DoE	Jul 2002	Jul 2002			Voluntary response of local governments to *Parliamentary Select Committee on Recycling* and *Waste Management* has resulted in separate green waste collections and less waste being burned. Various local government authorities are dealing with the issue of green waste disposal by providing green waste collection and/or banning backyard burning.
INITIATIVE 10: ENERGY EFFICIENT BUILDINGS						
Program 1: Adoption of energy efficiency principles through building codes	DHW	Jan 2002	Jan 2002			Changes to the BCA came into effect in WA from 1 July 2003 to incorporate energy efficiency measures. These changes apply to single detached residential buildings and air-conditioned or heated outbuildings. The ABCB in conjunction with the States and Territories, are developing further provisions for application to multi-residential and commercial/industrial buildings. These are scheduled to come into effect from 1 May 2005 and 2006 respectively.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 2: Encourage energy efficient building design and planning	SEDO	Jul 2001	Jul 2001	→		About 7,500 copies of the *Energy Efficient Housing for the South West* brochure are published each year. Approximately 750 people were trained in the use of FirstRate by 1 July 2004. There were 150 Accredited Assessors using FirstRate to assess energy performance by 1 July 2004, with 9% of dwellings applications rated. SEDO held a series of seminars where community members could bring in their plans for a quick rate assessment.
INITIATIVE 11: CLEANER PRODUCTION						
Program 1a: Promote cleaner production	DoE	Jan 2003	Jan 2003	→		Cleaner Production Directory for Small to Medium Businesses guide being developed. Guide reviewed to include air quality issues during drafting.
Program 1b: Develop a series of emission management guidelines	DoE	Jan 2003				Initial evaluation of the contribution by small to medium enterprises to air emissions to commence late 2004.
Program 1c: Facilitate the provision and use of sustainable energy technologies and practices in the commercial and industry sectors	SEDO	Jan 2003	Jan 2003	→		Energy Smart Directory was launched to enable easy access to sustainable energy solutions. This on-line directory of energy efficiency and renewable energy product and service providers attracts an average of 1,500 visits per month. Additional on-line web toolbox for business planned to compliment existing tools. Information brochures on energy efficient technologies for use by industry and commercial building operators were completed in May 2003 and distribution commenced January 2004. A series of six energy efficiency seminars were conducted, concluding in October 2003. A seminar was conducted for government organisations on energy efficiency and office fit out. More than 30 government departments attended.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
						41 government departments achieved a reduction in their energy use, of which 28 government departments achieved their target of a 5% energy reduction.
Program 1d: Develop a discussion paper on the range of financial and economic mechanisms available for industrial emissions control	DoE	Jan 2004			Project being scoped for commencement in 2004-05.	
Program 1e: Promote the awareness of industry achievements in atmospheric emission reduction through 'green industry' awards	DoE	Apr 2002	Apr 2002	→		An air quality category established within the annual WA Environment Awards, presented in October each year. BP Refinery won the 2003 award for 90% reduction in VOCs.
Program 1f: Amend the *Environmental Protection Act 1986* to include principles of waste minimisation	DoE	Jan 2002	Jan 2002			Principles of waste minimisation that were to be incorporated into the *Environmental Protection Act 1986* to be incorporated into the new waste management legislation (*Resource Recovery and Waste Avoidance Bill*). Instructions for drafting the Bill are still being finalised.
Program 2: Ensure proper airshed planning for future industrial development and power generation in the Perth metropolitan region	DoE 2002	Jan 2002	Jan			DoE have been involved in the strategic review of power procurement options. Further assessments will be required as realistic scenarios are developed.
INITIATIVE 12: SMOKE MANAGEMENT						
Program 1: Establish a Smoke Management Awareness Group to facilitate community education and information about smoke impacts from planned burns	FESA	Jan 2002	Jan 2002			Development of a smoke management protocol for haze reduction in burning by local governments, volunteer brigades and land-owners is continuing. Leaflets reviewed prior to distribution to all metropolitan local governments to be attached to burn permits. Leaflets will require ongoing review. A number of FESA staff consulted over the application of the draft smoke management guidelines for prescribed burning. The FESA prescribed burning course with 18 participants have been exposed to the guidelines. A number of volunteers fire fighters have also been exposed to the smoke management requirements.

Program/Sub Program	Agency Responsible	Planned Start Date	Actual Start Date	Planned Completion Date	Program Constraints	Lead Agency Comments
Program 2: Smoke Management Liaison Group	DoE	Apr 2001	Apr 2001	→	A review of SMLG protocol to assess effectiveness has not commenced.	SMLG meets pre and post fire season.
Program 3a: Support the development of consistent approaches and procedures for smoke management by FESA and local government authorities	FESA	Jul 2002	Jul 2002	→		*Rural/Urban Bushfire Threat Analysis* distributed and trialed in Shire of Gingin and Shire of Mundaring. FESA and CALM are working toward having a state-wide bush fire threat analysis tool that will have the capability to be able to be applied across all land tenures.
Program 3b: Promote the development of environmental management plans to incorporate fire hazard reduction strategies for regionally and locally significant remnant bushland in the Perth metropolitan region	FESA	Jul 2002	Jul 2002	→		Urban bushland fire response plans are developed and updated and improved each October.
Program 3c: Develop environmental guidelines and codes of practice for use of fire in horticultural and agricultural practices within the Perth metropolitan region	DoE	Jan 2002	Jan 2002			The Smoke Management Awareness Group will consider whether this action needs to include agricultural practices outside the metropolitan region.
Program 4a: Undertake studies on weather and smoke modelling to improve burn decision processes	CALM	Prior to Dec 2000	Prior to Dec 2000			Undertaken as a National project coordinated by AFAC. Final Report submitted August 2003. Trialed and validated in Spring 2003 and Autumn 2004 burning seasons. Smoke trajectory models now used daily. Extension of Smoke prediction research being incorporated in Bushfire CRC programs.
Program 4b: Quantify significant emissions sources outside the Perth metropolitan region contributing to Perth's air quality	DoE	Jan 2003	Jul 2003			An exploratory study was completed using current available data. An internal report was produced, which will guide future work. The outcome of the EPA review of CALM's *Fire Management Policy* will be used to guide future work areas and priorities.
Program 4c: Continue to promote and review risk assessment of wildfire impacts, taking into account air quality and other environmental impacts	DoE	Jan 2004				Risk assessment and modelling of the potential impact on populations from burn events.

Appendix 2:

MEMBERSHIP AND MEETING SCHEDULES OF THE AQCC AND AQMP WORKING GROUPS

MEMBERSHIP OF THE AQCC

The AQCC membership consisted of the following representatives for the period July 2003 to June 2004:

State Government (6 Representatives)

Fred Tromp, Director Resource Science, Department of Environment (AQCC Chair)

Robert Griffiths, Department for Planning and Infrastructure

Kathy Macklin (Proxy), Department for Planning and Infrastructure

Rick Sneeuwjagt, Department of Conservation and Land Management

Margaret Stephens, Department of Health (July 2003 to December 2003)

Jim Dodds, Department of Health (January 2004 to June 2004)

Mark Feldwick (Proxy), Department of Health

Nicole Workum, Sustainable Energy Development Office (July 2003 to December 2003)

Tanya Carpenter, Sustainable Energy Development Office (January 2004 to June 2004)

Antony Mee, Department of Housing and Works

Non-Government (7 Representatives)

Local Government

Nathan Malin (Proxy), WA Local Government Association (July 2003 to December 2003)

Dale Newsome (Proxy), Local Government Association (January 2004 to June 2004)

Business and Industry

Mary Askey, Chamber of Commerce and Industry WA

Chad Bishop, Kwinana Industries Council

Community

Philip Jennings, Conservation Council of WA

Chris Tallentire (Proxy), Conservation Council of WA

Dr Sue Graham-Taylor, Pollution Action Network

Mike Upton, Royal Automobile Club of WA

Department of Environment Project Team (AQCC Support)

John Sutton, A/Manager, Air Quality Management Branch

Deanna Tuxford, Program Manager, Air Quality Management Branch

James Forrest, Environmental Officer, Air Quality Management Branch

Jenniffer Scott, Administrative Assistant, Air Quality Management Branch

SCHEDULE OF AQCC MEETINGS (JULY 2003 TO DECEMBER 2004)

Implementation Meeting 2:	11 August 2003
Implementation Meeting 3:	22 September 2003
Implementation Meeting 4:	3 November 2003
Implementation Meeting 5:	17 May 2004
Implementation Meeting 6:	26 July 2004
Implementation Meeting 7:	6 September 2004
Implementation Meeting 8:	25 October 2004
Implementation Meeting 9:	6 December 2004

MEMBERSHIP OF AQMP WORKING GROUPS

Several of the AQMP working groups have been active during this reporting period. Membership of these working groups has changed, and current membership is provided below.

Community Education

Melissa Patt, DoE (July 2003 to December 2003)

Peter Musk, DoE (January 2004 to June 2004)

Deanna Tuxford, DoE

Greg Allen, DoE

Richard Olive, DoE

Karin Stark, DoE

Gary John, DPI

Heide Newton, DPI

Rick Sneeuwjagt, CALM

Tanya Carpenter, SEDO

Mary Askey, CCIWA

David Wake, CCWA

Kylie Ashenbrenner, Alcoa Australia

Vehicle Emissions Reduction

John Sutton, DoE

Anthony Stuart, DoE

Drew Farrar, DoE

James Forrest, DoE

John Dombrose, DPI

Trevor McDonald, DPI

Ken Johnsen, Orbital Engine Company

Geoff Armstrong, Orbital Engine Company

Tom Baskovich, Orbital Engine Company

Don Rijavec, TAFE

John Hakesley, MechPlant Installations and Repairs

Howard Croxon, Transport Forum of WA

Mike Upton, RAC WA

David Wake, CCWA

Air Pollution and Health Network

Mark Feldwick, DoH

Jim Codde, DoH

Tina Runnion, DoE

Andrea Hinwood, ECU

Louis Landau, UWA

Nick de Klerk, UWA

Tom Lyons, Murdoch University

Jane Heyworth, UWA

Drew Farrar, DoE

Greg Allen, DoE

Jeffrey Spickett, Curtin University

Peter Dingle, Murdoch University

Peter Franklin, UWA

A/Professor Frank Murray, Murdoch University

Krassi Rumchev, Curtin University

Ian Tremain, QED Environmental Services

Haze Reduction

John Sutton, DoE

Deanna Tuxford, DoE

Melissa Patt, DoE (July 2003 to December 2003)

James Forrest, DoE

Constance Dewan, DoE

Peter Musk, DoE (January 2004 to June 2004)

Marko Pasalich, DoE

Llew Withers, DoH

Trevor Davies, DoH

Dave Peckitt, DoH

Nathan Malin, WALGA (July 2003 to December 2003)

Dale Newsome, WALGA (January 2004 to June 2004)

Alison Edmunds, City of Joondalup

Peter McKenzie, Town of Kwinana

Janet Armarego, City of Melville

SCHEDULE OF AQMP WORKING GROUP MEETINGS (JULY 2003 TO JUNE 2004)

Community Education

7 July 2003

Vehicle Emissions Reduction

29 October 2003

Air Pollution and Health Network

8 June 2004

Haze Reduction

5 August 2003

24 September 2003

28 October 2003

2 December 2003

14 January 2004

2 February 2004

17 February 2004

16 March 2004

11 May 2004

26 May 2004

APPENDIX 3: ACRONYMS

ABCB	Australian Building Codes Board
ABGR	Australian Building Greenhouse Rating Scheme
ADR	Australian Design Rule
AFAC	Australasian Fire Authorities Council
AQCC	Air Quality Coordinating Committee
AQMP	Air Quality Management Plan
APHN	Air Pollution and Health Network
BCA	Building Code of Australia
CALM	Department of Conservation and Land Management
CCIWA	Chamber of Commerce and Industry of WA
CCWA	Conservation Council of WA
GCMS	Gas Chromatography Mass Spectrometer
CNG	Compressed Natural Gas
COPD	Chronic Obstructive Pulmonary Disease
CRC	Cooperative Research Centre
DHW	Department of Housing and Works
DoE	Department of Environment
DoH	Department of Health
DPI	Department for Planning and Infrastructure
ECU	Edith Cowan University
EPHC	Environment Protection Heritage Council
FESA	Fire and Emergency Services Authority of WA
GP	General Practice
GTP	Green Transport Plan
HHS	Home Heating Survey
KIC	Kwinana Industries Council
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas

MoU	Memorandum of Understanding
NATA	National Association of Testing Authorities
NEPM	National Environment Protection Measure
NHT	National Heritage Trust
NOx	Oxides of Nitrogen
PAN	Pollution Action Network
PID	Photo Ionisation Detector
RACWA	Royal Automobile Club of WA
ROC	Reactive Organic Compounds
SEDO	Sustainable Energy Development Office
SNAQ	Schools Network for Air Quality
STO	Sustainable Transport Officer
UWA	University of WA
VOC	Volatile Organic Compound
WA	Western Australia
WALGA	WA Local Government Association
WAPC	WA Planning Commission
WHRP	Wood Heater Replacement Program

APPENDIX 4: AQMP PUBLICATIONS

Perth Air Quality Management Plan - Progress Report to June 2003 (March 2004)

2002 Annual Summary of Ambient Air Quality Monitoring in Western Australia (Technical Series 115) (October 2003)

Research on Health and Air Pollution in Perth Morbidity and Mortality: A Case-Crossover Analysis 1992-1997 (Technical Series 114) (May 2003)

Perth Air Quality Management Plan - Progress Report to June 2002 (April 2003)

2001 Annual Summary of Ambient Air Quality Monitoring in Western Australia (Technical Series 112) (July 2002)

Implementing the Perth Air Quality Management Plan - Summary Document (June 2002)

Implementing the Perth Air Quality Management Plan - Supporting Document (June 2002)

2000 Annual Summary of Ambient Air Quality Monitoring in Western Australia (Technical Series 111) (January 2002)

Perth Airshed Inventory Update 1998 - 1999 (Technical Series 110) (January 2002)

National Environment Protection Measure for Ambient Air Quality - Monitoring Plan for Western Australia (May 2001)

Air Quality in Perth 1992 - 1999 (Technical Series 109) (May 2001)

Perth Air Quality Management Plan (December 2000)

Perth Air Quality Management Plan - State of Knowledge Report (July 2000)

Volatile Organic Compounds Monitoring in Perth - Baseline Air Toxics Project (January 2000)

Air Quality information folder

File contents

1. Air Pollution and you – Department of Environment introduction to Perth's air pollution Information about causes and effects of Perth's air quality, including haze, smog, and other common pollutants.

2. DPI – Better ways to get to school
brochure outlining alternatives to driving children to school

3. Hot Tips – Department of Environment and Heritage - booklet on how to maximise heat and to reduce woodsmoke pollution

4. DoE Woodsmoke Workshops presentation Perth 2005 – home heating survey, and replacement program.

5. Dr John Todd woodsmoke handbook 2005 – woodheater, firewood and operation practice. Background information with an eastern states perspective

6. Progress Report 2004 - Implementing the Perth Air Quality Management Plan
Outlines achievements and future reporting responsibilities for key air quality initiatives upto 2004 and beyond. Includes indoor and ambient air.

7. 'West Australian' article on climate change in WA, February 4,2006

8. Smog show – Department of Environment photochemical smog modelling, showing smog forming scenarios Perth metropolitan area.

9. AirWatch brochure 2004 – brief description of AirWatch program

Welcome to our nightmare

Bleached coral reefs, extinct species, long hot summers of 35C-plus, narrow beaches as the ocean rises and dengue fever at Shark Bay. That is the nightmare vision painted by an Australian study. **Eloise Dortch** reports.

It is the year 2070 — when if not all of us, but certainly our children, will be alive. A "hot" summer will mean more than a month of weather over 35C.

Temperatures generally have been 5.5C higher than now.

Winter rainfall will have declined by two-thirds, meaning inflow into our dams is virtually non-existent.

And when we seek respite from the heat on our long, white beaches, they will be 60m narrower after a 60cm sea level rise.

Sounds overly pessimistic?

It is simply the worst case scenario predicted by Australia's most respected scientific organisation — CSIRO — and its Indian Ocean Climate Initiative partners, the Bureau of Meteorology and the State Government.

The case is based on Australia and other countries maintaining present greenhouse emission levels.

If draconian emission cuts were made now, IOCI predicts rainfall would decline only 5 per cent in the next 65 years and Perth would only warm by 1C — not enough to feel unpleasant, but enough to cause the extinction of three South-West frog species, 15 threatened mammal species and a third of WA's 92 dryandra species, according to a Federal Government study.

'The AMA estimates by 2100, up to 3000 West Australians will die annually from heat stress.'

Some say the world will warm much faster than CSIRO predicts, others dismiss global warming altogether but whatever one says about predictions, it is impossible to deny the dramatic change which has already overtaken WA.

In the past century, average temperatures have risen nearly 1C.

In the same time, the mean sea level at Fremantle has risen nearly 20cm.

In less than half that time, the ocean at Ningaloo has warmed 0.6C in the past 30 years, winter rainfall has decreased 15 per cent and in-flow into South-West dams has dropped nearly two-thirds.

The impacts of more warming are likely to extend well beyond the water shortage prompting the State Government to spend $400 million on a desalination plant at Kwinana.

WHAT DOES CLIMATE CHANGE MEAN FOR WA?

ALREADY OCCURRED

- Average WA temperatures have risen 0.8C since 1910 - more than the global increase of 0.6C
- South-West winter rainfall has dropped 15 per cent since 1975
- Inflow into Perth dams has dropped 60 per cent since 1975
- The mean sea level at Fremantle has risen 20cm since 1897
- The Indian Ocean at Ningaloo has warmed 0.6C since 1960
- Average number of summer days over 35C in Perth now: 15

BY 2030

- Average South-West temperatures will warm by 0.5 to 2.1C
- Average South-West winter rainfall will decline by 2 to 20 per cent
- Sea levels will rise up to 25cm
- Sandy beaches will erode up to 25m
- Predicted average number of summer days over 35C in Perth: 16 to 22

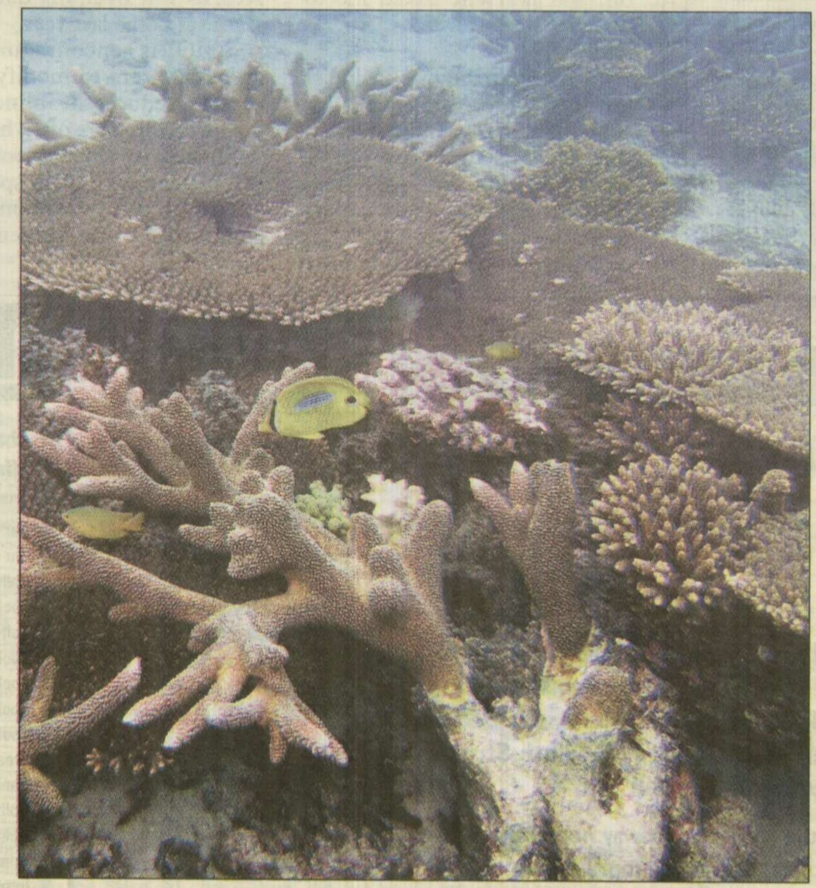
BY 2070

- Average South-West temperatures will warm by 1 to 5.5C
- Average South-West winter rainfall will decline by 5 to 60 per cent
- Sea levels will rise by up to 60cm
- Sandy beaches will erode by up to 60m
- Average number of summer days over 35C in Perth: 18 to 39

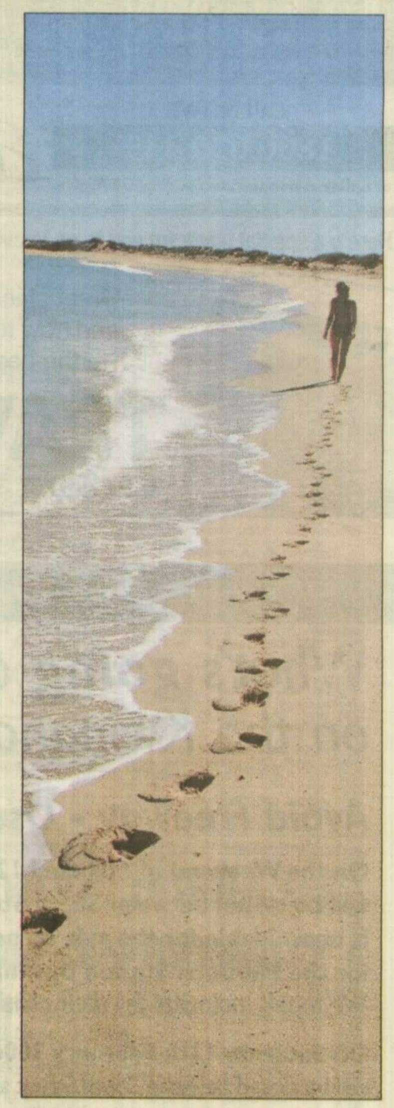
BY 2100

- Sea levels will rise by up to 88cm
- Sandy beaches will erode by up to 88m

Canning Dam: Will it fill ever again?



Ningaloo Reef: Higher temperatures put coral in jeopardy.



WA beaches: Erosion looms.

(SOURCE: INDIAN OCEAN CLIMATE INITIATIVE, INCLUDING CSIRO, BUREAU OF METEOROLOGY AND THE WA DEPARTMENT OF ENVIRONMENT. RANGES ARE GIVEN BASED ON DIFFERENT CLIMATE MODELS AND EMISSION SCENARIOS.)

The Australian Institute of Marine Science in Townsville blames widespread coral reef bleaching off northern WA in 1998 on the warming of the ocean and warns more bleaching — that is, the death of algae which helps coral grow — is certain.

On the up side, the WA Fisheries Department predicts warmer sea temperatures may boost rock lobster, prawns and whitebait numbers — as this suits juveniles of the species.

Increased carbon dioxide in the atmosphere from industrial emissions may also boost wheat growth as it would increase photosynthesis, the Australian Greenhouse Office says — but in WA low rainfall would also have a negative effect.

Fewer cold days will hurt South-West stone fruit industries and the AGO predicts less rain, affecting pasture, will cause annual milk losses of 250-310 litres per cow by 2030. Beef cattle in northern WA will experience more heat stress and ticks, affecting animal welfare and production.

The Australian Medical Association estimates by 2100, up to 3000 West Australians will die annually from heat stress.

Waterborne diseases such as giardiasis, infectious diseases and food poisoning will increase and it will be possible to catch dengue fever as far south as Shark Bay, while the risk area for another mosquito-borne disease, Ross River virus, may also increase.

Engineering firm GHD predicts peak electricity demand, driven by air-conditioners, will increase, requiring more generating capacity.

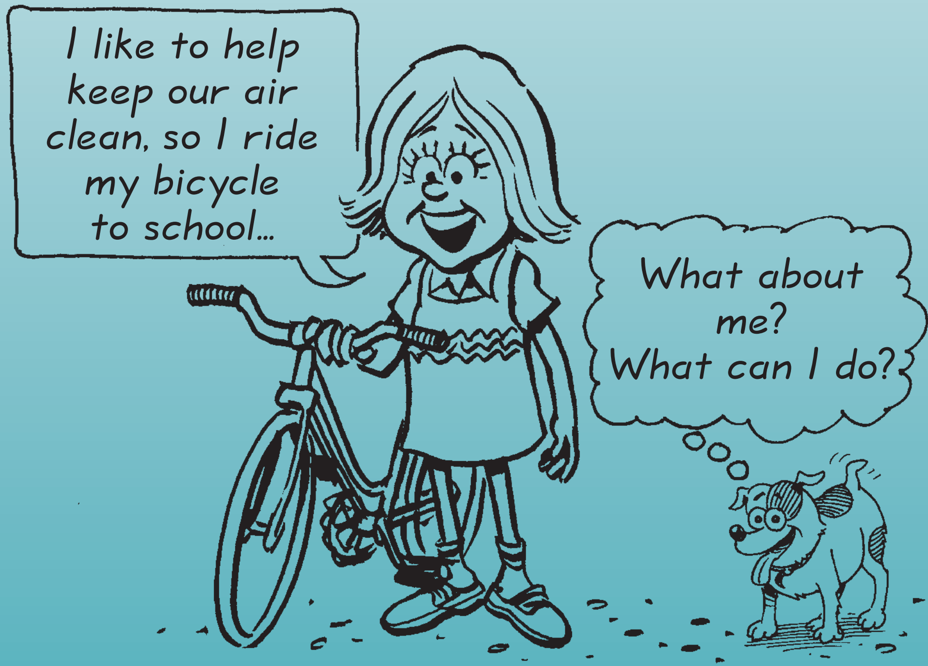
Meanwhile, as soon as temperatures rise 1C, power transmission efficiency will decrease 3 per cent.

GHD also warns the coast will erode from Dunsborough to Mandurah and in Perth, at South, Port and Swanbourne beaches and Pinaroo Point.

Finally storms in the South-West may decrease in number but increase in intensity, meaning higher insurance premiums.

Department of Environmental Protection

AirWatch
BREATHE EASY ™



Who cares about our air?

A workbook on air pollution for Primary Schools

AirWatch Western Australia

AlintaGas
The Natural Gas Company

AirWatch
BREATHE EASY ™

Who cares about our air?

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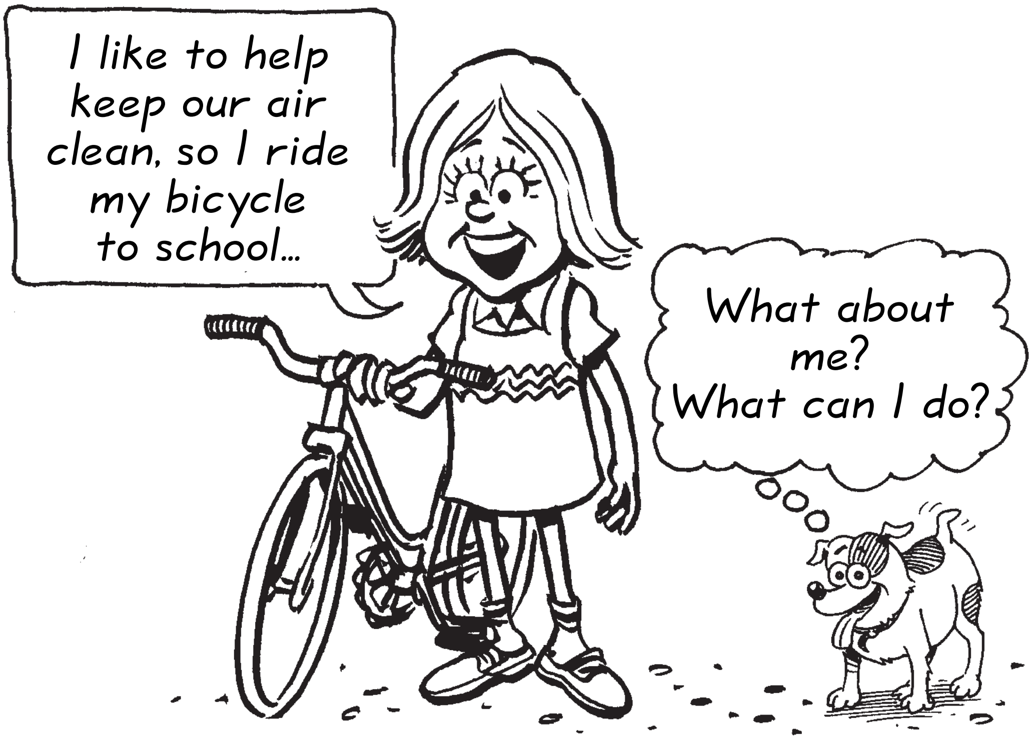

Department of Environmental Protection

THE GOVERNMENT OF WESTERN AUSTRALIA

AlintaGas
The Natural Gas Company

Who cares about our air?

A workbook on air pollution
for Primary Schools

Who cares about our air?

A workbook on air pollution for Primary Schools

Written and compiled by Jennifer Anderton and Gabrielle Robertson.
ISBN 0 7307 6621 7

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AirWatch

The AirWatch program developed by the Department of Environmental Protection (WA) promotes awareness in the community about air quality issues.
AirWatch includes air monitoring programs in secondary schools and primary schools and air and weather data collection programs.

For more information about the AirWatch program or to obtain copies of this manual please contact the AirWatch Co-ordinator in your state.
Department of Environmental Protection,
141 St Georges Terrace, Perth, Western Australia, 6000. Phone: (08) 9222 7000, Fax (08) 9322 1598.
EPA Victoria
40 City Road, Southbank, Victoria, 3001. Phone: (03) 9695 2825, Fax (03) 9695 2819

The aim of this workbook is to develop environmental awareness in students, specifically about air pollution.

It will help students realise how their own and their family's behaviour contributes to air pollution problems and that they are the key to the solutions.

Objectives

On completing this booklet, students should be able to:

- list the causes of air pollution
- discuss simple weather phenomena
- describe how weather affects air quality
- discuss how air pollution can be controlled
- examine alternatives for action
- relate air quality to their own activities
- develop positive feelings about clean air.

The workbook

Student activities, located on the right hand pages of this booklet, are designed to be copied and given to students as required. Teacher notes are on the left hand pages.

Some of the activities can be carried out by individual students, while others are designed for small groups. Space is provided in many of the worksheets for written answers.

Further activity sheets headed "Eddie's Extras" can be used for extension work across the curriculum.

The 'Who Cares about Our Air' workbook is accompanied by the AirWatch Primary Kit, which is a box of equipment and consumables to implement workbook activities.

This kit is available free of charge from:

AirWatch,
Department of Environmental Protection, Perth, WA, Ph: (08) 9222 8622 and sponsored by AlintaGas; or
Environmental Protection Authority, Melbourne, Victoria, Ph: (03) 9695 2825 and sponsored by TXU Gas and Electricity.

AlintaGas

TXU Gas and electricity.

CURRICULUM LINKS

The Curriculum Links 'cloud' gives the subject, as well as the links to the Curriculum Framework, that relates to the activities described on the Teacher's Notes.

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1. Let's check out the air ______ 1

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3. Polluting the air ______ 21

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7. What can I do? ______ 71

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Appendix 2: Types of air pollution ______ 82

Glossary ______ 84

So that we do not confuse the students, this workbook deals with local air quality issues only. It does not examine global problems such as the greenhouse effect or the hole in the ozone layer.

Thank you

The author would like to extend sincere thanks to the following teachers who trialled and assessed some of the activities in this workbook:

Wendy Connell - Rossmoyne Primary School
Jan Wickham - Attadale Primary School
Trudi Summers - Grovelands Primary School.

We would also like to acknowledge that some of the activities are based on materials from "Let's Clear the Air", a publication of the State Pollution Control Commission, New South Wales, 1988.

Let's check out the air!

Unit Summary

This unit encourages students to investigate the physical properties of air through observations using their senses and some simple equipment. Students will also identify the ways they use air and the importantance of clean air to them.

Background notes

The Atmosphere

The atmosphere is a layer around the earth hundreds of kilometres thick with air surging, flowing, swirling and mixing at different depths above the surface of the earth. The layer closest to the ground contains the air which maintains all life.

Air

Air is colourless, odourless and tasteless and is, in fact, made up of a mixture of gases, some of which are essential for life, for example, oxygen.

Air exerts a pressure around us and affects many of our everyday activities. The gases in air are essential for the survival of the plants and animals on this earth and it is important for many things which we take for granted, such as the transmission of sound and the use of fire.

Clean air

Clean air is something we take for granted and rarely think about until its quality is so reduced that we start to observe health problems, especially in our very young and our elderly or those who already have respiratory conditons. Poor air quality can also have harmful effects to our plants or property.

Clean Air!

Summary

This activity encourages students to think about aspects of their environment that they value. Students often ignore the natural environment when considering the area in which they live.

Discussion should identify clean air as a valuable resource, develop an understanding of the reasons why we need clean air and how students feel about their own air being dirty and polluted.

Activity 1.1

Divide the class into small groups. Students choose a leader for their group. The leader gives each person in the group two minutes to read out their choices regarding the best things about where they live and their explanations. Each leader makes a list of the aspects chosen by the group, and reports back to the rest of the class on the group's decisions.

Discussion questions

1. What things do most people seem to like about this area?
2. Which of these were present before roads and houses were built?
3. How many students listed clean air as one of the aspects they liked about the area?

Activity 1.2

Students read out their lists of reasons why we need air, and make a class list. Some expected responses may be:

- people need air to breathe
- sound needs air to travel
- plants need air to make their food
- fires need air to burn for cooking and heating
- cars need air to burn petrol.

Activity 1.3

Discuss descriptive words which would be useful to describe their reactions to this picture of pollution in a city.

Discussion questions

4. What problems might you experience living in air shown in Figure 1?
5. How would you feel if you had to live in this sort of air all the time?

CURRICULUM LINKS

English
Students participate in speaking, responding and listening.

Society and Environment (SOSE)
Students have knowledge, skills and values regarding their local geography and the places & spaces that surround them.

Clean Air!

Activity 1.1

Think about aspects of your environment that you value. Picture the area in which you live.

List three things which you like most about the area where you live.

a. ______________________________

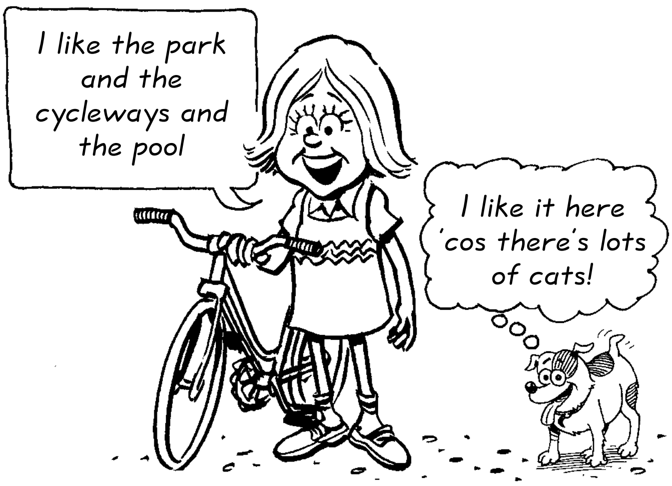
____

b. ______________________________

____

c. ______________________________

____



Explain why you chose these.

____

____

____

Activity 1.2

Make a list of all the things for which we need air.

____

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____

____

Activity 1.3

Figure 1

Write a poem about how you would feel living in a city that has air pollution like this.

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Air - is it there?

Summary

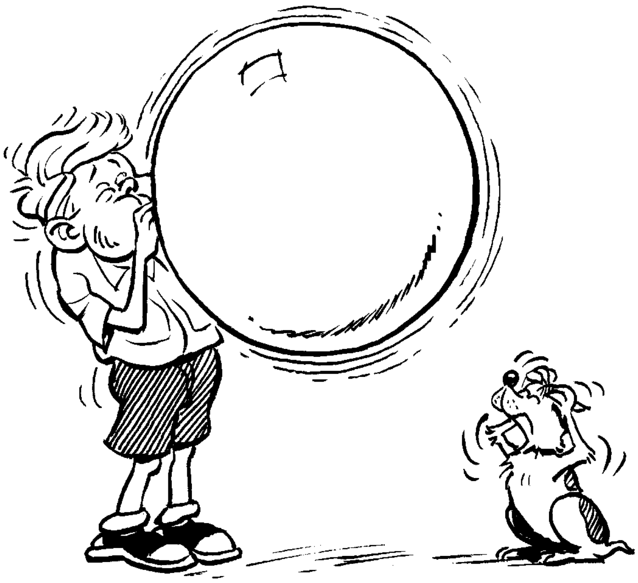
Air is all around us and is essential for us to live. It cannot be seen, but by doing the following activities, the students will see that it does exist. They should be able to describe air as a colourless, odourless and tasteless gas.

Activity 1.4 - Introduction

Materials

One plastic bag for each student

Have the students blow up the bag and observe. Discuss what they see and what they infer must be there.



Discussion questions

1. What changes have occurred to the bag? (Increase in size, walls have become rigid, maybe the bag has gone misty on the inside).
2. What has caused this? (The air from our lungs).
3. Describe the air (Colourless)
4. Why are the walls of the bag rigid (The air is pushing against them).
5. Does it smell and taste? (No)
6. Why do you think the walls are misty? (Water from our breath).

Activity 1.5

The purpose of this activity is to show the student that air takes up space (and has weight) so the balloon will not blow up.

Discussion questions

7. What happened to the balloon? (It couldn't be blown up)
8. Why do you think this happened? (Because the air took up the space)

Activity 1.6

This activity shows that air takes up space.

Discussion questions

9. Can you see the air in the glass? (No)
10. How does this experiment show that air is present in the glass? (Because it pushes the water out of the way)

CURRICULUM LINKS

Science

Students demonstrate working scientifically doing activities in chemical science.

Students generate responses from physical science activities focusing on energy and change.

Air - is it there?

Activity 1.5

Air is all around us and is essential for us to live. It cannot be seen, but by doing the following activities, you will see that it does exist.

Materials

One small plastic drink bottle
One balloon

Push a deflated balloon into a drink bottle and stretch the open end of the balloon back over the bottle's mouth.

Predict what will happen if you tried to blow the balloon up.

____

Now blow up the balloon. What happened?

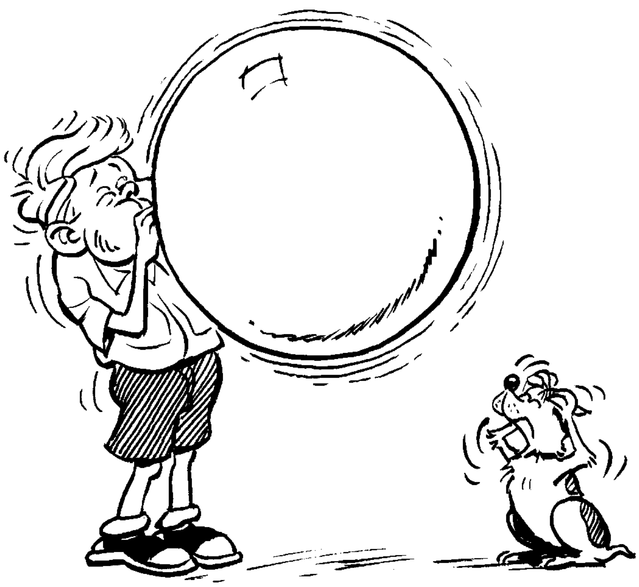
____

Why do think this occurred?

____

Was your prediction correct?

____



Activity 1.6

Materials (per group)
Large glass jar
Clear glass
Cork

Pour water into a large glass jar until it is half full. Float a cork on the top of the water. Lower a drinking glass, mouth downward over the cork.

What do you observe?

____

Draw your results.

Summary

What have these two experiments shown you about air?

____

____

____

____

Pushy Air

Summary

These activities show that air exerts a force which can be observed through experiments. Normally, air pressure acts in all directions so we are often unaware of it.

Activity 1.7

In this activity, when the air is driven out of the can by boiling the water (hot air rises when heated), the air pressure on the outside crushes the can.

Materials

Tin can with an airtight lid.
Gas stove.
Water.

Teacher demonstration only

Put a small amount of water into a new tin can. Heat the tin without the lid on until the water is boiling. Allow to boil for several minutes. Take the can off the heat and quickly screw on the lid. Observe what happens.

Discussion questions

1. What happened to the tin? (the tin buckles inwards).
2. Why do you think this happened? (Air pressure outside is greater than pressure inside the can.)
3. Air exerts pressure. Scientists use a special instrument to measure air pressure. What is this instrument called? (barometer).

Activity 1.8

These simple exercises illustrate the effect of air pressure, which normally acts equally in all directions. Experiments (a), (b) and (c) show the effect of air pressure acting in one direction.

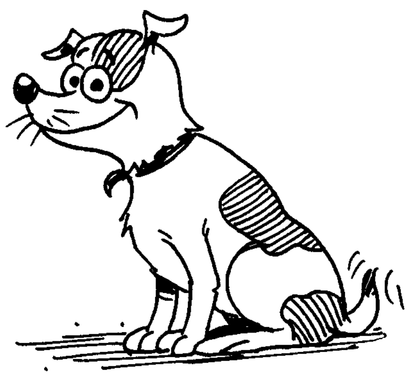
Experiment (d) shows that air flows from an area of high pressure (in the balloon) to an area of low pressure (the air). This can help initiate a discussion on winds.

Experiment (e) shows that when air pressure on top of the water is no longer pushing down the air pressure outside the can stops it from flowing out.

Experiment (f) shows the power of the column of air trapped in the straw.

Discussion questions

4. What is keeping the water in the straw and the cardboard on the glass (air pressure).
5. Why can't you suck up through the straw. (because the air can't push down on the water surface).
6. What's happening to the air in the balloon? (Its moving from high pressure to low pressure.)
7. What's keeping the water from coming out of the can? (air pressure on the outside of the can).



CURRICULUM LINKS

Science
Students demonstrate working scientifically by conducting scientific investigations.

Students generate responses from physical science activities focusing on energy and change.

Pushy Air

Activity 1.8

These activities show you that air exerts a force which can be observed. Normally, air pressure acts in all directions so we are often unaware of it.

Materials (per group)

2 straws	glass
heavy paper	scissors
balloon	drink bottle
opened can	potato
water	

(a) Place the end of a straw into water. Cover the other end with your finger; raise the tube out of the water. What do you observe?

___

___

___

(b) Cover a glass tumbler full of water with a square of heavy paper. Hold the paper and turn it on its side, then upside down. Describe what happens when you take your hand away.

___

___

(c) Fill a small jar with water. Make a hole in the lid big enough for a straw to go through. Put a straw into the water through the hole and seal up the space around the straw with modelling clay. Now try to suck water through the straw. Be sure there are no leaks. What happens?

___

___

(d) Prick an inflated balloon with a pin. What happens?

___

___

Why do you think it happens?

___

___

(e) Put a hole near the bottom of an opened can and then put some water in the can.

What happens to the water?

___

Put some more water in the can. This time put your hand over the top of the can to completely seal it.

What happens now?

___

Why do you think this happens?

___

(e) Place your finger over one end of a straw and hold a potato in the other. Now quickly jab the straw into the potato.

Describe what happens.

___

Explain your results.

___

Extension

These experiments show you air pressure in action. In your own words try to explain what you think air pressure is?

___

___

___

___

The Atmosphere

Activity 1.9

In this activity, students learn that the air forms a layer around the Earth called the atmosphere and explore its characteristics. It can be done as a library activity or homework exercise.

Background

The world's atmosphere extends more than 100 kilometres from its surface. It is made up of air which has weight and exerts a pressure. This air is a mixture of gases including oxygen, nitrogen, carbon dioxide, water and other gases as well as water particles.

It also contains some solid particles such as ash, dust, sea salt and particles from fires. The four layers of the atmosphere are shown in the diagram below.

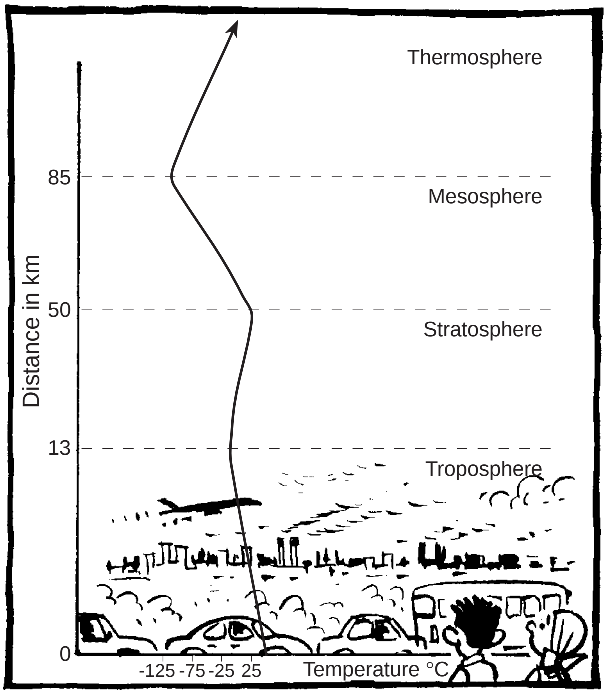


Figure 2: Layers of the atmosphere

The troposphere is about 15 kilometres high and contains about three quarters of the air in the atmosphere. This is where the weather occurs. As you go higher in the troposphere, the cooler it becomes.

The air is also less dense (more spread out) the higher you go. That is why it is difficult to breathe at high altitudes.

The stratosphere is the next layer from 15 to 50 kilometres. As you go higher in the stratosphere the temperature increases due to the presence of ozone which absorbs energy from the sun, heating the air in this region.

Notes

The following answers can be expected from the students' research.

Q1: Troposphere – it is the layer in which we live and contains the air and other gases we need. (Discussion may also include the stratosphere and how it protects us from the sun)

Q2: Troposphere

Q3: Troposphere – but high up usually 10- 15 kms, near the edge of the stratosphere.

Q4: Rockets travel so fast that there is a great deal of friction on the outside of the rocket which causes it to become red hot.

Q5: Troposphere – this is where the pollutants accumulate in the air and we have to breathe them in.

Q6: (i) Jet streams – very fast winds found about 10-12 kms above the ground in the troposphere. Used by pilots to increase the speed of their plane.

(ii) Trade wind – atmospheric winds caused by the different heating of the Earth at the Equator compared to the Poles. These are twisted to the East because of the spinning of the Earth.

(iii) Coriolis Force – the force produced because of the differences in speed between the movement of one place to another (equator area moves faster than poles) causing winds in Southern hemisphere to be deflected west.

CURRICULUM LINKS

English
Students acquire information through reading.

Science
Students apply understandings of Earth and space sciences.

The Atmosphere

Activity 1.9

Find out more about the four layers of the atmosphere. Draw and label a picture to show the layers of the atmosphere.

1. Which is the most important layer to us and why ?

2. In which layer does the weather occur?

3. In which layer do aeroplanes usually fly?

4. Why do rockets need special shielding on the outside?

5. Which layer is the most important to us when we consider local air pollution?

6. Find out about the following;

(i) Jet streams

(ii) Trade winds

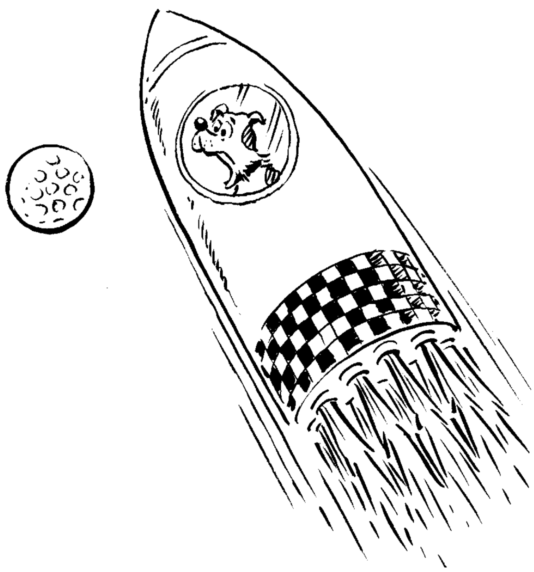
(iii) Coriolis force

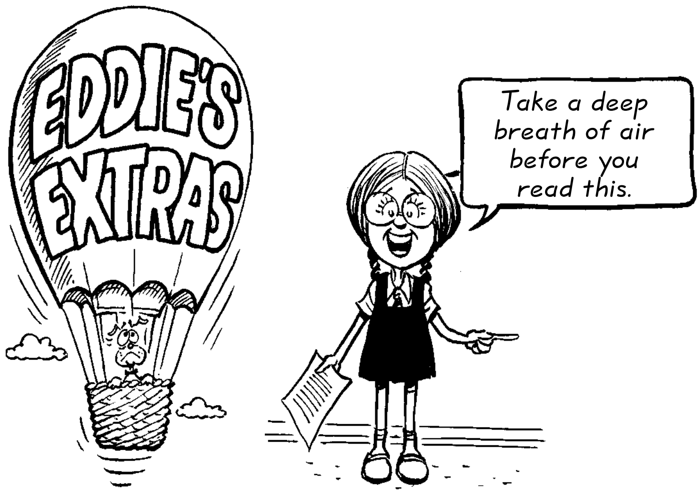
Extension – Word Scramble

See how many new words you can make from the following air words.

ATMOSPHERE
TROPOSPHERE
AIR POLLUTION
POLLUTANTS

Count the number of words you have made from the words above. Highest score wins!



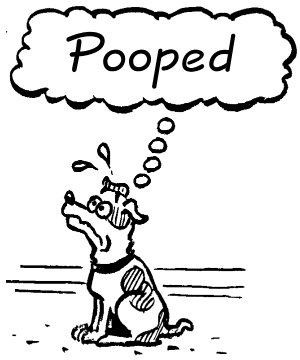


"Air is used for breathing by humans, animals and plants and it is also used for burning oil and petrol to provide transport and for burning coal to make electricity and to give heat in our homes, schools and work places and to make things in factories and to get rid of wastes and rubbish and THEREFORE .... air is vital to our lives!"

Try this: Hold your nose and breathe through a straw for one minute. Then run on the spot for two minutes. Then hold yours nose and breathe through the straw again for 1 minute.

HOW DO YOU FEEL?

Sometimes when you have been exercising you need more air than at other times.



Find the following words in the word sleuth below.

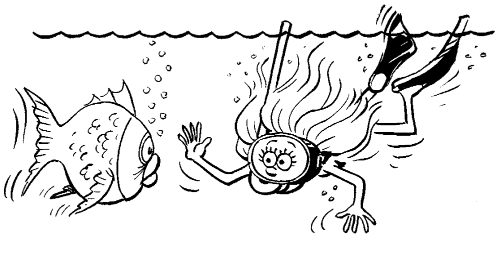
AIR PRESSURE
OXYGEN
ATMOSPHERE
POLLUTANTS
JET STREAM
CORIOLIS
CLEAN AIR
EXPERIMENT

A	I	O	L	P	R	E	N	V	F	G
F	E	X	P	E	R	I	M	E	N	T
A	I	R	P	R	E	S	S	U	R	E
C	O	B	H	P	J	I	C	J	X	D
O	A	T	M	O	S	P	H	E	R	E
R	M	C	B	L	C	O	X	T	F	H
I	N	L	V	L	F	X	S	S	T	U
O	W	E	Q	U	Y	Y	G	T	C	R
L	J	A	H	T	F	G	D	R	S	A
I	A	N	S	A	Y	E	K	E	I	U
S	D	A	F	N	G	N	H	A	J	K
V	B	I	N	T	N	M	B	M	C	G
X	S	R	H	S	H	N	M	S	K	L

Start a class news board. Look for newspaper articles about air and air pollution. Don't forget to look in your local newspaper.

Draw a picture of yourself doing your favourite activity that involves using air.

Imagine you are an astronaut on the moon or a scuba diver. Suddenly you discover the air in your tanks will run out in two minutes. Write a story about what happens.



Line up 10 empty glass bottles of different sizes with their top screwed on. Use a ruler or stick and strike them on their sides. Order the bottles from highest to lowest sound they make.

Questions
Are these bottles really empty?
Try composing a tune on these bottles.

What's in the air?

Unit Summary

This unit encourages students to find out that air is made up of a mixture of gases, what these gases are called and their characteristics. They will also learn how some of these gases are used by humans and animals and which of them are recycled by plants and trees.

Background notes

Air is made up of a mixture of gases, some of which are essential for life.

Nitrogen (N_2)	78%	inert gas
Oxygen (O_2)	21%	used for respiration by plants and animals
Argon (Ar)	~1%	inert gas
Carbon dioxide (CO_2)	~0.03%	used by plants to make their own food
Trace gases		methane, oxides of nitrogen

Water can exist in our air in varying amounts as a gas and comes from evaporation from water bodies, rainy weather or be given off from plants during the day. Humidity is determined by the amount of water vapour in the air. The air also contains tiny particles such as dust, sea salt, volcanic ash and soot, all of which are small enough to float in the air for a long time.

Pollutants

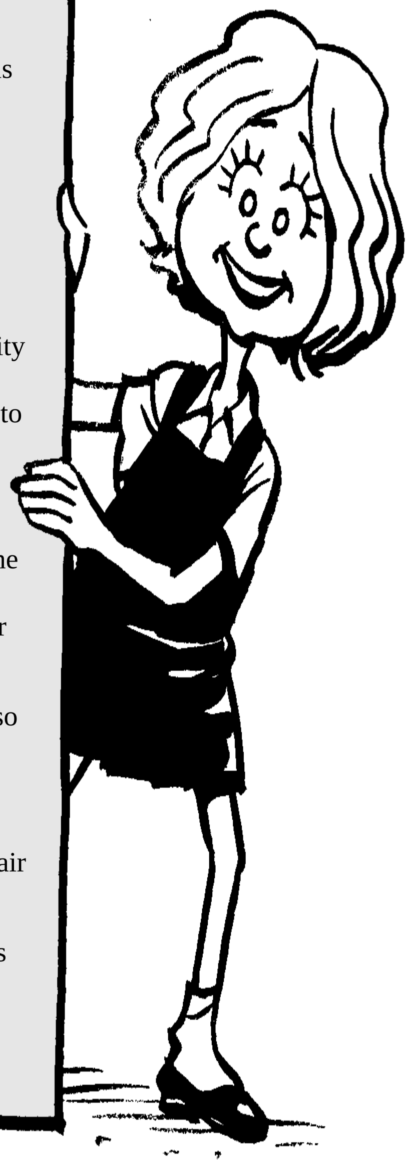
The air can also contain other gases and particles which are not normally found in the air. These usually come from some human activity such as car usage or factories. When they reach a high enough level of concentration in the air , they become an air pollution problem.

Pollutants can cause health problems, especially in the young and the elderly and also damage plants and materials.

How good is the air in Australia?

Many cities in Australia have an air pollution problem or are on the threshold of an air quality problem.

The pollution problems of Australian cities tend to come in episodes. These episodes are influenced by seasonal and meteorological factors.



What’s in the air?

Activity 2.1

This activity enables students to “visualise” air, helping them to realise that air is not homogeneous but made up of different types of molecules which do not interact.

It also highlights the difference between a compound and a mixture.

Background

A **mixture** is where different substances are mixed together but do not interact with each other. For example, muesli is a mixture with different components which can be separated.

A **compound** is where different substances have interacted to form a new substance and cannot be separated into their separate parts again. For example, the ingredients in a cake.

Activity 2.2

In this activity students collect the water which exists in the air as water vapour. The term “humidity” can be introduced to describe the amount of water vapour in the air.

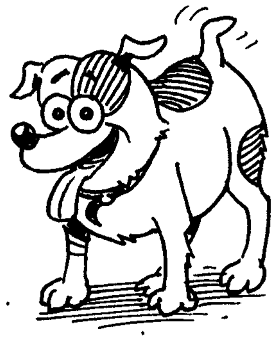
Discussion questions

1. What is the name of the gas we need to survive? (oxygen)
2. What is the name of the waste gas we breathe out? (carbon dioxide)
3. What has formed on the glass? (condensation) Where do you think this water comes from? (the water vapour in the air)
4. Describe what the air in the bathroom is like after you have had a shower. (steamy)
5. In this situation, would humidity be high or low? (high)
6. People, animals and plants have been using the oxygen in air for many millions of years, yet the amount of oxygen in our air has remained almost the same. Try to find out why this is so. (The gases are recycled in the air by plants to animals.)

CURRICULUM LINKS

Science

Students demonstrate working scientifically by doing activities and processing data in chemical science.



What's in the air?

Activity 2.1

In a glass jar, make the following mixture using the following recipe. Stir to mix well.

78 dried peas
21 peanuts
1 pop corn
1 raisin
1 fruit loop
1-3 walnuts pieces

This is called a mixture. How would you describe a mixture?

How is this mixture different to the ingredients in a cake?

This mixture in your jar represents the gases which make up our air. Use the key below to examine your jar of "air".

dried peas = nitrogen gas
peanuts = oxygen gas
pop corn = carbon dioxide
raisin = water vapour
fruit loop = trace gases
walnuts pieces = pollutants

Looking at the mixture, which is the most abundant gas in the air?

Which of these gases is important to our survival? Why?

Does it make up most of our air?

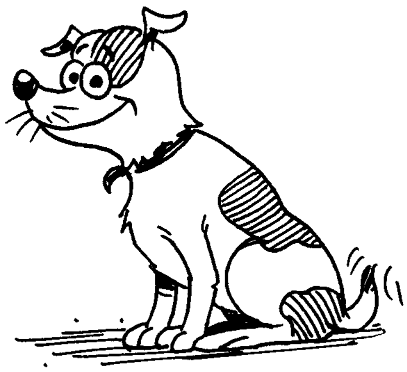
The amount of oxygen in the air is always about the same. What keeps it that way?

Predict what might happen if the amounts of these gases changed.

Activity 2.2 - Humidity

Place a tin or glass of crushed ice and water outside for several minutes. Describe what happens.

Explain what you think has happened.



Changing the air

Background - Plants - our air recyclers

When people, plants and animals breathe, they take in oxygen, use it and breathe out carbon dioxide, water and some other gases. The oxygen helps burn food to produce energy which is used to keep the plants and animals alive. This process is called respiration.

Although plants use oxygen they also make it in a process called photosynthesis. The plants absorb carbon dioxide through their leaves. Using sunshine, the green matter in the leaves combines the carbon dioxide with water to make sugars which act as food for the plants to use in respiration which enables them to live and grow.

During photosynthesis, oxygen is given off into the atmosphere to be used by the plants, animals and people. So plants make oxygen for us and use up carbon dioxide which is a waste product. This happens only when the sun is shining.

It is important to note that plants are also using oxygen during the day for the process of respiration but are producing much more during photosynthesis than they use, so they give out the excess. At night, however, they no longer produce any oxygen by photosynthesis so they must take it in.

Activity 2.3

This activity is to help the students understand the basics about photosynthesis and the important role that plants play in supplying oxygen for humans and animals.

They should also be able to understand that plants will only photosynthesise and give off oxygen in the presence of sunlight.

Prediction

If you breathe in and out of a bag, your body uses up the oxygen and high levels of carbon dioxide build up in the bag. Your brain shuts down due to lack of oxygen.

Discussion questions

1. What gas do plants give off during the day? (oxygen)
2. Do plants give off oxygen at night? Why not? (no sunlight, no photosynthesis)
3. What would happen to people and animals if all the plants in the world died? (no oxygen to live)
4. What gas do plants take in during the day? (carbon dioxide)

CURRICULUM LINKS

English
Students acquire information through reading.

Science
Students understand functions of living things.

Changing the air

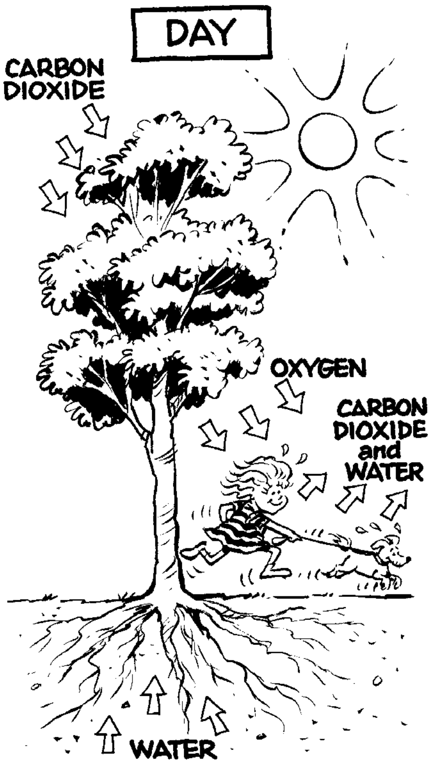


Figure 3

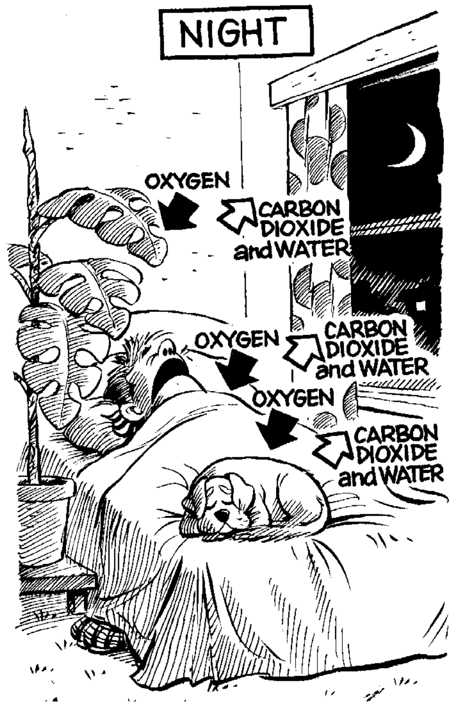


Figure 4

Activity 2.3

Animals and plants are important factors in changing what's in the air.

Using the two diagrams on this page find out what they add and take from the air.

Questions

1. Using figure 3, what gas do plants give off during the day?

____

2. What gas do plants take in during the day?

____

3. Using figure 4, do plants give off oxygen at night? Explain your answer.

____

4. What would happen to people and animals if all the plants in the world died?

____

Prediction

If you breathe in and out of a plastic bag for awhile, you will faint. Why do you think this happens?

Extension

5. The process by which plants make oxygen is called **photosynthesis**. Use the library to find out more about it.

6. Find out what happens to a person who "hyperventilates". How do you help them with this problem?

More about air

Activity 2.4

In this exercise students observe that plants give off water vapour which then condenses into liquid droplets.

Activity 2.5, 2.6

These activities are research topics where the students can use the library or complete as a homework task.

Answers to 2.5

	Percentage %	Symbol	General information
Nitrogen	78	N_2	A generally unreactive gas in the air.
Oxygen	21	O_2	Gas essential for life. All plants and animals need oxygen. Also essential for combustion.
Water vapour	varies	H_2O	Varies greatly. Lots of moisture in the air gives high humidity.
Carbon dioxide	0.03	CO_2	A waste product of respiration
Trace gases		none	Includes methane, oxides of nitrogen in very small quantities
Argon	~1	Ar	Inert gas – does not react with other gases

Discussion questions

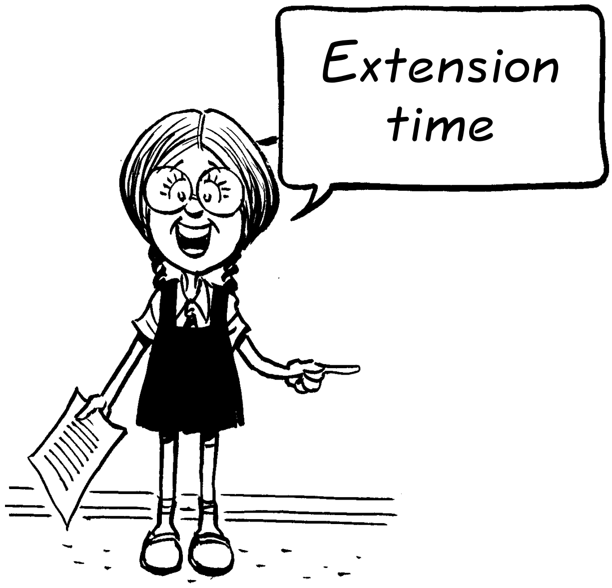
1. What two gases do plants give off into the air (oxygen, water vapour).
2. Do they do this in the light and in the dark (light).

CURRICULUM LINKS

Science
Students demonstrate working scientifically doing activities in chemical science.

English
Students acquire information through research and reading.

More about air



Activity 2.4

Put a plastic bag around a branch of a bush or a tree. Fasten it with a rubber band. Leave it in the sun for the day and collect it before the end of the day.

What do you observe in the plastic bag?

____

Try to explain what you see.

____

____

Activity 2.5 - Library

Use your school library to find out a bit about each of the gases that make up our air.

	Percentage %	Symbol	General information
Nitrogen			
Oxygen			
Water vapour			
Carbon dioxide			
Trace gases		none	
Solid particles		none	

Activity 2.6 - Research Zeppelin

1. Find out what Zeppelins were. How did they stay in the air? Why aren't they used anymore?
2. The Goodyear blimp is used for advertising. How is it different to the Zeppelin?
3. How do hot air balloons stay aloft?
4. What gas is used in meteorological balloons?
5. How big are meteorological balloons?
6. Why are they used?

Adding to the air

bottle of perfume. Ask the students in the line to raise their hands when they can smell the perfume. Repeat the experiment with different smells.

Do the experiment again, this time with a fan blowing away from the students. Try with the fan blowing towards the students.

Summary

The purpose of these activities is to show that other gases can be added to the air. The molecules that make up the smell move forward in a process known as "diffusion". As they reach a person they are detected by special cells in their nose. A fan can change the direction of the smell because the "smelly" molecules are sent in a different direction.

Activity 2.6

Background

Substances can be added to the air. Sometimes they are natural, sometimes they are the result of human activity.

When these substances get to a level where they start to affect the health or comfort of humans or are damaging to plants or materials, they are known as pollutants.

Many substances which enter the air cannot be easily detected, as we cannot see, smell or taste them. This is the problem with many of the pollutants in the air. We only know they are there if we use sophisticated equipment.

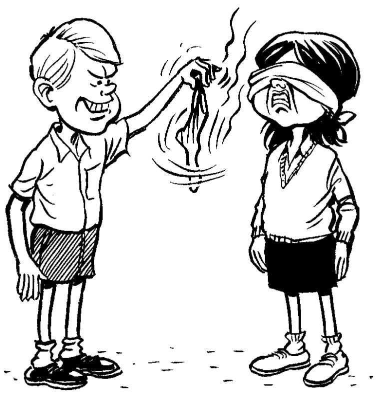
Activity 2.6 (a)

Students break into groups, blindfold a volunteer and pass various smelly substances under their nose asking them to guess the smell.

Activity 2.6b

Have six people line up along the front of your classroom and blindfold each of them. One student stands at the beginning of the line holding an open bottle of perfume. Ask the students in the line to raise their hands when they can smell the perfume. Repeat the experiment with different smells.

Get the students to write this activity up as an experiment.



Discussion questions

1. Which substances were the easiest to smell? (Strongest smelling.)
2. Who smelt the perfume first?
3. Can you explain why this happened? (Molecules closest to the person, move through the air.)
4. What did the fan do to the perfume? (Shift the molecules in a different direction.)

CURRICULUM LINKS

Science
Students demonstrate working scientifically by conducting investigations and processing data.

Adding to the air

Often new substances can be added to the air. Let's see if we can detect some of them.

Activity 2.6 (a)

Materials

Chalk, milk, orange, coconut, cabbage, cheese, a crushed gumleaf, vegemite toast, bubblegum, other 'smelly' things.

Blindfold a volunteer and pass different smelly substances under their nose. Ask them to guess the smell. Fill in the results below, using a tick if they correctly identified the substance, a cross if they didn't.

Name of smelly substance	Volunteer 1	Volunteer 2

Questions

Which substances were the easiest to identify?

____

Why are some substances hard to identify?

____

Substances in the air which are harmful are known as pollutants. Can you name one pollutant?

____

Pollutants are sometimes hard to detect. Can you explain why?

____

Activity 2.6(b)

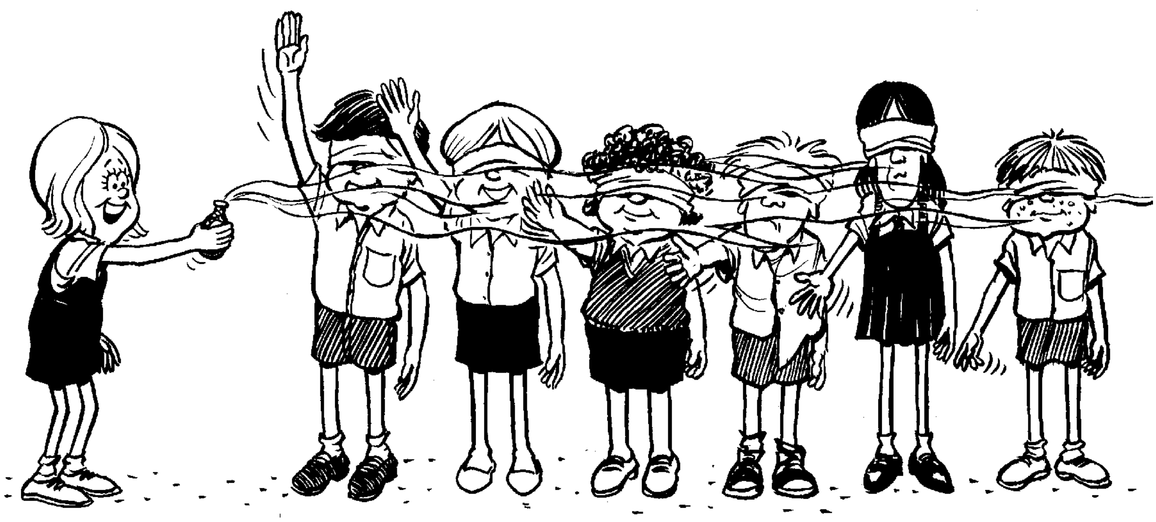
Materials

Strong perfume
Blindfolds
Fan

1. Blindfold six volunteers and get them to stand in a line at the front of the classroom. One student to stand at the end of the line and open a bottle of perfume. Ask them to put their hands up when they can smell the perfume.
2. Repeat the experiment with a fan blowing away from them and then again with the fan blowing towards them.
3. Repeat the experiment making the line longer and then again making it shorter.

Follow up

Write up part 1, 2 or 3 of the activity as an experiment.



If nitrogen was blue, oxygen pink and argon green, colour a page using the correct percentages for air. Remember, the molecules are mixed in with each other. Use black to show humidity.

Investigate what the "air" is like on other planets. Prepare a two minute talk on a planet of your choice outlining what the air is like and other interesting things about it.

The site 'Nineplanets', found at http://seds.lpl.arizona.edu/nineplanets/nineplanets.html will help you with your research.

Plants are important because they produce oxygen which we breathe. Write a list of other ways plants are useful to us.

____

____

____

____

____

____

Polluting the air

Unit Summary

This unit introduces students to the idea of air pollution. Air pollution is caused by having particles or molecules in the air in such concentrations that could be harmful to health or comfort of humans and animals or cause damage to buildings or materials.

Types of Pollution

Photochemical Smog

Photochemical smog, which is often invisible to the naked eye, is caused by high concentrations of ground level ozone. In large Australian cities this tends to happen in late spring, during summer and early in autumn when there is lots of sunlight, high temperatures and calm weather.

Haze

Haze, also known as winter smog, occurs when many tiny particles from wood smoke and vehicles make our skies look brown. Haze occurs mostly on cold, calm winter mornings.

Carbon Monoxide

Carbon monoxide is a colourless, odourless and very toxic gas, which comes from incomplete burning, industrial processes and biological decay.

Oxides of Nitrogen

The most common of these are nitric oxide and nitrogen dioxide. These help form photochemical smog and have significant impacts on health.

Air Toxics

A range of harmful chemicals, sources of which include cars, cigarette smoke and fuel vapour.

Odours

Odour causes a great deal of concern for many people. Generally odours are annoying. In rare cases, the compound causing the odour may be poisonous and lead to illness in people. (See Appendix 1, page 61.)

Factors affecting air pollution

Weather conditions and geographical features are important to the amount of pollution experienced in a certain area. For example, local winds may cause pollution to be blown back over a populated area where the pollution has been produced.

Geographical features such as valleys will often trap pollution and make it difficult to disperse.

Pollutants

Activity 3.1

Students will observe differences between pollutants which occur as suspended particles (particulates) and those which occur as a solution in the air.

This activity takes approximately 15 to 20 minutes. Students can do this in small groups using cups instead of bowls.

Explain to the students that the bowl of water represents a model of the air, the milk represents gaseous air pollution and the pepper represents particles in the air.

Students will observe the differences between the reactions of the milk and the pepper when put into the water. They will observe how long it takes the pepper to settle to the bottom. Discuss the results with the class.

If this is done as a demonstration with the clear glass bowl, it helps to have a light or white paper behind the bowl so the pepper is easier to observe.

Answers to questions for Activity 3.1

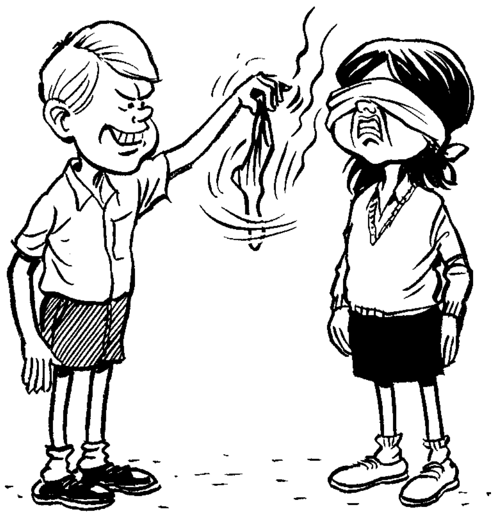
1. Gases
2. Particles (particulates).
3. Pepper (in a controlled area, particulates can be removed by filtering the air. Removing gases from the air is more difficult. Some gases can be removed by using industrial "scrubbers").

Discussion questions

1. In winter we can often see a brown "smudge" over the city or in the distance. What do you think this is? (Particles in the air)

2. What can cause particles to be present in the air? (Woodfires, burning off, car exhaust)

3. Cars put lots of pollutant gases into the air. Can you always see them? (No) Why not? (they are invisible)

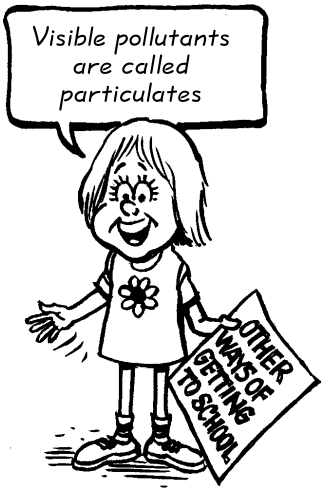


CURRICULUM LINKS

Science
Students demonstrate working scientifically by conducting investigations and processing data in chemical science.

Pollutants

The **visible pollutants** we call particles (or particulates) which are tiny particles of solid or drops of liquid which float in the air. These can be natural like pollen or dust, or man-made from sources such as woodfires, wood heaters industry, power plants or from cars and trucks.



Invisible pollution are gases which mix with air and, at times, even react with it to form other gases. An example of this are the invisible gases from car exhausts.

Activity 3.1

Let’s see the difference between visible and invisible pollution.

- Half fill two clear disposable cups with water.
- Add one tablespoon of milk to one cup, stir to mix.
- Add one teaspoon of pepper to the other cup, stir.
- Observe the differences between the milk and the pepper.

1. What kind of pollutant(s) did the milk act like in the water?

____

2. What kind of pollutant(s) did the pepper act like in the water?

____

3. Would it be easier to get the milk or the pepper out of the water?

____

4. Would it be easier to remove the gases or particles out of the air?

____

5. Suggest how you could get the pepper out of the water.

____

____

____

____

Extension

Start collecting newspaper articles about air pollution and pin these on a board in the classroom.

Collecting particles

Activity 3.2

The aim of this activity is for students to collect particles from the air using their own hand-made particle tester. Students should also develop some awareness of what the paticle source is likely to be.

Background

The air around us has never been completely clean. Pollutants such as smoke, dust and pollen, gases from rotting plants and sea-salt were all here before people lived on the earth. However, the activities of humans now add extra pollutants to the air, some of which are poisonous or too concentrated and which cause health problems for individuals and affect the place in which they live.

The trouble with trying to find the substances that pollute our air is that many of them are invisible gases.

However, one visible air pollutant is particulate matter (PM). PM is made up of tiny particles of solid or droplets of liquid which float in the air. With time, PM settles on the ground or on surfaces or is washed out of the air by the rain.

The natural kinds of airborne particulate matter include such things as pollen and dust. Man-made particles come from coal and oil burnt in power plants, fuel burning in cars and trucks, wood fires, slow combustion heaters and industry.

Particulates can be harmful to our health, affect plant and animal life and discolour buildings and other structures.

The Activity

To get an idea of what the particle levels are like around your area, students can try this simple way of collecting them. Particle testers can be made using cardboard or plastic from an ice-cream container lid. They are put outside for a few days but make sure they are not obvious as they may disappear! They can then be analysed for particles.

The trick to making these testers useful is to ensure you are putting them somewhere that you think particle levels may be high, such as near roads, incinerators or cleared land. *When looking at the results ensure students use a white background so the particles can be easily seen.*

There are some other activities using the testers in Eddie's Extras at the end of this section.

Discussion questions

1. In which area did your tester collect most particles?
2. Does the tester you made pick up all the pollutants in the air? Explain.
3. List possible sources of these particles?
4. Why do you think the particles are bad for you?

Extension - Five day record

Store 5 testers in a plastic bag and hang a new one out each day. After all five have been collected, compare them. Students can observe which days were high pollution days and look for weather patterns and their affect on air pollution. Refer to Eddie's Extras for the method.

CURRICULUM LINKS

Science
Students demonstrate working scientifically by planning and conducting investigations in chemical science and using science in daily life.

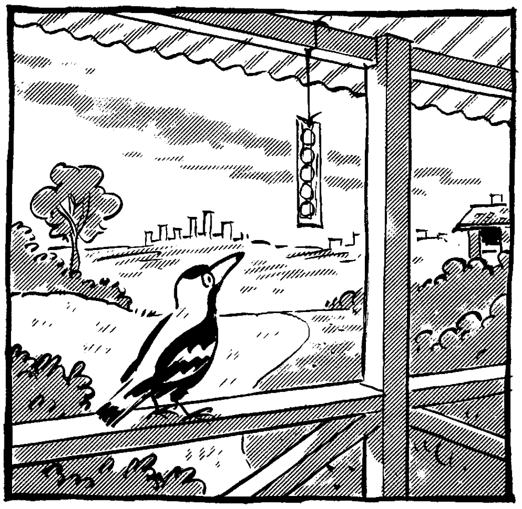
Technology and Enterprise
Students exhibit skills using the technology process.

English
Students acquire information through reading.

Collecting particles

In this activity we are going to investigate a particular type of pollution – particles. These are tiny particles in the air which can come from natural sources or from human activity such as woodheaters and burning off.

Particles can be harmful to our health and affect plant and animal life around us.



Activity 3.2a

Making a particle collector

To collect these particles you need to make a Particle Tester, using the instructions below.

- Cut a strip of cardboard that is 5cm wide and 25cm long and cut five holes, each about the size of a 20 cent piece.
- Cover all five holes with sticky tape. The sticky side of the tape will collect particles from the air. Make sure you do not touch the sticky side of the tape over the holes.

Activity 3.2b

One day particle collection study

- Select three locations and site testers at different places around the school or your neighbourhood. Write on your tester the date, location and your name.
- Keep one in a clean plastic bag. This is called a control.
- At the same time on the next day remove the testers and record the information in the table below.

Compare your tester to the one in the plastic bag. Describe the difference.

____

____

Compare your tester to those of other students.

Were some areas dirtier than others around your school? If so, list the three dirtiest locations.

____

____

Can you explain why these locations would be dirtier?

____

____

____

Extension

Five day particle collection study

The method for collecting particles over a five day period can be found in Eddie's Extras.

Date	Location	Tester Description

Table 1: Particle testing data.

Types of Pollutants

Notes

Students can fill in the missing information during the play or the table can be used as a follow up activity.

Activity 3.3

This play focuses the students' attention on the causes and hazards of air pollution. Students should be able to list and describe the six major air pollutants.

Background

There are hundreds of pollutants that float around in the air that we breathe. Australia has established National air quality standards for six of these pollutants: ozone, carbon monoxide, nitrogen dioxide, particulate matter, sulfur dioxide and lead. These air quality standards are designed to protect the health and welfare of people, plants, and animals, and to protect our water, buildings, monuments and other resources.

Reference:

The *Air Pollution Gremlins* were created by the Texas Natural Resource Conservation Commission.

Pollutant	Where it comes from	Effect
Smelly Sulfur Dioxide		
Nasty Nitrogen Oxide		
Odious Ozone		
Pesky Particulate		
Cranky Carbon Monoxide		
Lumpy Lead		

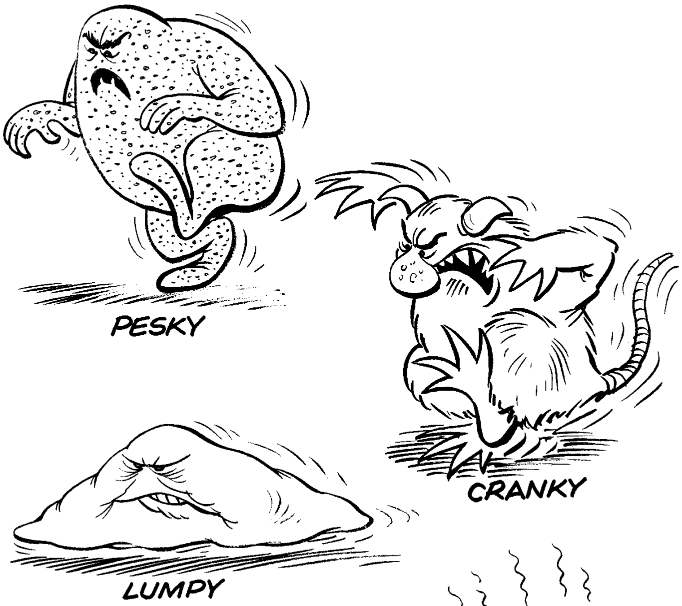
Table 2: Pollutants.

CURRICULUM LINKS

English

Students acquire information through speaking and listening.

Types of Pollutants



Activity 3.3

What type of substances cause pollution in our air. This play will help you find out.

Characters:

Christina

Steven

The Gremlins:

Smelly Sulfur Dioxide

Nasty Nitrogen Oxide

Odious Ozone

Pesky Particulate

Cranky Carbon Monoxide

Lumpy Lead

(The Gremlins may be cast singularly or as a group of actors.)

Setting

Christina and Steven are sitting in a lounge room with the television, radio, fan, and three or four lights on. They are watching a television show.

Dialogue

Christina: This is my favourite show!

Steven: Yeah, I just love the Power Rangers. The song that's playing on the radio right now is pretty cool too. It goes along with the action on the TV.

Christina: (She gets up and looks outside the window) Hey, Steven look at that! (points to the sky).

Steven: Wow! I wonder what it is? Let's go outside and get a better look.

Steven and Christina go outside. A large cloud comes closer to them. Underneath or behind the cloud are the Air Pollution Gremlins. The cloud stops right in front of Steven and Christina. Immediately, the Gremlins start jumping around and making faces at the audience and Christina and Steven.

Steven: Who are you?

Smelly Sulfur Dioxide: We are the Air Pollution Gremlins. We've come to take over your town.

Christina: Why would you want to do that? Only nice people live here.

Pesky Particulate: You may be nice people, but nobody seems to care about the air in this town. So, it looks like a good place to live (sneer).

Steven: I notice each of you has a different name. Why is that? Aren't you guys all the same?

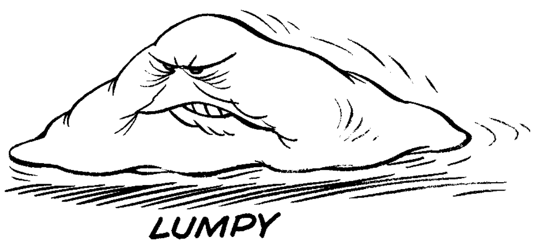
Cranky Carbon Monoxide: We have different names because we come from different sources and cause different problems.

Steven & Christina: Oh No!!

Cranky Carbon Monoxide: I'm Cranky Carbon Monoxide. I mostly come from car exhaust. I like to make people dizzy and give them headaches (twists hands menacingly).

Smelly Sulfur Dioxide: I'm Smelly Sulfur Dioxide. I come from smokestacks of power plants and industries. I can hurt your eyes, noses and lungs. I can even eat away iron and steel. I like to make the air look hazy (lunges at audience).

Nasty Nitrogen Dioxide: I'm Nasty Nitrogen Dioxide. I have a yellow-brown colour and I come from cars, electric power plants, and other large industries. I can make the air brown and hazy. I like to hurt lungs, plants and metals. (makes an evil laugh)



Lumpy Lead: I'm Lumpy Lead. I can contaminate the air, food and water. Also, I am found in some old paints. I'm very harmful to children and fish (does a little dance).

Odious Ozone: I'm Odious Ozone. I'm invisible by myself, but when I get together with my friends, I can help form smog. I can make it hard to breathe (lunges at audience).

Pesky Particulate: I'm Pesky Particulate. I live in the air and like to travel on the wind. I make things dirty and I can carry harmful chemicals into your lungs as well (makes a very loud and evil laugh).

Christina: All of you sound so terrible! We don't want you to live here.

Odious Ozone: You make it easy for us by wasting electricity and asking your parents to drive you everywhere you want to go!

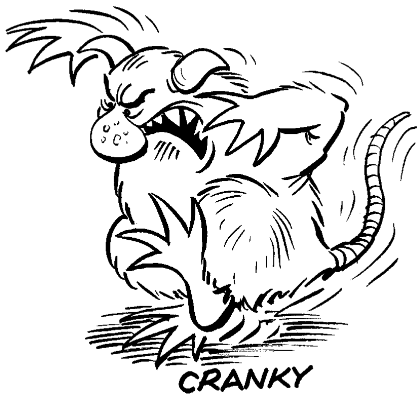
Lumpy Lead: And by using your wood heaters incorrectly all winter.

Steven: You mean that just because we waste electricity, use wood heaters and ride around a lot in the car, you guys are here to stay?

Nasty Nitrogen Dioxide: Bingo! Thank you for the invitation to live in your town!

Christina: Well from now on, you're not invited to our town. I'm not wasting electricity anymore and I'm going to walk or ride my bike if I want to go somewhere nearby.

Steven: Yeah! (firmly), and I'm going to find out how to use our wood heater properly! We're starting right now!



Steven and Christina rush inside and turn off all the lights and appliances they had left on.

Gremlins: OH NO! We can't live in this town if no one is wasting energy! This doesn't seem like a very good place to live after all.

Lumpy Lead: I'm sure we can find another town where people are wasting energy. C'mon, let's go!

The Gremlins leave in their cloud.

Christina: What do you want to do now?

Steven: Let's go outside and ride our bikes in the fresh, clean air.

Christina: I hope those Gremlins don't come back.

Steven: They won't as long as we continue to do things right.

The End

Fill in the table from the information given in the play.

Pollutant	Where it comes from	Effect
Smelly Sulfur Dioxide		
Nasty Nitrogen Oxide		
Odious Ozone		
Pesky Particulate		
Cranky Carbon Monoxide		
Lumpy Lead		

Table 2: Pollutants.

Moving pollutants

You may wish to do this as a demonstration with the students if the number of balloons required proves to be too expensive. Also ask the shop for balloons which will hold the gas for several days to stop you having to return for new balloons if you are testing over several days.

Activity 3.4

The following exercises will allow students to see what the air around them is doing on different days and let them get an idea of the various ways in which pollutants may be dispersed. Of course, it may also show them where pollution may be coming from in their local area.

Background

The layer of air in which we live is called the troposphere. This is the layer in which the pollution which we produce is dispersed or scattered. How this pollution moves around us depends on how the air in this layer is moving.

If the air is still, many of the pollutants will stay close to the ground and to us. If it is turbulent (blustery), pollutants will be dispersed all over the place. If the air is moving in a constant direction, the pollutants will move with it.

Notes

Students may find that the balloons move in different directions at different heights and at different times of the day. This shows that the atmosphere does not act as one layer but can have different layers of air moving in different directions.

Discussion questions

Use the questions below for activities (a) and (b). Students select the appropriate answer.

Would this air movement have made pollutants in the air

a) stay close to its source
b) move around its source
c) move away from the source
d) move widely
e) move away from its source, but not break up and disperse
f) other, please describe.

SAFETY!!

This exercise can only be carried out up to 100 metres as regulated by the Civil Aviation Authority, so as to ensure flying craft are not endangered by a tethered object.

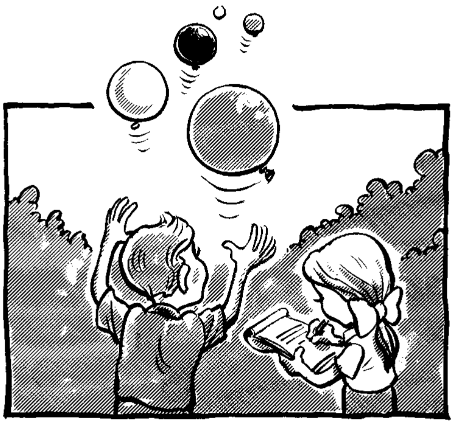
CURRICULUM LINKS

Science

Students make decisions about physical science, focusing on energy and change.

Moving pollutants

Pollutants do not always stay in the one place because air can move. Let's investigate this.



Activity 3.4

Materials

Balloons
Party balloon gas
String/fishing line (100m)
Piece of wood

(a) Observation of air movement

Collect a brightly coloured balloon which is filled with balloon gas. Tie one end of the string to the piece of wood and wind the string/fishing line onto it. Tie the other end to the balloon. Let the balloon into the air by paying out the line:

1) at different times during the day
2) from different places on the same day
3) from the same place on different days

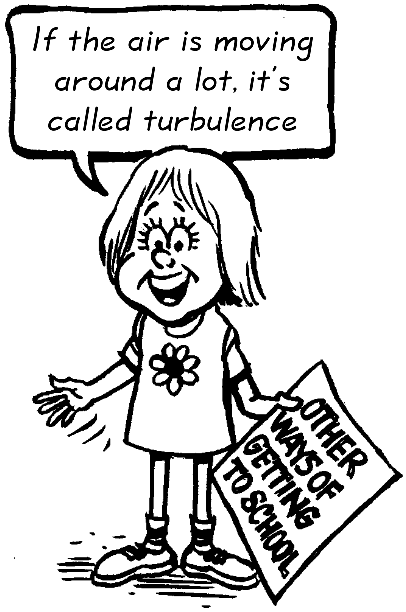
Write down comments about what happened to your balloon, eg: the direction, the pattern of flight etc. Record your results for each trial.

(b) Observation of turbulence

Turbulence means the air is moving around, spreading the pollutants throughout the air.

Loosely tie together several balloons filled with party gas and attach them to the string on your piece of wood. Pay out the line and follow their movement.

Describe their movement.



NOTE:

100 metres is as far as the balloon is allowed into the air while tethered. This is to ensure that planes do not get caught in the lines.

Conditions	Trial 1	Trial 2	Trial 3
(1) Different times			
(2) Different places			
(3) Different days			

Table 3: Local air movement.

Five day particle collection

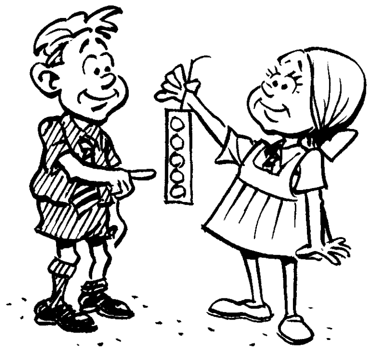
You will need six particle testers for this study. One will be the control. Select a location for your study.

Day 1; Expose one collector for 24 hours. Write date, location and name on the collector and record the weather conditions.

Repeat tthe procedure for the next four days.

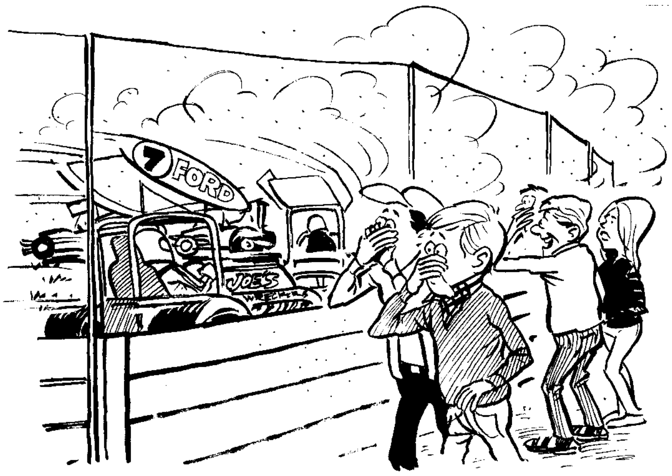
Compare your weather data and particle tester results for the five days. Report your findings.

Sometimes the air can be very dusty. Talk about some very dusty places you have been. Describe what causes the dust, where its coming from and how it feels on you and in your mouth.



Volcanoes add dust and ash to the air. Find out more about volcanoes and what precautions planes have to take when volcanoes erupt.

Draw pictures of some things which you think cause grit and dirt to be in the air near your school. Circle in red those things which are made by people.

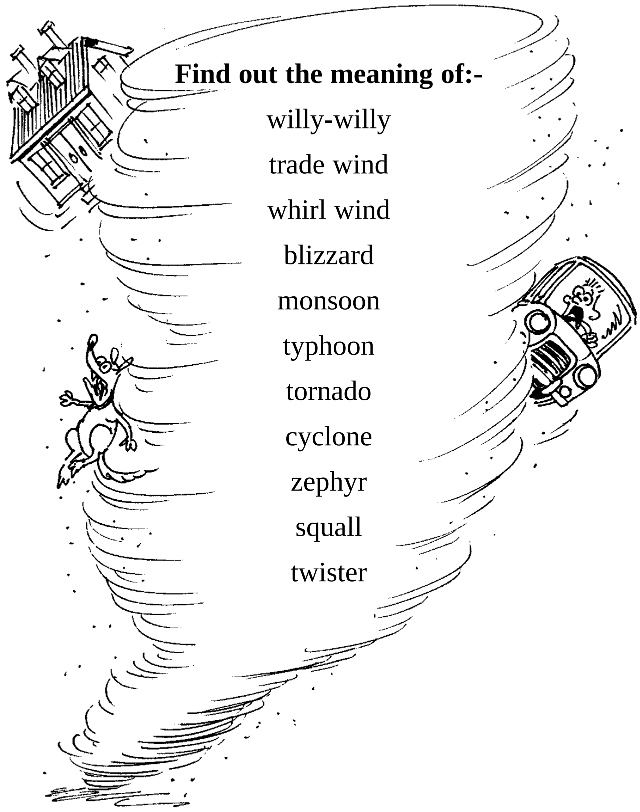


Testing for the source of particles

Use the particle testers in other places such as other schools, homes, churches, stores, urban and rural areas, factories, the bumpers of cars or school buses, on roofs. Compare results with other students.

Make four testers and place them at 90 degree angles to each other so they are facing different directions. Examine each to see if particles seems to be coming from a particular direction.

Write a report on this experiment.



Find out the meaning of:-

willy-willy
trade wind
whirl wind
blizzard
monsoon
typhoon
tornado
cyclone
zephyr
squall
twister

Understanding weather

Unit Summary

This unit is designed to provide the students with an understanding of temperature, rainfall and wind. These aspects of weather are very important as they have a significant affect on air pollution. This chapter will focus on weather phenomena and how to make simple weather instruments that the students will enjoy.

Background notes

In the previous chapter we concentrated on the main medium of weather - the air. For students to understand air pollution and why air quality can vary from day to day, we must be able to measure meteorological conditions as well.

Temperature

Energy from the sun warms the earth's surface, in turn heating the air. Temperatures differ around the State based on the intensity of the sun and the proximity to the sea.

Wind

Wind is simply moving air and it is very important in understanding the transport of pollutants. Wind speed and direction will help you to calculate the direction the pollutants are travelling and how much mixing there will be with unpolluted air.

Winds in Australia vary with the seasons. However, there are two main wind patterns over Australia known as the south-east trade winds and the westerlies. These winds are known as prevailing winds and frequently come from one direction.

Other winds are named from the direction the wind is blowing, ie: Northerlies come from the North.

Rainfall

The higher the air temperature, the more water vapour it can hold. If the amount of water vapour exceeds what the air can hold at a given temperature, then the excess will condense to form rain, dew, fog or frost.

Rainfall is measured using an instrument called a rain gauge. The gauge consists of a funnel that leads down to a graduated cylinder, with the rainfall being measured in millimetres.

Weather and Pollution

Weather is important when talking about air pollution as temperature, wind and rain can all affect the formation and maintenance of haze and smog in our cities.

For example, wind transports pollutants and mixes the pollutants with unpolluted air. The result can be dilution of pollutants in the air.

How hot is it?

Activity 4.1

Students will observe temperature changes in different areas over a day, recording the temperature readings in Fahrenheit and Celsius.

This activity can be conducted several times during the day (morning, midday, afternoon) and will take approximately 10-15 minutes. Students can work in small groups to determine the temperature readings.

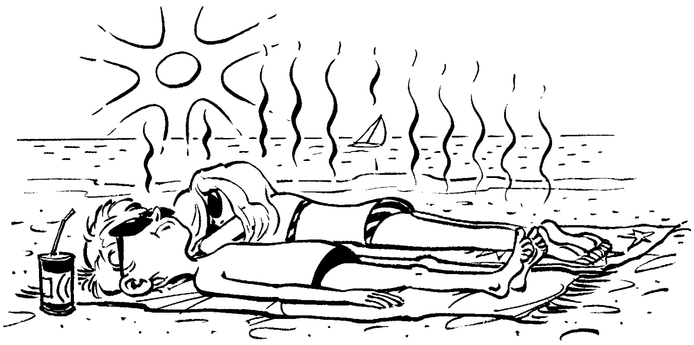
Explain to the students how to read a thermometer, using the master sheet 'Reading a Thermometer', (Appendix 1). Discuss with students suitable areas around the school to place the thermometers such as the classroom, under the verandah or a tree, out in the sun etc. Students will record temperatures over the day in the tables and the results can be discussed.

Discussion questions

1. Which temperature scale do we use in Australia? (Celsius)
2. Which is hotter – (i) 20^{o} Celsius or (ii) 20^{o} Fahrenheit? (20^{o} Celsius)

Background

Temperature is measured around the world in two different units, Fahrenheit and Celsius. The Celsius scale was named after Anders Celsius (1701 - 1744) and the Fahrenheit scale was named after Gabriel Fahrenheit (1686 - 1736). Temperature is measured using a thermometer, which contains mercury that expands as it warms and moves upwards to indicate temperature in one of these scales. There are also alcohol thermometers which have a red liquid which expands when heated.



Notes

It is important when using a thermometer to measure outdoor temperature, that the thermometer be kept out of the weather and in the shade.

CURRICULUM LINKS

English
Students acquire information through reading.

Mathematics
Students integrate number and measurement with chance and data.

Science
Students demonstrate awareness of energy as part of physical science.

How hot is it?

There are two scales for measuring temperature. One is called the Celsius scale and was named after Anders Celsius (1701 - 1744) and the other scale is called the Fahrenheit scale, named after Gabriel Fahrenheit (1686 - 1736).

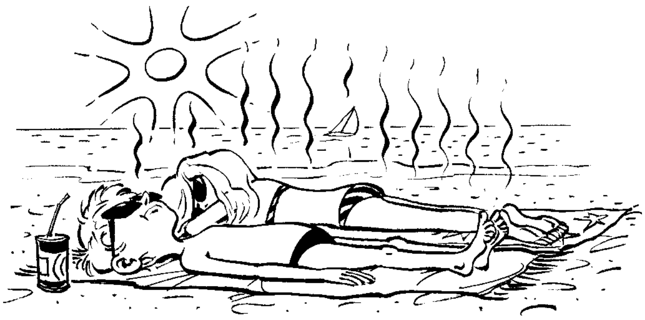
Gabriel Fahrenheit was the first person who is believed to have used mercury (a silvery, liquid metal) in thermometer bulbs.

(i) Can you name any countries which use the Celsius scale?

____

(ii) What about the Fahrenheit scale?

____



Activity 4.1

Materials

Thermometer
String
Master 'Reading a Thermometer'

1. Using your sheet titled 'Reading a Thermometer', (see Appendix 1), find the temperature in Fahrenheit for the following:

	Celsius	Fahrenheit
Room temperature	22(°C)	
Outside temperature	41(°C)	
Body temperature	37(°C)	

2. Using the tables below, record the temperature readings at each of the different locations around your school.

Location	Celsius (°C)	Fahrenheit (°C)
1		
2		
3		
4		
5		

Questions

Where was the coldest temperature recorded?

____

Where was the warmest temperature recorded?

____

When do you think the minimum temperature for the day would occur?

____

When do you think the maximum temperature for the day would occur?

____

Do the maximum and minimum temperatures happen at different times in different seasons? Explain your answer.

____

____

____

____

____

Weather check

Activity 4.2

Students are to collect a week's weather data to identify what information is available, where they can find this information and what units are used to measure the different aspects of weather.

Start a class weather chart. Ready made ones are available from the Gould League or in the 'Timesavers' books. Alternatively, students could keep individual records for a set period of time.

Get students to draw up a table or use the activity sheet to collect weather information for a selected period of time (usually one week). Students can collect their data by:

- checking the daily paper or watching the TV weather report;
- using the data from their electronic weather station if they have one OR
- checking their weather instruments if the school has a Stevenson screen.

The pollution information can be found on the weather page of most major newspapers in your city.

Discussion questions

1. What units are used to measure the following:
   - Temperature (°C)
   - Rainfall (mm)
   - Wind speed (m/s)
2. What was the trend with the maximum and minimum temperatures?
3. Was there any rainfall?
4. Have the winds been the same or varied over this time?
5. What pollution information did you collect?
6. What other information can be read from the weather reports on TV and in the newspaper?

CURRICULUM LINKS

Mathematics
Students integrate number and measurement with chance and data.

English
Students acquire information through reading.

Weather check

Activity 4.2

We are going to find out more about weather. To start with, we are going to monitor what it is like for one week. Check your daily newspaper or watch the TV weather report, and record the information in the table below.

Date	Maximum temperature (°C)	Minimum temperature (°C)	Rainfall (mm)	Wind direction	Wind speed m/s	Pollution information

Table 4: Class record for weather and pollution.

Questions

What units are used to measure

i) Temperature______________________________

ii) Rainfall_________________________________

iii) Wind speed______________________________

What type of pollution information did you find in the paper?

____

Describe the wind patterns for the week.

____

Has pollution been a problem this week? Explain.

____

____

____

____

Was pollution information the same for all areas around your city? If not, explain why you think it can vary throughout the metropolitan area.

____

Extension

Your teacher will show you how to graph your temperatures. Make a separate graph for the maximum and minimum temperatures or do both on the same graph, but use a different colour for each.

Graph any rainfall information on another graph.

Wind direction

Activity 4.3

This activity is designed to provide students with an understanding of the direction from which the wind is blowing and how to name winds.

Background

Winds are very important as they have a strong influence over temperature, humidity, cloud formation, rain and air pollution. Wind is measured using a wind vane for direction and an anemometer for speed.

Winds are named by the direction from which they come. The directional arrow on a wind vane will point in the direction from which the wind is blowing. For example, a southeast wind will show the directional arrow pointing southeast and the wind will be moving from the southeast to the northwest.

Notes

Students need to be reasonably careful when building their weather instrument to ensure it works correctly.

If you want to extend your students, allow them to build the wind vane, in groups, without giving them any building instructions.

Discussion Questions

1. What is the wind direction in the morning?

2. What is the wind direction in the late afternoon?

CURRICULUM LINKS

Technology and Enterprise
Students exhibit skills using the technology process.

English
Students acquire information through reading.

Wind direction

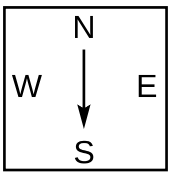
In this activity you will learn how to identify which direction the wind is blowing and how to name winds. You will also make a wind vane to measure wind around your school.

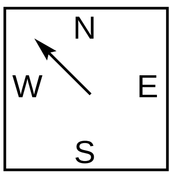
Naming winds

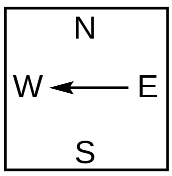
Wind direction is given as the direction from which the wind is coming. A wind vane will show the directional arrow pointing into the wind, indicating the direction from which the wind is blowing. We name the winds from the direction they come. For example, if the directional arrow is pointing to the north, the wind is called a northerly and blows from the north towards the south.

Knowing the wind speed and direction is very important if we are to understand where air pollutants are coming from and moving to.

Name the following winds:





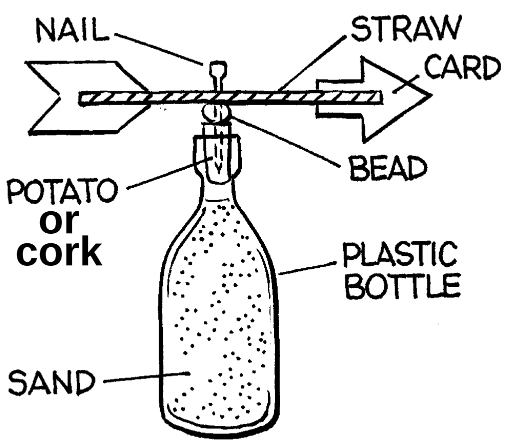


1. 2. 3.

(a) __________ (b) __________ (c) __________

Activity 4.3

When we want to measure winds, we need to determine the direction they are blowing and their speed. This activity will allow you to build your own wind vane, so that you can determine the wind direction.



Materials

1. Thick card (for the arrow head and tail piece)
2. A piece of dowel or a straw of 30cm length
3. 500ml plastic bottle
4. A small bead for the arrow head to spin on
5. Thin long nail
6. Glue (PVC)
7. Compass
8. Sand to fill plastic bottle
9. Potato, plasticine, corks
10. Apple Corer

What to do

1. Make a wind vane - as shown in the diagram.
2. Cut your card to make one arrow head and one tail piece as shown.
3. Attach these cut out pieces with glue, to each end of the dowel or straw.
4. Balance the dowel or straw to find the exact centre, using a ruler. Mark this spot with a pen.
5. Using the nail, make a hole through the dowel or straw at the marked spot. Place the nail through the hole you have made. Thread the bead onto the nail, so the dowel or straw is between the nail head and the bead.
6. Fill the plastic bottle with sand and using the apple corer, cut out a piece of potato to act as a cork in the top of the bottle.
7. Mount your wind vane onto the plastic bottle by pushing the nail through the centre of the potato in the neck of the bottle.
8. Label each side of the plastic bottle with N, S, W, E, using your compass to determine these directions.
9. Place your wind vane out in the wind, making sure the directions are correct, and see which direction the arrow points.

Questions

1. Using your wind vane, determine the wind direction.
2. Which way is the wind coming from and blowing to?

Acknowledgement

This activity is taken from Project Atmosphere On-line. www.schools.ash.org.an/paa

Wind speed

Activity 4.4

This activity will enable students to make very simple equipment that can help them determine the wind speed in kilometres per hour.

Background

The equipment used in measuring wind speed is an anemometer which consists of small cups that spin around in the wind. The stronger the wind the faster the cups spin. Measurements are made in metres per second, kilometres per hour or knots.

Knots were the traditional units used and is equal to one nautical mile per hour or slightly less than 2km/h. If the measurement was made in metres per second then 1m/s is roughly equal to 4km/h or 2 knots.

There is also another way of estimating wind speed. In 1805, before the advent of weather instrumentation, Admiral Sir Francis Beaufort developed a scale based on observations about wind speed. This scale distinguishes between twelve different levels of wind strength, with the speed being estimated in kilometres per hour. Below is a copy of the Beaufort Scale.

Note:

It would be appropriate to talk with the students about the accuracy of the various methods of measuring wind speed.

If the school has a weather station students should be able to identify the anemometer.

An Alternative

Give students a copy of the Beaufort Scale to use outside on various days to assess wind speed and compare their results if they have made the ping pong ball equipment.

Speed	Description
0 km/h	Calm. Smoke rises vertically.
1-5 km/h	Light air. Wind direction shown by smoke, not by wind vanes.
6-11 km/h	Light breeze. Wind felt on face, leaves rustle, ordinary vanes move.
12-19 km/h	Gentle breeze. Leaves and twigs constantly move, wind extends light flag.
20-29 km/h	Moderate breeze. Raises dust and loose paper, small branches on trees move.
30-39 km/h	Fresh breeze. Small trees sway, small waves on lakes.
40-50 km/h	Strong breeze. Large branches on trees move, difficult to use an umbrella.
51-61 km/h	Near gale. Whole trees sway, difficult to walk against the wind.
62-74 km/h	Gale. Twigs broken off trees, very difficult to walk.
75-87 km/h	Severe gale. Chimney pots and roof tiles break.
88-101 km/h	Storm. Trees uprooted, buildings damaged.
102-117 km/h	Violent storm. Very rarely occurs, widespread damage.

Discussion questions

1. What was the wind speed in the morning? Did it increase in the afternoon?
2. How difficult was it to obtain the wind speed?
3. How could you improve your accuracy?
4. Was the wind speed different in different areas of your school? For example, out in the middle of the school oval compared to under the school verandah. Why do you think this would be?

CURRICULUM LINKS

Technology and Enterprise
Students exhibit skills using the technology process.

Science
Students generate responses from physical science activities focusing on energy and change.

Wind speed

Activity 4.4

In this activity you will be making a piece of equipment which can measure wind speed. The name for equipment which does this is an anemometer. The wind speed will be measured in kilometres per hour.

Materials

1. Strong thread or fishing line (40cm length)
2. One ping-pong ball
3. One large protractor / wind chart template.
4. Glue and tape
5. A thick piece of cardboard or card to mount the template protractor on (about A4 size)

What to do

1. Using the glue, mount the template to the cardboard or card.
2. Tape the thread to the ping-pong ball and tie or glue the other end of the thread to the centre of the protractor.

The wind chart table

String angle	Speed (kph)
90	0
80	13
70	19
60	24
50	29
40	34
30	41
20	52

Table 5: Wind chart.

Using your anemometer

3. Hold your anemometer outside in the wind, keeping the ball and string on 90°. As the wind blows, let the ball go and read the angle it blows to on the card protractor.
4. Convert this angle to the wind speed using the chart above your card protractor.

Take measurements throughout the day to see how wind speed changes.

Did the wind speed change throughout the day? How

____

From where in your school grounds did you take your wind measurements?

____

Do you think this spot accurately reflects the wind for today? Explain.

____

(Hint: Look at the tree tops.)

Where do you think is the best place to take wind measurements? (Hint: Look at the tree tops) Why?

____

Why?

____

____

Acknowledgement

This activity is taken from Project Atmosphere On-line.
www.schools.ash.org.an/paa

Clouds and temperature

Activity 4.5

The purpose of this activity is for students to identify different cloud types and the effect they have on surface temperature.

Background

Clouds are made up of water droplets that are much smaller than raindrops. They are only able to form clouds if condensation particles are present. These particles can be dust, sea salt evaporated from sea spray, particles from forest fires, volcanic material or pollution.

The formation of clouds occurs in three different ways:

- As the land warms, the air above warms and rises. This rising air gradually cools and expands, with tiny water droplets forming, resulting in a visible cloud. The processes involved are known as convection.
- Air rising due to topography (land formations), such as a mountain range. The air is forced to rise above the mountains, cooling as it does, resulting in the formation of clouds.
- The heavy air in a cold front moving in under the warm air ahead of it, forcing the warm air to rise. This sudden uplift can cause clouds to form and commonly will generate storm activity.

Naming clouds

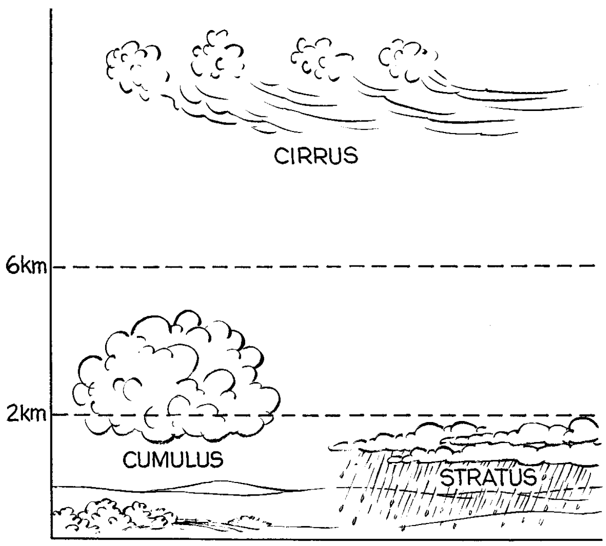
Cloud names are based on their height, shape and colour. There are three basic cloud types:

- Cumulus – clouds which have a woolly appearance and often produce rain.
- Cirrus – clouds which are high, white and feathery and don't bring rain.
- Stratus – low grey clouds which can cause drizzle.

In general, high clouds warm the Earth and low clouds have a cooling effect.

Discussion questions

1. What effect did high clouds seem to have on the Earth's temperature? (Warming)
2. What effect did the low clouds have? (Cooling)
3. Did the clouds fall easily into the three types given? (No)
4. What do you think a "stratocumulus" cloud might be like? (Part low and grey topped by woolly clouds)



CURRICULUM LINKS

Science
Students apply understandings of Earth and space sciences.
Students make decisions about physical science, focusing on energy and change.
Students demonstrate working scientifically doing activities in chemical science.

Clouds and temperature

In this activity you will identify different cloud types and the effect they have on surface temperature.

Clouds are made up of water droplets that are much smaller than raindrops. They are only able to form clouds if condensation particles are present. These particles can be dust, sea salt evaporated from sea spray, particles from forest fires, volcanic material or pollution.

Naming clouds

Cloud names are based on their height, shape and colour. There are three basic cloud types:

- Cumulus – clouds which have a wooly appearance and often produce rain.
- Cirrus – clouds which are high, white and feathery and don't bring rain.
- Stratus – low grey clouds which can cause drizzle.

Activity 4.5

Materials

Thermometer

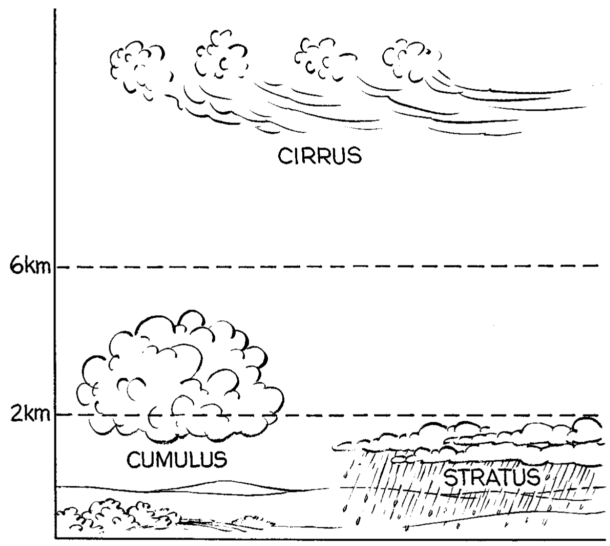
Cloud chart (Optional)

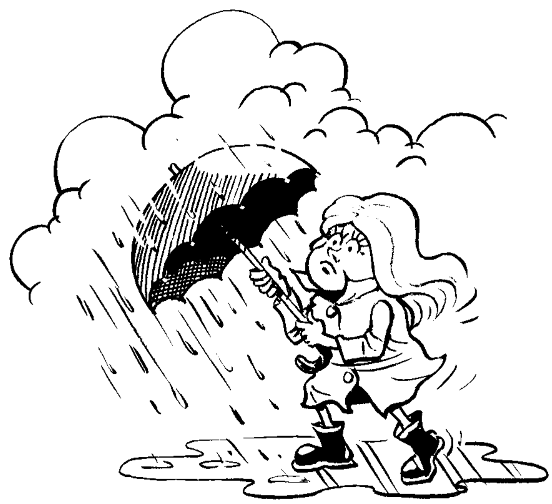
What to do

1. Measure the temperature in a shady location away from buildings over several weeks.
2. Estimate cloud cover. To do this, observe how many eighths of the sky is cloudy. For example, if about half the sky is cloudy, the cover would be 4 / 8. If only a little is, it would 1/ 8.
3. Fill in the chart below.

Questions

1. What effect did i) Cumulus ii) Cirrus iii) Stratus clouds have on temperature?
2. Did the clouds fall easily into the three types given?
3. Investigate other cloud types. Draw and describe at least three others.





Date	Time	Cloud type	Cloud cover	Temperature (°C)

Thunderstorms

To understand how a thundercloud forms you must be able to understand a process called convection. The following activity will help you to describe the process of convection.

Materials

One clear container, like an aquarium or large plastic container.

Red food colouring.

Ice cubes made with water dyed with blue food colouring.

Coloured pencils

Paper

The experiment

1. Fill container to 2/3 full with water at room temperature.
2. Let the water sit for a minute until it is completely still.
3. Place a blue ice cube gently into one end of the container.
4. Very gently add two drops of red food colouring to the water at the opposite end of the container.

Using red and blue coloured pencils, draw what you see happening.

Describe the movement of the red food colouring.

____

What happened to the blue colouring?

____

Which is warmer, the red water or the blue? Explain

____

____

This experiment shows convection, that is where hot air rises over cooler air. This is what happens to air which on rising cools and becomes a visible cloud.

Tornadoes

Tornadoes or whirlwinds can be very destructive and they do occur in Australia. They usually occur in sparsely populated areas, so we do not often hear about them. There was one that actually made its way through NE Victoria and damaged housing, even removing a child from inside a house!

Materials

A jar with lid
Vinegar
Dishwashing liquid
Glitter

The experiment

1. Fill the jar 3/4 full with water.
2. Put in one teaspoon of vinegar and one teaspoon of dishwashing liquid.
3. Sprinkle into the jar a small amount of glitter.
4. Close lid tightly.
5. Twist jar to see a tornado like vortex form.

Draw a picture of the tornado in the jar.

Label the part of the diagram showing the vortex. What is a vortex?

____

In outback regions of Australia, a small type of tornado can pass through an area. What are these types of tornadoes often called?

____

Extension

Using the Internet, search for temperature recordings for the United States of America.

The temperature recordings will be in Fahrenheit. Copy out a map of the United States and write the temperature recordings found on the map. Convert the temperature recordings into Celsius to see the different temperatures around the States.

The burning question

Unit Summary

In this unit, students will learn about the major air pollution problem of haze experienced in the winter and spring months. Haze, or winter smog, is mainly caused by smoke from woodheaters, people burning rubbish in their backyard and burning off. The students will investigate the different conditions for burning which contribute particles to the air and how proper use of wood heaters and incinerators can reduce their impact on air quality.

Background notes

The major source of particles in our air comes from burning. This may be from using our wood heaters, our backyard incinerators, burning off garden refuse, natural bushfires or a controlled burn such as those done in our forests to control leaf litter build up.

Smoke consists of very fine particles of carbon and also grit, ash and soot which tend to be larger in size. The larger particles settle to the ground or are washed out of the air by rain and can cause problems because they make buildings, plants, clothes and other things dirty when they fall.

At the same time, smaller particles remain in the air for some time and are more dangerous to health because they can be inhaled deep into the lungs making conditions such as bronchitis and asthma worse. The elderly, young children and those with existing lung or heart disease are most at risk from high haze levels.

One of the sources of particles is the slow combustion wood heater. Unfortunately, because of their popularity, the smoke produced has become a problem, particularly during cold, calm winter nights and mornings where the high levels of smoke particles can be seen as a brown haze over many cities and towns.

To reduce the number of particles in the air produced by our wood heaters we can follow these guidelines.

- Avoid using open fires and woodheaters where possible.
- Burn a hot fire with bright glowing coals so that it produces as little smoke as possible.
- Use small pieces of untreated and well dried wood.
- Control the heat by regulating the amount of wood you put on the fire rather than closing the flue.
- Never use green wood.
- Stack your wood and keep it dry in winter.
- If your chimney is smoking a lot, open up the flue and give the fire more air.
- Don’t burn household rubbish such as plastics in your wood heater.
- Try to use your heater less. If it’s not very cold, wear a jumper.
- Do not burn your garden rubbish. Instead, compost your garden clippings and recycle them back into your garden as mulch. If the garden prunings are too big to compost, take them to a tip which can mulch your prunings and recycle them.

Woodsmoke

Activity 5.1

This activity will help students to recognise that wood fires give off particles which can be seen and collected. Some of the conditions which cause particles to be given off will also be noted.

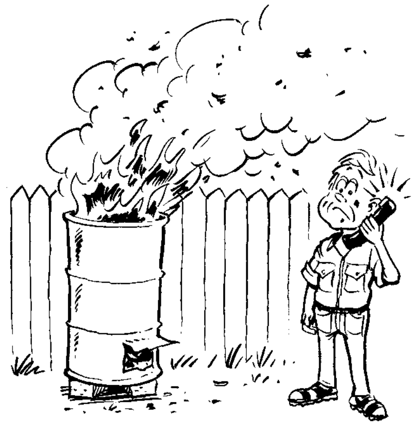
In activity (a), students should identify that the lid does not allow as much air (oxygen) to the fire which causes incomplete burning. This gives rise to lots of smoke containing harmful particles.

In activity (b), students will observe that wet fuel means more particles are given off.

Optional: Get some dry wood which has been cut and stored for a reasonable time and some "green" wood which has been recently cut. Use small pieces of each on the fire and observe the difference in how they burn. The dry wood should burn with little smoke while the green wood, which still has a high moisture content should give off more smoke.

Discussion questions

1. What causes fires to give off too much smoke? (Lack of air (oxygen), wet or green fuel)
2. What can we do to prevent particles getting into the air? (Burn fires brightly by giving it lots of air, using seasoned, dry wood.)
3. What do you thinking "damping down" your fire means? (Reducing the air getting to the fire so it burns more slowly)
4. What does it mean when wood is green? (Freshly cut, has not dried out)
5. How should people keep their wood during winter? (Loosely stacked and under cover)



The following messages are the ones which should come out of this exercise.

To reduce particles in the air:

- Never use wet or green wood.
- Stack your wood under cover to keep it dry.
- Burn at a high level and do not damp down over night.
- Instead of turning up the heat - put on a jumper.

CURRICULUM LINKS

Science
Students demonstrate working scientifically doing activities in physical and chemical sciences.

English
Students acquire information through reading.

Health and Physical Education
Students know and understand health concepts and exhibit attitudes and values that promote personal health and demonstrate self-management skills.

Woodsmoke

In this activity, you will investigate what conditions cause a lot of smoke when burning a fire.

Activity 5.1(a)

Your teacher will light up a fire outside in a suitable container. When the fire is burning well, put a lid on to partially cover the fire. Keep moving the lid until the fire is almost completely covered.

What happens to the fire as you do this?

____

What is the lid doing to the fire?

____

Predict what would happen if you made it completely airtight.

____

Activity 5.1(b)

Put some wet wood or wet newspaper onto the fire. At the same time, dangle some white paper or material above the fire (try putting the material on the end of a long stick to do this).

What happens to the fire when wet fuel is used?

____

Look carefully at the white material that was above the fire.

Describe what you see

____

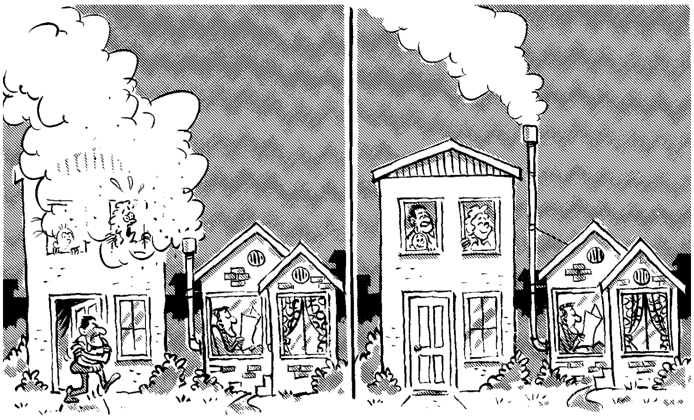
Activity 5.1(c)

What is the message in the picture below?

____

____

____



Summary

From these activities, what advice would you give to people to stop them having smoky fires?

____

____

____

Woodsmoke and health

Activity 5.2

This activity will help students learn about woodsmoke and the harm it can cause to human health.

Notes:

This activity will require the students to use the library or have access to reference books on the respiratory system.

Answers to Activity 5.2

What does the respiratory system do for us? (Helps us get oxygen into the body and remove the carbon dioxide.)

What is the important gas which gets into our body via this system? (Oxygen)

What gas leaves the body this way? (Carbon dioxide)

Draw arrows showing the paths the woodsmoke particle can take to get into your lungs. (See the diagram above)

What have you got in your nose and throat which stop the particles from entering your lungs? (Hairs)

Discussion questions

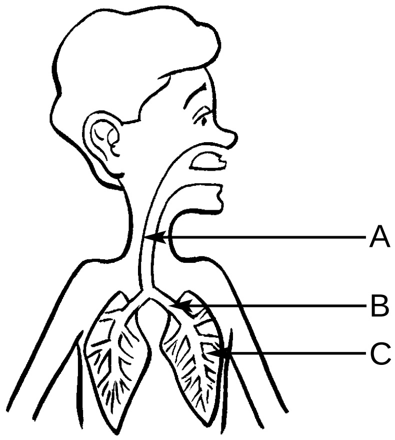
1. Why is oxygen important to our body? (It burns our food to give us energy)
2. Why do we breathe faster when we've been running? (More energy is required)
3. Why do you think some particles get past the hairs in our nose and throat? (They are too small to be caught)
4. Give at least three reasons why woodsmoke can be bad for you. (Makes old and young people sick, can cause respiratory conditions to get worse, can cause cancer, can cause premature deaths)

CURRICULUM LINKS

Health and Physical Education
Students know and understand health concepts and exhibit attitudes and values that promote personal health and demonstrate self-management skills.

Woodsmoke and health

In this activity you will learn about woodsmoke and the harm it can cause to human health.



Activity 5.2

Using a reference book, label the parts of the respiratory system in the diagram above.

What does the respiratory system do for us?

____

What is the important gas which gets into our body via this system?

____

What gas leaves the body this way?

____

Draw arrows showing the paths the woodsmoke particle can take to get into your lungs.

What do you have in your nose which stop the larger particles from entering your lungs?

____

When particles are breathed in, they can cause health problems, especially in the very young, the elderly or people with lung or heart disease. Very small particles make health problems like bronchitis, emphysema and asthma worse and can cause "premature" death. These particles can also bring in carcinogens with them when they enter the body.

Find out the meaning of the following:

bronchitis:________________________________

____

emphysema: ________________________________

____

asthma: ___________________________________

____

premature death: ____________________________

____

carcinogens: _______________________________

____

How many students in your class suffer from asthma?

____

How many students have someone in their family who has asthma?

____

These people may be being affected by woodsmoke in their local area.

Woodheaters

Activity 5.3

In this activity students will find out what problems incorrectly operated woodheaters cause and how they should use them to reduce the amount of woodsmoke in the air.

The brochure "Woodsmoke", included with this booklet, can be photocopied and given to your students to help them complete the crossword puzzle.

Answer to crossword

ACROSS

1. clean
2. summer
6. haze
7. particulate
9. night
10. twenty
14. on
15.ventilated
19. cut
20. or
21. UN
22. burn out
24. lungs
26. heavier
27. health
32. local council
34. lead
35. green
36. elderly

DOWN

2. split
3. EG
4. regulations
5. open
6. hot
8. right
11. wed
12. no
13. young
17. loud
18. art
21. undercover
22. be
23. eye
24. live
25. garbage
27. hollow
28. son
29. bright
30. clear
31. ice
33. logs

CURRICULUM LINKS

English
Students acquire information through reading.

Science
Students demonstrate working scientifically doing activities in chemical science.

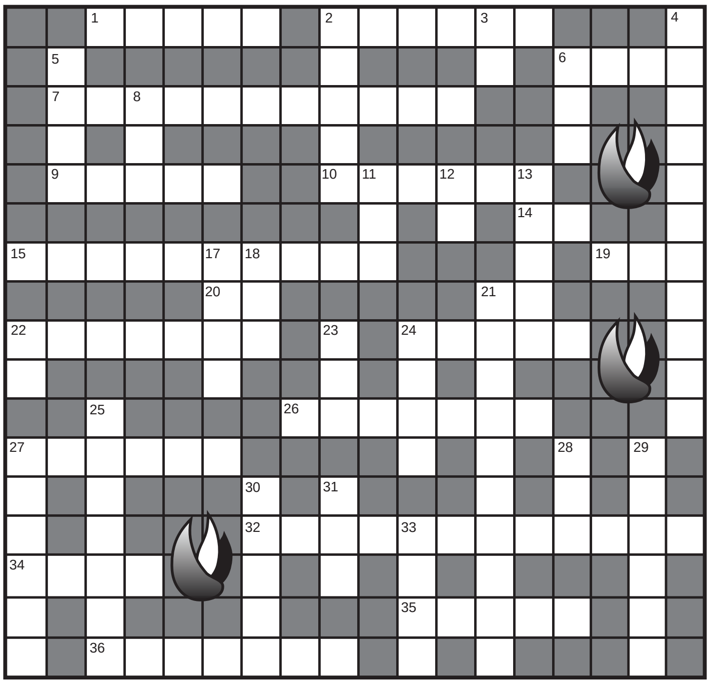
Woodheaters

Activity 5.3

In this activity you will find out what problems incorrectly operated woodheaters cause and how you should use them to reduce the amount of woodsmoke in the air.

Your teacher will give you a ‘Woodsmoke’ brochure from the Department of Environmental Protection. Use it to complete the crossword and find out all about the proper use of wood heaters.

CROSSWORD



ACROSS

1. What you should do to your chimney regularly
2. Best time to store your wood
6. The brown smudge in the sky
7. Woodsmoke is the major source of this type of pollution
9. The flue should not be shut at this time
10. Wood is illegal if its moisture content is more than this percentage
14. Opposite to off
15. Store firewood in this type of place
19. Green wood is wood that has just been ___
20. Either, ___
21. United nations (abbreviation)
22. What a fire should do at night (two words)
24. Part of our body which can be damaged by particles
26. The weight of wet wood
27. Particles in the air can cause these sought of problems
32. Who you contact if you see a very smoky chimney
34. Another air pollutant
35. This type of wood does not burn properly
36. Others who are most at risk from particles in the air

DOWN

2. This type of log dries faster
3. For example
4. These control the type of woodheaters sold
5. The flue should be this way when starting a fire
6. A fire must be as ___as possible
8. Wood must be stored this way
11. To marry
12. The amount of smoke which should come from the chimney
13. Some people most at risk from particles in the air
17. Very noisy
18. Letters 1, 18, 20 of the alphabet
21. Woodpiles should be kept this way to stop getting wet
22. To___ or not to be, that is the question
23. Part of body needed to use chimney checker
24. Live and let _____
25. Something which should never be burned
27. Dry wood should make this sound
28. Male offspring
29. Fire should always burn this way
30. How we like our air to look
31. Solid water
33. Wood should be split into small _____ for storage

What wood?

Summary

These activities show students that they can use simple methods to ensure that that they are not producing lots of smoke particles when operating a woodheater or fire.

Background

Freshly cut wood from a living tree will contain about 50% moisture, ie about half the weight of the green wood is water. If it is left to dry, it will gradually lose its moisture until it reaches about 12-15%. At this point it reaches equilibrium with the air and does not lose any more moisture.

If wood is oven dried so that its moisture content is less than air, and then put back into the air, it again reach 12-15% moisture content.

Activity 5.4 (a)

Dry wood produces less smoke. Wood should contain less than 20% moisture if it is to be burnt. This activity shows that dry wood floats higher in a bucket of water than wet wood. If it floats with one sixth of its length out of the water it has less than 20% moisture. This is an easy way to predict whether wood is dry enough to burn.

Activity 5.4 (b)

Drying your wood and storing it correctly is important preparation for the correct use of your woodheater. Using sponge to represent wood, students will prepare it differently to observe the best conditions for drying their wood before burning.

Things to do to keep your wood dry:

- Cut it into small logs
- Stack it so air can circulate
- Stack it under cover

Activity 5.4 (c)

Using the chimney checker is simple way to test a fire when it is going.

Discussion questions

1. Why should you use dry wood in your fire or woodheater? (To reduce the amount of particles put in the air)
2. In what way should you stack your wood to ensure it dries most quickly? (With plenty of air spaces between logs and undercover)
3. Who uses woodheaters at home? (Give them a chimney checker)

CURRICULUM LINKS

Science
Students work scientifically in predicting and conducting investigations and processing data in physical and chemical science.

What wood?

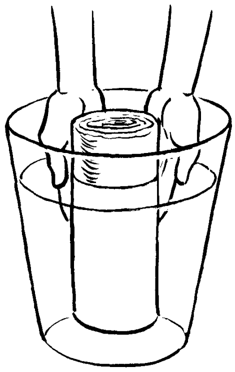
These activities will show you some simple ways you can ensure that you are not producing lots of smoke particles when operating a woodheater or fire.

Activity 5.4 (a)

Materials

Dry wood
Wet wood
Bucket 3/4 filled with water
Marker pen

Get two pieces of similar size wood, one which has been freshly cut and one which is old and dry. With the pen, mark into sixths. Put each into the bucket of water and hold upright. See how much of the log sticks out of the water.



Draw your results

Which wood floated lower in the water?

____

Why would that happen?

____

The more moisture in the wood the heavier it is.

Which log was the wetter one?

____

Which of the two logs should you use to burn? Why?

____

Activity 5.4 (b)

Materials

Sponges (3)
Scissors
Bowl of water

This activity will show you the best way to treat your wood to get it ready for burning.

Sponge 1 - wet in the bowl of water and squeeze. Roll it in a ball and use a lacky band to keep in this shape.

Sponge 2 - cut the sponge into long strips and wet in the bowl and then squeeze. Tie loosely together with another lacky band.

Sponge 3 - Treat as Sponge 2 but lay strips out beside one another.

Leave all the sponges in a safe place for 15 minutes. Then check for "wetness". Check again in another 10 minutes.

Describe your results.

Can you use this experiment to guess what you can do to make you wood dry out more quickly?

____

Can you think of any other practical things to keep your wood dry?

Activity 5.4 (c)

Your teacher will give you a chimney checker. This can be used to check that your fire is not giving off too much smoke.

Describe the type of fire you need to produce the least amount of smoke.

____

How do you get this type of fire?

____

Haze and Smog Alerts

In Australian capital cities, haze and smog alerts are issued throughout the year. These are given over the radio, television and in the newspapers.

Find out whether any air pollution warnings are given in your state and what you should do when you hear one issued.

Household heating

Summary

As woodsmoke is the major cause of air pollution in winter, students can find out what sort of household heating is used in their local area. This activity introduces the students to many important features of social survey work.

Activity 5.5

Each student is to survey approximately 10 households, and then work out the percentage of each type of heating in their sample, then put all the survey results together. This illustrates how a small sample (10) will probably give very different results to a large sample (say 200).

The following points should be made about the survey:

- Students should be encouraged to use people they know in the neighbourhood rather than strangers who may not appreciate being surveyed by young students.
- They should appreciate through this survey that the larger the numbers, the more likely they are to get a true picture of household heating in their area.
- Although the formula is given in the activity, students, depending on their age, may need to be helped when working out percentages.

Discussion questions

1. What was woodheater usage in i) your sample ii) the class sample?
2. Which one would be more accurate? Class sample.
3. Why? Larger number of surveys.
4. Does this area have a lot of woodheaters?
5. If we don't, should we still worry about particles in the air? Why? Yes, because the wind can shift them one area to another.

CURRICULUM LINKS

Mathematics
Students integrate number and measurement with chance and data.

English
Students interact with others through speaking.

Household heating

The type of heating being used in your neighbourhood will affect your local air quality. Woodheaters, if not correctly used, can emit a lot of smoke into the air and cause haze or winter smog, especially in the colder months.

What type of heating do you use in your house? Does everyone in your neighbourhood use the same? These questions are important to answer if we are to understand how your local air quality is being affected by those who live there.

Activity 5.5

1. The following survey will allow you get some idea of the types of heating used in your neighbourhood. Try to collect the information from people you know.

Household	Open fire	Wood heater	Gas heater	Electric heater	Oil heater	Other (specify)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
TOTAL						
CLASS TOTAL						
%age						

Table 6: Household heating survey results.

2. Back at school, collate your class results.
3. To calculate the percentage of each type of heating use the following formula:

$$\text{Heating type \%age} = \frac{\text{Type of heating x 100}}{10}$$

Calculate the percentage of different heating types for the whole class and add the results to your table.

What type of heating is used most in your area?

___

Which types of heating puts particles into the air?

___

Do you think particles may be a problem in your area? Explain.

___

Which results do you think are the best to use - your own or the whole class? Why?

___

Eddie's extras

Check out the regulations for using your incinerator in your area. You might need to ring your local council.

Make up a woodsmoke brochure about problems of woodheaters and how to correctly use them. Distribute these brochures to all the people in the school who have wood fires.

Read a story about a bushfire and then make up a play about being trapped in a bushfire.

Using charcoal, draw a picture of a city showing what the it will look like if too many people use woodheaters incorrectly.

Make a poster which informs people how to use their wood heater properly. Use the information out of the wood heaters brochure. Put these around the school. Use a different message from the posters to go into the weekly school newsletter

Cars - A big headache

Unit Summary

In this unit students will investigate the pollution caused by car exhausts. They will also examine issues such as car usage, people's attitudes to cars, alternative transport and possible actions which the students can undertake to help reduce air pollution.

Background notes

More than half the pollution in our cities is caused by vehicles such as cars and trucks. It has been estimated that by the year 2030 there will be one billion vehicles world wide.

Cars and trucks release pollutants such as lead, carbon monoxide, nitrogen oxides and particulate matter. The nitrogen oxides which are released react further, in the presence of strong sunlight, with the air to form ozone, the major component of photochemical smog. Smog occurs mainly in the summer months when there are high temperatures and long hours of sunlight.

Ozone affects the healthy and the fit as well as the more susceptible members of the population. These include the very young, the elderly and those with lung and heart disease.

What can we do to reduce photochemical smog?

As cars are the major source of the chemicals which help to form smog, we need to change the way we use them. Here are some hints.

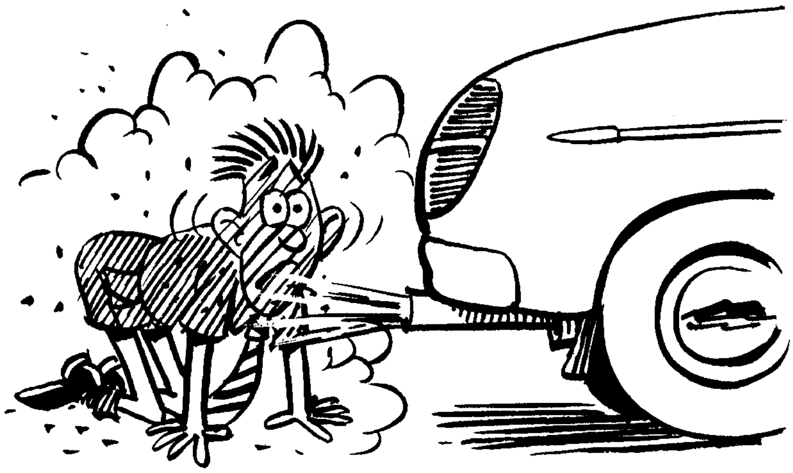
- Don't drive if you don't have to. Some trips are short and a quick walk or bike ride will get you there.
- Carpool - try to organise trips with other people who are going in the same direction. Organise for the team to go to training as a group.
- Catch public transport where possible and convenient.
- Ride or walk to school. You will not only help the air pollution problem but you'll get fit at the same time.
- When driving, drive smoothly as this leads to less air pollution. Try to avoid peak hour traffic and combine trips if you can.
- Consider buying a small, fuel efficient car. They produce fewer emissions.
- Keep your car tuned, remove any wind resisting items such as roof racks and reduce the load carried in the car. This saves fuel and reduces car emissions.
- Keep tyres inflated and try to avoid 'hotting up' your car.

Car Exhausts

Activity 6.1

In the following activity, we are going to examine the exhaust of various types of cars to see which produces the greatest visible pollution.

NOTE: This activity must be done in the open air and the handbrake of the vehicle must be on. Make sure the tailpipe is not touched as it will be hot. Students need to stand to the side of the exhaust rather than in front of it while the engine is running to avoid the full force of the fumes.



Discussion questions

1. Was there a difference between filter papers for different cars?
2. Which car produced the dirtiest filter paper? (Produced the most particulate matter)
3. Was there any relationship between the dirtiest filter paper and the:

- Age of the car
- Type of car
- Fuel used by the car?

4. Is the car with the dirtiest filter paper the most polluting? (No, as other cars may be giving off more invisible pollutants such as nitrogen oxide and carbon monoxide).

CURRICULUM LINKS

Science
Students demonstrate working scientifically doing activities in physical science and presenting and interpreting data.

Health and Physical Education
Students know and understand health concepts and exhibit attitudes and values that promote personal health and demonstrate self-management skills.

Car Exhausts

Vehicles which use fuels such as petrol and diesel release pollutants into the air. These can cause us harm directly or change into other forms of pollution, such as smog, under the right conditions.

Activity 6.1

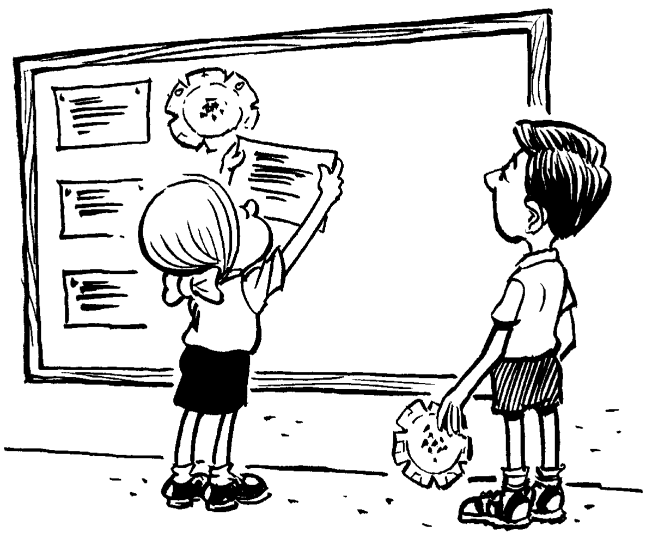
In this activity, you will be testing cars to see which ones produce the most visible pollution. This type of pollution is called particulate matter (PM).

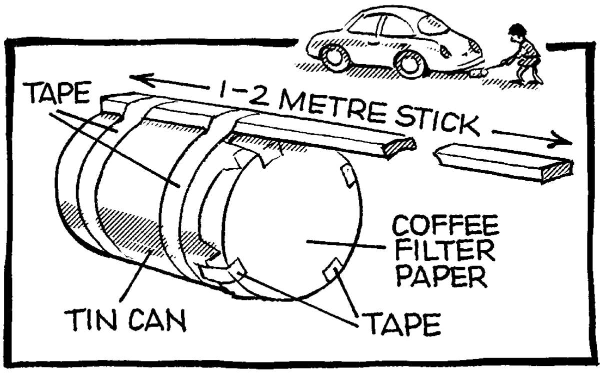
Materials (per group)

Tin can
1.5 m stick
Masking tape
Filter paper (or coffee filters)

What to do

1. Make up a car testing device - as shown in the diagram.
2. Attach the first filter over one end of the can. Write a label to identify which car you are testing with this filter, eg. Mr Jones, 1987 Camry, unleaded petrol.
3. Test each car by holding the open end of the can over the tailpipe while the car is running.
   Leave it for at least 30 seconds, or until there is colouration on the paper.
4. Take off the device; wait until cool; remove used filter paper and keep. Draw up a summary table to record your results.
5. Repeat this process for at least three different cars.





6. Back in class, make a class chart and paste onto it the used filter papers and the information about the test cars.

What happened?

What differences do you notice on the filter papers?

____

____

Why do you think this might be so?

____

____

Does the car which produced the dirtiest filter necessarily produce the most air pollution? Explain (remember you are looking at visible pollution)

____

____

____

____

Smog

Summary

This activity will help students develop an understanding that looking at air does not always help identify whether it is polluted or not.

Photochemical Smog

When we hear the word ‘smog’, we think of the ‘pea-soupers’ made famous in London. This type of smog was a combination of fog and smoke.

However, when we talk about smog these days we are referring to photochemical smog. This type of smog is invisible to the naked eye and is due to a build up of ozone in the air. Ozone forms when gases such as nitrogen dioxide and reactive organic compounds have reacted together in the air under the influence of sunlight and high temperatures.

Ozone is colourless and odourless in low concentrations but has a pungent odour and bluish colour in higher concentrations.

Ozone causes health problems such as eye, nose and throat irritations and damages the respiratory system. When people come in contact with higher levels of ozone they may feel tightness in the chest and experience wheezing.

There is also evidence that higher ozone levels can trigger asthma attacks and increase our susceptibility to infection.

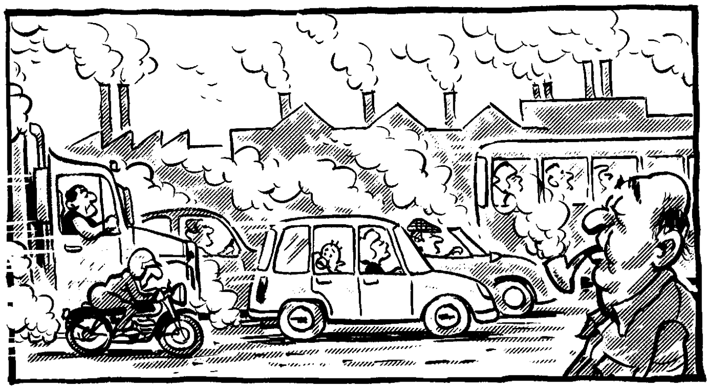
Activity 6.2

Smog is becoming a problem in many cities in summer and is largely due to vehicle emissions. Also the weather conditions during this time often ensures that the smog build up is greater.

Discussion questions

1. What seems to cause the smog? (traffic).
2. How do weather conditions make smog worse over Australiana? (Australiana is a large coastal city and the seabreeze blows smog back over Australiana).
3. Why doesn’t this happen in winter? (incorrect weather conditions, not enough sunlight and prevailing winds are different).
4. Smog contains ozone which can be harmful. Why are people worrying about the hole in the ozone layer then? (the hole in the ozone layer is a different problem.)

NOTE: Ozone high up in the atmosphere protects you from too much radiation. Ozone close to you is harmful and affects your health.



CURRICULUM LINKS

Health and Physical Education
Students know and understand health concepts and exhibit attitudes and values that promote personal health and demonstrate self-management skills.

Science
Students apply understandings of Earth and space sciences.

Smog

What do you know about smog?

Photochemical smog contains ozone gas which can affect your health. It occurs mostly in summer when there is lots of sunlight and high temperatures.

A cool sea breeze in summer is not as freshening as we expect. Why?

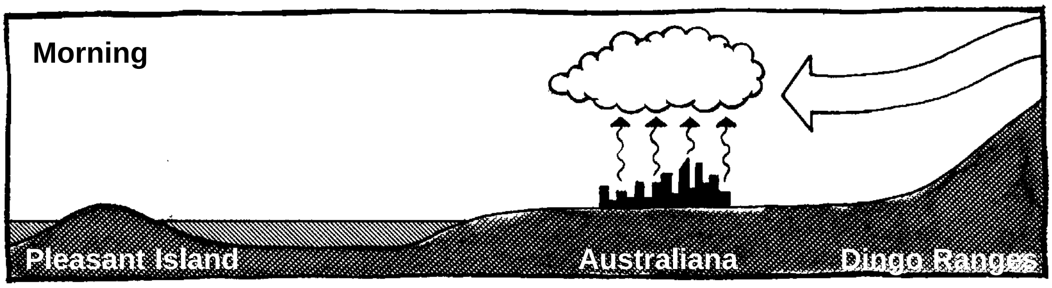
____

____

____

____

A



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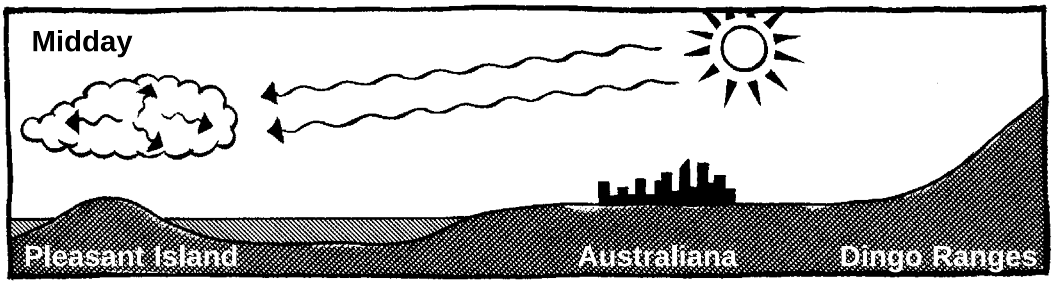

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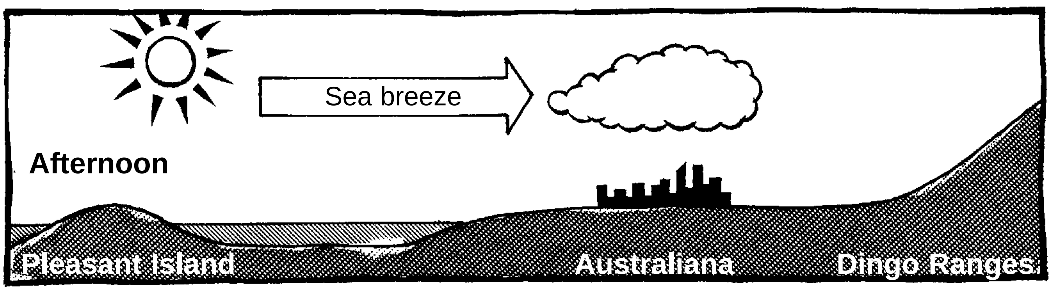


Activity 6.2

To unerstand how smog can form examine the pictures above carefully and describe what is happening in each.

A

____

____

B

____

____

C

____

____

Extension

When we hear the word "smog", we think of the 'pea-soupers' made famous in London. This type of smog was a combination of fog and smoke.

Find out what the 'pea-soupers' were like, what caused them, what problems they caused and how they were eventually eliminated

Family cars

Activity 6.3

This activity gets students to look at their own family car usage and its affect on air pollution. They then consider the alternatives to private car usage, their benefits and disadvantages.

Background

Cars are responsible for emissions of carbon dioxide, nitrogen oxides, hydrocarbons and lead. Ones which are not running properly give off more of these pollutants and also use up more petrol.

So, how do we use our cars? Is there any way in which we can change our use of cars that might reduce the amount of pollutants being pumped into the air?

Notes

Contact the RAC for average running costs for a range of different cars or use the following website to calculate the cost per year to run a vehicle:

www.nrma.com.au/motoring/buyingacar/opcosts

or

203.89.198.226/racvm/whichcar/expertsays

Discussion questions

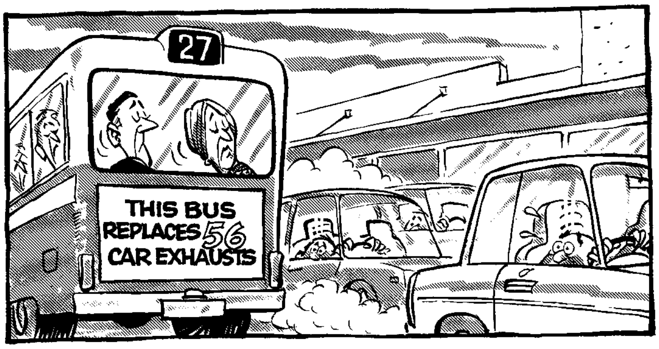
1. Why do you think most people choose to own a car rather than use public transport? (Convenience, safety, saves time)
2. What could be done to encourage people to use their cars less? (Make alternative transport more attractive, better public transport, better cycle / walk paths, increased parking costs, etc.)

CURRICULUM LINKS

Society and Environment
Students have knowledge, skills and values regarding their local geography and the places & spaces that surround them.

Mathematics
Students integrate number and measurement with chance and data.

Family cars



Cars are a big contributor to air pollution. Let's look at how your family uses the car.

Activity 6.3

Form a group of four students, discuss and fill in the following table.

Student	Number of people in family	Number who are drivers	Number of cars	Age of each vehicle (yrs)	Number which used for work*	Average running costs per week
Average						

* Cars used as part of your work, not just getting to work.

How does the number of cars relate to the number of drivers in the family?

Can you suggest ways your family could cope with one less car?

What advantages would there be to your city or town if families got rid of one car? Would there be advantages to the families?

Think about it

One alternative to using a car is using public transport.

With your group discuss some of the advantages and disadvantages of using public transport. Write them in the space below.

Advantages	Disadvantages

Table 7: Public transport.

What other alternatives are there to using a car?

Car Logs

Activity 6.4

This exercise is to enable the students to critically analyse how cars are used by families and examine alternatives which will help reduce the use of the car.

Discussion questions

1. How many cars does your family have?
2. How could your family use one less car?

Extension

The students might examine their own family's use of vehicles and report back to the class. A car log is provided on Eddie's Extras page at the end of this section.

This could be a project or homework assignment.

CURRICULUM LINKS

Mathematics
Students integrate and interpret number and measurement data.

Society and Environment
Students have knowledge, skills and values regarding their local geography and the places & spaces that surround them.

Car logs

Activity 6.4

Here is a daily car log for the Butler family for three days. Examine how they use their car each day and then answer the questions below.

Day	Driver	Car used	Distance (kms)	Reason for journey
Monday	Mum	Mum's 4WD	2	Kids to school
	Dad	Dad's Camry	10	Going to work
	Mum	Mum's 4WD	3	Grocery shopping
	Mum	Mum's 4WD	2	Pick kids up
	Mum	Mum's 4WD	3	Tom to football practice
	Mum	Mum's 4WD	3	Pick up Tom
	Dad	Dad's Camry	10	Home from work.
Tuesday	Mum	Mum's 4WD	2	Kids to school
	Dad	Dad's Camry	10	Going to work
	Mum	Mum's 4WD	20	Family errands
	Mum	Mum's 4WD	2	Pick kids up
	Mum	Mum's 4WD	6	Debbie to ballet
	Mum	Mum's 4WD	6	Pick Debbie up
	Mum	Mum's 4WD	4	Mum's netball and return
	Dad	Dad's Camry	10	Home from work
Wednesday	Dad	Dad's Camry	50	Business trips and home
	Mum	Mum's 4WD	2	Kids to school
	Mum	Mum's 4WD	2	canteen duty at school
	Mum	Mum's 4WD	2	Home from school
	Dad	Dad's Camry	4	Squash night and return
	Mum	Mum's 4WD	5	Pick kids up, visiting friends and home.

Table 8: Butler car log.

List the major reasons for the use of the Butler's cars.

____

____

Which car would use the most petrol and cause the most pollution?

____

Who is doing most of the trips?

____

Which of the two cars should Mum drive to reduce pollution?

____

How could Mum reduce the amount of driving she does?

____

Where could Dad save on driving?

____

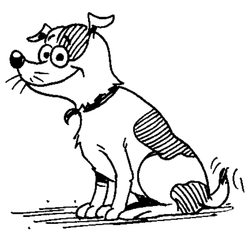
Outline a way the Butlers could still do all the things they do but have only one car. Which car do you think it should be? (Remember, Dad sometimes uses the car for work.)

____

____

Extension

Draw up a table similar to the one on this page. Fill in the car log for three days for your own family, and then answer the questions on this page again.



Smoky vehicles

Summary

Students will be able to identify smoky vehicles and discuss their cause, effects and ways to reduce their emissions.

Activity 6.5

Students to identify smoky vehicles along a busy road. Ensure safety issues are addressed.

Background

Investigations have shown that smoky vehicles contribute far more to air pollution than well-maintained vehicles. Smoky vehicle exhausts pose a risk to public health and are often offensive to people using roads and footpaths.

It is environmentally and socially unacceptable when vehicles continuously emit visible smoke.

What is a smoky vehicle?

A vehicle—either petrol or diesel fuelled— which emits visible smoke from its exhaust pipe for longer than 10 seconds is classified by the Department of Environmental Protection as a smoky vehicle.

How is the smoke harmful?

Smoke is a by-product of incomplete combustion. Incomplete combustion is where there is not enough oxygen to completely burn the fuel through to carbon dioxide and water. It can significantly increase the number and amount of certain toxic chemicals which are released from vehicles into the air.

These chemicals can cause mild to severe irritation to the eyes, nose, throat and lungs. They can also be absorbed into the body and cause deterioration in general health. The extent of these detrimental effects on people's health is related to the length of time they are exposed to vehicle emissions, the concentration of fumes that they may breathe and various other factors such as their age and health.

What causes a vehicle to be smoky?

A car which is not well tuned and maintained can emit smoke due to the burning of oil or fuel.

Discussion questions

1. What percentage of the vehicles were smoky?
2. What was the most common type of smoky vehicle? (Old, new, truck, bus??)
3. What should people do to ensure their car does not become smoky? (Tune and service it)
4. Anyone can report a smoky vehicle to the Department of Environmental Protection. Do you think that's fair?

CURRICULUM LINKS

Society and Environment
Students have knowledge, skills and values regarding their local geography and the places & spaces that surround them.

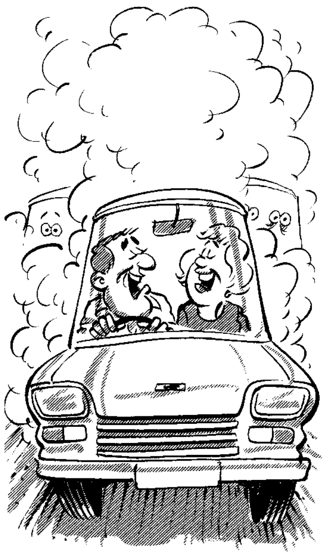
English
Students acquire knowledge and values through speaking and listening.

Smoky vehicles

Investigations have shown that smoky vehicles contribute far more air pollution than well-maintained vehicles. Smoky vehicles affect our air quality and our health.

A smoky vehicle is one which gives off visible smoke for 10 seconds or more.

You are going to find out how many smoky vehicles we have on our roads.



Activity 6.5

Choose a busy road which is flat and cars are not having to accelerate. Have one person count all the vehicles that go by. Use another person to count only the number you would classify as smoky.

NP. If you have time, try to identify the type of smoky vehicle (eg. old car, new car, bus truck).

Discussion questions

Calculate the percentage of smoky vehicles found in your survey. (Show your calculation)

____

____

____

Discuss what the pictures at the bottom of the page tell you about smoky vehicles.

What do you think should be done about smoky vehicles?

____

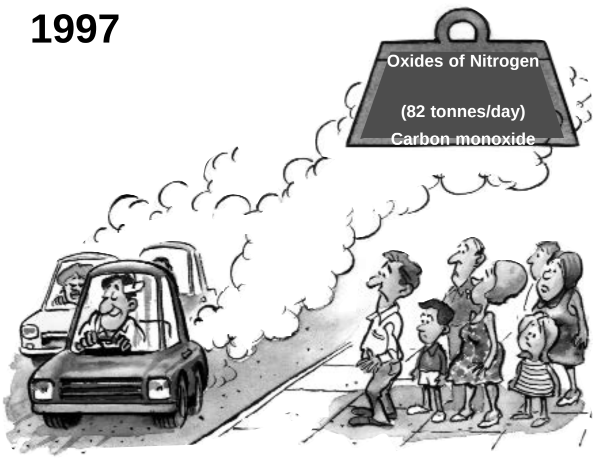
____

____

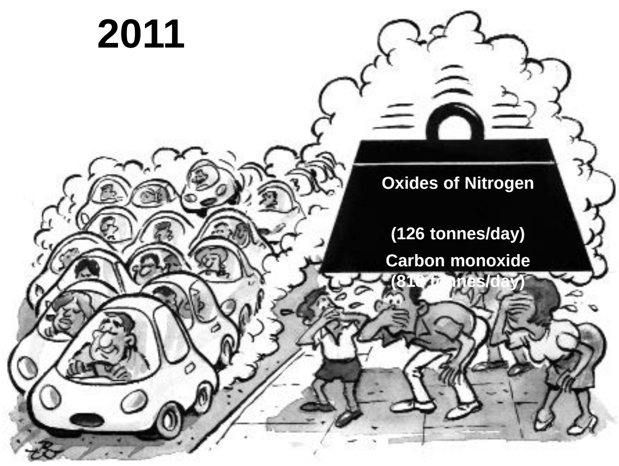
Date & Time	Place	Total number of vehicles	Number of Smoky Vehicles	Vehicle types

Table 9: Smoky vehicles.

1997



2011



Vehicle counts

Summary

Using a survey, you will collect traffic data to determine what sort of vehicles use your local roads. The type and amount of local traffic determines how much air pollution and traffic congestion there is in your area.

Background

Traffic type and flow information is important if you wish to reduce air pollution from vehicles in your area.

Vehicles contribute almost all of the carbon monoxide pollution and about half of the hydrocarbons and oxides of nitrogen. Smog is a direct result of the way we use our cars.

Of particular interest are single occupancy vehicles (SOVs) which increase vehicle numbers, traffic congestion and air pollution.

To reduce traffic congestion and air pollution in major cities, we must reduce the emissions from cars. There have been many suggestions including reducing the large number of SOVs currently on the roads.

Activity 6.6

Students should use a fairly busy road to take a count of the number and type of vehicles using it.

A group of four students should be able to cover all vehicle types by putting a mark against a category each time they see the particular type of vehicle. Back in class they can tally each for a final result.

Discussion questions

1. What are the advantages and disadvantages of having more than one person in a car?

2. Car pooling is where a group of people will share a lift to work. What are the advantages and disadvantages of carpooling?

3. What are other ways of reducing cars with only one person in them? (using alternative transport).

CURRICULUM LINKS

Mathematics
Students integrate number and measurement with chance and data.

Society and Environment
Students have knowledge, skills and values regarding their local geography and the places & spaces that surround them.

Vehicle counts

Using a survey, you will collect traffic data to determine what sort of vehicles use your local roads. The type and amount of local traffic determines how much air pollution and traffic congestion there is in your area.

Activity 6.6

To do this activity, you will be standing alongside a busy road counting the type of vehicles as listed in the table below that pass you.

Form a group of about four students. Decide which types of vehicles each person is going to count.

When out doing your survey, remember your safety rules.

Discussion

What type of vehicles are there in greatest number?

____

Using the class results, calculate the percentage of single occupancy vehicles (SOV)?

What was the percentage of i) trucks ii) buses?

Which vehicles do you think are responsible for a lot of the pollution? Explain

____

____

Suggest three ways to reduce the number of cars on the road which have only one person in them.

____

____

____

Date: ______ Time: ______ Street Name: ______	Group Results (Number)	Class Results (Number)
Motorbikes		
Car - 1 person		
Car - 2 persons		
Car - >2 persons		
4WD		
Buses		
Vans		
Trucks		
Semi-trailers		

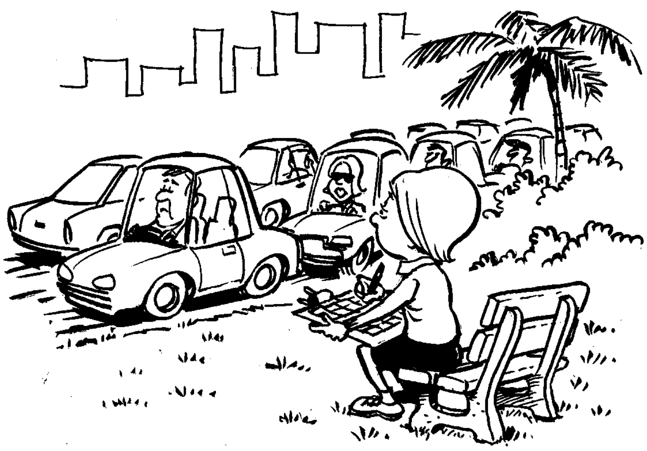
Table 9: Vehicle counts.

Van: Classed as a car if there is only 1 rear wheel on each side of van.

Truck: A solid body with 2 rear wheels on each side. eg.one tonne truck

Semi-trailer: A prime mover with a trailer attached to it.

Back in class, combine your results to make a class set.



Eddie's extras

Complete a family car log with the following information for a week. Tick those journeys which could have been avoided. Discuss the results with your class.

Date	Distance (kms)	Type of car	Reason for journey

Table 10: Family car log.

Write a story " The Traffic Jam".

Make a collage of different types of public transport, both old and new.

Write a limerick "The Day the Car was Banned".

What Can I Do?

Unit Summary

In this unit students are encouraged to sum up all the information they have about air pollution. They also need to discuss their feelings and attitudes to develop a stance on air pollution and then to act on their position.

It is easy to talk about these issues, it is far more difficult to act upon them. We would encourage the students to commit to one act, however small, as their contribution to improving air quality in our state. This may take the form of walking or cycling to school for a week instead of using the car, or helping with a shopping centre display on air pollution one day of their weekend.

They are further encouraged to translate their information, feelings and values about air pollution into their art, craft, language and drawing activities.

Background notes

At this point in time we have the opportunity to prevent our cities becoming seriously polluted.

Populations are growing and our use of private vehicles and wood heaters is showing an increasing trend. If no changes are made, more toxic emissions will be pumped into the air. Some of these will cause immediate effects for us and our environment, while others will show their effects at later stages.

Air pollution has its costs. It affects the health and quality of life for people, animals and plants. Buildings, monuments and artworks are also damaged by a variety of pollutants.

Our personal efforts can help reduce air pollution emissions, and contribute towards a cleaner and healthier environment. Activity 7.2 lists many of these for the students.

What do you know?

Activity 7.1

Using a simple survey, students are able to measure what their family, friends and others in the community know and feel about air pollution. This exercise also enables them to identify what are good and bad survey techniques.

Materials

Photocopies of two questionnaires per student.

Discussion questions

1. Who did you ask?
2. If you asked only your friends, are you getting a good sample? (They do not reflect the overall population.)
3. To do a reliable survey, how many and what type of people do you think you should ask? (A cross section of the population.)

Answers to Survey

2. Yes
3. Yes
4. Yes
5. Yes
6. Yes

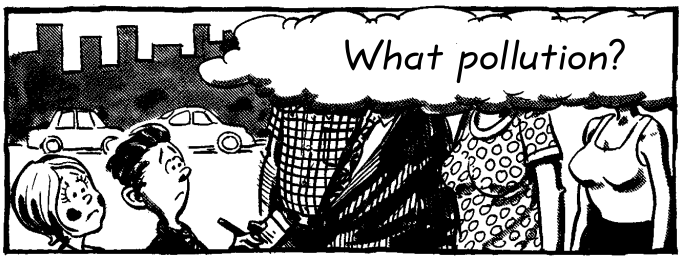
1, 7, 8, 9 are opinions and attitudes to which there are no correct answers.

CURRICULUM LINKS

Society and Environment

Students demonstrate that time, continuity and change affect decision making in relation to society and environment.

What do you know?



Activity 7.1

The following survey will give you a good idea what your family and friends think about air pollution. Try to get a least two surveys answered. Use the same sheet but a different colour for each person's answers.

Using the results

Add up the number of YES, NO and UNSURE answers for each question. Collect the class results in the table below if you have time.

Survey

1. Do you think this city has an air pollution problem?
   YES NO UNSURE
2. Photochemical smog is a problem mainly in summer.
   YES NO UNSURE
3. Photochemical smog is caused by emissions from cars.
   YES NO UNSURE
4. Haze is a winter problem.
   YES NO UNSURE
5. Particles in the air cause haze.
   YES NO UNSURE
6. You should use only dry wood in wood heaters.
   YES NO UNSURE
7. Cars should be banned to help improve the air.
   YES NO UNSURE
8. Would you give up your car to help improve your city's air quality?
   YES NO UNSURE
9. Would you give money to help the environment?
   YES NO UNSURE

Discussion questions

Do the people you asked seem to know much about air pollution?

____

____

Do they seem willing to make changes in their behaviour to help the environment? Explain.

____

____

What could you do to help make people in your community more informed about air pollution?

____

____

Question number	Yes	No	Unsure
1			
2			
3			
4			
5			
6			
7			
8			
9			

Table 11: Class survey results.

Using the car less

Summary

This activity asks students to look at the alternatives to using the car and the associated advantages and disadvantages.

Activity 7.2

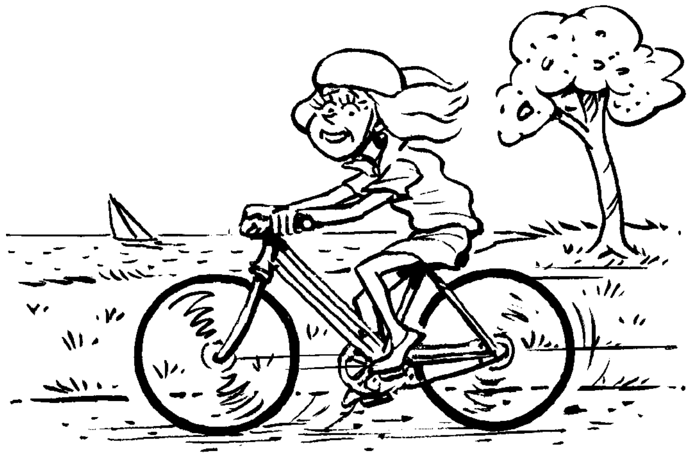
Depending on the age of the students, they may need help in developing their answers.

Students should be able to identify that advantages of the car include time efficiency, safety, convenience and disadvantages such as cost, pollution, traffic congestion, prevention of exercise etc.

Alternatives should include walking, cycling, public transport, carpooling and their associated benefits, especially health and cost benefits. Other benefits can include reduction in congestion around the school, safety, social and community interaction as people share lifts or walk together to school.

In this activity, students should be able to identify the positives of alternative transport and develop a positive attitude to changing how they and their family use the car.

It is essential that students realise that if they want to make a difference to the environment, one of the biggest steps they can take is to reduce their reliance on the car for some of their travel needs.



CURRICULUM LINKS

Society and Environment
Students demonstrate that time, continuity and change affect decision making in relation to society and environment.
Students have knowledge, skills and values regarding their local geography and the places & spaces that surround them.

Using the car less

In other activities you have learnt that using your car helps increase air pollution in your local area. Let's look what alternatives we could use and what benefits we can gain from them

Activity 7.2 (a)

In the table, list all the advantages and disadvantages of using a car for getting to school and other trips you need to do.

Advantages	Disadvantages

Activity 7.2 (b)

Now list as many alternatives as you can to making those same trips without using the car.

Activity 7.2 (c)

For each alternative write down the advantages and disadvantages.

Activity 7.2 (d)

As a whole class, discuss your answers and put a summary on the board .

Questions

What were the disadvantages to using the car?

Do you think these are important disadvantages? Why?

Of all the alternatives ways to get to school, which one would you be able to use? Why?

Why couldn't you use the other types of transport?

Which do you think is the best reason for not using the car.

Which is the best reason for using your chosen alternative?

Would it be practical to use one of the alternatives for all your travel needs? Explain.

Alternative transport mode	Advantages	Disadvantages

Green Transport Plans

Summary

One practical way your students can help the environment is to develop a Green Transport Plan.

Activity 7.3

Green Transport Planning examines the ways people commute to work or school and promotes the use of "greener" modes of travel, that is walking, cycling, public transport or carpooling.

Your students may develop a plan to get their class to change to greener transport for at least 2 days of one week. That is, four trips to or from school.

Activity 7.3 helps them identify what is currently stopping students from using the alternatives and finding practical solutions, which may involve asking the school administration or the P&C for assistance.

Students will need to plan how they will implement their Green Transport Plan and assess whether they have been successful. The older the student, the more sophisticated these plans may become, including the whole school community.

Discussion questions

1. What seems to be stopping students using alternative transport modes?
2. How can we overcome some of these barriers?
3. Which travel modes will we include in our Green Transport Plan?
4. How will we encourage students to swap to an alternative?
5. Do we need to talk to i) parents? ii) the Principal iii) other teachers?

Other organisations

If your class/school wishes to become involved in alternative travel modes, organisations which can help you include:

- Safe Routes to School – Roadwise
  Telephone: (08) 9213 2066
- Travelsmart to School – Transport WA
  Telephone: (08) 9320 9320
- Walk Friendly Schools Program – Sport and Recreation
  Telephone: (08) 9387 9700
- Smogbuster's Way to School – Conservation Council of WA
  Telephone: (08) 9420 7268
- Smogbusters Victoria– Environment Victoria
  Telephone: (03) 9348 9044

CURRICULUM LINKS

Society and Environment
Students demonstrate that time, continuity and change affect decision making in relation to society and environment.
Students have knowledge, skills and values regarding their local geography and the places and spaces that surround them.

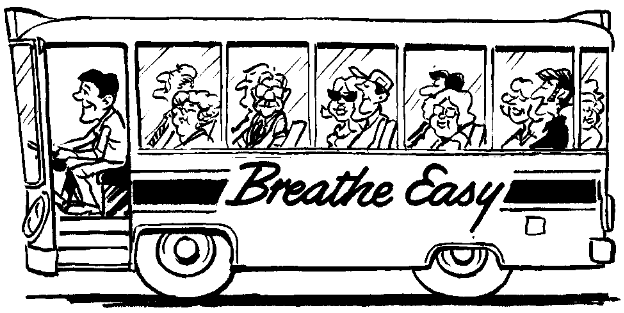
Health and Physical Education
Students know and understand health concepts and exhibit attitudes and values that promote personal health and demonstrate self-management skills.

English
Students acquire information through reading and apply writing skills.

Green Transport Plans

One practical way your class, and even your whole school, could help the environment is to develop a Green Transport Plan. 'What's that?' you ask.

A Green Transport Plan looks at the ways people get to work or school and then tries to plan ways they can make those trips using "greener" modes of travel, that is walking, cycling, public transport or carpooling.



Activity 7.3

In a group of 3-4 students, discuss the questions in the circles below and fill in the most common answers.

How do I get to and from school each day?

____

Why I don't use one of the alternatives? (eg: Mum doesn't think its safe.)

- Walk ______________________
- Ride ______________________
- Carpool ______________________
- Bus/Train ______________________

Things which would help me use an alternative (eg: secure bike racks at school)

- Walk ______________________
- Ride ______________________
- Carpool ______________________
- Bus/Train ______________________

Ideas to get more people using alternative travel (eg: introduce people who could walk to school together.)

- Walk ______________________
- Ride ______________________
- Carpool ______________________
- Bus/Train ______________________

Results

As a whole class put your ideas together on a sheet of butchers paper or the board.

Questions

Do most students get to school by car?

____

What alternative seems the most likely that students could swap to?

____

What steps need to be taken first to get students to change to this mode?

____

____

Writing the Plan

Write a summary of all the things which need to be done for your Green Transport Plan.

Implementing the Plan

Assign jobs to different students to make sure your plan works.

Assessing the Plan

At the end discuss with the class how successful you think the plan was, what worked, what didn't work, what you would do if you did another one.

What can I do?

Activity 7.4

This activity encourages students to take action from what they have learnt. If they value the quality of the air in which they breathe, they should be willing to do one small thing which will help improve its quality.

Notes

Often inaction occurs because we do not know what we can do or are not encouraged to think how we can make a difference to such a big problem as air pollution.

Here are some options that students should be able to suggest:

Car Usage

- avoid peak hour traffic
- combine car trips
- drive smoothly, avoid excessive acceleration and breaking
- buy a small, fuel efficient car which produces fewer emissions
- get your car tuned regularly and keep it well maintained
- make sure fuel caps fit well
- convert to LPG
- remove wind resisting items on your car such as roof racks
- don't carry luggage if you don't have to
- keep tyres inflated
- don't alter the car ("Hotting" up the car)
- use unleaded petrol

At home

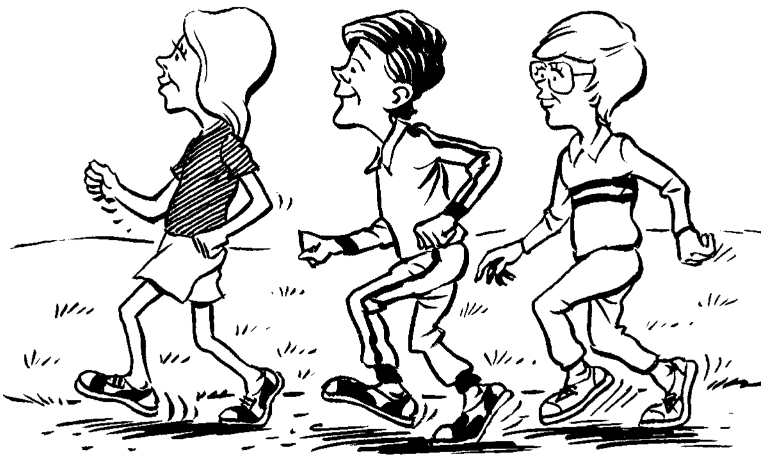
- compost your garden rubbish, don't burn it
- avoid using two-stroke motors if possible
- use water based paints
- use a gas BBQ rather than a wood-fired one
- make sure people smoke outside

Woodheater usage

- burn the wood brightly
- avoid using wet, green or painted wood
- don't damp the fire down at night
- avoid burning household rubbish
- make sure your heater conforms to Australian Standards
- put on a jumper rather than increasing the heat.

Discussion questions

1. Which actions do you think you could do?
2. How can you get your family to take some action too?
3. Do you think we should try to get the rest of the school involved? Is so, how?



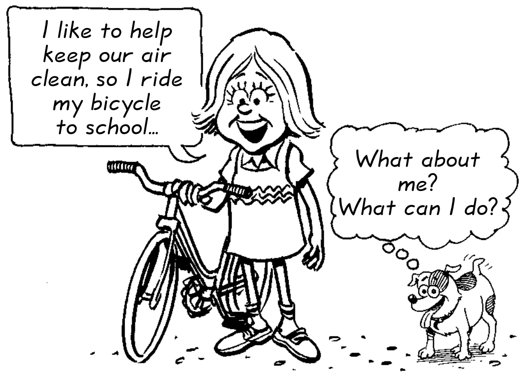
CURRICULUM LINKS

Values
Students demonstrate awareness of the need for conservation of the environment.

Society and Environment
Students demonstrate the ability to make informed decisions and implement relevant social action.
Students demonstrate active citizenship through practices in the school environment.

What can I do?

Well you've learnt a lot about air pollution - but are you going to anything about it?



You will have learnt that a lot of the problems with our air are caused by the way we live, the way we use our cars and our woodheaters. Here is your chance to take some small actions which will help improve air quality.

Activity 7.4

Materials

butcher's paper
coloured dots (sticky)
blue tac
texters

What to do

What to do is always a problem. The following activity uses focus groups to decide what you would like to do to help improve air quality.

Split into groups of 4-6 students.

Exercise 1:

Write down as many words that you can which make you think of which shows how you feel when the air is

i) clean and clear and

ii) polluted.

Each person in the group is to gives their lists and explain their feelings.

Exercise 2:

As a group, brainstorm what could be done to help reduce air pollution. Write these on a piece of butcher's paper.

Exercise 3:

A representative from each group presents these solutions to the class.

Exercise 4:

Each group reforms and discusses which of these solutions the students could actually become involved in.

- Write these on butcher's paper.
- Add any extras not mentioned on the bottom.
- Put a star next to the two actions you think would be the best for your class to undertake.

Exercise 5:

Each group post their lists around the room and discusses them, focussing on the two preferred actions for their group.

Exercise 6:

- List on the board the two preferred actions from each group.
- The class now has to vote for two to be undertaken by the whole class. To do this give each student 3 sticky coloured dots. They can use these to pick their most preferred options, one dot against three different items or three dots against one item.

Exercise 7:

The two actions with the most dots are the ones the students have voted to undertake.

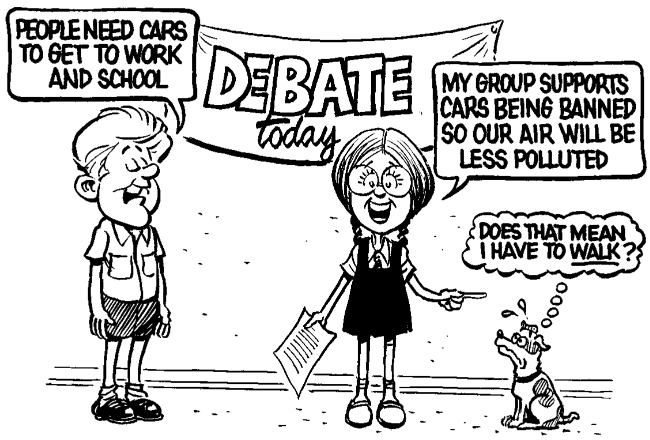
Discuss how these could be implemented and ask students to draw up plans to get these actions started.

Plan a campaign on air quality in your community. Here are some ideas, but you may think of better ones for yourself!

- Design posters, talks, brochures etc which can be handed out to people;
- Arrange a shopping centre display in your area; or
- Have an open day at school focusing on air quality.

Debate the Issue

" Air pollution in our city is not a problem".



Class discussion

Break into groups of four to six students and discuss what you could do to take the message to people in your community about helping to keep our air clean.

Report back to the class

Take one of these actions and make it into a poster or brochure which tells people clearly what they can do and why it needs to be done.

Put these posters around the school. Maybe you can ask your community newspaper about running the best ones in their paper.

Imagine you are a journalist who has to write an article on air pollution in your city. Research your topic and then write an article for your newspaper.

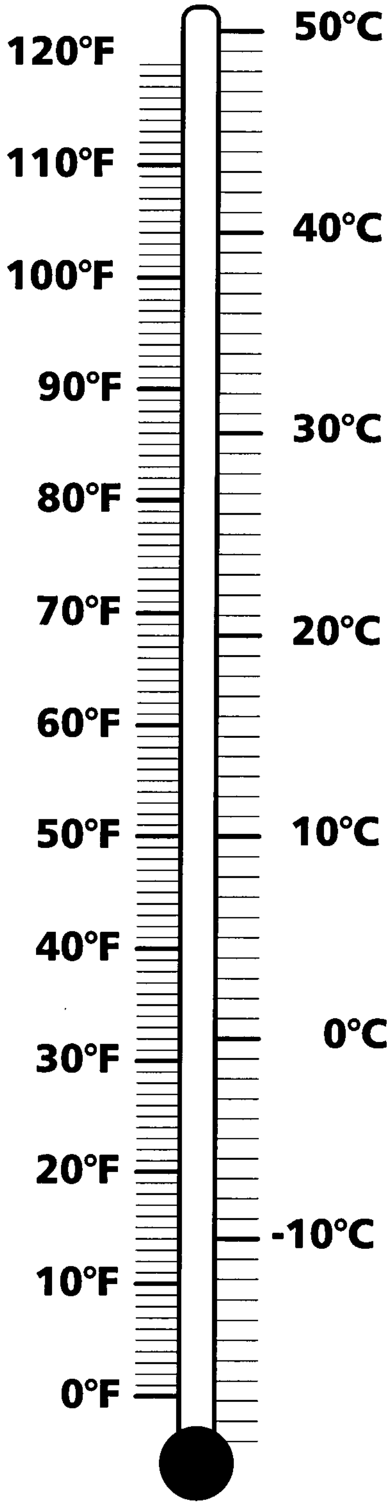
Make up a song or rap which gives the message

"Do the right thing!" when it comes

to keeping our air clean.

Make a collage from things you can find in the playground showing an environment which has good air quality.

Reading a Thermometer



Types of air pollution

Photochemical Smog

Photochemical smog, which is often invisible to the naked eye, is characterised by high concentrations of ground level ozone. In Perth this tends to happen in late spring, during summer and early in autumn when there is lots of sunlight and high temperatures.

Motor vehicles are the major contributor to Perth's smog. Industry and other sources also make significant contributions.

High ozone levels have been measured from Rockingham in the south to Two Rocks in the north, Rottnest to the west and Rolling Green to the east.

Ozone affects the healthy and fit as well as the susceptible members of the population such as the elderly, the young and those with respiratory problems.

The effects of ozone include eye, nose and throat irritations, damage to our respiratory tracts, chest tightness and wheezing. There is also evidence that ozone can increase our sensitivity to allergens, trigger asthma attacks and increase our susceptibility to infection.

Ozone can also damage plants and reduce their ability to photosynthesise as well as damage materials such as plastics, rubber, concrete, stone, cloth, dyes and paintwork.

Haze

Haze occurs when many tiny particles from wood smoke and vehicles make our skies look brown. Haze occurs mostly on cold, calm winter mornings.

The largest source of haze forming particles in winter is smoke from domestic wood heaters. In autumn and spring particles come from burning off. Exhaust fumes, especially from diesel engines, also contributes to haze.

Haze is worst when there is a temperature inversion which occurs on cool, calm nights when the ground and the air near the ground cool down. As it cools the air becomes heavier and will not mix with the warmer air above, so the particles are trapped close to the ground where people can easily breathe them in.

When we breathe in particles, the larger ones are trapped by the fine hairs inside our noses and windpipes. We get rid of these when we blow our noses or cough. However, the smaller particles can travel deep into our lungs and have serious impacts on our health.

Fine particles are known to make bronchitis, emphysema and asthma worse. There is also evidence that they cause premature deaths. The main group at risk are elderly people who have chronic respiratory problems. We should also be aware that particles may contain chemicals which can damage our lungs, or even worse, cause cancer.

When particles settle they add a fine film of “dirt” to the natural and physical environment.

Carbon Monoxide

Carbon monoxide which is colourless, odourless and very toxic, comes from incomplete burning, industrial processes and biological decay.

Motor vehicles contribute 80 per cent of the carbon monoxide, other sources contribute 18 per cent while industry accounts for only two per cent. Other sources include our homes, gardens, schools, shops and service stations.

One of the most significant individual sources of carbon monoxide is cigarette smoke. Scientific research indicates that smokers, and passive smokers (people who breathe air that contains smoke), are exposed to four times more carbon monoxide than people in a smoke free environment.

Low levels of carbon monoxide can reduce our ability to carry out exercise. Greater levels reduce our ability to concentrate and cause headaches. Very high levels can be fatal.

The health threat of carbon monoxide is greatest for people who suffer from heart disease with a correlation being shown between carbon monoxide levels and hospital admissions of elderly people with heart failure.

Oxides of Nitrogen

The most common of these are nitric oxide and nitrogen dioxide. These help form photochemical smog and also have significant impacts on health.

The largest man-made source of nitrogen oxides is the combustion of fossil fuels. In Perth, motor vehicles contribute 51 per cent of these emissions and industry contributes about 44 per cent.

While nitric oxide (NO) is relatively safe, it is converted into nitrogen dioxide in the atmosphere. At certain levels, nitrogen dioxide can affect our respiratory system and increase our susceptibility to infection. This is a real problem for babies, older people or for those people with problems such as bronchitis and asthma. There is evidence that nitrogen dioxide can trigger asthma attacks and long term exposure can irreversibly damage our lungs.

Nitrogen dioxide can also age materials such as paint, metals, rubber, fabric, leather, paper and building materials. It can also react with water to form acid rain.

Air Toxics

There are many of these, most of which come from cars and other sources such as cigarette smoke and fuel vapour.

These have wide ranging effects from reduced consciousness and irritation of the respiratory system to increased levels of cancers.

Odours

Odour causes a great deal of concern for many people. Generally odours are annoying. In rare cases, the compound causing the odour may be poisonous and lead to illness in people.

Most odour complaints are related to industries which deal with animals or animal by-products. Examples include poultry farms, piggeries, cattle feedlots and tanneries.

Glossary

Air pollution - occurs when the air contains gases, dust, fumes or odour in amounts which are harmful to human health.

Air toxics - harmful organic compounds which come from sources such as car exhausts, cigarettes, building materials and cleaning products.

Allergens - substances which cause allergic reactions.

Combustion - burning in the presence of oxygen.

Components - parts which make up the whole.

Compound - a substance where its components are chemically combined.

Carbon monoxide (CO) - a poisonous gas formed when incomplete burning occurs.

Emissions - the gases discharged into the air from cars, trucks, factories and appliances.

Emphysema - a disease of the lungs which makes breathing difficult.

Flue - the smoke passage in a chimney.

Haze - a form of pollution where tiny particles float in the air, decreasing visibility.

Hydrocarbons - compounds made of hydrogen and carbon.

Incinerator - furnace for burning.

Incomplete combustion - burning where there is insufficient oxygen.

Inversion - where a warm layer of air is trapped close to the ground by a more dense cool layer above.

Kindling - wood chopped into small pieces used to start a fire.

Mixture - where two or more substances are mixed but not chemically combined.

Molecule - one or more atoms joined together.

Neutralise - to counteract and make ineffective.

Nitrogen oxides (NOx) - gases which form when fossil fuels are burnt. Some forms, such as nitrogen dioxide, are harmful to human health.

Oxygen (O2) - a gas in the air used by humans and animals for respiration.

Ozone - the main constituent of smog.

Particulates - solid or liquid particles which float and pollute the air.

Photochemical - chemical reactions which need light for the reaction to happen.

Photosynthesis - a process which uses sunlight to produce an energy source in plants.

Smog - a form of pollution which is characterised by high levels of ozone in the air.

Turbulence - air movement which is irregular, indicated by gusts and winds.

AirWatch

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